# PART 2

## Technical Requirements

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SECTION 1. GENERAL

1.1. Scope

The Design-Builder shall be responsible for complying with all terms of the Agreement, the Hampton Roads Crossing Study Final Supplemental Environmental Impact Statement (Final SEIS), dated April 25, 2017, the Record of Decision (ROD), dated June 12, 2017 and shall thoroughly examine, review and understand all terms prior to starting work on the project. The Design-Builder shall be responsible for determining and executing the full scope of the Project by undertaking a thorough examination of the Agreement, the Final SEIS, the ROD and all other applicable documents, along with an understanding of the site conditions. All elements of work that such an examination determines to be necessary for the proper implementation of the Project shall be deemed to be included in the scope of the Design-Builder’s work, whether or not specifically cited in Agreement.

The Design-Builder shall not rely solely on the description contained in the Agreement or these Technical Requirements in order to identify all project components to be designed, furnished, constructed, and/or installed by the Design-Builder. It is the Design-Builder’s responsibility to obtain clarification of any error, omission, conflict or ambiguity relating to the scope of the project or any Agreement requirement.

The Department will deliver the Interstate-64 (I-64) HRBT improvements as defined in the I-64 / Hampton Roads Crossing Study (HRCS) Final SEIS. The preferred alternative from the Environmental Impact Study was the basis for the project development. The project is the subject of this RFP and consists of widening and reconfiguring the interstate to eight lanes that includes provisions for High Occupancy Toll/High Occupancy Vehicle (HOT/HOV) lanes as described below.

The project is located on I-64 in the Cities of Hampton and Norfolk beginning approximately 0.177 miles west of Settlers Landing Road and ending approximately 0.289 miles east of Little Creek Road.

The existing interstate configuration is as follows; In the eastbound direction, from the project beginning to Settlers Landing Road, the mainline roadway is a three (3) lane section that transitions to a two (2) lane section to the end of the Project east of Little Creek Road and includes seven (7) interchanges. In the westbound direction, from the project beginning to 800 feet west of the Settlers Landing Street overpass, the mainline roadway is a three (3) lane section that transitions to a two (2) lane section to the I-564 interchange and includes seven (7) interchanges. The existing interstate is divided by a median barrier, from the project beginning to the northern trestles of HRBT, then divided on trestles and tunnels across the Hampton Roads waterway and then divided by a variable width grass median beginning on the Norfolk side after the southern trestle, to the end of the project.

The project includes widening and reconfiguration of the existing interstate to accommodate two (2) general-purpose (GP) lanes, one HOT/HOV lane, with three-foot buffer, and one (1) part-time Hard Running Shoulder in the eastbound and westbound directions; a new EB tunnel that can accommodate four (4) lanes of traffic; a slip ramp from eastbound I-64 to I-564 for direct connection of HOT/HOV lanes; and a slip Ramp from I-564 to westbound I-64 for direct connection of HOV/HOT lanes. The proposed improvements include, but are not limited to: a new eastbound HRBT including trestles over the Hampton Roads waterway; removal and replacement of the existing eastbound northern trestle; partial removal, replacement and widening of the existing westbound northern trestle; expansion of the existing north and south islands of the HRBT; pavement widening to accommodate new lane configurations; full depth Hard Running Shoulders for part time use; outside shoulders; retaining walls; noise barriers; full depth construction on mainline roadway pavement where indicated in the Concept Plans; milling and
asphalt overlay where indicated in the Concept Plans; removal and replacement of the overpass bridge at South Mallory Street including any necessary improvements and/or realignment of Mallory Street; widening of 25 existing I-64 Bridges at 14 locations, over Settler’s Landing, Bayville Street, Willoughby Bay, 4th View Street, Mason Creek Road, 1st View Street, Bellinger Boulevard/West Ocean View/West Bay Avenue, Evans Street, West Bayview Boulevard, Oastes Creek, New Gate Road near Gate 22 Naval Station Norfolk, Granby Street (EB only), I-64 to I-564 Ramp (EB only), Little Creek Road (EB only); new direct connect slip ramps from I-64 to I-664 for HOT/HOV lanes; entrance/exit Ramp modifications; installation of storm drain pipes and SWM facilities; roadway signing both ground mounted and overhead; pavement marking, pavement markers and delineators; roadway lighting; relocation of existing ITS infrastructure and equipment.

It is noted that the description and length are approximate only and are based on the RFP concept plans shown in the RFP Information Package. The final Project length may vary depending on the Design-Builders final design; however, any change in the project limits requires approval by the Department.

The conceptual design contained in the RFP information package reflects a basic line, grade, typical sections, minimum pavement structures, major cross drainage structures, potential locations of SWM ponds, conceptual bridge and retaining wall locations, and general length and location of sound barriers. These elements are considered to be the basic project configuration. The Design-Builder is responsible for final design in accordance with the Agreement and these Technical Requirements. The PDF copy of the RFP Concept Plans shall supersede the electronic drawing files (DGN) contained in the RFP Information Package.

1.1.1. Anticipated Scope

The anticipated scope of work to be undertaken by the Design-Builder under the Agreement for this project will include, but is not limited to:

A. Survey
B. Developing and completing the design through the Department approval process.
C. Acquiring the necessary Environmental Permits, including USCG Permit and approval.
D. Acquiring right of way.
E. Coordinating and performing, or causing to be performed, required utility relocations, additions, and adjustments.
F. Coordinating and cooperating with the Department existing tunnel operations.
G. Reporting procedures.
H. Roadway construction and widening.
I. Tunnel design, construction and systems.
J. Reconstruction of existing mainline travel lanes, shoulders and ramp acceleration / deceleration lanes.
K. Milling and overlaying and/or building up of existing pavement.
L. Clearing and grubbing.
M. Pavement reconstruction and/or new pavement additions.
N. Demolition and/or relocation of existing Roadway assets.
O. Bridge demolition and bridge construction.

P. Bridge repair and rehabilitation.

Q. Bridge fender construction and waterway navigation coordination.

R. Scour protection.

S. Bridge pier protection systems, new installation, repair, and/or replacement.

T. Guardrail/barrier planning, design, and installation.

U. Retaining wall new installation, repair, and/or replacement.

V. Sound barrier wall new installation, repair, and/or replacement.

W. Geotechnical work.

X. Planning, design, and construction of signs, sign structures, and foundations.

Y. Traffic signal modifications.

Z. ITS components including CCTV cameras, Dynamic Messaging Signs (DMS), and Fiber Optic Communications (COMM) Infrastructure.

AA. System integration, testing, maintenance until final acceptance, and documentation.

BB. Overhead signs structures and other traffic control measures new installation, repair, and/or replacement.

CC. ITS for monitoring traffic conditions and safety.

DD. Coordination of work efforts with the toll operations concessionaire work efforts.

EE. Planning, design, and construction of roadway and marine navigation lighting.

FF. Traffic maintenance and management during all phases of construction.

GG. Pavement markers and markings.

HH. Completion of Hydraulic and Hydrologic Analysis (H&HA)

II. Planning, design, and construction of storm drainage.

JJ. Planning, design, and construction of SWM facilities.

KK. Culvert inspection, repair and rehabilitation.

LL. Underdrain installation.

MM. Planning and implementation of ESC.

NN. Quality Assurance (QA) and Quality Control (QC) for design and construction.

OO. Stakeholder coordination and public outreach.

PP. Overall project management and coordination with other active construction projects in the vicinity.

QQ. Planning, design, and construction of landscape architecture.

RR. Potential HAZMAT remediation.
SS. Mobilization, including field or project offices.

Descriptions and Technical Requirements of the anticipated work are set forth in Part 2, Sections 2 through 35.

1.1.2. Anticipated Design Services

Design services shall address all items necessary for construction and operation of the completed facility. Design services are anticipated to include, but are not limited to, those services necessary to produce roadway, bridge and tunnel construction plans relative to the technical disciplines listed in Part 2, Section 1.1.1 above. Other data collection and technical studies anticipated include, but are not necessarily limited to: geotechnical investigation, design quality management, public outreach support, design exceptions and design waivers, right of way support, borings and analysis, materials analysis, pavement design, foundation design, traffic counts and analyses, utilities design and relocation, additional environmental studies and noise analyses (if warranted as described in Part 2, Section 5, Environmental Compliance), and H&HA. Design-Builder should note that all work performed on this project shall be completed using the English language and United States (U.S.) customary units of measure. Design-Builder shall develop and adhere to a design submittal schedule. Design-Builder is expected to adhere to the standards and references, design criteria and basis of design.

1.1.3. Anticipated Environmental Services

The Design-Builder shall meet environmental commitments during design and construction, as applicable, as identified in the Final SEIS and/or ROD; the final Right of Way Authorization (EQ-201); the final plans, specifications, and estimates (PS&E), Re-evaluation Authorization (EQ-200); and the final Environmental Certification/Commitments Checklist (EQ-103). All commitment compliance shall be supported by the appropriate documentation, to be provided by the Design-Builder to the Department. Further details are provided in Part 2, Section 5, Environmental Compliance.

The Design-Builder shall acquire all Water Quality Permits for the project in the Design-Builder’s name (i.e. the Design-Builder will be the “Permittee”) and shall provide for any necessary stream and/or wetland compensation required by permits to accomplish the work.

Section 4(f) and Section 6(f) Resources have been identified within the Project corridor and are reflected in the environmental documents. The Design-Builder shall ensure that all avoidance and minimization measures and other commitments regarding these resources are incorporated in the project’s final design and implemented during construction.

The Design-Builder shall avoid all impacts to the environmentally sensitive areas identified in the environmental documents. All design and construction operations shall completely avoid these properties. Additionally, the following federally-listed resources have been identified as potentially occurring in the project area and therefore potentially impacted by the project: Atlantic sturgeon, critical habitat, and other anadromous species; Essential Fish Habitat (EFH); listed sea turtles; Wilson’s plover, gull-billed tern, piping plover, red knot, and northern long-eared bat (NLEB). The following State-listed resources were also identified as potentially occurring in the project area and therefore potentially impacted by the project: Mabee’s salamander, canebrake rattlesnake, tricolored bat and little brown bat, benthic species, and submerged aquatic vegetation (SAV).

There are Section 4(f) resources in the project vicinity, for which FHWA has made de minimis impact findings. The Design-Builder shall continue to coordinate with all environmental agencies as the Project develops.
In addition, the Design-Builder shall conduct a Final Design Noise Analysis. For more information, please see Part 2, Section 5, Environmental Compliance.

The Design-Builder shall be responsible for compliance with pre-construction and construction-related environmental commitments and will be responsible for compliance with pre-construction, construction-related permit conditions, as well as post-construction monitoring if required by regulatory agencies. The Design-Builder will assume all obligations and costs incurred by complying with the terms and conditions of the permits and environmental certifications. Any fines assessed to the project associated with environmental permits or regulatory violations is the financial responsibility of the Design-Builder.

Any changes in scope or project footprint from that contained in the Agreement proposed by the Design-Builder, which are acceptable to the Department, may require additional environmental technical studies and analysis to be performed by the Design Builder and all costs associated with those changes will be sustained by the Design-Builder. These technical studies and analysis are to be conducted in accordance with the professional standards and guidelines of each NEPA-related discipline, as well as the criteria described in Part 2, Section 5, Environmental Compliance. The Department will be responsible for the coordination of any NEPA document re-evaluations with FHWA. The Design-Builder shall then carry out any additional environmental commitments that result from such coordination at its sole expense and at no additional cost and/or time delays to the project.

1.1.4. Anticipated Right of Way and Utilities

The Design-Builders conceptual design included in its Proposal shall be wholly-contained within the proposed Right of Way limits shown on the RFP Concept Plans, except for temporary construction easements, permanent drainage easements (other than permanent drainage easements for SWM facilities), and utility easements. Utility easements have not yet been identified or shown on the RFP Concept Plans. Deviations from the proposed Right of Way limits shown on the RFP Concept Plans will be subject to the Department approval in accordance with Part 1, Section XXXXX. The Design-Builder’s final design shall also be contained within the Right of Way limits shown on the RFP Concept Plans, with the exception of temporary construction, permanent drainage, and utility easements (other than permanent drainage easements for SWM facilities) and where minor adjustments are required during the final design process, and only after approval by the Department. If the Design-Builder proposes significant change to the Right of Way limits shown on the RFP Concept Plans, then this shall be considered a deviation from the Agreement documents.

The Design-Builders services shall include all work necessary for Right of Way acquisitions and to perform utility coordination, relocations, and/or adjustments as required by the project. All Right of Way costs (compensation paid to landowners for Right of Way or permanent Easement) will be paid by the Department, and shall not be included in the Design-Builders price. All costs for utility relocations, excluding betterments, shall be included in the Design-Builder’s price. Utility betterments shall not be included in the Design Builder’s price, but shall be reimbursed to the Design-Builder through agreement with the requesting utility owner. Betterments must be requested by and/or approved by the affected utility owner and must meet Buy America requirements as described in Part 5, Exhibit XXXXXX, Use of Domestic Material.

Permanent aerial easements may be needed for the widening and new construction of structures over any municipal property. Permanent aerial easements shall be the responsibility of the Design Builder to acquire.
1.1.5. Anticipated Construction Services

The construction services to be undertaken by the Design-Builder for this project are anticipated to include, but are not limited to: earthwork, roadway, tunnel, bridge and structures (including all necessary dredging, excavation, foundation work, substructure work, and superstructure work), bridge fender construction, bridge pier protection systems, retaining walls, sound barrier walls, the demolition and removal of portions of the existing pavements, milling and overlaying or building up of existing pavement, full depth construction of new pavement, demolition and removal of existing structures, drainage, SWM facilities, utility relocations/adjustments and coordination, maintenance of traffic, overhead sign structures and other traffic control devices, ITS components, civil infrastructure, traffic signal modifications, lighting, ESC, and compliance with all environmental requirements, commitments and permit conditions, as described in the environmental documents of this RFP. The Design-Builder shall provide construction engineering inspection and management, quality assurance and quality control, including plant quality assurance inspection and testing, but excluding items listed under Part 2, Section 3.1.2, Quality Management During Construction.

1.1.6. Scope Validation

The purpose of the scope validation clause is to provide the Design-Builder an opportunity to notify the Department of issues that are discovered during the post-Award review period that materially differ from what the Department provided in the RFP documents during the procurement process. If it is not reasonable for the Design-Builder to have discovered these issues prior to the Agreement date, and the issues materially impact the price or time to perform the Work, then the Department is willing to consider relief in accordance with [Part 4 Article XXXXXX] of the Agreement.

The clause is not intended to serve as a vehicle for the Design-Builder to raise issues that would ordinarily arise during the final design iteration process. The RFP Documents on the project are never represented to be complete. The Design-Builder is expected to make a variety of assumptions as to what they view as necessary to finalize the design and provide the Department with a firm price and schedule. The RFP documents contain numerous general depictions of existing conditions which the Design-Builder is obliged to verify through field investigations and surveys before completing its final design of the project and then integrating such design into its construction means and methods. It is the Design-Builder's responsibility to consider all of this during the proposal process in developing its price and schedule. The scope validation process does not envision that the final design development and related construction services (e.g., surveying and MOT transitions) would, on their own, create scope validation issues.

1.2. Standards and References

The Standards identified in Section 4 of these Technical Requirements represent requirements that the Design-Builder must comply with in performing the work.

The Design-Builder may utilize the engineering data provided in these Technical Requirements. However, the Design-Builder has the responsibility to validate any information it uses and the Design-Builder has the ultimate responsibility for the performance of the project.

1.3. Requirements

The “requirements” subsection of the individual sections of the Technical Requirements establishes the Department’s expectations with respect to the respective project elements. These include administrative, managerial and technical considerations as deemed appropriate to the subject, and encompass performance specifications, design criteria, and directive instructions as the Department deems best suited.
to the subject. The Design-Builder shall develop its design and work packages, along with any special specifications and provisions necessary to complete the work in conformance with these Technical Requirements.

The Design-Builder shall be responsible for meeting all requirements and terms contained in these Technical Requirements, unless explicitly stated otherwise.

The specific requirements in these Technical Requirements may be more stringent and shall govern over the criteria given in the Standards. However, where a specific requirement in the Technical Requirements is more stringent than the criteria specified in a Standard, said specific requirement shall become the basis for determining compliance. Non-standard features needing justification and FHWA approval are defined as those not meeting the criteria cited in the Standards listed in these Technical Requirements.

1.4. Deliverables

The subsection entitled “deliverables” in each Technical Requirements establishes the Department’s expectations. The deliverables have been summarized in Section 6 – Deliverables and Document Control of these Technical Requirements. These shall supplement the review plan and consultation and written comment cycles cited in Part 2, Section 3, Quality Management. The Design-Builder may submit deliverables for the Department’s consideration or consultation and written comment in addition to those requested. The Design-Builder shall include such additional submittals in its review plan and revise the review plan as necessary to incorporate sufficient advance notice to the Department.

Unless otherwise indicated in a Technical Requirement, all deliverables shall be submitted in both electronic format and hardcopy format. Acceptable electronic formats include but are not limited to; [Microsoft Word, Microsoft Excel, ArcGIS, MicroStation] or searchable portable document format (PDF) files, with no copy or password protection on the file content, unless otherwise indicated in a Technical Requirement or a Standard cited in a Technical Requirement.

1.5. Plan Preparation

1.5.1. MicroStation and OpenRoads / GEOPAK

When the Design-Builder is given a notice to proceed, they will be furnished with the following Software and files which run in WindowsXP or Windows7 only: OpenRoads (also known as GEOPAK SELECTseries 4) is current version used by the Department, MicroStation V8i (SELECTseries 4) is current version used by the Department, and the Department configuration and resource files, cell libraries, and all the design files used to develop the RFP Concep Plans including aerial images, if available, and survey files.

1.5.2. Software License Requirements

The Department has an Enterprise License Subscription agreement with Bentley Systems which provides maintenance and licenses for MicroStation and OpenRoads/GEOPAK. The VDOT CADD Support group provides technical support for these licensed Software packages. The Software is issued for the duration of each individual active Project Contract. Design-Build Projects in the SYIP are eligible for Software license.

The Department shall furnish a license or other access means for all the software products the Department makes available to the Design-Builder. The license or access means will be supplied upon request by the
Design-Builder, based on the data provided on a completed VDOT Software and License Request Form, LD-893, and subsequently reviewed and approved by the Department.

The license or access means are provided for use on the project detailed on the request only for the duration specified for the Project. Any adjustment made to the project schedule will be taken into consideration in adjusting the time the license or access means is available. Justification for the number of license(s) requested shall include the estimated number of total computer hours for the task of design, detailing, relating project management and other computer based engineering functions requiring the software requested.

The appropriate use of the license or access means provided to the Design-Builder will become the responsibility of the Design-Builder, regardless of who on the team uses it. The Design-Builder will be responsible for keeping track of the license or access means provided to them or a team member and, upon completion of the project, the prompt notification to the VDOT CADD Support Section of project completion and removal of the software from any system used solely for the project for which it was obtained.

1.5.3. Drafting Standards

All Plans shall be prepared in U.S. customary units and in accordance with the VDOT’s Road Design Manual, VDOT’s CADD Manual and VDOT’s I&IMs and VDOT’s Manual of Structure and Bridge Division, Vol. V, Part 2, Design Aids and Typical Details.

1.5.4. Electronic Files

The Design-Builder shall submit all plans in accordance with the Department’s policies and procedures (Right of Way and/or design, released for construction submittals, and As-Built record drawings in electronic format using the provided CADD Software. Files shall be submitted in both MicroStation DGN and Adobe PDF formats, by way of VDOT’s ProjectWise Web Client.

The Design-Builder will complete forms ITD-36E (VDOT Information Security Agreement) and LD-899 (VDOT Request for Access to the Location and Design ProjectWise Site) for access to the ProjectWise Web Client. The Department will furnish electronic files of all applicable standard detail sheets upon request by Design-Builder. The files will use standard VDOT cell libraries, level Structures, line types, text fonts, and naming conventions as described in the most recent version of the VDOT CADD Manual and VDOT’s Manual of the Structure and Bridge Division, Vol. V - Part 2, Design Aids and Typical Details. Files furnished to Design-Builder in electronic format shall be returned to the Department and removed from Design-Builder and its designer’s computer Equipment upon completion of this Project.

1.5.5. Plan Submittals

In addition to electronic files as described in Part 2, Section 1.5.4 above, the Design-Builder shall prepare and distribute hard copy paper plans in the quantities as specified below, for each of the following deliverables (at a minimum, as other submittals and/or work packages may be necessary or desired):

A. Preliminary Design Plans
B. Right of Way Plans
C. Released for Construction Plans
D. Right of Way and/or Construction Revisions
E. Record Plans (As-Built)
F. Approved Shop Drawings
G. Design Calculations

The Design-Builder will, at a minimum, make two (2) Bridge plan submissions for review and approval; 1) Preliminary Plan (Stage I) Submission and 2) Final Plan (Stage II) Submission.

A. Preliminary Plan (Stage I) Submission
   o The Design-Builder will submit a preliminary plan for each permanent structure (new bridge, bridge replacement, and bridge widening/rehabilitation) documenting how the structure geometrics were determined.
   o The preliminary plan submittal will include:
     ▪ a plan view, developed section along Bridge centerline/construction baseline and a transverse section. Refer to the Department’s office practices for more complete information;
     ▪ completed Stage I Bridge Report Summary Form; The preliminary geotechnical recommendation report is required with the Stage I submission; and
     ▪ copies of design exceptions and design waivers that influence the design of the structure or roadway approaches both over and under and will include a write up on how the design exceptions and design waivers affect the bridge.
   o Preliminary plans and associated design calculations must be submitted to and approved by the Department prior to any final bridge design submittal. The Department will not review any final design submittals until the preliminary plan has been submitted to the Department. The commencement of the final design prior to the review of the preliminary plan submittal by the Department will be done solely at the risk of the Design-Builder.
   o The Stage I bridge submittal will be subject to modifications based upon requirements identified in the detailed Hydrologic and Hydraulic Analysis (H&HA) and scour analysis of the waterway crossing.

B. Final Plan (Stage II) Submission
   o The Design-Builder will submit final plans for each permanent structure. The final plans will be assembled according to the procedures and guidelines presented in the Department’s office practices.
   o Final bridge plans may be submitted as completed bridge plan set(s) or in plan submission packages (i.e., foundation plan package, substructure plan package, superstructure plan package). The GBR and associated design calculations is required with the Stage II submission. The final plans are to be submitted for review and approval by the Department / FHWA prior to construction of that element and should be submitted according to the submission schedule provided by the Design-Builder.
   o For each bridge, the Design-Builder shall submit estimated quantities as outlined in the Manual of Structure and Bridge Division Vol. V Part 2 Chapter 3.

The bridge plans must use the standard sheets in Volume V (all parts) of the VDOT Manual of Structure and Bridge Division. Structural elements that have a corresponding standard sheet in Volume V must be detailed using the appropriate standard sheet. The sequence of concrete deck placement operations for beams or girder construction shall be given for continuous structures, and all erection stresses shall be
computed where necessary for design. A summary table of moments, shears, reactions and stresses for 
primary load carrying members shall be included in the plans.

The Right of Way and/or construction plans may be submitted for approval in logical subsections (such as 
from bridge to bridge) or consisting of work packages such as: 1) clearing and grubbing along with 
erosion and siltation control, 2) grading and drainage, 3) final roadway, and 4) traffic control. individual 
bridge plans may be submitted in logical components such as: 1) foundation, 2) remaining substructure, 
and 3) superstructure. A submittal schedule and planned breakdown of work packages shall be submitted 
to the Department for review and approval as part of the planned project baseline schedule.

Right of Way and/or construction plans shall be accompanied by 1) a VDOT LD-436 Quality Control 
Checklist filled out as appropriate for the specific submittal, and 2) a written notice signed by the Design-
Builder’s design manager that includes the following:

- The logical subsections or work packages for which review and approval is being 
  requested
- Certification that the submittal has been checked and reviewed in accordance with the 
  Design-Builder’s approved QA/QC plan.
- Certification that the submittal either meets all requirements of the Agreement and 
  reference documents or that any deviations from the contract documents and reference 
  documents have been identified and previously approved by the Department.

The Design-Builder shall submit all Right of Way and/or construction plans to the Department and 
FHWA simultaneously, for review and approval. The Department shall receive one (1) full-size sets and 
five (5) half-size sets of each submission, with the exception of the released for construction plans (see 
Section 1.5.8 below). FHWA shall receive two (2) half-size sets of each submission. The plan 
submissions shall be delivered to the following addresses:

VDOT
Attention – Frank Fabian, PE PMP
7447 Central Business Park Drive, Suite 100
Norfolk, VA 23513

FHWA
Attention – John Mazur
400 N. 8th Street, Suite 750
Richmond, VA 23219-4825

The Department and FHWA shall have the right to review all Right of Way and construction plans and 
provide comments regarding compliance with the requirements of the Agreement and reference 
documents. The Design-Builder shall be responsible for satisfying all such comments. Formal responses 
to the Department and FHWA comments shall be provided in subsequent submittals.

The Department and FHWA have the right to disapprove any design approach that is not in compliance 
with the requirements of the Agreement and referenced documents.
The Department’s written approval of any deviations from requirements of the Agreement and reference documents shall be attached to the plans submitted for review.

1.5.6. **Right of Way Plans**

Right of Way Plans and any associated design calculations shall be submitted to the Department and FHWA simultaneously for review. The time frame for plan review and approval shall be in accordance with the requirements of the Agreement. All the Department and FHWA comments must be adequately addressed before the Right of Way Plans will be approved. Notice to Commence Right of Way acquisition will be granted in accordance with Part 2, Section 1.5.5 above. The Design-Builder shall be responsible for the design details and ensuring that the design and Right of Way acquisition work are properly coordinated.

1.5.7. **Construction Plans**

Construction plans and any associated design calculations, shall be submitted to the Department and FHWA simultaneously for review. The time frame for plan review and approval shall be in accordance with the requirements of the Agreement. All the Department and FHWA comments must be addressed to the satisfaction of the commentator before construction plans are recommended for approval to the Department / FHWA. This plan milestone includes plans that may be submitted as soon as sufficient information is available to develop construction plans for certain portions or elements of the project (or work packages). The Design-Builder shall meet commitments for review and approval by other entities/agencies as specified in other portions of the RFP and its attachments. The Design-Builder shall be responsible for the design details and ensuring that the design and construction work are properly coordinated.

1.5.8. **Released for Construction Plans**

Released for Construction Plans (RFC) are those that are issued for construction after approval by the Department / FHWA. Notice to commence construction will only be issued by the Department upon approval of the construction plans (or work packages) by the Department / FHWA.

The Released for Construction Plans shall be distributed simultaneously to the Department and FHWA. The Department shall receive one (2) full-size set and ten (10) half-size sets of Released for Construction Plans, along with all electronic files. FHWA shall receive two (2) half-size hard copy sets, along with all electronic files, of the Released for Construction Plans. The Plans shall be delivered to the following addresses:

**VDOT**

Attention – Frank Fabian, PE PMP

7447 Central Business Park Drive, Suite 100

Norfolk, VA 23513

**FHWA**

Attention – John Mazur

400 N. 8th Street, Suite 750
1.5.9. **Record (As-Built) Plans**

The final plan milestone is Record (As-Built) plans. As-Built plans shall be prepared, signed and sealed by a Professional Engineer (PE) licensed in Virginia, and submitted to the Department with the final application for payment. These plans will show all adjustments and revisions to the construction plans made during construction and serve as a permanent record of the actual location of all constructed elements.

1.6. **Concept Plans**

The Concept Plans provided to the Design-Builder in this RFP in conjunction with the SEIS Environmental Documents convey a potential solution to the project’s needs that the Design-Builder may wish to consider in developing its design. Directive Plans

1.7. **Environmental Re-Evaluation**

Decisions to deviate from the Concept Plans may require a review in relation to the Final SEIS and other environmental approvals.

If it is determined that the Final SEIS must be re-evaluated or supplemented, the Design-Builder, in coordination with the Department and the FHWA, shall be responsible for undertaking the supplemental process and addressing its implications to the baseline project schedule and the prosecution of work. Further details are provided in Part 2, Section 5, Environmental Compliance.

1.8. **Alternative Technical Concepts (ATC)**

Where the provisions and requirements of an approved ATC differ from the requirements of the clause of these Technical Requirements, the provisions and requirements of the approved ATC shall govern.
SECTION 2. PROJECT MANAGEMENT

2.1. Design-Builder’s Role
The Design-Builder shall have responsibility for controlling and managing the work. This includes the Design-Builder’s responsibility for quality management as defined in Part 2, Section 3, Quality Management. This Technical Requirement summarizes the management plan and schedule to be produced by the Design-Builder in accordance with the Agreement. It also sets out the requirements for the Design-Builder’s attendance at meetings; and the Design-Build office and facilities to be provided by the Design-Builder.

2.2. Management Plan
The Design-Builder shall provide the items listed in Table 2.2.12-1, which together shall comprise the management plan. Table 2.3.2-1 lists the schedule that the Design-Builder shall provide. Each document shall be a development of the corresponding initial plan or schedule submitted as part of the Design-Builder’s proposal.

2.2.1. DBE/SWaM Utilization Plan
The Design-Builder shall use the Disadvantaged Business Enterprise (DBE) and Small, Women- and Minority-owned Businesses (SWaM) Utilization Plan submitted with its proposal and develop it, as necessary, to produce the DBE/SWaM Utilization Plan and meet the requirements of the Agreement [Section XXXXXX]. The Design-Builder shall submit the DBE/SWaM Utilization Plan to the Department for review and approval in accordance with Table 2.2.12-1.

2.2.2. Workforce Participation Plan
The Design-Builder shall use the Initial Workforce Participation Plan submitted with its proposal and develop it, as necessary, to produce the Workforce Participation Plan to meet the requirements of the Agreement [Section XXXXXXX]. The Design-Builder shall submit the Workforce Participation Plan to the Department for review and approval in accordance with Table 2.2.12-1.

2.2.3. Safety Plan
The Design-Builder shall use the Initial Safety Plan submitted with its proposal and develop it, as necessary, to produce the Safety Plan and meet the requirements the Agreement Section [XXXXXXXX]. The Design-Builder shall submit the Safety Plan to the Department for review and approval in accordance with Table 2.2.12-1.

2.2.4. Site Security Plan
The Design-Builder shall use the Initial Site Security Plan submitted with its Proposal and develop it, as necessary, to produce the Site Security Plan and meet the requirements of Agreement Section [XXXXXXXX] and these Technical Requirements Part 2, Section 11, Security. The Design-Builder shall submit the Site Security Plan to the Department for review and approval in accordance with Table 2.2.12-1.

2.2.5. Quality Assurance and Quality Control Plan (QA/QC Plan)
The Design-Builder shall use the Initial Quality Assurance and Quality Control Plan (QA/QC Plan) it submitted with the Proposal and develop it, as necessary, including incorporation of content required by
Part 2, Section 3, Quality Management. The Design-Builder shall submit the QA/QC Plan to the Department for review and approval in accordance with Table 2.2.12-1.

# - Sections 2.2.2 and 2.2.3 are subject to change upon completion of the Final RFP

2.2.6. Project Management Plan

The Design-Builder shall use the Initial Project Management Plan submitted with its proposal and develop it, as necessary, to produce the Project Management Plan and submit it to the Department for review and approval. Submittal of the Project Management Plan shall take place in accordance with Table 2.2.12-1.

Consistent with the guidance in the Project Management Institute’s Project Management Body of Knowledge (PMBOK) Guide, the Project Management Plan shall include but not be limited the following component plans, as a minimum:

A. Scope Management Plan
B. Change Management Plan
C. Schedule Management Plan
D. Cost Management Plan
E. Process Improvement Plan
F. Human Resources Plan
G. Communication Management Plan
H. Procurement Management Plan
I. Project Document Management Plan
J. Risk Management Plan
K. Stakeholder Management Plan
L. Quality Management Plan

2.2.6.1. Organization Charts

The Project Management Plan shall include two organization charts (each on 11-inch x 17-inch sheets of paper) illustrating: the structure around the Design-Builder’s Key Personnel; staff in roles named in the Technical Requirements; other individual staff or roles that the Design-Builder deems appropriate to detail in its organization chart; and any subcontractors having a material role in the project’s design work and construction work. The organization charts shall identify individuals assigned to provide peer reviews of the design and construction activities. The organization charts shall be titled “Design Organization” and “Construction Organization” respectively.

The Design Organization chart shall illustrate the proposed design organization, indicating the roles and reporting relationships of the design staff, down to and including discipline leads and the staff positions proposed in each discipline. The Design Organization chart shall identify individuals assigned to undertake independent checks of the design.
The Construction Organization chart shall illustrate the construction organization, indicating the roles and reporting relationships of the construction staff, down to and including field superintendents and the staff positions proposed under each field superintendent for all shifts.

The Design Organization and Construction Organization charts shall show clearly how the design and the construction arrangements are integrated with the quality management organizational arrangements as required in Part 2, Section 3, Quality Management.

2.2.6.2. Design Management Concept

The Project Management Plan shall describe the Design-Builder’s design management concept. The description shall, at a minimum, include:

A. The structure of the Design-Builder’s design organization.

B. The names of the individuals the Design-Builder commits to use for independent design checks and peer reviews of the design.

C. The proposed design sequencing.

D. The resources and personnel needed to timely produce the required design.

E. The project management plan shall also include: the Design-Builder’s design disciplines and design review plan; and a description of designer involvement during construction.

2.2.6.3. Construction Management Concept

The Project Management Plan shall describe the Design-Builder’s construction management concept. The description shall, at a minimum, include:

A. The structure of the Design-Builder’s construction organization.

B. The resources and personnel needed to manage the project effectively and efficiently during the construction phase, including those individuals undertaking QA/QC activities of construction activities.

C. The management and integration of subcontractors and suppliers.

2.2.6.4. Internal Coordination

The Project Management Plan shall describe interrelationships and interfaces between each discipline within the Design-Builder’s organization, including design, construction, safety and quality management.

2.2.6.5. External Coordination

The Project Management Plan shall describe interrelationship and interfaces between the Design-Builder’s organization and the Department, other governmental agencies, utility owners, stakeholders, regulatory agencies, emergency services and first responders, businesses, the public, and other contractors working in the vicinity and impacted by the construction of the project. This description shall, at a minimum, address the following activities:

A. Plans and permits reviews

B. Progress, workshop, partnering and Utility coordination meetings

C. Construction, engineering and inspection activities

D. Community relations
2.2.7. Risk Management Plan

The Design-Builder shall prepare a Risk Management Plan (RMP) and perform risk management for the project consistent with the guidance in the Project Management Institute’s PMBOK Guide and the VDOT Risk Management Guide for Project Development.

The Design-Builder’s RMP shall cover all phases of the project including design, construction and demolition, and shall include but not limited to the following elements as a minimum:

A. The Design-Builder’s risk management policy for the project.

B. Project team roles and responsibilities concerning risk management.

C. Approach to risk identification and assessment, for all phases including design, construction and demolition; and including regular reviews and updates at appropriate milestones and whenever risk levels change, and/or when new risks are identified that may impact risks already identified. The Department may elect to observe risk identification workshops.

D. Risk monitoring and control approach, including performance measurement strategy and reporting.

E. Methodologies for risk identification, quantification, analysis, response planning, mitigations, monitoring and management, within each project phase and as a continuum throughout the project.

F. Risk registers that identify; at a minimum, risks to cost, schedule, operational performance, and the quality of the work. The Design-Builder shall provide a copy of the project risk register to the Department at least quarterly, and at any substantive material change to the register. The Department may review and provide written comment on any item in the risk register that, in the opinion of the Department, is of relevance or concern to the Department.

The Design-Builder shall update the RMP at any material change to the Project’s risk profile or at least every quarter. The Design-Builder shall provide the updated RMPs to the Department.

2.2.8. Information Technology (IT) Plan

Within 30 days of the NTP, the Design-Builder shall submit its IT Plan identifying:

A. All Software, including names and versions to be used on the project.

B. Internet network provider(s) to be used on the Project, including call out information for providers.

C. Third party vendors and call out information (including third party cloud providers).

D. All IT hardware to be used on the project.

E. IT security protocol.

F. Information back-up protocols.

G. Call out arrangements, including day/night and weekend coverage, of the Design-Builder’s IT support staff.
2.2.9. **Public Information and Communications (PICP) Plan**

The Design-Builder shall produce the Public Involvement Plan (PIP) support plan and submit it to the Department’s Project Manager for consultation and written approval in accordance with the requirements of Part 2, Section 7, Communications – Public Affairs.

2.2.10. **Stakeholder Management Plan**

The Design-Builder shall produce the Stakeholder Management Plan and submit it to the Department’s Project Manager for consultation and written approval in accordance with the requirements of Part 2, Section 7, Communications – Public Affairs.

2.2.11. **Management Plan Deliverables**

Unless otherwise stated herein, the submission to the Department of each component item of the Management Plan shall be within 30 days of NTP.

**Table 2.2.12-1: Items comprising the Management Plan**

<table>
<thead>
<tr>
<th>Component Title</th>
<th>Delivery Schedule</th>
<th>Updates</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBE/SWaM Utilization Plan</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Workforce Participation Plan</td>
<td>No later than 60 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Safety Plan</td>
<td>No later than 60 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Site Security Plan</td>
<td>No later than 60 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Project Management Plan</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Risk Management Plan (RMP)</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>IT Plan</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Public Involvement and Communications Plan (PICP)</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Stakeholder Management Plan</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Quality Assurance and Quality Control Plan (QA/QC Plan)</td>
<td>No later than 30 days after issuance of NTP</td>
<td>Monthly Reports &amp; Quarterly Updates</td>
</tr>
</tbody>
</table>

2.3. **Schedule**

2.3.1. **Project Schedules**

A. Purpose, Format, and Content of the Project Schedule:
1. Terms not defined herein or in the Agreement shall have the same meanings ascribed to them in the AACE International Recommended Practice No. 10S-90 (Cost Engineering Terminology).

2. The Project Schedule shall be generated and developed in accordance with the guidelines of Section 7.2 - Schedule Planning and Development of AACE’s Total Cost Management Framework (TCM) and the associated Recommended Practices.

3. The purpose of the Project Schedule is to ensure that adequate planning, scheduling, and resource allocations occur to provide a reasonable and executable work plan, baseline cash flow projections, and continuous monitoring and reporting for Work performed or remaining. The Baseline Schedule and the monthly updates to the Project Schedule shall be used for coordinating the work, monitoring the progress of work performed, identifying work to be performed, evaluating changes, and utilized as a tool for measuring progress.

4. The Project Schedule shall consist of the approved Initial Baseline Schedule, the approved Baseline Schedule, the monthly Project Schedule Updates as further described in Section 2.3.3 (e) herein below, and the As-Built Schedule.

5. The Initial Baseline Schedule and accompanying Exhibits are the Design-Builder’s plan for the design and construction of the project and shall be submitted to the Department for review and approval prior to incorporation in the Agreement. This schedule shall be used to monitor performance of the work until the Baseline Schedule is approved by the Department pursuant to Section 2.3.2 below. The Department shall have twenty (21) days to review Project Schedule submittals to ensure compliance with these Technical Requirements. Project Schedule submittals found to be incomplete or materially deviating from these Technical Requirements may be returned for revision and resubmission without further technical review.

6. The Department shall review submittals of the Project Schedule for conformance with these Technical Requirements, the applicable provisions in the Agreement, and good planning and scheduling practices as indicated in the AACE Recommended Practices.

B. General Requirements:

The Project Schedule shall:

1. Include an adequate number of activities in the schedule, sufficient to ensure adequate planning of the work and to permit monitoring and evaluation of progress and perform the analysis of alleged time impacts; AACE RP 37R-06 Schedule Levels of Detail – As Applied in Engineering, Procurement, and Construction. The schedule shall be an AACE Class 3 Schedule, and an AACE EPC Level 3 to provide a sufficient level of detail for the Department’s needs with respect to management and oversight of the Project.

2. Ensure that design activities identify AFC documentation.

3. Apply the Critical Path Method (CPM) of network calculation to generate the Project Schedule (the critical path shall be based on the longest network path through the project) and prepare the Project Schedule using the Precedence Diagram Method (PDM) to establish relationships and interdependencies between the individual activities required to complete the project; Total Float criteria are not acceptable for identifying or representing the Critical Path. The switch in Primavera Project Management shall be set to longest path in any schedule.
calculations and graphical representations. The Design-Builder shall take care to distinguish between the critical path and near critical paths.

4. Ensure that activity identification numbers, textual descriptions, and codes are consistently applied in the Project Schedule and are unique for each specific activity.

5. Divide all Work through Final Acceptance of all Project Assets into activities with appropriate logic ties to show the Design-Builder’s overall approach to sequencing, include logical relationships between activities reflecting the Design-Builder’s actual intended sequence of Work, logically tie all activities to avoid open ends, and the Project Schedule shall not use imposed constraint dates to begin or complete any activity unless such dates are called for specifically in the Agreement. The Project Schedule shall have a single start and a single completion point. Activities shall be used in lieu of lags where an activity is appropriate, i.e. use a concrete curing activity in lieu of a 7- or 28-day lag to achieve strength for a subsequent activity. If lag relationships are used or altered, they must be identified explicitly in a narrative report.

6. Avoid the use of non-typical relationships that cannot be shown to demonstrate a true dependency. Resource driven and elective logic and relationships shall be specifically listed in the narrative report. Any added or deleted logic and relationships that are based on presumed resource dependency or other elective (i.e. non-physical) restraints shall be identified with each schedule update, revision or submittal. Non-typical relationships may require explanation and delay the review and approval. Use of relationships and lags to position an activity at certain dates will not be permitted.

7. Show the Project milestones including commencement of design work, the anticipated issuance of Notice to Proceed and the Substantial Completion Date; The following Milestones shall be included in the Project Schedules:


   b. Milestones should be included for significant components of work that are critical to the start of key subsequent activities and will assist with managing the Project Schedule. Milestones may consist of key design submissions required prior to the start of fabrication; completion of dredging; key permitting required for start of construction activities; completion of tunnel fabrication; major traffic changes; and other items required for the successful management of the project and high priority items required for public relations needs.

   c. Milestones shall be added to the Project Schedule at the Department’s request and as needed by the Design-Builder.

8. Show phasing of the work as detailed in the plans, subcontractor work, procurement, fabrication, delivery, installation, testing of materials and equipment, commissioning of systems, and any long-lead time orders for major or significant materials and equipment.

9. For the Initial Baseline and approved Baseline Schedule allocate an estimated cost/planned value to each activity). The Work Breakout Structure (WBS) and cost loading shall be organized and cost distributed to the final agreed to Design-Build price. The WBS shall be complete and address 100% of the Project Scope at all Levels of the WBS.

10. Include a well-organized WBS, the development of which is based on a deliverable-oriented methodology that captures all the Project activities.

11. Include for the Initial Baseline Schedule all activities with early start days to be resource-loaded, broken down into work packages and deliverables generally completed in not less
than one but no more than 30 days (unless such deliverable is a procurement or other non-
construction activity), with dollar value (price) of each activity identified. The total cost
loaded Initial Baseline Schedule shall be equal to the total cost of the Design-Build price
cited in the Agreement.

12. Depict the required coordination with and work to be performed by other Contractors, Utility
Owners, Governmental Authorities, engineers, architects, Contractors, and suppliers.

13. Identify Regulatory Approvals required and the dates by which such approvals are necessary.

14. Incorporate the ROW Acquisition Plan.

15. Include with each submission of the Project Schedule, the following:

a. Two sets of compact disks containing an electronic working copy of the Project Schedule
in Primavera proprietary exchange format (XER) file format. Each submission shall have
a unique file name to indicate the type and order of submission. Each compact disk shall
be labeled to indicate the type of submission, file name, and schedule data date.

b. A narrative progress report of the Project Schedule that describes, at a minimum, the
Design-Builder’s plan of operation for meeting the interim milestones and the Substantial
Completion Date, an evaluation of the critical path, a discussion of project-specific issues
encountered since the last submission as such issues relate to the schedule, proposed
solutions thereof, work calendars, constraints, delays experienced, and the status of any
submitted or pending Time Impact Analyses (TIA), float consumption, documentation of
any logic changes, duration changes, resource changes or other relevant changes. The
report shall identify the Baseline Schedule in effect at the data date of the current update
and the preceding Schedule Update for that period.

c. Time-scaled logic diagram indicating the critical path, early start and early finish dates,
total float, grouped by WBS and total float, and sorted by early start.

C. The scheduling software employed by the Design-Builder shall be compatible with the
Department’s scheduling software. The Design-Builder shall implement any new operating
practices as a result of the Department’s amendments to any such software, standards, and
procedures. The Design-Builder’s scheduling software must have the capability to import and
export data in the Primavera proprietary exchange format (XER). As of the Agreement Date, the
Department’s scheduling software is the latest version of Primavera’s Project Management
software (currently P6 version 7.1).

D. Float available in the Project Schedule, at any time, shall not be considered for the exclusive use
of either the Department or the Design-Builder. During the course of the work, any float
generated due to the efficiencies of either party is not for the sole use of the party generating the
float; rather it is a shared commodity to be reasonably used by either party. A Project Schedule
showing work completing in less time than the Substantial Completion Date, and accepted by the
Department, will be considered to have project float. Project float will be a resource available to
both the Department and the Design-Builder. Delays caused by the Owner resulting in the
Design-Builder failing to complete by such a date earlier than the Substantial Completion Date
shall not be grounds for a delay claim nor will the Design-Builder begin to accrue liquidated or
actual damages for failure to meet such a date earlier than the Substantial Completion Date. No
time extensions will be granted unless a Delay Event occurs which impacts the project's critical
path, consumes all available float or contingency time, extends the work beyond the Substantial
Completion Date as defined by the Agreement, and is it is determined that responsibility for the
Delay resides with the owner. Float sequestering techniques will not be an acceptable practice in
scheduling on this project. The Department reserves its right to have the Design-Builder demonstrate the calculation of its durations and costs based on quantities, resource loading, and productivities.

2.3.2. **Baseline Project Schedule**

The Design-Builder shall develop the Initial Baseline Project Schedule submitted with its Proposal into the Baseline Project Schedule and submit it in accordance with Part XX Section XXXXXXX.

The Baseline Project Schedule shall include planned dates/deliverables for design output, including all design submissions and other documentation required to be submitted by the Design-Builder to the Department.

A. Within 60 days of the Notice to Proceed, the Design-Builder shall submit to The Department for its review and approval a proposed Baseline Schedule, which shall include the Design-Builder’s detailed plan for design and construction of the project. The Design-Builder shall develop its proposed Baseline Schedule from the Initial Baseline Schedule. The Design-Builder shall submit to the Department six hard copies (printed on 11” by 17” paper) of its proposed Baseline Schedule, along with two sets of compact disks containing an electronic version of the proposed Baseline Schedule created in the Primavera proprietary exchange format (XER).

B. The Design-Builder shall address any and all comments received from the Department on the proposed Baseline Schedule until the Department approves the proposed Baseline Schedule. Upon approval by the Department, the proposed Baseline Schedule will become the Baseline Schedule.

C. The Baseline Schedule shall utilize the same WBS, as the Initial Baseline Schedule and retain the same cost loading established in the Initial Baseline Schedule.

D. Activities in the Baseline Schedule shall be assigned project-specific activity codes.

E. The Baseline Schedule shall include all major activities of the work in sufficient detail to enable the Department to monitor and evaluate design and construction progress from the Notice to Proceed until Substantial Completion.

F. The Baseline Schedule shall include separate activities for major submittals proposed by the Design-Builder, together with appropriate activities for the Department’s review or approval, provided that such review and/or approval times by the Department shall be no less than the time provided for such reviews in the Agreement.

G. The Baseline Schedule shall be resource-loaded, broken down into work packages and deliverables generally completed in not less than one but no more than 20 working days (unless such deliverable is a procurement or other non-construction activity), with dollar value (price) of each activity identified. The total cost loaded Baseline Schedule shall be equal to the total cost of the Design-Build Agreement price. Activities on the critical path shall not have a duration greater than 20 working days. Critical resources should be identified in the schedule.

2.3.3. **Monthly Progress Reports and Project Schedule Updates**

A. The Project Schedule shall be current, reflecting actual progress ending on the last day of each calendar month and shall be kept current and submitted as a component of the Monthly Progress Report.
B. The Monthly Progress Report shall describe the work performed since the previous update as well as the Design-Builder’s plan for accomplishing the remaining work. It shall describe the current status of the project and any deviations from scheduled performance as well as the causes and effects of the deviations. It shall also describe any progress deficiencies or schedule slippages against both the previous approved Schedule Update and the Baseline Schedule in effect on the data date for the current Schedule Update, as well as any actions taken or proposed to avoid or mitigate the progress deficiencies or schedule slippages.

C. Monthly Progress Reports shall have a reporting period ending on the last day of each calendar month and shall be submitted on or before the 7th of the month following the reporting period. The Monthly Progress Report shall be submitted in accordance with this section for the Department’s review and comment.

D. The Department will notify the Design-Builder of comments within five business days of receipt of an acceptable submission.

E. Project Schedule Updates:

1. Design-Builder shall update the Project Schedule monthly to reflect actual progress to date and to forecast progress going forward (the Project Schedule Updates). The Design-Builder will not be required to provide updates of any cost or resource information in the Project Schedule Update. The Project Schedule Update shall be submitted as an attachment to the monthly Progress Report. The last day of the reporting period shall be the status date or data date used to calculate the schedule. Project Schedule Updates shall comply in all respects with the Project Schedule requirements set forth in this Section 2.3.

2. The approved Initial Baseline Schedule will be the basis for Project Schedule Updates until such time as the Baseline Schedule is approved by the Department. Thereafter, the Baseline Schedule shall be the basis for Project Schedule Updates.

3. Project Schedule Updates shall depict activities that have started, are on-going, or completed as of the new data date; show actual start dates for activities that have started; and actual finish dates for completed activities.

4. Project Schedule Updates shall depict percent complete for on-going activities. Activity percent complete for work-in-place shall be based on the quantity of work completed relative to the total amount of work planned for the activity (i.e. measured or estimated units of work in place as compared to the amounts estimated at the AFC design stage).

5. Project Schedule Updates shall depict remaining duration for on-going activities. Remaining duration for unfinished activities shall be based on the amount of time required to complete the remaining work as of the new data date.

6. Activity relationships for the remaining activities shall be modified as necessary to correct out-of-sequence progress for on-going activities or to reflect the Design-Builder’s current plan for completing the remaining Work.

7. Changes to the Project Schedule shall be documented in the Monthly Progress Report. Such changes include: additional, revised or deleted activities, durations, calendar assignments, lag, or logic ties.

8. Whenever the Project Schedule shows negative float, the Design-Builder shall address the cause of delay and present a workable plan for recovery of the schedule.

9. Upon obtaining a Substantial Completion certificate for all project assets the Project
Schedule Update submitted and approved with the last Monthly Progress Report will be identified by the Design-Builder as the As-Built Schedule.

2.3.4. **Revisions to the Baseline Schedule**

A. The Design-Builder may make written requests for revisions to the Baseline Schedule. In such an event, the Design-Builder will submit a revised Baseline Schedule to the Department for review and approval. Once approved, this revision shall then become the Baseline Schedule.

B. The Department may elect to require revisions to the Baseline Schedule by the Design-Builder. The Department will make such requests in writing. The Design-Builder shall make such revisions within seven days after receiving the Department’s request. The Design-Builder may request in writing from the Department an additional five days to complete such revisions. Once approved, this update shall then become the Baseline Schedule. At no time shall the Design-Builder continue to reflect an item of non-concurrence from the Department in the updates to the Baseline Schedule. If the Design-Builder objects to the Department’s request for revisions, the Design-Builder may refer the matter to dispute resolution pursuant to Part XX Section XXXXX of the Agreement.

C. In the event of a Delay Event for which the Department grants relief to the Design-Builder in accordance with the terms of the Agreement, the Baseline Schedule shall be revised and submitted to the Department for approval in accordance with Section 2.3.2 above.

2.3.5. **Project Recovery Schedule**

A. Pursuant to Part XX Section XXXXX of the Agreement, whenever the Project Schedule shows the Substantial Completion Date has 90 days (or 10% of the Contract time remaining, whichever is less), of negative float or more, the Design-Builder shall submit a Project Recovery Schedule to the Department for approval. Project Recovery Schedule submittals shall include a list of all activities changed, added or deleted along with all logic changes, and an accompanying narrative explaining the nature of the changes.

B. Once a Project Recovery Schedule is reviewed and approved by the Department, with no exceptions, it shall become the Baseline Schedule and shall also be used as the basis for subsequent Monthly Progress Reports. The Design-Builder shall archive all approved Project Schedules.

2.3.6. **Time Impact Analysis (TIA) for Proposed Extensions of Time**

As per AACE International Recommended Practice No. 45R-08 (Rev. June 1, 2009) SCHEDULING CLAIMS PROTECTION METHODS, all parties agree to address schedule issues as quickly and as contemporaneously as possible.

AACE International Recommended Practice No. 29R-03 FORENSIC SCHEDULE ANALYSIS (Rev. April 25, 2011), and AACE International Recommended Practice No. 52R-06 (Rev. October 2006) TIME IMPACT ANALYSIS: AS APPLIED IN CONSTRUCTION will be used as guidelines in addressing delay issues.

The following shall apply if a Time Impact Analysis (TIA) is required under these Technical Requirements:
A. The TIA shall be based on the date on which the alleged Delay Event is determined to have occurred, or, in the event of a proposed change, the date on which the implementation of such change is proposed to be commenced. In the event that the Design-Builder perceives that a Delay Event has occurred, he is required to give notice of the alleged delay no later than 10 working days after the alleged Delay Event.

B. The TIA shall show the current status of the work using the most recent Schedule Update prior to the initiation of the events in question. The time computation of all affected activities shall be shown in the TIA along with a demonstration of steps used to mitigate impacts.

C. Each TIA shall include a Fragmentary Network (fragnet) demonstrating how the Design-Builder proposes to incorporate the impact into the most recent Schedule Update prior to the initiation of the events in question. A fragnet is defined as the sequence of new activities and/or activity revisions, logic relationships, and resource changes that are proposed to be added to the existing schedule to demonstrate the influence of impacts to the schedule. The fragnet is subject to the same requirements for activities including resource loading and assignment of activity codes and assignment to the appropriate WBS structure. In the event of an alleged Delay Event, the Design-Builder shall demonstrate the calculation of its durations, resource loading, and productivities for both the fragnet activities and the affected and impacted activities. The fragnet shall identify the predecessors to the new activities and demonstrate the impacts to successor activities. The Design-Builder shall insert the fragnet into the most recent Schedule Update prior to the initiation of the alleged Delay Event, run the schedule calculations, and submit the impacted schedule in accordance with this section. The Design-Builder shall include a narrative report describing the effects of new activities and relationships to Agreement milestones and the Substantial Completion Date with each TIA.

D. The Design-Builder shall not be entitled to any extension of the Term automatically as the result of an activity delay. The Design-Builder recognizes that certain events will not affect the existing critical activities or cause non-critical activities to become critical, thereby not causing any effect on the Substantial Completion Date. No extension of time will be granted without demonstration to the Department of merit for the time extension.

E. All TIA or requests for extension of time shall also address concurrent and predecessor delays in the determination of excusable/inexcusable and compensable/non-compensable events.

F. The Department reserves its right to identify and generate fragnets for inclusion in the Project Schedule should it become aware of Design-Builder caused delays.

G. Two copies of each TIA report together with an electronic file (in XER file format) of the Project Schedule impact analysis shall be submitted to the Department for its review in accordance with Part XX Section XXXXXX of the Agreement.

H. Upon approval, a copy of the TIA signed by the Department will be returned to the Design-Builder and incorporated into the next update to the Baseline Schedule.

I. The approved TIA related to a Change shall be incorporated into, and attached to the applicable Change Order.

J. A disapproved TIA will be returned to the Design-Builder with appropriate comments for revisions or the Department’s basis for rejection of the alleged Delay Event. Should Design-Builder disagree with the Department’s assessment of Delay Event, Design-Builder may pursue
recourse in accordance with provisions established in Dispute Resolution, Part XX Section of the Agreement.

2.3.7. Schedule Deliverables

At a minimum, the deliverables shall include the items listed in Table 2.3.7-1 for the Department’s comment and approval.

<table>
<thead>
<tr>
<th>Schedule Title</th>
<th>Contract Document Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Project Schedule</td>
<td>With RFP Technical and Price Proposal</td>
</tr>
<tr>
<td>Baseline Project Schedule</td>
<td>Part x Section XXXXXXXX</td>
</tr>
<tr>
<td>Project Recovery Schedule</td>
<td>Technical Requirement Section 2.3.5</td>
</tr>
</tbody>
</table>

2.4. Collaboration

In addition to meetings specified elsewhere in the Agreement, the Design-Builder shall convene or participate in meetings as indicated in Section 2.4.1. below.

It is the Department’s policy to use the principles of partnering to guide the management of Design-Build projects and the Design-Build program within the parameters covered by the laws, regulations, and other policies that govern the Work. The Design-Builder shall convene or participate in meetings designed to foster the principles of partnering in accordance with Section 2.4.2 below.

2.4.1. Meetings

The Design-Builder shall participate in meetings as indicated in herein. The party leading the meeting shall record minutes of all meetings and distribute them within five days of the meeting. Meeting minutes shall clearly identify the following:

A. Action items and issues.
B. The party responsible for the action item.
C. The status of issues.
D. Due dates for identified action items.

Action items and issues shall be retained on the minutes until the required action is completed and/or the issue is resolved.

2.4.1.1. Pre-Work Conference

The Department’s Project Manager will consult with the Design-Builder and arrange and lead a meeting promptly after issuance of NTP.
The Design-Builder shall be represented by all appointed Key Personnel identified in Part XX Section XXXXX of the Agreement.

The meeting will take place at a location determined by the Department in the project’s geographical vicinity.

The agenda of the meeting shall include the following items:

A. Submission of executed bonds, guarantees, warranties, and insurance policies and certificates, if not already provided.

B. Planned activity for the first 60 days after NTP.

C. Submission of the list of intended subcontractors.

D. Submission of the Plans required under the Agreement.

E. Submission of all software anticipated to be used on the project, including a file naming convention.

The Department or the Design-Builder may add other items to this agenda.

2.4.1.2. Value Engineering and Proposal Concepts Evaluation Meetings

The Department will consult with the Design-Builder and arrange and lead meetings within 30 days of NTP to complete the following:

A. Review initial Value Engineering Change Proposals (VECPs) Part XX Section XXXXXX of the Agreement submitted by the Department or the Design-Builder.

B. Discuss the concepts and ideas contained in other proposals that may be incorporated into the Agreement.

If requested by the Department, the Design-Builder shall prepare an estimate of effects (time and cost) for VECPs or to incorporate concepts included in other proposals into the Agreement.

Attendance at the meetings and the preparation of the estimate of effects shall not entitle Design-Builder to any increase in the Agreement Design Build price.

Other VE meetings may be called by the Design-Builder or the Department, as necessary, to discuss and evaluate additional VECPs that may arise.

2.4.1.3. Design Mobilization Meeting

The Design-Builder’s Project Manager will consult with the Department’s Project Manager and will arrange and lead a meeting at the Designer-Builder’s Project office prior to the Design-Builder’s initiating design Work. The Design-Builder’s key personnel who will be responsible for activities on the agenda shall attend the meeting.

The agenda shall be developed in consultation between the Department’s Project Manager and the Design-Builder and prepared by the Design-Builder and shall include the following:

A. Organization for design.

B. Review of qualifications of design QC and QA staff.

C. Design workshop agenda Part XX Section XXXXXX of the Agreement.

D. Location of design personnel.
E. Design schedule and time allocations for design reviews.

F. Design Quality Control and Quality Assurance.

2.4.1.4. Site Mobilization Meeting

The Design-Builder will consult with the Department and arrange a meeting at the Design-Builder’s office prior to the Design-Builder’s occupying any part of the project site. The Design-Builder’s Key Personnel who will be responsible for activities on the agenda shall attend the meeting.

The agenda shall be developed in consultation between the Department and the Design-Builder and prepared by the Design-Builder and shall include the following items:

A. Use of premises by the Department and the Design-Builder.

B. Department’s requirements.

C. Temporary utilities and facilities.

D. Security and “housekeeping”.

E. Right of Way and construction survey.

F. Schedule for establishing Work areas, temporary facilities, and facilities and Equipment for Department’s staff.

G. Temporary Works.

H. Plans for early construction, if any.

2.4.1.5. Progress Meetings

Progress meetings shall be held at least weekly throughout the duration of the Project. The Design-Builder shall prepare (1) a meeting agenda in consultation with the Department’s Project Manager and (2) a current summary of all issues (including reference to the relevant version of any report, schedule or other document) to be included in the next monthly progress report with respect to each item listed in Part XX Section XXXXXX of the Agreement and distribute copies of the meeting agenda, the issues summary and draft minutes of the previous meeting to all planned participants at least five days prior to the meeting. The Design-Builder shall lead the meetings.

The Design-Builder’s Key Personnel shall attend the progress meetings.

A typical agenda shall include the following items:

A. Confirmation of minutes of the previous meeting and matters arising at the previous meeting.

B. Review of work progress.

C. Design problems and decisions.

D. Field observations, problems, and decisions.

E. Identification of issues affecting planned progress.

F. Planned activities (design and construction) for the coming two-week period.

G. Maintenance of quality and work standards.

H. Safety.
I. Environmental issues.

J. Schedule updates (monthly).

K. MOT.

L. Status of Work Orders, if any.

M. Utilization of DBE and SWaM Businesses.

N. Public Involvement Plan.

2.4.1.6. Special Meetings

The Department may require special meetings at any time and that all or specified Design-Builder Key Personnel attend.

2.4.2. Partnering

It is the Department’s policy to use the principles of partnering to guide the management of Design-Build (DB) contracts and the DB program within the parameters covered by the laws, regulations, and other policies that govern Work in the public sector.

These partnering principles are intended to promote quality through continuous improvement at all stages of design and construction. The goal of the Department is to complete each project in the most efficient, timely, safe, and cost-effective manner to the mutual benefit of the Design-Builder and the Department, meaning a quality project delivered on time, within budget, and without significant disputes.

None of the actions identified as part of, or taken in the course of, partnering shall be construed to alter, modify, delete, or waive any of the provisions or requirements of the Agreement or any applicable Governmental Rules.

The Department, with the Design-Builder, will manage the Agreement in a cooperative manner utilizing the following principles of partnering:

A. Establish communications with all involved parties early in the partnering process.

B. Establish a relationship of shared trust, equity, and commitment.

C. Develop strategies for identifying mutual goals.

D. Develop strategies for timely communications and decision making.

E. Establish a process for timely response to changes or variations in field conditions.

F. Solve potential problems at the lowest level, before they negatively impact the project.

G. Encourage the use of products, technology, and processes that provide a demonstrated level of improved quality.

H. Develop a plan for periodic joint evaluation based on mutually agreed goals.

These principles are to be implemented in an equitable fashion that recognizes the problems that are inherent in design and construction, addresses the different-than-expected field conditions, resolves disputes in an open communications manner, and makes adjustments in a timely and fair manner, consistent with the terms of the Agreement.
The Department will consider additional suggestions from the Design-Builder regarding the incorporation of partnering into the coordination and cooperation required with third parties such as subcontractors, suppliers, utility owners, and railroads, or as otherwise desired by the Design-Builder.

Any cost associated with effectuating partnering will be agreed to by both the Design-Builder and the Department and will be shared equally with no change in the Agreement Design Build price. The Design-Builder shall pay all costs and submit paid invoices to the Department for 50% reimbursement.

2.5. Design-Build Office

The Design-Builder shall provide and maintain a co-located Design-Build office with sufficient space to accommodate the design and construction requirements of the Project. The Design-Build office shall accommodate and include co-location by the Department’s staff of approximately thirty-five [35] individuals. The Design-Builder shall provide adequate parking spaces for the Design-Builder’s and Department’s staff at the Design-Build office facility.

The Design-Builder shall coordinate with the Department prior to securing any data or phone connections for a co-located office. The Department’s office space, data and phone connections shall be separate and secured from the Design-Builder’s section of the Design-Build office.

2.5.1. Facilities for the Department

Each interior office space shall be at least 100 square feet per individual, wired for one personal computer (unless otherwise specified) on the Department’s network, and wired for one telephone. The Design-Builder shall provide the following office and storage spaces for the Department/GEC Contractor:

A. Six [6] full-time, reasonably sound-proofed, closed-door office spaces, two of which have a table with a minimum of four chairs

B. One [1] full-time, reasonably sound-proofed, closed-door office space wired for two personal computers: one linked to the Department’s network, and the other linked to the Design-Builder’s network

C. Twenty-two [22] full-time office spaces

D. One network room that conforms to the requirements of Section 2.5.4.2 herein

E. Six [6] hot-desk “drop-in” office spaces (100 square feet each)

F. Access to conference rooms

G. Forty-six [46] parking spaces

H. Sufficient storage capacity for hard copy files, including at a minimum: eight (8) 8.5-inch x 11-inch in plan, four-drawer locking file cabinets; one (1) 11-inch by 17-inch in plan locking file cabinet; and eight (8) vertical filing racks suitable for drawings

The Design-Builder shall also provide the Department’s field Laboratory in accordance with [DB §106-11] and this Section 2.5.1. In addition to the requirements of [DB §106-11], the Design-Builder shall provide: one storage container (8-foot tall, 20-foot long, 8-foot wide), and one parking space for the Department’s materials’ testing van. The parking space for the van shall be parallel and adjacent to the field Laboratory, on the same side as the access doors to the field laboratory. The storage container shall be adjacent to the Department’s materials’ testing field laboratory. The Design-Builder shall provide a water connection, a sewer connection to the sink drain, and connection to 200-amp electrical service.
2.5.2. **Office Location**

The Design-Builder will work collaboratively with the Department to locate the D-B office within or near the project limits.

2.5.3. **General Requirements**

The office facilities for the Department shall be provided by the Design-Builder and shall include the following furniture and equipment, which shall be new and unused:

A. One (1) each of the following in each office space: desk, chair, two-drawer locking filing cabinet, bookcase, and telephone

B. Copying/scanning/printing Equipment (at least one (1), with multiple trays for letter-sized sheets and 11-inch x 17-inch sheets)

C. One (1) touch-tone speaker telephone for each office space with a status indicator and access to all outside lines and conference call systems. Each telephone shall be connected to a phone service with voice mail for each extension. The Department will pay all long-distance charges for the Department’s phones after installation

D. Meeting facilities suitable for all Project-related meetings, including video-conferencing Equipment. In the event the requirements for any meeting exceed the space available, the Design-Builder shall provide meeting space at a suitable alternate location. The alternate location shall be located within two miles of the Project Limits

E. At least two (2) exits from each building or trailer

F. A (1) secure door lock plus a deadbolt lock on each entrance

G. Separate men’s and women’s restrooms

H. Trash and recycle containers for paper, clean glass containers, metal cans, and plastic containers

I. Daily janitorial service (except public holidays) including trash pickup and [recycle pickup for paper, clean glass containers, metal cans, and plastic containers]

J. Maintained exterior office space areas, including access to parking areas and snow removal

K. Overhead lighting that meets the requirements of the United States Occupational Safety and Health Administration, and building and electrical codes for office space, which shall include a minimum circuit capacity of 20 amperes, and at least two duplex receptacles for each office space

L. Heating, ventilation, air conditioning, and cooling systems capable of maintaining temperatures between 65°F and 75°F in all spaces, including the network room, throughout the year

M. One room with a lockable door for use by the Department as a computer server and telephone network connection room. The room shall be at least 100 square feet. The computer network and phone network connections for the Department’s office spaces shall terminate in this room. This room may be common with the Design-Builder's phone and computer network service room

N. Access requirements that meet the Americans with Disabilities Act

O. An office space that meets all local building code requirements
P. Kitchenette with standard size refrigerator, microwave, sink, table and chairs

The Design-Builder shall maintain all office space for the Department from [21 days after the NTP] until at least 90 days after Final Acceptance, unless otherwise agreed to by the Department in writing. Except for the Design-Build office, the Design-Builder shall remove all facilities and perform any required site restoration work related to facilities provided by the Design-Builder, prior to Final Acceptance. The Design-Builder shall remove all facilities and perform any required site restoration work related to the Design-Build office within 100 days after Final Acceptance.

2.5.4. Information Technology

2.5.4.1. Network Communication

The Design-Builder shall ensure that the office space for the Department can be wired for a leased line or fiber connection designated for the exclusive use of the Department. The Department will arrange for installation of the connection and will pay for the connection charges.

The Design-Builder shall provide 1000-BASET (Category 6) ethernet wiring from each of the Department’s closed-door office and office space to the wiring closet. The wall plates shall be located to permit the use of the 12-foot patch cords provided by the Department. In addition to the 12-foot patch cords, the Department will provide its own hub, router, and DSU/CSU to connect its computers to the internet. The Design-Builder may, at its own expense, provide additional infrastructure for its own use, provided that the additional infrastructure does not interfere with the Department’s use.

The Design-Builder shall provide space in the network room for one two-post phone network rack for the Department’s Equipment. The Department’s Equipment may be in the same network room as the Design-Builder's Equipment. The Design-Builder shall submit a wiring and office floor plan to the Department for its review and approval five calendar days of NTP.

2.5.4.2. Software

The Design-Builder shall acquire, use and maintain all software for the project. The following requirements shall be met for all software used by the Design-Builder for the project:

A. Version: The Design-Builder shall use the version of the Software current on date of the RFP, unless otherwise specified.

B. Updates: The Design-Builder shall update software programs within six months of release of a software update, or earlier if mutually agreed upon with the Department.

C. File server: The Design-Builder shall store all data files for the software programs on or have them accessible through the Design-Builder’s central file server.

At the Pre-Work Conference (see Section 2.4.1.1) the Design-Builder shall submit a list of all software to be used by the Design-Builder for the project and the file naming convention to be adopted for the project. To the extent that the Design-Builder uses software and versions not currently used by the Department, the Design-Builder shall provide all necessary licenses, software and training.

The Design-Builder shall develop and implement data security and a data backup and recovery plan. The Design-Builder shall back-up electronic files as follows: (i) back-up every day all files that have been revised since the previous daily back-up; (ii) back-up all files every week; and (iii) store all backup media in a secure off-site facility.

2.5.4.3. Project Data Management

Except as otherwise directed, the Design-Builder shall host and manage electronic project data and files until Final Acceptance.
As directed by the Department, the Design-Builder shall provide specified access for designated representatives of the Department to access live and archived project data and files.

All data and file-naming conventions shall be consistent with the VDOT CADD Manual.

In addition, the Design-Builder shall coordinate during the project with the Department to develop file management practices that provide for complete conversion and transfer of project file and data management hosting capabilities to the Department. Arrangements for transfer shall be established and a protocol for regular transfers shall commence within twelve (12) months following NTP. The transfer process shall be completed by Final Acceptance. The transfer process shall include transfer of all information and files, in a manner that retains all data links and file associations, to the Department. The transfer process for data and files to the Department system shall be scripted to place automatically files and data within a live and archived Project folder structure defined by the Department.

### 2.5.5. **Virginia Occupational Safety and Health Standards**

The Project shall comply with Virginia Occupational Safety and Health Standards in accordance with Part XX Section XXXXXX of the Agreement.

At a minimum, all Design-Builder Personnel shall comply with the following, unless otherwise determined unsafe or inappropriate in accordance with OSHA regulations:

- **A.** Hard hats shall be worn while participating in or observing all types of field Work when outside of a building or outside of the cab of a vehicle, and exposed to, participating in or supervising construction.

- **B.** Respiratory protective Equipment shall be worn whenever an individual is exposed to any item listed in the OSHA Standards as needing such protection unless it is shown the Employee is protected by engineering controls.

- **C.** Adequate eye protection shall be worn in the proximity of grinding, breaking of rock and/or concrete, while using brush chippers, striking metal against metal or when working in situations where the eyesight may be in jeopardy.

- **D.** Approved high visibility Safety apparel shall be worn by all exposed to vehicular traffic and construction Equipment.

- **E.** Standards and guidelines of the current Virginia Work Area Protection Manual shall be used when setting, reviewing, maintaining, and removing traffic controls.

- **F.** Flaggers shall be certified in accordance with the Virginia Flagger Certification Program.

- **G.** No person shall be permitted to position themselves under any raised load or between hinge points of equipment without first taking steps to support the load by the placing of a safety bar or blocking.

- **H.** Explosives shall be purchased, transported, stored, used and disposed of by a Virginia State Certified Blaster in possession of a current criminal history record check and a commercial driver’s license with hazardous materials endorsement and a valid medical examiner's certificate. All Federal, State and local regulations pertaining to explosives shall be strictly followed.

- **I.** All electrical tools shall be adequately grounded or double insulated. Ground Fault Circuit Interrupter (GFCI) protection must be installed in accordance with the National Electrical Code (NEC) and current Virginia Occupational Safety and Health agency (VOSH). If extension cords are used, they shall be free of defects and designed for their environment and intended use.

- **J.** No person shall enter a confined space without training, permits and authorization.
K. Fall protection is required whenever an Employee is exposed to a fall six (6) feet or greater.

2.6. **Deliverables**

At a minimum, the deliverables shall include the items listed in Table 2.6-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
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<th>Reference Section</th>
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<td>Workforce Participation Plan</td>
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<tr>
<td>Safety Plan</td>
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<td>1</td>
<td>Use Initial Safety Plan submitted in RFP, Update with 30 days after NTP</td>
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<td>Project Management Plan</td>
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<td>Risk Management Plan (RMP)</td>
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<td>Information Technology (IT) Plan</td>
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<tr>
<td>Baseline Project Schedule</td>
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SECTION 3. QUALITY MANAGEMENT

3.1. Scope

The Design-Builder shall submit its Quality Assurance/Quality Control Plan (QA/QC Plan), also referred to as the Quality Management System Plan (QMSP), for both design and construction to the Department in accordance with Table 2.2.12-1 in Section 2- Project Management of these Technical Requirements. Along with the QA/QC Plan submittal, the design manager and Quality Assurance Manager (QAM) shall provide a presentation to the Department within five days of its submittal of the QA/QC Plan for both the Design QA/QC Plan (Design Quality Management Plan – DQMP) and the Construction QA/QC Plan (Construction Quality Management Plan – CQMP). Project scenarios to be reflected in the presentation shall include, but not be limited to:

A. Preparatory Inspection Meeting requirements, including incorporation of at least one each, witness and hold point, as set forth in Sections 5.14 and 5.15 of the Department’s guidance document for Minimum Requirements for Quality Assurance and Quality Control on Design Build and PPTA Projects, January 2012 (January 2012 QA/QC Guide).

B. At least one (1) material which the Department retains responsibility for testing as identified in Table 5-2, January 2012 QA/QC Guide.

C. Situation arising requiring the issuance of a Non-Conformance Report and subsequent review of the report, including completion of corrective measures and the issuance of a Notice of Correction of non-conformance work with proper log entries and proper interface with auditing and recovery requirements as set forth in Sections 5.10 and 5.11 of the January 2012 QA/QC Guide for Non-Conforming Work resulting from:
   1. Defective Equipment.
   2. Construction activities/materials which fail to conform as specified.

D. Inspection documentation capturing requirements as set forth in Section 5.20 and 5.21 of the January 2012 QA/QC Guide; as well as inspection of foundation and pavement subgrades that are to be performed and certified by the Design-Builder’s licensed geotechnical engineer in accordance with the Agreement requirements.

E. Application for payment for work package which includes work element, including review and approval by Quality Assurance Manager (QAM).

F. Measures that will be implemented to ensure compliance with Buy America requirements on the project.

G. Detail two (2) sample entries in the proposed project materials notebook showing completion of Form C-25, including subsequent submission and review by the Department as set forth in Section 5.28 of the January 2012 QA/QC Guide and Materials Division Memorandum MD 407-17. Refer to Section 803.73 of VDOT’s Manual of Instruction for Materials Division, Form TL-142S, for an example of a completed materials notebook and VDOT Materials Division Manual of Instruction, Chapter VII.
3.1.1. Quality Management during Design

The Design-Builder is responsible for design quality in accordance with the Department’s Minimum Requirements for Quality Assurance and Quality Control on Design Build and PPTA Projects, January 2012 (January 2012 QA/QC Guide). The Design-Builder’s Design Manager shall be responsible for establishing and overseeing a QA/QC program for all pertinent disciplines involved in the design of the project, including review of design, working plans, shop drawings, specifications, and constructability of the project. This individual shall report directly to the Design-Builder’s Project Manager, and is responsible for all of the design, inclusive of QA and QC activities. Members of the design QA and QC team are responsible for review of all design elements to ensure the development of the plans and specifications are in accordance with the requirements of the Agreement. Design QA should be performed by one or more member(s) of the lead design team that are independent of the Design QC. The Design QA/QC Plan (Design Quality Management Plan – DQMP) will provide the Department assurance that the design plans and submittals will meet all Agreement requirements. The Quality Assurance Manager (QAM) shall verify that all design related work packages submitted for payment have been certified by the Design Manager as being in conformance with the Agreement documents and the Design QA/QC Plan.

Appendix 2 of the January 2012 QA/QC Guide provides minimum requirements that shall be met for development of the Design QA/QC Plan.

3.1.2. Quality Management During Construction

The Design-Builder shall develop, execute, and maintain a Construction QA/QC Plan (Construction Quality Management Plan – CQMP) for the full duration of the Agreement in accordance with the Department’s January 2012 QA/QC Guide. The Design-Builder shall have the overall responsibility for both the QA and QC activities and shall be responsible for all QA activities and QA sampling and testing for all materials used and work performed on the project. These QA functions shall be performed by an independent firm that is not involved in the construction and QC program/activities. There shall be a clear separation between QA and construction, including separation between QA inspection and testing operations and construction QC inspection and testing operations, including testing laboratories. Two (2) independent, AASHTO Materials Reference Laboratory (AMRL) certified testing laboratories will be required, one for QA testing and one for QC testing.

The QAM shall have the authority to enforce the Agreement requirements when deficient materials or unsatisfactory finished products fail to conform to Agreement requirements. The QAM, in accordance with his/her assignment, shall be responsible to observe the construction in progress and to provide the QA and QC testing and inspection in accordance with the Agreement requirements. The Design-Builder shall establish and maintain a Quality Assurance Auditing and Nonconformance Recovery Plan (AR Plan) for uniform reporting, controlling, correction and disposition and resolution of nonconformance (including disputed nonconforming items) issues that may arise on the project. The Design-Builder’s AR Plan shall establish a process for review and disposition of nonconforming workmanship, material, equipment or other construction and design elements of the work including the submittal of the design review process for field changes. All deficiencies (hereinafter referred to as a Non-Conformance), including those pertaining to rules, regulations, and permit requirements, shall be documented by the QAM. Unless otherwise approved by the Department via the Construction QA/QC Plan, a Non-Conformance Report (NCR) referenced by a unique number, shall be forwarded to the Design Builder and the Department within 24 hours of discovery of the Non-Conformance. Non-conformance procedures are provided in Section 5.10.5 of the January 2012 QA/QC Guide.

The Design-Builder also shall be responsible for providing QA and QC testing for all Materials manufactured off-site, excluding the items listed below:

A. Prestressed concrete structural elements (beams, girders (the Department adopted Bulb-T
sections), and piles).

B. Structural steel elements (beams, girders, and sign structures).

C. Pipe (concrete, steel, aluminum, and high-density polyethylene) for culverts, storm drains, and underdrains.

D. Precast Concrete Structures.

E. Asphalt Concrete Mixtures.

F. Aggregate (dense and open graded mixes).

G. Metal traffic signal and light poles and arms.

The Department will provide plant QA and plant QC inspection and/or testing of these items. In the event that the Department determines that materials fail to meet the tolerances in the VDOT 2016 Road and Bridge specifications, a NCR will be issued by the Department and addressed to the Design-Builder’s DBPM for resolution. The Design-Builder is required to submit documentation of the source of materials, including the source of each material to be incorporated into the project and the acceptance method that will be used for the material. A VDOT Form C-25 may be used to meet this requirement (alternate form utilized to identify source of materials shall be submitted to the Department for approval); however, the Design-Builder is required to submit a VDOT Form C-25, for all materials that the Department retains responsibility for testing. The source of materials, C-25 is for informational purposes only and will not be approved or rejected by the Department since it is the Design-Builder’s responsibility to obtain materials that meet the Agreement requirements. The Design-Builder will be responsible for providing QA and QC testing of all off-site Materials that are not identified above, including materials obtained from off-site soil borrow pits.

The Design-Builder’s QAM shall report directly to the Design-Builder’s Project Manager and be independent of the Design-Builder’s physical construction operations. The Design-Build team shall establish quantities prior to commencing construction, and provide the Department a total number of QC, QA (Independent Assurance (IA) and Independent Verification Sampling and Testing (IVST)), Owner’s (the Department) Independent Assurance (OIA), and Owner’s Independent Verification Sampling and Testing (OVST) required as a result of the quantities and the sampling and testing requirements as set forth in Table A-3 and A-4 of the January 2012 QA/QC Guide. The Department will provide all OIA and OVST tests and, therefore, final determination of the actual number of OIA and OVST tests to be performed will be made by the Department based on these quantities.

The QAM shall be responsible for the QA inspection and testing of all materials used and work performed on the project to include observing the Design-Builders QC activities, maintaining the materials notebook (including adherence to the Special Provision (SP) for Design-Build Tracking (DBT) numbers included in the RFP Information Package), documentation of all materials, sources of materials and method of verification used to demonstrate compliance with the Agreement requirements. This includes all materials where QA testing is to be performed by the Department. The QAM shall be vested with the authority and responsibility to stop any work not being performed according to the Agreement requirements. The construction QA and QC inspection personnel shall perform all of the construction inspection and sampling and testing work in accordance with the Agreement requirements. This includes the documentation of construction activities and acceptance of manufactured materials. The Design-Builder’s Quality Assurance firm shall have a presence on-site during any and all construction operations. The QAM shall assign a Lead QA Inspector to the project prior to the start of construction. This individual, who must be on the site full-time for the duration of all construction of the project, shall be responsible to observe construction as it is being performed, to include all QC activities to ensure inspection and testing, and correction of any non-conformities of the work are being performed in accordance with the Agreement requirements. The Lead QA Inspector shall be supported by other QA
Inspectors under his/her direction to ensure at any time all construction operations and QC activities are being observed. The Lead QA Inspector shall report directly to the QAM.

All sampling and testing shall be performed by a laboratory that is accredited in the applicable AASHTO procedures by the AASHTO Accreditation Program (AAP). For test methods not accredited by AAP, the Laboratory must comply with AASHTO R18 (most current edition) and must be approved by the Department at its sole discretion. Two independent testing laboratories will be required, one for QA testing and one for QC testing. The entities performing QA operations, inspections, sampling, and laboratory testing and the entities performing QC operations, inspections, sampling, and laboratory testing shall be unique and independent from one another.

All construction QA and QC personnel shall hold current VDOT Materials certifications for the types of materials testing that they are assigned to perform in accordance with Section 3.6 of the January 2012 QA/QC Guide, and for the safety and use of nuclear testing equipment as required by the Road and Bridge Specifications. The QA programs shall be performed under the direction of the QAM. The QC programs shall be performed under the direction of the Construction Manager. Substitution of Construction Manager and the QAM shall require Department approval. In addition, the Department shall have the right to order the removal of any construction QA and QC personnel, including the QAM and the Construction Manager for poor performance at the sole discretion of the Department. The QA/QC plan shall include rapid reporting of non-compliance to the Department, and shall include the remedial actions to be taken as discussed in Sections 5.10 and 5.11 of the January 2012 QA/QC Guide.

The Design-Builder shall provide, prior to Final Application for payment, a complete set of project records that include, but are not limited to the following:

A. Project correspondence.
B. Project diaries.
C. Test reports.
D. Invoices.
E. Materials books.
F. Certified survey records.
G. DBE/EEO records.
H. Warranties.
I. As-Built Record drawings.
J. Special tools.

3.1.3. Specialty Structures

The Design-Builder is responsible for providing QA and QC testing and inspection for all specialty structures (i.e. segmental bridges) in accordance with the Special Provision (SP) for Supplemental Owner Quality Assurance During Post-Tensioned Structure and Bridge Construction. The Department will provide OIV and OVST testing and inspection for these type structures. The Department’s required minimum OIV and OVST testing and inspection are outlined in the Special Provision (SP) and shall represent a hold point in the Design-Builder’s QA/QC plan and schedule.

3.2. Department’s Oversight Role

The Department’s oversight activities include:

A. Meeting with the Design-Builder.
B. Reviewing progress reports and payment requests.
C. Verifying progress.
D. Auditing payroll records.
E. Partnering.
F. Auditing the subcontracting process.
G. Verifying DBE, EEO, and other affirmative action compliance.
H. Conducting management reviews.
I. Participating in progress meetings.
J. Reviewing Baseline Schedules and updates.
K. Reviewing management-related plans.
L. Reviewing compliance and control.
M. Providing approvals (see Section 3.2.1 herein).
N. Reviewing Design-Builder’s design (see Section 3.1.1 herein).

3.2.1. Department Approvals

The Department will approve only those submittals, activities, actions, and/or work that are specifically identified as being for approval in Agreement Part X [Section XXXXXXX]. Any approvals by the Department will be provided to the Design-Builder in writing only.

The Department’s approvals identified in Agreement Part X [Section XXXXXXX] are summarized below, provided that nothing in this sub-section shall limit any other approvals that may be required pursuant to or in connection with the requirements of Agreement Part X [Section XXXXXXX] and these Technical Requirements:

A. Agreement Periodic Payment Schedule (Agreement Part X [Section XXXXXXX]
B. Requests for periodic payments (Agreement Part X [Section XXXXXXX]
C. Requests for payment for materials delivered to the Site Agreement Part X [Section XXXXXXX]
D. Meeting Minutes (Section 2.4.1)
E. Changes to Agreement Price (by Work Order only) Agreement Part X [Section XXXXXXX]
   1. Revised Schedule of Prices (Agreement Part X [Section XXXXXXX]
   2. Revised Contract Periodic Payment Schedule Agreement Part X [Section XXXXXXX]
F. Partnering (Part 2, Section 2.4.2)
G. DBE/SWaM Utilization Plan and updates (Part 2, Section 2.2.1)
H. Workforce Participation Plan and updates (Part 2, Section 2.2.2)
I. Site Security Plan and updates (Part 2, Section 2.2.4)
J. Quality Assurance and Quality Control Plan (QA/QC Plan) and updates (Part 2, Section 2.2.5 and Section 3 herein)
K. Project Management Plan and updates (Part 2, Section 2, Project Management)
L. Public Involvement Plan and updates (Part 2, Section 7, Communications)
M. Visual quality management plan (Part 2, Section 32, Aesthetics)
N. TMP, work site access plan and traffic control staff certification (Part 2, Section 13, TMP)
O. Value Engineering Change Proposals (VECPs) concepts and VECPs (Section 2.4.1.2)
P. Use of overweight construction Equipment or vehicles on the Project Agreement Part X [Section XXXXXXX]
Q. Use of ROW for storage Agreement Part X [Section XXXXXXX]
R. Assignment of payment to creditors Agreement Part X [Section XXXXXXX]
S. Project Specifications representing lower quality than that specified in the Contract, including the Design-Builder’s Proposal Agreement Part X [Section XXXXXXX]
T. Project Specifications for Work not covered in the Standard Specifications Agreement Part X [Section XXXXXXX]
U. Record (As-Built) Plans (Section 1.4.9)
V. Design reviews (at time of approval of As-Built Plans) (Section 1.4.9)
W. Deviations from sampling and testing methods and/or frequencies Agreement Part X [Section XXXXXXX]
X. Final Supplemental Agreement - Agreement Part X [Section XXXXXXX]
Y. Department’s review and written comments

The Department’s review, Oversight, audit, and inspection activities are referred to as “consultation and written comment” (Agreement Part X [Section XXXXXXX] The Department’s consultation and written comment will be confirmed to the Design-Builder in writing only, by the Department only. The Design-Builder shall be responsible for addressing the Department’s comments.

[Providing consultation and written comment, approvals, and Non-Conformance Reports pursuant to Agreement Part X [Section XXXXXXX]

The Design-Builder shall indicate in writing whether it concurs with the Department’s comment. If the Design-Builder does not concur with the Department’s comments, then the Department and Design-Builder will Work together to resolve the issue before proceeding with design.

If agreement cannot be reached, the issue must be resolved as provided in the Contract Documents for Dispute resolution in accordance with Agreement Part X [Section XXXXXXX]
3.2.2. **Department’s Oversight Role during Design**

The Department’s oversight role during design and design review consists of monitoring and auditing design progress including for payment, interpreting Agreement requirements, and verifying design compliance with Agreement requirements.

The Department’s oversight roles and activities relating to design will include, but are not limited to, the following:

A. Assisting in providing interpretation and answers regarding Agreement requirements on a regular basis, often daily (such involvement is often termed over-the-shoulder review).

B. Providing input and participation in the review process as agreed during the design workshop.

C. Participation in design reviews, excluding detailed checks of plans and calculations except in cases where it is deemed in the best interest of the Department.

D. Verifying through monitoring and auditing of QC and QA records that the Design-Builder’s Design Quality Manager is fulfilling his/her responsibilities and that the Quality Systems contained in the Quality Plan are being followed. An audit may include detailed checks of plans and calculations in some cases.

3.2.3. **Department’s Oversight Role during Construction**

The Department’s oversight role during construction consists of monitoring and auditing construction progress including for payment, interpreting Agreement requirements, and verifying construction compliance with Agreement requirements.

The Department’s oversight roles and activities relating to construction will include, but are not limited to, the following:

A. Independent Assurance.

B. Verification Sampling and Testing.

C. Auditing and monitoring of QC and QA to verify that the Design-Builder’s Quality Manager is fulfilling his/her responsibilities and that the Quality System contained in the Quality Plan is being followed.

D. Auditing safety and security records and checking of the qualifications of safety and security personnel.

E. Reviewing and spot-checking Design-Builder’s work zone traffic control activities and installations.

F. Conducting the reviews of As-Built Plans.

G. Assuming responsibility for coordinating with appropriate State or Federal agencies should previously unknown, unidentified Hazardous Materials be encountered.

3.3. **Deliverables**

At a minimum, the deliverables shall include the items listed in Table 3.3-1 for the Department’s review and approval.
## Table 3.3-1 Deliverables

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>QA/QC Plan (Quality Management System Plan)</td>
<td>5</td>
<td>60 days after NTP</td>
<td>3.1.1</td>
</tr>
<tr>
<td>Design QA/QC Plan (DQMP)</td>
<td>5</td>
<td>60 days after NTP</td>
<td>3.1.1</td>
</tr>
<tr>
<td>Construction QA/QC Plan (CQMP)</td>
<td>5</td>
<td>15 days before start of investigation work</td>
<td>3.1.2</td>
</tr>
<tr>
<td>Quality Assurance Auditing and Nonconformance Recovery (AR) Plan</td>
<td>5</td>
<td>60 days after completion of investigation, including testing</td>
<td>3.1.2</td>
</tr>
<tr>
<td>Non-Conformance Report (NCR)</td>
<td>5</td>
<td>As issued</td>
<td>3.1.2</td>
</tr>
</tbody>
</table>
SECTION 4. STANDARDS

4.1. General Requirements

The Design-Builder shall use the version of Standards in force on the date of issue of the RFP.

It is the Design-Builder’s responsibility to obtain clarification of any apparent error, omission, ambiguity or conflict regarding any Standard. Should the requirements in any Standard contain any apparent error, omission, ambiguity or conflict, the Department at its sole discretion will determine the applicable clarification.

For Work not specifically covered by the individual sections of the Technical Requirements, the Design-Builder shall, at a minimum, apply the Standards normally applied by the Department for such Work, to the extent they do not conflict with express requirements in the Agreement. The Design-Builder shall be solely responsible for ensuring that it identifies and applies all correct Standards.

Access to and document ordering information for most VDOT Standards are available from the following website http://www.virginiadot.org/business/manuals-default.asp

These website addresses have been supplied to the Design-Builder for convenience only, to help the Design-Builder locate the required Standard, and are not guaranteed to be correct. It is the Design-Builder’s responsibility to locate the required Standard and to determine if the Standard has been modified pursuant to the Agreement.

4.2. Specific Requirements

The design and construction Work for the Project shall be performed in accordance with the applicable Federal and State laws and VDOT Standards, Specifications and Reference Documents to include, but not limited to the documents listed herein. The Design-Builder must verify and use the latest version of the documents listed herein as of the date of the RFP or latest Addenda. The Design-Builder must meet or exceed the minimum roadway design standards and criteria except for the design waivers and design exceptions shown in Table [4-X].

If during the design, the Design-Builder determines that a specific Standard, Specification or Reference Document is required but is not listed herein, it is the responsibility of the Design-Builder to identify the pertinent Standard, Specification, or Reference Document and submit to the Department for review and approval prior to inclusion in the Agreement Documents.

The VDOT 2016 Road and Bridge Specifications, and its associated Special Provision Copied Notes (SPCN), contain pricing language under sections entitled “Measurement and Payment” that is not applicable in the Design-Build context of this RFP. Thus, in accordance with the hierarchy of documents, the Design-Builder will refer to Part 3, Articles 6 and 7, Part 4, Article 6, and applicable portions of the Division I Amendments (Part 5) to the Standard Specifications for more information regarding the pricing and payment to the Design-Builder. Similarly, other references below which contain pricing methodologies for the “Contractor” shall likewise not be used. The requirements as described in the text of Part 2 herein take precedence over the referenced documents listed below, unless otherwise indicated.

A. The Design-Builder shall assume that all provisions of the Standards, including the figures and tables, are mandatory and guidelines contained therein shall be assumed to be requirements.

B. When a Standard refers to an action being necessary, needed, or recommended, the Design-Builder shall construe the action as required unless the context requires otherwise, as determined in the sole discretion of the Department.
Technical Requirements  Part 2, Section 4

May 21, 2018  Standards

C. Except with respect to any Work for which Design-Builder is to be paid on a unit price or force account basis, any references in the Standards related to payment, Pay Items or quantities, measurement for payment, method of measurement, basis of payment, Extra Work, Adjustment of unit prices, or similar phrases, shall be disregarded by the Design-Builder, since the Agreement Price is full compensation for the Work.

D. Where reference is made in the Standards to items that are indicated in the Plans or Special Provisions (SP) or required in the plans or Special Provisions, the Plans or Special Provisions (SP) shall mean the Design-Builder’s Plans [or the Special Provisions (SP)]

E. References in the Standards to approved products or Materials shall mean approved by the Department

F. All references in the Standards to the Inspector, the field Inspector, the Project Engineer, the Engineer, the Materials Engineer, the District Materials Engineer, the survey crew, the Project supervisor, the agency certified technician, the certified plant technician, and the Representative of the Office of Materials shall mean the Design-Builder, except as otherwise expressly provided in the Agreement or otherwise directed by the Department.

G. When a Standard uses the term “Engineer” relating to activation or de-activation of railroad or highway signals, or the approval of any activities involving the use of explosives, such term shall mean the Department.

H. When approval or authorization by the “Engineer” is required in a Standard for the use of alternative or substituted processes or components, this shall mean the Department.

I. When a Standard requires actions, dimensions, spacing, design information, Materials as designed, means, or methods that are “either as indicated in the Plans or as designated by the Engineer,” the Design-Builder shall disregard the phrase “or as designated by the Engineer”

J. When a Standard refers to the “Engineer” ordering Work beyond the scope of work in the Agreement, “Engineer” shall mean the Department

K. Wherever references to “Engineer” result in testing or acceptance procedures being assigned to the Engineer, acceptance will be on behalf of the Department. The Department reserves the right to perform additional tests and inspections as necessary to confirm that the Work is in conformance with Agreement requirements and will be the only party authorized to accept or approve the Work on behalf of the Department

L. When a Standard refers to unauthorized work or to acceptance of Non-Conforming Work by the “Engineer,” the “Engineer” shall mean the Department

M. When any references occur in a Standard to the “Engineer” that refers to the time period after Final Acceptance, the term “Engineer” shall mean the Department

N. When a Standard requires notifications to the “Engineer”, the “Engineer” shall mean the Department

O. When a Standard refers to an approval of any correction or repair that deviates from the Agreement requirements, the Approval must be by the Department

P. When a Standard refers to items that will be performed or provided by the Department or by a division or Employee of the Department, the Design-Builder shall construe the requirements as applying to the Design-Builder unless otherwise specified in the Agreement Documents, or unless the context requires otherwise. It shall be in the Department’s sole discretion to determine when the context requires otherwise
Q. When a Standard refers to the “Project Manager” as it relates to plan processes, sending information or requesting information from the Department entities, the term “Project Manager” shall mean the Department. The Design-Builder shall submit all requests directly to the Department’s Project Manager.

R. The Design-Builder shall perform Work relevant to each Technical Requirement in accordance with the Standard(s), if any, that are listed in that Technical Requirement, unless otherwise stipulated in that Technical Requirement.

S. The Design-Builder shall follow all standards, laws and rules necessary to perform its Work regardless of whether an applicable standard, regulation, law or rule is specified in the Technical Requirements.

4.3. Standards and Specifications

The standards and references for the Project are listed below in the following order: (a) Standards and Specifications; (b) Additional Reference Documents; (c) Special Provisions (SP) List including Special Provisions, Special Provision Copied Notes (SPCN) and Supplemental Specifications. Items (a) and (b) are published references that are available publicly, for which copies are not provided to the Offerors in the RFP Information Package, but these items are to be used as manuals for design and construction. Items listed in (c) are included in the RFP Information Package.

General

2. VDOT Materials Approved Lists
4. VDOT Post Construction Manual (December 2016)
5. VDOT Construction Inspection Manual (January 2017)
6. VDOT Minimum Requirements for Quality Assurance and Quality Control on Design Build & Public-Private Transportation Act Projects (January 2012)
7. VDOT Traffic Engineering Design Manual (September 2014)
12. VDOT Land Use Permit Regulations 24 VAC 30-151 (March 17, 2010)
14. VDOT Instructional & Information Memorandums (IIM) – All Divisions (as of date of RFP)
15. VDOT Road and Bridge Standards, Vol. 1 and Vol. 2 (2016), including all revisions as of the date of the RFP

16. VDOT Road and Bridge Specifications (2016) including Supplements, Special ProvisionCopied Notes (SPCNs), Special Provisions (SPs) and Supplemental Specifications (SSs)

17. VDOT Statewide Maintenance Practices Manual


19. US Department of Justice Americans with Disabilities (ADA) Standards for Accessible Design (September 15, 2010)


22. VDOT Policy for Integrating Bicycle and Pedestrian Accommodations, adopted March 18, 2004 by the Commonwealth Transportation Board (CTB)

23. Transportation Research Board Highway Capacity Manual (December 2010)


25. VDOT State Noise Abatement Policy (July 13, 2011)


29. Uniform Relocation Assistance and Real Property Acquisition Act (URA) of 1970, as amended (as of date of RFP)

30. Code of Virginia, Titles 25.1 and 33.2, as amended (as of date of RFP)

31. DGS Bureau of Capital Outlay Management (BCOM) Construction and Professional Services Manual (CPSM)

32. Commonwealth of Virginia Energy Conservation Code

33. ASCE 37 Design Loads on Structures during Construction

34. fib Model Code for Service Life Design

35. Occupational Safety and Health Administration (OSHA) Regulations

- **Environmental**
  1. VDOT Asbestos Project Monitoring and Clearance Air Monitoring Procedures
  2. VDOT Asbestos Inspection Procedures

- **Roadway Design**
  1. VDOT State Bicycling Policy Plan (September 2011)
  2. VDOT State Pedestrian Policy Plan (September 2014)
3. VDOT 2014 Functional Classification Maps
5. VDOT Allowable Lane Closure Hours for the State Highway System in Hampton Roads District (June 2016)
12. FHWA 23 CFR 630 Subpart J Work Zone Safety and Mobility (September 2005)
14. FHWA Price Managed Lane Guide (October 2012)
15. FHWA Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy (February 2016)

**Geotechnical and Pavement Design**

3. VDOT Materials Division, Pavement Design and Evaluation Section, Guidelines for AASHTO Pavement Design
5. VDOT Manual of Instruction for Material Division (January 2018)
6. VDOT Manual of Instructions (MOI) for Materials Division, Chapter VI Pavement Evaluation and Design
10. AASHTOWare Pavement ME, Version 2.2.6 and VDOT’s AASHTOWare Pavement ME User Manual, dated September 2017
11. ASTM Standards, Soil and Rock, Volumes 04.08 and 04.09
12. ASTM Standards, Concrete and Aggregates, Volume 04.02


16. Virginia Transportation Research Council (VTRC) 06-CR12 Design of Bridging Layers in Geosynthetic-Reinforced, Column-Supported Embankments

- **Structures**
  1. VDOT Manual of the Structure and Bridge (Latest version)
  2. VDOT Structure and Bridge Division’s Instructional and Informational Memorandum IIM-S&B-90.2 (April 28, 2016), VDOT Modifications to AASHTO Standard Specifications for Structural supports for Highway Signs, Luminaires, and Traffic Signals
  3. VDOT Structure and Bridge Division’s Instructional and Informational Memorandum IIM-S&B-81.7 (December 13, 2016), Corrosion Resistant Reinforcing Steels (CRR)
  4. VDOT Structure and Bridge Division’s Instructional and Informational Memorandum IIM-S&B-86.1 (December 13, 2016), Load Rating and Posting of Structures (Bridges and Culverts)
  5. VDOT Supplement to the AASHTO Manual for Bridge Element Inspection (January 2016)
  15. FHWA Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation’s Bridges, December 1995, including Errata sheets and Revisions
  16. FHWA 23CFR625 – Design Standards for Highways (October 14, 1997), including Errata sheets and Revisions
  17. FHWA 23CFR630 Subpart B – Plans, Specifications, and Estimates (December 9, 1991)
  18. FHWA 23CFR650 Subpart C – National Bridge Inspection Standards (“NBIS”) (December 7, 1994), Subsection 650.301 or the latest revision(s)
23. AASHTO/NSBA Steel Bridge Collaboration Shop Detail Drawing Presentation Guidelines, G1.3 – 2002
24. AASHTO/NSBA Steel Bridge Fabrication Guide Specifications, S2.1-2016
27. ANSI/AWS D1.6M/D1.6 Structural Welding Code – Stainless Steel
29. AISC Design Guide 27: Structural Stainless Steel
31. AASHTO Manual for Assessing Safety Hardware, 1st Edition
32. AASHTO/FHWA Joint Implementation Plan for the AASHTO Manual for Assessing Safety Hardware (MASH), 2009
39. VDOT Memorandum – Asbestos Containing Materials on Bridges – October 23, 2009
40. VDOT Asbestos Inspection Procedures, dated May 4, 2004
42. ADA Standards for Accessible Design
43. Society for Protective Coatings (SSPC) Standards
44. VA Statewide Fire Prevention Code

47. ACI 318-14 Building Code Requirements for Structural Concrete and Commentary

48. ASCE 37-02 Design Loads on Structures during Construction

49. Virginia Work Area Protection Manual

50. Virginia Construction Code.

51. Virginia Uniform Statewide Building Code (USBC)

- **Tunnel**

  1. FHWA NH1-10-034, Technical Manual for the Design and Construction of Road Tunnels – Civil Elements


  3. FHWA-HIF-15-006, Specifications for National Tunnel Inventory

  4. FHWA Bridge Security Design Manual

  5. FHWA Highway and Rail Transit Tunnel Maintenance and Rehabilitation Manual – 2005 (Gannett Fleming)

  6. FHWA Highway and Rail Transit Tunnel Inspection Manual - 2005 (Gannett Fleming)

  7. 23CFR650 Subpart E - FHWA National Tunnel Inspection Standards (NTIS)

  8. ACI 544.7R Report on Design and Construction of Fiber-Reinforced Precast Concrete Tunnel Segments


  12. Fib Model Code for Service Life Design

  13. ACI 544.7R-16 Report on Design and Construction of Fiber-Reinforced Precast Concrete Tunnel Segments


  16. Best Practices for Implementing Quality Control and Quality Assurance for Tunnel Inspection prepared for AASHTO T-20

  17. 23CFR650 Subpart E – National Tunnel Inspection Standards (NTIS)
Drainage

1. VDOT 2002 Drainage Manual (including current Errata Sheets) and revisions (Revised July 2017)
4. Virginia Department of Environmental Quality (DEQ) 2013 BMP Standards and Specifications
7. FHWA Hydraulic Design Series Number 6 (HDS-6), River Engineering for Highway Encroachments, 2001
8. FHWA Hydraulic Engineering Circular Number 9 (HEC-9), Debris Control Structures Evaluation and Counter Measures, 2005
10. FHWA Hydraulic Engineering Circular Number 14 (HEC-14), Hydraulic Design of Energy Dissipaters for Culverts and Channels, 2006
11. FHWA Hydraulic Engineering Circular Number 17 (HEC-17), The Design of Encroachments on Flood Plains Using Risk Analysis, 1981
17. FHWA, Highways in the Coastal Environment, HEC 25, FHWA NHI j05-077
18. FHWA Culvert Design for Aquatic Organism Passage, 2010
20. US Army COE, Hydrologic Modeling System (HEC HMS) Version 4.0
22. FEMA National Flood Insurance Program Regulations
23. US Army COE, River Analysis System (HEC RAS), Version 5.0.3
24. The Virginia Stormwater Management (SWM) Law dated 2015 (as listed in the Code of Virginia)
25. The Virginia SWM Regulations dated 2015 (as listed in the Virginia Administrative Code)

**Traffic Control Devices and Lighting**
5. ANSI/IESNA RP-8-14 Roadway Lighting
6. ANSI/IESNA RP-20 Lighting for Parking Facilities
7. ANSI/IESNA RP-22 Tunnel Lighting
12. FHWA Roadway Lighting Handbook

**Miscellaneous**
2. VDOT Guardrail Installation Training Manual (GRIT), Revised 2015
3. USACE EM 1110-2-1003, Hydrographic Surveying, November 30, 2013

**ITS**
1. Institute of Electrical and Electronics Engineer (IEEE) 802.3 Local and Metropolitan Area Networks
2. National Electric Manufacturers Association (NEMA) TS-4 Hardware Standards for Dynamic Message Signs (DMS) with NTCIP Requirements
5. National Transportation Communications for Intelligent Transportation Systems Protocol (NTCIP)

- **Building, Tunnel, Mechanical, and Electrical Systems**
  
  1. Virginia Plumbing Code
  2. Virginia Mechanical Code
  4. NFPA 70E – Standard for Electrical Safety in the Workplace
  7. NFPA 3, Recommended Practice for Commissioning of Fire Protection and Life Safety Systems
  8. NFPA 10, Standard for Portable Fire Extinguishers
  10. NFPA 14, Standard for the Installation of Standpipe, Private Hydrant and Hose Systems
  12. NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection
  13. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances
  15. NFPA 72, National Fire Alarm Code
  16. NFPA 80, Standard for Fire Doors and Other Opening Protectives
  17. NFPA 92, Standard for Smoke Control Systems
  22. NFPA 780 – Standard for the Installation of Lightning Protection Systems
  23. NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities, specifically Chapter 7
  27. ANSI/IES RP-8 Roadway Lighting
28. ANSI/IES RP-1 Office Lighting
29. ANSI/IES RP-20 Lighting for Parking Facilities
30. ANSI/IES RP-33 Lighting for Exterior Environments
31. ANSI/TIA/EIA 607 – Grounding and Bonding Requirements for Telecommunications in Commercial Buildings
32. ANSI/TIA/EIA 568 – Commercial Building Standard Telecommunication and Cabling Standard
33. ANSI/TIA/EIA 569 – Commercial Building Standards for Telecommunication Pathways and Spaces
34. ANSI/TIA/EIA 758 – Customer Owned Outside Plant Telecommunications Cabling Standard
35. ASTM Standards, Soil and Rock, Volumes 04.08 and 04.09;
36. ASTM Standards, Concrete and Aggregates, Volume 04.02;
37. IEC 61131 – Standard for Programmable Controllers
38. ISA/IEC 62443 – Standards on the Cyber Security of Industrial Controls
39. ANSI/TIA/EIA 455 – Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
40. ANSI/TIA/EIA 604 – Optical Fiber Cabling Color Coding
41. NEMA IA 2.1-8 – Programmable Controllers
42. NEMA ICS 5 – Control Circuits and Pilot Devices
43. NEMA ICS 6 – Industrial Control and System Enclosures
44. TSB 140 – Additional Guidelines for Field Test Length, Loss and Polarity of Optical Fiber
45. IEC 61850 Communication Networks and Systems for Power Utility Automation
48. ASHRAE 51 - Laboratory Methods of Testing Fans for Rating
49. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality
50. ASHRAE Guideline 1.5 - The Commissioning Process for Smoke Control Systems
51. ASTM A112.6.3-2001 Floor and Trench Drains
52. ACI 318-14 Building Code Requirements for Structural Concrete and Commentary
53. AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
54. AMCA 204, Balance Quality and Vibration Levels for Fans
55. AMCA 250, Laboratory Methods of Testing Jet Tunnel Fans for Performance
56. AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data
57. AMCA 500-D, Laboratory Methods of Testing Dampers for Rating
58. AMCA 500-L, Laboratory Methods of Testing Louvers for Rating
59. ASTM A795, Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use
60. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
61. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA)
62. UL 10C - Standard for Safety – Positive Pressure Fire Test of Door Assemblies
63. UL 555S Standard for Smoke Dampers
64. UL 508, Industrial Control Equipment (ANSI)
65. UL 723, Standard for Safety Test for Surface burning Characteristics of Building Materials

(b) Additional Reference Documents

1. ACI 301: Specifications for Concrete
2. ACI 201.2R Guide to Durable Concrete
4. FHWA Geotechnical Engineering Circular No. 4 - Ground Anchors and Anchored Systems, FHWA-IF-99-015, 1999
5. FHWA Geotechnical Engineering Circular No. 5, Evaluation of Soil and Rock Properties dated April 2002
6. FHWA Geotechnical Engineering Circular No. 7 - Soil Nail Walls, FHWA-IF-03-017, 2003 – February 2015
11. FHWA Geotechnical Engineering Circular No. 6, Shallow Foundations, September 2002, FHWA-SA-02-054
13. FHWA Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Volumes I & II, November 2009, FHWA-NHI-10-024
15. FHWA Drilled Shafts Construction Procedures and LRFD Design Methods, May 2010, FHWA NHI-10-016
16. FHWA The Osterberg Cell for Load Testing Drilled Shafts And Driven Piles, FHWA-SA-94-035, 1994
17. FHWA Load and Resistance Factor Design (LRFD) For Highway Bridge Superstructures (April 2007), FHWA-NHI-08-048
18. FHWA Load and Resistance Factor Design (LRFD) for Highway Bridge Substructures (April 2007), FHWA-NHI-08-036
19. FHWA Load and Resistance Factor Design (LRFD) For Highway Bridge Superstructures - Examples (April 2007), FHWA-NHI-08-049
20. FHWA LFRD for Highway Bridge Substructures and Earth Retaining Structures (Jan 2007), FHWA-NHI-05-095
21. FHWA Ground Improvements, Reference Manual Volume I, FHWA-NHI-06-019 (latest date as of date of RFP)
22. FHWA Ground Improvements, Reference Manual Volume II, FHWA-NHI-06-020 (latest date as of date of RFP)
23. FHWA Earth Retaining Structures (RM), FHWA-NHI-07-071, June 2008
25. MicroPiles – FHWA-SA-97-070
27. Driven Piles – FHWA HI 97-013 and FHWA HI 97-014
28. NAVFAC Design Manual 7.1
29. NAVFAC Design Manual 7.2
33. Policy and Procedural Guidance for Processing Requests to Alter U.S. Army Corps of Engineer (USACE) Civil Works Projects Pursuant to Section 408 (Latest version)
35. Prosser, M.J., Propeller Induced Scour, BHRA
36. USCG Bridge Permit Application Guide, COMDTPUB P16591.3D, July 2016
37. Design of Sheet Pile Walls, USACE EM 1110-2-2504
39. ASTM C827: Change in Height at Early Stages of Cylindrical Specimens of Cementitious Mixtures
40. Post-Tensioning Institute Recommendations for Prestressed Rock and Soil Anchors PTI
DC35.1

(c) Special Provisions (SP) List, Special Provision Copied Notes (SPCN) and Supplemental Specifications

General

2. VDOT Special Provision for Limitations of Operations, November 29, 2016

Materials

1. VDOT Special Provision for Lightweight Aggregate - July, 2016
3. VDOT Special Provision for Reflection Cracking Retardant Material (English Units) - March 22, 2010
4. VDOT Special Provision for Low Density Cementitious Fill - June 24, 2011
5. VDOT Special Provision for Subbase and Aggregate Base Material Crushed Hydraulic Cement Concrete (CHCC) - July 12, 2016
6. VDOT Special Provision for Open Graded Drainage Layer (OGDL), November 10, 2016

Roadway Construction

1. VDOT Special Provision for Sealing Cracks in Asphalt Concrete Pavement or Hydraulic Cement Concrete Pavements (Prior to Overlay) - July 12, 2016
2. VDOT Special Provision for Undersealing Portland Cement Concrete Pavement - January 3, 1995
3. VDOT Special Provision for Needle-Punched, Non-Woven Geotextile Stabilization Fabric, October 1, 2015
4. VDOT S303J00-0708 Special Provision for Turbidity Curtain - January 14, 2008
5. VDOT Special Provision (S302G02-0610) for Flowable Backfill - March 11, 2010
6. VDOT Special Provision Copied Notes c302h00 - Section 302.03(b) Precast Drainage Structures - July 12, 2016
7. VDOT Special Provision for Pipe Rehabilitation - July 12, 2016
8. VDOT Special Provision for Pipe Replacement - July 12, 2016
9. VDOT Special Provision for Hot Mix Asphalt Patches - July 12, 2016
10. VDOT Special Provision for Sawing and Sealing Joints In Asphalt Overlays Over Jointed Concrete Pavement - July 12, 2016
11. VDOT Rideability Special Provision for Design Build Projects, November 16, 2016
12. VDOT Special Provision for Section 302.03(a)1- Jack and Bore for Design-Build Projects, October 13, 2009
13. VDOT Special Provision for Section 302.03(a)3- Micro Tunneling for Design-Build Projects, September 14, 2009
• **Bridges and Structures**

1. VDOT Special Provision for Elastic Inclusion - July 12, 2016
3. VDOT Special Provision for Drilled Shafts– December 12, 2016
4. VDOT Special Provision for Drilled Shafts Using Self-Consolidating Concrete for Design-Build and PPTA Contracts– December 12, 2016
5. VDOT Special Provision for Wave Equation Analysis for LRFD for Design-Build and PPTA Contracts - February 7, 2014
6. VDOT Special Provision for Dynamic Pile Testing for Friction Piles for LRFD (S403B01-0714) for Design-Build and PPTA Projects - February 7, 2014
7. VDOT Special Provision for Dynamic Pile Testing for End Bearing Piles for LRFD (S403C01-0714) for Design-Build and PPTA Contracts - February 7, 2014
10. VDOT Special Provision for Powder Coated Galvanized Railing – February 18, 2016
11. VDOT Special Provision for Filling and Sealing Pattern Cracks in Concrete Decks and Overlays - July 12, 2016
12. VDOT Special Provision for Shotcrete and Permanent Concrete Facing - June 6, 2011
13. VDOT Special Provision for Secant Pile or Tangent Pile (Drilled Shaft) Walls - June 8, 2011
14. VDOT Special Provision for Permanent Soil Nails - June 7, 2011
15. VDOT Special Provision for Reinforced Earth Walls With Low Density Cementitious Fill (LDCF) - June 24, 2011
16. VDOT Special Provision for Densified Aggregate Piers for Foundation Reinforcement - June 24, 2011
17. VDOT Project - Specific Special Provision for Densified Cement-Treated/Grouted Aggregate Piers for Foundation Reinforcement - June 10, 2011
18. VDOT Special Provision for Exposed Aggregate Finish - R July 12, 2016
19. VDOT Special Provision for Mechanically Stabilized Earth Walls (Segmental Block Facing) for Design Build and PPTA Projects - September 30, 2015
20. VDOT Special Provision for Mechanically Stabilized Earth Walls (Concrete Panel Facing) for Design Build and PPTA Projects - April 8, 2016
21. VDOT Special Provision for Micropiles for Design Build and PPTA Projects, January 20, 2010
22. VDOT Special Provision for MSE Walls (Modular Cantilever Facing), December 10, 2009
24. VDOT Special Provision for T-Wall Retaining Wall System for Design-Build and PPTA Contracts, December 10, 2009

25. VDOT S404B00-0708 Special Provision for Concrete Surface Color Coating - July 2008

26. VDOT S407D00-0708 Special Provision for Metallization of Ferrous Metal Structures - July 12, 2016

27. VDOT SPCN for Waterproofing Coating, October 28, 2014

28. VDOT c413d01-0416 SPCN Dismantling and Removing Existing Structures or Removing Portion of Existing Structures – September 10, 2015

29. VDOT Special Provision for Low Cracking Bridge Concrete, August 4, 2015

30. VDOT Special Provision for Reinforcing Steel - July 12, 2016

31. VDOT Project Specific Technical Special Provision for Movable Bridge Barrier and Warning Gates, November 4, 2016

32. VDOT Project Specific Technical Specification for Warning Gong System, November 4, 2016

33. VDOT Project Specific Technical Special Provision for Instrumentation and Monitoring of Adjacent Structures and Facilities (To be provided)


37. VDOT Special Provision for Concrete Cylinder Piles (To be provided)

38. VDOT Special Provision for Concrete Cylinder Piles, Using Stainless Steel Prestressing Strand and Reinforcement (To be provided)

39. VDOT Special Provision for Concrete Cylinder Piles, Using CFRP Prestressing Strand and Reinforcement (To be provided)

40. VDOT Special Provision for Jack and Bore Casing Pipe, October 26, 2015

41. VDOT Special Provision for Superstructure Erection Stability for Design-Build and PPTA Contracts (To be provided)

42. VDOT Special Provision for Concrete Cylinder Piles for Design-Build and PPTA Contracts

43. VDOT Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts

44. VDOT Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts

- **Incidental Construction**
  
  1. VDOT Special Provision for Architectural Finish, Concrete Form Liners and Color Stain Coating - July 6, 2016

  2. VDOT Special Provision for Architectural Treatment - February 27, 2012
3. VDOT SPCN for Locating, Removing and Disposing Of Recessed Pavement Markers and Raised Snow-Plowable Markers - R July 12, 2016
4. VDOT SPCN for Table V-1, ADT Groups - R July 12, 2016
5. VDOT SPCN for Police Patrols - R July 12, 2016
6. VDOT SPCN for Notice To Remove Parked Vehicles - R July 12, 2016
7. VDOT SPCN for Uniformed Flaggers - R July 12, 2016
8. VDOT SPCN Section 512 — Maintaining Traffic, R July 12, 2016
9. VDOT Special Provision for Work Zone Traffic Control Management, R July 12, 2016

- Traffic Control Devices
  2. VDOT Special Provision for Mast Arm Hanger Assembly Std SM-3 and SMD-2, R July 12, 2016
  3. VDOT Special Provision for Section 704 — Pavement Markings and Markers, (Asphalt Schedules), R July 12, 2016
  4. VDOT Project Specific Special Provision for Surface Mount Tubular Marker, November 7, 2016
  5. VDOT Special Provisions for Signal Controller and Cabinets (To be provided)

- Environmental
  1. VDOT Special Provision for Asbestos Removal and NESHAP-Related Demolition Requirements for Structures On Design-Build Projects, June 22, 2009
  2. VDOT Special Provision for Inspection of Structures for Asbestos Containing Materials (ACM) on Design-Build Projects, June 22, 2009
  3. VDOT Special Provision for Sound Barrier Walls, November 1, 2016
  4. VDOT SPCN for Demo Notice of Structures not Requiring Asbestos Removal, June 25, 2009
  5. VDOT Special Provision Volatile Organic Compound (VOC) Emissions Control Areas, December 18, 2013
  6. VDOT Special Provision for Section 108.02 Limitation of Operations, Protection of Emancipation Oak

The above list of Special Provisions (SP) is not intended to be an all-inclusive list. The Design-Builder is responsible for achieving the Work in accordance with all current VDOT standards as of the date of the RFP issuance, including any revisions and/or addenda thereof. If a construction element is not adequately addressed within VDOT Standard Specifications or the Special Provisions (SP) listed for the purpose of the Design-Builder's design, it is the responsibility of the Design-Builder to develop an alternative specification that is acceptable to the Department for that element of work.

In the event of a discrepancy between the Department and non-VDOT Standards and References listed herein, the VDOT Road and Bridge Specifications, design standards, and manuals shall take precedence, with the following exception. If AASHTO or the MUTCD require that a higher or better standard be
applied, then AASHTO and/or the MUTCD shall take precedence. In accordance with Section [X.XX] below, all deviations from AASHTO minimum specified design values shall be documented, justified, and approved by the Department and FHWA.

Special Provisions (SP) included in this Agreement document or other Special Provisions (SP) approved by the Department shall govern over the VDOT specifications, design standards and manuals. Special Provision Copied Notes (SPCN) approved by the Department and requirements specified within the text of this RFP shall govern over both the Special Provisions (SP) and VDOT specifications, design standards and manuals.
SECTION 5. ENVIRONMENTAL

5.1. Scope

A. The Design-Builder shall carry out environmental commitments during design and construction, as applicable, as identified in the Record of Decision (ROD) dated June 12, 2017; the final Right of Way (RW) Authorization (EQ-201); the final Plans, Specifications, and Estimates (PS&E) Re-evaluation Authorization (EQ-200); and the final Environmental Certification/Commitments Checklist (EQ-103). All commitment compliance shall be supported by the appropriate documentation, to be provided by the Design-Builder to the Department.

B. The Design-Builder shall acquire all water quality permits for the Project in the Design-Builder’s name (i.e. the Design-Builder shall be the “Permittee”) and shall provide for any necessary stream and/or wetland compensation required by permits to accomplish the work.

C. The Design-Builder shall be responsible for compliance with pre-construction and construction-related environmental commitments and shall be responsible for compliance with pre-construction, construction-related permit conditions, as well as post-construction monitoring if required by regulatory agencies. The Design-Builder shall assume all obligations and costs incurred by complying with the terms and conditions of the permits and environmental certifications. Any fines associated with environmental permit or regulatory violations shall be the responsibility of the Design-Builder.

D. The following Appendix Specification applies to this Section:
   1. Appendix A5-1 Protection of Emancipation Oak

5.2. References

A. FHWA Final Supplemental Environmental Impact Statement dated April 25, 2017
B. FHWA Record of Decision dated June 12, 2017
C. [VDOT Environmental Manual]
D. VDOT Programmatic Agreement Among the Federal Highway Administration, the Virginia State Historic Preservation Officer, and the Virginia Department of Transportation Regarding the Hampton Roads Crossing Study, Cities of Hampton and Norfolk, Virginia, executed April 11, 2017
E. VDOT Letter from VDOT to VA SHPO re: Section 106 effects determination, dated November 22, 2016
F. VDOT Hampton Roads Crossing Study SEIS, Architectural Survey: Management Summary (Revised July 2016)
G. VDOT Hampton Roads Crossing Archaeological Survey, Hampton and Norfolk, Virginia (July 2017)
H. VDOT Letter from VDOT to VA SHPO re: archaeological survey findings, dated July 13, 2017
I. VDOT Hampton University Memorandum of Understanding and Right of Entry Agreement, executed December 22, 2017
J. VDOT Programmatic Agreement among the Federal Highway Administration, the U.S. Army Corps of Engineers, Norfolk District, the Tennessee Valley Authority, the Advisory Council on Historic Preservation, the Virginia State Historic Preservation Officer, and the Virginia Department of Transportation Regarding Transportation Undertakings Subject to Section 106 of the National Historic Preservation Act, executed August 6, 2016

5.3. Requirements

5.3.1. Environmental Document

A. FHWA has issued a NEPA decision for the Project. A copy of the ROD dated June 12, 2017 is included in the RFP Information Package. The Department has also completed preliminary document re-evaluations for Right of Way (RW) Authorization (EQ-201) dated [●]; Plans, Specifications and Estimates (PS&E) Authorization (EQ-200) dated [●]; and a preliminary Environmental Certification/Commitments Checklist (EQ-103) dated [●], which are included in the RFP Information Package.

B. Once the Design-Builder has completed the design, the Department shall update and finalize the Document Re-evaluation for RW Authorization (EQ-201) prior to RW authorization, update and finalize the Document Re-evaluation for PS&E Authorization (EQ-200), and update and finalize the Environmental Certification/Commitments Checklist (EQ-103) prior to the Department releasing the Project for construction. If the Project includes phased work, then final versions of these documents shall be updated and finalized by the Department prior to authorizing RW and construction for each phase. The Department shall verify that the EQ-200, EQ-201 and EQ-103 forms have been updated and finalized prior to obtaining approval signatures for each title sheet submittal required for RW and Construction.

C. The Design-Builder shall carry out environmental commitments during design, right-of-way acquisition, and construction, as applicable, as identified in the Final SEIS and ROD, the final Document Re-evaluations for RW and PS&E Authorization, and the final Environmental Certification/Commitments Checklist forms. All commitment compliance shall be supported by appropriate documentation, to be provided by the Design-Builder to the Department.

D. If the Design-Builder contemplates any changes in the scope or footprint of the Project concept for which the Department has obtained NEPA clearance, the Design-Builder shall discuss these with the Department to assess whether NEPA re-evaluation is necessary. If so, the Design-Builder shall be responsible for developing any additional environmental studies and other information necessary to support the Department’s coordination of NEPA document re-evaluation with FHWA. The Design-Builder shall provide this information and perform any additional environmental commitments that result from such coordination at its sole expense and with no time delays to the Project.

E. The results from any additional work needed to support the Design-Builder’s final design shall be conveyed to the Department as quality deliverables in accordance with professional standards and guidelines for each NEPA-related discipline, as well as with the criteria described in the following sections. Moreover, the Department reserves the right to return any inadequate or substandard deliverables to the Design-Builder for revision prior to coordination.

F. The Design-Builder is solely responsible for any costs or schedule impacts related to the permit acquisition, permit modifications, and NEPA document re-evaluations associated with Design-Builder’s design changes or means-and-methods, as well as any impacts related to the submission of inadequate or substandard deliverables.
5.3.2. **Cultural Resources**

A. On April 11, 2017, the FHWA, the Virginia State Historic Preservation Officer (VA SHPO), and the Department executed a Programmatic Agreement (“Section 106 PA”) pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. 306108; 36 CFR Part 800) to resolve the Project’s effects on historic properties. In signing the Section 106 PA the VA SHPO concurred that the Project would have No Adverse Effect on the twenty (20) historic buildings, structures, non-archaeological districts, and non-archaeological objects listed on or eligible for listing on the National Register of Historic Places (herein after “architectural historic properties”) located within the Area of Potential Effects (APE) provided that the conditions/commitments described in the Section 106 PA and in the letter from the Department to the VA SHPO dated November 22, 2016, are met.

B. The Project APE includes the area in which direct impacts to archaeological and architectural historic properties may occur and the area in which architectural historic properties may experience indirect effects (e.g. visual, auditory). The direct effects APE is the proposed Limits of Disturbance (LOD) plus an Inventory Corridor developed along the length of the existing HRBT and approaches, extending from the eastern edge of the existing bridge-tunnels to 30 feet beyond the western edge of the proposed bridge-tunnel, as both the LOD and Inventory Corridor are depicted in Appendix B, Figures 1, 2, 3, 4, 5, 6, 7, 8 of the Final Supplemental Environmental Impact Statement (April 2017). The locations of the twenty architectural historic properties located within the APE are also depicted in these figures. The indirect effects APE is depicted in Figures 3a and 3b in the letter from the Department to the VA SHPO dated November 22, 2016, and in greater detail in Appendices A, C, and D in the report Hampton Roads Crossing Study SEIS, Architectural Survey: Management Summary (Revised July 2016).

C. The twenty (20) architectural historic properties in the Project APE are as follows:

<table>
<thead>
<tr>
<th>VDHR No.</th>
<th>Resource Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>114-5600</td>
<td>Hampton Coliseum</td>
</tr>
<tr>
<td>114-0155</td>
<td>Elmerton Cemetery</td>
</tr>
<tr>
<td>114-0118</td>
<td>Pasture Point Historic District</td>
</tr>
<tr>
<td>114-0006</td>
<td>Hampton Institute Historic District (National Historic Landmark)</td>
</tr>
<tr>
<td>114-0148</td>
<td>Hampton National Cemetery</td>
</tr>
<tr>
<td>114-0101</td>
<td>Hampton Veterans Affairs Medical Center Historic District</td>
</tr>
<tr>
<td>114-5002</td>
<td>Phoebus-Mill Creek Terrace Neighborhood Historic District</td>
</tr>
<tr>
<td>114-0002</td>
<td>Fort Monroe (National Historic Landmark)</td>
</tr>
<tr>
<td>114-0114</td>
<td>Chamberlain Hotel</td>
</tr>
<tr>
<td>114-0021</td>
<td>Old Point Comfort Lighthouse</td>
</tr>
<tr>
<td>114-0041</td>
<td>Fort Wool</td>
</tr>
<tr>
<td>114-5471</td>
<td>Battle of Hampton Roads</td>
</tr>
<tr>
<td>122-5426</td>
<td>Battle of Sewell’s Point</td>
</tr>
<tr>
<td>None</td>
<td>Captain John Smith Chesapeake National Historic Trail</td>
</tr>
<tr>
<td>None</td>
<td>Washington-Rochambeau Revolutionary Route National Historic Trail</td>
</tr>
<tr>
<td>122-0410</td>
<td>Norfolk Naval Base Historic District</td>
</tr>
<tr>
<td>122-5930</td>
<td>Willoughby Elementary School</td>
</tr>
<tr>
<td>122-0954</td>
<td>Ocean View Elementary School</td>
</tr>
<tr>
<td>122-5434</td>
<td>Merrimack Landing Apartment Complex/Merrimack Park Historic District</td>
</tr>
<tr>
<td>122-0531</td>
<td>Forest Lawn Cemetery</td>
</tr>
</tbody>
</table>
D. The Department has fulfilled the requirements of Stipulation II of the Section 106 PA by completing terrestrial and underwater archaeological survey of the Project’s APE for direct effects. The VA SHPO has concurred with the results of the survey, which are described in the report *Hampton Roads Crossing Archaeological Survey, Hampton and Norfolk, Virginia* (July 2017) and are summarized in the Department’s letter to the VA SHPO dated July 13, 2017. The Department has also completed terrestrial archaeological survey of a potential construction staging area on Willoughby Spit, and the VA SHPO has concurred with the results of this survey as summarized in the Department’s letter to the VA SHPO dated April 16, 2018. For each survey, there are no archaeological historic properties located within the Project’s APE for direct effects.

E. Copies of the Final Supplemental Environmental Impact Statement, the Section 106 PA for the Project, other related agreement documents, the architectural and archaeological technical reports, and relevant VDOT/VA SHPO correspondence are included in the RFP Information Package.

F. The following commitments must be carried out by the Design-Builder in accordance with the specific requirements detailed in the referenced documents. The Design-Builder is responsible for conducting all technical studies, preparing all assessment, monitoring, landscape, and design plans necessitated by these commitments, and implementing these plans after approval by the Department. The Department is responsible for coordinating the studies and plans with the VA SHPO and the Consulting Parties named in the Section 106 PA. The Design-Builder shall not proceed with construction activities covered by these commitments until the Department releases the work in writing.

1. Architectural Historic Properties
   Any changes proposed by the Design-Builder to the scope or footprint of the Project beyond what is shown on the RFP Conceptual Plans must be consistent with the VA SHPO’s concurrence (dated December 29, 2016) with the Department’s determination (as described in the letter from the Department to the VA SHPO dated November 22, 2016) that the Project will have No Adverse Effect on architectural historic properties.

2. Hampton Institute Historic District (National Historic Landmark)
   a. The Design-Builder shall not construct any permanent highway improvements within the National Register of Historic Places (NRHP) boundaries of the historic district. (Section 106 PA, Stipulation I.A.1)
   b. On December 22, 2017, the Department and Hampton University executed the Memorandum of Understanding and Right of Entry Agreement, thereby fulfilling the requirements of the Stipulation I.A.2 of the Section 106 PA. The Design-Builder shall not enter into a separate right of entry agreement with Hampton University, or perform Project-related activities under such separate agreement, unless the agreement and activities conform to the terms of Stipulations I.A.1-I.A.6 of the Section 106 PA.
   c. The Design-Builder shall fulfill the Department’s duties under the Memorandum of Understanding and Right of Entry Agreement, Stipulation 3.c., to install plantings for the purpose of revegetating and/or screening Hampton University property from I-64 at a level mutually agreeable to the Department and Hampton University.
   d. The Design-Builder shall not construct any Project improvements or conduct any construction activities, including ancillary activities such as stockpiling or staging,
within the Emancipation Oak Tree Limit of Disturbance (Section 106 PA, Stipulation I.A.3 and Attachment 7). The Design-Builder shall provide fencing in this area in accordance with Appendix Specification A5-1, Protection of Emancipation Oak.

e. The Design-Builder shall develop a plan for conducting a baseline assessment of the condition of the Emancipation Oak and the row of loblolly pines that runs along the southwest side of the I-64 eastbound entrance ramp at Exit 267-US 60/VA 143 Settlers Landing Road, and provide the plan to the Department, who will coordinate it with the VA SHPO and other Consulting Parties. Upon the Department’s approval of the assessment plan, the Design-Builder shall complete the baseline assessment and provide a draft baseline assessment report to the Department. The Design-Builder shall incorporate comments received from the Department, the VA SHPO, and Consulting Parties into a final baseline assessment report and provide it to the Department for approval. The Design-Builder shall not begin construction on I-64 at the Hampton Institute Historic District until the Department has approved the final baseline assessment report. (Section 106 PA, Stipulation I.A.4).

f. The Design-Builder shall develop a plan for monitoring the condition of the Emancipation Oak and the row of loblolly pines that runs along the southwest side of the I-64 eastbound entrance ramp at Exit 267-US 60/VA 143 Settlers Landing Road during Project construction and for a period of one (1) year following completion of construction, and shall provide the plan to the Department. The Design-Builder shall incorporate comments received from the Department, the VA SHPO, and Consulting Parties into a final monitoring plan and provide it to the Department for approval. The Design-Builder shall implement the approved monitoring plan. (Section 106 PA, Stipulation I.A.5)

g. The Design-Builder shall provide the draft Final Design Noise Analysis to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. If a noise barrier is constructed on the eastbound lanes of I-64 at the Hampton Institute Historic District, the Design-Builder shall provide proposed barrier design plans to the Department, who will consult with the VA SHPO and Hampton University on the aesthetic treatment of the barrier. The Department will not approve the Design-Builder’s barrier design until the VA SHPO has concurred that the barrier is compatible with the historic character of the historic district and will not diminish the district’s integrity of historic setting or feeling. (Section 106 PA, Stipulation I.A.6)

3. Pasture Point Historic District

The Design-Builder shall provide the draft Final Design Noise Analysis to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. If a noise barrier is constructed on the eastbound lanes of I-64 at the Pasture Point Historic District, the Design-Builder shall provide proposed barrier design plans to the Department, who will consult with the VA SHPO and the Consulting Parties on the aesthetic treatment of the barrier. The Department will not approve the Design-Builder’s barrier design until the VA SHPO has concurred that the barrier is compatible with the historic character of the historic district and will not diminish the district’s integrity of historic setting or feeling. (Section 106 PA, Stipulation I.B)

4. Hampton National Cemetery
a. The Design-Builder shall provide the draft Final Design Noise Analysis to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. (Section 106 PA, Stipulation I.C.1)

b. If the Final Design Noise Analysis indicates that a noise barrier should be considered for the westbound lane of I-64 at the Hampton National Cemetery, Phoebus Section, the Design-Builder shall prepare a sun and shadow analysis of the proposed barrier and shall provide it to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. (Section 106 PA, Stipulation I.C.2)

c. If a noise barrier is constructed on the westbound lanes of I-64 at the Hampton National Cemetery, Phoebus Section, the Design-Builder shall provide proposed barrier design plans to the Department, who will consult with the VA SHPO and the Consulting Parties on the aesthetic treatment of the barrier and on potential plantings that would screen or soften the view of the barrier from the cemetery. The Design-Builder shall provide final barrier and landscape design plans to the Department. The Department will not approve the barrier and landscape design until the VA SHPO has concurred that the barrier and landscaping are compatible with the historic and architectural character of the historic cemetery district and will not diminish the cemetery’s integrity of historic setting or feeling. The Design-Builder shall install the approved landscape plan prior to the end of Project construction and shall maintain it in good condition for a one (1)-year establishment period. (Section 106 PA, Stipulation I.C.3)

d. If no noise barrier is installed on the westbound lanes of I-64 at Hampton National Cemetery, Phoebus Section, the Design-Builder shall participate with the Department in consulting with the SHPO and the Consulting Parties on the design of a landscape plan consisting of fencing and/or plants installed between I-64 and the cemetery for the purpose of preventing highway litter from entering the cemetery and screening or softening the view of the highway from the historic property. The Design-Builder shall provide draft and final landscape plans to the Department for review and coordination. The Department will not approve the landscape plan unless the VA SHPO has concurred that the landscape plan is compatible with the historic and architectural character of the historic cemetery district and will not diminish the cemetery’s integrity of historic setting or feeling. The Design-Builder shall install the approved landscape plan prior to the end of Project construction and shall maintain it in good condition for a one (1)-year establishment period. (Section 106 PA, Stipulation I.C.4)

e. If the Design-Builder finds that an appropriate landscape plan cannot be accommodated between I-64 and the cemetery, the Design-Builder shall provide documentation of this finding in writing to the Department for review and approval and subsequent coordination with the VA SHPO and the Consulting Parties. The Department will assume responsibility for fulfilling the requirements of Stipulation I.C.5 of the Section 106 PA.

5. Phoebus-Mill Creek Terrace Neighborhood Historic District

The Design-Builder shall provide the draft Final Design Noise Analysis to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. If a noise barrier is constructed on the westbound lanes of I-64 at the Phoebus-Mill Creek Terrace Neighborhood Historic District, the Design-Builder shall provide proposed barrier design plans to the Department, who will consult with the VA
6. Norfolk Naval Base Historic District

The Design-Builder shall provide the draft Final Design Noise Analysis to the Department, who will provide it to the VA SHPO and the Consulting Parties for review and comment. If a noise barrier is constructed along I-64 at Norfolk Naval Base Historic District, the Design-Builder shall provide proposed barrier design plans to the Department, who will consult with the VA SHPO and the Consulting Parties on the aesthetic treatment of the barrier. The Department will not approve the Design-Builder’s barrier design until the VA SHPO has concurred that the barrier is compatible with the historic character of the historic district and will not diminish the district’s integrity of historic setting or feeling. (Section 106 PA, Stipulation I.E)

7. Design for Adding Capacity to the HRBT

The Design-Builder shall provide its design plans for adding capacity to the HRBT to the Department for review. The Department will coordinate the Design-Builder’s plans with the VA SHPO and the Consulting Parties as required under Stipulation I.F of the Section 106 PA. The Department will not approve the Design-Builder’s design plans unless the VA SHPO has concurred that the design will have No Adverse Effect on the following historic properties: Phoebus-Mill Creek Terrace Neighborhood Historic District (DHR Inventory No. 114-5002), Fort Monroe (DHR Inventory No. 114-0002), Chamberlain Hotel (DHR Inventory No. 114-0114), Old Point Comfort Lighthouse (DHR Inventory No. 114-0021), Fort Wool (DHR Inventory No. 114-0041), Battle of Hampton Roads (DHR Inventory No. 114-5471), Battle of Sewell’s Point (DHR Inventory No. 122-5426), the Captain John Smith National Historic Trail, and the Washington-Rochambeau Revolutionary Route National Historic Trail. The Design-Builder shall implement the design as approved.

8. Post Review Discoveries (Section 106 PA Stipulation III)

a. In the event that previously unidentified potential historic properties are discovered within the APE during project construction, or if unanticipated effects on historic properties occur during construction activities, the Design-Builder shall immediately halt all construction work in the area of the resource and, for any discovered archaeological resources, in surrounding areas where additional subsurface remains can reasonably be expected to occur and be disturbed by project construction, and shall notify the Department. Construction work in all other areas of the project may continue. The Department will notify the FHWA and the VA SHPO and assist the FHWA in notifying appropriate Tribes.

b. The Design-Builder shall engage a qualified archaeologist or architectural historian, as appropriate, to investigate the worksite and the resource, and shall provide an assessment of the NRHP eligibility of the resource and proposed treatment actions to resolve adverse effects to the Department, who will coordinate the discovery with the FHWA, the VA SHPO, and the Tribes.

c. The Design-Builder shall take into account the recommendations of the FHWA, the Department, the VA SHPO, and the Tribes regarding NRHP eligibility of the
resource and/or the proposed treatment plan to resolve adverse effects, and then provide an action plan to the Department for review and approval. The Design-Builder shall not proceed with work in the area of the resource until the Department and the VA SHPO have determined the resource is not eligible for inclusion in the NRHP or the Design-Builder has demonstrated to the Department that appropriate treatment measures have been implemented.

9. General Commitments

All work conducted by the Design-Builder shall meet the requirements of Stipulations IV (Treatment of Human Remains), V (Professional Qualifications), VI (Preparation and Review of Documents), and VII (Curation Standards) of the Section 106 PA. Stipulation IV of the Section 106 PA for the Project contains, by reference, the requirements for the treatment of human remains contained in Stipulation VII and Attachment C of the Programmatic Agreement among the Federal Highway Administration, the U.S. Army Corps of Engineers, Norfolk District, the Tennessee Valley Authority, the Advisory Council on Historic Preservation, the Virginia State Historic Preservation Officer, and the Virginia Department of Transportation Regarding Transportation Undertakings Subject to Section 106 of the National Historic Preservation Act.

G. The Design-Builder shall consider historic properties to be design constraints and avoid impacting them beyond what is shown on the RFP Conceptual Plans. In addition, the Design-Builder shall notify the Department in advance of any other project-related activities, including but not limited to staging, borrow/disposal, and any temporary or permanent easements, proposed to be located on or within the viewshed of historic properties. These activities, any changes to the design, alignment, right-of-way limits, or easements, shown on the RFP Conceptual Plans, or any additions to the Project such as stormwater management facilities, wetland mitigation sites, or noise barriers, require cultural resources review by the Department and could require additional cultural resources studies and/or coordination with the VA SHPO. The Design-Builder is responsible for conducting all cultural resources studies necessitated by these activities and proposed changes or additions, in accordance with the Secretary of the Interior’s Standards and Guidelines for Archeology and Historic Preservation, and the Virginia Department of Historic Resources’ most current Guidelines for Conducting Survey in Virginia, while the Department is responsible for coordinating both the studies and these activities and proposed changes or additions with the VA SHPO. The Design-Builder shall then carry out any additional cultural resources commitments that result from such coordination at its sole expense and at no additional cost to the Project.

5.3.3. Section 4(f)

A. The FHWA has made a *de minimis* impact finding for the following 4(f) Resources:

<table>
<thead>
<tr>
<th>Section 4(f) Resource</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battle of Hampton Roads</td>
<td>164 acres—<em>de minimis</em></td>
</tr>
<tr>
<td>Battle of Sewell’s Point</td>
<td>137 acres—<em>de minimis</em></td>
</tr>
</tbody>
</table>

B. FHWA’s *de minimis* impact finding is based upon the conclusion that there is no feasible and prudent alternative to the use of land from Section 4(f) resources, and that the Project as currently designed includes all possible planning to minimize harm resulting from the use of these resources. These findings are also based on the planning level Limits of Disturbance illustrated in the Final SEIS which avoids the use of the following Section 4(f) resources:
- Hampton Institute Historic District including Hampton Institute National Historic Landmark
- Phoebus-Mill Creek Terrace Neighborhood Historic District
- Willoughby Boat Ramp
- Norfolk Naval Base Historic District

C. The Design-Builder shall ensure that their final design incorporates the specified minimization and mitigation measures, and is consistent with the *de minimis* impact finding. Appendix B of the Final SEIS includes mapping showing the location of 4(f) resources are included in the RFP Information Package.

D. The Design-Builder shall consider 4(f) resources to be design constraints and avoid any impacts to them beyond the acres of use identified in this section. In addition, the Design-Builder shall avoid any other project-related activities on these resources, including but not limited to staging, borrow/disposal, and temporary or permanent easements.

E. Any changes to the right-of-way or easements as shown on the RFP Conceptual Plans, proposed by the Design-Builder and acceptable to the Department, may require additional technical studies and analysis to be performed by the Design-Builder. The Design-Builder shall be responsible for notifying the Department of plan revisions, right-of-way/easement changes, and providing any necessary studies and other necessary information to support the Department’s completion and re-evaluation of the 4(f) *de minimis* impact finding. The Department shall be responsible for the coordination of any 4(f) documentation with FHWA. The Design-Builder shall then carry out any additional commitments that result from such coordination at its sole expense and with no time delays to the Project.

5.3.4. **Section 6(f) Resources**

A. No use of Section 6(f) resources is anticipated. These findings are based on the planning level Limits of Disturbance illustrated in the Final SEIS which avoids the use of the following Section 6(f) resources:

- Willoughby Boat Ramp

5.3.5. **Water Quality Permits and Compensatory Mitigation**

A. Wetlands and Waters of the U.S. were originally assessed through photointerpretation as part of the development of the Final SEIS. A wetland delineation was performed from March through April 2017 with a Preliminary Jurisdictional Determination (PJD) prepared by the USACE on September 19, 2017. Based on the information provided in the Final SEIS, wetland delineation, PJD and conceptual design, approximately □□□□ acres of tidal wetlands, □□□□ acres of non-tidal wetlands and □□□□ acres of tidal waters (including □□□□ acres of shallow water habitat) are anticipated to be impacted by the Project.

B. The Design-Builder is responsible for obtaining all water quality permits required to construct the Project (including utility relocations by the Design-Builder). The Design-Builder shall be the Permittee. The Design-Builder shall review information provided as part of the PJD and conceptual impact quantities to wetlands and Waters of the U.S. to develop final impact quantities and permit impact sketches based on their final design. The Design-Builder shall also determine the required sequencing methodology to limit Project impacts to wetlands and Water of the U.S. The Design-Builder shall utilize this information to obtain required permits. Should the Design-Builder propose design changes acceptable to the
Department, permitting requirements may also change; the Design-Builder remains responsible for obtaining any and all necessary water quality permits and permit modifications required by the regulatory agencies. Any informational needs the USACE may require as part of water quality permit issuance will be the sole responsibility of the Design-Builder.

C. If the Design-Builder determines that wetlands and/or stream mitigation is required to secure the permit authorization, the Design-Builder shall provide the required compensatory mitigation. The Offeror shall account for all costs associated with water quality permit acquisition, as well as compensatory mitigation, in the Price Proposal.

D. The Design-Builder shall ensure that Project schedules accommodate any Special Provisions, Time of Year Restrictions (TOYR), and the duration of permit acquisition from the regulatory agencies. The Design-Builder shall be responsible for adhering to permit conditions and Special Provisions, as identified in the permit authorizations including but not limited to TOYR, avoidance and minimization recommendations, restoration of temporary impact areas, and countersinking culverts.

E. The Design-Builder shall be responsible for compliance with pre-construction, construction, as well as post-construction monitoring if required by regulatory agencies. This shall include costs associated with acquiring water quality permits and additional compensatory mitigation for the Project if needed.

F. The Design-Builder shall provide to the Department copies of all permits, documentation, and correspondence with regulatory agencies. Construction activities shall not impact regulated areas within the Project limits until all applicable water quality permits have been issued to the Design-Builder. The Design-Builder shall not proceed with work covered by the water quality permits until the Department releases the work in writing. The Department may release a portion or all of such work not in jurisdictional areas, but may order a suspension of the same work after its release. The Design-Builder shall not be allowed to begin work that pre-determines the work required in the jurisdictional areas until the permits are secured.

G. After receiving the Department’s release of the work, the Design-Builder shall notify the Department and the regulatory permitting agencies in writing fourteen (14) days prior to beginning work in the jurisdictional areas covered by the water quality permits.

H. The Design-Builder shall carry out any additional permit conditions/commitments that result from change in footprint and/or scope (assuming it is approved by the Department) and shall be responsible for any schedule delays and additional costs.

I. At the conclusion of the Project, the Design-Builder shall notify the Department and the regulatory permitting agencies in writing of the completion of the work in the jurisdictional areas covered by the water quality permits. At the completion of the Project, the Design-Builder is required to transfer any Virginia Marine Resources Commission (VMRC) permit back to the Department.

J. All permitted construction activities shall be identified as hold points in the Design-Builder’s Critical Path Method (CPM) Schedule.

5.3.6 Threatened and Endangered Species

A. The Department has performed preliminary database reviews to determine the Project’s potential effects on threatened and endangered (T&E) species, indicating that the Project may affect T&E species.
B. The FSEIS and Natural Resources Technical Report have identified the following federally listed resources as potentially occurring in the project area and therefore potentially impacted by the project: Atlantic sturgeon, critical habitat, and other anadromous species; Essential Fish Habitat (EFH); listed sea turtles; Wilson’s plover, gull-billed tern, piping plover, red knot, and northern long-eared bat (NLEB). The following state-listed resources were also identified as potentially occurring in the project area and therefore potentially impacted by the project: Mabee’s salamander, Canebrake rattlesnake, tricolored bat, and little brown bat, benthic species, and submerged aquatic vegetation (SAV). Lastly, sensitive colonial nesting waterbird species are known to occur in the project area. The Design-Builder shall carry out any additional coordination with federal and state permitting and resource agencies to resolve these issues as needed.

1. Listed Bats

The Design-Builder shall follow the Final 4(d) Rule for the NLEB and shall coordinate with the USFWS Virginia Field Office during Endangered Species Act (ESA) Section 7 consultation for potential impacts to this species. If NLEB maternity roosts occur within the project vicinity, the Design-Builder shall follow the Time-of-Year-Restriction (TOYR) for tree removal per the Final 4(d) Rule for NLEB. In addition, if little brown bat or tricolored bat maternity roosts are known to occur within the project vicinity, the Design-Builder shall implement the TOYR for tree removal during the construction season for these species as well.

The Department conducted a bridge inventory in June 2017 and found no evidence of bats roosting on the approach bridges. The Design-Builder shall conduct an initial bridge inventory for visual presence of roosting bats and shall conduct subsequent inventories annually, until the commencement of construction activities on the bridge. Once construction has commenced, no additional inventories are required. Inspections shall follow the VDOT Bat Inventory Guidelines for Bridges and shall be documented on the Bat Inventory Form contained in the guidelines. A copy of the completed form shall be provided to the Department and the District Environmental Manager within two (2) business days of completing the inspections and no less than two (2) business days prior to beginning work. The Bat Inventory Guidelines, Inventory forms, and Bat Special Provision Copy Note are included in the RFP Information Package.

If bats are observed roosting on bridges, the Design-Builder shall follow the notification requirements provided in the Special Provision Copy Note. The Department, at its sole discretion, may permit the Design-Builder to work in other areas of the bridge that are a span away from the location where bats are observed. No additional payment shall be made for delays due to any observation of bats and resultant limitation of operations imposed by the regulatory agencies.

As an alternative to conducting the bridge inspection for bats as described above, the Design-Builder along with the Department may choose to coordinate with the USFWS and the Virginia Department of Game and Inland Fisheries (VDGIF) to determine if appropriate exclusionary devices can be used to exclude bats from roosting on the existing bridges during the project. Exclusionary devices shall only be used with the prior approval of the USFWS and the VDGIF and installation shall be within the timeframes prescribed by these agencies. The Design-Builder shall provide notification to the Project Manager and the District Environmental Manager of the intent to utilize this alternative approach prior to initiating coordination efforts with the USFWS and the VDGIF.
No additional payment shall be made for the coordination for, or installation of, bat exclusionary devices.

2. Atlantic Sturgeon and Critical Habitat

The Selected Action falls within Atlantic sturgeon range and designated critical habitat. The Department anticipates this project will require an individual, formal Section 7 consultation with NMFS for this species and other federally-listed species. To the extent practicable, the Design-Builder shall consider implementing the Project Design Criteria outlined in Section 5.0 of FHWA’s *Transportation Projects, Design Criteria, and Procedures for Authorization under a Programmatic Determination of Not Likely to Adversely Affect Select ESA-Listed Species in the Greater Atlantic Region* (Feb 2018) or more current version. The Project Design Criteria identified above were created to represent high-level, best design practices to avoid and minimize impacts to Atlantic sturgeon and other NOAA trust resources.

3. Essential Fish Habitat

The Department anticipates that the Design-Builder will jointly incorporate the project’s consultation for EFH and Section 7 consultation with NMFS into one joint consultation. The Design-Builder shall implement the construction impact avoidance and minimization measures to EFH outlined in the FEIS Mitigation section for EFH.

4. Anadromous Fish and Marine Mammals

The Department anticipates that the Design-Builder’s consultation with NOAA Fisheries will jointly cover all NOAA trustee resources including those resources offered protection under ESA Section 7, the Magnuson-Stevens Fishery Conservation and Management Act and Marine Mammal Protection Act (MMPA) that NOAA Fisheries also implements. As part of the project’s permit package submittal to NOAA Fisheries, the Design-Builder shall consider the need for an Incidental Harassment Authorization (IHA) for pile driving activities and potential impacts to marine mammals and other NOAA trust resources based on the proposed design and construction sequencing. The Design-Builder shall implement the construction impact avoidance and minimization measures to avoid and minimize impacts to anadromous fish, loggerhead sea turtle, green sea turtle, Kemp’s Ridley Sea Turtle, and Leatherback sea turtle outlined in the FSEIS Mitigation section for anadromous fish.

5. Benthic Species

The Design-Builder shall implement the construction impact avoid and minimize to reduce turbidity during construction as outlined in the FSEIS Mitigation section for benthic species.

6. Submerged Aquatic Vegetation

The Design-Builder shall implement the construction impact avoidance and minimization measures to avoid and minimize impacts to SAV outlined in the FSEIS Mitigation section for SAV and further discussed in the May 23, 2017 agency meeting notes.

7. Colonial Nesting Birds

The Design-Builder shall implement the following measures at the South Island:

a. Maintain all South Island paved areas in the condition at contract award. Implement any Department-identified corrective actions/ pavement maintenance needs prior to each nesting season to further discourage inhabitation by nesting birds.
b. Continue to implement corrective actions/pavement maintenance needs as identified by the Design-Builder and/or the Department prior to subsequent nesting seasons.

c. Develop and implement training for the Department’s South Island facility staff on bird management and site paving, operations, and maintenance needs at least two years prior to the completion of construction.

d. Maintain and properly adjust the passive hazing measures described in the Design-Builder’s Environmental Management Plan (see [●]). This will include an annual meeting with the Department at the end of each nesting season to discuss the previous season and future adjustments for the following season.

C. The Offeror shall be advised that new and updated T&E information is continually added to agency databases. The Design-Builder shall obtain a current Official Species List from US Fish and Wildlife Service USFWS IPAC and maintain a current list of at least 6 months throughout the NEPA re-evaluation and endangered species permitting. The Design-Builder shall also obtain a current Official Species List from NOAA Fisheries from the Greater Atlantic Region Field Office. The Design-Builder shall be responsible for any subsequent coordination to obtain updated information, requirements, and clearances from environmental regulatory agencies that provide threatened and endangered species oversight. The Design-Builder shall copy the Department’s Project Environmental Manager on any submittals requesting concurrence from USFWS on ESA Section 7 effect determinations of federally-listed species. This additional T&E species coordination is also a standard component of the water quality permit acquisition process and may result in permit conditions for which the Design-Builder shall be responsible. The Design-Builder is responsible for ensuring that all T&E species are correctly identified and impacts assessed, noting that more or less resources may be present than initially identified. Avoidance and minimization measures shall be implemented to the greatest extent possible. The Design-Builder shall provide to the Department copies of all documentation and correspondence with regulatory agencies.

5.3.7. Hazardous Materials

A. The Department has performed studies to determine the potential for hazardous materials and/or contamination within the Project area including:

- Sampling and Analysis Report for Sediments
- Environmental Corridor Study, Hampton Landside
- Environmental Corridor Study, Norfolk Landside

B. The Sampling and Analysis Report for Sediments, dated [●], provides preliminary data to assist the Design-Builder in considering management options for sediment/dredge spoils, including ocean disposal, upland disposal and/or landfill disposal. The Design-Builder may consider, but is not limited to, these options or others including a beneficial reuse such as beach nourishment/ restoration. The Design-Builder shall be responsible for the completion of all requirements and obtaining approvals associated with dredging/sediment management activities for the Project. These potentially include, but are not limited to the following:

- Management, sampling/testing (including sampling/testing plans, determinations of adequate characterization and dredge unit evaluations, test parameters including physical, chemical and ecotoxicological tests and test frequency);
- Permitting/regulatory approvals;
- Treatment/remediation;
• Handling, storage, containment/controls; and
• Monitoring, removal, transport and/or disposal.

These requirements apply to all dredge/sediment removal areas for the project including, but not limited to, any tunnel or island construction, access dredging and/or disposal sites. The Design-Builder shall specify in detail the sediment/dredge material management procedures and disposal site(s) in the Environmental Management Plan. Reports and other information pertaining to these studies are included in the RFP Information Package and constitute Known Pre-existing Hazardous Materials as defined in [Part 4, Article 4].

In addition, the Design-Builder shall comply with the following documents:

1. VDOT Special Provision for Phase I and Phase II Environmental Site Assessments for Design-Build Projects – June 25, 2013
2. VDOT Special Provision for Inspection of Structures for Asbestos Containing Materials (ACM) on Design-Build Projects – June 22, 2009
3. VDOT Special Provision Copied Note – Demolition Notification for Structures not Requiring Asbestos Removal
4. VDOT Special Provision for Asbestos Removal and NESHAP-Related Demolition Requirements for Structures on Design-Build Projects – June 22, 2009
5. VDOT Asbestos Project Monitoring and Clearance Air Monitoring Procedures
6. VDOT Special Provision for Asbestos-Containing Soil – February 2, 2000
7. VDOT Special Provision for Removal or Connection of Asbestos Cement Pipe – November 7, 2005
8. VDOT Asbestos Inspection Procedures

C. The Design-Builder shall manage solid waste, hazardous waste, and hazardous materials and any uncontaminated project generated media (soils, sediments, groundwater and surface water) in accordance with all applicable federal and state environmental regulations and shall implement good housekeeping, waste minimization and pollution prevention practices.

D. Unless a structure has been otherwise classified, the Design-Builder shall assume all coated structures are Type B.

E. The Design-Builder shall perform asbestos inspections on all structures (including bridge structures) and, as applicable, perform asbestos abatement, abatement monitoring, notifications and demolition in accordance with Department procedures and specifications. Prior to demolition, asbestos abatement shall be performed for all structures found to contain regulated asbestos materials (RACM) and non-RACM that is expected to become friable (i.e. RACM) during the course of demolition The Design-Builder shall make all appropriate abatement and demolition notifications as required by Federal and State regulations.

F. Asbestos inspection, abatement and project monitoring shall be performed by individuals and firms with current licenses by the Virginia Department of Professional and Occupational Regulation. Asbestos abatements shall not be performed by an asbestos contractor who has an employee/employer relationship with, or financial interest in, the laboratory utilized for asbestos sample analysis nor shall the asbestos contractor have an employee/employer relationship with, or financial interest in, the asbestos inspector and project designer working
on the Project. Copies of all asbestos inspection, monitoring and disposal records shall be provided to the Department.

G. For any asbestos waste and other non-hazardous waste, the Design-Builder shall have the signatory responsibility for the waste shipping manifest(s) and/or bill(s) of lading. For Resource Conservation and Recovery Act (RCRA) hazardous waste, the Design-Builder shall be considered the co-generator and shall be responsible for preparing the hazardous waste shipping manifest(s) for the Department representative’s signature and as otherwise consistent with the signatory requirement under Section 411 of the VDOT Road and Bridge Specifications.

H. The Design-Builder shall be responsible for the development of a Spill Prevention, Control, and Countermeasures (SPCC) Plan as required by regulation and for submission of any required plan to the Department prior to start of construction. In the event of spills or releases of petroleum products and other chemicals/hazardous liquids or solid materials, the Design-Builder shall take immediate action to contain and eliminate the spill release, including the deployment of environmental protection measures to prevent the migration of the spill into the waters of the United States and of worker exposure protection measures. The Design-Builder shall notify the Department immediately of all instances involving the spill, discharge, dumping or any other releases or discovery of hazardous materials into the environment and shall provide all required notifications and response actions.

I. The Design-Builder shall not acquire property or property interests (including total or partial takes; or permanent easements) until the Design-Builder completes a Phase I Environmental Site Assessment (ESA) that meets the requirements of ASTM E1527. The Phase I ESA report shall provide any recommendations for a Phase II ESA and shall be provided to the Department for review and concurrence. Following such concurrence, the Design-Builder shall perform the Phase II ESA and provide the report of findings and any recommendations for remediation/mitigation to the Department for review and concurrence prior to property acquisition. This shall represent a hold point in the Design-Builder’s CPM Schedule.

J. The Contract Price shall include all costs associated with complying with the above listed requirements, except that asbestos abatement and abatement monitoring, Phase II ESAs and Corrective Actions for Unknown Pre-Existing Hazardous Materials shall be addressed in accordance with [Article 9 of Part 4 (General Conditions of Contract)].

5.3.8. Air Quality

A. The Project has been assessed for potential air quality impacts and conformity with all applicable Federal and state air quality regulations and requirements. The Air Quality Analysis Report, dated July 2016, is provided in the RFP Information Package. The Report identifies federal and state regulatory requirements that shall be adhered to during construction of the project.

B. This project is located in an area that is currently in Attainment with the National Ambient Air Quality Standards (NAAQS), and in a volatile organic compounds (VOC) and nitrogen oxides (NOx) Emissions Control Area. As such, all reasonable precautions should be taken to limit the emissions of VOC and NOx during construction of the project. In addition, the following VDEQ air pollution regulations shall be adhered to during the construction of this project: 9 VAC 5-130-10 et seq., Open Burning restrictions; 9 VAC 5-45-760 et seq., Cutback Asphalt restrictions; and 9 VAC 5-50-60 et seq., Fugitive Dust precautions. The Design-Builder shall adhere to the limitations outlined in Special Provision 107E for Volatile Organic Compound Emissions Control Areas.
C. Construction activities shall be performed in compliance with all applicable local, state, and federal air quality regulations, as stipulated in VDOT’s Road and Bridge Specifications.

5.3.9. Noise Mitigation

A. A preliminary noise analysis was completed by the Department during NEPA, and a Final Design Noise Analysis shall be completed by the Design-Builder during final design. It was determined from the preliminary noise evaluation that mitigation measures are required for the Project. However, noise abatement measures that were found to be feasible and reasonable during the preliminary noise analysis may not be found to be feasible and reasonable during the Final Design Noise Analysis. Conversely, noise barriers that were not considered feasible and reasonable may meet the established criteria and be recommended for construction. A copy of the Hampton Roads Crossing Study SEIS Noise Analysis Technical Report, June 2016, is included in the RFP Information Package.

B. A Final Design Noise Analysis shall be submitted to the Department for review and approval. The Final Design Noise Analysis shall consist of a re-analysis of all noise sensitive receptors in the project area to confirm whether noise mitigation is required.

C. Noise Barriers as shown in the Preliminary Noise Analysis, shall be utilized for proposal preparation purposes. As shown in Table 6-2 of the Preliminary Noise Analysis, a total of [935,887 square feet] of noise barrier shall be assumed for proposal purposes. The noise barrier square foot shall be measured from the finished grade to the sound attenuation line as described in Section 519.04 of VDOT’s Road and Bridge Specifications.

D. If the results of the Final Design Noise Analysis dictate, the Design-Builder shall provide permanent noise mitigation in compliance with the Virginia State Noise Abatement Policy, the Highway Traffic Noise Impact Analysis Guidance Manual (February 2018), FHWA’s Highway Traffic Noise Analysis and Abatement Guidance (December 2011), the VDOT Noise Report Development and Guidance Document Version 5, Special Provision for Sound Barrier Walls, and the Soil Design Parameters for Sound Barrier Walls, Retaining Walls and Non-Critical Slopes, and the VDOT Road Design Manual (updated January 2016). Based on results of the Final Design Noise Analysis, one of the following scenarios will occur:

1. If the Final Design Noise Analysis indicates additional noise barrier square footage is required in excess of the Offeror’s Proposal that’s not due to changes in plan and profile as part of the Design-Builder’s final design, the Department shall compensate the Design-Builder for the material and installation costs associated with any additional square footage above what was proposed.

2. If the Final Design Noise Analysis indicates a reduction of noise barrier square footage than that provided in the Offeror’s Proposal regardless of any design changes, the Design-Builder shall credit the Department for the material and installation costs associated with the square footage reduction.

3. If the Final Design Noise Analysis warrants noise barriers but some or all the barriers are not desired by the public, the Design-Builder shall credit the Department for the material and installation costs associated with the square footage reduction.

E. The Design-Builder shall not deviate from the Department’s noise barrier policy, guidance, or special provisions without allowance granted in this document or prior written approval from the Department.

F. The final barrier location(s) and dimension(s) will be determined during the Final Design Noise Analysis. A draft Final Design Noise Analysis Report shall be submitted for review.
and approved prior to the submittal of the final report. The Final Design Noise Analysis shall be conducted by an individual qualified in the field of highway traffic noise impact analysis as noted in Section 3.0 of the Highway Traffic Noise Analysis and Abatement Guidance Manual. The Final Design Noise Analysis shall be furnished by the Design-Builder at its sole cost and expense. The Design-Builder shall be responsible for developing the Environmental Traffic Data (ENTRADA) for the Final Design Noise Analysis based on the project’s final design.

G. Upon approval of the Final Design Noise Analysis the Department shall prepare a concurrence letter outlining the results of the analysis for the Department’s Chief Engineer and FHWA. Once concurrence is achieved the Design-Builder shall prepare and mail letters “certified return receipt” to benefitted receptors to ascertain the desire to have noise barriers constructed as part of the project. Upon completion of the citizen survey the Department shall prepare a second concurrence letter documenting the results, if necessary. All noise barriers shall be named as presented within the Final Design Noise Analysis.

H. The aesthetic treatment (e.g. color, surface treatment) of noise barriers constructed adjacent to any of the following five historic properties is subject to the outcome of consultation between the Department and the VA SHPO, local government, and property owner/representative: Hampton Institute Historic District, Pasture Point Historic District, Hampton National Cemetery (Phoebus Section), Phoebus-Mill Creek Terrace Neighborhood Historic District, and Norfolk Naval Base Historic District (see Section 5.3.2 of this Technical Requirement).

I. All noise barriers recommended for construction and concurred with by the Chief Engineer and FHWA are included in the scope of the Construction Project and shall be funded by the Design-Builder at its sole cost and expense. This includes barriers with conditions, as long as those conditions have been met.

J. Prior to submitting a noise barrier plan for the Department’s review, the Design-Builder shall have the noise consultant that completed the Final Design Noise Analysis review the plan set and certify that the proposed design meets the noise abatement requirements. This certification shall be included in the plan set when it is submitted to the Department for review.

K. If deviations in the horizontal or vertical alignment of a noise barrier (or the roadway alignment) are proposed following concurrence from the Chief Engineer or FHWA, then additional noise analysis shall be provided to the Department for review and approval prior to construction. This shall include a plan and profile view of the roadway with the recommended barrier alignments and the proposed design. A justification of any deviation shall be included with the plan set. The revised Final Design Noise Analysis chapter for the noise barrier for which modification is requested shall be submitted with this additional information.

L. A key plan shall be clearly labeled to show the location of any ground-mounted combo barriers (sound barriers on retaining walls) and bridge-mounted noise barriers. Plan view will provide the alignment of the noise barrier with the roadway plan view. Profiles of the wall alignment will include the noise attenuation line and the existing and proposed elevation. If combo barriers or bridge-mounted barriers are present along the alignment, the pattern of the line will be different so that all lines can be distinguished. Stations of the roadway and noise barrier will be included on both the plan and profile views.

M. Access shall be provided by access doors for Department maintenance personnel. Sound barrier wall design shall also be coordinated with first responders to ensure access to fire
hydrants and other emergency equipment. In lieu of access doors, gaps may be provided in the walls with a minimum 3:1 ratio of barrier overlap.

N. The Design-Builder shall begin construction of new sound barrier walls within sixty (60) days of the start of demolition of an existing sound barrier wall or cutting of trees whichever occurs first, unless otherwise approved by the Department. The Design-Builder shall complete construction of any new sound barrier wall intended to replace an existing sound barrier wall or trees which were acting as a screen for adjacent properties within 240 days from the start of demolition of the existing sound barrier wall or cutting of trees, whichever occurs first, unless otherwise approved by the Department.

5.4. Environmental Compliance

A. The Design-Builder is responsible for compliance with all applicable state and federal environmental laws, regulations, and permits. If, at any time, the Design-Builder is not in compliance with all applicable environmental laws, regulations, Executive Orders, commitments, etc., the Department has the authority to suspend work, in whole or in part, until such time as the deficiencies or non-compliant items have been corrected. Should any non-compliant item(s) be identified during construction, immediate and continuous corrective action shall be taken by the Design-Builder to bring the item(s) back into compliance. The Design-Builder shall notify the Department immediately of all non-compliant item(s) and shall provide to the Department copies of all documentation and correspondence with regulatory agencies related to non-compliant item(s) and their resolution, concurrent with each submission.

B. The Design-Builder shall be responsible for any schedule delays and associated costs as a result of any delays and/or shut downs associated with non-compliance. Any monetary fines associated with violations and/or any environmental restoration activities required to resolve violations and other non-compliance issues are the responsibility of the Design-Builder.

C. The Design-Builder shall carry out environmental commitments during design and construction, as applicable, as identified in the Final SEIS and ROD; the final Document Re-evaluations for RW Authorization (EQ-201) and PS&E Authorization (EQ-200); and the final Environmental Certification/Commitments Checklist (EQ-103). All commitment compliance shall be supported by appropriate documentation, to be provided by the Design-Builder to the Department.

D. The Design-Builder shall be responsible for compliance with pre-construction and construction-related environmental commitments and permit conditions. The Design-Builder shall assume all obligations and costs incurred by complying with the terms and conditions of the permits and certifications. Any fines associated with environmental permit or regulatory violations shall be the responsibility of the Design-Builder.

5.5. Deliverables

At a minimum, the deliverables shall include the items listed in Table 5.5-1 for the Department’s consultation and written comment. All submittals shall be accompanied by appropriate level of analysis calculations to justify all engineering decisions made. The Department reserves the right to reject incomplete submittals.
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Appendix A5-1 – Protection of Emancipation Oak

A5-1.1 General

A. The Emancipation Oak is located on Hampton University property and is a contributing element of the Hampton Institute Historic District and Hampton Institute National Historic Landmark.

B. No vehicle or equipment traffic, clearing or grubbing, or any ancillary construction activities (including, but not limited to, stockpiling or staging) are allowed within the boundaries of the Tree Limit of Disturbance depicted in Attachment 7 to the Programmatic Agreement Among the Federal Highway Administration, the Virginia State Historic Preservation Officer, and the Virginia Department of Transportation Regarding the Hampton Roads Crossing Study, Cities of Hampton and Norfolk, Virginia (executed April 11, 2017). Along the I-64 eastbound entrance ramp at Exit 267 – US 60/VA 143 Settlers Landing Road, the Tree Limit of Disturbance runs along an existing chain link fence immediately north of a row of loblolly pine trees. For the purpose of ensuring that the Tree Limit of Disturbance is not crossed, the Design-Builder shall erect a safety fence along the chain link fence before initiating any construction activities in Hampton and shall maintain the safety fence in good condition for the duration of Project construction.

C. Design-Builder shall not access Hampton University property without prior University approval.

A5-1.2 Materials

A. Safety fence shall be no less than four feet high, colored bright orange polyethylene web with the following requirements:
   • Tensile yield – ASTM D638; Average 2000 lbs. per 4-foot width
   • Ultimate tensile strength – ASTM S 638; Average 2900 lbs. per 4-foot width
   • Elongation at break (%) – Greater than 1000%

A5-1.3 Procedures

A. Design-Builder shall erect safety fence along the chain link fence that runs along the I-64 eastbound entrance ramp at Exit 267 – US 60/VA 143 Settlers Landing Road. The Design-Builder shall install the fence on metal “T” or “U” posts spaced on 6-foot centers driven to a minimum depth of 18 inches. The Design-Builder shall maintain the safety fence until Final Acceptance and shall then remove the safety fence and dispose of it off the project site.

B. Design-Builder shall notify the Department immediately in the event of any encroachment by the Design-Builder or his agents into the Tree Limit of Disturbance. The Design-Builder shall be held liable for any damage to parcel within the Tree Limit of Disturbance or the Emancipation Oak caused by the Design-Builder or his agents during construction of the Project.
SECTION 6. DELIVERABLES & DOCUMENT CONTROL

6.1. Scope
This Section of these Technical Requirements provides a list of required deliverables that need to be included in the Design-Builder's work plan and schedule development identified in Section 2 Project Management of these Technical Requirements. Table 6-4-1 Deliverables is not an all-inclusive list and does not include the required permit submittals, design drawings, calculations and specifications, third-party documents and typical construction related submittals required before and during construction. It is the Design-Builder’s responsibility to develop the required deliverables to achieve Department and Third Party/Permit approval.

6.2. References
Refer to Section 4 Standards

6.3. Requirements
Not Applicable

6.4. Deliverables
At a minimum, the deliverables shall include the items listed in Table 6.4-1 for the Department’s review, provision of comments and if applicable, approval.

Table 6.4-1 Deliverables

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**Section 33 – Demolition**

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<td>Testing Plan</td>
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6.5. Document Control System (DCS)

I. Description:

This project will use a Document Control System (DCS) for managing, tracking and controlling all transmittals, submittals, design drawings, reports, correspondence and other pertinent project documents including, but not limited to Civil Rights Compliance documentation. The DCS will be Kinsman Group (formally CADAC Organice); a hosted (internet based) software package developed by Kinsman Group. DCS access will be provided by the Department at no cost to the Design-Builder. The Design-Builder shall prepare, transmit, electronically file, and status all project documentation, including, but not limited to, Drawings (plans), project correspondence, Shop Drawings, Submittals, Schedules, Pay Requests, Letters, Requests for Information, and meeting minutes using the DCS. The DCS will also provide uniform project information and reporting. The Design-Builder shall access the DCS via the internet.

The DCS is being used to ensure timely processing of all contract documentation in coordination with the contract Progress Schedule.

All information residing on the shared Document Control System (DCS) shall become the sole property of the Department.

II. Document Control Personnel:

The Design-Builder shall furnish the services of one or more of their employees to act as Document Control Specialist(s), who will ensure that the Design-Builder and all other parties as designated by the Department’s Project Manager prepare, status, electronically file, and transmit all project plans, correspondence, shop drawings, submittals, Requests for Information (RFI), meeting minutes and other project related documents having importance or action for the Department using the Document Control System (DCS) provided by the Department or its agents.

When more than one person is assigned to perform the Document Control Specialist role, one person shall be designated as the Document Control Manager who shall be responsible for coordinating the work of the Document Control Specialists; shall be knowledgeable of the status of all contract documentation throughout the duration of the contract; and shall act as the DCS contact person for the Design-Builder.
The Document Control Manager shall be responsible for maintaining information related to the responsibility, status, elapsed time since submission, held time, and all submittal revision histories.

Training for the DCS will be provided by the Department at no cost to the Design-Builder.

III. Documentation Control System Access Requirements:

After the Notice to Proceed (NTP) Date, the Design-Builder shall submit a request to the Department’s Project Manager for access to the DCS, requesting the Department establish and authorize a user account for the employee(s) designated as the Document Control Specialist(s) and Document Control Manager. The Department’s Project Manager may allow Design-Builder personnel including, but not limited to, design staff, construction staff, inspection staff, or subcontractors; to access the DCS at his/her sole discretion.

The Design-Builder must adhere to the Department standards for handling CII/SSI documentation. Critical Infrastructure Information (CII) is the designation to identify information that is not appropriate for public release without a need-to-know. Sensitive Security Information (SSI) is the designation used to identify information related to maritime critical infrastructure that is not appropriate for public release without a need-to-know. The DCS is recognized as a secure electronic means of transfer.

The Department will issue a user ID and password to each of the authorized Design-Builder personnel for access to the DCS upon successful completion of the two forms, ITD-35E and ITD-36E. The Design-Builder shall ensure that only Department Authorized Design-Builder personnel access and use the DCS in a responsible manner. The Design-Builder shall prevent the disclosure or sharing of access information (usernames and passwords) to prevent unauthorized use of the DCS.

The Department may revoke any users’ access authorization if it is determined that:

a) the user has used the DCS for any other reason than is intended by this specification;
b) the user is no longer the Design-Builder’s employee or associated with the project; or
c) the user has disclosed their access information for use by another person or party.

IV. Documentation Requirements:

The Design-Builder shall use the Document Control System after the NTP Date through the Final Completion and Acceptance process. All written and electronic project related correspondence within the Design-Builder’s organization and from the Design-Builder to the Department or the Department’s representatives (e.g., the VDOT Project Manager(s)) shall be transmitted and controlled using the DCS, including, but not limited to: design reviews, constructability reviews, construction reviews, plans, transmittals, meeting minutes, design documents/requests for approval, Requests for Information (RFI’s), Shop Drawings, Schedule files, field memos, notices, letters, and punch lists, Civil Rights Compliance documentation. All common correspondence files (submittals, requests, responses, changes, reports, minutes, agendas, letters, etc.) shall be stored in the DCS. The Design-Builder shall coordinate the overall
creation and submission of all project documentation to meet the requirements of the project schedule and specifications, along with facilitating the Department’s reviews.

DCS use will be complimentary to hard copy submission requirements and will not supersede or invalidate any submission requirement. When a signed hard copy original submittal is required, a scanned copy shall be added to the DCS. Documents related to the project (letters, logs, drawings, sketches, etc.) to be transmitted within the Design-Builder’s organization and to the Department by the Design-Builder, not available electronically, shall be scanned, converted into an Adobe Acrobat PDF format, and submitted accordingly. Documents shall be submitted with Optical Character Recognition (OCR) turned on. Files shall be names in searchable and retrievable fashion.

All Correspondences between the Department and Design-Builder shall be transmitted through the DCS. Submissions must follow the VDOT CADD Standards, Falcon and/or RUMS requirements. Reports that are resubmitted shall contain a redlined or track changed copy as well as the final clean copy for review. DGN’s, CADD modeling or other working/live copies may be requested in their original format.

The Design-Builder and the Department may still utilize email for general project correspondence during the project; however, final copies of all project related email threads that including official notifications, transmittals, or decisions shall be posted to the DCS upon completion of the correspondence aforementioned thread by the Design-Builder.

The DCS is not a substitute for the Design-Builder’s 48 CFR 31 compliant internal processes and document control.

V. Documentation Control System Availability:

The Document Control System (DCS) shall be available for the Design-Builder’s use at all times unless system maintenance (e.g., backups, upgrades, etc.) is being performed. System maintenance will generally be limited to non-core business hours. If a Design-Builder’s authorized user cannot access the control system, the Department will notify the VDOT Project Manager(s). If the DCS becomes unavailable during normal business hours for an extended period of time, the Design-Builder may issue correspondence requiring immediate attention by the Department or Department’s representative in hard copy format. The hard copy correspondence must be entered into the document control system immediately after it available again. The inability of the Design-Builder to gain access to the DCS for any reason shall not be grounds for claim. The Design-Builder may request alternative submittal protocols for proprietary cost and contract information.

Help Desk and other support services will be provided by Kinsman Group throughout the course of the project.

VI. Computer Requirements:
The Design-Builder shall ensure their authorized Document Control System users have high speed access to the public internet (25 Mbps minimum).

Microsoft Internet Explorer shall be configured on each authorized users’ computer with a Trusted Site address(es) provided by the Department, and appropriate custom Security Privilege settings also provided by the Department. Additionally, it is the Design-Builder’s sole responsibility to maintain a compatible software system. Compatibility is defined as the ability to send and receive all required documents within the DCS in a format viewable by the Department. The Design-Builder must provide to the Department valid email addresses for each authorized user based upon a MAPI-compliant email system, such as Microsoft Outlook or Exchange. The Design-Builder shall ensure that anti-virus software is installed and maintained on any computer accessing the DCS.
SECTION 7. COMMUNICATIONS – PUBLIC AFFAIRS

7.1. Scope

During the design phase of the Project, no later than 90 days after Agreement execution, the Design-Builder shall develop, for the Department approval, the required processes and procedures for media relations and public information in the form of a Public Information and Communications Plan (PICP). The Design-Builder shall develop a Stakeholder Management Plan to incorporate the required processes and procedures for handling affected stakeholders within the Project area.

The Design-Builder shall be responsible for providing a point of contact, email address and phone number for the public to use in calling to request information or express concerns during the project development and delivery. The Department will review, make comment on, and have final approval for all project advertising, marketing, communication, and public outreach material. All information to be released to the public shall be approved by the Department.

During the design and construction phase, the Design-Builder shall operate as a liaison between the Department, Cities of Hampton and Norfolk, and the Design-Builder’s Construction Manager to ensure compliance with applicable local ordinances and provide appropriate notification to affected property owners.

A. As identified in Appendix 7.1; and
B. All applicable Federal, State and local Laws.

7.2. References

A. VDOT Project Development Manual
B. VDOT Public Information Manual

7.3. Public Outreach

7.3.1. General

A. The Public Information and Communications Plan (PICP) will be presented to the Department for review, comment and approval and will form the basis for all communication activities during the design and construction of the Project. Once approved by the Department, the Design-Builder will perform the Work as detailed in the PICP. At a minimum, the PICP will include a detailed account of the following:

1. Communication plan goals
2. Communication plan objectives
3. Traffic Management Plan (TMP): Information in this plan should include a list of possible alternative routes and detours, formalized chosen alternate routes for each audience, identified infrastructure resources available to assist with project information (i.e. HAR, VMS signs, 511, etc.), and potential project traffic impacts during construction.
4. Identified communication and project challenges
5. Target audiences and key stakeholders: The Stakeholder Management Plan should identify key stakeholders that can help communicate the project messaging throughout different audiences.
6. Communications partners: Communication with elected officials and other High-Level Stakeholders as defined by the Department shall be managed by the Department. Additionally, coordination with local agencies shall be coordinated in conjunction with the Department. Other communications partners should be utilized to communicate consistent messaging for the Project by the Design-Builder, including message coordination with other contractors in the area.

7. Crisis Communications/Risk Management Plan: The plan shall contain a detailed crisis communications plan, including the procedures for coordination with the Department and responsiveness to the media during an emergency. The Design-Builder will develop processes for managing communication surrounding emergency management and recovery operations. The Design-Builder shall provide to Department an emergency contact list of project personnel and response plan to respond to any onsite emergency, including any work zone incidents in accordance with VDOT IIM-241.

8. Communications tools, tactics, and strategies (See 7.3.1.B)

9. Advertising and Marketing Budget: The Design-Builder’s Proposal should be broken down by general line item in an advertising timeline showing estimated media buys during the Project. All advertising and marketing materials will be paid for by the Design-Builder. The advertising and marketing campaign must be approved by the Department, and shall include regular, equal coverage in print media, radio, social media advertising, as well as online/interactive media. Advertising shall be placed in all the above-mentioned mediums to alert the public.

10. Construction beginning/Construction coming to an end
   a. At a minimum, advertising shall run for two weeks to announce the start of construction.
   b. Any changes to traffic patterns during construction, as well as any pertinent detour information
   c. Continuous and pertinent safety messages
   d. HOT/Express Lane education at key milestones, prior to and through implementation of HOT/Express Lanes, in consultation with the Department

11. Action Steps/Deliverables/Time Line
   B. Communications Tools, Tactics and Strategies: The PICP shall provide a detailed outline of communication tools, tactics and strategies to be employed during the Project. These will include, but are not limited to:
      1. Design-Builder must participate in monthly communication coordination meetings with the Department, Cities of Norfolk and Hampton communication teams, starting immediately after Contract execution, continuing through the design and construction phases of the Project.
      2. Community Outreach Efforts/Public Information: The Design-Builder shall establish ongoing mechanisms for stakeholder information and input during construction. They will incorporate a notification program into their PICP to inform motorists and the broader community about expected traffic changes/delays through, at a minimum, the Department’s weekly lane closure report, traffic advisories, and a paid advertising campaign. The advertising campaign shall include regular coverage in print media, radio, social and interactive media. The Design-Builder will maintain a log or database of questions, complaints, and/or comments received from stakeholders and the public either via public outreach efforts or direct contact, along
with dates received, Responses generated, and how/when the issues or concerns are addressed. If appropriate, this list of questions and responses will be posted on the Department’s website.

3. Quarterly newsletter: The Design-Builder shall produce and email a quarterly newsletter to send to affected stakeholders as directed by the Department through both the design and construction phases. A list of affected stakeholders (including, but not limited to, community associations, area civic leagues, churches, business owners, police, fire & rescue, school bus transportation, transit operators) shall be developed by the Design-Builder and submitted to the Department for acceptance within 90 days of the contract. All newsletter content must be approved by the Department.

4. Monthly Project updates: The Design-Builder shall produce a monthly Project update to send to affected stakeholders as directed by the Department through construction using constant contact or a similar email marketing service approved by the Department. All update content must be approved by the Department.

5. Community meetings: The Design-Builder shall host community meetings one month prior to construction start and one month prior to construction end, as well as quarterly meetings with impacted business groups during both the design and construction phases. The Design-Builder should also be prepared to meet with local civic leagues as requested, as well as preparing presentations for the Department staff to present to the local Transportation Planning Organization (TPO) and Hampton Roads Transportation Advisory Committee (HRTAC) when project updates are requested. All presentations must be approved by the Department.

6. Traffic Impacts/Notifications: The Design-Builder will produce traffic advisories for the Department whenever there are new planned impacts to motorists, specifically announcing construction start dates, end dates, implementation of new traffic phase changes, and any additional press releases as deemed necessary by the Department. All information for Traffic Advisories must be submitted at least one week in advance of the traffic impact and must be approved by the Department. If the planned impact is major (changes or additional lane closures that are anticipated to cause traffic delays that exceed existing conditions), the Department must be notified one month in advance.

7. News Media Relations Strategy: The Design-Builder and the Department will ensure close coordination with each other on media outreach activities, issues, and Responses, and will promote consistency with the PICP. The PICP strategy for the Design-Builder will include, but should not be limited to these guidelines:

   a. Adhere to the Department’s media protocols governing responsibilities and reporting in relation to contact with the media, including guidelines for information sharing, policies to promote consistent messages, and procedures specific to managing emergencies and incidents.

   b. Develop and provide to the Department for review, comment and approval a set of media protocols within the Project team, with clearly defined spokespeople and roles.

   c. Proactively build and maintain media relationships, in collaboration with the Department.

   d. Provide timely response (as defined below) to media inquiries and keep the Department informed of media inquiries regarding the Project and the nature of responses that are documented as mutually agreed.

   e. Provide relevant Project information to the media in a timely fashion.
f. Monitor all known media coverage of the Project (stories requiring input from the Design-Builder, involving interviews of the Design-Builder, etc.) and report coverage to the Department by the next business morning (9 a.m.).

g. Provide at least three (3) Business Days to the Department for review of all press releases or other media materials deemed non-Emergency for review and approval before external distribution.

8. Timely responses are defined as follows:
   a. Response to standard media inquiries are to be given within the same working day.
   b. Responses to inquiries during emergencies shall be immediate.

9. Website Strategy: The Design-Builder will provide web site copy to the Department for review and input prior to posting. The web site shall, at a minimum, contain a graphical Project overview, design-builder contact information, plan of Work for the coming month, overall Project Schedule, a frequently asked questions area, and updated Project photos. The web site shall be updated quarterly throughout the duration of the Project. The Project page website will be managed by the Department and incorporated into a previously created standalone website for the Project.

10. Social Media Strategy: The Design-Builder will provide timely (as defined above) and appropriate social media pictures and posts that can be utilized by the Department Communications on the Department social media accounts (currently Twitter, Facebook, YouTube, Flickr, etc.).

11. Project Advertising Strategy: The Design-Builder shall develop a paid advertising and marketing strategy for the Department’s review and approval to ensure they are consistent with both parties’ values, needs, and goals. All public communication on the Project will be undertaken within the framework of a uniform VDOT ‘brand’ to ensure consistency of the marketing and communication across the Project boundaries. This ultimate ‘brand’ identity and its use will be subject to the Department’s review and approval. All costs associated with a paid advertising and marketing strategy are the responsibility of the Design-Builder and must follow the Department’s best practices for implementation and need. The Department has final approval on all advertising for this Project.

12. Collateral Materials: The Design-Builder will develop tailored marketing and communication material for relevant stakeholder groups, including but not limited to the general traveling public, tourism, and trucking industries. They shall provide the Department with advance copies of communications materials for review, comment and approval prior to dissemination. All costs associated with collateral materials are the responsibility of the Design-Builder and must follow the Department’s best practices for implementation and need.

C. Ground Breaking Ceremony: The Design-Builder shall plan for, coordinate and deliver a groundbreaking ceremony to publicize the start of Project construction. Department Communications shall review and have final approval for all ceremony plans, including the invitation list and the invitation content and format. Discussions with the Department to select a date for the ceremony shall begin within seven (7) days following the Date of NTP.

Components of the groundbreaking ceremony for which the Design-Builder is responsible shall include, but are not limited to:

1. A suitable location in or near the Project area that is conducive to visual media coverage and interviews, with suitable parking for the expected crowd.
2. A tent to cover speakers and guests. Minimum size 30’x30’.

3. A public-address system and the necessary electrical power to support it, including a multibox for media plug-ins.

4. An elevated stage no more than 1-foot high, large enough to support chairs for all speakers and the speaker’s lectern.

5. A standalone lectern, to be adorned with a Department-provided Commonwealth of Virginia seal.

6. An American flag with stand and a Commonwealth of Virginia flag with stand for display at event.

7. No fewer than twelve (12) padded chairs for VIPs scheduled to speak.

8. No fewer than one hundred (100) chairs for the audience.

9. An elongated sand pile suitable for the groundbreaking. Size to be coordinated with the Department, suitable for 12 dignitaries to participate in the groundbreaking. At a minimum, pile will be 5 cubic yards.

10. No fewer than twelve (12) pointed shovels of the same size, with shovel heads spray-painted gold. The exact number shall match the number of VIPs (speakers or other VIPs) predetermined to be involved in the groundbreaking.

11. Department-approved hardhats for VIPs participating in groundbreaking.

12. A Project board displaying the Project logo. Minimum size shall be 18”x36”.

13. A program to hand out to attendees that details the event lineup, names and titles of guest speakers and program participants, and a brief description of the Project including a graphic. Assume one hundred (100) color copies will be required.

14. Media outreach, including the issuance of a media advisory, prior to the event to draw media coverage of the ceremony, and follow-up the day of the event with media to ensure receipt of groundbreaking details, including a press release with photos of the event that shall be prepared for release immediately following the event.

15. A bulleted Project fact sheet or FAQ sheet for media the day of the event.

16. Invitations, with directions and an RSVP option, to be sent by email/Evite to the guest list as approved by the Department at least two weeks prior to the event.

17. Water bottles for speakers/VIPs.

18. Event parking signs prominently displayed for parking directions.

19. One (1) edited video running two to four (2-4) minutes in length featuring footage and audio from the ground-breaking ceremony and explaining the Project, suitable for public outreach purposes

20. Light refreshments

D. Time-Lapse Camera and Video Monitoring System

A dedicated time-lapse camera system shall be provided by the Design-Build for users to remotely view high interest areas of the Project on a secure web site via a network connection. The camera system shall provide high resolution cameras mounted to enable observation of the Project at all hours of the day and in all weather conditions normally encountered in Virginia, consistent with reported visibility restriction (i.e., during snow storms, fog, etc.), and fitted with maintenance-
free lens wipers. The areas of high interest that shall be captured include the entire Project construction. The Design-Builder shall provide a minimum of four (4) cameras to cover the entire span over water, island activity and tunnel construction.

The proposed camera monitoring system shall not be connected to the VDOT ATMS network or make use of existing or proposed ATMS cameras.

The cameras shall include an integrated pan/tilt mechanism capable of providing 360-degree continuous pan with a minimum 90-degree tilt range (i.e. 0 to -90 degrees), integrated camera/optics for day/night operation, 18x optical zoom, and a minimum resolution of 24 Megapixels. The cameras must be capable of live streaming video preview; user controllable pan, tilt, and zoom (PTZ); auto generated panoramas; instant live snapshot capability in addition to preset scheduled archives; and a time-lapse feature for instant time-lapse viewing, downloading and embedding. The following three functions shall be provided:

- 24 Megapixel Time lapse camera system to provide overall time-lapse videos at the end of the Project.
- 24 Megapixel secure, private CCTV video coverage including PTZ control for internal Department access using secure website.
- 24 Megapixel video clips that can be accessed from social media.

The Design-Builder shall provide all service and maintenance, including cleaning of the camera system throughout the duration of the Project construction, and make appropriate arrangements for cameras to remain in operation as necessary for beginning-to-end time-lapse recording.

The Design-Builder shall coordinate with a system vendor to provide a custom public website development. The website shall be developed to be accessible to the public and controlled by the Department. The website shall be separate from the online interface, match the look and colors of the Project’s website, and be delivered as embed code or standalone web page. Additional features include Facebook, Instagram and Twitter integration, full screen mode, image comparison, weather, multiple logos, graphical background image and Project description. The system vendor shall provide up to ten (10) time-lapse movie(s) at the end of the Project. Time-lapse movies shall be professionally edited by a video editor using image stabilization software. The movie will start with a graphic, incorporating project title, date and logo. Periods of bad weather or inactivity shall be removed to produce a compelling and consistent movie. A machine edited movie will not be acceptable. The movie shall incorporate aerial footage of construction recorded from an unmanned aerial vehicle (drone) as provided by the Design-Builder.

The Design-Builder shall submit design drawings, installation Plans and catalog cut sheets for all system materials identified in this Section and/or the PICP to the Department for review. The Design-Builder must obtain approval of design drawings, installation plans and catalog cut sheets from the Department prior to purchasing any equipment, and subsequently perform the installation per the approved documents, contract plans, and specifications. The location of the pole mounted camera assemblies shall be staked in the field by the Design-Builder, as directed by the Department. When all equipment is installed and connected, the Design Builder shall, for each camera, test and demonstrate, as specified herein, the performance and accuracy of that camera. This test shall ensure that video is acceptable. Prior to Final Acceptance the Design-Builder shall ensure that all installed cameras, supports, and other system components are removed; and that the web service is discontinued.
7.4. **Media Relations**

7.4.1. **General**

A. While there will be some overlap between the partners on some communication and outreach activities during the Construction Period, the Department will serve as the sole source to the news media and community stakeholders on specific lane closures, delays, detours, and other construction impacts associated the Project. Design-Builder and the Department will ensure close coordination with each other on media outreach activities, issues, and Responses, and will promote consistency with the communications, public outreach and community engagement plan.

B. The Design-Builder shall:

1. Develop and provide to the Department for review and approval a set of media protocols governing responsibilities and reporting in relation to contact with the media, including guidelines for information sharing, policies to promote consistent messages, and procedures specific to managing emergencies and Incidents.

2. Develop and provide to the Department for review and comment a set of media protocols within the Project team.

3. Proactively build and maintain relationships, in collaboration with the Department, with local media.

4. Provide timely response to media inquiries and keep the Department informed of media inquiries regarding the Project and the nature of responses that are documented as mutually agreed.

5. Provide relevant Project information to the media in a timely fashion.

6. Monitor all media coverage of the Project.

7. Provide copies of all press releases or other media materials to the Department in advance of distribution.

7.5. **Deliverables**

At a minimum, the deliverables shall include the items listed in Table 7.5-1 for the Department’s consultation and written comment.

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<td>Stakeholder Management Plan</td>
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<td>60 days after NTP</td>
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Appendix 7.1 – Applicable Local Ordinances and Agreements

[TBD]
SECTION 8. SURVEYING AND GIS

8.1. Scope

A. The Design-Builder is advised that the field survey and utility data provided is not represented to be complete for purposes of design and construction of the Project. The Design-Builder’s scope of Work shall include performing all surveying and utility designation that is necessary to design and construct the Project in accordance with VDOT’s Survey Manual.

B. Preliminary field survey and utility data has been obtained for this Project. The survey is bounded by the I-664/I-64 interchange to the west and the I-564/I-64 interchange to the east. Survey data limits can be generally described as contained within the Right-of-Way, except in specific outfall areas. The field survey was conducted using conventional and aerial lidar methods and data was collected within the tolerances defined in the VDOT Virginia Map Accuracy Standards. Preliminary activities have been performed and preliminary field survey and utility data have been obtained consisting of the following:

1. Notification of property owners
2. 3D survey control at 300’ intervals along outside shoulders
3. Conventional survey acquisition for hard surfaces
4. Aerial lidar (softscape)
5. Field data verified and updated
6. Planimetrics (limited to signs, pavement, curbing)
7. Property data and R/W
8. Bridge surveys
9. Drainage surveys
10. Utilities (Level B sub-surface utility investigation) crossing the project corridor, as described below.
11. Digital Terrain Model
12. Hydrographic Surveys (not including archeological or cultural resource surveys)

C. The preliminary field survey and utility data provided in the RFP Information Package contains the general depiction of existing conditions which the Design-Builder is obligated to verify and finalize through survey before completing final design of the Project. The horizontal accuracy of the preliminary survey is at the Class 1 level at [XX] scale. The vertical accuracy is Class 3 with 1-foot contours. The Design-Builder shall be responsible for obtaining any survey data, including all right-of-entry and land use permits, locating and/or designating underground utilities, digital terrain model (DTM), utility test holes and obtaining other related data necessary for the design, Right of Way acquisition, limited access revisions, and construction of the Project. Additionally, the Design-Builder will be responsible for any update (property owner changes, subdivisions, etc.) that may occur; updates need to be reflected on the plans to acquire Right of Way and complete the final design. Any survey changes shall be verified and certified, and submitted in final documentation.
D. Preliminary Information Collected by the Surveyors includes:

1. Aerial Lidar: Aerial lidar data obtained in March 2015 for 3D map compilation within the softscape areas within the project corridor limits. The horizontal accuracy of the preliminary survey is at the Class 1 level at [XX] scale. The vertical accuracy is Class 3 with 1-foot contours. The aerial lidar was cleaned to remove areas within the hard surfaces. The aerial lidar data was replaced with conventional survey data in areas of overlap to create a digital terrain model and 1-foot contours.

2. Property data and R/W: Research through the Virginia Department of Transportation for existing Right-of-Way plans along the project corridor. These plans were utilized for compilation to aid in efficient field reconnaissance and location efforts. The found monumentation was surveyed and the Right-of-Way is depicted in the Concept Plans. The departing property lines and ownership information shown are based on the City of Hampton and the City of Norfolk GIS data. No land record research for adjacent properties was conducted.

3. Bridge Surveys: All bridges within the project limits and under each bridge down to any waters’ edge. The bridge columns and pier protection at each bridge were located and shown. Bridge clearances at the bottom of girder have been provided.

4. Drainage Surveys: The location of paved and/or concrete ditches. The location of drainage structures within the project limits include rim elevations, pipe sizes, invert elevations where accessible, and direction of flow. The project limits for this task are within the limits of the Right-of-Way. Underdrains are shown, to the extent possible, and do not include invert elevations. Outfall surveys for locations are included. Data obtained is based on conventional surveys and aerial mapping. The data was merged into the conventional survey and aerial lidar to provide a seamless digital terrain mode.

5. Utility Surveys: Utility identification and designation of only know utilities shown on records (or visibly identified in the field) which cross the entire interstate corridors (Right of Way to Right of Way). Utilities parallel to the interstate Right of Way were also included in this effort. Arterial roadway limits included full utility identification and designation from Right of Way within the project limits.

6. Horizontal & vertical survey control; conventional survey: Static GPS network survey related to local National Geodetic Survey (NGS) First Order control monuments to update the horizontal and vertical values on existing VDOT Project Monuments. A secondary control network was established along the corridor at 300’ intervals for the data acquisition activities. The horizontal and vertical units are in U.S survey feet. Differential leveling was conducted between the VDOT Project Monuments and secondary control points were incorporated into these circuits. Conventional surveying techniques were employed to acquire the pavement surface elevations. The elevation data obtained from the secondary control points was utilized to build the terrain surface for paved surfaces. A maximum variance of ± 0.033’ was found to fit with 95% of the project control points (targets).

8.2. References

A. VDOT Project Development Manual

B. VDOT Survey Manual

8.3. Requirements

8.3.1. Vertical and Horizontal Control
A. Vertical control (Based on NAVD88 Geoid 2012A)
B. Horizontal control (Based on NAD83-2011)

8.3.2. General – Notification of Property Owners
A. The Virginia Code 33.2-1011 requires that Notice of Intent letter “shall be sent to the owner by mail, at the address recorded in the tax records, not less than 15 days prior to the first date of the proposed entry. Notice of intent to enter shall be deemed made on the date of mailing.” “The notice shall include the anticipated date such entry is proposed to be made and the purpose of such entry.” Advance notification of property owners is required for all data collection efforts related to the development of highway plans. As soon as they become available, copies of the letters and address labels shall be provided to the Department for approval.

8.3.3. Topographic Surveys
A. Perform topographic surveys in accordance with the requirements of the VDOT Survey Manual.

8.3.4. Hydrographic Surveys:
A. Hydrographic surveys are required for the inspection of the following: Dredged trenches (including underwater slopes); immersed tube tunnel placement and backfill; island expansions; offshore engineered fill berm construction; and borrow source and ocean disposal sites.
B. Hydrographic surveys shall be conducted to meet the minimum accuracy standards described in Table 8.3.4-1.
C. Provide a list of hydrographic surveying equipment including type, brand, frequency and precision. Provide calibration certificates of all equipment to be used. Equipment with expired calibration certificates shall not be used.
D. Unless stated otherwise, the hydrographic equipment, survey and protocols shall follow the USACE standards defined in EM 1110-2-1003 Table 3-1 for “New Work or Rock Cuts.”
E. Hydrographic surveys shall be performed through multiple sweeps of a coupled system, consisting of a coupled single vertical beam transducer and a multi-beam transducer.
F. Horizontal positioning shall be obtained from an appropriate D-GPS (Differential Global Positioning System) or RTK-GPS (Real Time Kinematics Global Positioning System) receiving unit. Non-GPS units may be used provided that adequate accuracy as specified in Table 8.4.1-1 below can be reached consistently. The coupled-transducer system shall be calibrated per the procedures outlined in USACE EM 1110-2-1003.
G. Prior to executing the hydrographic survey, the operator shall demonstrate its adequacy and compliance with the requirements on a Department-approved test area.
H. Underwater inspection of the final conditions shall be obtained by means of a coupled side-scan and multi-beam sonar acoustic survey. Survey shall comply with the protocols and tolerance requirements described in USACE EM 1110-2-1003.
Table 8.3.4-1: Minimum Hydrographic Tolerance Requirements

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<th>Description</th>
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<td>Resultant elevation accuracy (95%), typical</td>
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<tr>
<td>Resultant elevation accuracy (95%), floor of immersed tube trench</td>
<td>To be determined by the Geotechnical Manager.</td>
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<td>Reference range: +0.25 in., -0.25 in.</td>
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<tr>
<td>Reported horizontal accuracy (95%) for plotted depth locations, typical</td>
<td>+6 in., -6 in.</td>
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<tr>
<td>Reported horizontal accuracy (95%) for plotted depth locations, concrete</td>
<td>To be determined by the Geotechnical Manager.</td>
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<td>Reference range: +0.25 in., -0.25 in.</td>
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<tr>
<td>Medium coverage density</td>
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Notes to Table: Items are defined in USACE EM 1110-2-1003.

8.3.5. Damaged, Destroyed or Lost Survey Control

A. The Design-Builder will be responsible to reset or relocate any survey control damaged, destroyed, lost or located within the footprint of the final design construction limits. The control shall be established by a land surveyor licensed in the Commonwealth of Virginia with LD-200 information and supporting computations submitted to the Department.

8.3.6. Completion

A. Prior to contract completion, the Design-Builder shall provide and set final VDOT RM-1 or RM-2 Right of Way monuments within the Project Limits. The Design-Builder shall depict the monuments on the Right-of-Way Plans in accordance with the VDOT Survey Manual.

8.3.7. Pre-Construction, Progress and Post-Construction Surveying

A. Pre-Construction Survey

Pre-Construction survey shall be performed prior to the commencement of Work as per methods accepted by the Department. The survey shall be conducted using established survey controls and shall be carried out in collaboration with the Department’s survey consultant, who may assign staff to check and witness the Design-Builder’s Work and may arrange for independent checks as necessary.

B. Progress Surveys

The Design-Builder shall conduct and report progress surveys in accordance with the Work. The Design-Builder shall notify the Department at least 24 hours in advance of progress survey(s) for the Department to have the opportunity to attend. At a minimum, the Design-Builder shall survey the area prior to and after placement of each type of fill. The extent of coverage of progress surveys shall be sufficient to identify all underwater slopes (toes and tops of slopes) within the limits of fill and dredge areas;

C. Post-Construction Surveys

Post-Construction surveys of the completed Work, or completed sections of parts of the Work, shall be conducted by the Design-Builder as per methods accepted by the Department. The Post-Construction surveys shall be conducted using established survey controls and shall be carried
out in collaboration with the Department staff, who may assign staff to check and witness the Design-Builder’s Work and may arrange for independent checks as necessary.

D. Survey Documentation

The Design-Builder shall submit, in a format acceptable to the Department (including ASCII format if requested), survey data including plan view drawings and cross-sections for all surveys (Pre-Construction, Progress, Post-Construction). Survey documentation shall include quantity calculations of materials dredged/placed, based on survey results. All surveys shall include a contour map with a contour interval of 1 feet elevations in a format consistent with the RFC Plans as well as representative cross-sections. The contour map shall include all base map and reclamation area limits information as well as indicators showing the location of cross-sections.

8.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 8.4-1 for the Department’s consultation and written comment.

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SECTION 9. RIGHT OF WAY

9.1. Scope
The Design-Builder’s Concept Design shall be wholly contained within the Right-of-Way limits shown on the Concept Plans, with the potential exception of temporary construction easements, permanent drainage easements (other than permanent drainage easements for stormwater management facilities), and utility easements. Utility easements have not yet been identified or shown on the Concept Plans. Deviations from the proposed Right-of-Way limits shown on the Concept Plans will be subject to the Department approval in accordance with Section [X.XX]. The Design-Builder’s RFC design shall also be contained within the Right-of-Way limits shown on the Concept Plans, with the potential exception of temporary construction, permanent drainage, and utility easements (other than permanent drainage easements for stormwater management facilities) and where minor adjustments are required during the final design process, and only after approval by the Department. If the Design-Builder proposes change to the Right-of-Way limits shown on the Concept Plans, then this shall be considered a deviation from the Contract Documents and shall be addressed as described in Section [X.XX].

9.2. References
A. VDOT Project Development Manual
B. FHWA Right of Way Manual of Instructions, 3rd Edition

9.3. Requirements

9.3.1. General
A. The Design-Builder, acting as an agent on behalf of the Commonwealth of Virginia (Commonwealth), shall provide all ROW acquisition services for the Project's acquisition of fee ROW and permanent, temporary and utility easements. ROW acquisition services shall include attorney-certified title reports, appraisals, appraisal review, negotiations, relocation assistance and advisory services and parcel closings, to include an attorney's final certification of title. All Right of Way acquisition costs (compensation paid to landowners for Right of Way or permanent easement) will be paid by the Department, and shall not be included in the Design-Builder’s Price Proposal.
B. Permanent Aerial Easements will be needed for the widening and new construction of Structures over [__________] Property. A Permanent Aerial Easement will also be needed for new construction of structures over the [__________] owned by [__________].
C. Design-Builders are encouraged to minimize Right-of-Way impacts to private entities for purposes of locating stormwater management facilities.
D. The Design-Builder’s final design shall not impact nor encroach upon wetlands. The Design-Builder’s final design shall not impact any billboards or advertising signs outside of Department Right-of-Way. Proposed Right-of-Way shall preserve access to billboards or advertising signs using permanent easements.
E. If the Design-Builder proposes change to the Right-of-Way limits shown on the Concept Plans, then this shall be considered a deviation from the Contract Documents and shall be addressed as described in Section [X.XX]. The Design-Builder shall be responsible for any time and/or
cost impacts and any NEPA document re-evaluation associated with the design changes that extends beyond the Right-of-Way limits reflected in the Concept Plans.


9.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 9.4-1 for the Department’s consultation and written comment.

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<td>Notice of Impasse – request to file Certificate of Take</td>
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<td>Complete parcel files at end of project</td>
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SECTION 10. UTILITIES

10.1. Scope

The Design-Builder shall provide qualified and competent personnel with extensive knowledge and experience in utility coordination and utility relocation construction on VDOT projects. These personnel shall have full understanding of the project requirements as outlined in this section of the Technical Requirements. The Design-Builder shall ensure that all laws, policies and procedures as related to the protection, adjustment and relocation of utilities are adhered throughout all Project activities.

The Design-Builder shall accurately identify the location of all existing utilities located within the project limits. Any utility found to be in conflict with the proposed construction of the project shall be protected, adjusted or relocated according to the Department policy and procedure as outlined in the VDOT Utility Manual of Instruction.

The Design-Builder shall provide project plans to each utility owner along with a completed preliminary VDOT Form UT-9 once the plans have reached a stage that fully identifies the impacts of the project on the utility. The Design-builder will obtain a plan and estimate from each utility that will require adjustment or relocation of their facilities. The Design-Builder shall be responsible for reviewing the plan and estimate to certify that it meets the requirements as outlined in the VDOT Utility Manual of Instruction and receiving written authorization from the Department.

The Design-Builder shall be responsible for all applicable cost associated with utility adjustments and relocations required for the project to include reimbursement to utility owners. The Design-Builder shall verify all cost and maintain accurate records that are subject to audit from the Department, FHWA, and other Governmental Agencies.

The Design-Builder shall provide inspection and oversight of all utility relocation construction activities required for the project to include Work being performed by the private utility companies and their subcontractors. The Design-Builder shall verify that the location and materials used are consistent with the approved plan and estimate submitted by the utility owner. The Design-Builder shall keep accurate field notes and records of all utility relocation construction Work performed and shall obtain bore logs and other documentation from the utility contractors to identify the location of the installed or adjusted utility. The Design-Builder shall provide accurate record drawings that show the final location of all utilities on the project.

10.2. References

A. VDOT Project Development Manual
C. VDOT Right of Way and Utilities Division Manual, Volume I and II
D. VDOT Land Use Permit Manual

10.3. Requirements

10.3.1. General

A. The coordination, design, and relocation of all utilities shall comply with these Technical Requirements, the Standard Documents including Right of Way and Utilities Division Manuals, Vol. I and II, and the requirements, standards and preferences of impacted utility owners.
B. Utility information provided on the Concept Plans identifies all known utilities, at the time of plan development, that are located within the Project limits. Aerial utilities are identified on the Concept Plans and/or in the survey files by the structure to which they are attached. However, it is the Design-Builder’s responsibility to verify, to their satisfaction, the owner, type, size, height and number of cables attached to the structure when preparing their Price Proposal.

C. All underground utility data was obtained and is depicted in accordance with CI/ASCE 38-02 SUE Quality Level B designation or as noted on the Concept Plans and/or survey files. However, it is the Offeror’s responsibility to verify, to their satisfaction, the owner, type, size, number of cable/conduits, pipes, services, and horizontal and vertical (depth) location of underground utilities to include service connections and laterals with the utility owners when preparing their Price Proposal.

D. All efforts and costs necessary for all utility designations, utility locations (test holes), conflict evaluations, cost responsibility determination, utility relocation designs, utility relocations and adjustments, utility reimbursements, replacement land rights acquisition and utility coordination shall be included in the Design-Builder’s Price Proposal.

E. The compensation paid to landowners for replacement land rights will be paid by the Department as a part of the Right of Way acquisition costs and shall NOT be included in the Design-Builder’s Price Proposal.

F. The Design-Builder shall be responsible for utility designations, utility locates (test holes), conflict evaluations, cost responsibility determinations, utility relocation designs, utility relocations and adjustments, utility reimbursement, determination of existing utility easements and the inclusion of such easements on plans, replacement land rights acquisition, and utility coordination required for the Project.

G. The Design-Builder shall design the project to avoid (or minimize) utility relocations. All utility relocations shall be designed to minimize the acquisition of property and to avoid conflicts with existing storm drainage systems and other existing utilities.

H. The Design-Builder shall be responsible for coordinating all necessary utility relocations and adjustments to occur in accordance with the accepted Baseline Project Schedule.

I. The Design-Builder shall coordinate with each affected utility owner to determine those relocation costs that are the Design-Builder’s responsibility and those relocation costs that are the responsibility of the utility owner.

J. The Design-Builder shall meet with the Department within forty-five (45) days from the date of NTP to gain a full understanding of what is required with each submittal.

K. The Design-Builder shall prepare and submit to the Department a preliminary utility status report within one hundred and twenty (120) days from the Notice to Proceed that includes a listing of all utilities located within the Project limits and a conflict evaluation and cost responsibility determination (VDOT Form UT-9) for each utility. This report shall include copies of existing easements, as-built plans or other supporting documentation that substantiates any compensable rights of the utility owner. The preliminary utility status report shall be updated every 30 days until utility relocations have been completed.

L. The Design-Builder shall use a Master Utility Agreement (MUA) like that utilized by the Department (provided for in VDOT’s Utility Relocation Policies and Procedures Manual) to establish the general framework for addressing the utility issues within the Project affecting a utility owner. The two-party agreement between the Design-Builder and the utility company shall set forth the terms and conditions under which the utility Work will be performed.
M. The Design-Builder shall coordinate and conduct a preliminary utility review meeting with all affected utility owners to assess and explain the impact of the Project. The Department shall be included in this meeting.

N. The Design-Builder shall obtain access to and use the VDOT’s Right of Way and Utilities Management System (RUMS) to manage and track the utility relocation process. The Department standard forms and documents, as found in RUMS, will be used to the extent possible. Training in the use of RUMS and technical assistance will be provided by the Department.

O. The Design-Builder shall verify the prior rights of each utility owner’s facilities if claimed by a utility owner. If there is a dispute over prior rights with a utility, the Design-Builder shall be responsible for resolving the dispute.

P. The Design-Builder shall provide all utility owners with roadway design plans as soon as the plans have reached a level of completeness adequate to allow them to fully understand the Project impacts. The utility owners will use the Design-Builder’s design plan for preparing relocation plans and estimates. If a party other than the utility owner prepares relocation plans, there shall be a concurrence box on the plans where the utility owner signs and accepts the relocation plans as shown.

Q. The Design-Builder shall obtain the following from each utility owner that has a utility located within the Project limits: relocation plans including letter of "no cost" where the utility owner does not have a compensable right; utility agreements including cost estimate and relocation plans where the utility owner has a compensable right; or letters of "no conflict" where the utility owner's facilities will not be impacted by the Project.


S. The Design-Builder shall also ensure that there are no conflicts with the proposed roadway improvements and ensure that there are no conflicts between each of the utility owner’s relocation plans.

T. The Design-Builder is expected to assemble the information included in the relocation plans in a final and complete form and in such a manner that the Department may approve the submittals with minimal review.

U. The Design-Builder shall receive written approvals from the Department prior to authorizing utilities to commence relocation construction. The utility owners shall not begin their relocation Work until authorized by the Design-Builder.

V. Each relocation plan submitted must be accompanied by a certification from the Design-Builder stating that the proposed relocation will not conflict with the proposed roadway improvement and will not conflict with another utility owner’s relocation plan.

W. At the time the Design-Builder notifies the Department that the Design-Builder deems the Project to have reached Substantial Completion, the Design-Builder shall certify to the Department that all utilities have been identified and conflicts have been resolved; and that those utility owners with compensable rights or other claims related to relocation or coordination with the Project have had their facilities relocated and their claims and compensable rights satisfied by the Design-Builder.
X. The Design-Builder shall ensure the utility owners submit as-built records to include the horizontal and vertical (depth) location of the relocated utilities upon completion of their relocation and/or adjustments. The Design-Builder shall accurately show the final location of all utilities on the record (as-built) drawings for the Project in accordance with Section [X.XX].

Y. The Design-Builder shall certify in writing to the Department that the as-built drawings are accurate and correct. The Department will issue an as-built permit to the utility owners after receipt of the permit application and the as-built drawings.

10.3.2. Design-Builder’s Responsibility For Utility Relocation

A. The Design-Builder shall provide a utility inspector to monitor all utility relocation construction activities performed for private and public utilities on the project.

B. The utility inspector shall be responsible for insuring that all utilities on the project are relocated according to the approved plan and/or estimate.

C. The utility inspector shall receive approval for any field changes to the approved plan and estimate from the Design-Builder.

D. The utility inspector shall maintain daily record of utility work being performed on the project (VDOT Form UT-7, -7a, or -7b as applicable). These records should include begin and end dates, begin and end times, name of utility contractors, personnel working on the project, equipment used on the project, material installed, materials removed, and a narrative description of Work performed.

E. The inspector shall create a set of red-lined “as-built” plans that depicts any changes made from the approved RFP plans.

10.3.3. Design-Builder’s Responsibility for Utility Property and Services

A. At points where the Design-Builder’s operations are on or adjacent to the properties of any utilities, and damage to which might result in expense, loss, or inconvenience, Work shall not commence until arrangements necessary for the protection thereof have been completed. The Design-Builder shall cooperate with owners of utilities so that:

1. Removal and adjustment operations may progress in a timely, responsible, and reasonable manner

2. Duplication of adjustment Work may be reduced to a minimum, and services rendered by those parties will not be unnecessarily interrupted.

B. If any utility service is interrupted because of accidental breakage or of being exposed or unsupported, the Design-Builder shall promptly notify the proper authority and shall cooperate fully with the authority in the restoration of service. If utility service is interrupted, repair Work shall be continuous until service is restored.

C. The Design-Builder shall comply with all requirements of the Virginia Underground Utility Damage Prevention Act (the Miss Utility law). The Design-Builder shall wait a minimum of forty-eight (48) hours after notifying the Miss Utility notification center before commencing excavation Work. The Design-Builder may commence excavation Work after forty-eight (48) hours only if confirmed through the Ticket Information Exchange (TIE) System that all applicable utilities have either marked their underground line locations or reported that no lines are present in the Work vicinity. The Design-Builder shall wait an additional twenty-four (24) hours before commencing excavation operations if any utility operators have failed to respond to the TIE within the first forty-eight (48) hours. The Design-Builder shall wait to commence
excavation Work five business days after an approved request for markings is submitted for VDOT-owned utilities or in accordance with Applicable Law for all other utilities. All known utilities shall be protected by the Design-Builder during excavation operations.

D. The Design-Builder shall reasonably seek to determine whether other utilities are present in addition to those notified by Miss Utility and shall afford those additional utilities equivalent notification protocol.

10.3.4. Public Utilities

10.3.4.1. General

A. Utility owners and their respective contact information that are known to the Department are provided below for reference only. It is the Design-Builder’s responsibility to verify whether other utility owners exist within the Project limits and coordinate with them.

City of Hampton
Department of Public Works
Lynn Allsbrook
419 N. Armistead Avenue
Hampton, Virginia 23669
(757) 727-6346
publicworks@hampton.gov

City of Norfolk
Department of Utilities
Kristen Lentz
401 Monticello Avenue
Norfolk, Virginia 23510
(757) 664-6700
utwainq@norfolk.gov

Hampton Roads
Sanitation District
Ryan Radspinner
1434 Air Rail Avenue
Virginia Beach, Virginia 23455
757.460.4232
rradspinner@hrsd.com

10.3.5. Private Utilities

10.3.5.1. General

A. Utility owners and their respective contact information that are known to the Department are provided below for reference only. It is the Design-Builder’s responsibility to verify whether other utility owners exist within the Project limits and coordinate with them.

Electric Distribution:
Dominion Energy
Joe Pincus
2700 Cromwell Drive
Norfolk, Va. 23509
(757) 262-6107
Joseph.R.Pincus@dominionenergy.com

Electric Transmission:
Dominion Energy
Ryan Joyce
701 East Cary Street Richmond, VA 23219
(804) 219-7126
ryan.t.joyce@dominionenergy.com
Crown Castle (Formerly Lightower Fiber Network and Sidera)
Rick Stransky
10976 Richardson Road
Ashland, Virginia 23005
(801) 669-4175
rstransky@lightower.com

Qwest/CenturyLink/Level3
Richard Browning
243F Burgess Road
Greensboro, North Carolina 27107
dennis.browning@centurylink.com

Verizon South
Toney Hunt
765 S. Battlefield Boulevard
Chesapeake, Virginia 23322
(757) 482-8004
toney.hunt@verizon.com

Cable Television:
Cox Communications
Anthony Crish
179 Louise Drive
Newport News, VA 23601
(757) 222-6576

Colonial Pipeline Company
Timothy Gross
2607 Willard Road
Richmond, Virginia 23294
(804) 672-3077, ext. 8
tgross@colpipe.com

Virginia Natural Gas
Jonathan Blackwell
544 S. Independence Boulevard
Virgmia Beach, Virginia 23452
(757) 616-7514
jblackwe@aglresources.com

Windstream
Geoffrey Voigt
929 Martha’s Way
Hiawatha, IA 52233
(800) 289-1901
Geoffrey.Voigt@windstream.com

Verizon
Charles D. Small
765 S. Battlefield Boulevard
Chesapeake, Virginia 23322
(757) 482-8063

10.3.6. Betterments

10.3.6.1. General

A. Costs for any utility betterment(s) shall not be included in the Design-Builder’s Price Proposal but shall be reimbursed to the Design-Builder through agreement with the requesting utility owner.
B. The Design-Builder shall be responsible for all utility designations, utility locates (test holes), conflict evaluations, cost responsibility determinations, utility relocation designs, utility relocations and adjustments, utility reimbursement, replacement land rights acquisition, utility coordination, and coordination of utility betterments required for the Project. The Design-Builder shall be responsible for all necessary utility relocations, adjustments, and betterments to occur in accordance with the accepted Baseline Schedule.

C. The Design-Builder shall be responsible for coordination of the Project construction with all utility owners that may be affected. The Design-Builder shall be responsible for coordinating the Work of the Design-Builder, its subcontractors, and the various utilities. The Design-Builder shall initiate early coordination with all utility owners with facilities located within the Project limits. The resolution of any conflicts between utilities and the construction of the Project shall be the responsibility of the Design-Builder. No additional compensation or time will be granted for any delays, inconveniences, or damage sustained by the Design-Builder or its subcontractors due to interference from utility owners or the operation of relocating utilities or betterments.

### 10.4. Deliverables

The deliverables shall include the items listed in Table 10.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Hardcopy</td>
<td>Electronic</td>
<td></td>
</tr>
<tr>
<td>Preliminary Utility Status Report</td>
<td>5</td>
<td>1</td>
<td>Within 120 days of NTP; updated every 30 days until utility relocations are complete.</td>
</tr>
<tr>
<td>Utility MUA’s</td>
<td>5</td>
<td>1</td>
<td>Individual utility MUA; submit to the Department within 21 days of receipt.</td>
</tr>
<tr>
<td>Utility relocation plan</td>
<td>5</td>
<td>1</td>
<td>Individual utility relocations plans, submit to the Department within 21 days of receipt.</td>
</tr>
<tr>
<td>Utility Relocation As-Builts</td>
<td>5</td>
<td>1</td>
<td>Within 21 days of receipt from utility owner</td>
</tr>
<tr>
<td>RUMS Updates</td>
<td>5</td>
<td>1</td>
<td>Update monthly</td>
</tr>
<tr>
<td>VDOT Form UT-7</td>
<td>5</td>
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</tr>
</tbody>
</table>
SECTION 11. SECURITY

11.1. Scope

An essential component of the Project is the safeguarding of Critical Infrastructure Information (CII) and Sensitive Security Information (SSI) in custody or under control by the Design-Builder. Except as otherwise detailed herein, the Design-Builder shall be responsible for preparing its design, carrying out its construction activities and undertaking other activities as needed to ensure compliance with the VDOT’s CII/SSI Policy.

This Project Requirement identifies certain required actions by the Design-Builder to ensure that the CII/SSI Requirements are complied with throughout the Project activities. The responsibilities of the Department in these areas are summarized.

11.2. References

A. VDOT IIM-S&B-71 CII/SSI
B. VDOT CCI/SSI Policy Guide for Employees, Vendors, Contractors or other Persons Accessing VDOT’s CII/SSI.

11.3. Requirements

11.3.1. General

A. Subject to the requirements of the Agreement, the Design-Builder shall adhere to VDOT policy on critical infrastructure information and sensitive security information (CII/SSI). The Design-Builder shall ensure that relevant CII/SSI is protected and not disclosed to unauthorized persons. The Design-Builder shall ensure that all personnel having access to CII/SSI for the Design-Builder and all subcontractors have met the requirements of IIM-LD-236 Critical Infrastructure (CII) / Sensitive Security Information (SSI).

B. The Department may request fingerprint-based criminal history background checks on any personnel working on specific structures or functions or having access to record drawings and/or specifications.

C. The Design-Builder shall review with the Department any information that should be designated as CII/SSI as specific design details become available. Any requirements for security review or other inspections will be mutually agreed to with the Department.

D. The Design-Builder shall comply with all property security rules and requirements when working on the existing tunnels and islands.

E. The Design-Builder shall comply with all US Navy and Hampton University Center property security rules and requirements when working on their property.
Deliverables

The deliverables shall include the items listed in Table 11.4-1 for the Department’s approval.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
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<td>CII/SSI Multi-Purpose Non-Disclosure Agreement</td>
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<td>5 days before access to any documents covered by CII/SSI</td>
<td>11.3.1</td>
</tr>
</tbody>
</table>
SECTION 12. MAINTENANCE DURING CONSTRUCTION

12.1. Scope

An essential component of the Project is to prosecute the work to provide for the safety and convenience of the public and residents along the roadway and the protection of persons and property. The Design-Builder shall be responsible for all typical repairs and maintenance such as guardrail, grass cutting, litter pick-up, debris removal, and pavement repair during construction except for snow removal.

12.2. References


12.3. Requirements

12.3.1. General

A. The Design-Builder shall maintain the Worksite beginning 6 months after NTP or when construction activities begin, whenever is soonest, ending on the Final Acceptance.
B. The Design-Builder shall keep the road being used by the public free from irregularities and obstructions that could present a hazard or annoyance to traffic.
C. Existing Department Transportation Management System (TMS) devices shall remain operational during construction unless otherwise approved by the Department. These TMS devices include, but are not limited to: (i) closed-circuit television (CCTV) cameras; (ii) dynamic message signs (DMS); (iii) ramp metering; (iv) detection; (v) mile markers; (vi) the reversible gate system; (vii) roadway lighting; and (viii) weather stations.
D. Existing detection (traffic sensors) shall remain in place during construction activities unless written approval is provided by the Department. Replacement detection shall be installed, operational, integrated, and collecting data before taking existing detection out of service.
E. The existing continuous count station at approximate mile markers 269.5 and 271.15 shall remain in place and fully operational until replacement stations at locations approved by the Department have been activated. The Design-Builder shall coordinate the work to relocate the continuous count station with the Department. The Design-Builder shall reimburse the Department for actual costs incurred as a result of the relocation of these continuous count stations.
F. The Design-Builder shall be responsible for the maintenance assets impacted or obstructed by the Design-Builder or any of the Design-Builder’s agents, subcontractors or parties for which the Design-Builder is responsible during the Project Duration for which the owning authority is a party other than the Department. The impacted asset shall be maintained by the Design-Builder until it is no longer impacted by construction and accepted back by the owning authority.
G. The Department, will operate the gates and maintain assets (components) necessary to operate gates for the existing HOT facility for the Project Duration. Damage to the gates caused by the Design-Builder, or any of the Design-Builder’s agents, subcontractors or parties for which the Design-Builder is responsible, (whether intentional or through negligence) will be repaired by the
Design-Builder within 48 hours of the incident. The Design-Builder shall reimburse the Department for the actual cost incurred to have such gates repaired.

H. The existing drainage system will be maintained by the Department until impacted or obstructed by Design-Builder or any of the Design-Builders agents, subcontractors or parties for which the Design-Builder is responsible. During the period for which the existing drainage system is impacted or obstructed, the Design-Builder’s will have sole maintenance responsibility for the system being impacted or obstructed. One week following the completion of activities within the impacted or obstructed system, the Design-Builder will notify the Department and schedule an inspection. The Department will, at its sole discretion, determine whether the impact or obstruction has been raised and, if so, reassert responsibility for the drainage system. If during the impacted or obstruction period the Department determines that maintenance is not being satisfactorily conducted, the Department may opt to maintain the facility and the Design-Builder shall reimburse the Department for the actual cost incurred.

I. The Design-Builder shall recognize the existence, conditions and requirements of the tunnel facility DEQ - VPDES discharge permit and take measures to ensure outfall discharge permit limits are not exceeded throughout the project.

J. The existing lighting and ITS systems will be maintained by the Department until impacted or obstructed by Design-Builder or any of the Design-Builders agents, subcontractors or parties for which the Design-Builder is responsible. During the period for which the existing lighting and ITS systems are impacted or obstructed, the Design-Builder’s will have sole maintenance responsibility for the system being impacted or obstructed. One week following the completion of activities within the impacted or obstructed system, the Design-Builder will notify the Department and schedule an inspection. The Department will, at its sole discretion, determine whether the impact or obstruction has been raised and, if so, reassert responsibility for the existing lighting and ITS systems. If during the impacted or obstruction period the Department determines that maintenance is not being satisfactorily conducted, the Department may opt to maintain the facility and the Design-Builder shall reimburse the Department for the actual cost incurred. If there is an existing asset the Design-Builder desires to tie in or connect to, but is prevented from doing so because of physical damage to such existing asset the Design-Builder may perform the repair work at its sole cost and expense.

K. The Department will perform snow and ice removal on all travel ways. The Design-Builder shall provide access as necessary for the Department to provide snow removal.

L. Tunnel facility assets coming under Design-Builders control must be maintained to ensure the safety, reliability, and performance of their critical systems & equipment. References 12.2 B, and C above delineate maintenance best practices. These references also establish requirements for periodic preventive maintenance and provide a directory of additional references germane and should be followed until these assets are turned over to the Department.

M. Design-Builder shall not impede Department maintenance personnel from performing routine and emergency maintenance on existing tunnel assets nor shall the Design-Builder impede Department maintenance personnel while the Design-Builder performs maintenance on existing tunnel assets.

N. Design-Builder, or any of the Design-Builders agents, subcontractors or parties for which the Design-Builder is responsible shall maintain free and open access and use to all parts of the infrastructure footprint of the Project including, but not limited to following: Inspection Stations; Dominion Virginia Power and VDOT electrical power substations; approach bridges, entrance and exit ramps and traffic control and security gates; trestles; islands; and on-island buildings, facilities, and those areas designated for the inspection and staging of over height vehicles.
O. Design-Builder shall not impede any access or use of any of the existing HRBT infrastructure unless duly authorized by the Department Project Manager and the Hampton Roads Harbor Tunnels (HRHT) Facility Manager.

P. Design-Builder shall not impede nor cause any interruption, in any manner, to ready access to all parts of the HRBT existing infrastructure by emergency first responders to include, but not be limited to the following: Virginia State Police; Hampton Fire Rescue; Norfolk Fire Rescue; VDOT contracted wrecker service; VDOT responders; and others responding to incidents within the footprint of the facility. In addition, the Design-Builder shall immediately suspend all operations as directed by the VDOT Control Room personnel that may impede any incident response activity. Design-Builder activities will only be authorized to begin again upon a notice of clearance from the VDOT Control Room Supervisor.

Q. Design-Builder shall be aware of the thousands of birds of numerous species that arrive on the south island to nest and fledge their young starting on/about April of each year and departing on/about September of each year. See Section [X.X] Threatened and Endangered Species - Colonial Nesting Birds for conditions and requirements regarding these birds.

R. Design-Builder must provide and maintain accountability for all personnel engaged in any way in the design and construction of the new tunnel facilities. This accountability shall include the ability to make an immediate and accurate report of the location of all personnel in the event of any incident declared by the VDOT Control Room Supervisor. A single point of accountability shall be established and maintained on both the north and south islands by the Design-Builder, each shall utilize two systems of constant, and immediate communications (one primary, and one secondary) with the control room at all times.

S. Design-Builder shall provide and maintain sanitary and rest facilities for all personnel engaged in the design and construction of the Project including Work performed in the islands and tunnels. At no time shall any Design-Builder personnel be granted access to any existing facility on either the north island, the south island, the HRBT Administration Building located at 204 National Avenue in Hampton, nor the HRHT Training Building located on Curry Street in Hampton, nor the Willoughby and Mallory Inspection Stations.

T. A management-level representative of the Design-Builder shall meet on a weekly basis with the management of the HRHT to review and discuss all work activities that are planned and may impact the normal daily operations and maintenance of the existing tunnel facilities in the next month. A four-week look ahead written schedule shall be provided on a continuing basis by the Design-Builder. All conflicts shall be resolved by the Design-Builder in the favor of the normal daily and emergency operation and maintenance of the existing facilities.

U. Any Design-Builder personnel, contractor or subcontractor personnel that cause undue interruption or discord with any Department personnel or private citizen shall be immediately removed from the project, and shall not be authorized to return to the project, upon notice by the Department Project Manager and the HRHT Facility Manager.
SECTION 13. TRANSPORTATION MANAGEMENT PLAN

13.1. Scope
The Design-Builder shall prepare a Transportation Management Plan (TMP) in accordance with the latest effective revision to IIM-LD-241/TE-351 for all proposed work associated with the Project. The TMP shall document how traffic shall be managed during the construction of the Project. The TMP Design shall be certified by a Professional Engineer (PE) licensed to practice in the Commonwealth of Virginia, and be designed using a design speed matching the existing posted speed limit. No speed reductions will be granted for any part of the project. Additionally, the TMP shall be certified by a Professional Traffic Operations Engineer (PTOE) with the accreditation card “Verification of Completion of Advanced Work Zone Traffic Control Training” per the latest effective revision of the IIM-TE-345. This Project is classified as a Type C, Project Management Category V in terms of the TMP. Major components of the TMP shall include the Temporary Traffic Control Plan, the Public Communications Plan, and the Transportation Operations Plan. The Design-Builder shall coordinate all work in accordance with the TMP.

The Design-Builder shall complete an assessment of the work zone traffic impact using a traffic analysis tool recommended in VDOT’s Traffic Operations and Safety Analysis Manual (TOSAM). Lane closures and detour routes shall comply with the Hampton Roads Regional Operation’s lane closure policies, with any deviations from the Virginia Work Area Protection Manual (VWAPM) shall be submitted to the Department for approval prior to implementation. Proposed deviations must be equal to or improve traffic operations, reduce safety risk, or both as documented by analysis per the TOSAM and IIM-LD-241/TE-351.

The work zone speed limit along I-64 shall be posted for 55 mph throughout the duration of construction operations that impact the existing roadway lane and/or shoulder widths. No speed reduction along I-64 will be allowed.

13.2. References
A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive, but include the latest revisions:
   3. IIM-LD-93.18 Safety Guidelines and Pay Items for Construction Work Zone
   4. IIM-LD-222.12/TE-358.8 NCHRP 350 Test Requirements
   5. IIM-LD-241.7/TE-351.4 Transportation Management Plan Requirements
   6. IIM-TE-345.1 Work Zone Traffic Control Training Procedures
   7. VDOT Allowable Lane Closure Hours for the State Highway System in Hampton Roads District (June 2016)

B. FHWA Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
13.3. Requirements

13.3.1. Temporary Traffic Control (TTC) Plan

A. The Design-Builder’s TMP shall include a Temporary Traffic Control (TTC) Plan detailing all phases of work, proposed lane closures, maintenance of traffic through the work area, and all construction accesses for approval by the Department. This plan shall also address safe and efficient operation of adjacent public transportation facilities, State Highways, and local roads and streets. The plan shall also include coordination with local agencies and other contractors performing work near I-64. This plan shall reflect the noted Scope of Work and all applicable VDOT Standards and Specifications regarding time of work. All users must be addressed and accommodated in the TMP, including pedestrians and bicyclists on affected surface roadways on detour routes; transit vehicles (the Design-Builder will submit any TTC plan that affects transit operations shall submit plans to Hampton Roads Transit for approval), and other motorists. The TTC Plan shall also ensure that marine traffic is accommodated. The TTC Plan shall also accommodate safe and efficient snow removal operations and ensure proper drainage during all phases of construction. Access must be maintained to all businesses, residential communities, and private entrances at all times. The phases in the Design-Builder’s suggested sequence of construction that accompany an approved work package shall be followed unless the Design-Builder submits and secures Department approval for a sequence which will both expedite construction while lessening the effect of such construction upon the traveling public.

B. Work zone information shall be shared with the Department’s Eastern Region Operations (ERO) Advanced Traffic Management System (ATMS) and any other regional ATMS and shall be approved by the Department.

C. The Design-Builder shall provide a primary TMP engineer to perform the following:

1. Coordinate implementation of the TMP as developed by the Department
2. Oversee the design and implementation of the Temporary Traffic Control (TTC) Plans
3. Coordinate TMP activities with the public and community outreach staff and the Department as part of the Public Communication Plan
4. Implement traffic management strategies
5. The TMP engineer or an approved designee shall be continuously available during construction until Project Completion and elimination of all construction traffic control.

D. The Design-Builder shall prepare traffic analyses and modeling for TTC for all construction phases and stages, exclusive of closed work identified in the Agreement, to identify traffic impacts. The Design-Builder shall use analytical and deterministic (HCM-based) analyses, supplemented with traffic simulation and optimization tools for the analysis as identified in the TOSAM. Traffic analysis and modeling shall also be required for all construction activities requiring a detour, requiring closure of multiple lanes, or deviating in any way from what is set forth in the Agreement.
E. Traffic analyses will vary depending on the magnitude of the closure, detour, or other change. The scope of the traffic analyses and the assumptions to be used will be determined in a meeting held with the Department.

F. All TTC plans and documents shall have a valid digital seal of the Professional Engineering working as TMP engineer.

G. All Temporary Traffic Controls shall be shown on Approved for Construction Plans.

H. Only TL-3, Type I Re-Directive Impact Attenuator shall be used on interstates, limited access highways, major arterials and its associated ramps unless otherwise approved by the Department in its sole discretion. TL-3, Type II Non-Redirective Impact Attenuator may only be used with movable barrier.

I. All stages and phases of construction, including installation and testing of the Electronic Toll Collection (ETC) system, shall be covered by a TTC plan.

J. If any sidewalk, bicycle, or shared use paths is affected by detours onto surface roadways, detours of bicycle, pedestrian and disabled users will be included in TTC plans.

K. If additional traffic counts are required, it will be the responsibility of the Design-Builder to collect such data. The Design-Builder shall note that any proposed detour utilizing local neighborhood streets that are maintained by the City of Hampton or the City of Norfolk will require the coordination and detailed impact analysis per IIM-LD-241.7 using the TOSAM manual, with the applicable locality, as appropriate and are subject to the terms and conditions of Department’s approval. Detour plans shall be provided in accordance with Section 13.3.4 Lane and Road Closure Restrictions.

L. In addition to the requirements of the Design-Builder’s approved Transportation Management Plan, the Design Builder shall provide the following:

1. Portable Changeable Message Signs (6 units) that can be remotely controlled from the Hamptons Roads TOC and shall be placed/relocated by the Design-Builder at mutually agree locations.

2. Portable Camera Trailers (2 units) that can be remotely controlled from the Hampton Roads TOC and shall be placed/relocated by the Design-Builder at mutually agreed locations.

3. “Truck Entering Highway” warning/queue systems as needed on I-64 for the Design-Builder’s construction operations.

M. The Design-Builder shall be responsible for coordinating a uniformed law enforcement officer with a law enforcement vehicle equipped with an emergency light during set-up and take-down of all daytime closures involving two or more lanes of traffic, engaged in a passive mode unless directed by the Department.

N. The Design-Builder shall coordinate the location of emergency crossovers with law enforcement and emergency services and shall maintain existing emergency crossover access during construction as coordinated with law enforcement, emergency services, and the Department.

O. The Design-Builder shall develop detour plans and submit to the Department for approval. The Design-Builder shall coordinate detour plans with local, state, and federal agencies (including the U.S. Navy) as applicable, and submit and update the TTC plan thirty (30) days in advance of any planned detour activity. The Design-Builder shall be responsible for all planning, consultation, and coordination with impacted parties, design, implementation and monitoring, and maintenance of detours – whether within or outside the Project Right of Way. The provision of detours and
marking of alternative routes will not relieve the Design-Builder of the responsibility for ensuring the safety of the public or from complying with any requirements of the Agreement.

P. The Design-Builder that identify Right-of-Way requirements for temporary highways, diversion channels, sediment and erosion control features, or bridges required by the Technical Requirements in plans provided to and approved by the Department.

Q. During any suspension of Work, the Design-Builder shall temporarily open to traffic such portions of the Project and temporary roadways as may be agreed upon by the Design-Builder and the Department.

R. Unless a Design Exception or Design Waiver is granted, the geometric design for temporary roadways and temporary traffic control shall be designed, at a minimum, to the existing posted speed.

S. Certified flaggers shall be provided in sufficient number and locations as necessary for control and protection of vehicular and pedestrian traffic in accordance with the requirements of the VWAPM. Flaggers shall be able to communicate to the traveling public in English while performing the job duty as a flagger at the flagger station. Flaggers shall use sign paddles to regulate traffic in accordance with the requirements of the VWAPM. Flagger certification cards shall be carried by the flaggers while performing flagging duties. Flagger found not to be in possession of their certification card shall be removed from the flagging site and operations requiring flagging will be suspended by the Department. Further, flaggers performing duties improperly will have their certifications revoked.

T. Long-term closures of the shoulders adjacent to the general-purpose lanes are allowable provided the closure is separated by concrete barrier as approved by the Department.

U. Where concrete barriers are used to close the shoulder, the Design-Builder will be required to provide pull-off areas per the requirements of the VWAPM.

V. Connections with roads and public and private entrances shall be kept in a reasonably smooth condition at all times. Stabilization or surfacing material shall be applied to connections and entrances.

W. All temporary traffic signal plans shall be submitted to the Department for review and approval prior to construction phase, detour or traffic shift. The Design-Builder is responsible for notification of travelling public in advance of the shift, for implementing any detour or traffic shift, and upon execution review of the TTC plan in accordance with the requirement of Section 13.3.3 Transportation Operations Plan below, including immediate assessment of effectiveness (within 24 hours of any such detour or shift) of the TTC measure and modifications as required to ensure safe travel through the work-zone for construction crews and the traveling public. Per requirements of Section 13.3.3.E all detours and shifts will be assessed weekly by Department staff with the Design-Builder responsible for corrective actions as soon as practicable.

X. Construction signs and pavement markings (temporary) shall be installed, maintained, adjusted, and removed by the Design-Builder throughout the duration of the Project.

Y. All entrances, intersections or pedestrian access points/routes that will be affected by the work zone or by the traffic control devices will be maintained or an acceptable alternate must be provided by the Design-Builder.

Z. If Traffic Barrier Service Concrete (TBSC) is warranted based on the criteria for determining the application of barrier per the 2011 Work Area Protection manual and a completed Engineering and Traffic Investigation-Work Zone Channelization/Barrier Analysis, the guidelines provided in the Roadway Design Manual and IIM-LD-93.18 shall be utilized.
AA. The minimum lane width for temporary traffic control on I-64 shall be 11 feet with a 9-foot paved right shoulder. When TBSC is used, a minimum of one foot shall be provided from the back of barrier to the saw cut line at the edge of the existing pavement and from the face of barrier to the edge of traveled way. The 11-foot lanes and the 9-foot paved shoulder must be provided for the entire work zone except at the following locations:

1. Settler’s Landing Road
2. 4th View Street
3. Granby Street

At these bridge locations 11-foot lanes may be used with a minimum of 2-foot shoulders on each side of traffic. The minimum lane width for temporary traffic control on all other routes shall be 11 feet. Any deviation from these widths noted above shall require concurrence from Department.

BB. The Design Builder shall maintain existing signals until the new signal is functional, which may require modifications to existing signal to adapt to the Design-Builder’s TMP. Should a modification be necessary, the Design-Builder shall develop a temporary signal plan accommodating all phases of the TMP and submit with the permanent signal plan as part of the Department review.

CC. All long-term stationary work zones on I-64 shall use the “Work Zone $500 Max. Fine for Exceeding Speed Limit When Flashing” signs and shall meet all requirements for fine signs in work zones.

DD. Long term work zones on I-64 shall meet the following requirements:

1. Pull-off areas meeting TTC-8.0 requirements shall be provided in all long-term stationary work zones on I-64 with activity areas greater than 1 mile in length. Maximum spacing between pull-offs shall be 1 mile.
2. Strengthening of the existing outside paved shoulder shall be required if temporary travel lanes overlap with the shoulder to maintain traffic during construction.
3. All long-term stationary work zones on I-64 shall include temporary acceleration and deceleration lanes for access to and from the work space. This access shall meet the guidance included in Section 6G.27 of the WAPM.

EE. I-64 is a primary hurricane evacuation route for the Hampton Roads region. Evacuation plans consist of a lane reversal of the eastbound travel lanes to accommodate westbound traffic (towards Richmond). All TTC measures applied to the eastbound side of I-64 must be designed to accommodate lane reversal as part of any evacuation order from the Governor or Virginia Department of Emergency Management (VDEM), in coordination with state and local law enforcement agencies. The Design-Builder shall be responsible for implementation of any lane reversal through the work zone. In the event of an emergency, the Design-Builder shall comply with emergency management and law enforcement officials to ensure proper measures are taken within the work zone to allow for lane reversal. This shall be identified in the TMP.

FF. The work space shall include continuous camera coverage. This includes, but is not limited to access for emergency and incident response vehicles through the entire length of the work zone (except at bridges) and four (4) wireless closed circuit television cameras. The Design-Builder is responsible for determining the wireless camera locations in coordination with the IMC and the VDOT TOC, based on the phase of work, proposed lane closures, and maintenance of traffic through the work area. The Department shall have access to cameras for viewing by the Hampton Roads Traffic Operations Center (TOC).
13.3.2. Public Communication Plan

The Public Communications Plan (PCP) shall be prepared and submitted to the Department for review and approval. This PCP is required and shall provide the following information (this information may be presented in a narrative format or as a separate Special Provision Copied Note):

A. A process to notify the Department of scheduled work plans and traffic delays.
B. A process to notify the Department of any unscheduled traffic delays.
C. A process for notifying Public Safety, Emergency Management and mass transit organizations (Hampton Roads Transit) of detour route(s) and available alternate routes during construction.

13.3.3. Transportation Operations Plan

The Design-Builder shall prepare the Transportation Operations Plan (TOP) and submit to the Department for review and approval. The PCP shall provide the following information.

A. A process to notify the Hampton Roads Regional Transportation Operations Center (HRTOC) to plan lane-closure information on the 511 system and VA-Traffic.
B. A contact list for local emergency response agencies.
C. Procedures to report to traffic incidents that may occur in the work zone.
D. A process to notify the Department of any incidents and expected traffic delays.
E. Details of the process to review incidents for modifying the Temporary Traffic Control Plan to reduce the frequency and severity of such incidents. The Design-Builder shall conduct daily and weekly MOT inspection to ensure all traffic devices and traffic patterns comply with the VWAPM and MUTCD standards. A weekly MUTCD report shall be provided to the Department and include the following:
   1. Date discrepancy was identified
   2. Description of discrepancy
   3. Corrective action required
   4. Date corrective action should be taken
   5. Date corrective action was completed
F. The Design-Builder shall schedule construction operations so that approved continuous access is provided for all roads, sidewalks, shared use paths, and properties. Connections or entrances shall not be disturbed by the Design-Builder until necessary. Once connections or entrances have been disturbed, they shall be maintained and completed as follows:
   1. Connections that had an original paved surface shall be brought to a grade that will smoothly and safely accommodate vehicular traffic through the intersection, using pavement. Connections that had an original unpaved surface shall be brought to a grade that will smoothly and safely accommodate vehicular traffic through the intersection, using either the required material or a temporary aggregate stabilization course that shall be placed as soon as practicable after connections are disturbed.
   2. Mainline connections shall have all lanes open during construction. If delays occur in prosecution of work for other connections, connections that were originally paved shall have at least two lanes maintained with a temporary pavement surface. Those that are not originally paved shall be maintained with a temporary aggregate stabilization course.
3. Maintain access and egress connections shall have all lanes open during the construction unless otherwise agreed with the Department. Other entrances shall be graded concurrently with the roadway with which they will intersect. Once an entrance has been disturbed, it shall be completed as soon as practicable, including placing the required base and surface course or stabilization. If the entrance must be constructed in stages, such as when there is a substantial change in elevation of the roadway with which it intersects, the surface shall be covered with a temporary aggregate stabilization course or other suitable salvaged material until the entrance can be completed and the required base and surface or stabilization course can be placed.

G. When the Design-Builder elects to complete the rough grading operations for the entire project or exceed the length of one full day’s surfacing operations, the rough grade shall be machined to a uniform slope from the top edge of the existing pavement to the ditch line.

H. When the surface is to be widened on both sides of the existing pavement, construction operations involving grading or paving shall not be conducted simultaneously on sections directly opposite each other. The surface of pavement shall be kept free from soil and other materials that might be hazardous to traffic. Prior to opening of new pavement to traffic, shoulders shall be roughly dressed for three (3) feet from the edge of paved surface.

I. Where the Design-Builder places obstructions such as suction or discharge pipes, pump hoses, steel plates, or any other obstruction that must be crossed by vehicular traffic, they shall be bridged in accordance with plans submitted by the Design-Builder and approved by the Department. Traffic shall be protected by the display of warning devices both day and night. If operations or obstructions placed by the Design-Builder damage an existing travelled roadway, the Design-Builder shall cease operations and repair damages.

J. Where existing hydraulic cement concrete pavement is to be patched, the Design-Builder shall restore all repaired pavement at the end of each shift such that the travel lane is open for use. Failure of the Design-Builder to comply with the time framed listed in the Agreement shall subject the Design-Builder to associated Liquidated Damages for Lane Closures. Necessary precautions shall be taken to protect traffic during patching operations.

K. The Design-Builder shall construct, maintain, and remove temporary structures and approaches necessary for use by traffic. After new structures have been opened to traffic, temporary structures and approaches shall be removed. The proposed design of temporary structures shall be submitted to the Department for its approval together with other associated Design Documentation prior to Limited Notice to Proceed.

L. If the Design-Builder fails to remedy unsatisfactory maintenance not complying with these Technical Requirements after receipt of a written notice by the Department, the Department may proceed with adequate forces, equipment, and material to maintain the project, without interference from the Design-Builder. The cost of the maintenance, plus twenty-five (25) percent for supervisory and administrative personal (including fully burdened wages plus overhead), will be paid by the Design-Builder.

M. The Design-Builder shall enter or shall cause to enter all lane closures on a weekly basis with appropriate daily confirmations for accuracy into the Department’s Lane Closure Advisory Management (LCAM) system.

N. All TTC plans affecting and adjacent to HRT facilities or operations are subject to review and approval by HRT.

O. All temporary traffic signal plans shall be submitted to the Department for review and approval prior to the Construction Phase, detour, or traffic shift. Construction signs and pavement
markings (temporary) shall be installed, maintained, adjusted, and removed by the Design-Builder through the duration of the Project.

P. Sidewalk or shared use path connections that had an original paved surface shall be brought to a grade that will smoothly and safely accommodate pedestrian and bicycle traffic through the intersection.

Q. Any field work performed which impacts travel lanes or shoulders, including but not limited to construction, geotechnical investigations, and survey, shall have an incident management plan developed and approved by Department prior to the start of field work.

R. As part of the TMP, the Design-Builder shall include an Incident Management Plan (IMP) to ensure the Design-Builder is prepared to respond to all incidents along the construction corridor. The IMP shall be submitted for review and approval by Department. No work zones (short-term or long-term) shall be permitted on the project until an IMP has been approved by Department and is in place, including shoulder and/or lane closures. The Design-Builder shall coordinate with appropriate Department, EMS, and stakeholders during the development of the plan and hold a stakeholder meeting to brief them on the IMP. The IMP shall address at a minimum the following with respect to incident management:

1. 24/7 point of contact for emergency notification of incident by TOC
2. Emergency detour routes and sign layout plans in addition to TMP signage
3. Agency and stakeholder Responsibilities Matrix/Checklist
4. Pre-staged detour equipment and material needs (i.e.; barrels, portable message boards, signage, etc.) as defined in the sign layout plans that shall be provided by the Design-Builder
5. Coordination with VDOT Hampton Roads TOC, located at 970 Reon Drive in Virginia Beach
6. Signage of emergency detour routes
7. Coordination with 1st responders, Sentara Norfolk General Hospital (Level I Adult Trauma), Children’s Hospital of the Kings Daughters (Level I Pediatric Trauma), Riverside Regional Medical Center (Level II), and other hospitals and stakeholders in project area
8. Law Enforcement, Fire, and Rescue access to the road network during incidents
9. Pre-planned Messages for various types of incidents for the portable DMS
10. Contact list for appropriate stakeholder response personnel.

S. As part of the IMP, the Design-Builder shall furnish all labor, equipment, supervision and qualified personnel to perform wrecker service to remove disabled vehicles within the Project limits. The wrecker shall have one Roll Back Wrecker with the ability to “snatch & go” on site 24 hours a day, and one light duty wrecker on site between the hours of 7 AM to 7 PM Monday through Friday whenever a long-term stationary work zone is in place, and shall drop the disabled vehicles at a public lot located within one mile of the project and to be agreed upon by the Design-Builder, VSP, and Department. In addition, the Design-Builder shall have access to a Heavy Duty (Rotatory Style) Wrecker that is available within thirty (30) minutes between 5 AM and 9 PM, and forty-five (45) minute at all other times when notified. Each wrecker shall be equipped with overhead emergency lights, rear floodlights, wheel lift and all other standard safety items required for wreckers. Under no circumstances shall a vehicle involved in a crash be removed or disturbed by the wrecker until the Virginia State Police or other law enforcement agency gives approval. The wreckers shall maintain a phone in each vehicle at all times.
T. Available alternate routes for incident management are network roadways adjoining the Project’s segments of I-64 include on the Hampton side Settlers Landing Road, Emancipation Drive/Martin Luther King Jr. Boulevard, Woodland Road, W County Street, Downes Street, and S. Mallory Street. On the Norfolk side alternative routes include W Ocean View Avenue, 4th View Street, Tidewater Drive, and Granby Street. These routes vary in speed limit, traffic control and number of lanes. These roads can be used to navigate around lane closures or incidents in the Project. The Design-Builder shall coordinate with the Department and localities to determine allowable alternative routes and detours. The Design-Builder shall be responsible for all detour signage and traffic control measures required. As necessary, this work shall extend beyond the defined Project Limits. Proposed changes to the signal timing for any signals on detour routes shall be submitted by the Design-Builder to the Department and municipalities for approval. The Design-Builder shall prepare Incident detour plans with appropriate signage for use in the field.

U. The Design-Builder shall provide a Contractor Incident Management Coordinator (CIMC). This individual shall respond to all incidents within the project limits and serve as VDOT’s representative applying National Incident Management System (NIMS) principles and practices. The CIMC will be the key point of contact for issues arising relative to incident management and shall be required to be on site for the duration of construction operations. This individual shall demonstrate successful completion of the following training classes: FHWA SHRP2 “TIM” Responder Training; FEMA ICS/NIMS 100, 200 & 700; an approved Hazardous Materials training course, or a statement shall be included indicating this individual will complete these classes prior to Notice to Proceed. The duties of the IMC shall include the following:

1. Presence on site during all construction operations.
2. Assist the VDOT IMC/Public Safety in coordinating a kick-off meeting with all first responder stakeholders prior to beginning construction operations on the project.
3. Distribute monthly updates, at a minimum, to the VDOT IMC providing a summary of crashes within the work zone, number of events requiring tow service, and recommendations, if any, to improve the safety of travel through the project.
4. Respond to all incidents within the Project Limits.
5. Abide by the VDOT safety regulations (hardhats, vest, etc.).
6. Work under the VDOT IMC when on the scene of an event.
7. Serve as the VDOT Incident Commander until the VDOT IMC arrives at an event.
8. Attend a two-week Orientation training with VDOT IMC.
9. Have a truck equipped for Incident Management as defined in Attachment 2.10.2-1 and shall be labeled “Incident Management”.
10. Supply the VDOT TOC with a portable radio to contact the CIMC on the scene and for the CIMC to contact the TOC as needed. The radio shall be capable of contacting the TOC from any location within the project limits.
11. Attend all IM meetings (Public Safety Meetings) for the project.
12. Meet one a week/as needed with VDOT IMC to discuss project.
13. Work closely with all emergency agencies—Virginia State Patrol (VSP), Fire, Local Police, and EMS.
14. Complete “After Action” Reports for all incidents (Level 3) in the work project by VDOT IMC.
V. If an incident on I-64 within the project requires the use of a detour, the Design-Builder shall implement the detour as shown in approved Incident Detour Plans. For any other activity that requires the use of a detour, the Design-Builder shall coordinate with the Department and localities to determine allowable alternate routes and detours. The Design-Builder shall be responsible for all detour signage and traffic control measures required. As necessary, this work shall extend beyond the defined Project limits. Proposed changes to signal timing for any signals on detour routes shall be coordinated with the respective signal owner.

W. Upon notification from the TOC of an incident requiring a detour, the Design-Builder shall establish the detour within one hour from 5 AM-9 PM daily. The Design-Builder shall establish the detour within two hours during all other times not referenced.

X. The Design-Builder shall coordinate with the Hampton Roads TOC. The Hampton Roads TOC will coordinate with the appropriate State and Local authorities. Incident times shall be based on those recorded at the Hampton Roads TOC Traffic Management System.

13.3.4. Temporary Barrier Service Concrete Anchoring Requirements

A. Traffic Barrier Service Concrete (TBSC) is designed to prevent an errant vehicle from entering a work zone. NCHRP 350 and the “Manual for Assessing Safety Hardware” (MASH) testing have provided lateral deflection distances for various barrier designs. The distances these barriers deflect may pose a hazard to workers and motorists in the work area if materials, equipment and workers are adjacent to and within the deflection area of the barrier. Additionally, TBSC placed on bridge structures are subject to movement caused by the vibration of vehicles, principally large trucks, when they traverse the structure. If TBSC is warranted based on the criteria for determining the application of barrier per the 2011 Virginia Work Area Protection Manual and completed Work Zone Channelization/Barrier Analysis, the following guidelines shall be used to determine if staking or bolting the TBSC is appropriate. Anchoring the TBSC, defined as the act of staking or bolting barrier in accordance with MB-10A and MB-11A standards, shall be required when the following conditions exist:

- Where barrier is placed within 2 feet of an excavation/drop-off greater than or equal to 4 feet deep.
- Where the barrier is used on bridge decks or as a parapet.
- Where materials and/or equipment are stored within the standard deflection area for more than 3 days.
- Where workers are present within the deflection area of TBSC placed on the outside of horizontal curves that have centerline radius less than 1000 feet.

B. For determining anchoring requirements, the standard deflection area shall be two feet in locations with a speed limit of 45 mph or less. For locations with speed limits more than 45 mph, Table 2 in Appendix A of the Virginia Work Area Protection Manual, Traffic Barrier Service Concrete Deflection Table, shall be used to determine the deflection area. If the Manufacturer of the barrier to be used is not known at the time traffic control plans are being developed for locations more than 45 mph, Designers and Engineers should use the VDOT pin and loop positive connection Precast Concrete Median Barrier (MB-INS) 6-ft dynamic deflection as the design criteria in determining anchoring requirements.

C. If bolting or staking the TBSC is required, it shall be indicated on the plan sheet and in accordance with the MB-10A or MB-11A standards.
D. An exception to the above guidelines for bridges may be permitted, with the approval of the Regional Traffic Engineer in coordination with the Department, provided the following conditions are met:

1. No through openings in the bridge deck.
2. One open lane for traffic with a stop/yield condition or temporary traffic signal controlling traffic.

E. The Design-Builder should refer to the Road and Bridge Standards for specific details on anchoring MB-10A and MB-11A.

13.3.5. Lane and Road Closure Restrictions

A. Department acknowledges that temporary lane closures may occasionally be required; however, temporary lane closures are only allowed at the sole discretion of Department when necessary to ensure the safety of the traveling public and no practical alternative exists. Offeror’s Technical and Price Proposals shall be developed to meet the required lane, shoulder, or road closure restrictions specified in this section. Any proposed deviations from these allowable lane closures shall be addressed in accordance with this section.

B. The Design-Builder shall submit all lane and/or shoulder closure requests to the Department for coordination purposes (for determination of conflicts with other projects, for instance) at least seven (7) days in advance of the proposed lane and/or shoulder closure and no later than close of business Wednesday the week prior to closure, stating the location, purpose, date, time, and duration of the closure. The Design-Builder shall be responsible for entering the information to the VDOT Lane Closure Advisory Management System (LCAMS) and VA511 Systems in accordance with SP 801-000100-01 regarding Lane Closure Coordination/Lane Closure Implementation. The Design-Builder shall confirm at least twenty-four (24) hours before any scheduled lane and/or shoulder closure and shall include a written reiteration of the proposed tasks and a listing of materials, labor, and equipment to be utilized, for TOC to confirm the information on the VDOT website and VA511 system. On non-VDOT owned routes, the Design-Builder shall be responsible for coordinating the closure with the local agency and securing any necessary permits.

C. The Design-Builder is responsible for providing advance notification via variable message and required static signing for lane and/or shoulder complete road closures in accordance with the Virginia WAPM. Once a closing is in place, work shall commence immediately and shall progress in a continuous basic to completion or to a designated time.

D. If the Design-Builder is unable to remove the lane and/or shoulder closure by the stipulated time the Design-Builder shall not be allowed further lane closures until the reasons for the failure are evaluated and the Design-Builder can provide assurance that the causes have been corrected. A formal submission as to the reasons for the failure to restore traffic lanes within the contract lane closure restrictions and the proposed corrective measures is to be provided to the Department within two (2) days of the occurrence. The Department will respond to the adequacy of the submission within two (2) working days of receipt. No consideration for extension of time and no additional compensation will be granted for these days.

E. The Department reserves the right to monitor traffic conditions impact by the work and to make additional restrictions as may be necessary including but not limited to terminating a lane closure early or rescinding a previously approved exception to the allowable work hours or as emergency situations dictate (this includes but is not limited to any type of traffic congestion and/or vehicle
delay that the Department deems unacceptable. These additional lane closure restrictions, if enforced, shall not alter the required construction fixed completion date.

F. All long-term duration lane, shoulder, or road closures shall be detailed in the Design-Builder’s Transportation Management Plan and must be coordinated and approved by Tunnel Operations for both the Hampton Roads Bridge-Tunnel (HRBT) and the Monitor-Merrimac Memorial Bridge-Tunnel (MMMBT). Specifically, lane closures in the WB side of I-64 through the HRBT shall not be permitted at the same time a lane closure is occurring on the NB side of I-664 through the MMMBT. Similarly, lane closures on the EB side of I-64 through the HRBT shall not be permitted at the same time as a lane closure on the SB side of I-664 through the MMMBT. One lane will remain open at all times in each tube of the HRBT. Long-term road closures of either tube of the HRBT will not be allowed. Anticipated and proposed temporary (mobile, short, short-term, and intermediate-term durations) lane and/or shoulder closures shall be reviewed and approved by the Department. The Design-Builder shall restore all lanes of traffic per the times specified in this section. Restoration of traffic shall mean the completion of all construction work, the removal of all traffic control devices, signs, workers, materials, and equipment from the roadway.

Table 13.3.5-1 (Summer April 15 to October 15)

<table>
<thead>
<tr>
<th>INTERSTATE 64</th>
<th>Weekday</th>
<th>Eastbound (Summer)</th>
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<tbody>
<tr>
<td>US 60/Settlers Landing Rd (Exit 267) to I-564/Rt. 460/Granby St. (Exit 276)</td>
<td>Short-term Complete Road Closure* (20 min. or less)</td>
<td>Short-term Complete Road Closure*</td>
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<td>8:00 PM to 5:00 AM No Shoulder Closures 5:00 AM to 9:00 AM</td>
<td>12:00AM to 4:00AM</td>
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<tr>
<td>All lanes open at 12:00 noon on Friday</td>
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</tr>
<tr>
<td>I-564/Rt. 460 Granby St. (Exit 276) to Rt. 169 Mallory St. (Exit 268)</td>
<td>Westbound (Summer)</td>
<td></td>
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<tr>
<td></td>
<td>Single-Lane Closures or Shoulder</td>
<td>Short-term Complete Road Closure* (20 min. or less)</td>
</tr>
<tr>
<td></td>
<td>8:00 PM to 5:00 AM No Shoulder Closures 5:00 AM to 9:00 AM</td>
<td>8:00 PM to 5:00 AM</td>
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<tr>
<td>All lanes open at 11:00am on Friday</td>
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<tr>
<td>WEEKEND</td>
<td>Eastbound (Summer)</td>
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<tr>
<td>Friday to Saturday</td>
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<td>Saturday to Sunday</td>
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<td>Sunday to Monday</td>
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<tr>
<td>WEEKEND</td>
<td>Westbound (Summer)</td>
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<tr>
<td>Friday to Saturday</td>
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<td></td>
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### Table 13.3.5-2 (Non-Summer October 16 to April 14)

#### INTERSTATE 64

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<thead>
<tr>
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<tr>
<td>Eastbound (Non-Summer)</td>
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<td>7:00 PM to 5:00 AM No Shoulder Closures 5:00 AM to 9:00 AM</td>
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<td>7:00 PM to 5:00 AM</td>
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<tr>
<td><strong>WEEKEND</strong></td>
<td></td>
<td></td>
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<tr>
<td>Eastbound (Non-Summer)</td>
<td>Single-Lane Closures or Shoulder</td>
<td>9:00 PM to 7:00 AM</td>
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<td>9:00 PM to 7:00 AM</td>
<td>9:00 PM to 7:00 AM</td>
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<td>Sunday to Monday</td>
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<td>9:00 PM to 5:00 AM</td>
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<td>Westbound (Non-Summer)</td>
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<tr>
<td>Sunday to Monday</td>
<td>8:00 PM to 5:00 AM</td>
<td>8:00 PM to 5:00 AM</td>
</tr>
</tbody>
</table>

G. These allowable hours are applicable to stationary (short, short-term, and intermediate-term durations) and mobile single lane closures on the mainline and CD roadway, shoulder closures, partial/full ramp closures, and full directional closures not exceeding 20 minutes. The Department will consider changes to the allowable lane closure hours only if the Design-Builder can demonstrate why the proposed work cannot be completed within the contract allowable lane closure hours. All requests shall include an assessment of the work zone traffic impacts using a sketch planning traffic analysis tool and/or operational level traffic analysis software program is
listed in VDOT’s TOSAM and shall be signed and sealed by a PE and be submitted for approval by the Department at least 30 days prior to the operation impacting the lanes. Traffic Engineering will provide an assessment of the work zone traffic impacts within two (2) weeks, and send the request to the Regional Operations Director for review and approval.

H. All existing travel lanes in each direction on I-64 shall be maintained at all times except for the allowable hours for lane closures listed in Table 13.3.5-1 and Table 13.3.5-2.

I. Full directional closures, not exceeding 20 minutes, meeting TTC-50.0 requirements are allowed daily at times identified in Tables 13.3.5-1 and 13.3.5-2 when lane closures of one lane are allowed, excluding Friday night to Saturday morning. Total closures needed for any of the projects for work that includes but is not limited to installation and removal of overhead sign structures, and erection of bridge members shall require the Design-Builder to coordinate with the Department and all significant stakeholders that include but are not limited to the Cities of Hampton and Norfolk, Hampton University, the VA Medical Center Hampton, Naval Station Norfolk, state and local law enforcement, and fire and rescue agencies. In addition, public notice shall be displayed on message boards 72 hours in advance of the closure event. Total closures shall be limited to ten (10) through the life of the project. Any additional closures shall be requested and approved by the Department.

J. Partial ramp closures are allowed at any time a shoulder closure is allowed on the Interstate. No shoulder closures are allowed in the project area between 5:00 am and 9:00 Monday to Friday. Full exit ramp closures during the time periods shown in Tables 13.3.5-1 and 13.3.5-2 when the interstate is allowed to be reduced to a single lane. The allowable hours for full entrance ramp closures shall be determined by the locality. Any proposed ramp closures outside of the allowable hours or any temporary reconfiguration of the ramps at the interchanges within the project limits will require a complete and detailed traffic analysis that must be coordinated and approved by Department and the locality that the reconfigured ramp is within.

K. The HOT/HOV Reversible Roadway between I-564 and I-264 can be closed to traffic at anytime except 4:00 am to 9:00 am and 2:00 pm to 9:00 pm Monday through Friday.

L. Detour plans will be required for any proposed temporary total road closures exceeding 20 minutes, and are subject to Department review and approval as part of the Design-Builder’s TMP. In addition to addressing the traffic analysis requirements in I&IM 241, the Design-Builder shall demonstrate in its detour plan(s) efforts to minimize impacts to the community (including noise, access, additional travel time, etc.), and address geometry, safety (including accident analysis along the detour route), capacity, and existing roadway conditions.

M. Total closures for such work as installation and removal of overhead sign structures, demolition of existing bridges, erection of bridge members or with substantiation of need by the Design-Builder will require coordination with appropriate stakeholders and public notice.

N. For closure on routes other than I-64, the Design-Builder shall follow any additional requirements as deemed necessary by the local jurisdiction.

O. In addition to the work restrictions for Holidays in Section [X.X] (Limitation of Operations), the following events shall also be considered Holidays, and therefore shall be subject to the same restrictions:

1. Martin Luther King Jr. Day
2. Lee Jackson Day

The Design-Builder may present traffic impact analysis for Department consideration to get additional work hours and closures for these holidays, subject to Department approval:
1. President’s Day
2. Columbus Day
3. Veteran’s Day

P. The Design-Builder is responsible for providing advance notification via variable message a minimum of one week in advance of the closure and required static signing for lane and/or shoulder and complete road closures in accordance with the 2011 Virginia Work Area Protection Manual. Once a closing is in place, work shall commence immediately and shall progress on a continuous basis to completion or to a designated time.

Q. The Design-Builder shall coordinate and host weekly MOT/Lane Closure meetings and invite all stakeholders identified in the TMP. This meeting shall address all upcoming lane closures, road closures and detours, changes in schedule impacting milestone dates that require changes in existing traffic patterns, and location and messages of PCMS’s.

R. If the Design-Builder is unable to remove the lane and/or shoulder closure by the stipulated time the Design-Builder will not be allowed further lane closures until the reasons for the failure are evaluated and the Design-Builder can provide assurance that the causes have been corrected. A formal submission as to the reasons for the failure to restore traffic lanes within the contract lane closure restrictions and the proposed corrective measures is to be provided to the Department within two (2) days of the occurrence. The Department will respond to the adequacy of the submission within two (2) working days of receipt. No consideration for extension of time and no additional compensation will be granted for these days.

S. The Department reserves the right to monitor traffic conditions impacted by the work and to make additional restrictions as may be necessary or as emergency situations dictate. Additional restrictions for other holidays or special local events may be necessary, however, in these situations the Department will endeavor to inform the Design-Builder at the earliest and in no case less than forty-eight (48) hours prior to the event.

13.3.5.1. Allowance for Additional Lane Closure Restriction by the Department and/or Design-Builder Request for Additional Lane Closures

A. At the Department’s reasonable discretion and approval, the Design-Builder may submit a request to Work outside the stated lane closure hours by providing adequate justification (including traffic analysis) demonstrating the viability of the request.

B. Closures of longer durations than those listed in Section [X.X] will require a review of plans, implementation of detours, and public outreach.

C. The Department reserves the right to monitor traffic conditions affected by the Work and to make additional restrictions as may be necessary, such as terminating a lane closure early or adjusting the I-64 Project’s allowable lane closure hours.

D. General Requirements:
   1. The Department will track any additional lane closure time granted outside of time allowed in the Agreement.
   2. Any additional time granted must comply with all the requirements set forth in the Agreement.
   3. The Design-Builder acknowledges that there will be instances where the Design-Builder may not be allowed to implement an approved lane closure during events that are beyond the Department’s control.
4. The Department will track all instances where the Design-Builder is directed by the Department not to implement any lane closures for special events such as, but not limited to, the following list:
   a. Presidential motorcades traveling through project limits
   b. Special events with regional impacts
   c. Special sport events with regional impacts
   d. Major accidents/Incidents with regional impacts
   e. Seasonal traffic patterns

E. Calculating Hours:
   1. Additional time (lane closures) – Any additional time requested by the Design-Builder and granted by the Department beyond the approved hours within the Agreement will be added for every instance and every location at 15-minute intervals.
   2. Additional Time (complete closures) – If a full closure of roadway not specified in the Agreement is implemented in lieu of 30-minute total temporary closure, hours will be calculated in the same manner as the hours that were requested/approved for the specific closure.
   3. Time Deducted – When the Design-Builder is not allowed to implement a lane closure by the Department during the approved hours within the Agreement, the hours during which such lane closure is not allowed will be deducted from the total hours accumulated.

F. Documentation:
   1. Within the first 60 days, the Department and Design-Builder will develop and agree on a format of documenting this information. The form should at least contain date, hours allowed, hours disallowed, impacted time and other agreed upon elements.
   2. By the 10th of each month, the Department and Design-Builder will reconsolidate and agree on the resultant number of hours allowed/disallowed.

G. Allowance:
   1. At the end of the Project, the Department and the Design-Builder will reconcile the resultant impacted time or additional granted time by subtracting the additional time granted by the Department from the time Design-Builder was disallowed per the Technical Requirements in accordance with the Agreement to implement the lane closures. The Department and Design-Builder will endeavor to maintain a neutral balance of resultant impacted and additional granted time throughout the duration of the Project.
   2. Any lane closures affected by inclement weather, snow and snow removal process, Emergency Department maintenance repairs safety shutdowns and from major accidents are not subject to above allowance and are excluded from the calculations and compensations.

H. General
   Notwithstanding anything to the contrary, it is agreed that:
   1. The Department will provide the Design-Builder with as much notice as is possible with respect to any lane closure request by the Design-Builder which is not approved by the Department.
2. The Design-Builder will provide the Department with as much notice as is possible with respect to any inability of the Design-Builder to implement lane closures which are otherwise allowed within the Agreement.

3. At the end of the Project, the Department and the Design-Builder will reconsolidate the impacted time by subtracting the additional time granted by the Department from the time the Design-Builder was disallowed per the technical requirements to implement the lane closures. If the Department disapproves requests for lane closures from Design-Builder, or otherwise prevents the Design-Builder from implementing lane closures which are otherwise permitted by the Agreement, and the impact of such actions by the Department is more than 120 cumulative hours, such actions may constitute a Change Order.

13.3.6. Damage Recovery

Damage recovery/user costs will be assessed against the Design-Builder if all lanes/ramps on I-64 are not open to traffic by the time required in the approved request for temporary lane closure. Costs will be assessed as stated in VDOT Special Provision for Limitations of Operations, November 29, 2016. For all other routes, the Design-Builder shall be subject to the conditions of the permit issued by the local agency.

13.3.7. Use of Virginia State Police

The Design-Builder shall be responsible for coordinating through the Department for Virginia State Police (VSP) service during Temporary Traffic Control operations involving lane closures and/or rolling lane closures, and any other operation as covered in Appendix C of the Virginia Work Area Protection Manual. The Design-Builder shall be responsible for the scheduling of VSP services a minimum of one week in advance and for documenting the hours of use on the project. The Department shall be responsible for all costs incurred by VSP specific to the Project.

13.3.8. Portable Changeable Message Signs

Portable Changeable Message Signs (PCMS’s) shall be used in advance of the work zone when closing or shifting lanes within the Project limits. The Design-Builder shall provide at least eight (8) PCMS’s to be made available solely for use on the project, of which four (4) are to be placed in advance of the Project at locations agreed upon by the Design-Builder and the Department. PCMS’s shall have the capability to be remotely controlled from the Transportation Operations Center (TOC) to facilitate emergency access during an incident only. The other four (4) PCMS’s shall be used to provide en-route travel information about planned construction, delays or other sudden changes in travel conditions throughout the Project’s duration. The PCMS shall be placed in a semi-permanent location, protected from traffic but highly visible to the public. The location and message of these four PCMS’s shall be agreed to by the Design-Builder and VDOT. The Design-Builder shall coordinate the implementation of PCMS’s with the Department. The use of PCMS’s shall not replace any traffic control device otherwise required per the MUTCD or the Virginia Work Area Protection Manual.

13.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 13.4-1 for the Department’s consultation and written comment.
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<thead>
<tr>
<th>Deliverable</th>
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<th>Delivery Schedule</th>
<th>Reference Section</th>
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<tr>
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<tr>
<td>Public Communications Plan</td>
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<tr>
<td>Transportation Operations Plan</td>
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<tr>
<td>Incident Management Plan</td>
<td>5</td>
<td>1</td>
<td>Approved prior to start of construction activities</td>
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</tbody>
</table>
SECTION 14. MAINTENANCE OF NAVIGATION CHANNEL

14.1. Scope

The scope of this section is to maintain maritime traffic within the navigation channel(s) and surrounding the project.

14.2. References

Section 14 of these Technical Requirements

14.3. Requirements

14.3.1. Design-Builder Activities In, Over and/or Adjacent to Navigable Water

A. The Design-Builder shall conduct the Work on navigable waters to ensure the least possible obstruction to navigation, and that the existing navigable depths will not be impaired, except as may be allowed by permits specifically issued by a Governmental Agency with jurisdiction over the navigable waters.

B. The Design-Builder shall coordinate with all parties and obtain and comply with the requirements of all permits or approvals relating to Design-Builder activities in, over and/or adjacent to navigable waters, including, but not limited to, the Joint Permit Application (JPA) and 33 USC 408 (Section 408) to request alterations to, or temporarily or permanently occupy or use any US Army Corps of Engineers (USACE) federally authorized Civil Works projects.

C. The Department, through the environmental process, has coordinated directly with the United States Army Corps of Engineers, the Virginia Marine Resources Commission and the Virginia Department of Environmental Quality. Information on this coordination has been provided as a Reference Document. The Design-Builder shall develop and complete the JPA and continue coordination with these parties to obtain and maintain required approvals.

D. The Design-Builder shall not commence activities until it has received the applicable permits or approvals and has provided the Department with copies of each.

E. In addition to the parties noted above, the Design-Builder shall coordinate any activities proposed in navigable waters to include but not be limited to this list of Navigable Waters Stakeholders:

1. The United States Coast Guard;
2. The United States Navy;
3. The United States Environmental Protection Agency;
4. The United States Maritime Administration;
5. The National Oceanic and Atmospheric Association;
6. City of Hampton Police Department – Homeland Security Unit;
7. City of Norfolk Police Department – Homeland Security Division;
8. The Virginia Port Authority;
9. The Virginia Maritime Association; and

F. If requested by the Design-Builder, the Department may aid the Design-Builder regarding coordination to obtain permits or approvals from the Navigable Waters Stakeholders.

G. The Design-Builder shall conduct a Navigable Waters Stakeholder coordination meeting during which it shall present its planned operations and their potential impact on navigable waters and water traffic. The Department and all Navigable Waters Stakeholders shall be invited to this meeting. The Design-Builder shall conduct additional Navigable Waters Stakeholders coordination meetings as necessary to ensure effective and timely coordination, permitting and approvals. These meetings and the Ocean Engineering Report will inform the Section 408 review.

H. The Design-Builder vessels must meet all requirements of Governmental Approvals and regulations including the installation of an electronic Global Positioning System (GPS) to transmit vessel position to a centralized internet-based program accessible by the Department at any time. In addition, the Design-Builder shall provide GPS units for all moored vessels, a centralized monitoring program, and an alert system that will readily identify break away vessels.

14.3.2. Submittals

A. The Design-Builder shall develop a Navigable Water Activity (NWA) Plan for marine vessel traffic.

B. The navigation channel NWA Plan shall include but not be limited to:
   1. Identification of water construction activities;
   2. Description and details of Work in the channel;
   3. Coordination with Navigable Waters Stakeholders, in compliance with Section 14.3.1;
   4. Maintaining marine vessel access during construction; and
   5. Contingency plans associated with minimizing impacts to marine vessels.

14.4. Deliverables

The deliverables shall include the items listed in Table 14.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Table 14.4-1 Deliverables</th>
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<tbody>
<tr>
<td><strong>Deliverable</strong></td>
</tr>
<tr>
<td>Navigable Water Activity (NWA) Plan</td>
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</tbody>
</table>
SECTION 15. GEOTECHNICAL

15.1. Scope

A. The geotechnical aspects of the Work (i.e., geotechnical Work) shall be investigated, designed, documented, constructed, inspected and monitored pursuant to this Technical Requirement.

B. The exact scope and nature of the geotechnical Work is dependent upon the Design-Builder’s approach to complete the Work. Aspects of the Work that will require geotechnical Work are anticipated to include the following:

1. Expansion of the existing islands (i.e., to enable construction of new tunnel(s), tunnel approach structures and ancillary facilities);

2. Creation of engineered fill berms to enable bored tunnel construction (if bored tunnel option is selected) in offshore areas where ground cover along the proposed tunnel alignment is otherwise insufficient;

3. Excavation of subaqueous trenches for immersed tube tunnel elements (if immersed tube tunnel option is selected) and subsequent placement of fill;

4. Foundations for structures and appurtenances, including but not limited to the following: Tunnels, tunnel approach structures, ventilation buildings and other tunnel ancillary facilities, bridges, signs and other traffic control devices;

5. Earthwork, including cut slopes and embankments, along the on-shore portions of the Project corridor (e.g., to enable roadway widening or other construction);

6. Retaining walls (e.g., for tunnel approach structures, bridges abutments, roadway widening or other construction);

7. Sound walls;

8. Drainage pipes and culverts;

9. Stormwater management basins; and


C. The Design-Builder shall consider all project geotechnical information including, but not limited to, the following reports:

1. Geotechnical Baseline Report (GBR)

2. Geotechnical Data Report (GDR) comprised of the following:
   a. Geotechnical Data Report - Islands
   b. Geotechnical Data Report – Marine
   c. Geotechnical Data Report – Landside

D. Each of the above aspects of the Work will require, or must otherwise address, one (1) or more of the following items, the Technical Requirements for which are also provided herein:

1. Geotechnical investigations

2. Seismic design
3. Excavations (e.g., for underground portions of the tunnel approach structures as well as bridge abutments, shallow foundations or other construction)
4. Dewatering systems
5. Slope design
6. Ground movement analysis, damage risk assessment, protective measures and repairs
7. Ground improvement (e.g., to reduce compressibility, to increase strength or to decrease permeability)
8. Geotechnical instrumentation and monitoring

E. The following Appendix apply to this Section 15:

15.2. References
A. VDOT Manual of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering
B. VDOT Manual of Instructions (MOI) for Materials Division, Chapter VI Pavement Evaluation and Design
C. VDOT Road and Bridge Specifications including Supplements, Special Provision Copied Notes (SPCNs), Special Provisions (SPs) and Supplemental Specifications (SSs)
D. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, Customary U.S. Units, including VDOT Modifications (VDOT IIM-S&B-80)
F. VDOT Materials Division, Pavement Design and Evaluation Section, Guidelines for AASHTO Pavement Design
G. AASHTO Guide for Design of Pavement Structures (Rigid Pavement and Flexible Pavement)
J. FHWA NH1-10-034, Technical Manual for the Design and Construction of Road Tunnels – Civil Elements
L. FHWA-HIF-15-006, Specifications for National Tunnel Inventory
N. VDOT Survey Manual
O. FHWA-NHI-10-016 Drilled Shafts – Construction Procedures and LRFD Design Methods, May 2010
P. FHWA Geotechnical Engineering Circular No. 2 - Earth Retaining Systems, FHWA-SA-96-038, 1996
Q. FHWA Geotechnical Engineering Circular No. 4 - Ground Anchors and Anchored Systems, FHWA-IF-99-015, 1999
R. FHWA Geotechnical Engineering Circular No. 5, Evaluation of Soil and Rock Properties dated April 2002
S. FHWA Geotechnical Engineering Circular No. 7 - Soil Nail Walls, FHWA-IF-03-017, 2003
W. FHWA Soil Nailing Field Inspectors Manual-Soil Nail Walls, FHWA-SA-93-068, 1993
X. FHWA The Osterberg Cell for Load Testing Drilled Shafts and Driven Piles, FHWA-SA-94-035, 1994
Z. Load and Resistance Factor Design (LRFD) For Highway Bridge Superstructures (April 2007), FHWA-NHI-08-048
AA. Load and Resistance Factor Design (LRFD) for Highway Bridge Substructures (April 2007), FHWA-NHI-08-036
BB. Load and Resistance Factor Design (LRFD) For Highway Bridge Superstructures (April 2007) Examples, FHWA-NHI-08-049
CC. LF RD for Highway Bridge Substructures and Earth Retaining Structures (January 2007), FHWA-NHI-05-095
FF. Earth Retaining Structures (RM), FHWA-NHI-07-071
GG. Micropile Design and Construction Reference Manual (December 2005), FHWA-NHI-05-039
HH. Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, FHWA-NHI-10-024 (Volume 1) and 10-025 (Volume 2), November 2009
II. NAVFAC DM 7.1
JJ. NAVFAC DM 7.2
KK. Shallow Foundations – FHWA-SA-02-054
LL. Driven Piles – FHWA HI 97-013 and FHWA HI 97-014
MM. Micropiles – FHWA-SA-97-070
NN. Continuous Flight Auger Piles – FHWA-HIF-07-039
OO. Retaining Walls – Refer to guidance from VDOT Structure and Bridge Division
PP. Box Culverts – Refer to VDOT Road and Bridge Specifications
QQ. Pipes – Refer to VDOT Road and Bridge Specifications


SS. Sheetpiles – Refer to USACE (U.S. Army Corps of Engineers) EM 1110-2-2504

15.3. Requirements

15.3.1. General Requirements

A. Key Personnel:

1. Geotechnical Manager - This individual oversees all geotechnical design for the Work and is available to review designs and to verify and modify designs, if necessary, based on field conditions and construction activities. This individual shall be responsible for ensuring that geotechnical investigations, analyses and recommendations that are necessary for the design and construction of the Work are performed in accordance with the Technical Requirements herein. The Geotechnical Manager shall have demonstrated experience in projects of similar scope and complexity with geotechnical conditions similar to those encountered at the Project location. The Geotechnical Manager shall have experience with the geotechnical design of tunnels in soft soils, marine works (e.g., reclamation), support of excavation, retaining walls, foundations, slopes, embankments, ground improvement, geotechnical instrumentation, and means and methods to monitor and minimize ground movement. The Geotechnical Manager shall be a licensed professional engineer registered to provide services in the Commonwealth of Virginia.

2. Geotechnical Construction Engineer – The Design-Builder shall employ a Geotechnical Construction Engineer who shall be responsible for providing written certification to the Quality Assurance Manager (QAM) that all geotechnical related work and materials are in conformance with the Technical Requirements and the Released for Construction (RFC) Plans. During construction, the Geotechnical Construction Engineer and/or his/her qualified inspectors shall inspect the adequacy of the geological subgrade conditions for support of shallow foundations prior to placement of reinforcing steel and footing concrete. The Geotechnical Construction Engineer and/or his/her qualified inspectors shall be present during installation of all deep foundations to confirm the work has been done in accordance with the Technical Requirements and the RFC Plans. The Geotechnical Construction Engineer and/or his/her qualified inspectors shall determine the suitability of the subgrade for pavements, embankments and approach abutments, in accordance with the Technical Requirements and the RFC Plans, prior to placement of pavement materials, prior to placement of embankment fills and prior to construction of approach abutments, respectively. Additionally, the Geotechnical Construction Engineer and/or his/her qualified inspectors are obligated to document the restoration of all failing subgrades, whether in cuts or fills, and quantify any remedies. Any modifications in the design must first be approved in writing by the Geotechnical Manager and accepted by the Department. The Geotechnical Construction Engineer must be a licensed professional engineer registered to provide services in the Commonwealth of Virginia and have at least ten (10) years of geotechnical engineering construction experience with similar size and type of projects. The Design-Builder shall submit at least three (3) projects with points of contact to verify the experience of the Geotechnical Construction Engineer.
3. Support of Excavation (SOE) Designer – Refer to Section 15.3.8, Excavations.
4. Dewatering Systems Designer – Refer to Section 15.3.9, Dewatering Systems.
5. Ground Improvement Specialist – Refer to Section 15.3.19, Ground Improvement.
6. Instrumentation Engineer – Refer to Section 15.3.20, Geotechnical Instrumentation and Monitoring.

15.3.2. Geotechnical Investigations

A. The Design-Builder is exclusively responsible for the adequacy of the subsurface investigation program with respect to the Design-Builder’s proposed design and construction means and methods for the geotechnical Work including safety precautions and programs. The subsurface data included in this RFP are being provided for the Design-Builder’s information in accordance with Section 102.04 of Division I Amendments (Part 5).

B. The Design-Builder shall develop a Geotechnical Exploration Plan (GEP) to supplement information provided in the Geotechnical Data Report(s) provided in the RFP. Additional explorations shall be performed, as determined necessary by the Design-Builder and to meet the minimum requirements of the Work. The GEP shall meet or exceed the most stringent requirements outlined in the following:

1. VDOT Manual of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering, Section 303
2. AASHTO LRFD Bridge Design Specifications, Article 10.4
4. VDOT Road and Bridge Specifications, Section 700.05 (c)

C. The proposed GEP shall be submitted to the Department for acceptance at least 30 days prior to the commencement of work. Modifications or clarifications to the minimum required exploration or laboratory testing programs as per Chapter III of the VDOT MOI (Section 303) shall be subject to the approval of the Department.

D. No field exploration work can proceed without written approval by the Department. Any exploration work performed by the Design-Builder without written approval of the Department will not be considered part of the supplemental information required for final design.

E. The GEP shall include at a minimum the following:

1. An overview of the GEP and objectives
2. GEP phases and schedule
3. Number, depths and purpose of the proposed borings/cone penetrometer soundings or other proposed explorations, monitoring wells, and other field investigations to meet the minimum requirements of the Work
4. Drilling methodology
5. In-Situ Soil sampling types and frequency
6. Lab tests and quantities
7. Site access and restoration plans and right-of-entry permits
8. Maintenance of Traffic Plan, if required
9. Utility clearance procedure
10. A hard copy and electronic pdf file graphically presenting the GEP including proposed boring and sounding locations

F. Utility Protection – Refer to VDOT MOI, Section 302.02.

G. The Design-Builder will be responsible for obtaining all necessary utility clearances, permits and approvals as required by the Department, the Commonwealth of Virginia, or any other jurisdictional body or owner prior to accessing public or private property for conducting geotechnical field work. Refer to VDOT MOI, Section 302.03.

H. The Design-Builder shall provide the necessary traffic control in accordance with the VDOT Work Area Protection Manual. Also refer to VDOT MOI, Section 302.05.

I. All boreholes left open while unattended by the drill crews shall be clearly marked and barricaded or otherwise secured to avoid possible injury or damage to the public.

J. Laboratory testing for geotechnical investigations shall meet the requirements of VDOT MOI, Section 304.

K. All as-performed boring/field testing locations shall be surveyed. The survey shall determine station and offset, elevation, and latitude and longitude, which shall be included on the boring logs with accuracy as stated in VDOT MOI, Section 303.06.

L. Following drilling and laboratory work, the Design-Builder shall retain all samples until Final Acceptance after which samples shall be relinquished to the Department.

M. Records of subsurface explorations shall be prepared in accordance with VDOT MOI, Chapter III Geotechnical Engineering. The records shall be prepared under the direct supervision of a professional engineer, licensed in the Commonwealth of Virginia, or a professional geologist, certified in the Commonwealth of Virginia. This individual shall have a minimum five years of geotechnical engineering experience and expertise working in the region and/or in areas of similar geologic settings with similar project features. The Design-Builder shall provide the Department with the Geotechnical Engineering Reports (GERs) and with electronic copies of all boring logs in gINT© software using the current versions of the VDOT template and library files.

N. Backfill: All boreholes shall be adequately backfilled to avoid settlement. Borings in contaminated areas, paved areas (such as pavements or sidewalks) or other areas likely to be traversed by the public shall be backfilled with cementitious grout.

O. Restoration: Reinstate surfaces in kind at a minimum. Site restoration shall be in accordance with the permits obtained by the Design-Builder.

15.3.3. Geotechnical Analyses, Design and Reporting

A. Geotechnical Analyses:

1. Geotechnical analyses shall meet the requirements outlined in the following:
   a. VDOT Manual of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering, Section 305;
b. AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, including VDOT Modifications (VDOT IIM-S&B-80); and

2. Geotechnical analyses shall be performed under the direct supervision of the Geotechnical Manager.

3. Geotechnical analyses shall be performed with the use of geotechnical software that is widely accepted within the industry (e.g., Plaxis, GeoSlope, Ensoft, Midas, FLAC), in the opinion of the Department.

B. Geotechnical Design Parameters:

1. The Design-Builder shall develop site specific geotechnical design parameters based on the data collected from the various geotechnical explorations as well as the laboratory testing results performed on representative samples.

2. Engineering analyses that include correlations to SPT N-values, shall include summary tables showing N60 and (N1)60 values, as required by the engineering correlation. These tables shall show the assumptions used in computing the effective overburden stress (i.e., unit weight, layer thicknesses and position of the water table).

3. The Design-Builder shall justify any assumed design strength gain associated with settlement through relations derived in the laboratory or other method as approved by the Department.

4. Unless otherwise addressed by AASHTO LRFD, the Design-Builder shall incorporate reliability assessments in conjunction with standard analysis methods to develop geotechnical design parameters in accordance with VDOT MOI, Chapter III Geotechnical Engineering. An acceptable method for evaluation of reliability is given by Duncan, J.M. (April 2000) Factors of Safety and Reliability in Geotechnical Engineering, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Discussions and Closure August 2001. A suitable design will provide a probability of success equal to or greater than 99 percent unless otherwise specified within the Contract. Reliability assessments shall address the selection of soil parameters used in retaining wall design, the factors of safety for slope stability and the requirements of LRFD. Reliability assessments shall also address settlement calculations.

5. The Design-Builder may propose to identify specific, non-critical features, and alternative methods for evaluating variability of subsurface conditions, reliability and minimum factors of safety, prior to submission of its design calculations and drawings. The Department may, in its sole discretion, accept or reject such proposed methods.

C. Geotechnical Engineering Reports (GERs):

1. Geotechnical Engineering Reports (GERs) shall be prepared in accordance with VDOT MOI, Section 306.03.

2. GERs shall be signed and sealed by the Geotechnical Manager and submitted to the Department for review and acceptance.

3. Coordination of GERs with Design Packages:
   a. The Design-Builder shall divide the geotechnical engineering reporting among the various GERs to match the Design-Builder’s division of design work (i.e., design packages). In other words, the content of each GER shall be consistent with the content
of the design package to which it pertains.

b. GERs shall be submitted concurrent with the corresponding design package.

c. GERs shall be fully coordinated with the corresponding design package. To this end, the Geotechnical Manager shall review each design package to assure it appropriately incorporates the geotechnical dataset, recommendations and components as documented in the corresponding GER. Evidence of this review shall be submitted with each design package. The review shall reference specific drawing numbers and specification paragraphs within the design package.

4. The GERs shall address all geotechnical Work including but not limited to the following: Island expansions and offshore engineered fill berms; each major and minor structure (see below for definitions); stormwater management facilities; road beds, critical/non-critical engineered embankments or cut slopes; sound walls; and pavement design.

a. Major structures for VDOT projects include tunnels, bridges, retaining walls greater than 10 feet high and any structures to be supported on deep foundations including pile-supported embankments, culverts, and utilities.

b. Minor structures for VDOT projects primarily include drainage pipes, culverts, and retaining walls less than 10 feet high. In many instances limited geotechnical engineering analyses are required for drainage pipes and culverts; however, when drainage pipes or culverts are greater than 36 inch diameter, or when a trenchless installation is proposed, the Department requires a specific subsurface exploration and geotechnical study. Any drainage pipe or culvert installed in soft ground prone to settlement shall include the data and analyses necessary to support long-term performance, irrespective of the pipe or culvert dimension or installation method.

5. The GERs shall, at a minimum, include the following:

a. Description of the Work including anticipated loads

b. Background information including but not limited to former studies, published geologic references and NRCS soil maps

c. Description of the subsurface conditions including a summary of field explorations and laboratory test results

d. Geotechnical design parameters with supporting analyses including but not limited to correlations to SPT N values and reliability assessments for selection of these parameters

e. Options evaluated with a summary justifying the recommendations

f. Independently checked calculations supporting the evaluations and recommendations including software input/output. The calculations shall reference and demonstrate compliance with the Technical Requirements herein (e.g., foundation design recommendations are in accordance with Section 5.13.10, Foundations; slope stability factors of safety are in accordance with Section 15.3.17, Slope Design; predicted ground movement and damage risk are in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs)

g. Instrumentation and Monitoring Plan in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring, including threshold levels for each instrument, fully coordinated with the ground movement analysis

h. Construction considerations
i. Recommended geotechnical Special Provisions

6. GERs shall be in the English language and use United States customary units (as opposed to metric) unless otherwise accepted or instructed by the Department.

15.3.4. Seismic Design Considerations

A. The Design-Builder shall account for seismic loadings in accordance with AASHTO LRFD Bridge Design Specifications for bridge structures and in accordance with AASHTO LRFD Tunnel Design and Construction Specifications for tunnel structures.

B. With reference to AASHTO LRFD, the importance category of the tunnel, tunnel approach structures and various bridge structures along the Project corridor is defined as “Critical.”

C. The Design-Builder shall demonstrate that the predicted seismic-induced movement of the tunnel can be accommodated by the design without damage (cracking) and without compromising the watertightness of the tunnel.

D. The Design-Builder shall demonstrate the adequacy of bridges against seismic load cases.

E. The Design-Builder shall evaluate liquefaction susceptibility of existing islands, proposed island expansions and proposed offshore engineered fill berms (if applicable) using Cyclic Resistance and Cyclic Stress Ratios estimated from in-situ SPT and/or CPT data (R.B. Seed or I.M. Idriss and R.W. Boulanger Methods). Liquefaction induced settlements may also be estimated using the in-situ SPT and/or CPT data (Ishihara and Yoshimi Method). Liquefaction assessments for other Work along the Project corridor shall be performed in accordance with AASHTO LRFD.

15.3.5. Island Expansions

A. Scope:

1. This section describes the Technical Requirements for the expansion of islands to accommodate the Work, including tunnels, tunnel approach structures and ancillary facilities.

2. Refer to Section 16, Marine Engineering for Technical Requirements related to protection of the expanded islands against scour, ship groundings, ship anchors and other marine hazards.

B. Design, Analysis and Design Submittals:

1. Drawings: The Design-Builder shall provide Drawings of the proposed island expansions to the Department for review and approval. The Drawings shall be signed and sealed by the Geotechnical Manager and shall include:

   a. Plans showing the general arrangement of the new land mass, including the locations of tunnels, buildings, retaining walls, paved areas and other relevant features. Clearly show the locations of geotechnical explorations on the plans for reference;

   b. Representative geotechnical profiles including a sketch of cross-sections of the island expansion shoreline protection. The profiles shall indicate the island expansion materials and extend from the proposed ground surface to firm, non-compressible soil at depth, below which settlement will not occur;

   c. Required engineering properties of the reclamation fill (e.g., grain size distributions, density and other properties identified by the Technical Requirements and the RFC Plans) and required engineering properties of any geotextiles, coordinated with settlement and slope stability analyses. The Geotechnical Manager shall establish thresholds for
tolerances for pockets of non-compliant material within the expanded islands. Acceptable thicknesses of non-compliant material for a single incident and the total accumulated thickness of non-compliant material pockets in the same profile shall be established;

d. Details of any ground improvement, surcharge fill and/or drainage system (e.g., wick drains) used to reduce or expedite consolidation settlement;

e. Construction sequence of the proposed island expansions; and

f. Work to protect existing islands, structures, utilities, slopes and other existing features during the proposed construction.

2. Specifications: The Design-Builder shall provide Specifications, signed and sealed by the Geotechnical Manager, for the proposed island expansions to the Department for review and approval. At a minimum the Specifications shall address and be consistent with the topics covered in the Technical Requirements. The Design-Builder shall bring to the attention of the Department any proposed deviation from the Technical Requirements.

3. Settlement analysis:

a. In advance of submitting its full settlement analysis, the Design-Builder shall submit its design approach for performing the settlement analysis to the Department for review and acceptance. The design approach submittal shall describe the proposed analysis methods, including the name and description of any computer software modeling programs to be used. The software shall be industry-recognized software (e.g., Plaxis, FLAC or Midas), in the opinion of the Department.

b. The settlement analysis shall consider elastic settlement, primary (consolidation) settlement and secondary compression.

c. The settlement analysis shall account for vertical and radial drainage (i.e., anisotropic permeability) as well as reduction in permeability that occurs with compression of the soil and changes in vertical stress that occur beyond the actual limits of loading.

d. The Design-Builder shall perform damage risk assessments for existing structures in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

e. Settlement limits: Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs for settlement limits.

4. Slope stability analysis: The Design-Builder shall perform slope stability analysis for temporary and permanent conditions in accordance with Section 15.3.17, Slope Design.

5. Documentation of analysis in Geotechnical Engineering Reports (GERs):

a. Refer to Section 15.3.3, Geotechnical Analyses, Design and Reporting (Work Products).

b. Provide a detailed summary of all geotechnical parameters used in the analyses and their supporting raw data (borehole logs, laboratory test results and their interpretations for use in the analyses).

c. Provide design computations for developing the fill/surcharge schedule considering slope stability (i.e., ensure the placement of fill for any lift does not result in short term
instability in the undrained condition). The fill/surcharge schedule shall, at a minimum, include maximum lift heights and target pore pressures for preventing slope failures. Document any assumed strength gains associated with compression from placement of preceding lifts (with justification based on laboratory testing or other method as approved by the Department).

d. Provide predicted settlement contour plans for expanded islands. Provide separate plans for predicted settlement at the end of primary (consolidation) settlement and predicted settlement at the end of secondary compression. Demonstrate the proposed construction meets the settlement limits given in Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

e. Provide an Instrumentation and Monitoring Plan meeting the requirements of Section 15.3.20, Geotechnical Instrumentation and Monitoring. The Plan shall detail the procedures, equipment, methods and materials planned for monitoring and documenting settlement, lateral movement and pore water pressure increase/dissipation resulting from the proposed island expansions. The Plan shall include threshold levels for each instrument, fully coordinated with the ground movement analysis.

C. Other Submittals:

1. Reclamation Plan: The Design-Builder shall submit the Reclamation Plan to the Department for acceptance prior to start of fill operations. The Plan shall contain the following:
   a. Copies of all permits and certifications (the Design-Builder is responsible to obtain all required permits and certifications from agencies having jurisdiction);
   b. Proposed equipment and method for removing and/or placing each material type. Provide the following information for each vessel to be used: Displacement, draft, length and beam; type and capacity of dredge; crane details; description of hydrographic survey equipment, positioning system and display system for dredging and placement of fill; nominal crew size and live-aboard capacity; size and types of anchors; size and type of jack-up barge legs; proof of insurance and proof of pollution insurance; indicated horsepower (HP), shaft horsepower (SHP) and bollard pull force for towboats;
   c. Submit Navigational Channel MOT Plan;
   d. Identification of key personnel conducting marine operations and submit records substantiating their past performance of similar work in the last five (5) years;
   e. Provide an Overwater Operations Safety Plan to include criteria and procedures for responding to changes in weather;
   f. Approximate schedule for the work associated with the proposed island expansion(s);
   g. Acceptance areas, and order and sequencing of the work associated with proposed island expansion(s), including but not limited to ground improvement, dredging and fill placement, installation of wick drains or other vertical drainage elements and placement and removal of surcharge fills;
   h. Mooring and anchor patterns and locations with respect to fixed structures for all vessels including proposed anchor, spud pile and jack-up barge locations;
i. All applicable quality control procedures including, but not limited to the following: Surveys; inspections; sampling and testing; instrumentation and monitoring; and reporting. The Design-Builder and the Department shall agree on the reporting procedures and formats;

j. Qualifications and equipment calibration certificates of the testing laboratory performing the required tests;

k. List of hydrographic surveying equipment including type, brand, frequency and precision. Provide calibration certificates of all equipment to be used. Equipment with expired calibration certificates shall not be used;

l. Layout and Shop Drawings of any dikes, drains, silt fences, berm and other measures to control erosion and siltation of the borrow materials, approved by the Geotechnical Manager;

m. Material Separation Plan (i.e., separation of suitable from unsuitable material);

n. Details of the Design-Builder’s intended corrective measures, should any environmental hazards be detected;

o. Location of materials supplies and documentation of supplier’s willingness and capacity to provide the needed quantities of materials for the proposed design;

p. Location of material disposal sites;

q. Methodology for densifying or otherwise improving the reclamation fill and/or subsurface strata if required to meet the Technical Requirements (e.g., settlement criteria as stated in Section 15.3.18) and achieve the engineering properties as stated in the RFC Plans; and

r. Demolition and Island Protection Plan including sequencing of the Work; and layout and shop drawings of all demolition and island protection features approved by the Geotechnical Manager.

2. Borrow Source Report: The Design-Builder shall submit a report to the Department pertaining to the borrow source location(s) prior to the start of fill operations. The report shall include the borrow source location(s), representative material gradation(s) and moisture density curves for each material proposed for use, laboratory test results and quantity of available material from each source. Depth of dredge shall be included if the material is being sourced from an offshore location. The Geotechnical Manager shall certify the borrow source is in accordance with the Technical Requirements and the RFC Plans.

3. Stone Materials:

a. Stone Sources: The Design-Builder shall submit records of all proposed stone sources approved by the Geotechnical Manager. The submittal shall include: (1) areas and lifts of the quarry or pit to be worked; (2) the specific geological stratum or strata to be utilized; (3) available laboratory testing records; (4) bulk specific gravity range; and (5) completed projects constructed of the same stone to be furnished. For the projects completed with stone from the same source, provide detailed descriptions of the size of stone produced, quantity of stone produced and the amount of stone that was rejected. Designate in writing the proposed stone sources at least 60 days in advance of using that source.
b. Stone Materials Control (SMC) Plan: The Design-Builder shall submit a written SMC Plan, approved by the Geotechnical Manager, describing the means and methods to be used for production, handling, transporting, placement, testing and inspection of stone materials. The SMC Plan shall also include the anticipated placement and delivery rates for each size of stone. Written procedures shall be included for guiding and instructing the Design-Builder’s inspectors and other employees in the techniques and criteria to be used for examining stone for acceptability and for the proper production gradation, handling, transporting and placement of stone. Procedures shall be described for tracing armor stones used in conducting gradation tests and for reporting the performance and results of the tests on Quality Control reports. Procedures shall be described for documenting that furnished stone complies with the applicable quarrying period and curing restrictions if any. The SMC Plan shall also include a sample of a Daily SMC QC Inspection Report, which shall be used during stone material production. The SMC Plan shall be made not less than 30 calendar days in advance of the date stone materials are to be shipped from the source. Acceptance of the SMC Plan by the Department shall not be provided until after the Design-Builder has produced satisfactory demonstration stockpiles including laboratory testing results.

c. Demonstration Stockpiles: Following submittal of source selection and the SMC Plan described above, the Design-Builder shall select the demonstration stockpile stones for review of the Department. The Design-Builder shall accompany the Department or their designated representative during the evaluation of the demonstration stockpiles. The stockpile shall contain at least 10 stones representing acceptable quality and weight within the specified size range for each type of stone to be furnished. The stones placed in the demonstration stockpiles shall be representative of the overall quality of materials in the source and representative of the stone quality to be furnished to the Project. The stockpiles shall be located at the source of the stone and be laid out in windrow fashion. The Design-Builder shall arrange to have individual stones to be free from any dust or mud covering the faces and turned as necessary to accommodate the Department’s evaluation. The Department will mark rejected stones with a “red X.” If greater than 20% of the stones within a demonstration stockpile are found to be unacceptable, the entire stockpile may be rejected by the Department and a replacement stockpile created for re-evaluation. The set-aside samples selected and marked during the inspection of the demonstration stockpile shall remain unchanged at the source until all other required material of the size range represented by the stockpile has been shipped from the source. Stones having each type of unacceptable features shall also be set aside at the quarry as examples of unacceptable stone that shall not be shipped.

4. Geotextiles:
   a. Submit manufacturer’s data sheet detailing the guaranteed physical properties of the geotextile material and confirm these properties are consistent with the design requirements as indicated on the RFC Plans.
   
   b. Describe proposed installation procedure for the geotextile, in accordance with this Section.
   
   c. Confirm the geotextile material is on Approved List #63 for the intended use. For high-strength geosynthetics and geogrids, submit manufacturer sample data for the lot that was delivered to site in accordance with VDOT’s latest Special Provision.
5. Daily Reports:
   a. Daily Reclamation Report: Provide an updated daily log of vessel activity including locations where each vessel was deployed on each day at the Project site; the volumes of each type of material dredged or placed at each location; and other construction activities related to island expansions; and
   b. Daily Stone Materials Control (SMC) Quality Control (QC) Inspection Reports (as per above).

6. Submit Pre-Construction, Progress and Post-Construction Surveys (hydrographic and/or topographic) in accordance with Section 8, Surveying and GIS and with the approved Reclamation Plan.

7. Results of material sampling and testing. Test results shall be issued to the Department daily. The Geotechnical Construction Engineer and/or his qualified inspector(s) shall provide written certification to the Quality Assurance Manager (QAM) that the test results are in compliance with the Technical Requirements and the RFC Plans and shall advise the Department of any discrepancies.

8. Instrumentation and monitoring results as per Section 5.3.20, Geotechnical Instrumentation and Monitoring.

9. As-Built report for each island expansion, including the results of surveys and the results of inspection, sampling, testing and monitoring. The Geotechnical Manager shall provide certification that the island expansions (reclamation) meet the Technical Requirements and the RFC Plans with reference to the inspection, sampling, testing and monitoring.

D. Material Requirements:

1. Fill Materials:
   a. Fill materials shall include suitable dredged fill material, suitable fill material from upland sources and rock fill. All fill materials shall be provided by the Design-Builder.
   b. Suitable fill shall include material classified as GW, GP, SW and SP per ASTM D2487.
   c. Fill material shall be composed of hard, sound particles, having a specific gravity of solids of not less than 2.6 and having a maximum soundness loss of 15% when tested in accordance with AASHTO T103 (freeze and thaw, 100 cycles) or a maximum soundness loss of 30% when tested in accordance with AASHTO T104 (magnesium sulphate, 5 cycles).
   d. Fill material shall be essentially free from thin, flat and elongated pieces (i.e., not more than 30% by mass of particles retained on 3/8-inch sieve having a maximum to minimum dimensional ratio greater than 5 as determined in accordance with ASTM D4791).
   e. The fill shall not contain cohesive soils such as marine mud or swelling clays; peat, vegetation, timber or organic material or other deleterious materials; material that is soluble or perishable in seawater; hazardous or toxic material or material susceptible to combustion; metal, rubber, plastic or synthetic material; or gypsum.

2. Stone:
a. All stone to be used in marine works (including rip-rap, filter and armor stone) and bedding material shall conform to VDOT Road and Bridge Specifications, Section 204.02(b).

b. Acceptability of stone materials shall be based on visual inspections, evaluation of service records and applicable laboratory test results. All materials shall meet the minimum quality requirements listed in Table 15.3.5-1, based on field examination and applicable laboratory testing.

c. The maximum aspect ratio (i.e., greatest dimension: least dimension, when measured across three mutually perpendicular axes) shall not be greater than 3:1 for stones used as armor stone and shall not be greater than 5:1 for stones used for other purposes (e.g., rip rap, filter and bedding). Up to 5% by weight of stones may exceed these maximum aspect ratio requirements.

d. Stone to be placed on existing slopes for protection shall be a minimum of five (5) tons.

Table 15.3.5-1: Criteria for Stone Quality

<table>
<thead>
<tr>
<th>Test</th>
<th>Text Method</th>
<th>Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>ASTM D6473</td>
<td>2.5 to 3.0</td>
</tr>
<tr>
<td>Absorption</td>
<td>ASTM D6473</td>
<td>&lt;3 percent</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>ASTM D7012</td>
<td>&gt;15,000 psi</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>ASTM C535</td>
<td>&lt;20 percent loss after 500 revolutions</td>
</tr>
<tr>
<td>Freeze Thaw(^2)</td>
<td>ASTM D5312</td>
<td>&lt;2 percent loss after 35 cycles</td>
</tr>
<tr>
<td>Wetting-Drying(^2)</td>
<td>ASTM D5313</td>
<td>&lt;2 percent after 80 cycles</td>
</tr>
<tr>
<td>Petrographic Examination</td>
<td>ASTM C295</td>
<td>No deleterious materials allowed</td>
</tr>
<tr>
<td>Field Examination</td>
<td>ASTM D4992</td>
<td>No deleterious materials allowed</td>
</tr>
<tr>
<td>Sodium Sulphate Soundness or Magnesium Sulphate Soundness</td>
<td>ASTM D5240</td>
<td>&lt;5 percent loss after 5 cycles</td>
</tr>
</tbody>
</table>

Notes:
1) See Paragraph E.2 and Table 15.3.5-2 below for applicability of tests.
2) Design-Builder shall ensure that the selected laboratory is Department accepted for the required capacity/equipment to allow for testing of large sample sizes. The minimum testing slab dimension shall be 13 in. x 15 in. x 2.5 in. for designation ASTM D5312 and D5313 and shall be cut perpendicular to the bedding planes of the stone.

3. Geotextiles:

a. Geotextiles shall meet the requirements of VDOT Road and Bridge Specifications, Section 245 Geosynthetics and AASHTO M288.

b. Geotextile material shall be on Approved List #63 for the intended use.
c. High-strength geosynthetics and geogrids shall meet the requirements of VDOT’s latest Special Provision.

d. Geotextiles shall be delivered to site in packaging that shall protect the rolls from degradation by ultra violet light and other weather elements. The labelling shall clearly identify the product supplied in accordance with ASTM D4873.

e. Geotextiles shall be kept in the wrappings provided by the manufacturer until required for use in the Work.

f. The Design-Builder shall ensure the quality and the protection of the product on site, following the manufacturer’s recommendations.

g. Geotextiles shall be protected against physical or chemical damage.

h. The rolls of geotextile shall be stored on level ground and stacked not more than five (5) rolls high and no other materials shall be stacked on top of the geotextiles.

4. Topsoil: In accordance with VDOT Road and Bridge Specifications, Section 602.

E. Quality Control - Material Sampling, Laboratory Testing and Inspection (As Supplied):

1. Fill:

   a. The Design-Builder shall sample and test all materials that may be used as fill on the Project. The Geotechnical Construction Engineer and/or his/her qualified inspector(s) shall certify the fill material meets the Technical Requirements and the RFC Plans.

   b. A grain size analysis (ASTM D6913) shall be performed for each 5,000 tons of material to be used as fill for island expansion. The Design-Builder shall submit daily reports with average grain size distribution analysis for the samples collected that day.

   c. Direct shear tests (ASTM D3080) and maximum and minimum dry density tests (ASTM D4253 and ASTM D4254, respectively) shall be performed for each 20,000 cubic yards of reclamation material. Direct shear tests shall be performed on specimens prepared to the design density, as per the RFC Plans. The Design-Builder shall allow the Department to witness sampling of the reclamation material at times and frequency determined by the Department.

   d. Each sample collected for grain size analysis shall be visually inspected for plasticity and, in any case of doubt, Atterberg Limits testing (ASTM D4318) shall be performed.

2. Stone:

   a. The Design-Builder shall perform the testing and visual inspection specified in Table 15.3.5-2. At a minimum, the required testing shall be performed once for each stone type listed and once for each quarry sourced.

   b. The Design-Builder shall submit copies of test results at least 60 calendar days in advance of shipment of stone to the Work site, and no later than the time of inspection of the demonstration stockpile by the Department.

   c. Gradation tests shall be performed for stone used for slope protection, tunnel protection and scour protection. One (1) gradation test at the quarry is required for each 20,000 tons
of stone, with a minimum of one (1) test for each rock class per quarry. Each armor stone or dry riprap stone used in gradation testing shall be marked, tracked and documented in accordance with the procedures submitted and approved in the SMC Plan. Gradation test reports for armor stone shall include the three (3) axis dimensions for aspect ratio measurement and the basis of individual stone weight calculations.

d. At least one (1) gradation test shall be performed of each 5,000 tons of filter or bedding stone to be delivered to the project site for each specified gradation in accordance with ASTM C136.

e. The stone quality testing frequency may be increased at the direction of the Department if geological changes in the stone material are observed.

f. The Design-Builder shall perform visual inspection of each proposed armor stone, both at the quarry and at the Project site. The visual inspections shall check size, elongation, fractures, deterioration and other defects to assure that handling during loading, transporting, unloading and placement has not caused damage to the materials and to assure the materials are placed in accordance with the requirements herein. Weighing or re-measurement of stones shall be performed to verify computed weights when the Department brings the size of specific stones into question.

g. The Department may elect to perform sampling, testing and inspection in addition to that required to be performed by the Design-Builder. The Design-Builder shall provide safe access for the Department and/or its representatives to perform sampling, testing and inspection. In the event the testing requires transportation of stone to an off-site location (e.g., testing laboratory), the Design-Builder shall bear the cost of handling and transporting the stone if the stone is found to be non-compliant with the TRs or RFC Plans, otherwise the cost of handling and transporting the stone shall be borne by the Department.

h. Except as allowed by gradation tolerances, any material broken, cracked, out of gradation or weight limitation or improperly placed in the Work shall be removed and replaced with satisfactory stones and corrective action taken at no additional expense to the Department. Rejected material shall be promptly removed from the Project site.

### Table 15.3.5-2: Stone Sampling and Testing Requirements

<table>
<thead>
<tr>
<th>Stone Type</th>
<th>Sample Size</th>
<th>Frequency</th>
<th>Stone Quality Testing</th>
<th>Visual Inspection of demonstration stockpile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armor Stone</td>
<td>One (1) stone</td>
<td>5,000 tons</td>
<td>All tests listed in Table 15.3.5-1</td>
<td>Yes</td>
</tr>
<tr>
<td>VDOT Dry Riprap Class I, II, III and AI</td>
<td>20 stones</td>
<td>5,000 tons</td>
<td>All tests listed in Table 15.3.5-1</td>
<td>Yes</td>
</tr>
<tr>
<td>Filter and Bedding Stone</td>
<td>2,000 lbs.</td>
<td>5,000 tons</td>
<td>ASTM D6473, ASTM C535, ASTM D5240</td>
<td>No</td>
</tr>
</tbody>
</table>

3. Geotextile:

a. Geotextile material shall be on Approved List #63 for the intended use.
b. For high-strength geosynthetics and geogrids, perform testing for the lot that was delivered to site in accordance with VDOT’s latest Special Provision.

F. Equipment:

1. The Design-Builder shall furnish, maintain and operate all equipment for island expansion Work including material removal, material placement and hydrographic surveys.

2. All marine equipment shall be seaworthy, operated safely, shall not compromise the safety of or permanently impair the function of the existing tunnels (including tunnel approach structures and facilities) and shall not interfere with navigation except when permitted in advance by the Governing Agencies with jurisdiction. No vessel shall operate on site without United States Coast Guard certification.

G. Activities In, Over and/or Adjacent to Navigable Waters:

1. The Design-Builder shall coordinate with third parties and obtain and comply with the requirements of all permits or approvals relating to Design-Builder activities in, over and/or adjacent to navigable waters in accordance with the Technical Requirements.

2. The Design-Builder shall be required to conduct Work in such manner as to cause as little obstruction to navigation as possible. In case the Design-Builder’s equipment so obstructs the channel, on the approach of a vessel, said equipment shall be promptly moved as necessary at no additional cost to the Department to allow a safe and practicable passage of the vessel.

3. Upon the completion of Work, the Design-Builder shall promptly remove equipment, including ranges, buoys, piles and other markers placed in navigable water or on shore.

4. Each night and during periods of restricted visibility, provide lights for floating plants, pipelines, ranges and markers. Also provide buoys that could endanger or obstruct navigation. When night work is in progress, maintain lights between 20 minutes prior to sunset and 20 minutes prior to sunrise for the observation of dredging operations. Lighting shall conform to United States Coast Guard requirements for visibility and color.

H. Operation of Existing Islands including Traffic: The Design-Builder shall not impede access to or the operation of the existing islands. Traffic through the existing tunnels shall be maintained in both directions at all times. All traffic shall be protected from construction operations throughout the Work.

I. Earthwork shall meet the requirements of VDOT Road and Bridge Specification, Section 303.

J. Settlement: It is anticipated that both the island expansion fill and underlying soils will settle. The Design-Builder shall make all necessary allowances for the effects of settlement on the proposed Work and on the existing buildings, utilities and infrastructure. Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

K. Ground Improvement: The Design-Builder may elect to perform ground improvement of existing soils to improve the engineering properties of these soils as required by the RFC Plans. Ground improvement shall be performed in accordance with Section 15.3.19, Ground Improvement.

L. Site Clearing:
1. The Design-Builder shall be responsible for identifying, removing, transporting and disposing of any unsuitable foundation soils (e.g., soft soils and organic soils) prior to placing reclamation material unless such soils are explicitly addressed in the RFC Plans (e.g., ground improvement).

2. Trash, debris and other miscellaneous man-made and natural objects may be encountered during dredging. Material to be expected includes, but is not limited to the following: Stones, tires, cables, chains, anchors, sheet metal, plastics, munitions, lumber and tree branches. The Design-Builder shall identify, remove, transport and dispose of such materials prior to placement of materials for island expansion(s).

3. All materials shall become property of the Design-Builder upon removal. All materials shall be properly disposed of in conformance with the requirements of the RFC Plans at no additional cost to the Department. The Design-Builder shall be solely responsible to identify disposal sites and obtain all necessary permits for disposal.

M. Demolition and Protection of Existing Island Perimeter:

1. The Design-Builder shall be responsible for removing any existing armor stone, seawalls, fencing, pavements, sidewalks, curbs, gutters, signage or other features that interfere with the proposed island expansion.

2. Demolition and/or stone removal operations shall be at the Design-Builder’s risk.

3. The Design-Builder shall plan construction to minimize disturbance to the existing islands.

4. The existing island slopes shall be protected throughout construction (e.g., against scour, erosion, slope failures and marine hazards). The existing islands shall be protected such that their integrity is not compromised during either normal, routine construction or during storm events arising throughout the duration of the Work. At a minimum provide protection from the 1% annual chance storm wave and current conditions at all times. During periods when construction may be interrupted, the Design-Builder shall provide protection of any exposed ends of construction from damage. Any damage to installed work during periods of interruptions shall be the Design-Builder’s responsibility.

5. Existing armor stone shall be removed, stockpiled and segregated as required for reuse or disposal. The Design-Builder shall determine the best use of the removed existing armor stone. All existing armor stone not meeting the requirements for reuse on the expanded island or existing slopes shall become the Design-Builder’s property and disposed of offsite. The Design-Builder shall be responsible for all permits required for reuse or disposal of the existing armor stone.

6. Existing outfalls, seawalls, structures, highways, roadways, utilities and equipment and other infrastructure, both on and leading up to the existing islands, shall be maintained and protected throughout construction unless specifically approved otherwise by the owner of the asset.

7. The Design-Builder shall be responsible for damage to areas or items designated by the Department to be protected. All areas disturbed shall be restored to a condition equal to or better than their original condition and shall be graded to provide positive drainage to stormwater management facilities. Repairs to or replacement of areas or items damaged shall
be made at the Design-Builder’s expense and to the satisfaction of the Department before acceptance of the completed Work.

N. Supply and Delivery of Reclamation Fill Material:

1. Reclamation fill material shall be taken from the borrow areas, as indicated on the RFC Plans, by means of dredging or by transporting from an upland source. The Design-Builder shall be responsible for identifying the fill material source and meeting the Technical Requirements and RFC Plans.

2. Materials shall be transported in dredges, barges or similar in compliance with permit conditions. Truck delivery of fill material is not allowed.

3. Based upon the fill material source, location and the Project Baseline Schedule, the Design-Builder shall select equipment of an appropriate capacity to perform the Work continuously. Any siltation which may occur is the Design-Builder’s responsibility to correct at no additional cost to the Department.

4. The Design-Builder shall be responsible for containment of the reclamation fill material at the dredge site, at the reclamation site and along the transportation route between the sites. In addition, the Design-Builder shall be responsible for protecting the material (i.e., from gulling, scour and erosion) once it is deposited on the island. Any losses of material shall be the Design-Builder’s responsibility at no additional cost to the Department.

5. Fill types and properties shall be in accordance with the Technical Requirements and the RFC Plans. If the fill material does not comply with the Technical Requirements and/or the RFC Plans, the Design-Builder shall submit a remediation plan, approved by the Geotechnical Manager, for review by the Department. The remediation plan shall show that the Technical Requirements and the RFC Plans for the finished island will be met after completion of remediation. Remedial measures shall be at the cost of the Design-Builder. This shall include the Department’s right to reject any material or area from which the sample was taken. In such case, disposal of the unsuitable material shall be the Design-Builder’s responsibility.

6. Restoration of borrow areas shall be in accordance with federal, state and local laws and regulations.

O. Dredging and Placing of Fill Materials:

1. All necessary site clearing shall be performed prior to placing any reclamation fill materials.

2. Construction shall proceed with a minimum of interruption to the prescribed lines and grades and in accordance with the RFC Plans. Furnish, set and maintain ranges, buoys or markers as needed to guide fill placement and to facilitate surveys and inspections. Suspend dredging and/or fill placement operations when ranges, buoys or markers cannot be seen.

3. The Design-Builder is to select fill placement methods that minimize loss of material and the possibility of silt/clay pocket formation within the reclamation. The Design-Builder’s construction methodology and sequence of activities shall protect the reclaimed material from losses from erosion due to wave actions, currents, tidal effects, or other natural forces until Final Acceptance. Provide and maintain necessary bulkheads, dikes, ditches, weirs, spillways and other construction necessary to confine and retain the fill.
4. The Design-Builder shall control the placement of fill materials in a manner than limits the turbidity of bay waters in accordance with permit conditions.

5. Segregation of reclamation materials (i.e., such that distinct bands or layers of soils with different grain sizes are created) shall not be permitted irrespective of the method of placement. If such segregation occurs, the Design-Builder shall make any required corrections at his own expense.

6. The Design-Builder shall remove any naturally-deposited sediment that accumulates at the base of dredged trenches or between fill placements at reclamation locations.

P. Densification of Fill:

1. Island fill material shall be densified or otherwise improved to meet the requirements of the RFC Plans and the minimum reclamation fill density as stated below.

2. Minimum Reclamation Fill Density: – During the reclamation process, the Design-Builder shall place approved material within the reclamation area to achieve an in-situ design density in accordance with the RFC Plans, but not less than 50% of the relative density of the soil, throughout the full thickness and lateral extent of the fill. If the estimated density of the reclaimed fill is less than the in-situ design density or 50% of the relative density of the soil, as determined by the procedures outlined in Section 15.3.6.Q below, then remedial measures will be required as per Section 15.3.6.R below.

3. Subgrade compaction testing and control shall be as outlined in Table 15.3.5-3.

Table 15.3.5-3 Subgrade Compaction Testing and Control – Testing Frequency per Lift of Fill.

<table>
<thead>
<tr>
<th>Location</th>
<th>Frequency¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings and structures</td>
<td>1 test group for every 10 square yards</td>
</tr>
<tr>
<td>Road</td>
<td>1 test group for every 100 feet of road</td>
</tr>
<tr>
<td>Parking lots</td>
<td>1 test group for every 24 square yards</td>
</tr>
<tr>
<td>Unpaved areas</td>
<td>1 test group for every 40 square yards</td>
</tr>
<tr>
<td>Pipe or conduit trench</td>
<td>1 test group for every 150 feet</td>
</tr>
</tbody>
</table>

Notes:
¹) One (1) test group consists of compaction tests on each layer of fill and backfill.

Q. Quality Control - Inspection, Sampling and Testing for Reclaimed Land (As Placed):

1. The Design-Builder is responsible for developing an inspection and testing program to demonstrate the reclaimed land meets the Technical Requirements and the RFC Plans.

2. At a minimum, the Design-Builder shall perform the following inspection and testing of the reclaimed land, finished in place:

   a. Pre-bored pressuremeter tests in accordance with ASTM D4719 shall be conducted on a grid with maximum 300 feet spacing between boreholes. Pressuremeter tests shall be conducted at 5 feet vertical spacing in each borehole from a depth of 5 feet below the ground surface to a depth of 25 feet below the original seabed. Standard Penetration Tests (SPTs) shall be conducted in accordance with ASTM D1586 in all borings at maximum 5 feet intervals and samples shall be collected using a split-barrel sampler for Particle
b. Cone penetration tests with pore water pressure measurements (CPTus) in accordance with ASTM D5778 shall be conducted on a grid with maximum 300 feet spacing between CPTus. Each CPT shall extend to a minimum 25 feet below the original seabed.

3. The Geotechnical Manager shall certify in writing that the reclamation meets the Technical Requirements and the RFC Plans, and all other requirements of the Geotechnical Manager, with specific reference to the inspection, sampling and testing program.

4. The Design-Builder shall furnish, at the request of the Department, boats, boatmen, laborers and materials necessary for inspecting the work. When required, the Design-Builder shall provide transportation for Department inspectors, personnel, representatives and visitors.

R. Non-Compliance of Reclaimed Land:

1. In the event non-compliant reclaimed land (e.g., a pocket/layer of silt or clay, loose material, or other condition in non-compliance with the RFC Plans) is encountered within the reclamation area, it shall be brought to the Department’s attention. Remedial actions, including but not limited to additional sampling and testing, ground improvement, vibro-compaction or other densification techniques shall be proposed by the Design-Builder for the approval of the Department and implemented at no additional cost to the Department;

2. The Department may require further investigation, including but not limited to boreholes, pressuremeter tests and CPTs, at no additional cost to the Department to further determine the extent and nature of non-compliant reclaimed land and to verify the success of remedial actions.

3. Following the completion of remedial actions and additional investigation, the Geotechnical Manager shall submit a report certifying that the Technical Requirements and the design requirements (as per the RFC Plans) have been achieved.

S. Installation of Geotextile:

1. General: Installation procedures shall be in accordance with manufacturer’s recommendations and shall meet the minimum requirements of the guidelines provided in Appendix X1 of AASHTO M288 and requirements below. For high-strength geosynthetics and geogrids, also follow installation requirements in VDOT’s latest Special Provision.

2. Laying: Geotextiles shall be laid on prepared surfaces in accordance with the manufacturer’s recommendations. The geotextile shall be laid and installed in the positions and to the line and levels described on the RFC Plans. Material, which shall be in contact with the geotextile, shall not have protrusions that are likely to damage the geotextile during installation or in service. Construction equipment shall not operate directly on the geotextile. On sloping surfaces, the fabric shall be laid with its longitudinal axis down the slope.

3. Overlaps: Overlapping widths between adjacent sheets/rolls shall be adapted to compensate the risk of soil uncovering during its installation or during armor stone placement. Geotextiles shall be laid with minimum 12 inch long overlaps between adjacent sheets/rolls above Mean Higher High Water (MHHW) unless detailed or specified otherwise. Where fabric is laid underwater (below MHHW), overlaps shall be a minimum of 36 inch long. The stitching of
adjacent sheets in accordance with the manufacturer’s instructions may be considered as an alternative to lapping.

4. Inspection: The Design-Builder shall conduct joint inspections with the Department for laid geotextile prior to backfill or rock placement. Geotextile placed underwater shall be inspected by a third-party dive company provided by the Design-Builder. The dive inspection shall include underwater video. The Design-Builder shall provide at least 48 hours notification for witnessing the dive inspections.

5. Repair: Should the fabric be damaged during any step of the installation; the damaged section shall be repaired by covering it with a piece of fabric which extends at least 3 feet in all directions beyond the damaged area. The repair fabric shall be secured by stitching per manufacturer’s repair procedures and as approved by the Geotechnical Manager.

6. Cover Material:
   a. Backfill materials shall be placed on the geotextile material as shown on the RFC Plans.
   b. During dumping and spreading, a minimum depth of 8 inch of backfill material shall be maintained between the fabric and wheels of trucks or spreading equipment, as required. All equipment used in spreading or travelling on the geotextile for any reason shall exert ground pressures sufficiently low so as not to tear or otherwise damage the geotextile and shall be approved by the geotextile manufacturer and the Engineer of Record. Equipment operations shall not make direct contact with the fabric.
   c. If tears occur in the fabric during the spreading operation, the backfill material shall be cleared from the fabric and the damaged area repaired as described in above section.
   d. Backfill material shall be spread in the direction of the fabric overlap. Large fabric wrinkles that may develop during the spreading operations shall be folded and flattened in the direction of the spreading. Occasionally, large folds may reduce the fabric overlap width. Special care shall be given to maintain proper overlap and fabric continuity. All land-based equipment spreading cover material or travelling on the cover layer shall avoid making sharp turns, quick stops or quick starts.
   e. The fabric shall be covered as soon as possible after placement to minimize exposure to sunlight. The fabric shall not be exposed to the sun for more than one (1) week. If, due to the nature of the Work, the entire area of geotextile cannot be covered within one (1) week of laying, the exposed areas shall be rolled and protected from sunlight, or shaded by other means approved by the Engineer of Record.
   f. The geotextile shall be protected from damage due to the placement of stone materials by limiting the height of drop of the material. Before any placement of stone, the Design-Builder shall demonstrate that the placement technique shall eliminate damage to the fabric.

T. Placement of Stone:
   1. General:
      a. All stone materials shall be placed in accordance with VDOT Road and Bridge Specifications, Section 414.
b. All stone materials shall be placed uniformly within the slope lines and grades indicated in the RFC Plans.

c. Care shall be taken to place the stone so that it shall form a compact mass and form as nearly as practicable a cross-section of the height, width and slopes as shown in the RFC Plans.

d. All stones shall be carefully placed to design porosity for each structure.

e. Material shall be placed by equipment capable of handling materials of the size specified.

f. The Design-Builder shall control the placement of stone in a manner than limits the turbidity of bay waters in accordance with the RFC Plans and applicable permit conditions.

2. Core materials:

a. Core materials (stone dikes, quarry run) shall be placed to the positions and slope indicated on the RFC Plans and in accordance with the Design-Builder’s sequence of construction operations.

b. Core materials may be discharged from stone transport barges directly into place, or by dozing or end-dumping. Core materials shall be placed to avoid segregation.

c. The Design-Builder shall make all necessary provisions, including but not limited to temporary mooring, special alignment surveys and reshaping material after discharging, to install the core material per the neat lines provided in the RFC Plans.

3. Under Layer/Secondary Armor

a. Placement of under layer, or secondary armor stone, shall be performed in such a manner as to avoid displacing core material or placing undue force on the underlying materials. The material shall be handled and placed in such a manner as to minimize segregation and provide a well graded mass. Rearranging of individual stones may be required to achieve this result.

b. The Design-Builder shall determine a maximum distance to advance the under layer and core material construction ahead of armor layer placement to limit the risk of damage during storms. Should damage to the placed stone occur, the Design-Builder shall be required to remediate any damage at no additional cost to the Department.

c. Placement shall be done in such a manner that the material is uniformly distributed over the previously placed stone. Placement shall begin at the bottom of the slope and proceed upward.

4. Primary Armor:

a. Primary armor stone shall be placed as soon as possible following the placement of secondary layers of stone.

b. Slope protection armor stone shall be placed individually to a full zone thickness in one (1) operation in a manner to avoid displacing the underlying material or placing undue impact force on underlying materials and supporting subsoils.
c. The armor stone shall be placed in a manner to produce a graded mass of stone in accordance with the Technical Requirements and the RFC Plans. Rearranging of individual stones may be required to achieve this result.

d. Unsegregated stone shall be lowered in a bucket or container and placed in a systematic manner directly on the underlying material. Casting or dropping of stone over 1 feet or moving by drifting or manipulating down the slope shall not be permitted.

e. Placement shall begin at the bottom of the slope and proceed upward.

f. The final slope and elevation shall be achieved as the armor stone materials are placed.

5. Scour Protection:

a. Scour protection stone shall be placed to a full zone thickness in one (1) operation in a manner to avoid displacing the underlying material or placing undue impact force on underlying structures, stones and supporting subsoils.

b. The scour protection stone shall be placed in a manner to produce a graded mass in accordance with the Technical Requirements and RFC Plans.

c. Unsegregated stone shall be lowered in a bucket or container and placed in a systematic manner directly on the underlying material. Casting or dropping of stone over 5 feet shall not be permitted.

d. The final elevation shall be achieved as the scour protection stone materials are placed.

U. Construction Tolerances:

1. Leveling and Trimming of Reclamation Area: The Design-Builder shall level the finished fill surface in accordance with the agreed tolerances as stated in the RFC Plans.

2. Slope Protection:

a. The finished surface and stone layer thickness shall not deviate from the lines and grades shown on the RFC Plans by more than the tolerances listed in Table 15.3.6-4.

b. The horizontal tolerance of the profile relative to the positioning shown on the RFC Plans shall be within a tolerance of 18 inch

c. The thickness of individual rock layers (normal to the actual surface) shall not be less than 80% of the thickness shown on the RFC Plans.

d. Mean actual slope profiles of armor layer shall not be steeper than the design slopes indicated on the RFC Plans.

e. The Design-Builder shall make reasonable allowance for stone work settlement that may occur during the Work such that the Work is within the tolerable limits at the time of completion of any section or part of the Work.

Table 15.3.5-4: Stone placement tolerances for core material and primary armor and under layers

<table>
<thead>
<tr>
<th>Depth of Placing</th>
<th>Bulk Placed Stone (Core Material) Design Profile to Actual</th>
<th>Primary Armor and Under Layers Design Profile to Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry – above MLW</td>
<td>+12 in., -8 in.</td>
<td>+0.35 D_{50}, -0.25 D_{50}</td>
</tr>
</tbody>
</table>
### Depth of Placing

<table>
<thead>
<tr>
<th>Bulk Placed Stone (Core Material)</th>
<th>Primary Armor and Under Layers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Profile to Actual</td>
<td>Design Profile to Actual</td>
</tr>
<tr>
<td>&lt; 20 feet below MLW</td>
<td>+18 in., -12 in.</td>
</tr>
<tr>
<td></td>
<td>+0.6 $D_{n50}$, -0.4 $D_{n50}$</td>
</tr>
<tr>
<td>&gt; 20 feet below MLW</td>
<td>+36 in., -12 in.</td>
</tr>
<tr>
<td></td>
<td>+0.6 $D_{n50}$, -0.4 $D_{n50}$</td>
</tr>
</tbody>
</table>

**Notes to Table:**

1) Tolerances are measured perpendicular to neatlines.

2) Extreme limits of the tolerances given shall not be continuous in any direction of more than five (5) times the nominal stone dimension nor for an area greater than 100 square feet of the structure surface. The intention is that the Work be built generally to the required elevation, slope and grade and that the outer surfaces shall be even and present a neat appearance. Placed material not meeting these limits shall be removed or reworked.

3. Scour Protection:

   a. The finished surface and stone layer thickness shall not deviate from the slopes, lines and grades shown in the RFC Plans by more than a tolerance of plus 18 inch or minus 12 inch, measured perpendicular to the indicated neatlines, but shall not develop a thickness less than that shown on the RFC Plans.

   b. Extreme limits of the tolerances given shall not be continuous in any direction for more than 25 feet, nor for an area greater than 400 square feet of the structure surface.

V. Areas of the island expansions that are not covered by pavement, structures or other facilities shall receive topsoil and seeding in accordance with VDOT Road and Bridge Specifications, Sections 602 and 603.

### 15.3.6 Offshore Engineered Fill Berms

A. This section addresses the requirements for offshore engineered fill berms, which may be required to make feasible the bored tunnel option, depending on the vertical tunnel alignment selected by the Design-Builder, by providing additional cover for the tunnel and possibly by providing the medium through which tunneling occurs.

B. Referenced Sections:

1. Refer to Section 15.3.5, Island Expansions. The Technical Requirements presented in Section 15.3.5, Island Expansions shall also apply to the design and construction of offshore engineered fill berms.

2. Refer to Section 16, Marine Engineering for Technical Requirements related to the protection of offshore engineered fill berms against scour, ship groundings, ship anchors and other marine hazards.

3. Refer to Section 23 for Technical Requirements for offshore engineered fill berms related to bored tunneling.

4. The Design-Builder shall perform slope stability analysis for temporary and permanent conditions in accordance with Section 15.3.17, Slope Design.

5. Settlement Limits: Refer to Section 5.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs for settlement limits of the berms.

6. The Design-Builder shall perform ground movement analyses and building damage assessments for existing and proposed facilities in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.
7. Refer to Section 15.3.19, Ground Improvement for Technical Requirements related to ground improvement, if proposed by the Design-Builder.

8. The Design-Builder shall perform instrumentation and monitoring, including slope stability monitoring and settlement monitoring, in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring

15.3.7. **Trench Dredging and Fill Placement for Immersed Tube Tunnels**

A. This Section addresses the Technical Requirements for:

1. The excavation (dredging), separation, hauling and disposing of existing sediments and debris from the proposed immersed tube tunnel trench.

2. The placement of locking fill, ordinary fill and stone, adjacent to and above the proposed immersed tube tunnel, to the elevations and limits shown in the RFC Plans.

3. Refer to Section 16, Marine Engineering for Technical Requirements related to temporary protection of the immersed tube tunnel trenches, and permanent protection of the immersed tube tunnels, against scour, ship groundings, ship anchors and other marine hazards.

4. Refer to Section 24, Immersed Tube Tunnel for additional Technical Requirements for ITT trenches and fill including the ITT foundation.

B. Design, Analysis and Design Submittals:

1. Drawings: The Design-Builder shall provide Drawings of the ITT trench excavations, ITT placement, backfill and protection to the Department for review and approval. The Drawings shall be signed and sealed by the Engineer or Record and shall include the following:
   
   a. Plans showing the limits of the dredging operation, ITT placement, fill placement and stone placement. Clearly indicate the locations of geotechnical explorations on the plans for reference. Clearly indicate the locations of any constraints, including but not limited to existing tunnels and other existing infrastructure, Work limits, navigation channel and/or anchorage limits.

   b. Representative cross-sections of the trench excavations, ITT placement, locking fill, ordinary fill and protective stone. The cross-sections shall show the anticipated geotechnical profile from the sea floor to firm, non-compressible material at depth, below which settlement will not be a factor.

   c. Required engineering properties of the ITT foundation layer, locking fill and ordinary fill (e.g., grain size distributions, density and other properties as specified in the Technical Requirements or the RFC Plans) and required engineering properties of any geotextiles, coordinated with settlement and slope stability analyses. The Geotechnical Manager shall establish thresholds for tolerances for pockets of non-compliant material within the fill materials. Acceptable thicknesses of non-complying material for a single incident and the total accumulated thickness of non-compliant material pockets in the same profile shall be established.

   d. Details of any ground improvement.

   e. Construction sequence of the proposed trenching, ITT placement, backfill and protection.
f. Work to protect existing islands, structures, utilities, slopes and other existing features.

2. Specifications: The Design-Builder shall provide Specifications for the proposed Work to the Department for review and approval. At a minimum the Specifications shall address and be consistent with the topics covered in the Technical Requirements. The Design-Builder shall bring to the attention of the Department any proposed deviation from the Technical Requirements.

3. Settlement analysis: Refer to requirements of settlement analysis for island expansions (i.e., Section 15.3.5.B.3).

4. Slope stability analysis: The Design-Builder shall perform slope stability analysis for temporary and permanent conditions in accordance with Section 15.3.17, Slope Design.

5. Documentation of analysis in Geotechnical Engineering Reports (GERs): Refer to documentation requirements for island expansions (i.e., Section 15.3.5.B.5).

C. Other Submittals:

1. Dredging and Fill Plan: The Design-Builder shall submit the Dredging and Fill Plan to the Department for acceptance prior to start of dredging operations. The requirements of the Dredging and Fill Plan are similar to those of the Reclamation Plan as described in Section 15.3.5.C.1.

2. Borrow Source Report: Refer to Section 15.3.5.C.2.

3. Stone Materials: Refer to Section 15.3.5.C.3.

4. Geotextiles: Refer to Section 15.3.5.C.4.

5. Daily Reports: Refer to Section 15.3.5.C.5.

6. Submit Pre-Construction, Progress and Post-Construction Surveys (hydrographic or topographic) in accordance with Section 8, Surveying and GIS, and with the approved Dredging and Fill Plan.

7. Results of material sampling and testing. Test results shall be issued to the Department daily. The Design-Builder shall check the compliance of the test results with the Technical Requirements and the RFC Plans and advise the Department of any discrepancies.

8. Instrumentation and monitoring results as per Section 5.3.20, Geotechnical Instrumentation and Monitoring.

9. As-Built report for completed placement, including the results surveys and the results of inspection, sampling and testing. The Geotechnical Manager shall provide certification that the Work meets the Technical Requirements and the RFC Plans with reference to the inspection, sampling and testing.

D. Materials:

1. Ordinary Fill: Refer to Section 24, Immersed Tube Tunnel.

2. Stone for Riprap and Bedding: Refer to Section 15.3.5.D.2.

3. Geotextiles: Refer to Section 15.3.5.D.3.
4. Locking Fill: Refer to Section 24, Immersed Tube Tunnel.

E. Quality Control - Material Sampling, Laboratory Testing and Inspection (As Supplied):
   1. Ordinary Fill: Refer to Section 15.3.5.E.1.
   2. Stone for Riprap and Bedding: Refer to Section 15.3.5.E.2.
   3. Geotextiles: Refer to Section 15.3.5.E.3.
   4. Locking Fill: Refer to Section 24, Immersed Tube Tunnel.

F. Equipment: Refer to Section 15.3.5.F.

G. Activities In, Over and/or Adjacent to Navigable Waters: Refer to Section 15.3.5.G.

H. Operation of Existing Islands Including Traffic: Refer to Section 15.3.5.H.

I. Earthwork: Refer to Section 15.3.5.I.

J. Settlement:
   1. It is anticipated that both the ITT backfill materials and underlying soils will settle. The Design-Builder shall make all necessary allowances for the effects of settlement.
   2. The Design-Builder shall make all necessary allowances for the effects of settlement on the proposed Work and on the existing buildings, utilities and infrastructure. Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.
   3. Soft soils and organic soil are anticipated at the Project site. The Design-Builder shall perform ground improvement or replacement of these soils, as required by its design, to control the settlement of the ITT. Settlement mitigation for future ITT settlement shall not include the use of light weight backfill materials, unless otherwise approved by the Department.

K. Ground Improvement: As indicated in the GBR, the Design-Builder is required to perform ground improvement of existing soils to improve the engineering properties of these soils to support the [Engineer of Record’s] design. Ground movement analysis and damage risk assessment shall be performed in accordance with Section [X.XX].

L. Site Clearing: Refer to Section [X.XX].

M. Demolition and Protection of Existing Island Perimeter: Refer to Section [X.XX].

N. Supply of Ordinary Fill Material: Refer to Section [X.XX].

O. Dredging and Placing of Fill Materials:
   1. Place foundation for new immersed tube tunnel in accordance with Section [X], Immersed Tube Tunnel, and in accordance with the approved RFC Plans.
   2. Place locking fill for new immersed tube tunnel in accordance with Section [X], Immersed Tube Tunnel, and in accordance with RFC Plans.
3. Place ordinary fill for new immersed tube tunnel in accordance with Section [X.XX], Immersed Tube Tunnel, and in accordance with RFC Plans.

4. Means and methods employed for placement of fill shall have sufficiently accurate control so as not to damage the new immersed tube tunnel.

P. Compaction of Fill:

1. Compact foundation for new immersed tube tunnel in accordance with Section 24, Immersed Tube Tunnel and in accordance with the approved RFC Plans.

2. Compact locking fill for new immersed tube tunnel in accordance with Section 24, Immersed Tube Tunnel, and in accordance with RFC Plans.

3. Compact ordinary fill for new immersed tube tunnel, if applicable, in accordance with Section 24, Immersed Tube Tunnel, and in accordance with RFC Plans.

4. Means and methods for compaction of fill shall have sufficiently accurate control so as not to damage the new immersed tube tunnel.

Q. Quality Control - Inspection, Sampling and Testing for Fill (As Placed): Refer to Section 24, Immersed Tube Tunnel and RFC Documents.

R. Non-Compliance of Placed Fill: Refer to Section 24, Immersed Tube Tunnel and RFC Documents.

S. Installation of Geotextile: Refer to Section 15.3.5.S.

T. Placement of Stone: Refer to Section 15.3.5.T.

U. Construction Tolerances:

1. Leveling and Trimming of Reclamation Area: The Design-Builder shall level the finished fill surface in accordance with the agreed tolerances as stated in the RFC Plans.

2. Slope Protection: Refer to Section 15.3.5.U.2.

3. Scour Protection: The finished surface and stone layer thickness shall not deviate from the slopes, lines and grades shown in the RFC Plans by more than a tolerance of plus 6 inch or minus 12 inch, measured perpendicular to the indicated neatlines, but shall not develop a thickness less than that shown on the RFC Plans. Extreme limits of the tolerances given shall not be continuous in any direction for more than 25 feet, nor for an area greater than 400 square feet of the structure surface.

15.3.8. Excavations

A. Scope: This section provides Technical Requirements for excavations, including temporary support of excavation (SOE), required for the following: Constructing tunnel approach structures; constructing substructures and superstructures of new bridges; altering existing bridges; and constructing or altering other structures along the Project corridor (e.g., retaining walls, sound walls, drainage pipes and culverts and stormwater management basins).

1. The Design-Builder shall furnish all design services, labor, tools, equipment and materials to perform the excavations and to design and install the temporary SOE as required.
2. The Work includes excavation, removal, transportation and disposal of materials and placement and compaction of backfill.

3. The Work includes performing dewatering in accordance with Section 15.3.9, Dewatering.

4. The Work includes performing slope design in accordance with Section 15.3.17, Slope Design, where applicable.

5. The Work includes ground movement analyses, damage risk assessments, protection of the Work and protection of adjacent structures and utilities in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

6. The Work includes performing ground improvement in accordance with Section 15.3.19, Ground Improvement, as required by the RFC Plans.

7. The Work includes instrumentation and monitoring in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring.

B. Design, Analysis and Design Submittals

1. Qualifications: Submit qualifications of the SOE Designer, if different from the Geotechnical Manager. The Temporary SOE Designer shall be a licensed professional engineer registered to provide services in the Commonwealth of Virginia and shall have a minimum five (5) years practical experience in designing excavations and excavation support systems similar to those proposed.

2. Drawings: Provide drawings presenting, at a minimum, the following:
   a. Plans showing the general arrangement of excavation and temporary SOE relative to the surrounding built environment. Indicate the locations of geotechnical explorations on the plans for reference;
   b. Representative cross-sections showing temporary SOE systems, including but not limited to depth of SOE embedment, excavation depth, lateral support levels, geotechnical profile and groundwater levels;
   c. Load diagrams (e.g., earth, water, surcharge, seismic, waves, currents, wind) shall be provided for each stage of the construction sequence;
   d. Lateral support details including pre-tensioning/preloading of anchors/struts, if applicable;
   e. Connection details;
   f. Details of any ground improvement, including design properties of improved soil;
   g. Construction sequence, including excavation and backfill sequence; and
   h. Works to protect adjacent structures, utilities, slopes and other existing features during the proposed construction.

3. Specifications: The Design-Builder shall provide Specifications for the proposed excavations to the Department for review and approval. At a minimum the Specifications shall address and be consistent with the topics covered in these Technical Requirements. The Design-
Builder shall bring to the attention of the Department any proposed deviation from the Technical Requirements.

4. Design and Analysis Requirements:
   a. Temporary SOE shall satisfy VDOT Road and Bridge Specifications, Section 401 Structure Excavation.
   b. Unless specifically approved by the Department, no temporary structures shall form part of the permanent structure’s walls.
   c. Tremie seals at the base of excavations shall not be considered part of the permanent structure, except for dead weight consideration as approved by the Department.
   d. The Design-Builder shall design excavation ground support to provide excavation stability (e.g., walls and base) with consideration to groundwater control and to ground movement and the resulting risk to adjacent structures and utilities.
   e. The design of temporary SOE systems shall consider several factors, including but not limited to the following: Soil and groundwater conditions; width and depth of excavation; configuration of the structure to be constructed within the cut; size, foundation type and proximity of adjacent structures; utilities crossing the excavation or adjacent to the excavation; requirements for traffic decking across the excavation, if any; and traffic and construction equipment surcharge adjacent to the excavation.
   f. Earth Pressures: The Design-Builder shall determine earth pressures for temporary SOE design, however, the earth pressures shall not be less than those calculated, assuming the active case.
   g. Water Pressures: At a minimum, the temporary SOE system shall be designed assuming a construction water level at 100-year flood elevation plus an additional 2 feet. The unit weight of seawater, if applicable (i.e., for temporary SOE on islands or located offshore), shall be taken as minimum 64.3 pcf. The Design-Builder shall assume all risk associated with flooding and therefore shall determine if a higher water level is appropriate for the design.
   h. Surcharge Loads: The design of the temporary SOE system shall account for all surcharge loads including, but not limited to, traffic, construction material and equipment and building loads. Live loads shall be consistent with the Contractor’s proposed means and methods.
   i. Software used to assist in the analysis shall be appropriate geotechnical software that is widely accepted within the industry, in the opinion of the Department.
   j. At a minimum, all connections (including but not limited to connections of struts to wales and wales to wall systems.) shall be designed and detailed to resist tensile and shearing loads equal to 75% of the member capacity.

5. Documentation of Analysis in Geotechnical Engineering Reports (GERs):
   a. Refer to Section 15.3.3, Geotechnical Analyses, Design and Reporting.
   b. Provide a detailed summary of all geotechnical design parameters used in the analyses including supporting data and reliability assessments;
c. Provide design computations for the excavation, including:
   i. Prediction of deflections and loads (i.e., axial, shear, moment) for SOE elements including but not limited to struts, rakers, wales, reaction blocks and anchors.
   ii. Documentation of structural adequacy of excavation supports and their connections against all relevant modes of failure using LRFD design methods unless otherwise approved by the Department.
   iii. Demonstration that progressive failure of the propping system will not occur in the event any single bracing element fails, or is removed, or is accidentally damaged. The criteria in such case shall be that no adjacent structures or roadways collapse and no failure occurs to any adjacent SOE elements.

d. Provide ground movement analysis and damage risk assessment for adjacent structures and utilities in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

e. Provide an Instrumentation and Monitoring Plan meeting the requirements of Section 15.3.20, Geotechnical Instrumentation and Monitoring. The Plan shall include threshold levels for each instrument, fully coordinated with the ground movement analysis.

C. Construction Submittals:

1. Shop Drawings: The Contractor shall submit shop drawings to the SOE Designer. The SOE Designer shall certify the shop drawings are in accordance with the design and RFC Plans, after which the shop drawings shall be submitted with certification to the Department for acceptance. Shop drawings shall be signed and sealed by a licensed professional engineer registered to provide services in the Commonwealth of Virginia. The shop drawings shall provide sizes and details of fabrication and placement of SOE elements for all stages of the Work.

2. Dewatering Plan – Refer to Section 15.3.9, Dewatering.

3. The Design-Builder shall inform the Department of the site(s) chosen for disposal of excavated materials and shall furnish to the Department copies of all regulatory permits and soil sampling analytical results.

D. Materials:

1. Timber:
   a. All timber used for sheeting, shoring, bracing or other temporary purposes shall be sound and free from any defects that may impair its strength.
   b. Timber shall be spruce, Douglas fir, white or yellow Lodgepole or Ponderosa pine, or Western Hemlock plank planed on one (1) side and either tongued and grooved or splined.
   c. Species, grades or timber and allowable stress shall be indicated on shop drawings.
   d. Timber shall not be less than nominal 4 inch thick and lumber shall not be less than nominal 2 inch thick.
2. Structural Steel:
   a. Structural steel for temporary SOE elements shall conform to ASTM A36 or A572, Grade 50.
   b. Reinforcing steel shall conform to VDOT Road and Bridge Specifications, Section 223.
   c. Structural steel for anchors, bolts, washers, nuts and other connection elements shall conform to VDOT Road and Bridge Specifications, Section 226.

3. Concrete:
   a. Conform to VDOT Road and Bridge Specification, Section 217.

E. Execution:

1. Perform excavations in accordance with VDOT Road & Bridge Specifications, Section 401 Structure Excavation.

2. The Design-Builder shall be solely responsible for the protection of the Works and the protection of adjacent existing structures, roadways and utilities.

3. The Contractor shall dig test pits to locate and identify building foundations, utilities and other subsurface structures for the purposes of determining the measures necessary to maintain and protect the same.

4. Excavation shall be performed to the lines, grades, and elevations as indicated on the RFC Plans, and shall be finished to a reasonable smooth and uniform surface.

5. Disposal of Excavated Materials:
   a. Expeditiously remove, transport and dispose of excavated materials in accordance with permit conditions.
   b. Vehiculars used for removal of material shall be tight and so arranged and loaded so as not to spill. Trucks shall be covered with canvas to prevent spilling of excavated materials. Whenever a truck, bucket or other vehicle so used is leaky or unsuitable, it shall be immediately withdrawn from the Project.

6. Groundwater Control:
   a. Provide groundwater control to prevent seepage gradients that result in soil instability (i.e., quick conditions) and/or seepage that carries soil particles into the excavation. Such measures may include, but are not limited to, extending SOE walls below final excavation level to provide groundwater cutoff; ground improvement of the basal soils to increase strength and lower permeability; and dewatering with the exception that such dewatering shall not result in unacceptable consolidation settlement of compressible soils.
   b. Take immediate action to modify groundwater measures at no additional expense to the Department if such instability, seepage and/or consolidation settlement occurs.
   c. Provide dewatering to lower groundwater levels within the limits/confines of the excavation to produce a dry subgrade as necessary for construction. Refer to Section 15.3.9, Dewatering.
7. Surface and Subsurface Drainage:
   a. Grade excavation perimeter to prevent surface water from entering excavations or adjacent properties.
   b. Do not allow water to pond or infiltrate into the soils at the top of excavations or along the slopes of excavations.
   c. At all times gutters shall be kept open for surface drainage.

8. Pumping:
   a. Remove water that enters excavations by bailing, pumping or other means, taking care to not disturb surrounding soils or structures.
   b. The discharge from all pumps shall be so arranged as to be readily inspected at all times to ascertain whether the water is free from soil particles.
   c. Provide settling basins or other methods to remove solid materials prior to discharge, in accordance with permit conditions.

9. Maintenance and Protection of Traffic: Refer to VDOT Road and Bridge Specifications, Section 512.

10. Temporary earth support walls may remain in place or be removed following the completion of the structure. Temporary earth support walls left in place shall be cut off no less than 5 feet below finished grade. Removal of earth support walls shall be allowed provided the Design-Builder submits a deformation analysis for review and acceptance of the Department. The analysis shall demonstrate that removal will not cause settlement or damage to the adjacent structures including the new structure. The Design-Builder shall be responsible for all remedial work if damage occurs.

15.3.9. Dewatering Systems

A. The Design-Builder shall design, install, operate and maintain dewatering systems (e.g., sumps, pumps, deep wells, vacuum-assisted deep wells, vacuum-assisted well points, educator wells, filter materials, header pipes, valves, settling basins/tanks and other treatment equipment, flow meters and other appurtenances) to achieve the following:
   1. Remove pore water from soil within the limits of excavations to facilitate excavation of the soil and to otherwise maintain a dry, stable excavation; and
   2. Lower groundwater levels outside the limits of the excavation and/or reduce water pressure outside or beneath the limits of the excavation, if required by the proposed means and methods to maintain a dry, stable excavation, provided the Design-Builder has demonstrated that such dewatering will not create unacceptable damage risk to adjacent structures, pavements, utilities or other facilities as per Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

B. Dewatering Systems Designer: The Design-Builder shall employ the services of a Dewatering Systems Designer to design dewatering systems as required for the proposed excavations. The Dewatering Systems Designer shall coordinate with the Geotechnical Manager to ensure the dewatering system design addresses the needs of the geotechnical design. The Dewatering Systems Designer shall be routinely engaged in the design of dewatering systems for similar excavations in similar ground and groundwater conditions.
C. Dewatering Plan: The Design-Builder shall provide a Dewatering Plan for Department review and acceptance. The Dewatering Plan shall include the following:

1. Qualifications of the Dewatering Systems Designer;
2. Copies of permits obtained by the Design-Builder;
3. Plans, elevations, sections and details identifying the arrangement, location and type of dewatering system.
   a. Indicate on the plans the locations of geotechnical explorations (e.g., boreholes, CPTs) used in the dewatering systems design.
   b. Indicate on the sections the assumed geotechnical profile and groundwater elevations, based on the geotechnical explorations.
   c. The dewatering system design (e.g., type of wells or well points, spacing of wells/well points) shall consider the nature of the soils to be dewatered as indicated by the geotechnical explorations.
   d. The dewatering system design shall consider the groundwater drawdown and/or pore water pressure relief requirements of the proposed support of excavation system. To this end, the Dewatering Plan shall reference, and be coordinated with, the relevant excavation design submittals, which are described in Section 15.3.8.B;
4. The means of collecting, handling, treating and discharging (disposing) of the water;
5. Means of measuring the volume of water discharged (disposed);
6. Details of equipment comprising the dewatering system, including manufacturers’ information;
7. Details of holding ponds, sediment and oil removal systems, and other treatment facilities;
8. Details of power supply and backup power supply;
9. Manufacturer’s instructions and calibration records for pumps, water meters, flow measuring devices and other water treating and handling systems equipment;
10. Safety and emergency response in the event of equipment malfunction, loss of power or other reasonably foreseeable calamity;
11. Procedures in the event contaminated groundwater is suspected;
12. Determination of expected settlement and the potential damage risk to adjacent structures and utilities in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs; and
13. Proposals to instrument and monitor the dewatering operation in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring.

D. The Design-Builder shall design, install and continuously operate and maintain dewatering operations to prevent erosion or loss of soil; ensure the stability of excavations and constructed slopes; allow construction operations to be performed in the dry as required for prosecution of the Work; and prevent flooding.

E. Select type and spacing of well points and/or wells as required to provide sufficient dewatering given the site specific geotechnical and groundwater conditions as revealed by geotechnical investigation.

F. Maintain piezometric water level a minimum of 48 inch below bottom of excavation.
G. The bearing surface for all structural slabs, footings and walls shall be kept dry and stable with no flowing, standing and/or piping of water permitted.

H. Use filters or other means to prevent pumping of fine sands or silts from the subsurface. Open sump pumping that leads to loss of fines, soil piping, subgrade softening, slope instability or other detrimental impact, in the opinion of the Department, will not be allowed.

I. Dewatering shall be conducted in a manner that prevents muddy water, eroded materials and other undesirable constituents from being discharged into receiving sewer systems or bodies of water in accordance with permit conditions. Provide settling basins, sedimentation tanks and other treatment devices as required to comply with permit conditions. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of Work under construction or completed.

J. Operate the system continuously until structures have been constructed and fill materials have been placed or until dewatering is no longer required.

K. Provide standby equipment on-site, including backup power systems, installed and available for immediate operation, to maintain dewatering on a continuous basis if any part of the system becomes inadequate or fails.

L. Immediately inform the Department in the event contaminated groundwater is suspected. Provide all necessary protective equipment for personnel and perform all necessary safety precautions to protect personnel and the public. Test groundwater for contaminants and hazardous materials. Treat and/or dispose of contaminated and hazardous water in accordance with permit conditions.

M. Prevent damage to subgrades, structures, utilities, pavements and other facilities as may be caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations. Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

N. Provide instrumentation and monitoring of the dewatering operation in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring including observation wells and piezometers to monitor the impact of dewatering both inside and outside the limits of excavation (if applicable) as well as instrumentation to monitor any resulting settlement.

O. Remove the dewatering system upon completion of dewatering. Fill or grout well holes with sand or cut off and cap wells a minimum of 36 inch below overlying construction. Reinstate the surface to its original conditions.

15.3.10. Foundations

A. The Design-Builder shall provide all design services, labor, tools, equipment and materials to design and construct foundations for the proposed structures that comprise the Works.

B. Design and construct foundations in accordance with applicable VDOT and AASHTO requirements, including but not limited to the following:

1. VDOT Manual of Structure and Bridge Division, Part 11, Chapter 8 Shallow Foundations;
2. VDOT Manual of Structure and Bridge Division, Part 11, Chapter 9 Deep Foundations; and
3. AASHTO LRFD Bridge Design Specifications, Chapter 10.

C. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for foundation analysis, design and reporting requirements.
D. Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs for settlement limits for new structures.

E. Geotechnical engineering recommendations for structural design shall conform to LRFD methodologies, where applicable. Refer to AASHTO LRFD Bridge Design Specifications, Customary U.S. Units, current addition and interim revisions for information on LRFD. It is incumbent on the geotechnical engineer to obtain anticipated structural loads and use appropriate load and resistance factors when providing design parameters.

F. Geotechnical design for foundations shall consider evaluation of the vertical and lateral resistance of the foundations, settlement (including compressibility of foundation soils) and the potential for downdrag loads on deep foundations.

G. Steel piles shall meet the requirements of VDOT Road and Bridge Specifications, Section 228.

H. Bearing piles shall meet the requirements of VDOT Road and Bridge Specifications, Section 403.

I. Trenches or pits for foundations shall be excavated to the lines, grades and elevations shown on the RFC Plans. They shall be of sufficient size to permit the placing of foundations to the full length and width shown.

J. Poor foundation material shall be removed below the normal designed elevation.

K. Disposal of excavated material is the responsibility of the Design-Builder.

15.3.11. Earthwork – Cut Slopes and Embankments

A. This section applies to earthwork along the Project corridor as it relates to road and bridge design and construction. This section does not apply to island expansions and offshore engineered fill berm construction, which are addressed in Section 15.3.5, Island Expansions and Section 15.3.6, Offshore Engineered Fill Berms, respectively.

B. Earthwork shall include regular, borrow, undercut, and minor structure excavations; constructing embankments; disposing of surplus and unsuitable material; shaping/grading; compaction; sloping; dressing; and installing and maintaining temporary erosion and siltation control work while performing these operations.

C. Earthwork shall be performed in accordance with the requirements stated in the following:
   1. VDOT Road and Bridge Specifications, including but not limited to Sections 106 and 303.

D. Borrow Source Report(s): The Design-Builder shall submit a report to the Department pertaining to the borrow source location(s) prior to the start of fill operations. The report shall include the borrow source location(s), representative material gradation(s) and moisture density curves for each material proposed for use, laboratory test results and quantity of available material from each source. Borrow material reports shall include all required test data for the intended use on the project. For example, in proximity to the road bed, the borrow materials may require AASHTO soil classification and/or unconfined compressive strength for correlation to MEPDG pavement design.

E. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for earthwork analysis, design and reporting requirements.
F. The Design-Builder shall consider slope stability of cut-slopes and embankments. Refer to Section 15.3.17, Slope Design.

G. The Design-Builder shall consider compressibility of the underlying soils to evaluate the magnitude and time rate of settlement for embankment fills with and without wick drains and/or surcharge loads. Both vertical and horizontal deformations shall be addressed.

H. The Design-Builder shall consider ground movement and damage risk to adjacent facilities. Refer to Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

I. The Design-Builder shall provide instrumentation and monitoring in accordance with Section 303 of the VDOT Road and Bridge Specifications and Section 15.3.20, Geotechnical Instrumentation and Monitoring.

15.3.12. Retaining Walls

A. Design and construct permanent retaining walls in accordance with applicable VDOT and AASHTO requirements, including but not limited to the following:
   1. VDOT Road and Bridge Specifications, Section 506;
   2. VDOT Manual of Structure and Bridge Division, Part 11, Chapter 10 Earth Retaining Structures; and
   3. AASHTO LRFD Bridge Design Specifications, Chapter 11.

B. Retaining walls used for temporary support of excavation (SOE) are addressed in Section 15.3.8, Excavations.

C. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for retaining wall analysis, design and reporting requirements.

D. Retaining walls shall be designed and constructed to control ground movement in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

E. The Design-Builder shall consider shear strength of the foundation soils to evaluate external stability for retaining walls (bearing, sliding and overturning). Global (slope) stability shall also be considered in design.

F. The Design-Builder shall consider compressibility of the underlying soils to evaluate the magnitude and time rate of settlement.

G. The Design-Builder shall consider lateral strength and deformation characteristics of the soils behind permanent retaining walls.

H. Design and construction of mechanically stabilized earth (MSE) walls shall be in accordance with the latest VDOT's Special Provisions for approved proprietary MSE walls (VDOT Manual of Structure and Bridge Division, Part 11, Chapter 10 Earth Retaining Structures). The Design-Builder shall provide both global and external stability analysis utilizing software that is widely accepted in the industry, in the opinion of the Department, and submit the results of the analysis, including boring logs, laboratory data, and any other applicable data, to the Department for review. The wall supplier shall provide to the Design-Builder, for submittal to the Department, an internal stability analysis that validates the design of the wall.
15.3.13. Sound Walls
A. Design and construct sound walls in accordance with applicable VDOT and AASHTO requirements, including but not limited to the following:
   1. VDOT Road and Bridge Specifications, Section 519; and
   2. AASHTO LRFD Bridge Design Specifications, Chapter 15.
B. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for analysis, design and reporting requirements.

15.3.14. Drainage Pipes and Culverts
A. Design and construct drainage pipes and culverts in accordance with applicable VDOT requirements, including but not limited to the following:
   1. VDOT Memorandum of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering, Section 305.05 Drainage Pipes and Culverts; and
   2. VDOT Road and Bridge Specifications, Section 302 Drainage Structures.
B. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for analysis, design and reporting requirements.
C. Pipe Installation Methods:
   1. Any utility pipes or storm drain installations that cross the I-64 mainline travel lanes or ramps are to be installed using trenchless methods (i.e., jack and bore, microtunneling, or other method of installation approved by the Department).
   2. Any utility excavations or excavations for storm drains in all other locations within pavement areas shall be backfilled with compacted structural fill in accordance with applicable sections of the Road and Bridge Specifications and applicable Special Provisions.
D. Trenchless Installation:
   1. The Design-Builder is responsible for all aspects of the trenchless design and construction and shall provide details of his/her proposed design and construction to the Department for review and acceptance.
   2. The Design-Builder shall choose the methods of installation best suited for the ground and site conditions.
   3. Jack and Bore shall be performed in accordance with VDOT Road and Bridge Specifications, Special Provision SP302-000120-00, Jack and Bore.
   4. Microtunneling shall be performed in accordance with VDOT Road and Bridge Specifications, Special Provision SP302-000130-00, Microtunneling.
   5. The Design-Builder shall be responsible to establish both the vertical and horizontal tolerances in support of the design. Such tolerances shall be noted on the RFC Plans. Under no circumstances shall the design tolerances used in design of either culverts or utility pipes exceed those specified in the VDOT Road and Bridge Specifications and the applicable Special Provisions.
   6. Performance requirements and tolerances stipulated in the Special Provisions shall also apply to conventional tunneling methods.
E. Drainage pipes and culverts shall be designed and constructed to control ground movement in accordance with Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs.

F. The Design-Builder shall provide instrumentation and monitoring in accordance with VDOT Road and Bridge Specifications, Section 302.03; the Special Provisions for Jack and Bore or Micro-Tunneling, as applicable; and Section 15.3.20, Geotechnical Instrumentation and Monitoring.

15.3.15. Stormwater Management Basins

A. Design and construct drainage pipes and culverts in accordance with applicable VDOT requirements, including but not limited to the following:

1. VDOT Memorandum of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering, Section 305.06 Stormwater Management Basins.

B. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for analysis, design and reporting requirements.

C. Perform excavations for stormwater management basins in accordance with Section 15.3.8, Excavations.

15.3.16. Minimum Pavement Sections

A. Minimum pavement sections and locations shall be utilized for Proposal preparation purposes. The anticipated locations for new pavement, mill and overlay, and demolish and replace pavement sections are provided on the RFP Conceptual Plans included in the RFP Information Package. The Design-Builder shall be required to validate the minimum pavement sections and to notify the Department of its findings. Pavement designs shall be in accordance with the AASHTO Mechanistic-Empirical Pavement Design Guide (August 2015 – Second Edition) using AASHTOWare Pavement ME Design software with data extracted from the Long-Term Pavement Performance (LTPP) database for the design of pavements for new alignments, lane additions, and total reconstruction. Sections of existing pavement that will be rehabilitated (i.e. overlay) and not considered new pavement shall be designed using the 1993 AASHTO procedure per Chapter VI of the Manual of Instruction for the Materials Division. If the Design-Builder’s findings require a deviation from the RFP requirements, it shall notify the Department during the Scope Validation Period consistent with Part 2 Section 1.1.6. Acceptable changes to the minimum pavement sections are limited to increasing the thicknesses of individual layers of the minimum pavement section. Any changes to the minimum pavement sections and/or locations of the pavement sections provided in this Part 15, Section 15.3.16 require approval by the Department. The Design-Builder shall be responsible for the final design and construction of the pavements for this Project in accordance with the Contract Documents including but not limited to Appendix 18.1 - “Traffic Design Criteria for Pavement Analysis and Design.”

B. The Design-Builder shall photographically document the existing condition of all pavements within and adjacent to the Project limits prior to the Design-Builder’s submission of final construction plans for Department approval and provide all photos to the Department. Photos shall be color digital images in .jpg format with 4 megapixels (approximately 2400 pixels wide x 1600 pixels high) or greater resolution. The Design-Builder shall be responsible for full-depth replacement of all pavement damaged resulting from Project construction activities, regardless of the method or location of the pavement damage.
C. The Design-Builder shall prepare and incorporate into the plans, typical sections, profiles and cross-sections the validated pavement sections in accordance with the applicable manuals noted in Part 2, Section 4 Standards. This includes drainage and subdrainage requirements to ensure positive drainage both within the pavement structure and on the pavement surface. Note that the existing I-64 general purpose lanes within the project limits do not have any sub-drainage system. A sub-drainage system for HOT/HOV/managed or other new lanes shall be independent of the existing pavement.

D. The final pavement surface on all I-64 lanes, except ramps, within the Project construction limits shall meet the requirements for rideability detailed in Part 2, Section 4 Standards 4.3. (c) Special Provisions Lists, Special Provision Copied Notes and Supplemental Specifications, Materials; specifically, the Rideability Special Provision for Design Build Project, November 16, 2016.

E. New Pavement, Pavement Widening and Mill and Overlay. The following items shall be considered for pavement design:

1. The HOT lane is defined as the HOT, HOV or managed lane and the adjacent buffer. Any recommendations in Section 15.3.6 for the HOT lane are also applicable to the buffer.

2. The type of pavement and the design life presented in Table 15.3.16-1 shall be used for the final pavement design.

3. For the arterial and local roads (e.g., Settlers Landing Road, S. Mallory Street, 13th View Street, 4th View Street, Mason Creek Road, 1st View Street, W Bay Avenue/W Ocean Avenue, Evans Street, E. Bayview Boulevard, Gate 22 Naval Station Road and Granby Street), new pavement with design life of 20 years shall be used.

4. All materials within the uppermost three (3) feet of the new pavement subgrade shall have minimum CBR value of 10.

5. For the HOT lanes, general purpose lanes and shoulders a stabilized OGDL shall be used to provide lateral drainage and the OGDL layer shall be connected to a standard UD-4 edgedrain placed beneath the outside edge of the paved shoulder.

6. For the new ramps and arterial roads, VDOT 21B can be used and shall be connected to a standard UD-4 edge drain placed beneath the outside edge of the paved shoulder or day lighted to the face of a ditch.

7. No drainage layer shall be used for reconstruction of the general-purpose lanes under the exiting bridges; S. Mallory Street and I-564.

8. FHWA vehicle classifications 4 through 7 were assumed to fall under single unit (SU) vehicles and classifications 8 and above was assumed to fall under tractor and semi-trailer (TTST) vehicles.

9. Overlays of the existing shoulder that change the elevation of the shoulder at the face of guardrail is considered a direct impact to the existing guardrail and will result in the need to upgrade the existing guardrail and terminals to meet current standards.

10. Tractor and semi-trailer (TTST) vehicles traffic shall be included within the permanent and temporary HOT lane designs.

11. The minimum pavement sections are provided in Table 15.3.16-2 and 15.3.16-3.

12. The minimum pavement sections require that proper grading be maintained to direct surface water away from paved areas and to provide for efficient runoff from surrounding areas.
13. Edgedrains/underdrains shall be provided for the pavements in accordance with VDOT guidelines.

14. Open Graded Drainage Layer (OGDL), asphalt or cement stabilized, will conform to VDOT Special Provision for Open Graded Drainage Layer (OGDL), (November 10, 2016).

### Table 15.3.16-1 Pavement Design Type and Design Life

<table>
<thead>
<tr>
<th>Roadway</th>
<th>I-64 Pavement</th>
<th>I-64 Pavement</th>
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<tr>
<td></td>
<td>West of HRBT</td>
<td>East of HRBT</td>
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<tr>
<td>GP travel lanes existing</td>
<td>Provide 11 years design life (until</td>
<td>Provide 30 years design life (until</td>
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<tr>
<td>pavements</td>
<td>2030) Asphalt Concrete (AC)</td>
<td>2050) AC or CRCP pavement</td>
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<tr>
<td>New HOT lane and left</td>
<td>Provide 11 years design life (until</td>
<td>Provide 30 years design life (year</td>
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<td>shoulder</td>
<td>2030) AC pavement with Aggregate</td>
<td>2050) AC pavement for the new I-64</td>
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<td>Type I, No. 21B</td>
<td>WB ramps</td>
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<tr>
<td>Under Existing Bridges</td>
<td>Provide 11 years design life (until</td>
<td>Provide 20 years design life (year</td>
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<td>2030) full reconstruction AC pavement under I-64</td>
<td>2040) new AC pavement for the I-64</td>
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<td></td>
<td>and S Mallory Street bridges over the</td>
<td>WB approaches only to the new Hampton Roads Bridge Tunnel tube</td>
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<td>interstate to match existing grades and</td>
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<td>maintain the existing bridge vertical clearance.</td>
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<tr>
<td>I-64 Ramps</td>
<td>No changes to the existing ramps</td>
<td>Provide 20 years design life (year 2040) new AC pavement for the proposed road … _____ .</td>
</tr>
<tr>
<td>Hampton Roads Bridge</td>
<td>Provide 30 years design life (year 2050) AC or CRCP pavement for the I-64 WB approaches only to the new Hampton Roads Bridge Tunnel tube</td>
<td></td>
</tr>
<tr>
<td>Tunnel Approaches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterial and Local</td>
<td>Provide 20 years design life (year 2040) new AC pavement for the proposed ramps to S. Mallory Street.</td>
<td>Provide 20 years design life (year 2040) new AC pavement for the proposed road … _____ .</td>
</tr>
<tr>
<td>Outside (Right) Shoulder</td>
<td>Evaluate the design life of the existing outside shoulder to support traffic during construction. Provide minimum AC overlay to temporarily extend the life to the shoulder to 2022. See Section below for design of shoulder strengthening and temporary pavement.</td>
<td></td>
</tr>
</tbody>
</table>

### Table 15.3.16-2 – Mainline I-64, EB and WB – General Purpose Lanes, HOT Lanes and Shoulder

<table>
<thead>
<tr>
<th>Roadway</th>
<th>Limits</th>
<th>Build-Up</th>
<th>Widening</th>
</tr>
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<tbody>
<tr>
<td>I-64, EB/WB</td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Mill 1”</td>
<td>Mill 1”</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-12.5 (76-22)</td>
<td>2” SMA-12.5 (76-22)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-19.0 (76-22)</td>
<td>2” SMA-19.0 (76-22)</td>
</tr>
<tr>
<td>I-64, EB/WB</td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Mill 1”</td>
<td>Alternative 1:</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-12.5 (76-22)</td>
<td>2” SMA-12.5 (76-22)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-19.0 (76-22)</td>
<td>2” SMA-19.0 (76-22)</td>
</tr>
<tr>
<td></td>
<td>I-64-WB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Mill 1”</td>
<td>Alternative 2:</td>
</tr>
<tr>
<td></td>
<td>I-64-WB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-12.5 (76-22)</td>
<td>11.0” Continuous Reinforced Concrete Pavement Slab</td>
</tr>
<tr>
<td></td>
<td>I-64-WB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2” SMA-19.0 (76-22)</td>
<td>2” OGDL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mill 1”</td>
<td>6” CTA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2” SMA-12.5 (76-22)</td>
<td>36” CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2” SMA-19.0 (76-22)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5” BM-25.0D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2” OGDL</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>6” CTA</td>
<td></td>
</tr>
<tr>
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<td></td>
<td>36” CBR10 (Existing/Borrow)</td>
<td></td>
</tr>
<tr>
<td>Roadway</td>
<td>Limits</td>
<td>Build-Up</td>
<td>Widening</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>I-64, EB/WB</td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Demolish Existing AC/CRCP and replace with 2'' SMA-12.5 (76-22)</td>
<td>Alternative 1: 2'' SMA-12.5 (76-22) 2'' SMA-19.0 (76-22) 5'' BM-25.0D</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2'' SMA-19.0 (76-22)</td>
<td>2'' OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
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<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>7.5'' BM-25.0D 36'' CBR10 (Existing/Borrow)</td>
<td><strong>Alternative 2:</strong> 11.0'' Continuous Reinforced Concrete Pavement Slab 2''</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td></td>
<td>OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Mill 1'' 2'' SMA-12.5 (76-22) 3'' SMA-19.0 (76-22)</td>
<td>2'' SMA-12.5 (76-22) 3'' SMA-19.0 (76-22) 3'' BM-25.0D 7'' 21B</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td></td>
<td>36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Demolish Existing AC/CRCP and replace with 2'' SMA-12.5 (76-22)</td>
<td>2'' SMA-12.5 (76-22) 2'' SMA-19.0 (76-22) 4'' BM-25.0D 7'' 21B</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>2'' SMA-19.0 (76-22)</td>
<td>36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>7.5'' BM-25.0D 36'' CBR10 (Existing/Borrow)</td>
<td><strong>Alternative 2:</strong> 11.5'' Continuous Reinforced Concrete Pavement Slab 2''</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td></td>
<td>OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td>I-64-EB Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Demolish Existing AC/CRCP and replace with <strong>Alternative 1:</strong> 2'' SMA-12.5</td>
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<tr>
<td></td>
<td></td>
<td>2'' SMA-19.0 (76-22)</td>
<td>(76-22) 5'' BM-25.0D 2'' OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5'' BM-25.0D</td>
<td><strong>Alternative 2:</strong> 11.5'' Continuous Reinforced Concrete Pavement Slab 2''</td>
</tr>
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<td>2'' OGDL 6'' CTA</td>
<td>OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36'' CBR10 (Existing/Borrow)</td>
<td><strong>Alternative 2:</strong> 11.5'' Continuous Reinforced Concrete Pavement Slab 2''</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Alternative 2:</strong> 11.5'' Continuous Reinforced Concrete Pavement Slab 2''</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OGDL 6'' CTA 36'' CBR10 (Existing/Borrow)</td>
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### Roadway Limits

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<th>Widening</th>
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<td>I-64-WB</td>
<td>Sta xx+yy.zz to Sta xx+yy.zz</td>
<td>Alternative 1:</td>
<td>Alternative 1:</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz</td>
<td>2” SMA-12.5 (76-22)</td>
<td>2” SMA-12.5 (76-22)</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz to</td>
<td>3” SMA-19.0 (76-22)</td>
<td>3” SMA-19.0 (76-22)</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz (I-64 WB)</td>
<td>5” BM-25.0D</td>
<td>5” BM-25.0D</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz (xx Road)</td>
<td>2” OGDL</td>
<td>2” OGDL</td>
</tr>
<tr>
<td></td>
<td>xx Road Right Shoulder – Sta xx+yy.zz to</td>
<td>6” CTA</td>
<td>6” CTA</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz (I-64 WB)</td>
<td>36” CBR10</td>
<td>36” CBR10</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz</td>
<td>(Existing/Borrow)</td>
<td>(Existing/Borrow)</td>
</tr>
<tr>
<td>xx Roads</td>
<td>Sta xx+yy.zz to</td>
<td>Demolish Existing</td>
<td>1.5” SMA-12.5 (76-22)</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz (xx Road)</td>
<td>AC 1.5” SMA-12.5 (76-22)</td>
<td>3” SMA-19.0 (76-22)</td>
</tr>
<tr>
<td></td>
<td>xx Road Right Shoulder – Sta xx+yy.zz to</td>
<td>3” SMA-19.0 (76-22)</td>
<td>4” BM-25.0D</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz</td>
<td>4” BM-25.0D</td>
<td>2” OGDL</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz</td>
<td>2” OGDL</td>
<td>6” CTA</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz</td>
<td>6” CTA</td>
<td>36” CBR10</td>
</tr>
<tr>
<td></td>
<td>Sta xx+yy.zz I-64 WB)</td>
<td>36” CBR10</td>
<td>(Existing/Borrow)</td>
</tr>
</tbody>
</table>

### Notes:
1. The limits stated in the table above are based on preliminary studies. The Design-Builder shall determine exact limits based upon archive plans and field verification of in-situ pavement sections.
2. Thicknesses of existing pavement materials are approximate; Design-Builder should expect some variability in these thicknesses; no impact methods to be used for removal.
3. OGDL = open graded drainage layer.
4. CTA = Agg. Base Material, Type I, Size No. 21A pugmill mixed with 4% hydraulic cement by weight.
5. All new paved shoulders on interstate shall have the same pavement recommendations as the mainline lanes except for using SM-12.5A and IM-19.0A instead of the SMA12.5 and SMA-19, respectively.
6. Mainline pavement includes all acceleration/deceleration lanes and auxiliary lanes.

### Table 15.3.16-3 – Ramps and Arterial Roadways – Travel Lanes and Shoulder

<table>
<thead>
<tr>
<th>Roadway</th>
<th>SM-12.5A</th>
<th>IM-19.0A</th>
<th>BM-25.0D</th>
<th>OGDL</th>
<th>CTA</th>
<th>21B</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-64 WB Ramp to Settlers Landing Road</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp from Settlers Landing Road</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp to S. Mallory Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp from S. Mallory Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp to S. Mallory Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp from S. Mallory Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp to 15th View Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp from 15th View Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp to Bayville Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
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</tbody>
</table>
### Technical Requirements

**Part 2, Section 15**

**May 21, 2018**

**Geotechnical**

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<table>
<thead>
<tr>
<th>Roadway</th>
<th>SM-12.5A</th>
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<th>BM-25.0D</th>
<th>OGDL</th>
<th>CTA</th>
<th>21B</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-64 EB Ramp from Bayville Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
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<tr>
<td>I-64 WB Ramp to 4th View Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp from 4th View Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp to 4th View Street</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
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<td>6”</td>
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<tr>
<td>I-64 EB Ramp from 4th View Street</td>
<td>1.5”</td>
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<tr>
<td>I-64 WB Ramp to Navy Station Bay Avenue</td>
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<td>I-64 EB Ramp from Navy Station Bay Avenue</td>
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<td>2.5”</td>
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<td>6”</td>
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<tr>
<td>I-64 WB Ramp from Granby Street</td>
<td>1.5”</td>
<td>2”</td>
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<td>6”</td>
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<tr>
<td>I-64 EB Ramp from Navy Station Gate 22</td>
<td>1.5”</td>
<td>2”</td>
<td>2.5”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp from Reversible HOT Lane</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp from I-564</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp to I-564/Granby Street</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
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<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 EB Ramp to Reversible HOT Lane</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
<tr>
<td>I-64 WB Ramp to I-564</td>
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<td>3”</td>
<td>4”</td>
<td>--</td>
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<td>6”</td>
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<tr>
<td>I-64 EB Ramp from I-564</td>
<td>1.5”</td>
<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
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<tr>
<td>I-64 Reversible HOT Lane from I-546</td>
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<td>3”</td>
<td>4”</td>
<td>--</td>
<td>--</td>
<td>6”</td>
</tr>
</tbody>
</table>

**Notes:**

OGDL = open graded drainage layer.

CTA = Agg. Base Material, Type I, Size No. 21A pugmill mixed with 4% hydraulic cement by weight.

**F. Shoulder Strengthening and Temporary Pavement**

The Design-Builders shall be responsible for the design of any temporary or shoulder strengthening pavement required to be used to maintain traffic during construction. These designs shall be in accordance with the AASHTO Guide for the Design of Pavement Structures (1993 edition) and Chapter VI of the MOI. All temporary and shoulder strengthening designs for interstate mainline or ramp pavements shall be designed to meet the following minimum design criteria:

1. Design Life – six months or the full duration the pavement will be in use in accordance of the approved Transportation Management Plan (TMP) plan (Part 2, Section 13), whichever is the longer duration.
2. Reliability – eighty-five percent (85%) minimum
3. Initial Serviceability – 4.2 minimum
4. Terminal Serviceability – 2.8 minimum
5. Standard Deviation – 0.49 minimum
6. CBR value for subgrade soils determined through laboratory tests
7. Temporary Pavement shall have at a minimum 6-inches of asphalt concrete.
8. Proper grading must be maintained to direct surface water away from paved areas and to provide for efficient runoff from surrounding areas.

All temporary and shoulder strengthening pavement designs shall be submitted to the Department for review and approval a minimum of 14-days prior to installation.

All temporary pavement shall be completely removed once it is no longer in service.

15.3.17. Slope Design

A. The Design-Builder shall perform engineered slope design (i.e., slope design supported by an engineering analysis based upon site-specific field investigation and site-specific laboratory strength testing) for the review and acceptance of the Department for slopes including, but not limited to, the following:

1. Cut and fill slopes along the Project corridor, either temporary or permanent, with a slope angle steeper than 2H:1V;
2. Sidewalls of trench excavation for immersed tube tunnel construction (immersed tube option) regardless of slope angle;
3. Fill slopes covering the tunnel, bored or immersed tube, regardless of slope angle;
4. Slopes of proposed island expansions, either temporary or permanent, regardless of slope angle; and
5. Global slope stability checks for temporary support of excavation systems and for permanent retaining walls and bridge abutments.

B. Engineering analysis shall include an evaluation of stability for interim construction stages, for the end of construction condition, and for design-life conditions. Both drained and undrained analysis shall be considered, as appropriate.

C. The stability analysis of fill embankments shall include multiple runs for various stages of construction accounting for pore pressure increases and dissipation. The Design-Builder shall justify any assumed design strength gain associated with settlement through relations derived in the laboratory or other method as approved by the Department.

D. Minimum factors of safety for soil slopes shall meet the requirements of VDOT Manual of Instructions (MOI) for Materials Division, Chapter III Geotechnical Engineering, Section 305.03. Exceptions to these requirements must be approved by the Department on a case-by-case basis.

E. Slope stability analysis:

1. Methods of analysis shall meet the requirements of VDOT MOI, Section 305.03.
2. Slope stability models shall be based on site-specific conditions. The Design-Builder shall clearly identify the location of each slope analyzed as well as the location of each soil boring log(s) and all relevant laboratory test data that were used to prepare each stability model.
3. Select geotechnical design parameters for slope stability analysis in accordance with Section 15.3.3, Geotechnical Analysis, Design and Reporting.
4. The Design-Builder shall use an industry recognized slope stability modeling software program such as GeoStudio Slope/W or approved equal to perform two-dimensional (2D) limit equilibrium analysis for critical slope sections.
5. Circular failure surfaces shall be analyzed by methods such as the Modified Bishop or Spencer methods. In addition, block (i.e., wedge failure) analyses shall be provided to verify the minimum factor of safety (FOS).

6. All slope stability analyses shall consider the effects of groundwater, external loads, tension cracks and other pertinent factors as applicable.

7. The Design-Builder shall demonstrate that the critical failure surfaces generated by the models meet the minimum FOS requirements and are representative of the anticipated construction conditions.

8. For slopes to be built on top of existing slopes, base-case slope stability calculations shall be performed first to establish the FOS of the existing slopes prior to analyzing the later construction stages.

F. Documentation of slope stability analysis in Geotechnical Engineering Reports (GERs):
   1. Refer to Section 15.3.3, Geotechnical Analysis, Design and Reporting for earthwork analysis, design and reporting requirements.
   2. All data, assumptions, and calculations (hand calculations and electronic files, if warranted, including software input and output files) shall be included in slope stability reports submitted for review.

15.3.18. Ground Movements Analysis, Damage Risk Assessment, Protective Measures and Repairs

A. Scope:

   1. The Design-Builder shall perform ground movement analysis, with consideration to both vertical movement (settlement or heave) and horizontal movement, for all Work that could potentially cause significant ground movement, in the opinion of the Design-Builder or the Department. Work that could potentially cause significant ground movement includes, but is not limited to, the following:
      a. Major excavations including but not limited to braced excavations (including installation of temporary support of excavation walls), cut slopes, subaqueous trenches and bored tunneling;
      b. Significant fill placements including but not limited to island expansions, offshore engineered berm construction, backfill and protection of immersed tube tunnel and embankments for roads and bridges;
      c. Placement of significant additional loads;
      d. Dewatering near compressible soils; and
      e. Installation of deep foundations (i.e., vibrations).

   2. The Design-Builder shall assess the risk of damage from predicted ground movement to adjacent structures and utilities, new or existing, which may potentially be impacted, in the opinion of the Design-Builder or the Department.

   3. The Design-Builder shall implement protective measures to reduce the damage risk to acceptable levels as specified herein at no additional cost to the Department.
4. The Design-Builder shall repair any damage caused by the execution of the Work at no additional cost to the Department regardless of the actual movement that has occurred.

5. The Design-Builder shall perform instrumentation and monitoring in accordance with Section 15.3.20, Geotechnical Instrumentation and Monitoring.

6. The Design-Builder shall perform pre- and post-construction condition inspections in accordance with Section 15.3.22, Pre- and Post-Construction Condition Inspections.

B. Analysis/Assessment and Documentation:

1. The ground movement analysis and damage risk assessment shall follow a phased approach, such as that proposed by Son and Cording (2005) or similar, in the opinion of the Department.

2. The Design-Builder shall account for the following:
   a. Historic movement and the impacts of previous damage (cracking) on future deformations.
   b. Elastic movement from loading (e.g., fill placements, surcharges) and unloading (e.g., excavations).
   c. Consolidation settlement and secondary compression. (Secondary compression may be assumed to begin after 90% of the predicted excess pore water pressure has dissipated.).
   d. Construction sequence.
   e. Soil-structure interaction.
   f. Proposed protective measures (e.g., ground improvement, structural strengthening elements).

3. The analysis/assessment shall be performed with the use of appropriate geotechnical software that is widely accepted within the industry (e.g., Plaxis, Flac or Midas), in the opinion of the Department.

4. The results of the ground movement analysis and damage risk assessment shall be included in the Geotechnical Engineering Report (GER) for the element (package) of the Work to which it pertains. Clearly document input assumptions (e.g., soil properties, geometry, engineering properties of structures and proposed protective work) and clearly present results. Refer to Section 15.3.3 for requirements for GERs.

5. In the event the actual ground movement, as measured by the instrumentation and monitoring (refer to Section 15.3.20, Geotechnical Instrumentation and Monitoring), differs significantly from the predicted values for a given stage of construction, in the opinion of the Department, the Design-Builder shall resubmit its analysis with updated geotechnical parameters, calibrated to produce the measured movement.

C. Performance Requirements - General:

1. The ground movement analysis and damage risk assessment shall demonstrate that the proposed Work will not result in predicted damage levels to new or existing structures and utilities that exceed the “very slight” damage risk category as defined by Son and Cording (2005). Additionally, the analysis/assessment shall demonstrate that the proposed Work will not result in increased water infiltration into existing tunnels and underground structures.
2. In addition to the above, the Department has set maximum movement limits for specific structures and utilities as indicated below. The ground movement analysis shall demonstrate the proposed Work will not cause movement of these structures/utilities that exceeds these limits, regardless of the damage risk category determined above.

3. Should the predicted damage level to a structure or utility exceed the “very slight” damage risk category, or should the predicted movement of the structure/utility exceed the maximum movement limits indicated below, the Design-Builder shall incorporate protective measures into the Work, at no additional cost to the Department. Protective measures may include ground improvement (refer to Section 15.3.19) or other measures that are acceptable to the Department.

D. Movement Limits for Specific Existing Structures:

1. Existing Immersed Tube Tunnels: Total Settlement [1.5 inches]; Differential settlement across any 40-foot length or width of tunnel section [0.5 inches]

2. Existing Tunnel Approach Structures: Total settlement [1.5 inches]; Differential settlement across the width or length of each 90-foot section (i.e between panel expansion joints) [0.5 inches];

3. Existing Ventilation Buildings: Total Settlement [1.5 inches]; Differential settlement across the width or length of the building [0.5 inches];

E. Regardless of the movement limits stated in 15.3.18.D, the Design-Builder shall not allow cracking or opening of joints that brings additional water and/or soil into the structures.

F. Movement Limits for New Structures and Utilities:

1. General: The movement limits for new construction (the Work) shall be determined and documented by the Design-Builder, subject to the review and acceptance of the Department, and meeting the restrictions stated below.

2. Acceptable total and differential settlement for new structures for which no specific design and analysis has been performed to accommodate total or differential settlement is limited to 0.5 inch. The total settlement (STOT) is defined as the arithmetic sum as follows: STOT = Elastic Settlement + Consolidation Settlement + Secondary Compression. The acceptable settlement shall be clearly indicated on the RFC Plans.

3. Acceptable total and differential settlement for new structures for which specific design and analysis has been performed to accommodate total or differential settlement shall be established by the Design-Builder and clearly indicated on the RFC Plans, subject to the review and acceptance of the Department, and meeting the following restrictions:
a. For tunnels, the Design-Builder shall demonstrate to the satisfaction of the Department that the stated movement limits will neither result in the infiltration of water into the tunnel nor cause cracking of the tunnel (interior or exterior).

b. For beam and slab bridges conforming to superstructure types a, e, f, g, k, i as defined in Table 4.6.2.2.2 of the AASHTO LRFD Bridge Design Specifications, when total settlement and differential settlement are limited to 0.5 inch, no additional analysis is required.

c. During construction and after all settlements have occurred, the structure (consisting of the superstructure, substructure and associated elements in the load path) must meet all structural capacity requirements for all loading combinations requiring such analysis. In addition, the structure must meet all structural capacity requirements for all load combinations for the listed differential settlement.

d. The bearings and substructure shall be designed to accommodate increases or decreases in loads due to total or differential settlement shown on the plans (Ref AASHTO 3.4.1; 3.12.6).

e. Creep and/or shrinkage may only be used to offset settlement effects when it occurs concurrently with settlement, and the designer is responsible for determining time rate of settlement and creep. For instance, if all settlement is elastic (instantaneous), creep cannot be used to offset loads imposed.

f. Joint rotations and bearing rotations due to settlement shall be considered in addition to all tolerances for rotations due to live load effects or for constructability.

g. In no case shall anticipated settlements (or rotations due to settlement) cause the structure to encroach on horizontal, vertical or navigation clearance envelopes.

h. Settlements that change super elevation shall not reduce super elevation below the minimum specified by AASHTO for the roadway design speed and roadway type, nor shall they negatively impact the performance of the deck or approach paving.

i. Settlements that change profile grade shall not:
   i. Increase spread of drainage beyond limits specified in AASHTO;
   ii. Change performance or maintainability of utilities;
   iii. Introduce a low spot on the bridge or in the tunnel; and

j. Coordinate predicted/expected settlement of the approaches with the bridges or tunnel structures to comply with contract rideability requirements.

k. The structure must be capable of carrying an additional future wearing surface equal to the magnitude of the total anticipated settlement placed uniformly from curb to curb and abutment to abutment. All parapets and railings shall accommodate the additional layer of surfacing with no modification or reduction in crash test level after construction.

l. Jacking and shimming shall not be allowed to correct differential settlement except as noted in the original design plans.
m. Settlements shall be treated as a load condition with \( \gamma_{SE} = 1.0 \) for all AASHTO indicated groups.

n. When differential settlement at a single substructure unit is anticipated, both the superstructure and substructure shall be analyzed by accounting for the differential deflection. For continuous footings, settlement may be considered to be linear along the long axis of the footing. For isolated footings, in addition to the linear distribution of settlement, adjacent footings shall be analyzed for a linear proportion of the differential settlement at each footing (for a three [3] column pier with two [2] equal spaces, 50%, for a four [4] column pier with three [3] equal spaces, 33% of the total pier differential shall be used at each column).

o. Angular distortion between adjacent foundations shall be compliant with the most recent AASHTO LRFD requirements. Angular distortions between adjacent bridge foundations greater than 0.008 radians in simple span and 0.004 radians in continuous span structures are not permitted unless first reviewed by the Department.

4. Design and construct pavements, subgrades, and embankments to meet the following post-construction settlement tolerances:
   a. Total vertical settlement (measured at the pavement surface) of less than 2 inch over the initial 20 years, and less than 1 inch over the initial 20-years within 100 feet of bridge abutments;
   
   b. Settlement shall not impede positive drainage of the pavement surface nor subject the roadway to flooding;
   
   c. Settlement shall not result in damage to adjacent or underlying structures, including utilities;
   
   d. For pavement sections of approach slabs, bridge decks, and tie-ins to the Work, grade tolerances shall be measured with a 10 feet long straightedge. The variation of the surface from the testing edge of the straightedge between any two (2) contacts with the surface shall not be more than plus 0.25 inch to minus 0.125 inch at structures and ±0.25 inch at Work tie-ins.
   
   e. Humps, depressions, and irregularities exceeding the specified tolerance will be subject to correction by the Design-Builder.
   
   f. Long term settlements shall not be a detriment to achieve and maintain the post-construction Performance Requirements for overall ride quality and localized roughness of the pavements nor exceed the grade tolerances of pavement sections of approach slabs, bridge decks, and tie-ins to the Work

5. Vibration-Induced Damage: It shall be the responsibility of the Design-Builder to determine the appropriate level of vibration monitoring and the threshold peak particle velocity during construction operations and implement this monitoring where necessary. In no event, however, shall vibration measured at an existing structure exceed 1 in. per second unless otherwise reviewed and approved by the Department.

15.3.19. Ground Improvement

A. The subsurface explorations performed to date for the Project have revealed the presence of soft or otherwise unstable ground within the Work limits. Therefore, in order to meet Technical Requirements for excavation stability, slope stability, overturning/sliding resistance, bearing
capacity, ground movement (settlement) and damage risk; ground improvement is required for island expansions, offshore engineered fill berms, tunnels, tunnel approach structures as indicated in the GBR.

B. Acceptable methods of ground improvement are as follows: Deep soil mixing; cutter soil mixing; jet grouting; and excavation of unsuitable soils and replacement with suitable soils.

C. The Design-Builder shall furnish all design services, labor, materials, equipment, testing and incidentals to design and implement ground improvement, in accordance with the Technical Requirements.

D. Quality:

1. The Design-Builder shall have completed at least three (3) successful similar ground improvement installations (i.e., the same type of ground improvement as proposed for the Work) within the last five (5) years, including at least one (1) successful installation of similar size and scope (application) and in similar ground conditions as the proposed installation within the last three (3) years. If the ground improvement is to be performed from a barge, then at least one (1) of the successful projects shall have been performed from a barge in a similar marine environment.

2. Key Personnel:

a. Ground Improvement Specialist: The Design-Builder’s Ground Improvement Specialist shall be routinely engaged in developing installation parameters (e.g., injection pressures, injection rate, withdraw rate) for ground improvement of the same type proposed for the Work to meet the performance requirements for improved ground as specified in the RFC Plans. The Ground Improvement Specialist shall have designed the installation parameters for at least three (3) successful similar ground improvement installations (i.e., the same type of ground improvement as proposed for the Work) within the last five (5) years, including at least one (1) successful installation of similar size and scope (application) and in similar ground conditions as the proposed installation within the last three (3) years. The Ground Improvement Specialist need not be a licensed professional engineer, but at a minimum must have obtained a bachelor’s degree in civil engineering or geology with courses in geotechnical engineering and soil mechanics from a reputable institution, in the opinion of the Department.

b. Foreman: The Design-Builder shall provide a foreman for the ground improvement task who has supervised at least two (2) successful ground improvement installations of the same type proposed for the Work within the last five (5) years, including at least one (1) successful installation of similar size and scope (application) as the proposed installation within the last three (3) years. If the Design-Builder is proposing to perform the ground improvement from a barge then at least one (1) of the successful installations completed by the proposed foreman must have been performed from a barge in a similar marine environment. The foreman shall be present during installation of all ground improvement including the Field Trial Program (FTP).

c. Rig Operator: The Design-Builder’s ground improvement rig operator shall be a competent person with experience in operating the same equipment that will be used for the Work. If the Design-Builder is proposing to perform ground improvement from a barge then the proposed rig operator shall be adequately trained in the operation of the proposed equipment from a barge in a similar marine environment.
d. Barge Crew: If the Design-Builder is proposing to perform the ground improvement from a barge, then the barge crew must be routine engaged in performing similar work in a similar marine environment.

3. The Design-Builder shall develop quality control and assurance programs for monitoring, sampling, laboratory testing and reporting that meet the Technical Requirements and requirements of the RFC Plans.

4. Independent Testing Laboratory: The Design-Builder shall employ an independent testing laboratory to transport, store and cure soil-cement samples, perform laboratory testing and report the results in accordance with applicable AASHTO or ASTM standards. The laboratory shall have American Association of State Highway and Transportation Officials (AASHTO) Material Reference Library (AMRL) accreditation or equivalent and shall be experienced with performing the required test methods. Laboratory technicians performing the tests shall be certified by the National Institute for Certification in Engineering Technologies (NICET) for Geotechnical Laboratory technicians at the appropriate level (I through IV) for tests performed and shall be experienced with performing the required test methods.

5. Field Trial Program (FTP): The Work as documented in the Ground Improvement Plan (GIP) shall include a Field Trial Program (FTP), performed over a minimum 30 feet long by 30 feet wide area, near the proposed production ground improvement and in similar soil conditions. The Design-Builder shall demonstrate to the satisfaction of the Department that the trial ground improvement meets the design requirements as per the RFC Plans. The same equipment, personnel, materials, mix designs, installation methods and procedures and quality control procedures (e.g., sampling and testing) used for the successful FTP shall be used for the production ground improvement.

6. All sample collection shall be performed in the presence of the Design-Builder’s Quality Control Manager.

E. Submittals:

1. Ground Improvement Plan (GIP): At least 60 days prior to mobilization for the Field Trial Program (FTP), submit a GIP approved by the Engineer of Record for the acceptance of the Department. Do not deviate from the accepted plan unless the changes are formally re-submitted. The GIP shall address the following:

   a. Identify the performance requirements (engineering properties) of the improved soil in accordance with approved RFC Plans. The performance requirements shall be fully coordinated with other design submittals, including Geotechnical Engineering Reports (GECs), as they pertain to geotechnical analysis including but not limited to slope stability analysis, ground movement analysis and settlement analysis.

   b. Address all aspects of the Technical Requirements presented in this section to the satisfaction of the Department. To this end, the GIP shall include drawings (plans, sections, elevations and details) to adequately describe the design and execution of the Work; proposed equipment; proposed personnel and their relevant experience; proposed materials including material sources, mix designs and laboratory testing of trial mixes; installation methods and procedures; and proposed quality assurance/quality control;

   c. Provide copies of permits and certifications.
d. Provide proposed details of the Field Trial Program (FTP).

e. Schedule: Sequence and time schedule of mobilizations, demobilizations, the FTP and the production ground improvement.

f. Working hours.

g. Details of spoil collection/containment means and methods to prevent contamination of the Chesapeake Bay and/or islands, in accordance with permit conditions.

h. Quality Control (QC) program: Methods for ensuring the design (performance) requirements of the ground improvement have been achieved. At a minimum the QC program shall include the FTP and the minimum requirements for in situ testing, sampling and laboratory testing of production ground improvement.

i. Protection of adjacent structures and utilities including proposed instrumentation and monitoring.

j. Sample of daily reports (forms) to be used during ground improvement.

2. Daily Reports (Forms) addressing the following:

a. Number and classification of crew members and equipment used.

b. Drill hole locations, length and angle.

c. Grout mix used, injection volumes, injection pressures and rates of rotation and withdraw.

d. Weather conditions.

e. Other pertinent observations (e.g., grout escapes, ground heave or unusual behavior).

f. Delays and their causes.

3. Field Trial Program (FTP) results, including certification by Geotechnical Manager that ground improvement meets the performance requirements as per the RFC Plans. The certification must be based on QC testing. If changes to the GIP are required, revise and resubmit GIP for acceptance of the Department.

4. Quality Control: In situ and laboratory testing results for improved ground as per the GIP.

5. Production Grouting Report (PGR) including As-Built Drawings of ground improvement as installed. The PGR shall be signed by the Ground Improvement Specialist. The PGR shall contain a complete set of installation records (see Daily Reports above) and the results of verification (QC) testing as required by the GIP. The PGR shall also include a certification by the Geotechnical Manager that the improved ground as installed meets the performance requirements of the design. The certification must be based on the QC testing.

F. Materials

1. General: All materials shall conform to the approved RFC Plans.

2. Cement Grout:

a. Grout shall be a stable homogeneous mixture of portland cement, admixtures and water.
b. The ratios of various components will be proposed by the Design-Builder’s Ground Improvement Specialist, accepted by the Geotechnical Manager, confirmed during the FTP, verified by testing throughout the Work, and will not change throughout the production ground improvement unless changes are formally submitted and accepted through the submittals process.

3. Portland Cement: All cement used shall be consistent in composition and properties, and shall be manufactured using the same methods at one (1) plant by one (1) supplier.

4. Water: Water used in ground improvement shall be potable, clean and free from sewage, oil, acid, alkali, salts, organic materials and other contamination.

5. Grout Admixtures including Bentonite: Conform to relevant ASTM standards.

G. Material Delivery, Storage and Handling:
   1. Conform with manufacturers’ recommendations and the Engineer of Record’s specification as provided in the RFC Plans.
   2. Store materials in a manner that will prevent damage by moisture. Material that has become caked due to moisture absorption shall not be used.
   3. No admixtures shall be used that have exceeded the manufacturers’ recommended shelf life.

H. The Design-Builder shall develop grout mixes and equipment operation parameters to perform ground improvement in accordance with the RFC Plans and the accepted GIP for the range of soil conditions encountered. The grout mixes and equipment operation parameters shall be based on observations and evaluation of data from the following sources:
   1. Laboratory testing of trial soil-cement mixtures using representative soil specimens; and
   2. Construction and subsequent sampling and testing of trial columns as part of the FTP.

I. The ground improvement technique selection, design, and construction shall consider the construction schedule, permit conditions, protection of utilities, and impacts on adjacent structures, facilities, and pavements. Install all measures necessary to maintain and protect adjacent facilities. Expose all near-surface utilities or foundations of adjacent structures near the ground improvement operation as required to ensure the ground improvement equipment (e.g., drill rig) does not penetrate the same. Maintain control of ground improvement operations to minimize or eliminate ground heave. Monitor the site during installation of ground improvement to provide real-time data pertaining to heave and settlement of the ground and adjacent facilities.

J. Install all measures necessary to maintain and protect water quality in the Chesapeake Bay and/or other water bodies in accordance with permit conditions, which shall be obtained by the Design-Builder.

K. Perform all demolition and removal of obstructions necessary for installing ground improvement. Use pre-cutting, pre-trenching, pile extraction or other means as necessary to remove obstructions.

L. The Design-Builder shall be solely responsible for all difficulties and delays caused by ground improvement elements that create obstructions to (or difficulty for) any subsequent aspect of the required construction.

M. Equipment:
   1. All equipment shall be maintained to insure continuous and efficient production during ground improvement operations.
2. All ground improvement equipment shall be equipped with controls to permit accurate and continuous variation and monitoring of ground improvement installation parameters (e.g., grout pressures, flow rates, rotation rates and withdraw rates).

3. All equipment shall have proven performance records for use in the type of ground improvement work used.

N. Field Trial Program (FTP):
   1. The Design-Builder must complete all aspects of the FTP, as outlined in this Section, before proceeding with production ground improvement.
   2. Trial ground improvement shall be installed using the same equipment, procedures (installation parameters), materials and personnel used for the production ground improvement.
   3. Trial ground improvement shall be continuously cored throughout the depth of the improved zone to confirm the continuity and quality of the improvement and to obtain samples for subsequent laboratory testing.
   4. If the results of the FTP do not meet the design (performance) requirements, as shown in the RFC Plans (accepted GIP), the Design-Builder shall propose changes to the GIP and repeat the FTP.

O. Production Ground Improvement:
   1. Install production ground improvement using the same equipment, materials and procedures as proposed in the GIP and proven in the FTP as accepted by the Department.
   2. Ground improvement shall be installed at locations indicated in the RFC Plans (accepted GIP) to create an improved zone meeting the design (performance) requirements, as shown in the RFC Plans (accepted GIP).
   3. Ground improvement installation for individual elements (e.g., jet grout column, cutter soil mix panel) shall be continuous and without interruption.

P. Coring and Other Quality Control Issues:
   1. Coring is required both for the FTP as well as for the production ground improvement.
   2. At least two (2) full-depth, continuous cores shall be obtained for every 1,000 square feet (in plan) of improved ground with a minimum of three (3) continuous cores at each improved ground location. One (1) set of cores shall be preserved for the Department’s independent Quality Control testing, if applicable.
   3. The following requirements apply to the coring:
      a. The cores shall be placed in boxes and properly labeled to indicate the depth and column from which the sample originated.
      b. The cores shall be wrapped in plastic film (e.g., Saran-wrap or equal) to prevent moisture loss.
      c. The cores shall be stored in a cool, dry location (preferably in a climate controlled trailer) on site the day they are drilled.
      d. The cores shall not be allowed to freeze.
e. Make the cores accessible to the Department for viewing. Surrender limited amounts of
the samples to the Department for any laboratory testing the Department may wish to
perform.

f. If core recovery is unacceptable based on the QC requirements as shown in the RFC
Plans and as stated herein, the Design-Builder shall perform supplemental coring with
modified coring equipment and/or techniques at no additional cost to the Department.

4. Perform any other quality control tests, coring or in situ testing as per the accepted GIP to
ensure the design (performance) requirements have been met.

Q. Containment, Collection and Disposal of Soils:

1. Control, process and dispose of all spoils created during ground improvement in accordance
with permit conditions and the accepted GIP.

2. Provide positive means of containing all spoil return, flush water, and other waste materials
within the immediate work area. Pipe or channel the spoil material to holding ponds, tanks or
other retention structures or facilities. Incorporate all sedimentation and turbidity control
measures required by applicable federal, state and local regulations.

3. Take any necessary precautions and implement measures to prevent any spoil return, other
waste materials or stockpiled materials from entering storm drain structures or from leaving
the site via surface runoff. Prevent the migration of spoil return, waste material or stockpiled
materials into Chesapeake Bay beyond the limits of any approved containment area.

4. In the event spoil return, waste materials or stockpiled materials enter an area or facility
outside the approved containment area, the Design-Builder shall be responsible for
immediately and completely cleaning and removing these materials to the acceptance of the
Department at no additional cost to the Department.

15.3.20. Geotechnical Instrumentation and Monitoring

A. The Design-Builder shall install instrumentation and perform real-time monitoring and reporting
for any new or existing structure (tunnels, bridges, buildings, retaining walls), utility, island,
berm, embankment, cut-slope, pavement or other facility that is part of the Work or could be
impacted by the Work, in the opinion of the Design-Builder or the Department.

B. The Design-Builder’s Instrumentation and Monitoring Program shall achieve the following
objectives:

1. Develop monitoring baselines

2. Observe impacts of construction on new and existing facilities

3. Calibrate and validate numerical geotechnical models

4. Monitor any change in deficiencies (e.g., cracks, infiltration) as observed during the pre-
construction condition inspection (refer to Section 15.3.22, Pre- and Post-Construction
Condition Inspections)

5. Provide early warning of potential adverse impacts such that corrective action can be taken

C. Department’s Instrumentation and Monitoring Program: The Department may elect to install its
own instrumentation (i.e., in addition to the instrumentation required in this section) and monitor
this instrumentation for its own benefit. In this event, the Department will provide the results of
its monitoring to the Design-Builder upon request. However, the performance of additional
instrumentation and monitoring by the Department shall in no way relieve the Design-Builder of
its instrumentation and monitoring responsibilities as described herein or its sole responsibility for the maintenance and protection of adjacent structures, utilities and facilities and the Work.

D. At a minimum, the Design-Builder shall install instrumentation and perform monitoring for the following:

1. Existing Immersed tube tunnels and approach structures:
   a. Monitor horizontal and vertical movement and tilt of the immersed tube tunnel elements and tunnel approach structures using a system of fixed displacement monitoring points and tiltmeters. Install and monitor a minimum four (4) fixed displacement points at each end of each existing immersed tube tunnel element (on either side of the joint between elements) and a minimum one (1) tiltmeter per existing immersed tube tunnel element. At a minimum, install and monitor fixed displacement points at top of walls of tunnel approach structures on either side of expansion joints.
   b. Measure vibration inside the tunnels using seismographs. Install and monitor seismographs at a minimum three (3) locations in each tunnel, including two (2) fixed seismographs at either end of each tunnel and one (1) seismograph that is periodically moved along the length of each tunnel to monitor the location nearest to outside excavation/tunneling activity.
   c. Monitor the progression of cracks within the tunnel, as identified during the pre-construction condition inspection, using crack gauges. Assume 20 crack gauges will be required per tunnel.
   d. Devise methods to take quantitative flow measurements at the locations of visible leaks.
   e. NOTE: In the event the proposed Work is limited to points west of the existing eastbound immersed tube tunnel, the Design-Builder may propose, for the acceptance of the Department, to omit instrumentation and monitoring of the westbound immersed tube tunnel and tunnel approach structures.

2. Existing Islands:
   a. Monitor settlement of the existing islands using a system displacement monitoring points and extensometers. Displacement monitoring points or extensometers shall be installed and monitored at minimum 100 feet spacing along the shared edge with expanded islands).

3. Existing Buildings and Structures:
   a. Monitor the horizontal and vertical movement and tilt of existing buildings and structures, including but not limited to buildings and bridges, which could be potentially impacted by the proposed Work in the opinion of the Design-Builder or the Department, with fixed displacement monitoring points and tiltmeters. Install and monitor a minimum of one (1) monitoring point at each column/pier/abutment location, at the corners of buildings and at minimum 100 feet spacing along continuous walls. Install and monitor a minimum one (1) tiltmeter per structure monitored.
   b. Monitor vibrations levels using geophones secured to the structures, including as necessary to address owner complaints.

4. Island Expansions, offshore engineered fill berms and onshore roadway embankments:
   a. Monitor settlement of island expansions, offshore engineered fill berms and onshore roadway embankments with settlement plates and surface monitoring points (minimum 100 feet spacing between settlement monitor devices in any direction).
b. Deep settlement monitoring points (i.e., extensometers) shall be used to monitoring the primary (consolidation) and secondary compression of soft soils at depth. Install and monitor a minimum of one (1) extensometer for every acre of expanded island surface/berm/embankment. Each extensometer shall consist of multiple monitored points extending from the installed ground surface to a minimum elevation of -100 feet NAVD88 with vertical intervals between monitored points not exceeding 15 feet.

c. Measure the dissipation of excess pore water pressure generated by fill placement and/or surcharge using piezometers (minimum one [1] piezometer for every acre of fill placement and/or surcharge).

d. Monitor slope stability using inclinometers and displacement monitoring points (maximum spacing of inclinometers of 300 feet, maximum spacing of displacement monitoring points of 100 feet).

5. New Tunnel:

a. Horizontal and vertical movement of tunnel: Should the new tunnel be an immersed tube tunnel(s), displacement monitoring points shall be installed along each side of each joint between tunnel elements and there shall be at least one (1) tiltmeter at the interior of each element. Should the new tunnel(s) be a bored tunnel(s), arrays of five (5) displacement monitoring points shall installed at maximum intervals of 100 feet around the interior of the tunnel liner to monitor both the spatial position of the tunnel as well as the convergence/extension of the tunnel cross-section.

6. New Bridges:

a. Monitor the horizontal and vertical movement and tilt of new bridges with fixed displacement monitoring points and tiltmeters. Install and monitor a minimum of one (1) monitoring point and one (1) tiltmeter at each column/pier/abutment location.

7. Excavations:

a. Monitor the vertical and lateral movement of support of excavation (SOE) walls using fixed monitoring points at a maximum spacing of 100 feet, on each wall of the excavation.

b. Additionally, monitor the lateral movement of SOE walls and adjacent soil with inclinometers at a maximum lateral spacing of 300 feet, on each side of the excavation.

c. Determine the loads and stresses in lateral supports using load cells and/or strain gauges (minimum two [2] lateral supports from each level of bracing shall be monitored).

d. Monitor groundwater levels and piezometric pressures adjacent to excavations with a maximum lateral spacing of observation wells or piezometers of 300 feet.

E. Quality:

1. The instrumentation and monitoring Work described herein is specialized and shall be performed by a Design-Builder or subcontractor with at least five (5) continuous years of documented experience in instrumentation and monitoring Work similar to that specified herein.

2. Instrumentation Engineer - All Work shall be performed under the direct supervision of a licensed professional engineer, registered in the Commonwealth of Virginia, with at least five (5) years of direct field experience in the installation and monitoring of the types of instruments specified herein. The professional engineer, referred to hereafter as the
Instrumentation Engineer, shall have professional capability in related geotechnical and structural evaluations.

3. A final quality control inspection shall be made by the instrument manufacturer before shipment. During the inspection, a check list shall be completed by the manufacturer to indicate each inspection and test detail. A completed copy of the check list shall be supplied with each instrument. The manufacturer shall certify on the checklist that each instrument was working properly when it left the factory.

4. Calibration: A factory calibration shall be performed on all instruments at the manufacturer’s facility before shipment. Each factory calibration shall include a calibration curve with data points clearly indicated, and a tabulation of the data. Each instrument shall be marked with a unique identification number. Calibration of instrumentation shall be carried out by the Design-Builder throughout the duration of monitoring according to the manufacturer’s recommendations.

5. The Instrumentation Engineer shall be on-site to supervise the installation of at least the first two (2) installations of each type of instrument, including pre-installation acceptance tests, post-installation acceptance tests, field calibration and initial reading.

6. Survey Chief: The Survey Chief, in charge of the surveyors, shall be a qualified land surveyor registered in the Commonwealth of Virginia with a minimum five (5) years of experience in deformation measures of the types and accuracies specified herein.

F. Submittals:

1. Instrumentation and Monitoring Plan:
   a. The Instrumentation and Monitoring Plan shall be signed and sealed by the Instrumentation Engineer and submitted for Department review and approval in advance of instrumentation purchase and installation.
   b. The Instrumentation and Monitoring Plan shall be divided into packages to match the packaging of the Geotechnical Engineering Reports (GERs). The Instrumentation and Monitoring Plan for each package shall be submitted concurrent with the GER as well as the results of the ground movement analysis and damage risk assessment for the package in question.
   c. Drawings – Include plans, section and detail drawings to show the locations of instruments and key details of their installation. Drawings shall indicate the survey control layout (i.e., locations of benchmarks). Drawings shall indicate the locations of total stations to demonstrate lines of sight for automated monitoring of target prisms. Drawings shall show the locations of power sources, data collection boxes and the locations of cable runs.
   d. Schedule of instruments – to be included in the Drawing set.
   e. Threshold levels for each instrument, consistent with the results of the ground movement analysis and damage risk assessment as well as the movement limits stated in Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs. Threshold levels are defined as follows:
      i. Level 1 Threshold – confirm legitimacy of readings; visually inspect instrumented structure/area for signs of damage; update (re-calibrate) geotechnical analysis models based on actual monitoring data; re-forecast movements, stresses and
capacity/demand ratios; revise Level 2 and 3 Thresholds if necessary; increase frequency of readings if necessary;

ii. Level 2 Threshold – Repeat tasks for Level 1 Threshold and develop remedial measures for implementation if Level 3 Thresholds are reached; and

iii. Level 3 Threshold – Stop construction. Implement remedial measures to stop further movement.

f. Instrument and instrument installation details (Note: The Geotechnical Manager is expected to coordinate with the Design-Build and the Instrumentation Engineer to provide specific information about instruments. Avoid making statements such as “or approved equal” or “installation details to be determined by Contractor” in the submittals.):

i. The type (manufacturers make and model) of each instrument installation along specifications, installation and maintenance instructions, instruction manuals and other pertinent data;

ii. Shop drawings with step-by-step installation procedures for each instrument, in accordance with manufacturer’s recommendations;

iii. Instrumentation check lists, calibration records and certifications from the manufacturer that instruments meet the specified requirements; and

iv. Grout mix: Material specifications and mix design for grout required for deep benchmarks (if necessary) and inclinometer and extensometer installations along with certification from Instrumentation Engineer that mix design is in accordance with manufacturer’s recommendations. Grout stiffness for inclinometer installations shall be similar to that of the surrounding soil.

g. Reinstatement details: Provide details of how each instrument will be removed or abandoned and how surfaces will be reinstated.

h. Submit copies of approvals/agreements from/with third parties whose property is to be instrumented and monitored as part of the Design-Builder’s Instrumentation and Monitoring Program.

2. Instrumentation and Monitoring Plan (As-Built):

a. The Instrumentation and Monitoring Plan described above shall be updated, signed and sealed by the Instrumentation Engineer, and resubmitted for Department review and approval following instrumentation installation and baseline readings but in advance of construction activity that could impact the readings.

b. Update pre-installation Instrumentation and Monitoring Plan to include as-built surveyed locations of instruments.

c. Installation records for each instrumentation shall include, as appropriate, the following: project name; contract name/number; instrument type and number including readout unit; location (horizontal position and elevation); orientation; personnel performing installation; plant and equipment used including diameter and depth of any drill casing or augers used; date and time of start and completion; borehole logs for instruments installed in boreholes (borehole logs shall meet requirements of VDOT Manual of Instructions for Materials Division, Chapter III Geotechnical Engineering); types and volumes of various backfill materials including results of grout testing; results of post-installation acceptance test; initial reading; notes of importance.
d. Provide baseline readings for each instrument.

e. Baseline vibration survey to determine the operational variations in vibration in the existing tunnels, approach structures and ventilation buildings.

3. Instrumentation and Monitoring Reports:

a. Reports shall be certified by the Instrumentation Engineer.

b. Within 24 hours after readings are taken, provide Daily Monitoring Reports to the Department for each area where on-going movement is occurring or where on-going construction activity that could influence the readings is occurring (e.g., during fill placement, excavation, surcharge loaded). The Department will consider decreasing the frequency of these reports on a case-by-case basis. The reports shall note any on-going activity that could influence the readings.

c. In addition to the Daily Reports, provide instrumentation readings on a limited access Project website for Department review as described herein.

d. Whether presented in a report or on a website, instrumentation and monitoring data shall be in a format that is easy to review visually and acceptable to the Department. To this end, the Design-Builder shall calculate elevations, calculate changes from initial locations and provide plots of the data versus time to show trends. Threshold levels as defined in Section 15.3.18, Ground Movement Analysis, Damage Risk Assessment, Protective Measures and Repairs, shall be included with the data for each instrument.

e. Final Monitoring Reports: Upon taking final readings for a given portion (package) of the Work, provide a final monitoring report with complete set of readings along with drawings that show how each instrument was removed/abandoned and surfaces reinstated, if applicable.

G. Materials/System Requirements:

1. Instrumentation shall be manufactured by a reputable company, in the opinion of the Department, routinely engaged in the manufacture of geotechnical instrumentation of the same type. Whenever any product is specified by brand name and model number, such specification shall be deemed to be used for establishing a standard of quality and facilitating the description of the product desired. The term “or approved equal” shall be understood to indicate that the approved equal product is the same or better than the product named, in function, performance, reliability, quality and general configuration.

2. Read-out units and data collection systems for each instrument type must be from the same manufacturer as the instrument, specifically designed for use with the instrument. The readout unit or data collection system must convert the signal from the instrument to the appropriate engineering unit.

3. Instrumentation and monitoring systems shall be fully automated to the extent possible. Instrumentation readings shall be continuously uploaded by the instrumentation subcontractor to the limited access Project website and made available to the Department without delay. The system shall be capable of sending e-mail and or text alerts to key personnel when predetermined threshold levels are reached.

H. Pre-Installation:

1. When instruments are received at the site, the Design-Builder’s instrumentation personal shall perform pre-installation acceptance tests to demonstrate that the instruments and readout units are functioning correctly before installation.
2. All instrumentation materials, after receipt at the site and prior to installation, shall be stored in an indoor, clean, dry and secure storage space. Instruments shall not be exposed to temperatures outside the manufacturer's stated working temperature range.

I. Installation:
   1. Install instrumentation in accordance with manufacturers’ recommendations and Instrumentation and Monitoring Plan.
   2. Install instruments in the presence of a Department representative. Notify the Department at least 48 hours prior to installing each instrument.
   3. Ensure that instruments are firmly in place so that any movement recorded reflects actual movement.
   4. Obtain representative grout specimens from each batch of grout mix for testing by a certified laboratory to verify that the compressive strength of the batch is as specified for the instrument installation.
   5. Protective terminal boxes with locking covers shall be installed over the top end of instrumentation installed in the ground and the covers locked. Each instrument installed in the ground shall be marked with a survey stake 3 feet long and tied with flags to clearly show its location.
   6. Inclinometer Casing
      a. Inclinometer casing installation shall be in accordance with the manufacturer’s recommendations. If possible, the bottom 10 feet of the inclinometer shall be installed within a stratum that will provide fixity.
      b. The instrument casing shall be installed within 1 degree angle of vertical for the entire length.
      c. The instrument casing shall be positioned so that the orthogonal grooves are parallel and perpendicular to the centerline of the Work to be monitored.
      d. After installation, the casing groove spiral shall not exceed 1 degree angle per 10 feet of length and the orientation of the grooves at the top of the casing shall be within 10 degrees of the planned orientation.
      e. Protective caps shall be placed on the bottom of the instrument casing and sealed with ABS solvent cement to provide a waterproof seal. Joints between casing segments should likewise be made watertight.

J. Baseline readings
   1. Before start of Work, establish bench marks for survey operations to the tolerances specified herein.
   2. Baseline readings for instrumentation on existing facilities shall be performed prior to construction activity that could potentially influence the reading, in opinion of the Design-Builder or the Department.
   3. Unless otherwise stated below, baseline readings shall be taken over a minimum seven (7) day period prior to the start of construction activity that could potentially influence the reading.
4. Baseline readings shall be taken at different times of days and in different weather and/or traffic conditions to establish the diurnal and environmental effects on the instrument readings.

5. Baseline readings for the existing tunnels, tunnel approach structures and ancillary facilities, including vibration monitoring, shall be taken for a period of one (1) year prior to start of construction that could potentially influence the readings to assess the impact of seasonal change on the readings.

K. Monitoring Accuracy:
   1. Elevations of benchmarks shall be established to 0.04 inch.
   2. Coordinates of benchmarks shall be established to 0.2 inch.
   3. Elevations of instruments shall be established to 0.1 inch.
   4. Initial coordinates of instruments shall be established to 0.4 inch.

L. Monitoring Frequency:
   1. All instruments shall be monitored at least once an hour during on-going construction activity near the instrument that could potentially impact the readings, in the opinion of the Design-Builder or the Department, and at least once a day otherwise until the Final Readings are taken as described herein. Requests for a reduced frequency of monitoring must be approved by the Department.
   2. The Design-Builder shall maintain safe access to the instruments at all times to inspect the instruments and to take readings.

M. Maintenance, Broken, Damaged or Missing Instruments:
   1. Protect and maintain instrument systems throughout the entire Comprehensive Agreement.
   2. Replace any broken, damaged or missing instruments as soon as reasonably possible, in the opinion of the Department, and account for movement recorded by predecessor instruments in the readings of replacement instruments.

N. Final Readings - the final reading for each instrument shall occur when:
   1. No additional construction activity that could influence the instrument readings will occur, in the opinion of the Design-Builder and the Department;
   2. Readings for the instrument are stable (i.e., do not indicate on-going movement or other changes) for a period of three (3) months; and
   3. Additional consolidation settlement or secondary compression is not expected to occur, in the opinion of the Department.

O. Disposition of Instruments Following Final Readings: Upon review and acceptance of the final reading for each instrument, the Department will instruct the Design-Builder to either: (1) remove the instrument and reinstate the surface (or backfill the hole with grout) to the Department’s satisfaction at no additional charge to the Department; or (2) turn the instrument over to the Department, along with any required readout unit or datalogger (with the exception of total stations and seismographs), at no additional charge to the Department, for continued monitoring by the Department. Instrumentation shall be in fully functional condition when transferred to the Department.
P. Disposition of Data: Instrumentation monitoring data shall be considered as property of the Department and may not be published or otherwise made public without the written consent of the Department.

15.3.21. Pre- and Post-Construction Condition Inspections

A. Pre-Construction Condition Inspection: Prior to construction, the Design-Builder shall perform a pre-construction condition inspection of the existing structures to remain in service, including but not limited to the existing immersed tube tunnels, tunnel approach structures, ventilation buildings, bridges, retaining walls, sound walls, drainage structures and pavements. Condition surveys will be required for any structure that could be impacted by the Work, in the opinion of the Design-Builder or the Department. The Design-Builder shall document the findings of the inspection and survey in the Pre-Construction Condition Inspection and Survey Report, complete with photographs, video and sketches with measurements of existing defects (including but not limited to cracks, leaks and offsets) and the location of these defects. Tunnel inspection shall be carried out in accordance with National Tunnel Inspection Standards. Bridge inspection shall be carried out in accordance with the National Bridge Inspection Standards. The inspectors shall meet the requirements of the referenced standards.

B. Post-Construction Condition Inspection: Following completion of construction activities that could potentially cause damage to adjacent structures, in the opinion of the Design-Builder and the Department, repeat the condition inspection and document the findings in the Post-Construction Condition Inspection and Survey Report.

C. A representative of the Department must accompany the Design-Builder during Pre- and Post-Construction Condition Inspections.

15.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 15.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
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<td>Island Expansion – As-Built Report</td>
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<td>Excavations – Permits &amp; Approvals</td>
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<td>Post-Construction Condition Inspection Report</td>
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<td>15.3.21.B</td>
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SECTION 16. MARINE ENGINEERING

16.1. Scope
A. This section provides the marine engineering requirements for the project which would encompass the waves, hydrodynamics, and establishment of other ocean conditions (sea level rise, wind, and currents), island reclamation, design of protective works for islands, offshore (tunnel approach) bridges and tunnels including protection for offshore berms and dredged trenches (e.g., rock sizing), navigational hazards, rock sizing, and vessel collision analysis criteria that the contractor will need to follow when designing and building the tunnel, islands and bridges. The above information is summarized in the Ocean Engineering Report dated [XX/XX/XX] as a reference document.

16.2. References
A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT Road and Bridge Standards;
   2. VDOT Manual of Instructions, Chapter III Geotechnical Engineering;
   3. VDOT Road and Bridge Specifications; and
   4. VDOT Instructional and Informational Memoranda Requirements
B. AASHTO LRFD Bridge Design Specifications, 8th Edition, September 2017
C. AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges
D. ASTM Standards, Soil and Rock, Volumes 04.08 and 04.09;
E. ASTM Standards, Concrete and Aggregates, Volume 04.02;
G. ASTM C827: Change in Height at Early Stages of Cylindrical Specimens of Cementitious Mixtures;
H. Post-Tensioning Institute Recommendations for Prestressed Rock and Soil Anchors PTI DC35.1-04;
I. US Army Corps of Engineers Laboratory Soils Testing EM-1110-2-1906;
J. US Army Corps of Engineers Sheet Pile Walls EM-1110-2-2504;
K. Federal Highway Administration (FHWA), Technical Manual for the Design and Construction of Road Tunnels – Civil Elements, FHWA NH1-10-034;
L. U.S. Army Corps of Engineers (USACE), Coastal Engineering Manual CEM-EM 1110-2-1100;
N. ACI 301: Specifications for Concrete;
16.3. Requirements

16.3.1. General

A. This section includes minimum requirements for environmental and navigational design parameters along with marine engineering related requirements for the Design-Builder. The data referenced in this document is based on the Ocean Engineering Report prepared at a Concept Design level. The parameters contained herein constitute minimum requirements, and the Design-Builder shall be fully responsible for advancing the Ocean Engineering Report and confirming the minimum requirements contained within these Technical Requirements.

16.3.2. Submittals

A. The Design-Builder shall submit an Ocean Engineering Final Design Report prepared by a coastal engineer with a minimum of 10 years of experience, including expertise and training in engineering, planning, and scientific studies in the coastal zone. In addition, the coastal engineer shall have experience in hydrodynamic and wave modeling as well as interpretation and evaluation of modelling results. At a minimum, the Report shall contain:

1. Environmental Data – The Report shall include all environmental data sources used for the Project
2. Local and nearshore hydrodynamics and wave study – Local and nearshore hydrodynamic and waves modelling shall be established for the islands. Numerical modelling studies shall be carried out using MIKE 21 by DHI, or equivalent coastal modeling tool. Extreme weather events shall be included in the Report. Guidelines from FHWA-NHI-14-006: Hydraulic Engineering Circular No. 25 – Volume 2 shall be followed.

3. Navigation and Vessel Impact Considerations – The Design-Builder shall prepare a study on vessel traffic near the islands inclusive of the areas within the navigation channel and within the zones between the islands and the navigation channel. This vessel traffic study shall identify site specific hazards, such as ship grounding, vessel impact on trestle or rubble-mound structures, scour due to propeller wash action, and drag anchor loads to be used by the Design-Builder to identify design vessel and loads on all elements of the project.

16.3.3. Bathymetry and Topography

A. The Design-Builder shall be responsible for collecting all necessary bathymetric and topographic information for the site.

B. Refer to Section 8, Surveying and GIS, for requirements related to bathymetry (hydrographic surveys) and topography.

16.3.4. Local Wind Speeds

A. The Design-Builder shall perform a wind data analysis for the Project. Minimum wind speeds which shall be considered are provided in Table 16-1 which is based on an omni-directional extreme value analysis of wind data from 1992 – 2017 (25.5 years) extracted from the National Oceanic and Atmospheric Administration (NOAA) Tides and Currents station 8638863 at Chesapeake Bay Bridge Tunnel, VA. Due to the proximity and similarity of the tidal conditions to the Hampton Roads Bridge Tunnel this information shall be used until further data can be gathered and compiled. The Design-Builder shall make use of available data and gather other necessary wind speed data to complete the Ocean Engineering Final Design Report and provide to the Department for review and acceptance.

B. National Oceanic and Atmospheric Administration (NOAA) Tides and Currents station 8638863 states the wind speed as an hourly speed, however, the average duration of wind speed is 2-minutes. The station elevation is at 26.8 ft., therefore, a conversion to the standard 32.8 ft. (10 meters) reference level was performed.

While these data indicate that the prevailing winds are from the south-southwest directions, most winds during storm events come from the Northeasterly direction. This does not eliminate the possibility of an extreme storm event coming from a different directional sector. Therefore, the Design-Builder shall apply the dominant wind speed to all directions, regardless of dominant directional sector. A summary of minimum wind speeds considering various exceedance levels are provided in Table 16-1.
Table 16-1

<table>
<thead>
<tr>
<th>Exceedance level (return period)</th>
<th>Wind speed (2-minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-yr.</td>
<td>39.8 knots</td>
</tr>
<tr>
<td>10-yr.</td>
<td>53.3 knots</td>
</tr>
<tr>
<td>25-yr.</td>
<td>62.3 knots</td>
</tr>
<tr>
<td>50-yr.</td>
<td>70.7 knots</td>
</tr>
<tr>
<td>100-yr.</td>
<td>80.9 knots</td>
</tr>
</tbody>
</table>

Note: Wind speeds are 2-minute durations at a reference level of 32.8 feet.

C. Table 16-1 includes minimum wind speeds to be considered for the exceedance levels (return period) specified. The above information does not replace design standards to be used for the design of structures. The Design-Builders shall follow the applicable codes and standards and applicable sections of the Standard Documents for wind speeds to be used in the design of structures.

16.3.5. Tidal Datums

A. NOAA Tides & Currents has established a tidal benchmark at Sewells Point, VA (Station ID 8638610). Based on its proximity to the project site, tide levels at the Sewells Point station are adopted for the project location. Table 16-2 below documents the various tidal datums for the tidal epoch of 1983-2001. In the present study, the Mean Sea Level (MSL) datum is adopted as the project datum.
### Table 16-2

<table>
<thead>
<tr>
<th>Tidal Datum</th>
<th>Abbreviation</th>
<th>ft. MSL</th>
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<tr>
<td>Mean Higher-High Water</td>
<td>MHHW</td>
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<tr>
<td>Mean High Water</td>
<td>MHW</td>
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<tr>
<td>North American Vertical Datum</td>
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<tr>
<td>Mean Sea Level</td>
<td>MSL</td>
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<tr>
<td>Mean Low Water</td>
<td>MLW</td>
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<tr>
<td>Mean Lower-Low Water</td>
<td>MLLW</td>
<td>-1.36</td>
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</table>

#### 16.3.6. Extreme Water Levels

A. The Design-Builder shall determine Extreme Water Levels, which shall consider both the tidal and non-tidal components, including any storm surge and wave setup. Wave run-up shall also be considered separately. The Extreme Water Level assessment shall include the possibility of a surge event occurring during high tide.

B. NOAA has conducted an Extreme Water Level assessment for NOAA station ID 8638610 Sewells Point, VA. NOAA’s study determines exceedance probability, or the likelihood that water levels will exceed a given elevation, based on a statistical analysis of historic values. A NOAA Technical Report, "Extreme Water Levels of the United States 1893-2010" describes the methods and data used in the calculation of the exceedance probability levels. According to the data, and per a standard extreme value analysis method performed by NOAA, the 100-year return levels for both the positive and negative Extreme Water Levels are those summarized in Table 16-3. They are applicable for the present year only (2018) and shall be the minimum required Extreme Water Levels to be considered by the Design-Builder. The MSL refers to current epoch (1983-2001) at NOAA station Sewells Point.

C. NOAA station at Sewells Point, VA reports total water level. The total water level at a given location typically consists of the astronomical tide and a non-tidal component. The non-tidal component is often referred to as storm surge or residual surge. Therefore, the surge data was derived by subtracting out the tide predictions from the observed total water level. An extreme value analysis performed on the surge levels resulted in a 100-year return level of 6.6 feet as displayed in Table 16-4.
### Table 16-3

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Parameter</th>
<th>Extreme Water Level (EWL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% annual exceedance &quot;100-year event&quot;</td>
<td>Positive EWL extreme</td>
<td>7.4 ft.-MSL</td>
</tr>
<tr>
<td>1% annual exceedance &quot;100-year event&quot;</td>
<td>Negative EWL extreme</td>
<td>-4.0 ft.-MSL</td>
</tr>
</tbody>
</table>

### Table 16-4

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Surge (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% annual exceedance &quot;100-year event&quot;</td>
<td>6.6</td>
</tr>
</tbody>
</table>

### 16.3.7. Current

A. The Design-Builder shall determine design current velocity at the project site. The Design-Builder shall conduct a current velocity analysis using an appropriate hydrodynamic model considering extreme events. Provisions should be made during constructions to work under the operational current conditions values as shown in Table 16-5. In no case shall the design current used by the Design-Builder be less than the minimum values shown in Table 16-6 for extreme current conditions.

B. For Table 16-5 and Table 16-6 below, the term Flood refers to the rising of the water level (from low to high water), and the term Ebb refers to the receding of the flood (high to low water).

### Table 16-5

<table>
<thead>
<tr>
<th>Direction</th>
<th>Minimum Current</th>
<th>Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>1.3 knots</td>
<td>238° from true North</td>
</tr>
<tr>
<td>Ebb</td>
<td>1.4 knots</td>
<td>57° from true North</td>
</tr>
</tbody>
</table>
Table 16-6

<table>
<thead>
<tr>
<th>Exceedance Level</th>
<th>Direction</th>
<th>Minimum Current</th>
<th>Heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat I</td>
<td>Flood</td>
<td>1.6 knots</td>
<td>240° from true North</td>
</tr>
<tr>
<td></td>
<td>Ebb</td>
<td>1.7 knots</td>
<td>55° from true North</td>
</tr>
<tr>
<td>Cat II</td>
<td>Flood</td>
<td>1.9 knots</td>
<td>240° from true North</td>
</tr>
<tr>
<td></td>
<td>Ebb</td>
<td>2.1 knots</td>
<td>56° from true North</td>
</tr>
<tr>
<td>Cat III</td>
<td>Flood</td>
<td>2.2 knots</td>
<td>241° from true North</td>
</tr>
<tr>
<td></td>
<td>Ebb</td>
<td>2.7 knots</td>
<td>56° from true North</td>
</tr>
</tbody>
</table>

16.3.8. Sea-level Rise

A. Sea level rise is expected to reach 5.5 ft. by 2100. The Design-Builder shall use Figure 16-1 to determine the appropriate sea level rise, using the ‘high’ curve. The ‘high’ curve represents sea level rise in Virginia if global systems carry on with business as usual (meaning no efforts are taken to reduce greenhouse gases). For example, using the high level, the predicted sea level rise for a design life of 50 years (from present year of 2018) is approximately 3.2 ft. Sea level rise shall be in addition to Extreme Water Levels for a one percent-annual chance of occurrence storm surge event.

Figure 16-1 (Source: The Virginia Institute of Marine Science and the Center for Coastal Resource Management)
16.3.9. Wave Conditions at Islands and Land

A. The Design-Builder shall determine wave conditions at the site. The islands refer to the two islands on either side of the tunnel while the land refers to the landing of the highway on Hampton and Norfolk, VA. A minimum requirement for wave height was determined by performing an extreme value analysis on offshore wave events extracted from the US Army Corps of Engineers, Wave Information Studies (WIS). A spectral wave model was used to transform the waves from offshore to nearshore to the project location using the extreme wave conditions from WIS. Based on this assessment, the minimum requirement for the 100-year (one-percent-annual-chance) wave height at the islands is 9.9 feet with a peak period of approximately 5.7 seconds. The return period wave heights and corresponding peak periods for 1-year to 100-year are presented in Table 16-7.

B. Anecdotal evidence presented in some past studies suggests that historical events may have exceeded the above one-percent annual threshold, including the event of Hurricane Isabel in 2003. Hurricane Isabel 2003 was the most severe hurricane examined in terms of surge level at the site, which is close to a 50-year extreme event. Therefore, the Isabel track has been utilized to assess the Hurricane Category I, II, and III conditions at the site. Each Category is defined per the Saffir–Simpson Hurricane Scale (SSHHS). The Design-Builder shall consider the available Category I, II, and III conditions presented in Table 16-7 in determining the Project design wave height.

C. A summary of minimum requirements for design operational and extreme wave conditions are provided in the following table.

<table>
<thead>
<tr>
<th>Table 16-7</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Exceedance level</th>
<th>Islands</th>
<th>Land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hₘ₀ (ft.)</td>
<td>Tp (s)</td>
</tr>
<tr>
<td>1-yr.</td>
<td>4.8</td>
<td>4.5</td>
</tr>
<tr>
<td>10-yr.</td>
<td>6.7</td>
<td>5.1</td>
</tr>
<tr>
<td>25-yr.</td>
<td>7.9</td>
<td>5.3</td>
</tr>
<tr>
<td>50-yr.</td>
<td>8.7</td>
<td>5.6</td>
</tr>
<tr>
<td>100-yr.</td>
<td>9.9</td>
<td>5.7</td>
</tr>
<tr>
<td>Cat I</td>
<td>7.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Cat II</td>
<td>8.8</td>
<td>6.3</td>
</tr>
<tr>
<td>Cat III</td>
<td>9.9</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Note: Nearshore wave conditions apply to both Islands, on all sides, and both landings (Norfolk and Hampton land)
16.3.10. Navigational Hazards

A. The Design-Builder shall consider navigational hazards. The following minimum requirements for design parameters for performing a Navigational Hazard Assessment are provided in the following sections. Note that the following sections are per the Project requirements.

16.3.11. Design Vessel

A. The design parameters to be used as the minimum design vessels for impact and scour scenarios are listed in Table 16-8 and Table 16-9 below. Design vessel(s) to be considered in the zone between the navigation channel and the islands shall be determined by the Design-Builder.

Table 16-8

<table>
<thead>
<tr>
<th>Minimum Design Vessel Parameters within Navigation Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Length Overall (LOA)</td>
</tr>
<tr>
<td>Bulk carrier capacity (long tons)</td>
</tr>
<tr>
<td>Beam</td>
</tr>
<tr>
<td>Draft (laden)</td>
</tr>
<tr>
<td>Minimum Speed over ground</td>
</tr>
</tbody>
</table>

1 Design Vessel to be determined by the Design-Builder. Minimum values are represented in this table unless otherwise approved by the Department.

Table 16-9

<table>
<thead>
<tr>
<th>Minimum design Vessel Parameters at Outer Slope of Islands</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Length Overall (LOA)</td>
</tr>
<tr>
<td>Bulk carrier capacity (long tons)</td>
</tr>
<tr>
<td>Beam</td>
</tr>
<tr>
<td>Draft (laden)</td>
</tr>
<tr>
<td>Minimum Speed over ground</td>
</tr>
</tbody>
</table>

1 Design Vessel to be determined by the Design-Builder. Minimum values are represented in this table unless otherwise approved by the Department.
16.3.12. Ship Grounding

A. The Design-Builder shall design for the potential of ship grounding. Based the Ocean Engineering Report dated [xx/xx/xx], the following minimum preliminary design parameters are suggested:

1. A furrow depth from 10 to 16.5 feet, depending on the angle, from a head-on collision into the armored slope occurring during MHHW (present day), with an impact angle measured from a direction perpendicular to the armor stone; and

2. A collision above the tunnel protective layer with furrow depth of 1.6 feet.

16.3.13. Prop Wash

A. The Design-Builder shall design for the potential of damage due to prop wash in accordance with the references in Table 16-10.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Suggested Guideline</th>
</tr>
</thead>
</table>

16.3.13.1. Accidental Loads

A. Accidental loads on the tunnel related to dropped and dragged anchors, and sunken ships shall be considered. Detailed calculations, steps and design recommendations shall follow Saveur, J. “Chapter 3 structural design of immersed tunnels,” in Tunneling and Underground Space Technology 12, no. 2 (Vol. 4, 1997): 93-109.

B. Preliminary recommendations are as follows:

1. Dragged and Dropped Anchor Loads
   a. The top armor layer to be placed above the tunnel shall be designed at a minimum to adequately spread the load imparted by a 15-tonnes (metric) anchor.
   b. In addition, the side extent of the protective layer shall provide sufficient thickness to avoid the risk of a dragged anchor damaging the sides of the tunnel. A recommended lateral extent of thirty (30) to forty-five (45) feet is suggested, the thickness of the berm shall be verified with the appropriate design guidelines.

2. Sunken Ship
   a. There is a possibility that a ship may partially rest on top of the tunnel during a grounding event.
b. The Design-Builder shall consider sunken ship loads according to the guidelines provided in the TUST report, Saveur, J. “Chapter 3 structural design of immersed tunnels.” in Tunneling and Underground Space Technology 12, no. 2 (Vol. 4, 1997): 93-109.”

16.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 16-11 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean Engineering Final Design Report</td>
<td>5 1</td>
<td>60 days after NTP</td>
<td>16.3.2</td>
</tr>
<tr>
<td>Environmental Data</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>16.3.2</td>
</tr>
<tr>
<td>Local and Nearshore Hydrodynamics and Wave Study</td>
<td>5 1 and 5 CDs</td>
<td>60 days after completion of investigation, including testing</td>
<td>16.3.25.3.3</td>
</tr>
<tr>
<td>Vessel Traffic Study</td>
<td>5 1</td>
<td></td>
<td>16.3.2</td>
</tr>
</tbody>
</table>
SECTION 17. ROADWAY DESIGN

17.1. Scope

The Concept Plans, major design criteria and other reference documents are included in the Appendices. The information contained in the Attachments shall serve as a basis for the Design-Builder to determine the appropriate criteria to apply to the design of Interstate 64, interchange ramps, connector roads and roadway crossings. Offerors are on notice that the entirety of the information contained in the roadway inventory and major design criteria (Appendix 17.1) and Part 2, Section 4, Standards, of this document including but not limited to the design criteria, and other notes and data, contain the minimum roadway geometric design requirements that the Design-Builder shall meet in its performance of the Work. Unless otherwise approved by the Department, no changes to or deviation from the listed criteria shall be allowed. Any schedule delays because of changes or deviations are the responsibility of the Design-Builder.

17.2. References

- A. VDOT, FHWA, AASHTO and other Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed in Section 4, Standards.
- B. Major Design Criteria Table in Appendix 17.1
- C. Design Exceptions and Waivers in Appendix 17.2
- D. Geotechnical Pavement Report in Appendix [X.XX]

17.3. Requirements

17.3.1. General

- A. The Project shall be designed and constructed pursuant to the design criteria and specifications set forth in the Agreement including these Technical Requirements.
- B. The Work shall not preclude the local, state, and federal long-range transportation planning improvements.
- C. All design documentation shall comply with the requirements of applicable Governmental Authorities.
- D. Where the Work to be performed does not meet minimum American Association of State Highway and Transportation Officials (AASHTO) standards and specifications, the Design-Builder shall submit to the Department a design exception, pursuant to the Department’s Instructional and Informational Memorandum on design exceptions No. 227, (using LD-440 format) for Department and FHWA approval. Appendix [X.X] identifies design exceptions already approved for use on the Project. Any design exception resulting from the Work of the Design-Builder shall be at the sole risk of the Design-Builder.
- E. Where the Work to be performed meets or exceeds minimum AASHTO design criteria, but does not meet the Department’s minimum standards and specifications, the Design-Builder shall submit to the Department a design waiver (using LD-448 format) for Department approval. Appendix [X.X] identifies design waivers already approved for use on the Project. Any design waiver resulting from the Work of the Design-Builder shall be at the sole risk of the Design-Builder.
F. The Design-Builder is solely responsible for acquiring any additional design exceptions and design waivers caused by the Work of the Design-Builder. The Department’s approval of a Design-Builder’s request for a design exception does not guarantee FHWA approval. Previously submitted design exceptions and design waivers are subject to re-evaluation if additional information becomes available that was not known at the time of initial submittal or conditions change that were used in the analysis of the original design exception or design waiver and, in either case, if such additional information or changed conditions materially affect the premise on which the original design exception or design waiver at issue was based.

G. The Design-Builder shall take all reasonable efforts to ensure that the condition of existing buildings, structures, roadways, sidewalks, paths, trails, signs, lighting, Tolling and Traffic Management System (TTMS) and signal equipment, or other property that is to remain is not adversely affected by the performance of the Work. Prior to commencing Work the Design-Builder shall perform property pre-condition surveys and monitor their condition during the Work period. The Design-Builder shall repair any damage caused by the Work to at least a condition comparable to that which existed immediately prior to the damage. The Department shall be given the opportunity to witness any pre-condition surveys and/or monitoring and the Design-Builder shall make the results available to the Department before commencing any Work that may affect the property.

H. Values for properties of materials to be used in the Work shall conform to the specified values or range of values in the standard documents and specified in the Technical Requirements. Less than complete conformity may be tolerated if obtaining exact or complete conformity would not be feasible and if authorized by the Department. If permissible tolerances are exceeded or if consistent deviations from the plans or abrupt changes in grade occur, even though within the tolerances, the Design-Builder shall ensure that the affected areas are reconstructed to conform to the specified tolerance such that the Work is fit for its intended purpose.

I. The Project is considered part of the Strategic Highway Network (STRAHNET).

J. All design documentation and construction documentation shall be in English units.

K. The Design-Builder shall ensure that areas impacted by the Work are subject to continual and un-interrupted removal of rubbish, scrap material, and debris. Work sites shall have a neat, safe and orderly appearance at all times. Prior to Final Acceptance the Design-Builder shall remove its construction equipment, materials and debris from the Project Right-of-Way and other property used by or adjacent to the Project.

L. When removal of mailboxes and newspaper boxes is made necessary by construction operations, the Design-Builder shall place them in temporary locations so that access to the boxes will not be impaired. Prior to Final Acceptance, boxes shall be placed in their permanent locations as agreed with the Department, upgraded to current criteria, and left in as good condition as when found.

M. The Design-Builder shall take all reasonable efforts to preserve property and improvements along the boundary lines of and adjacent to the Work unless the removal or destruction is absolutely required and consistent with the RFC Documents. The Design-Builder shall use suitable precautions to prevent damage to such property. If property is damaged, the Design-Builder shall restore property to a condition similar or equal to that existing before such damage was done by repairing, rebuilding, or restoring, or making settlement with the property owner. Where property of third parties has been damaged and repaired by the Design-Builder, the Design-Builder shall secure from the owner a release from any claim against the Department. A copy of this release shall be furnished to the Department.
N. The Design-Builder shall provide certified letters to the property owners at the address on record that comply with the Code of Virginia § 33.1-94, Right of Entry. Copies of the letters, signed return receipt or proof of delivery shall be provided to the Department fifteen days after the proof of delivery. Notice of intent to enter shall be deemed made on the earlier of the date of mailing, if mailed, or on the date delivered.

17.3.2. Geometry

A. I-64 is functionally classified as an urban Interstate. The Department geometric design standard that will be utilized for Interstate 64 will be GS-5 (Urban Principal Arterial - Interstate) in level terrain with a minimum design speed of 60 mph.

B. This Project Concept Plans include widening of I-64 to provide 12-foot outside shoulder, two 12-foot General-Purpose lanes, one 12-foot HOT lane and one 14-foot hard running shoulder/inside shoulder in each direction. The General-Purpose lanes will be separated from the HOT lanes by a 4-foot buffer with tubular markers. This typical section shall be a requirement unless otherwise directed by the Department.

C. Existing crossovers are to be replaced with paved crossovers in locations nearest to their existing locations which are both constructible and that meet current VDOT and AASHTO requirements and have been reviewed with the local emergency response agencies. Existing crossovers shall remain accessible to emergency vehicles for the duration of construction until completion of the paved crossovers. At that time, the paved crossovers shall remain accessible to emergency vehicles. At no time shall any crossover location be restricted for use by emergency personnel unless previously approved by the Department and coordinated with VDOT Maintenance and the local emergency response agencies.

D. Bridge pier protection is to be designed and constructed in accordance with the requirements as noted in Section 21, Bridges and Structures, for all the bridges along I-64.

17.3.3. Access Management

A. An Interchange Modification Report for the Project may be required. Ramp acceleration/deceleration lanes along the I-64 mainline should be lengthened to meet or exceed the current AASHTO standards for deceleration lengths, acceleration lengths, and taper lengths, unless physical limitation exist preventing lengthening to meet standards. Where existing physical limitation prevent lengthening deceleration lengths, acceleration lengths, and taper lengths to meet standards, a Design Exception will be required. This shall be based on the mainline design speed along I-64 (60 MPH) and the posted or advisory speed along the ramps or the design speed of the existing ramp based on the existing horizontal curve radii’s and existing superelevation of the ramps as they diverge from the mainline, whichever is less and results in a longer length. All existing acceleration/deceleration lane and shoulder pavement shall be reconstructed as a part of this project. This pavement reconstruction shall include all lane and shoulder pavement to the end of the physical gore. Any existing acceleration/deceleration lanes which exceed the required AASHTO standard lengths shall be reconstructed to match existing conditions. Under no conditions shall the length or number of lanes of any acceleration or deceleration lane be permitted to be reduced in the final condition.

B. The Design-Builder shall reconstruct existing I-64 eastbound off-ramps from the physical gore up to the nearest tie-in point on the existing ramp that will provide a smooth transition both vertically and horizontally. The reconstructed ramp shall meet all the requirements of the VDOT GS-R standard matching design speeds of existing ramps. Modifications including mill and overlay, pavement marking removal and installation, median island/curb demo and installation,
full depth pavement replacement, traffic signal installation, existing traffic signal modification, traffic signal co-ordination, signing redesign, furnishing and installation of traffic control devices and signing to match revised traffic pattern, roadside barrier modification, sight distance clearing, and temporary traffic control are anticipated to accommodate the proposed ramp modifications.

C. Naval Station Norfolk has force protection standards that require them to be made aware of any construction activity within 20 feet of their security fence and/or property line. The Design-Builder shall coordinate all Work within 20 feet of the security fence and/or property line with Naval Station Norfolk base security, including Work within the Department Right of Way. The Design-Builder shall not store materials or equipment within 20 feet of the security fence and/or property line. The Design-Builder shall immediately make Naval Station Norfolk personnel aware of any damages to U.S. Government property resulting from construction activities, including but not limited to tree removal and grading. The Design-Builder is financially responsible for any damage their activity causes to U.S. Government property (to include, but not limited to, fencing and security systems). Any repairs to or replacement of government property must be in accordance with U.S. Government standards and the property shall be restored to its pre-damaged state. The Design-Builder shall include Naval Station Norfolk in the plan review process for all construction within 20 feet of the Naval Station Norfolk security fence and/or property. Contact information for Naval Station Norfolk is identified below.

Commander, Naval Installations Command
Naval Station Norfolk
1530 Gilbert Street, Suite 2000
Norfolk, VA 23511
(757) 444-0000

17.3.4. Hydraulics

The Design-Builder shall provide and/or perform all investigations, evaluations, analysis, coordination, documentation, and design required to meet all hydrologic and hydraulic, drainage, stormwater management, erosion and sedimentation control, stormwater pollution prevention, and Virginia Storm Water Management Program (VSMP) permitting requirements of the standards and reference documents listed in Section [X.X] Standards and Specifications.

17.3.4.1. Hydrologic and Hydraulic Analysis (H&HA)

An H&HA, including scour analysis shall be completed for bridges over waterways and major culvert crossings that have a total 100-year design discharge greater than 500 CFS. The Design-Builder shall deliver to the Department a final H&HA, including scour analysis for proposed major drainage structures. These analyses shall be submitted to the Department for review and approval prior to the commencement of construction. The H&HA shall include an established level of construction tolerance to allow for the hydraulic performance established in the H&HA to be maintained. The approval of the H&HA represents a hold point in the Design-Builder’s CPM Schedule. The ultimate proposed conveyance system (inclusive but not limited to culverts, stream realignment, and outfall conveyance channels through the project area) shall be designed by the Design-Builder to meet all applicable hydraulic requirements, including current Federal Emergency Management Administration (FEMA), Federal Highway Administration (FHWA), and Department guidelines as described in the VDOT Drainage Manual, (including current Errata Sheet), Hydraulic Design Advisories, applicable VDOT IIMs and any applicable local zoning floodplain restrictions.

Natural stream design, bank hardening, and revetments will be considered as part of the hydraulic design to minimize downstream impacts in accordance with State and Federal requirements applicable to this project. Natural stream design, bank hardening and revetments shall be designed in
accordance with acceptable FHWA Publications. Acceptable FHWA publications include, but are not limited to, HDS-6, HDS-7, HEC-11, HEC-14, HEC-20, and HEC-23.

The hydrologic and hydraulic analysis shall be documented by the completed VDOT LD-293 forms and as outlined in Chapter 3 of the VDOT Drainage Manual. The Design-Builder shall provide the Department two (2) paper and two (2) electronic copies (Adobe PDF format) of the final H&HA, HEC-RAS (or other Department approved analysis software for this project) Files and LD-293. The final H&HA and Scour Report(s) shall be certified by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia.

Routine Inspection Reports for the existing box culverts are available to Offerors upon request and submission of a signed and completed Critical Infrastructure Information (CII)/Sensitivity Security Information (SSI) Individual Non-Disclosure Agreement form.

Upon completion of the installation of any major drainage structure, the Design-Builder shall prepare a final as-built survey of the major drainage structure and related upstream and downstream appurtenances. The as-built survey shall include the horizontal location and vertical elevations of the constructed major drainage structure in sufficient detail to confirm pre-construction hydraulic performance. A post construction as-built H&HA and report shall be developed based on the as-built survey and submitted to the Department for review and acceptance. The post construction H&HA shall demonstrate that the anticipated post construction hydraulic performance of the major drainage structure matches or betters that of the pre-construction H&HA. If the post construction analysis shows an impact greater than the pre-construction H&HA and/or exceeds the construction tolerances established with the pre-construction H&HA, then the Design-Builder shall be responsible for mitigating the adverse impacts of the post construction condition at no additional cost to the Department. The Design-Builder shall have all final H&HA reports certified by an engineer licensed to perform engineering in Virginia.

17.3.4.2. Drainage
The drainage Work shall include the design and construction of culverts, open channels, storm sewer systems, underdrains, bridge deck drainage assemblies and structures, downstream channel and flood protection measures, stormwater management facilities, and erosion and sediment control measures in compliance with the standards and reference documents listed in Section [X.X], Standards and Specifications, and the VDOT Erosion and Sediment Control and Stormwater Management Programs. All pipe culverts and storm sewer pipe for the Project shall be determined in accordance with the VDOT Drainage Manual and the VDOT 2016 Road and Bridge Standards and all pipe joints shall be determined in accordance with VDOT IIM-LD-254. The Design-Builder shall provide the Department two (2) paper and two (2) electronic copies (Adobe PDF format) on compact disc (CD) for all interim submissions and the final drainage report incorporating all drainage calculations including pre- and post-development discharges, capacities, and supporting data such as drainage areas (with maps), ground cover calculations, etc. in accordance with the documentation requirements as outlined in the VDOT Drainage Manual. The design software electronic files shall be provided with each interim submission and the final submission. All drainage reports (to include the H&HA, Scour Analysis and SWM Plan) shall contain a table of contents with tabbed sections. All electronic copies of the drainage reports provided shall be in Adobe PDF format and shall be bookmarked for ease of review. The final drainage report shall be certified by a Professional Engineer holding a valid license to practice engineering in the Commonwealth of Virginia.

The Department has not evaluated the structural condition of any of the existing storm sewer systems or culverts of the Project. For the purposes of developing the price proposal, the Design-Builder shall assume the existing storm sewer pipes or culverts located in the Project, which are a functional element of the proposed design are structurally deficient and are to be plugged and abandoned.
If after award the Design-Builder investigates the structural condition of the existing culverts and storm sewer systems that have not been inspected, and as a result proposes use (or repair) of some or all, then it shall be done only with the Department’s approval. The Design-Builder shall credit the Department, the differential in cost for utilizing the existing or rehabilitated pipes in lieu of removing and replacing the pipes. The Design-Builder shall assess the structural condition and serviceability of the structure by performing a visual/video inspection of the existing culverts utilizing the assessment criteria for Post Installation Inspections presented in VDOT Road and Bridge Specification 302.03(d). The Design-Builder shall provide the Department with an inspection report documenting the assessment following the methodology as prescribed in the Road and Bridge Specification 302.03(d). The report shall include a certification from the Design-Builder’s engineer attesting to the structural adequacy of the structures and specific recommendations relative to improvements to the structural condition and serviceability of the structures. The Design-Builder shall provide the report to the Department for review and approval prior to proceeding to final design and prior to proceeding to construction. With the Department’s approval, pipes deemed repairable shall be rehabilitated in accordance with the Department’s guidelines including, but not limited to those methods outlined in Chapter 8, Section 8.3.6.7 of the VDOT Drainage Manual and Special Provisions SQ302-000110-00 Pipe Rehabilitation and SQ302-000100-00 Pipe Replacement.

Pipes to be rehabilitated using methods that reduce the pipe cross sectional flow area by 10% or more will not be allowed without the written approval of the Department. Circular pipes 24-inches or less in diameter, and elliptical pipes 30-inches by 19-inches or smaller, are not eligible for a rehabilitation method that reduces the cross-sectional flow area unless approved in writing by the Department.

Underdrain outfall locations are not shown in the Concept Plans and it shall be the responsibility of the Design-Builder to develop the underdrain design including adequate outfall locations according to the guidelines set forth in the 2016 VDOT Road and Bridge Standards and the VDOT Drainage Manual. The Design-Builder may not utilize access structures (i.e. cleanouts) in lieu of EW-12’s.

All existing or proposed drainage channels within the Right-of-Way shall be rendered in a serviceable condition, free of debris and physical obstructions. In addition, the Design-Builder shall be responsible for repairing or addressing any scour or undermining at existing box or pipe culverts beneath I-64.

17.3.4.3. **Stormwater Pollution Prevention Plan (SWPPP)**

A SWPPP, including, but not limited to, an Erosion and Sediment Control (ESC) Plan and Narrative, a Pollution Prevention (P2) Plan, and a post construction Stormwater Management (SWM) Plan shall be prepared and implemented by the Design-Builder in compliance with applicable requirements of the standards and reference documents listed in Section 4., Standards, including the Virginia Erosion and Sediment Control Law and Regulations and the Virginia Stormwater Management Program (VSMP) Law and Regulations.

It shall be the responsibility of the Design-Builder to have a qualified person within their team structure, in addition to the ESC and post construction SWM Plan designer, who is authorized and/or certified by the Virginia Department of Environmental Quality (VDEQ) to perform plan reviews, independently review and certify that the ESC Plans and Narrative and post construction SWM Plan for the Project are in accordance with the Department’s Approved ESC and SWM Standards and Specifications. Before implementing any ESC or post construction SWM measures not included in the Department’s approved ESC and SWM Standards and Specifications, a variance or exception respectively must be requested through the Department in accordance with Chapter 10 of the VDOT Drainage Manual and the latest versions of VDOT IIM-LD-195, and VDOT IIM-LD-251.

The Design-Builder shall complete and submit the ESC and SWM Plan Certification form (LD-445C) to the Department Project Manager. The Design-Builder shall provide the Department two (2) paper and two (2) electronic copies each on CD of the final ESC Plan and Narrative, P2 Plan and post construction...
SWM Plan incorporating all calculations, analysis, documentation and evaluations required. The ESC Narrative shall specifically include calculations (with supporting data) documenting that the design meets the water quantity requirements for downstream channel flood protection in the ESC Law and the VSMP Regulations, as appropriate, for each location where stormwater is discharged from the Project site. The SWM Plan shall include a narrative documenting the design meets the water quality requirements utilizing either Part IIB or Part IIC technical requirements. The Design-Builder shall submit a design using only Part IIB or only Part IIC technical requirements for the entire project to comply with stormwater management regulations, for both Water Quantity and Quality. The conceptual SWM Plan submitted for review by the Design-Builder prior to obtaining the VSMP permit shall be of sufficient detail to enable VDOT to confirm the plan is feasible for the entire Project and will meet the requirements of the VSMP regulations as set forth in 9VAC25-870-55 of the Virginia State Code. The conceptual plan shall include items described under paragraph 2B of 9VAC25-870-55 with the understanding that the computations identified within 2B.6 and 2B.7 will be of a preliminary nature but contain enough information to verify the adequacy of the Project SWM Plan.

The Project requires coverage under the Virginia Pollutant Discharge Elimination System (VPDES) General Construction Permit for the Discharges from Construction Activities (VPDES Construction Permit). The Design-Builder is responsible for providing to the Department the necessary information and funds for it to secure permit coverage for the Project. The Design-Builder shall be responsible for all fees necessary for coverage under the VPDES General Construction Permit. The Design-Builder shall complete the applicable sections of the VPDES Construction Permit Registration form (LD-445), VPDES Construction Permit Contact Information (LD-445A), VPDES Construction Permit Fee Registration form (LD-445B). These forms along with the completed ESC and SWM Plan Certification form (LD-445C) and a check in the amount of the permit fee made payable to the Treasurer of Virginia shall be submitted to the Department. The Department will review the submitted information and, if complete and acceptable, process a request for coverage under the VPDES Construction Permit in accordance with the Department’s guidelines as outlined in the latest version of VDOT IIM-LD-242. If any information submitted by the Design-Builder is found to be incomplete and/or unacceptable, the assembly will be returned to the Design-Builder for corrective action and resubmission.

A working conceptual ESC and post construction SWM Plan and SWPPP for the entire Project must be submitted for review and approval with the initial application for permit coverage. This initial conceptual Plan submittal shall include the proposed total expected Land Disturbance Area and Land Development Area, including any off-site facilities, for the entire Project. Where the Project will be constructed in segments, the Design-Builder shall submit a final ESC Plan, a post construction SWM Plan and a P2 Plan, including the expected Land Disturbance Area, for the proposed initial Work segment in addition to the conceptual plan for the entire Project. It is expected that the individual Work segment submittals will be self-sustaining and not incur a deficit in post construction SWM design requirements requiring mitigation on future work segments. Subsequent Work segment submittals shall include required modifications to the Land Disturbance Area value. However, these modifications, in total, shall not exceed the initially submitted Land Development Area value. The Design-Builder shall not proceed with Work to be covered by the permit until permit coverage is secured and the Department Project Manager releases the Work in writing, and the final SWM Plan and final ESC Plan and final P2 Plan are reviewed and approved. It is noted that permit coverage, and subsequent release of Work, can take up to ninety (90) days from the time that the Design-Builder submits a request for coverage that includes all required information. This represents a hold point in the Design-Builder’s Project Schedule. Design-Builder shall provide a completed SWPPP Certification form (LD-455E) before commencement of any land disturbing activity and shall complete and include the SWPPP General Information Sheets in the plan assembly per Chapter 10 of the VDOT Drainage Manual. The SWPPP Certification form (LD-455E) and SWPPP General Information Sheets shall be updated with each Work segment submittal as necessary.
The Design-Builder shall be responsible for compliance with construction-related permit conditions and shall assume all obligations and costs incurred by complying with the terms and conditions of the permit. Any fines associated with permit or regulatory violations shall be the responsibility of the Design-Builder. Upon completion of the entire regulated land disturbing activity (including final stabilization of all disturbed areas), the Design-Builder shall provide updated/revised Permanent Best Management Practice (BMP) information in Section VI of the SWPPP General Information Sheets for each post construction BMP placed into service on the Project, complete the VPDES Construction Permit Termination Notice form (LD-445D) and submit both documents (without signature) to the Department for processing. The Design-Builder shall also have on-site during any land disturbing operations an individual or individuals holding a VDEQ Erosion and Sediment Control Inspector Certification, a VDEQ Responsible Land Disturber (RLD) Certification and a VDOT Erosion and Sediment Control Contractor Certification (ESCCC) to ensure compliance with all VDEQ and Department ESC Plan implementation requirements.

The Design-Builder shall use the erosion and sedimentation control practices found in the VDOT Road and Bridge Standards. If the Design-Builder desires a variation from VDEQ’s specifications regarding stormwater, stormwater management, or from VDOT’s erosion and sedimentation control standards, it is the responsibility of the DB team to perform all coordination with VDEQ to obtain the variance, and provide the Department with written approval from VDEQ for the variance. All variances from VDEQ specifications, or VDOT erosion and sedimentation control standards, must be recorded in the SWPPP and detailed in the plans.

Additional VPDES Requirements
- During the development of the VPDES submittal, coordination with VDOT Cultural Resources will be required, as well as, preliminary concurrence to avoid conflicts with SWM basins and roadway improvements
- Clearing and grubbing is considered land disturbance.
- BMP facility water table elevations shall be confirmed and shown on the plans submitted along with the VPDES permit application.
- The Design-Builder shall obtain permit coverage for all support facilities for the Project per the requirements of the latest version of VDOT IIM-LD-242, Section 4.0.

Additional Submittal Requirements
- Advanced work packages for activities defined as routine maintenance in I&IM-195, such as shoulder strengthening, do not require VPDES permit coverage.

For the VPDES Permit Package, a complete ESC plan is defined as:
- 100% Phase I E&S Plan
- FI Level Phase II E&S Plan (per current LD-436 checklist)
- Supporting computations and materials per 9VAC25-870-55.B.1-9 and VDOT Drainage Manual, which have been reviewed and approved by the Department.

For the VPDES Permit Package, a substantially complete SWM plan is defined as:
- FI Level designed stormwater management plan (per current LD-436 checklist)
- Supporting computations and materials per 9VAC25-870-55.B.1-9 and VDOT Drainage Manual, which have been reviewed and approved by the Department.

A complete P2 plan as defined by the VSMP regulations and the current VDM.
17.3.4.4. Post-Construction Stormwater Management Facilities

The Design-Builder shall be responsible for the design and construction of stormwater management facilities as required for the Project in accordance with the latest version of VDOT IIM-LD-195, and the other standards and reference documents listed in Part 2, Section 4.3, Standards Specifications, including the Virginia Stormwater Management Program Law and Regulations, and shall comply with the minimum geotechnical requirements contained therein. The Department has identified potential locations for post construction stormwater management facilities as part of the Concept Plans.

However, these locations are preliminary and have not been fully evaluated to determine if these locations are suitable, feasible or sufficient to address all the stormwater management requirements of the project. The Design-Builder, as part of their final design, shall evaluate these locations, and if found acceptable shall use these locations to develop a final post construction stormwater management plan.

If any of the locations are found to be unacceptable, the Design-Builder must identify acceptable location(s) to meet the post construction stormwater management requirements of the Project. The Design-Builder is to insure proper ingress and egress to any stormwater management facility and that any specific proprietary facilities have proper maintenance details included in the Record (As-Built) Plans. When a stormwater management basin is located outside of the limited access fencing, maintenance access should be provided from a separate public road where economically feasible. When maintenance access can only be provided from a limited access roadway, the Right of Way line shall encompass the entire stormwater management facility. Provide a lockable gate for all stormwater management facilities that require an entrance for maintenance access.

The Design-Builder shall provide ‘As-Built’ drawings of all post-construction storm water management facilities located on the project. The ‘As-Built’ drawings shall show the actual finished ground contours, outlet structure dimensions and elevations, entrance grading and all applicable details originally shown in the design plans as they exist at the completion of the project. These drawings shall be certified by a Professional Engineer or Land Surveyor registered in the Commonwealth of Virginia. A minimum of two benchmarks shall be provided for each BMP in the form of a Commonwealth of Virginia Survey Control Mark (3.25" aluminum disc mounted on top of a #5 bar set in concrete).

The Design-Builder shall identify the original condition of the in-situ soils, vegetation, and hydrology where each proposed post-construction stormwater management facility for the Project is located. The Design-Builder shall provide the Department sufficient documentation to define if the stormwater management facility will be located on wetlands or uplands with photographic evidence and a brief description of the site soils.

The Design-Builder may elect to purchase up to 25% of the required phosphorous load reduction as nutrient credits in accordance with VDOT IIM-LD-251 to satisfy the post-construction water quality reduction requirements for the Project. It is the responsibility of the Offeror to investigate the availability of nutrient credits and as such their purchase shall be at their risk. All costs associated with the purchase of the nutrient credits shall be included in the Offeror’s Price Proposal. The use of such nutrient credits shall be identified in the Design-Builder’s SWPPP. Where the Design-Builder elects to purchase nutrient credits, the Design-Builder shall complete a Nutrient Credit Assignment Agreement, and shall submit the agreement to the Department for execution. The agreement is to be used for the transfer of the ownership of nutrient credits from the purchaser to the Department. The agreement is to be completed with the appropriate project specific information and a copy of the bill of sale between the Nutrient Credit Bank and the purchaser is to be attached as Exhibit A. A copy of the executed agreement is to be included with the BMP information submitted with the VDPES Construction Permit Termination form LD-445D.

Additional SWM Facility Requirements

- All proposed basin facilities shall be fenced with chain link fence including gates with
locking mechanisms or as directed by the Department.

- BMPs which require mulch shall use shredded cypress mulch.
- To facilitate maintenance, all BMPs that impound water shall include a method to drain the entire BMP within 48 hours without pumping.
- VDOT has determined preliminary groundwater elevations for the post construction management facilities. These elevations and locations are preliminary, and therefore have not been fully evaluated. If groundwater is found to be unacceptable, the Design-Builder must identify other acceptable location(s) to meet the post construction stormwater management requirements of the project. Specifically, work orders for any level of variation from the GDR water table elevations are not acceptable. High water table is a risk on the Design-Builder.

- Underground storage shall not be used for this project

### 17.3.4.5 Other Drainage Requirements

**A. Storm Sewer Inlets, Storm Sewer Piping, and Culverts**

1. Additional requirements for storm sewer inlets, storm sewer pipes, and culverts, including, but not limited to:

   a. Storm Sewers and Culverts which cross one or more lanes of the Interstate or ramps shall have a minimum diameter of 24 inches.

   b. Storm Sewers and Culverts not crossing one or more lanes of the interstate, or ramps, shall have a minimum diameter of 15 inches.

   c. Any pipe or culvert that is 24 inches or less in diameter pipes cannot be rehabilitated

   d. All proposed pipe rehabilitation plans, specifications, and work packages shall be submitted with the Right of Way submittal

   e. Rehabilitated pipes that have an existing HW/D less than or equal to 1.5 shall not have a HW/D of more than 1.5 in the rehabilitated condition for the design storm event.

   f. Existing pipes with a HW/D greater than 1.5 shall not experience an increased headwater elevation in the rehabilitated condition.

   g. If a rehabilitated pipe increases the headwater, the Design-Builder shall submit a report that includes a detailed map and narrative showing the impacts to the property. If the headwater travels outside the ROW, the Design-Builder shall provide an approval letter from each affected property owner with the Right-of-Way submittal.

**B.** All drainage pipes, culverts, storm sewers and structures (existing and newly constructed) located within the Project limits that are disturbed or extended as a part of the project to include existing downstream culverts from I-64 to 150 feet from the Department Right-of-Way are functional elements of the final design and shall be rendered in a serviceable condition, free from debris and physical obstructions. Existing sediment or debris and accumulated sediment or debris resulting from project construction activities shall be removed by the Design-Builder, as such maintaining the original line and grade, hydraulic capacity or construction of the facility prior to the final acceptance of the Project. Damaged pipes discovered during cleaning that are beyond the VDOT Right-of-Way should be reported to the Department.

**C.** A 10-foot wide gravel maintenance access shall be provided around the entire perimeter of all stormwater management facilities, except for DEQ specifications Number 3 (grass channel), Number 10 (dry swale), and Number 11 (wet swale).

**D.** Groundwater elevations will fluctuate through the year. Groundwater elevations if provided by
the Department are only the elevations where water was encountered at the time of the soil boring and do not necessarily reflect the seasonably high groundwater elevation. Groundwater elevations will likely be different from those observed by the Department. The Design-Builder shall obtain groundwater elevation data that confirms the seasonably high groundwater elevations within the project limits to use for the project SWM design.

E. DI-2 inlets require both IP-A and IP-B inlet protection.

F. For interstate culverts and storm sewer outlets, outlet protection is required if the design storm velocity is greater than 2.3 feet per second.

G. Stormwater management facilities which include plants, shrubs, and trees as part of the pollutant removal mechanism, such as bio-retention and constructed wetlands, are to be planted with actual plants, shrubs, and trees. Using seeds instead of plants is not acceptable.

H. Check dams, which are permanent stormwater management features, shall be constructed out of earth and use a 10:1 slope on sides which face traffic. For example, the check dams of a grass swale shall be constructed out of earth.

I. Standard Paved Flumes, PG-4, shall not be used unless authorized in writing by the Department. The Design-Builder shall use the DI-13 structure instead. Existing paved flumes that require replacement shall be replaced with DI-13 structures.

J. Level spreaders shall not be used unless authorized in writing by the Department.

K. If complying with VSMP Part IIB technical requirements, at the first plan submittal, and at each milestone submission, the Design-Builder will provide the completed Virginia Runoff Reduction Method spreadsheets in hard copy and Microsoft Excel format.

L. Existing concrete or asphalt gutters adjacent to guardrail located along the outside of the EB and WB I-64 paved shoulders and ramps, shall be removed or filled with asphalt concrete. These locations may require additional drainage infrastructure.

M. Temporary rock check dams are not to be used within stormwater management BMPs as permanent structures unless authorized in writing by the Department.

N. The shredded hardwood mulch that is specified as cover over the filter media of the bio-retention layers for BMPs found within the BMP Clearing House (i.e. Dry Swales or bio-retention facilities) shall consist of shredded cypress mulch.

O. The use of manufactured treatment devices is not permitted unless approved in writing by the Department.

17.3.4.6. Scour

A scour analysis will be required for the bridges over all water bodies. Scour analysis and the design of scour countermeasures shall be performed in accordance with the procedures recognized as appropriate by the FHWA and the Department. Appropriate procedures include, but are not limited to, “Evaluating Scour at Bridges – HEC 18 (current version),” and “Bridge Scour and Stream Instability Countermeasures – HEC 23 (current version).” Other procedures can also be considered during the scour evaluation upon prior approval by the Department. The Department may, in its sole discretion, accept or reject such proposed methods. Design and check scoured bed elevations should consider the magnitude of the flood that generates the maximum scour depth up to the 100-year and 500-year events respectively.

The Design-Builder will be responsible for the final design and construction of the foundations for this Project, including the final Hydrologic and Hydraulic Analysis and the final Scour Analysis, in accordance with the Contract Documents.
17.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 17.4-1 for the Department’s consultation and written comment.

Table 17.4-1 Deliverables

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hardcopy</td>
<td>Electronic</td>
<td></td>
</tr>
<tr>
<td>Interim and Final Drainage Report</td>
<td>2</td>
<td>2 (Adobe PDF) on CD</td>
<td></td>
</tr>
<tr>
<td>Conceptual Erosion and Sediment Control Plan</td>
<td>5</td>
<td>1</td>
<td>60 days after NTP</td>
</tr>
<tr>
<td>Post construction SWM Plan</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SWPPP plan for entire project</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SWM As-Built Drawings</td>
<td>5</td>
<td>1</td>
<td>60 days after completion of storm water construction</td>
</tr>
<tr>
<td>Hydrologic and Hydraulic Analysis (H&amp;HA) and Scour Analysis</td>
<td>5</td>
<td>1 and 5 CDs</td>
<td>60 days after completion of investigation, including testing</td>
</tr>
</tbody>
</table>
## Appendix 17.1 – Major Design Criteria Table

### Table A17.1-1 Major Design Criteria Table

<table>
<thead>
<tr>
<th>VDOT Geometric Design Standard</th>
<th>I-64, I-564</th>
<th>Direction Connection Ramps</th>
<th>Loop and Diagonal Ramps&lt;sup&gt;7&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urban Principal Arterial (GS-5) - Interstate, Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interchange Ramps (GS-R) - Level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Design Vehicle</strong></td>
<td>WB-67</td>
<td>WB-67</td>
<td>WB-67</td>
</tr>
<tr>
<td><strong>Design Speed</strong></td>
<td>60 mph&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Varies, match existing</td>
<td>Varies, match existing</td>
</tr>
<tr>
<td><strong>Minimum Radius</strong></td>
<td>@ 8% Max: 1204' @ 4% Max: 1500'</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td><strong>Vertical Grade</strong></td>
<td>0.5% Min 4.0% Max – Roads and Bridges 5.0% Max – Tunnels and Tunnel Approaches&lt;sup&gt;5&lt;/sup&gt;</td>
<td>0.5% Min Upgrade 5.0% Max Downgrade 4.0% Max</td>
<td>0.5% Min Upgrade 5.0% Max Downgrade 4.0% Max</td>
</tr>
<tr>
<td><strong>Stopping Sight Distance</strong></td>
<td>570'</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td><strong>Lane Width</strong></td>
<td>GP-12' HOT-12'</td>
<td>Single Lane: 16' Mult. Lanes: Varies&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Single Lane: 16' Mult. Lanes: Varies&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Buffer width (Between GP and Hot)</strong></td>
<td>4' (Includes tubular markers)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Shoulder Width Paved: X', Graded: (XX')</strong></td>
<td>Right: 12 (16) Left: 14'&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Right: 8' (10') w/GR (14') Left: 4' (6') w/GR (10')</td>
<td>Right: 8' (10') w/GR (14') Left: 4' (6') w/GR (10')</td>
</tr>
<tr>
<td><strong>Structure Width</strong></td>
<td>See Section 21.3.3 New Construction</td>
<td>Match clear roadway width See Section 21.3.3 New Construction</td>
<td>Match clear roadway width See Section 21.3.3 New Construction</td>
</tr>
<tr>
<td><strong>Cross Slope Super elevation</strong></td>
<td>Normal Crown: 2%&lt;sup&gt;3,5&lt;/sup&gt; 4% Max (Hampton) 8% Max (Norfolk)</td>
<td>Normal Crown: 2% 8% Max</td>
<td>Normal Crown: 2% 8% Max</td>
</tr>
<tr>
<td><strong>Vertical Clearance</strong></td>
<td>16'-6&quot;</td>
<td>16'-6&quot;</td>
<td>16'-6&quot;</td>
</tr>
</tbody>
</table>

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1. Current posted speed is 55 mph throughout the corridor.
2. Left shoulder will be a Part-Time HOT Running shoulder. 12' lane + 2' shy line. 14' is also recommended for roadside enforcement (Section 3.5.2, AASHTO Guide for High-Occupancy Vehicle Facilities.)
3. Per original design, I-64 was built with a 4% max super elevation in Hampton.
5. Design exception required.
6. Side Streets design to match existing condition.
7. FHWA's Use of Freeway Shoulders for Travel, February 2016, page 79, states "Part-time shoulder use may introduce design elements that are below the minimum criteria specified in AASHTO’s Green Book, (37) and design exceptions may be required. If the facility is an Interstate Highway, design elements in AASHTO’s A Policy on Design Standards – Interstate System (38) also apply."
### Table A17.1-2 Major Design Criteria Table – Side Streets

<table>
<thead>
<tr>
<th></th>
<th>S. Mallory Street</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VDOT Geometric Design Standard</strong></td>
<td>Urban Minor Arterial Street (GS-6) -</td>
</tr>
<tr>
<td><strong>Design Vehicle</strong></td>
<td>WB-50</td>
</tr>
<tr>
<td><strong>Design Speed</strong></td>
<td>30 mph&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Minimum Radius</strong></td>
<td>@ 4% Max: 251'</td>
</tr>
<tr>
<td><strong>Vertical Grade</strong></td>
<td>0.5% Min 8.0% Max</td>
</tr>
<tr>
<td><strong>Stopping Sight Distance</strong></td>
<td>200'</td>
</tr>
<tr>
<td><strong>Lane Width</strong></td>
<td>11'</td>
</tr>
<tr>
<td><strong>Buffer width (if Curb &amp; Gutter)</strong></td>
<td>4’ behind CG-2 / CG-6</td>
</tr>
<tr>
<td><strong>Shoulder Width</strong></td>
<td>10’ (14’) – graded 4’ left – 8’ right - paved</td>
</tr>
<tr>
<td><strong>Graded: X’, Fill w/GR:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>(XX’); Paved Left (Right)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Structure Width</strong></td>
<td>See Section 21.3.3 New Construction</td>
</tr>
<tr>
<td><strong>Cross Slope Super elevation</strong></td>
<td>Normal Crown: 2% 4% Max (Std. TC-5.11U)</td>
</tr>
<tr>
<td><strong>Vertical Clearance</strong></td>
<td>NA</td>
</tr>
</tbody>
</table>

1. Current posted speed is 30 mph throughout the corridor.
Appendix A17-2 – Design Exceptions and Waivers
SECTION 18. TRAFFIC ENGINEERING

18.1. Scope
The Project shall include all Traffic Control Devices (TCD), including temporary and permanent installation of the following: traffic signals, signage, lighting, guardrail including terminals, fixed object attachments, impact attenuators, pavement markings/markers, and delineation. All TCD designed and installed under the Project shall be in accordance with standards and references in these Technical Requirements. The signing and pavement marking plans, Transportation Management Plan (TMP), including temporary traffic control/public information and traffic operations plans are required from the Design-Builder for final approval by the Department. The Design-Builder shall comply with the Special Provision for Personnel Requirements for Work Zone Traffic Control and the Special Provision for Work Zone Traffic Control Management, Design-Build Projects.

All existing TCD impacted by the Project shall be modified, upgraded, or replaced by the Design-Builder to meet current VDOT standards.

The required safety improvements that were determined from the traffic safety assessment performed on the project corridor shall be incorporated into the Project unless they are located outside the Project limits. The list of safety improvements is included as a Reference Document.

18.2. References
A. VDOT Project Development Manual
B. FHWA Manual on Uniform Traffic Control Devices (MUTCD)
C. VDOT Supplement to the MUTCD
D. VDOT Traffic Engineering Division Instructional & Informational Memorandum
E. VDOT Traffic Engineering Design Manual
F. VDOT Standard Drawings
G. FHWA Standard Highways Signs Book
H. VDOT Standard Highway Signs Book
I. AASHTO Manual for Assessing Safety Hardware, First Edition
J. USDOT Roadway Lighting Handbook
K. AASHTO Roadway and Lighting Design Guide

18.3. Requirements

18.3.1. Signs
18.3.1.1. General
A. The Design-Builder shall be responsible for modifications to existing signs and sign structures, and furnishing and installing all required new temporary and permanent signs and structures. The final lines of sight and sight distances must be considered in the placement of all Project signage.
B. Existing interchange guide signs impacted by the Project shall be replaced with interchange guide signs in conformance with the current MUTCD and the VA Supplement to the MUTCD, using the same destinations as existing (unless the number of destinations is more than allowable) unless approved otherwise by the Department. All existing overhead signs shall be replaced with overhead signs as defined in the MUTCD, and ground mounted signs replaced with ground mounted signs. The Design-Builder shall review all ground mounted signing and delineators at all interchanges within the project limits and remove/replace/add signing/delineation as required in the VA Supplement to the MUTCD, 2011 Edition. All existing ground mounted signs using wood posts shall be replaced as required per the VDOT Standard Drawings, Section 1300.

C. The Design-Builder shall provide cross-road identification signing on I-64 where signing does not exist today or does not meet current MUTCD and Department standards. Design-Builder shall provide regulatory signing as required where signs are to be placed to the left and right of traffic throughout the project limit.

D. The Design-Builder shall clear existing vegetation obstructing the view of any existing or proposed signing within the limits of construction as defined in this section.

E. An existing sign inventory shall be completed prior to site demolition in accordance with the VDOT Traffic Engineering Design Manual. This existing information shall be submitted at the same time as the first plan submittal for proposed signing.

F. All signs and sign structures to be removed during the construction of the Project shall be disposed of by the Design-Builder. Existing signs and sign structures which meet current MUTCD and VDOT standards and meet minimum MUTCD retro reflectivity requirements and are in good condition (no bending, cracked/faded letters, bullet holes, or graffiti) may be reused as a part of this Project. For the Construction Duration and prior to Final Acceptance, the Design-Builder shall ensure all new and reused signs are clean and clear of all vegetation. All signs and sign structures to be removed during the construction which do not meet current MUTCD and Department standards or will not be reused as a part of the Project shall be disposed of by the Design-Builder. The Work may include temporary relocation of signs may be necessary as part of this Project and it is the responsibility of the Design-Builder to perform all the required sign relocations.

### 18.3.1.2. Limits of Project Signing

A. Any signing on adjacent roadways beyond the Project limits that require relocation, replacement, or modification due to the proposed design shall be the responsibility of the Design-Builder.

### 18.3.1.3. Signing Plan Requirements

A. The signing plans shall be certified by a Professional Engineer registered in the Commonwealth of Virginia and shall be in accordance with the VDOT Traffic Engineering Design Manual. The signing plans shall be prepared at a one (1) inch = fifty (50) feet scale when plotted full size at thirty-five (35) inches by twenty-three (23) inches. The signing plans shall show the proposed sign message, MUTCD or Virginia Supplement sign designation (if applicable), size and location of all signs. The structure type used for mounting sign shall be noted on the signing plans. These signing plans shall show the location and messages of all existing signs including any ITS devices that display messages to traffic, e.g. VMS, VSL, LUCS, and signal supports. All existing sign removals and relocations shall be shown on the signing plans. The signing plans also shall include the location and type of delineation devices (including pavement markings, and pavement messages/arrow).
18.3.1.4. Design of Sign Panels and Locations

A. Proposed and replaced sign panels shall be in accordance with the VDOT 2016 Road and Bridge Specifications and other references in these Technical Requirements. Overhead sign structures shall be located, designed, fabricated, and constructed in accordance with applicable standards and specifications. The Design-Builder shall coordinate all sign locations with all proposed and existing signing, landscaping, fencing, signals, utility, drainage, and all other roadside features to assure proper clearances and adequate sight distances. Sign sizes shall adhere to the latest edition of the FHWA Standard Highways Signs Book, the current edition of the MUTCD, the VA Supplement to the MUTCD, and all applicable Traffic Engineering Division Instructional & Informational Memoranda. All advance guide signs shall be mounted on overhead sign structures; Supplemental guide signs may be ground mounted. New/relocated guide signs shall not be bridge-parapet mounted. All sign structures shall be designed in accordance with Section [X.X].

B. The Design-Builder shall use standard VDOT sign structures for new and relocated VDOT owned signs. Ground-mounted VDOT sign structures on I-64 shall use Standard SSP-VIA, SSP-VA, or STP-1 structures, unless otherwise approved by the Department. For all non-standard signs, the Design-Builder shall use GUIDSIGN software to design the sign panels. The Design-Builder shall utilize the current edition of the MUTCD, 2011 Virginia Supplement to the 2009 MUTCD, the FHWA’s Standard Highway Signs including Pavement Markings and Standard Alphabets to design all non-standard signs that do not have a MUTCD or VDOT standard sign designation.

C. Any existing illuminated signs affected by the Project shall be evaluated as per Traffic Engineering Division Instructional & Informational Memorandum Overhead Sign Lighting (IIM-TE-380), resulting in a signed and sealed engineering study that assesses whether the replacement signs should be illuminated or unilluminated. The engineering study shall be approved by the District Traffic Engineer. For sign structures to be illuminated, luminaire retrieval systems shall be provided for all structures unless approved otherwise by the Department. All sign lighting luminaires shall be LED.

D. Signs shall not be attached to median barriers without approval of the Department. Signs attached to median barriers shall use the barrier-mount special design drawings to be provided by the Department.

E. Prior to obtaining the Department approval of final signing plans, the Design-Builder shall coordinate the permanent location of sign structures and all proposed, relocated, or modified with Integrated Directional Signing Program (IDSP) signs such as Supplemental Guide Signs (SGS), Specific Travel Services (Logo) Signs, General Motorist Services Signs (GMSS), Tourist Oriented Directional Signs (TODS), and all other signs approved and maintained as part of the IDSP. All impacts to IDSP signs shall be reviewed and approved by the IDSP Manager before relocation, fabrication, and installation. All proposed, relocated, or modified IDSP signs shall not be installed in sign assemblies with other non-IDSP signs unless approved otherwise by VDOT. IDSP signs shall be installed on either square tube posts as per Standard STP-1, or on steel I-beam post per Standards SSP-VA an SSP-VIA. The Design-Builder is responsible for costs associated with removal and replacement of IDSP signs.

F. Longitudinal BMP features such as bio-retention swales shall be clearly delineated by signs/markers for maintenance purposes at the beginning and end of the feature. The Design-Builder shall provide markers for other elements, including but not limited to underdrains and combination drains, in areas along I-64 which have existing markers.
18.3.1.5. HOT Lane Signage and Markings

A. As part of the Design-Builder’s signing plan, a detailed plan for the entrances at the beginning of the HOT lane, the intermediate entrance/exit points, end of access-restricted HOT lanes, and for the transition from HOT lane to General Purpose lanes in accordance with the most recent version of the MUTCD, the FHWA Priced Managed Lane Guide (Section 6.5). The design shall be incorporated into the proposed signing plan and ITS plan. The advanced signing sequence at each HOT lane entrance shall include two DMS signs visible to approaching traffic and each mounted on an overhead sign structure capable of displaying comparative travel times and Traveler Information Messages. All advanced signs shall be mounted on over-lane overhead sign structures, and shall note that the HOT lanes are accessible to HOV 2+ vehicles. The Design-Builder shall design the signs to be consistent with the Express Lane Signing for I-64 Segment [XXX]. The recommended signing is included in I-64 Segment [XXX] Toll Signs. The signing in Segment [XXX] is subject to change based on FHWA approval. The Design-Builder shall include regulatory signing in the design restricting truck access to the HOT lanes.

B. The Design-Builder shall mark the [XXX] lane of I-64 as a HOT Lane. The HOT lane shall begin [XXX] of the Hampton Roads Bridge Tunnel on I-64 Eastbound (From-To) and continue to the western limits of the project. The HOT lane shall begin at the western limits of the project and end approximately at the [XXX] of the new Hampton Roads Bridge Tunnel on I-64 Westbound (FROM-TO). The existing HOV lane shall be extended in the eastbound direction (FROM-TO) to mark the [XXX] lane as an HOV lane and continue (FROM-TO), and then transition to the beginning of the HOT lane. In the westbound direction (FROM-TO), at the point where the HOT lane ends, the left [XXX] lane shall transition to a managed lane with no vehicular restrictions and continue until the [XXX] lane matches into the existing HOV lane. A minimum of 0.50 miles must be provided to transition the HOV lane to the HOT lane (I-64 FROM-TO) and to transition the HOT lane to the managed lane (I-64 FROM-TO) to allow for traffic to enter/exit the restricted lane. The HOT lane shall begin/end at the [XXX] limits of the project no less than 1 mile and no more than 1.25 miles from the physical gores points of the ramps to and from [XXX]. The Design-Builder shall be responsible for installing/removing/modifyng all pavement markings and signing necessary in accordance with the design documents. The Design-Builder shall be aware that some of the pavement markings and signing to be installed/removed/modified may be beyond the physical limits of construction.

18.3.2. Pavement Marking

A. The Design-Builder shall include all required pavement markings, markers, and delineators. Pavement markings, markers, and delineators shall conform to the requirements of the MUTCD, the 2011 Virginia Supplement to the 2009 MUTCD, and applicable special provisions (included in the RFP Information Package). All pavement marking plans shall be in accordance with VDOT Traffic Engineering Design Manual.

B. The Design-Builder shall install retroreflective surface mounted tubular markers on 8’ centers within the 4’ buffer separating the HOT lane, HOV lane and managed lane from the general-purpose lane in both directions of I-64. Tubular markers shall be placed between the HOV lane and the general-purpose lanes on I-64 to restrict traffic from entering the HOV lane from the [XXX] entrance ramp. Tubular markers shall be as per Section 702 of the Specifications.

C. All new lane markings, edge lines, and center lines on I-64 and ramps shall be Type B, Class VI, except that Type B, Class II markings shall be used inside the tunnels. Type B, Class II markings shall be used on non-limited access roads. Contrast Type B, Class VI tape shall be
used for all I-64 lane lines for the I-64 EB and WB HRBT approach structures, and the EB and WB structures over River Street/Pembroke Ave/ Hampton River, Willoughby Bay, and Bay Avenue/Oastes Creek. All HOV diamond symbols on concrete pavement or concrete bridge decks shall have contrast black outline as per Standard Drawing PM-10.

D. All permanent snow-plowable raised pavement markers (SRPMs) shall be installed in accordance with VDOT Standard PM-8. Permanent SRPMs shall be omitted inside tunnels. Permanent SRPMs shall be provided on bridge decks except where directed otherwise. Damaged existing snow-plowable raised pavement markers within the Project limits shall be replaced in accordance with VDOT Standard PM-8.

E. On the existing I-64 Hampton Roads Bridge Tunnel, the Design-Builder shall be responsible for modifying the pavement markings to accommodate two general purpose lanes and two HOT lanes in each direction. The Design-Builder may elect to leave the existing barrier in place on the bridge in lieu of using surface mounted tubular markers. If the Design-Builder does elect to leave the current barrier in place, the Design-Builder shall be responsible for protecting any blunt ends of the barrier.

18.3.3. Signals

A. The traffic signal plans for new or modified permanent signals shall be reviewed and approved by the Department and the Cities of Hampton and Norfolk, and be compatible with the adjacent signal system. All traffic signals shall be designed in accordance with the MUTCD and the Virginia Supplement to the 2009 MUTCD.

B. The Design-Builder shall design, construct, program, and adjust controller timings for the new signalized intersections for coordinated operations matching the maintaining agency’s existing coordination plans. The Design-Builder shall provide timing for existing or new signal coordination plans in the same format as the maintaining agency. Additionally, the Design-Builder shall develop signal timings for modified signals and corridors while also developing signal timings for new signals. The signal timing parameters, including but not limited to vehicle and pedestrian clearance intervals, shall be calculated based on Department’s standards, and in accordance with the VDOT TOSAM.

C. The Design-Builder shall purchase and install the traffic signal controller cabinets and controllers. For partial impacts to existing signals where the existing cabinet is not impacted by construction, the existing controller and cabinet can remain. However, if the project will impact the existing cabinet, then the Design-Builder shall furnish and install new controller and cabinet that meets locality specifications.

D. The Design-Builder shall incorporate signal poles with luminaires, if requested by local municipalities, into the design and construction of the traffic signal unless approved otherwise by the Department and the local jurisdiction.

E. The Design-Builder shall configure any traffic signal detection equipment to provide continuous traffic counts at the intersection according to maintaining agency requirements.

F. For any existing signals that are impacted by the project, pedestrian accommodations (countdown pedestrian signal heads, marked crosswalks, and pushbuttons) shall be include for all crossings which have pedestrian access routes on both ends of the crossing, unless approved otherwise by the District Traffic Engineer. Pushbuttons shall be Accessible Pedestrian Signals unless required otherwise by Hampton or Norfolk. Accessible Pedestrian Signals shall be as per VDOT’s Special Provision.
G. Any newly constructed traffic signals must be inspected by the Department and/or maintaining agency designated signal technician and satisfy all punch-list items before they are turned over to the Department, or local jurisdiction, for maintenance and operations.

H. The Design-Builder shall install and be responsible for all aspects of temporary and permanent traffic signal installation to include but not be limited to design, obtaining permits, construction, modifications, rehabilitation of disturbed areas, and acquiring timely installation of power and communication connections.

I. The Design-Builder shall install and connect power service for temporary and permanent traffic signals for the Project.

J. Conductor/communication cables shall be placed in buried conduit, embedded conduit, and structure and bridge-mounted conduit. Aerial or direct buried cable installation shall not be allowed.

K. The Design-Builder shall not cut any open trenches in pavement for the installation of conduit.

L. Any Work that requires partial or full reconstruction of any existing signals that include Emergency Vehicle Preemption (EVP), shall be maintained during construction and EVP shall be included in the new signal as per maintaining agency requirements.

M. Traffic signals shall have High Visibility Backplates where recommended or required by VDOT IIM-TE-378, unless requested otherwise by the maintaining locality.

18.3.4. Guardrail / Barrier

A. The Design-Builder shall be responsible for furnishing and installing new guardrail where necessary in accordance with VDOT’s Guardrail Warrants as shown in Appendix J of the VDOT Road Design Manual.

B. The Design-Builder shall be responsible for MC-4 asphalt paving under new or replaced guardrail per Appendix J of the VDOT Road Design Manual.

C. The Design-Builder shall ensure that the clear zone within the Project limits is free from hazards and fixed objects. If removal or relocation of hazard and fixed objects from the clear zone is not feasible, the Design-Builder shall design and install a Department approved guardrail barrier system and end treatments, where appropriate, for protection in accordance with AASHTO Manual for Assessing Safety Hardware (MASH). The same clear zone requirement applies to existing conditions affected by this Project where guardrail upgrade will be required. Existing sub-standard guardrail within the Project Limits must be upgraded by the Design-Builder to meet current standards per Appendix J in the Road Design Manual (RDM) and as per the VDOT Road & Bridge Standards. This may require the upgrade of guardrail to the nearest logical termination point beyond the current Project limits.

D. The guardrail plans shall be a part of the roadway plans and shall be signed and sealed by a Professional Engineer. The guardrail plans shall be prepared at a one (1) inch = fifty (50) feet scale when plotted full size at thirty-five (35) inches by twenty-three (23) inches. The guardrail plans shall show the location, type (including terminals and fixed object attachments) and disposition (removal, reset, left in place, etc.) for each existing guardrail run. The guardrail plans shall show a begin station, end station, offset from face of rail to edge of travel way, and type of barrier (including terminals and fixed object attachments) for each proposed guardrail run. Length of need calculations shall be submitted for each guardrail run protecting
a fixed and hazardous object. Cross sections shall be submitted for each guardrail run protecting an embankment slope. Additionally, the Design-Builder shall provide a copy of the manufacturer’s recommendations for installation of all guardrail terminals to the Department Project Manager before the installation of any guardrail end treatment or terminating device.

E. Attachment 2.9.2-1 provides the existing guardrail schedules for I-64 and is included as a Reference Document.

F. While this section of I-64 is a designated hurricane evacuation route that is intended to utilize contraflow operations in an emergency, proposed guardrail, barrier and terminal design shall be performed for normal traffic operations. Designs for potential contraflow operations for hurricane evacuation are not required.

18.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 18.4-1 for the Department’s consultation and written comment.

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<tr>
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<th>Delivery Schedule</th>
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<td>Pavement Marking Plan</td>
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SECTION 19. ITS AND TOLL SYSTEMS

19.1. Scope

A. The Project shall include an Intelligent Transportation System (ITS) as described in this section. The purpose of the ITS is to improve traveler safety, improve traffic efficiency by minimizing congestion, mitigate the impact of incidents, and minimize traffic-related environmental impacts.

B. Provide an ITS in accordance with the architecture and standards of the Department. The elements of the ITS will include vehicle detection for traffic management, roadway weather information systems (RWISs) to report bridge conditions, closed-circuit television (CCTVs) cameras for incident detection, verification and monitoring, dynamic message signs (DMS), lane use signals (LUS), traffic control signals, over height (OH) detection system, variable speed limit signs (VSS), flashing beacons, and roadway gates.

C. The ITS shall also include all fiber-optic, leased telephone, and wireless communications; electrical power; and supporting infrastructure to provide a complete, fully operational ITS that is ready to be integrated, monitored, and controlled by the HRBT Tunnel Primary and Secondary Control Rooms.

D. The tunnel operations and control system shall consist of new systems that are integrated into the existing systems. This Section provides the ITS requirements for the following areas:
   1. New Tunnel Roadway;
   2. New Shore and Trestle Roadways;
   3. Ventilation Buildings;
   4. Existing Control Rooms.

19.2. References

A. Virginia Uniform Statewide Building Code (USBC)
B. National Fire Protection Act (NFPA) Standards and Guidelines including:
   1. NFPA 70 – National Electric Code (NEC)
   2. NFPA 502, Standard for Road Tunnels, Bridge and Other Limited Access Highways
C. ANSI/TIA/EIA 607 – Grounding and Bonding Requirements for Telecommunications in Commercial Buildings;
D. ANSI/TIA/EIA 569 – Commercial Building Standards for Telecommunication Pathways and Spaces;
E. ANSI/TIA/EIA 568 – Commercial Building Standard Telecommunication and Cabling Standard;
F. ANSI/TIA/EIA 758 – Customer Owned Outside Plant Telecommunications Cabling Standard;
G. IEC 61131 – Standard for Programmable Controllers; and
H. ISA/IEC 62443 – Standards on the Cyber Security of Industrial Controls
I. ANSI/TIA/EIA 455 – Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components;
J. ANSI/TIA/EIA 604 – Optical Fiber Cabling Color Coding;
K. NEMA IA 2.1-8 – Programmable Controllers;
L. NEMA ICS 5 – Control Circuits and Pilot Devices;
M. NEMA ICS 6 – Industrial Control and System Enclosures;
N. TSB 140 – Additional Guidelines for Field Test Length, Loss and Polarity of Optical Fiber;  
O. FHWA Tunnel Operations, Maintenance, Inspection, Evaluations (TOMIE) Manual;  
P. FHWA National Tunnel Inspection Standards (NTIS); and  
Q. FHWA Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)  
R. Virginia Supplement to the 2009 Manual on Uniform Traffic Control Devices for Streets and Highways  
S. National Transportation Communications for Intelligent Transportation System Protocol (NTCIP)  
T. National Electrical Contractors Association (NECA) Standard or Installation  
U. Federal Communications Commission Code of Federal Regulations (CFR) Title 47

19.3. Requirements

19.3.1. General

A. The diverse existing control systems are managed from various control locations. The new and existing HRBT tunnels will use a common Human Machine Interface (HMI), servers and workstations. The HMI graphics, maps, panels, and other features shall be separated by tunnel facility, but both tunnels will operate from the same set of HMI systems. All work involving the operating ITS HMI software shall be coordinated with the Department and scheduled to provide a seamless transition and to avoid any disruption of HRBT operations.

B. The ITS monitoring and control functions shall be performed through new and existing operator workstation located in the new primary control room and secondary control room. The operator workstations shall contain all the screens, reports, data stores and processes allowing the control room operators to perform the required monitoring, control and reporting functions, and include the following functionalities:
   1. ITS incident, event notification, acknowledgement, tracking and logging;
   2. ITS device control and monitoring;
   3. Control room operator actions tracking and logging; and

C. The existing ITS system operator workstation interface shall be modified to utilize the new HMI software to accommodate the existing and new ITS subsystems monitoring, control and reporting functions.

D. The ITS system shall contain all hardware and software necessary to perform all monitoring and control functions required to support the operation of all the connected subsystems.

E. The ITS system shall provide “monitor and control” functionality for the following new and existing subsystems:
   1. CCTV Cameras (secondary, primary through CCTV system);
   2. LUSs;
   3. Traffic Control Signals;
   4. DMSs;
   5. Variable Speed Limit Signs;
   6. Over-height Detection Systems;
   7. Dangerous Switches;
8. Vehicle Detection;
9. Roadway Weather Information System;
10. Traffic Control Gates;
11. Flashing Beacons; and
12. Dedicated Short Range Communications (DSRC).

F. The ITS system shall provide “monitor” functionality for the following subsystems:
   1. Primary and Secondary Control Rooms.

G. The ITS system shall provide:
   1. Efficient movement of traffic on and around the Project;
   2. Early detection of traffic incidents that cause slowdowns and/or blockages using video surveillance;
   3. Motorist alerts, through its software and the action of the Operator, to incidents and communicates through the direct interface of Traffic Control Signals, Lane Use Signs (LUS), Mass Notification System and DMSs;
   4. Systematic lane control for closing or shifting traffic through the tunnel by means of DMS, LUS, and gates;
   5. Visual traffic monitoring using CCTV cameras and monitors; and
   6. Continuous monitoring and logging of traffic conditions within the tunnel through the CCTV cameras; and automatic re-direction of CCTV cameras to an Intrusion alarm.

19.3.2. Primary and Secondary Control Rooms and Server Rooms

A. The Primary Control Room (PCR) shall be the new Primary Control Room located in a new Traffic Operations Building on the north island.

B. The Secondary Control Room (SCR) shall be coordinated with the Department for location during the Concept Design.

C. The existing ITS System server configuration supports a primary server and a secondary server, both of which are located in the PCR. The primary server shall remain in the PCR and the secondary server relocated to the SCR. If additional servers are needed, they shall be distributed in a similar fashion.

19.3.3. ITS System Hardware and Software

A. The new ITS hardware shall consist of the following:

   1. Hot Standby Programmable Logic Controllers (PLC) - The Hot Standby PLC system shall consist of two (2) PLCs, PLC 0 (Primary) and PLC 1 (Backup), as well as power supplies, communication cards and other components for a fully operational system. Each Hot Standby PLC shall also be capable of exchanging information with the existing facility wide ITS System. In the event of a failure in the Primary PLC, there shall be a seamless transfer of control and monitoring capabilities to the Backup PLC. The Hot Standby PLC system shall be used as a data concentrator, collecting information from all associated devices and receiving commands from the ITS HMI;
2. Remote IO racks – All field devices shall be connected to a remote IO rack. Rack location shall be near the device locations;

3. Remote IO racks shall have the necessary communication modules and power supplies to provide the operator with the full functionality of the tunnel systems;

4. All new equipment shall have identical properties and characteristics to match the existing ITS functionality; and

5. The PLC software shall be a Commercial Off-the-Shelf (COTS) package. This program creation and editing software shall allow the functional program to be edited both "online" and "offline."

B. The Hot Standby PLC shall communicate with the HMI software.

C. Provide an ITS operating HMI software for the entire new and existing HRBT facility. The ITS HMI software shall preserve all its functionality. The ITS HMI software shall be fully tested and debugged to HRBT’s satisfaction. All ITS HMI software work shall be coordinated with the Department and so scheduled to provide a seamless transition between the new and existing ITS operations to minimize the disruption of existing operations.

19.3.4. Workstation Computer & Server Hardware

A. The ITS servers shall be managed as described below:

1. All tunnel systems information shall be managed by Hot Standby PLCs that communicate with the existing ITS servers. If the new ITS system requirements exceed that of the existing ITS servers, those servers may be required to be modified, upgraded and/or replaced. All features in the existing servers shall be maintained in any modified, upgraded, and/or replaced servers. In this event the servers shall reside in their existing locations; and

2. Any additional servers required to provide functional system shall be located in the new Primary Control Room and Secondary Control Room. These servers shall have the latest Microsoft Windows Server Operating System approved by the Department. The operating systems between the new and existing server shall be identical.

B. The following are the minimum hardware requirements for the ITS servers:

1. Servers shall run the main system software, provide a location for a central system database, and run the associated configuration software;

2. Servers shall be 19” rack mounted chassis with front control panel;

3. Processor - Eight-Core @ 2.1Ghz with 20MB Cache;

4. Memory - 16GB or better;

5. Hard Drives - (2) 1TB Hard drive in Raid 0 Configuration;

6. Controllers - Raid 0 Controller;

7. Operating System - Latest Windows Server Operating System as approved by the Department;

8. Video - (2) 4GB with support for Dual Monitors;
9. Network Interface Cards - (2) Dual Port 1GB Network Card;
10. Slots - PCIe/PCI;
11. Front Ports - Minimum of 2 USB, VGA;
12. Rear Ports - Minimum of 2 USB, VGA, Serial, RJ45, Microphone, Headphone;
13. Audio - Integrated Sound Card;
14. Additional Drives - 16x DVD+/-RW Drive; and

C. Dedicated server will be provided for each of the following:
   1. Alarming;
   2. Reporting;
   3. Domain Management;
   4. Virtual Machine Server; and
   5. The above servers will at a minimum meet the requirements of the ITS server.

D. The existing ITS servers and workstations will be replaced with new ITS servers and
   workstations. The new ITS servers and workstations will allow the operators to manage the
   existing and new tunnels systems associated with the ITS system.

E. The ITS servers shall be redundant servers. The redundant servers will consist of a Primary and
   Backup server. In the event of a failure of the primary server transition to the backup server will
   be seamless without any disruption to the operations.

F. The following are the minimum requirement for Desktop Workstations:
   1. Processor - Quad-Core @ 3.7Ghz with 10MB Cache;
   2. Memory - 16 GB or better;
   3. Hard Drives - 500GB or better;
   4. Operating System - Latest Windows Operating System as approved by the Department;
   5. Tower Console with Dual 23" Monitors Desktop Mounted;
   6. Video Cards - 4GB with support for Dual Monitors;
   7. Network Interface Cards - Dual Port 1GB Network Card;
   8. Slots - PCIe/PCI;
  10. Rear Ports - Minimum of 4 USB, PS2, Serial, RJ45;
  11. Audio - Integrated Sound Card; and
  12. Additional Drives and Servers - 16x DVD+/-RW Drive.
G. The workstation computers shall have the latest Microsoft Windows® Operating System and shall contain the current state-of-the hardware that are coordinated with and approved by the Department. All software to be installed on the workstations shall be compatible with the operating system. The workstations shall have comprehensive functions for operator control and monitoring.

1. Provide sufficient sit-stand workstations, at both the PCR and SCR, for operators and supervisors to perform their tasks overseeing the ITS at both the existing and new tunnel facilities.

2. Provide ITS workstation computers with 23-inch flat screen monitors mounted with similar hardware and functionality in both the PCR and SCR. The screens shall support a resolution of 1080p or higher. Additionally, the screen aspect ratio shall be maintained across all monitors and shall be capable of functioning with the ITS HMI software.

3. The workstation computers shall support a Client/Server configuration.

19.3.5. Replacement of the ITS HMI Softwares

A. If the replacement of the existing ITS HMI software is necessary, it shall be replaced with new HMI software for each of the respective independent subsystems to incorporate all the respective new and existing ITS equipment, and traffic control system functions throughout the entire HRBT facility.

B. The HMI software requirements shall be defined and developed in coordination with the Department and the traffic control system requirements.

C. The compatibility of the new ITS HMI software (if necessary) with the respective complete (new and existing) ITS subsystems equipment shall be tested, verified, debugged and accepted by the Department prior to replacing the existing HMI software.

D. The ITS HMI software shall be provided by one of the following manufacturers:
   1. Siemens – WinCC OA;
   2. Schneider Electric – Wonderware;
   3. GE – Cimplicity;
   4. Rockwell Automation – FactoryTalk;
   5. Or Approved Equivalent.

E. The HMI software manufacturer shall have a field service department with experienced representatives in the U.S. with the capability to provide telephone consultation and prompt on-site service. On-site Emergency Service shall be available within 24 hours of notification.

19.3.6. FHWA Rule 940 Compliance

A. The Design-Builder shall follow the System Engineering Process as defined by Federal Highway Administration (FHWA) 23CFR, Part 940, commonly referred to as Rule 940. The Design-Builder shall go through and comply with the entire process including, but not limited to:

   1. Providing all documentation, such as an updated regional architecture, Concept of Operations, Requirements Documents, etc., required under Rule 940;
2. Developing Test plans and procedures; and
3. Verifying all Test plans and procedures.

B. System Architecture

1. The following systems all interact together to control and monitor tunnel traffic and incidents and MUST be included with and part of the Intelligent Transportation System documentation requirements of Rule 940:
   a. SCADA System EPCS and ITS;
   b. Ventilation;
   c. Pumping;
   d. Electrical;
   e. Lighting;
   f. Fire Protection;
   g. Fire Alarm, Detection and Control System;
   h. Communication Systems;
   i. Traffic Control Signals;
   j. Cameras;
   k. Message Signs;
   l. Gates; and
   m. Air Quality.

The Design-Builder shall coordinate with stakeholders to review and verify the existing regional architecture. The existing Regional Architecture associated with the Department can be found on the website: [http://local.iteris.com/virginiaitsarchitecture/architectures/central/html/stakeholders/sh97.html](http://local.iteris.com/virginiaitsarchitecture/architectures/central/html/stakeholders/sh97.html)

The Design-Builder must review and verify that the Virginia Eastern Region's ITS Architecture includes all the systems that shall be part of the HRBT. If anything is missing, then it must be added by the Design-Builder to update the document. A procedure for updating the architecture is provided on the website: [http://local.iteris.com/virginiaitsarchitecture/architectures/central/docs/CRArchMaintenancePlanV2.0(2014-05-31).pdf](http://local.iteris.com/virginiaitsarchitecture/architectures/central/docs/CRArchMaintenancePlanV2.0(2014-05-31).pdf)

All new market packages must be identified and defined. All new equipment, systems, functionality and data flows shall be included in the updated regional architecture. Also, how the new systems shall interface and function with all the HRBT existing systems and components shall be addressed. The Design-Builder shall use the latest version of “Turbo Architecture” to update the regional architecture.

C. Concept of Operation

1. Provide a detailed concept of operations document that complies with requirements of Rule 940, and IEEE 1362 or the current Standard that replaces IEEE 1362. The concept of operations shall describe in general all systems components associated with the new tunnel and how those systems shall interface and function with all the Department’s existing systems and components.
2. The concept of operations document shall be submitted to the Department for review and approval prior to advancing the Concept Design.

D. System Engineering Analysis

1. Provide a detailed system engineering analysis document that complies with requirements of Rule 940 and describe in detail with specific information all systems and components associated with the new tunnel and how those systems shall interface and function with all the Department existing systems and components.

2. The system engineering analysis document shall be submitted to the Department for review and approval prior to advancing the Concept Design.

E. System and Component Traceability Matrix

1. Provide a detailed system and component traceability matrix document that complies with requirements of Rule 940. The traceability matrix shall identify all the systems and components associated with the new tunnel, how those systems and components operation and function shall be tested, and how the tests results are documented.

2. The traceability matrix document shall be submitted to and accepted by the Department prior to the testing and/or commissioning of system and component covered under or with the traceability matrix.

19.3.7. Graphics

A. Develop and implement the graphic views as applicable. Each view shall show current, real-time conditions of the system. The ITS System HMI/GUI graphic screens shall include the following, as a minimum:

1. Tunnel and Facilities menu screens with system login passwords for the various operator access levels system;

2. Tunnel and Facilities Graphic Overview screens;
   a. Tunnel and Facilities ITS System screens;

B. Coordinate with the Department for the specific criteria for each screen to be created.

C. Coordinate with the Department on the look, configuration and operator interaction requirements of all graphic screens for all workstations.

19.3.8. Communications Network System

A. In accordance with the current state architectures, design, furnish and construct communications conduits and a backbone fiber-optic communications network for the ITS. The fiber-optic network shall support the data and video communications requirements of all ITS assets, installed and existing, in the HRBT facility. Design and construct the system with redundant routing capabilities. Redundant routing shall be such that all field devices are provided a minimum of two separate and unique physical and logical network paths and that a break, failure or other interruption occurring at any point of one of those paths at any time shall not cause a loss of communication between the field device and the traffic control system. The system shall automatically discover the most efficient path of transmission and route communications through that path.

B. The existing ITS Communications Network System provides a communication path to manage the various operations systems at the Hampton Roads Bridge and Tunnel. The
existing ITS communications network system consists of a single-mode fiber backbone loop that provides a layer 2 rapid spanning tree protocol (RSTP). The new ITS communications fiber network shall be integrated into the existing ITS fiber network to form a dual physically redundant network.

C. Connectivity into the existing network shall allow for all the tunnels systems to be managed from any control location.

19.3.9. Infrastructure

A. Provide the infrastructure cabling and raceway to support the ITS Systems requirements, equipment, functions and operations. All cabling and raceway shall be installed according to all pertinent NFPA and state standards for its application and location.

B. All ITS equipment shall be housed in enclosures, cabinets and racks according to all pertinent NEMA and UL standards for their respective use and location.

19.3.10. Intelligent Transportation Systems

A. Closed Circuit Television (CCTV)

1. The Closed-Circuit Television System shall provide 100% coverage of the facility roadway, tunnel and tunnel approach areas to monitor traffic and provide visual confirmation of all LUS, DMS, VSS and other roadway signage that shall be coordinated with the Department during development of the design.

2. The CCTV system shall be integrated into the existing Video Management System (VMS). CCTV Camera specifications shall be compatible with the VMS.

3. Roadway CCTV Cameras shall be Pan Tilt Zoom (PTZ) IP camera and shall be in IP66 weatherproof pressurized enclosures designed to mount on camera poles/towers or sign gantry structures to provide continuous coverage of desired areas.
   a. Roadway CCTV Camera locations shall be coordinated with the Department during development of the design.
   b. CCTV Camera Pole and Towers shall be designed in compliance with the Department standards on pole sizes, foundations, concrete paving and lightning protection, and shall have concrete work pad for maintenance.
   c. All pole mounted CCTV cameras shall use a camera lowering system in compliance with the Department standards for ease of future maintenance.
   d. Roadway CCTV Camera communication, control, and power equipment shall be housed in field cabinets and enclosures.

4. Tunnel CCTV Cameras shall be fixed IP cameras and shall be in IP66 weatherproof pressurized enclosures designed to mount to tunnel structures or sign gantry structures to provide complete tunnel coverage.
   a. The minimum and maximum spacing between camera locations shall be coordinated with the Department during development of the design;
   b. Cameras shall provide one hundred (100) percent viewing of the entire Tunnel roadway from side wall to side wall;
c. Camera pendant mounting shall be diagonally braced to prevent any camera vibration or movement due to wind, vehicle traffic or jet fan operation.

d. Tunnel CCTV Camera communication, control, and power equipment shall be housed in tunnel niche or passage way/utility room cabinets and enclosures.

5. The Tunnel shall also have Pan Tilt Zoom (PTZ) IP Cameras, which shall be in IP66 weatherproof pressurized enclosures designed to mount to tunnel structure or sign gantry structures. These cameras shall provide the best view of and PTZ functionality to identifying of the specific incident and alarm event locations within the Tunnel.

a. For any Tunnel alarm or incident condition, the Tunnel PTZ camera with the best view of the alarm initiating device shall be manually used to focus on and zoom into the location of the corresponding alarm initiating device or incident location within the Tunnel.

b. Camera pendant mounting shall be diagonally braced to prevent any camera vibration or movement due to wind, vehicle traffic or jet fan operation.

c. Tunnel CCTV PTZ Camera communication, control, and power equipment shall be housed in tunnel niche or passage way/utility room cabinets and enclosures.

B. Lane Use Signs (LUS)

1. Tunnel lane use signals (LUS) shall be light emitting diode (LED) based, two-sided combination, three-element (Red-Yellow-Green) traffic signal heads used to inform drivers of downstream lane use conditions in accordance with MUTCD guidelines. The Tunnel LUS shall be mounted to the top-side tunnel wall adjacent to each traffic travel lane. Each signal head shall be controllable to display different or the same indication on either side.

a. Tunnel LUS control and power equipment shall be housed in field cabinets and enclosures.

2. Roadway lane use signals (LUS) shall be a light emitting diode (LED), two-sided combination display signals based on arrays of red and green LEDs on a black background, and shall be capable of displaying an 18-inch by 18-inch GREEN Downward Arrow, AMBER X, and RED X. The Roadway LUS shall operate to inform drivers of downstream lane control conditions in accordance with MUTCD guidelines.

3. The Roadway LUS shall be mounted above each lane to display lane control states to drivers. The states shall be OFF (Blank), GREEN Downward Arrow, AMBER X, and RED X. The roadway LUS shall be dimmable to suit the full range of ambient lighting conditions.

4. The full graphical display of the LUS shall be positioned in the line-of-sight of the roadway segment so it is clearly visible and legible from in-vehicle view under clear daylight and night-time conditions.

5. The LUS shall be subject to manual intervention or override by an operator if the LUS fails to respond to the remote communications commands. The manual control, when activated, will override any automatic control commands. LUSs shall also send current statuses to the traffic control system when polled.

6. Roadway LUS shall be mounted on a gantry structures and located central to each traffic travel lane. Each LUS face shall be controllable to display different or the same indication on either face.

a. Roadway LUS control and power equipment shall be housed in field cabinets and enclosures.
7. Control of the LUS shall be initiated by the traffic control system, via PLCs directly to HMI servers.

8. The LUS shall be fully interlocked to prevent conflicting indications. Faulty signs or control functions shall cause the affected signs to show a blank face.

9. The LUS design and operation shall comply with all pertinent state guidelines, MUTCD, NEC, and NEMA standards. The LUS shall be NTCIP compliant.

C. Traffic Control Signals

1. Roadway Traffic Control Signals shall be a one-sided, three-element (Red-Yellow-Green) traffic signal head, mounted on a gantry above the travel lanes, and shall be operated by the traffic control system to close the travel lane and stop vehicles from proceeding in the direction of travel in the event of an emergency.

2. Tunnel Portal Traffic Control Signals shall be operated by traffic control system, tunnel portal surface mounted at the entrance to each tunnel and at the exit from each tunnel, to close the tunnel and stop vehicles from entering the tunnel in the current direction of travel in the event of an emergency.

3. Control of the traffic control signals shall be initiated by the traffic control system, via PLCs directly to HMI servers.

4. The Traffic Control Signal design and operation shall comply with all pertinent state guidelines and MUTCD standards.

D. Dynamic Message Signs (DMS)

1. Dynamic Message Signs shall be permanent electronic signs used to display traveler information and advisory messages. Light Emitting Diode (LED) technology overhead, full-matrix signs. Each sign will meet NTCIP standards and will be capable of displaying monochrome (amber) alpha numeric static messages, multi-frame messages, and flashing messages. The DMS will be able to be operated locally and remotely. CCTV cameras will be located and setup to verify messages that have been placed remotely.

2. The DMSs will be controlled by the traffic control system, with a fixed message library and custom message capability, and with the message states initiated by either the traffic control system (ITS HMI) software, the DMS System software or by the remote-control unit (RCU) at the sign location housed in an adjacent field cabinet/enclosure. The DMS System Software shall manage its virtual configuration, troubleshooting and maintenance.

3. The DMSs will be integrated over the ITS network to the respective traffic control system directly or indirectly via PLCs to backend PCR/SCR servers.

4. The Roadway DMSs shall be front access full-matrix signs capable of displaying three (3) lines of up to 21 characters each.
   a. The DMSs shall be mounted on new or existing structures at locations as determined with coordination with the Department.

5. The Tunnel DMSs shall be front access full-matrix signs capable of displaying a single line of up to 21 characters.
   a. The DMSs shall be mounted to the ceiling in the new tunnel at locations as determined with coordination with the Department.
   b. The adjacent tunnel ceiling surface shall be painted black to eliminate the DMS display reflections on tunnel ceiling surfaces.
6. The DMS design and operation shall comply with all pertinent state guidelines, MUTCD, NEC, NEMA and NTCIP standards.

E. Variable Speed Limit Signs (VSLS)
   1. VSLSs shall be a combination of a static and electronic (two-sided) sign used to manage and control traffic on the shore and bridge roadways by altering the posted travel speed in an area or zone.
   2. The VSLSs shall be controlled at the PCR and SCR with power and control facilitated either by the traffic control system (ITS HMI) software or by the VSLS remote control unit (RCU) housed in an adjacent field cabinet/enclosure. The RCU communicates directly or indirectly via PLCs to backend PCR/SCR servers.
   3. The VSLSs shall utilize an active programmable/changeable LED speed limit pixel matrix and surrounding reflective 48-inch wide by 60-inch high MUTCD complaint static panel.
   4. The VSLS LED pixel matrix shall be highly legible and capable of two (2) 18-inch black digits on a white background. The LED pixel matrix shall be legible from greater than 1,000-ft, with a 30-degree LED viewing angle.
   5. The VSLS shall use a blend of long-life red, green, and blue LEDs to create the white light used for the pixel matrix background. The VSLS shall use an integrated light sensor to automatically adjust the LED intensity for all ambient lighting levels.
   6. In full sunlight, the VSLS LEDs pixel matrix shall match the reflectivity of the surrounding speed limit panel. At night, the LEDs pixel matrix shall dim to a very legible level that shall not blind drivers and shall not be washed out by headlights.
   7. The VSLS design and operation shall comply with all pertinent state guidelines, MUTCD, NEC, NEMA and NTCIP standards.

F. Over-height Vehicle Detection System
   1. The over-height vehicle detection system shall be furnished, installed and deployed to warn facility operators of vehicles that exceed the set maximum height for existing and new upcoming infrastructure;
   2. The system shall consist of dual-beam, visible red/infrared, direction discerning transmitter and receiver sensors mounted as coordinated with the Department on existing and new gantry structures locations;
   3. The sensors shall be mounted at a range of 200ft apart for optimal performance and have a reaction speed of 1 to 75 miles per hour for a 2.5-inch diameter object 1-inch above the beam plane;
   4. The sensors shall be configured such that the plane of both beams must be broken before an over-height event alarm is initiated;
   5. The system shall be coordinated with the Department for operation and integration into the existing and new traffic control system and its components and utilities including but not limited to warning signs, flashing beacons, alarm and notification systems, and inspection stations.

G. Vehicle Detection
   1. The vehicle detection shall feature a wireless vehicle detection system that uses wireless magneto-resistive sensors to detect the presence and movement of vehicles;
2. The vehicle detector sensors shall be installed in the surface or in small holes cored in the roadway, and shall transmit detection data in real-time via low-power radio technology to a nearby access point, and relayed to a traffic signal controller and the traffic control system;

3. The new vehicle detection system shall be integrated into the existing vehicle detection system to make one fully functional system.

H. Roadway Weather Information System (RWIS)

1. The RWIS shall be remote sensing locations, which make up an information system that gathers and transmits road-related weather information, and is integrated into the traffic control system (ITS HMI).

2. The RWIS shall feature equipment which provide both air and surface weather data, including the following:
   a. Atmospheric data: temperature, precipitation, visibility, humidity solar radiation, remote camera imaging and wind data; and
   b. Surface/subsurface data: pavement temperature, subsurface temperature, surface condition, amount of deicing chemical on roadway, and freezing point.

3. The RWIS shall include all hardware, software, and licenses to operate as follows:
   a. Passive in-pavement surface sensors shall measure bridge deck and roadway pavement surface temperature along with surface wetness and communicate the data to the Remote Processing Unit (RPU);
   b. Roadway atmospheric sensors will measure their respective weather parameters and communicate the data from each to the RPU;
   c. Atmospheric weather sensors will measure their respective weather parameters and communicate the data from each to the RPU;
   d. The RPU will acquire data from all connected sensors. The RPU will process and temporarily store the output from the pavement sensors and atmospheric sensors;
   e. The RWIS server will poll the RPU of each local RWIS system on a scheduled basis. The RPU will respond to the poll and transfer all its data to the RWIS server;
   f. All data transfers between the RWIS server and local RWIS will be compliant with the most current NTCIP protocols; and
   g. The RWIS user displays will include all sensor and forecast data in a Windows based Graphical User Interface or browser-based data display format.

4. The RWIS shall feature a Remote Processing Unit (RPU) panel enclosed in an adjacent traffic field cabinet, and shall be capable of gathering, processing, storing and transmitting data from all the RWIS connected and remote sensors to the traffic control system.

I. Flashing Beacons

1. The flashing beacons shall be an 8-inch Amber color LED single section traffic signal head that operates in flashing mode and provides traffic control warning status in the event of an intended stoppage of traffic and in conjunction with an accompanying static warning or advisory sign panels.

2. The flashing beacons shall be flashed at a rate of not less than 50 or more than 60 times per minute, with the illuminated period of each flash shall be a minimum of 1/2 and a maximum of 2/3 of the total cycle.
3. The flashing beacon design and operation shall comply with all pertinent state guidelines and MUTCD standards.

J. Dedicated Short Range Communications (DSRC)

1. The DSRC shall be consists of equipment used in vehicle-to-vehicle and vehicle-to-roadside communication. The DSRC systems shall consist of short-range, wireless links to transfer data between vehicles and roadside units; other vehicles, and portable units, as designed to support the ITS system.

19.3.11. Electronic Tolling Collection System (ETCS)

There is no Electronic Tolling Collection System (ETCS) included in the Work. The Department will be procuring the tolling equipment as a separate agreement. The Design-Builder shall cooperate with the Department and the ETCS vendor during the Project Duration to aid in the location and incorporation of the ETCS.

19.3.12. Wireless Communication Systems

A. Distributed Antenna Systems (DAS)

1. The DAS shall be a Radio Frequency (RF) distribution telecommunication system capable of coexisting and accommodating multiple service providers, utilizing common neutral infrastructure, using emerging technologies to optimize facility space.

2. The DAS shall provide consistent, gap-free coverage and real-time roaming capability throughout the HRBT facilities and anticipate the future growth of emerging technologies for the foreseeable future.

3. The DAS shall feature a Neutral-Host carrier colocation facility with related infrastructure within the tunnel facility. The facility shall be located shall be coordinated with the Department and shall independent of existing HRBT facility security control and access and from the Department systems and operations.

4. The DAS shall provide coverage for the Wireless Service Providers (WSP) and Public Safety Network (PSN) listed below on all frequencies currently being used by the designated WSPs and PSN in the given market.
   a. AT&T Wireless;
   b. Sprint/Nextel;
   c. T-Mobile;
   d. Verizon; and
   e. 800 MHz PSN Coverage

5. The DAS shall have expansion capabilities to support the following WSP and PSN frequencies deployed in a Single-Input, Single-Output/Multiple-Input, Multiple-Output (SISO/MIMO) antenna environment. The system design shall be expandable for a future 4G to 5G upgrade. Any additional Components required for system expansion shall comply with all specifications of this Section.
### Technical Requirements

**Part 2, Section 19**

**May 21, 2018**

**ITS and Toll Systems**

<table>
<thead>
<tr>
<th>Service</th>
<th>Uplink, MHz</th>
<th>Downlink, MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular</td>
<td>824 - 849</td>
<td>869 - 894</td>
</tr>
<tr>
<td>PCS</td>
<td>1850 - 1915</td>
<td>1930 - 1995</td>
</tr>
<tr>
<td>AWS</td>
<td>1710 - 1755</td>
<td>2110 - 2155</td>
</tr>
<tr>
<td>Commercial 700 Band</td>
<td>698 – 716, 776-787</td>
<td>728 - 746</td>
</tr>
<tr>
<td>Narrow Band Public Safety 700 Band</td>
<td>799 - 805</td>
<td>769 - 775</td>
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<tr>
<td>800 Band</td>
<td>806 - 824</td>
<td>851 - 869</td>
</tr>
<tr>
<td>900 Band</td>
<td>896 - 902</td>
<td>935 - 941</td>
</tr>
<tr>
<td>BRS/EBS</td>
<td>2496-2690</td>
<td></td>
</tr>
</tbody>
</table>

6. On a per channel bases, the downlink Receiver’s Signal Level (RSL) for each frequency band shall meet or exceed the criteria in the Table below. The DAS shall deliver coverage per the criteria in the table below throughout 95% of the tunnel and its surrounding buildings and areas, including but not limited to all stairwells, elevators, basements and garages.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Unit</th>
<th>Lower 700 MHz, BRS/EBS</th>
<th>Cellular, PCS, AWS, Commercial 800/900 MHz</th>
<th>Public Safety 380-512, 700, 800 MHz</th>
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<tbody>
<tr>
<td>Minimum downlink receives signal level (RSL)</td>
<td>dBm</td>
<td>-75</td>
<td>-85</td>
<td>-95</td>
</tr>
</tbody>
</table>

7. The DAS shall be capable of receiving WSP approval for interconnection to the WSPs’ macro networks and receiving approval of the PSN authority having jurisdiction (AHJ).

8. The DAS shall be capable of upgrade, without additional hardware or software, to allow for changes to system frequencies within the deployed frequency band to maintain radio system coverage as originally designed.

9. All work done to furnish, install, integrate and test the DAS shall comply with the latest editions of the NFPA, NEC, NECA, and all applicable local rules and regulations for the nature of the work.


### B. Two-Way Radio System (VHF/UHF)

1. The Two-Way Radio system shall feature a communications system with frequencies and channels for police department, fire rescue, local emergency services, highway patrol unit,
maintenance unit, and the National Government Interoperability frequencies, etc. as deemed necessary by the IFA. Actual frequencies are to be determined in coordination with first responder operating on the 150, 450 and 800 MHz bands. The Two-way Radio system shall operate within a frequency band 136-174 MHz or 400-500 MHz, and 900MHZ.

2. The system shall have repeaters and infrastructure to support rebroadcast of up to 25 frequency pairs within the first responder frequency bands. All Tunnel areas shall have coverage by this system to generate, receive, and re-transmit radio signals for continuous two-way radio communication between authorized vehicles or hand-held terminals in the tunnel and their respective central dispatchers.

3. Redundancy shall be provided to preclude the loss of signal due to physical damage or equipment failure to a single antenna. The local equipment of the system shall be controlled and monitored from a designated console at the tunnel operator workstations and shall be designed to communicate with all participating agencies via their approved communications protocols.

4. The radio system capability shall be provided at signal strength in conformance with FCC regulations inside the Tunnel. All system equipment shall be designed in conformance with FCC rules and regulations Section 90.242, and fully test and integrate the system into the tunnel operator workstations.

C. AM/FM Rebroadcast System

1. The AM/FM rebroadcast system shall feature a commercial radio rebroadcast system through the Tunnel capable of rebroadcasting all commercial radio stations that can be received at the Tunnel portals.

2. The radio rebroadcast system shall include override capabilities, permitting a tunnel operator to override all commercial frequencies to convey instructions to motorists for traffic and emergency response instructions. All override programming shall originate from the PCR or SCR operator workstations.

3. Redundancy shall be provided to preclude the loss of signal due to physical damage or equipment failure to a single antenna. The local equipment of the rebroadcast system shall be controlled and monitored from a designated console at the tunnel operator workstations and shall be designed to communicate with all participating agencies via their approved communications protocols.

4. The rebroadcast capability shall be provided at signal strength in conformance with FCC regulations inside the Tunnel. No degradation of the radio system shall be permitted by the rebroadcast system. All rebroadcast equipment shall be designed in conformance with FCC rules and regulations Section 90.242, and fully test and integrate the system into the tunnel operator workstations.

19.3.13. Fiber Optic Cable

[To be determined]

19.3.14. Installation

A. Install ITS in accordance with VDOT Standards, NFPA 70, and NFPA 502.

B. All associated wiring, cables and/or conductors serving the Tunnel and Tunnel Egress Corridor and Stairs shall be considered “Emergency Circuits with respect to NFPA 502” and MUST
comply with the requirements of NFPA 502-2014, Chapter 12, Sections 12.1.2 and 12.2.1.3 or as modified by the current applicable edition of NFPA 502.

19.3.15. Testing

A. Provide detailed test plans for all testing. The test plans must test the entire ITS Systems, including all equipment devices, software and wiring.

B. Provide detailed test plan for testing each of the new ITS operating HMI software.

C. Provide a detailed procedure and test plan for implementing the replacement of the existing ITS operating HMI software, as necessary.

D. Submit Detailed Procedures for all inspections and tests to be performed.

E. Testing and Inspection for all components (equipment and cable) of the ITS system shall progress through four stages of testing as described as follows:

1. Factory Acceptance Test (FAT): The first test shall be the Factory Acceptance Test. As part of their submittals, the Design-Builder shall develop a plan which assembles, configures and connects all equipment in a manner which simulates the complete Project. The Design-Builder shall then perform extensive testing to demonstrate that the hardware and system work as intended. The factory test shall have an un-witnessed phase, where the Design-Builder shall perform the tests themselves and submit signed test forms documenting the results. After certifying that the test has passed, a witnessed test shall be scheduled with the Department. The FAT must take place within the continental United States.

2. Local Equipment Test: Once the equipment has been fully exercised as part of the FAT and installed according to the Contract Documents, the Design-Builder shall perform a local site test. This test shall verify that the equipment has not been damaged in shipment and has been installed properly. To the extent possible, the equipment shall be exercised locally to demonstrate full functionality. This test shall be witnessed by the Department.

3. Remote Equipment Test: After passing the Local Equipment Test, the Design-Builder shall demonstrate that the equipment can function as a part of a complete system. From a designated control point, the Design-Builder shall exercise the remote equipment and demonstrate full functionality. This test shall be witnessed by the Department; and

4. Final System Acceptance Test: The final test of the system shall be a Final System Acceptance Test. This test shall be an endurance test, requiring flawless operation for the designated time period as described below.

F. Factory Test can utilize Manufacturers’ Standard Factory Tests or be developed by the Design-Builder.

G. Local Equipment Tests and Remote Equipment Tests shall be developed by the Design-Builder and submitted to the Department for acceptance.

H. Final System Acceptance Test shall follow all the Inspection and Tests listed in ANSI/NETA ATS (current edition) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, Section 8 System Function Tests, and shall be developed by the Design-Builder and submitted for Department acceptance to demonstrate that all equipment and systems operate as specified.

I. Submit Detailed Certified Inspection and Test Reports for all inspections and tests performed.
19.4. Deliverables

The deliverables shall include the items listed in Table 19.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
</tr>
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<tbody>
<tr>
<td>FHWA Rule 940 Compliance Documents</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.6</td>
</tr>
<tr>
<td>Develop/Verify Rule 940 Test Plans</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.6</td>
</tr>
<tr>
<td>Rule 940 Concept of Operation Document</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.6</td>
</tr>
<tr>
<td>Rule 940 Systems Engineering Analysis Document</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.6</td>
</tr>
<tr>
<td>Rule 940 System and Component Traceability Matrix</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.6</td>
</tr>
<tr>
<td>ITS Communications Network System Plan</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.8</td>
</tr>
<tr>
<td>Intelligent Transportation System Plan</td>
<td>5 1</td>
<td>15 days before start of investigation work</td>
<td>19.3.10</td>
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<tr>
<td>Wireless Communication System Plan</td>
<td>5 1</td>
<td>60 days after NTP</td>
<td>19.3.12</td>
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<td>Electronic Toll Collection Plan</td>
<td>5 1</td>
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<td>19.3.11</td>
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<tr>
<td>Test Plans</td>
<td>5 1 and 5 CDs</td>
<td>60 days after completion of investigation, including testing</td>
<td>19.3.15</td>
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</tbody>
</table>
SECTION 20. CIVIL SITE DESIGN

20.1. General

A. This Section provides the requirements for the civil site layout for the islands.

20.2. Standards and References

The applicable Standards and References are as follows:

A. Primary Standards and References:

1. Virginia Department of Transportation (VDOT) Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all-inclusive:
   a. VDOT Road and Bridge Standards, Vol. 1 and Vol. 2 including all revisions;
   b. VDOT Utility Manual of Instructions;
   c. VDOT Road Design Manual; and
   d. VDOT Drainage Manual.


B. Secondary Standards and References:

1. VDOT Road and Bridge Specifications, including all revisions;
2. VDOT Hydraulic Design Advisories;
3. VDOT Water Quality Permit Manual;
4. VDOT Virginia Work Area Protection Manual;
5. AASHTO Roadside Design Guide;
   AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals;
7. Virginia Erosion and Sediment Control Handbook;
8. Virginia Department of Health Waterworks Regulations;
9. Virginia Department of Environmental Quality Sewage Collections and Treatment Regulations (SCAT);
10. 28 CFR35 – Title II of the Americans with Disabilities Act (ADA);
11. 28 CFR36 – Title III of the Americans with Disabilities Act (ADA);
12. ADA Standard for Accessible Design; and
13. AWWA Standards.

C. Tertiary Standards and References:

1. AASHTO A Policy on Geometric Design of Highways and Streets
2. Virginia Supplement to MUTCD;
4. VDOT Guardrail Installation Training Manual (“GRIT”).
20.3. Civil Site Design Criteria

20.3.1. Tunnel Support and Facility Buildings

A. Tunnel Support Buildings.

1. Parking:
   a. The tunnel support buildings will be located near each portal, over the tunnel.
   b. No personnel spaces are intended for use inside the tunnel support buildings, therefore
      the only parking that will be required is for maintenance personnel.
      i. A minimum of five (5) parking spaces shall be provided at each tunnel support
         building.
      ii. Loading spaces will be provided in accordance with the number of loading docks.

2. Water and Sewer:
   a. Each tunnel support building will require a minimum of one (1) restroom facility.
      i. Potable water connections shall be provided and sized as required per design load
         calculations.
      ii. Sanitary sewer shall be treated via drain field in accordance with Virginia DEQ
         SCAT regulations.

3. Power and Communication:
   a. Concrete encased ductbanks shall be provided to the tunnel support buildings to facilitate
      the power and communications cabling, as noted elsewhere in these Technical
      Requirements.
   b. Ductbanks shall be sized per the requirements of the building systems.

B. Traffic Operations Center Building.

1. Parking and Site layout:
   a. The traffic operations center building will be the primary personnel building on the north
      island. Parking, drive aisles, loading spaces, ADA accessibility, and landscaping shall be
      per the CPSM.
   b. The new traffic operations center building will be located by the Design-Builders to serve
      the entire HRBT facility and submitted to the Department for review and approval.

2. Water and Sewer:
   a. The traffic operations center building will require restrooms and a locker room, including
      showers.
      i. Potable water connections shall be provided and sized as required per design load
         calculations.
      ii. Sanitary sewer shall be treated via drain field in accordance with Virginia DEQ
         SCAT regulations.
3. Power and Communication:
   a. Concrete encased ductbanks shall be provided to the traffic operations center building to facilitate the power and communications cabling, as noted elsewhere in these technical requirements.
   b. Ductbanks shall be sized per the requirements of the building systems.

C. Facility Maintenance Building.
   1. Parking:
      a. The existing maintenance building, on the north island, will be expanded to accommodate the complete facility. Additional parking will be required per the CPSM.
      b. The expanded maintenance building will require new restrooms and a locker room, including showers.

   2. Water and Sewer:
      a. The existing water and sewer services shall be upgraded to accommodate the expanded building occupancy.

3. Power and Communication:
   a. Concrete encased ductbanks shall be provided to the expanded facility maintenance building to facilitate the expanded power and communications cabling.
   b. Ductbanks shall be sized per the requirements of the expanded building systems.

D. New Garage Building.
   1. Parking:
      a. A new garage building will be constructed on the north island. Parking and loading spaces will be required per the CPSM.
      b. The garage building will be located on the north island near the south end of the island.

   2. Water and Sewer:
      a. The new garage building will require restroom facilities.
         i. Potable water connections shall be provided and sized as required per design load calculations.
         ii. Sanitary sewer shall be treated via drain field in accordance with Virginia DEQ SCAT regulations.

   3. Power and Communication:
      a. Concrete encased ductbanks shall be provided to the new garage building to facilitate the power and communications cabling.
      b. Ductbanks shall be sized per the requirements of the building systems.

E. Crash House Buildings.
   1. Parking:
      a. There are two options for the crash house building on the north island: expand the existing or construct a new building. Either option will require the appropriate parking, per CPSM.
b. The new crash house on the south island will require parking per the CPSM.

2. Water and Sewer:
   a. The crash house buildings will require restrooms and a locker room, including showers.
      i. Potable water connections shall be provided and sized as required per design load calculations.
      ii. Sanitary sewer shall be treated via drain field in accordance with Virginia DEQ SCAT regulations.

3. Power and Communication:
   a. Concrete encased ductbanks shall be provided to the new crash house buildings to facilitate the power and communications cabling, as noted elsewhere in these technical requirements.
   b. Ductbanks shall be sized per the requirements of the building systems.

F. Island Inspection Booth Buildings.
   1. Parking:
      a. New inspection booths will be required for the expanded facility. Current operation procedures do not require the need for parking at the booths. However, personnel will need to access the booths safely on foot.
   2. Water and Sewer:
      a. Each island inspection booth building will require a minimum of one (1) restroom facility.
         i. Potable water connections shall be provided and sized as required per design load calculations.
         ii. Sanitary sewer shall be treated via drain field in accordance with Virginia DEQ SCAT regulations.
   3. Power and Communication:
      a. Concrete encased ductbanks shall be provided to the island inspection booth buildings to facilitate the power and communications cabling, as noted elsewhere in these technical requirements.
      b. Ductbanks shall be sized per the requirements of the building systems.

20.4. Island Traffic Circulation

20.4.1. Building Connectivity

A. All buildings (existing and proposed) and parking lots shall be accessible by an asphalt paved roadway system, striped and signed to indicate traffic directions and flow.

1. Asphalt design shall accommodate a WB-67 truck.
2. Internal access roads, with two-way traffic, shall be a minimum of 24 ft. wide with shoulders.
3. Internal access roads, with one-way traffic, shall be a minimum of 18 ft. wide with shoulders.

B. A specific path shall be designated to allow wrecker vehicles direct access to each of the tunnel portals.
20.4.2. **Unsecure Island Perimeter Road**
   A. An unsecured perimeter road shall be provided around each island. This unsecured access road shall allow semi-truck and pedestrian vehicles the ability to navigate the perimeter of each island without entering the secured areas of the facility.
   
   1. The perimeter access road shall be a minimum of 18 ft. wide with shoulders.

20.4.3. **Acceleration/Deceleration Lanes**
   A. Acceleration/Deceleration lanes shall be added to the island entrances and exits. The length of these lanes will be designed in accordance with the AASHTO A Policy on Geometric Design of Highways and Streets, 2011 6th Edition, Section 10.9.6 and VDOT Geometric Design Standards for Interchange Ramps (GS-R) for highway design speed of 60 mph.

20.4.4. **Pavement Design**
   A. All pavement design (i.e., rigid, flexible) shall be per Section [X.X].

20.5. **Drainage**

20.5.1. **Drainage Criteria**
   A. The VDOT Drainage Manual shall be used to design all stormwater collection and conveyance systems.

   B. Design-Builder shall ensure existing tunnel facility drainage conveyance systems are accessible to an island outfall.

20.5.2. **Site Grading**
   A. Grading of the site shall be designed and constructed to provide positive drainage to properly located drainage inlets. The proposed grade elevation of the site shall meet the existing grade at the tie-in locations.

20.6. **Stormwater Management**
   A. The Virginia Stormwater Management Handbook shall be used for stormwater management related to water quality control.

   B. Contractor will take necessary measures to prevent exceedance of existing facility VPDES stormwater discharge permit limits.

20.7. **Site Lighting**
   Exterior lighting for the new and expanded buildings, parking lots, drive aisles and access roads shall be per the Section 31 of these Technical Requirements and per the CPSM.
20.8. Cell Provider Co-Location Facility

20.8.1. Co-location Area

A. A minimum 2,500 square foot area shall be set aside for cell providers, to locate communications gear, on both islands. This area shall be outside the VDOT secure perimeter and accessible to cell provider vendor contractors.

1. The co-location area shall have a standalone security fence that is not connected or tied in to VDOT’s security fencing.

B. Dedicated ductbanks shall be installed from the co-location area to portal of each tunnel, both existing and proposed. This ductbank system shall be used by the cell providers only.

1. Ductbank design will need to be coordinated with each cell provider vendor.
2. A dedicated power source will be provided to the co-location area by the Department. The co-location area will be incorporated into VDOT’s power and backup power distribution system.
SECTION 21. BRIDGES AND STRUCTURES

21.1. Scope

Table 21.1-1 represents the bridge structures anticipated to be widened, replaced and newly constructed as shown within the Concept Plans. This table is not all inclusive nor is it a required approach of the Design-Builder. The Design-Builder shall address each structure with respect to adherence to this Section of these Technical Requirements. The Design-Builder shall design and construct each structure to comply with the requirements of the Project.

Table 21.1-1 Structures

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</tbody>
</table>

### 21.2. References

A. VDOT Project Development Manual  
B. VDOT Manual of Structure and Bridge Division  
C. AASHTO LRFD Bridge Design Specifications, including all interim revisions and VDOT modifications  
D. VDOT Instructional and Informational Memorandum (I&IM)  
E. AASHTO Guide Specification for Structural Design of Sound Barriers

### 21.3. Requirements

#### 21.3.1. General

A. The Design-Builder is responsible for selecting the dimensions of bridges and culverts for this Project so they comply with all Sections of these Technical Requirements.

#### 21.3.1.2. Durability and Service Life

A. The Design-Builder shall design and construct all reinforced concrete structure to achieve the required 100-year Service Life requirement. The Service Life, for reinforced concrete structures, is defined as the total duration to the initiation of steel corrosion plus five (5) years of propagation for carbon steel. The Design-Builder shall prepare a comprehensive durability report for all reinforced concrete structures and their associated metal components, if used, with regard to materials, additives, concrete strength, fabrication/curing techniques, cover to reinforcement, construction/erection expedients, climate parameters, carbonation, concrete diffusion coefficient, surface chloride concentration (loading rates) level, threshold value to initiate steel corrosion, etc., which will demonstrate how the Design-Builder intends to fulfill the Project durability and service life requirements.

B. The Design-Builder shall also submit a Concrete Quality Control (QC) Protocol Report for proposed concrete mixes to ensure the diffusion coefficient of the production concrete will be consistent with those being tested based on the above testing method.

C. Analysis, modelling, and design shall include the pH level, chloride content, sulfates, and other contaminants in the soil/groundwater. The Design-Builder shall conduct all testing and analyses required to confirm the conditions and these conditions shall be used as parameters for Service Life.

D. Concrete
1. The Design-Builder shall use Concrete Class A4 (Low Shrinkage) for all bridge decks, bridge parapets/railings, bridge sidewalks, and bridge medians.

2. The design of the concrete mixes for all buried structures shall consider the chemical composition of the soil and groundwater.

3. The application of a waterproofing membrane, concrete surface impregnation coating, or other concrete surface coatings, corrosion inhibitors, etc. shall not be justification for a relaxation of the primary requirements for durability (i.e., cover, maximum chloride diffusivity, permeability, etc.) and Service Life. The application of waterproofing membranes and coatings are supplemental protective measures that shall not be considered as factors which impact Durability and Service Life.

4. The water/binder ratio shall be between 0.35 and 0.42, unless otherwise approved by the Department. The maximum water/binder ratio shall not exceed 0.42. The minimum water/binder ratio shall be selected to limit the adverse effects of autogenous shrinkage on early age cracking, but no less than 0.35, unless otherwise approved by the Department. Autogenous, or “early age cracking” that typically occurs within the first seven (7) days, shall be limited with the use of shrinkage-reducing admixtures or internal curing.

5. The chloride diffusivity of the concrete at a concrete age of 28 days shall not exceed 1,000 Coulombs. The diffusivity shall be determined by Virginia Test Method 112 and ASTM C 1202

E. Prestressed Concrete

1. Structures with permanent prestressing shall be based on no tensile stress in the concrete in any serviceability limit state combination.

2. The Design-Builder shall use concrete class A5 (Low Shrinkage) having a minimum specified cylinder compressive strength at 28 days of not less than 6,000 psi. Concrete cylinder compressive strength at 28 days more than 10,000 psi shall not be permitted.

F. Mass Concrete: Furnishing and placing hydraulic cement concrete for concrete elements whose minimum dimensions exceed 5 feet shall be performed in accordance with the Special Provision for Hydraulic Cement Concrete Operations for Massive Construction. Regardless of minimum concrete element dimensions, the maximum allowable thermal gradient between the core and skin temperature of a concrete pour is limited to 35° Fahrenheit and the maximum allowable temperature in any portion of the concrete pour shall be 170° Fahrenheit for slag and cement mixes and 160° Fahrenheit for fly ash and cement mixes. For concrete elements where the minimum dimension is 5 feet or less, and where the potential for exceeding the maximum allowable thermal gradient and maximum allowable temperature limits above may exist, it shall be the Design-Builder’s responsibility to determine if the Special Provision Hydraulic Cement Concrete for Massive Construction should be used for furnishing and placing the hydraulic cement concrete for such elements.

G. Reinforcing Bars

1. Tunnel Approach and Willoughby Spit Bridges: All reinforcing steel shall be deformed and shall be in accordance with VDOT S&B-81, with the following exceptions:

   a. Beams/Girders: Reinforcing steel in beams/girders shall conform to one of the following:
i. Solid stainless-steel reinforcing bars conforming to AASHTO Designation MP 18M/MP 18-15; UNS Designation S30400, minimum Grade 60. Tie wires shall be Gage 16 stainless-steel. Tie wires of other alloys or materials shall be submitted for review.

ii. Low-carbon, chromium, steel reinforcing bars conforming to the ASTM A1035A/A1035M Alloy Type 1035 CS with a minimum chromium content of 9.2%.

b. Bent caps: Reinforcing steel in bent caps shall conform to Solid stainless-steel reinforcing bars conforming to AASHTO Designation MP 18M/MP 18-15; UNS Designation S30400, minimum Grade 60. Tie wires shall be Gage 16 stainless-steel. Tie wires of other alloys or materials shall be submitted for review.

c. Piles: Reinforcing bars in prestressed concrete piles shall be solid stainless-steel reinforcing bars conforming to AASHTO Designation MP 18M/MP 18-15; UNS Designation S30400, minimum Grade 60 or Carbon Fiber Reinforced Polymer (CFRP) in accordance with the Manual of the Structure and Bridge Division, Part 2, Chapter 12.

i. Where CFRP reinforcing is selected for use in prestressed concrete piles, CFRP reinforcing shall be in conformance with the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts. CFRP reinforcing shall not contact reinforcing steels, corrosion resistant reinforcing steel, or steel ducts, including steel duct which has been galvanized.

ii. Where stainless-steel reinforcing is selected for use in prestressed concrete piles, reinforcing shall be in conformance with the Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts.

2. All other bridges: All reinforcing steel shall be in accordance with VDOT IIM-S&B-81. Epoxy coated reinforcing steel shall not be used.

a. Reinforcing steel types in substructure units shall be in accordance to VDOT IIM- S&B-81, except that where any part of the substructure elements is located in a tidal area or are less than 5 feet above the Mean Higher High Water (MHHW) elevation these elements shall meet or exceed the corrosion resistance requirements listed below. The limit of an element for the purpose of placing CRR steel may be defined by a construction joint.

b. Drilled Shafts, Footings, Pile Caps, Columns, Abutments, Abutment Walls shall:

i. use Class I Corrosion Resistant Reinforcement (CRR) steel (bars or mesh); Class I CRR as defined by VDOT IIM-S&B-81.

ii. comply with all other requirements of VDOT IIM-S&B-81 for design, detailing, and use of inserts, ties, splicers, chairs/bar supports, and spacers.

iii. not use mechanical couplers to connect conventional reinforcing steel with CRR steel.

iv. transition from CRR steel to conventional reinforcement only at construction joints which are a minimum of 5 feet above MHHW.

v. maintain a minimum clear concrete cover to principal main reinforcement for the following elements:
• Concrete Cylinder Piles, 3 inches.
• Precast Prestressed Concrete Piles, 3 inches
• Drilled Shafts, 5 inches
• Pile Cap, 4 inches
• Pier Column, 4 inches
• Elements not listed see VDOT IIM-S&B-80

a. Steel Piling
i. Top of pile elevation shall be no higher than 3 feet below the Mean Lower-Low Water (MLLW) nor less than 5 feet below finished grade or mudline.

ii. In areas where scour may expose the top of a pile, top of pile elevation shall be no higher than 3 feet below MLLW or 5 feet below the scoured grade whichever is higher.

iii. The total thickness of steel must be the sum of that needed to meet AASHTO LRFD design requirements plus a sacrificial corrosion thickness as determined by AASHTO/FHWA for aggressive salt water environments.

• Sacrificial corrosion thickness shall be computed assuming that corrosion occurs equally on all surfaces at 100% of the required rate on each surface.

H. Prestressing Strands –

1. Tunnel Approach and Willoughby Spit Bridges:

a. Precast, prestressed beams/girders shall be reinforced with stainless-steel or CFRP. Prestressing and post-tensioning strand for prestressed beams/girders shall be 250 ksi low relaxation stainless-steel, grade 2205, or carbon fiber reinforced polymer (CFRP).

i. Where stainless-steel strands and related stainless-steel bars for reinforcement of precast, prestressed members, are used in prestressed concrete elements or selected for use in prestressed concrete beams/girders, strands shall be in conformance with the Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts.

ii. Where CFRP reinforcing is selected for use in prestressed concrete beams/girders, CFRP reinforcing shall be in conformance with the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts. CFRP reinforcing shall not contact reinforcing steels, corrosion resistant reinforcing steel, or steel ducts, including steel duct which has been galvanized.

b. Precast, Prestressed Concrete Piles shall be reinforced with stainless-steel or CFRP, in accordance with the Manual of the Structure and Bridge Division, Part 2, Chapter 12.

c. Where Carbon Fiber Reinforced Polymer strands are selected for use in prestressed concrete piles, strands shall be in conformance with the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts.

d. Prestressing and Post-Tensioning Strand for concrete cylinder piles shall be 250 ksi low relaxation stainless-steel, grade 2205, or carbon fiber reinforced polymer (CFRP).
The cylinder piles shall be manufactured and installed in accordance with the Special Provision for Concrete Cylinder Piles.

e. Where stainless-steel strands, and related stainless-steel bars for reinforcement of precast, prestressed members, are used in prestressed concrete elements or selected for use in prestressed concrete piles, strands shall be in conformance with the Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts.

2. All other Bridges:
   a. Precast, Prestressed Concrete Piles shall be reinforced with stainless-steel or CFRP, in accordance with the VDOT Manual of the Structure and Bridge Division, Part 2, Chapter 12.
   b. Where Carbon Fiber Reinforced Polymer strands are selected for use in prestressed concrete piles, strands shall be in conformance with the Special Provision for Carbon Fiber Reinforced Prestressed Concrete Piles for Design-Build and PPTA Contracts.
   c. Prestressing and Post-Tensioning Strand for concrete cylinder piles shall be 250 ksi low relaxation stainless-steel, grade 2205, or carbon fiber reinforced polymer (CFRP). The cylinder piles shall be manufactured and installed in accordance with the Special Provision for Concrete Cylinder Piles.
   d. Where stainless-steel strands, and related stainless-steel bars for reinforcement of precast, prestressed members, are used in prestressed concrete elements or selected for use in prestressed concrete piles, strands shall be in conformance with the Special Provision Copied Note for Stainless Steel Strand for Design-Build and PPTA Contracts.

I. Retaining Walls
   a. Tunnel Approach and Willoughby Spit Bridges: Retaining walls at bridge abutments shall be designed for a minimum service life of 100 years. The longitudinal limits of the 100-year abutment wall shall extend a distance behind the backwall of 1.5 times the maximum wall height at backwall.
   b. All other Bridges: Retaining walls at bridge abutments shall be designed for a minimum service life of 100 years. The longitudinal limits of the 100-year abutment wall shall extend a distance behind the backwall of 1.5 times the maximum wall height at backwall.

21.3.2. Design Requirements

A. Bridge width and length shall be determined by the functional classification of roadways being considered and the facility being intersected. Under no circumstance shall the minimum vertical clearance be less than 16 feet 6 inches over existing and proposed roadways and streets carrying vehicular traffic, unless an applicable Design Exception or Design Waiver is listed in Attachment [X.XX]. Minimum vertical clearance of 18 feet 6 inches shall be provided for roadways, bridges, or other structures under straddle bents, integral straddle bents, and integral pier caps. For bridges over I-64, the required minimum clearances (outlined above) shall also be verified for the lane and shoulder layout shown within the Concept Plans.
B. Infinite life fatigue requirements shall apply to all bridges.

C. The Design-Builder shall make reasonable efforts to design structures that do not require fracture critical bridge elements. Fracture critical bridge elements shall only be permitted where demonstrated to be required and as approved by the Department.

D. Structures shall be designed to sustain the most severe combination of loads to which they may be subjected to over their life, including temporary loads resulting from transportation, shipping, erection, or any other temporary loads occurring during construction.

E. The Design-Builder is prohibited from any deviation of VDOT’s bridge standards without allowance granted in this document or prior written approval from the Department. VDOT’s Standard Details, including VDOT Design Aids, are available from the VDOT Website. These standards, design aids, and typical details shall be used to the maximum extent possible in the development of the plans. Future wearing surface loads and construction tolerance loads shall be utilized in accordance with VDOT IIM-S&B-80.

F. Each new bridge parapet or rail shall include a bridge conduit system. The conduit system shall comprise of two (2) 2-inch diameter conduits. A junction box system shall be required for each of the conduits. No more than two (2) conduits shall be embedded in each parapet or railing. The maximum size of conduits embedded in parapets or railing shall be 2-inches in diameter. The location of the first conduit shall be as shown in the standard drawing for the bridge conduit system. The second conduit shall be located such that crash test criteria for the parapet or railing is not voided, as determined by the Department.

G. Bridge longitudinal joints shall not be permitted on new bridges or modified existing bridges, except when the joint is located within the median. When, elimination or relocation of a raised median results in an existing longitudinal joint to be located outside the limits of a raised median, the longitudinal joint shall be eliminated. At a minimum, longitudinal joint elimination shall require the removal and replacement of deck concrete on either side of the joint to centerline of the adjacent girders. Furthermore, the performance of all bearings impacted by the longitudinal joint elimination shall be evaluated and all necessary modifications to bearings, including bearing replacements, shall be considered.

H. Post-tensioning of any type shall not be allowed (with or without grout or ducts). Exempt are prestressed concrete voided slabs with transverse ties or prestressed concrete box beams with transverse ties, as specifically noted in the VDOT Manual of the Structure and Bridge Division, Part 2, Chapter 12.

I. Drainage

1. Bridges shall be designed to meet all applicable hydraulic requirements, including current FEMA and the Department guidelines as described in the latest edition of the VDOT Drainage Manual. The Design-Builder shall deliver to the Department a final Hydrologic and Hydraulic Analysis and final Scour Analysis for the proposed bridge designs as outlined in these Technical Requirements. These analyses shall be submitted to the Department for review and approval prior to the commencement of bridge construction.

2. Adequate drainage for the bridge structure shall be provided; the designed system must be able to control and drain water from the deck. Bridge deck drainage analysis and design shall be performed in accordance with the latest version of FHWA Publication HEC21- Design of Bridge Deck Drainage, the VDOT Manual of the Structure and Bridge Division, Part 2 and the VDOT Drainage Manual.
3. The minimum diameter of pipe used in a drainage system for new bridges and widened portions of existing bridges shall be 8 inches.

4. To the extent possible, pipes and downspouts should be hidden or coordinated with the design of the bridge and they should be designed and installed at four (4) percent or greater slope to achieve self-cleansing velocities. The use of ditches and open channels with grades greater than 10% shall not be permitted on slopes directly underneath a bridge or on slopes located within 100 ft. of a bridge structure. An enclosed drainage system shall be used to capture the bridge deck runoff including runoff from its approach slab, and convey the runoff to the bottom of the slope or into a drainage system.

5. The Design-Builder shall design and provide drainage for any new independent pedestrian or shared use path bridge or underpass structure. Drainage scupper grates on bridges and in underpass structures shall be located within the 2-foot shoulder of the path unless otherwise approved by the Department. All drainage grates shall be bicycle friendly and meet ADA requirements. All drainage grate installation orientation shall prevent bicycle or pedestrian encumbrance.

6. All hardware components for the deck drainage system shall conform to requirements of Section 226 of the VDOT 2016 Road and Bridge Specifications, shall be galvanized steel, and shall be designed to minimize maintenance activity (min. 8” diameter pipes or pipes of equivalent areas shall be used) as well as avoid interference with aesthetics of the bridge. Provisions shall be made to provide clean-outs in the pipe and downspout systems.

J. If rigid pavement is selected for roadway construction, a full-depth asphalt pressure relief joint is required at each bridge approach, in accordance with the VDOT XJ-1 Standard.

K. The walls of retaining wall and u-wall approach structures shall be designed such that their interior faces shall be vertical after soil pressure and design hydrostatic pressure are applied, including consideration of long-term effects.

L. The use of temporary support of excavation as part of the permanent structure is not permitted.

21.3.2.1. Details and Drawings

A. Deviation from details in the VDOT Manual of the Structure and Bridge Division initiated by the Design-Builder shall be requested in writing and shall be clearly identified in any submitted plans and shall be submitted for approval by the Department in accordance with the VDOT Manual of the Structure and Bridge Division, Part 1. Explicit supporting justification shall be furnished specifically describing the reason for the requested deviations. Justifications shall include background, computations and effects on safety, maintenance, and constructability. Should any such details not be acceptable, the Design-Builder shall make the necessary modifications or shall submit an alternate detail that is acceptable to the Department. Details deviating from the VDOT Manual of the Structure and Bridge Division shall be developed by the Design-Builder such that the alternate detail complies with AASHTO LRFD and be submitted at the time of development for review and approval. Any schedule delay resulting from deviations requiring additional approvals is solely borne by the Design-Builder.

B. Plan Submittals shall be in accordance with VDOT IIM-S&B-19 and VDOT Manual of the Structure and Bridge Division. Details provided in technical proposals are not considered the Preliminary Plans. After award and as part of the Preliminary Plans, a type, size, and location
plan (TS&L), including all proposed stages of construction, and a Stage I Report shall be submitted by the Design-Builder to the Department for review and approval for both proposed new construction and proposed bridge widening. The Design-Builder shall not advance the design beyond Preliminary Plans without Department approval. For proposed bridge widening, the Design-Builder shall be responsible for verifying existing dimensions of the bridges to be widened. The proposed stages of construction plans shall outline expected methods of protecting roadway users and pedestrian traffic during each stage.

C. Any changes in subsequent submittals to skew, span length, unit length, girder, beam, pier type, bearing type and layout, requests for additional design waivers or other changes affecting navigation, or long-term maintenance of the structure shall be communicated in writing by the Design-Builder and may result in a Stage I Preliminary Plan re-approval process unless the Department, at its sole discretion, approves proposed modification in writing. Any schedule delay resulting from modifications requiring additional approvals is solely borne by the Design-Builder. Additional requirements for Plan Submittals shall be in accordance with the Agreement as outlined in Section 6 and other sections of the Technical Requirements.

D. All bridges and structures shall:

1. Use VDOT standard parapet and rail.

2. Use pedestrian fence for bridges on or over the interstate from one of the following accepted types:
   - Guardian 5000 with DutyGuard 3-5-8 mesh as manufactured by BetaFence USA, or approved equal;
   - Invisible Wall as manufactured by ClearVu, or approved equal;
   - ACRYLITE SOUNDSTOP as manufactured by EVONIK or approved equal.

3. Use pedestrian fence for bridges not on or over the interstate in conformance with VDOT standard pedestrian fence, BPF.

4. Powder coat all fence elements in accordance with the manufacturer’s specifications. Fence color shall be in accordance with the requirements of Section X.XX and as approved by the Department.

5. Test fence posts and rail sections for continuity to ensure system grounding.

21.3.2.2. Safety and Acceptance Inspection for Bridges and Culverts

Acceptance of the bridge structure will require the following two (2) independent inspections by the Department:

A. A satisfactory safety/inventory inspection by the Department as described below is required prior to Substantial Completion and opening the structure or portion of the structure to public traffic. This safety/inventory inspection by the Department will serve as the initial inspection of the structure. Data gathered will include location, date completed, alignment, description, horizontal/vertical clearances, structure element description and condition data, and traffic safety features. These inspections will be required prior to opening any newly constructed portion or phase of the bridge to traffic.

B. A satisfactory final construction inspection by the Department is required prior to Final
Acceptance of the structure. To facilitate the safety/inventory and acceptance inspections of
the structure by the Department, the Design-Builder shall ensure that all structural elements
are accessible and shall provide adequate resources, including but not limited to:

1. Man-lifts, bucket trucks, under bridge inspection vehicles, or other equipment
   necessary to inspect the structure as well as properly trained staff of sufficient
   composition to support the inspections.

2. Plans, procedures, personnel, and equipment to implement traffic control measures.

C. The Design-Builder shall provide a minimum of thirty (30) days’ notice to the Department
   whenever it requires the Department to undertake an inspection. The Design-Builder’s
   notice to the Department shall include the latest version of the plans (including all field-
   design changes), traffic control procedures, a description of the items to be inspected, and
   an anticipated schedule for the inspections.

D. Unless otherwise approved by the Department, structures shall be Substantially Complete
   before the final construction inspection will be performed.

21.3.3. New Construction

21.3.3.1. Superstructure

A. The use of continuous span units and jointless bridge design technologies shall be in
   accordance with VDOT Manual of the Structure and Bridge Division, Part 2, Chapters 15
   and 17 (latest revision). For new structures located over tidal water, main members shall be
   VDOT standard prestressed concrete shapes and shall be designed to be composite with the
   cast-in-place concrete deck. All other structures may be VDOT standard prestressed
   concrete shapes or structural steel plate girders and shall be designed to be composite with
   the cast-in-place concrete deck.

B. Existing bridge spans to be widened shall be designed and constructed with the same beam
   type and same material (i.e., steel or concrete) to the greatest extent feasible; where deviation
   is proposed, beam type and material shall be approved by the Department.

C. No timber bridge elements of any kind will be acceptable in the proposed structures.

D. To the greatest extent feasible, curved beams/girders shall be parallel; where the alignment is
   curved, the deck shall also be curved. Maximum beam spacing for steel I-girders and precast
   concrete Bulb-T beams shall be limited to 12 feet-0 inches. Where bridge deck overhang
   exceeds 0.30 times the beam/girder spacing, a yield line analysis shall be performed and the
   results incorporated into the design of the deck. Bridge deck overhang shall not exceed 0.35
   times the beam/girder spacing or 4’-0, whichever is less, including where straight beams/girders are used on a curved alignment and including where a yield-line analysis has
   been performed.

E. For prestressed concrete alternatives, the precast concrete Bulb-T sections adopted by
   the Department shall be used. AASHTO shapes shall not be permitted. The use of HPC
   (high performance concrete) for prestressed concrete beams in excess of 10,000 psi
   concrete strength shall not be considered.

F. For structural steel alternatives, the girders/beams shall be ASTM A709 Gr. 50W uncoated
   weathering steel, except as otherwise noted herein. The use of ASTM Grade HPS (high
   performance steel) 50W shall be used for fracture critical members, except for trusses. The
   use of HPS 70 ksi shall not be permitted without an approved Design Waiver. The use of a
   hybrid girder shall not be permitted without an approved Design Waiver. In any case, hybrid
girders shall not be used for curved girders. Live load deflections for Grade 70 steel shall be no less than the requirements for Grade 50 steel. The use of HPS 100 ksi shall not be permitted. Cover plates on continuous rolled beam sections shall not be used; longitudinal stiffeners shall not be used. Fatigue prone details shall not be utilized. No field welding to structural steel members, primary or secondary, shall be permitted except as allowed by the VDOT Manual of the Structure and Bridge Division. The use of structural steel girders/beams over marine environments will not be permitted when the vertical clearance above Mean High Water to the lowest portion of any steel girder/beam is equal to or less than 20 feet 0 inches.

G. Structural approach slabs will be required at each end of each bridge on the Project, including tunnel approach structures. Approach slabs and sleeper pads, if the latter are required, shall conform to the requirements of the VDOT Manual of the Structure and Bridge Division, Parts 2 and 3. A sleeper pad will be required when the bridge abutment is either integral or semi-integral.

H. Simple span prestressed Bulb-T sections made continuous for superimposed dead loads, live loads, and impact loads with closure diaphragms in accordance with the VDOT Manual of the Structure and Bridge Division shall be used. Link slabs shall not be used as a substitute for span continuity or closure diaphragms in new superstructures or new bridges.

I. If the Design-Builder proposes to use lightweight concrete for the bridge deck, consideration shall be given to the difference in coefficients of thermal expansion between the deck concrete and the superstructure elements. The Design-Builder shall provide calculations for review and approval by the Department to show that the use of lightweight deck concrete will not result in deck cracking due to the differences in the coefficients of thermal expansion.

21.3.3.2. Substructure

A. The substructure units for the bridge shall be designed to be aesthetically pleasing. Multi-column (3 or more columns), frame type piers will not be permitted over a height of 35 feet from existing grade or Mean High Water to bottom of the pier cap without approval by the Department. Substructure units of different types (i.e., pile bents, hammerhead piers and 2-column piers) shall be designed to aesthetically complement each other by having similar geometric shapes, proportions, aspect ratios, and features.

B. Spread footings shall not be used. Foundation recommendations for the proposed bridge shall be submitted for review and approval prior to the submittal of final foundation construction plans.

C. Drilled shafts, if used, for support of bridges and any related retaining structures shall be designed and constructed in accordance with the requirements of VDOT Special Provision for Drilled Shafts Using Self-Consolidating Concrete for Design-Build and PPTA Contracts referenced in Part 2, Section 4.

D. All substructures located in the Hampton Roads Harbor shall be designed for marine vessel collision in accordance with the [Appendix [X.XX] - Vessel Collision Criteria].

E. All substructures adjacent to vehicular traffic shall be investigated for crash guidelines in AASHTO 3.6.5 – Vehicular Collision Force and shall conform to the requirements of the VDOT Manual of the Structure and Bridge Division, Part 2.
21.3.4. Bridge Widening

21.3.4.1. General

The intent of the bridge improvements for this Project is to provide a widened structure that meets the minimum required typical section requirements in the given area of the project which may include median barrier, shoulders, HOT lanes, buffer area, general purpose lanes, acceleration or deceleration lanes, auxiliary lanes, and/or other elements. The minimum lane width to be maintained for traffic during construction shall be 11'-0". Additional widening may be required to satisfy drainage requirements which shall be determined by the Design-Builder. A geometric cross section depicting the Department’s proposed concept is included in the Concept Plans for each of the bridge widenings.

The Design-Builder will develop the actual transverse locations of the longitudinal deck construction joints and temporary traffic barriers on the bridges. Longitudinal deck construction joints shall be located over an existing beam/girder line; however, an exception may be provided for closure pours provided that one longitudinal joint is located above a girder centerline. Deck cross slope grade breaks are not permitted within the general purpose or HOT lanes.

21.3.4.2. Superstructure for All Proposed Bridge Widений

The superstructure modifications selected shall not result in a substantial increase in the total load (dead load plus live load) on the existing substructure (e.g. loads due to additional secondary members may be satisfactory, however loads from new primary members should be supported by new substructure elements). The existing structure shall be analyzed for increased loads from the bridge widening and may require modifications to resist the additional loads.

Bridge modifications and widening shall result in satisfactory load rating and shall reduce long term maintenance costs for the Department. Where existing main members have a proposed load path that is different from the existing load path, a load rating for each stage of construction shall be submitted for review with the Stage 1 Report.

Deflections for the widened portion of the bridge shall be compatible (+/- 10%) with deflections for beams that remain in place. The proposed beams should be parallel to the existing beams and have approximately the same stiffness. Provisions shall be made in the design to accommodate the dead load deflection and to limit differential deflection between the existing and widened portion. The design and construction sequence shall account for the differences in age between the existing concrete deck and new concrete deck. Therefore, construction methods and/or materials shall be used to minimize differential creep and shrinkage between the two (2) decks. Additionally, due to the large width of the widened bridge, the load path shall be designed to account for thermal forces and/or movement which may develop in the transverse direction. No timber bridge elements of any kind will be acceptable in the proposed structure.

Structural steel shall be painted to match the existing structural steel. The girders/beams shall be ASTM A709 Gr. 50W uncoated weathering steel, except as otherwise noted herein. The use of ASTM Grade HPS (high performance steel) 50W shall be used for fracture critical members, except for trusses. The use of HPS (high performance steel) 70 ksi shall not be permitted without an approved Design Waiver. The use of HPS 70 ksi shall not be permitted. The use of a hybrid girder shall not be permitted without an approved Design Waiver. The use of HPS 100 ksi shall not be permitted. Cover plates on rolled beam sections and longitudinal stiffeners shall not be used. Fatigue-prone details shall be minimized. No field-welding to structural steel members, primary or secondary, shall be permitted except as allowed by the VDOT Manual of the Structure and Bridge Division.

Existing compression seals at joint locations shall be removed and replaced with new elastomeric expansion dams (Type F2) installed full width of the existing bridge plus the new widened portion. These bridge widenings are exempt from the requirements in the VDOT Manual of the Structure and Bridge Division.
and Bridge Division, Part 2 relating to jointless design and construction. If the Design-Builder proposes full superstructure replacement or complete replacement for any of these widenings, these bridges shall be designed and constructed in accordance with the jointless provisions in the VDOT Manual of the Structure and Bridge Division, Part 2.

Existing approach slabs shall be widened to include the full width of the bridge widening and shall conform to the requirements of the VDOT Manual of the Structure and Bridge Division, Parts 2 and 3.

21.3.4.3. Substructure for All Proposed Bridge Widenings

Spread footings shall not be used. Foundation recommendations for the proposed bridge shall be submitted for review and approval prior to the submittal of final foundation construction plans.

When drilled shafts or micropiles are proposed, the Design-Builder shall refer to the Special Provision for Drilled Shafts Using Self-Consolidating Concrete for Design-Build and PPTA Contracts or the VDOT Special Provision for Micropiles for Design Build and PPTA Projects for design and construction requirements.

For the existing bridges on the Project, pier protection shall be evaluated and provided for existing and new piers in accordance with the requirements found in the VDOT Manual of the Structure and Bridge Division, Part 2 - Chapter 15.

New substructures (piers and abutment extensions) shall be designed to aesthetically complement the existing substructure elements. The proposed final appearance of the completed structure shall be submitted to the Department for approval. The submittal shall show a general plan and elevation view of the substructures including a description of the finishes which will be applied. Single column substructure units, excluding hammerhead type piers, will not be permitted.

21.3.4.4. Miscellaneous for All Proposed Bridge Widenings

The bridges shall be designed to support any necessary utilities including their associated structural supports and/or hangers. The inspection report for the existing structures will be made available upon written request to the Design-Builder with appropriate Critical Infrastructure Information/Sensitive Security Information (CII/SSI) documentation as described in Part X, Section X.X.X

21.3.5. Bridge Repair

21.3.5.1. General

The Design-Builder shall be responsible for submitting a structure monitoring program to the Department for review and approval. The structure monitoring program shall specifically address the proposed methodology for monitoring each component of the structure during construction, provide acceptable tolerances for movement, and document corrective actions and timeframes to be performed by the Design-Builder should the tolerances be exceeded during construction activities.

The estimated quantities of the proposed required repairs for affected structures are to be itemized by the Design-Builder for each proposed bridge repair and provided within the Technical Proposal per the Instruction to Proposers (ITP). Bridge Assessments are included as a Reference Document and will identify major work items for each structure. Repairs may include but are not limited to:

A. Concrete beam repairs shall be evaluated according to the requirements listed in the VDOT Manual of the Structure and Bridge Division, Part 2, Chapter 32.

B. Repairs and overlays for the existing bridge decks are described in the individual bridge sections of this RFP. The patching and overlays shall be placed to provide a uniform appearance between all stages of construction.
C. Other repairs to the existing superstructure may include repairing cracks, spalls, and delamination on concrete beams and deck slabs, and joint repair.

### 21.3.5.2. Concrete Repairs

A. Substructure repairs performed by the Design-Builder for all bridges may include, but not be limited to, cracks, spalls, and delamination of all existing exposed concrete surfaces including beam seats, brick repair, brick replacement, undermining of abutment footings, and slope protection cracking, settlement, and erosion.

B. Spalls and delamination shall be repaired in accordance with Section 412 of the 2016 Road and Bridge Specifications, and shall include the use of galvanic anode units. Galvanic anode units shall be approved by the Engineer and shall be installed in accordance with the manufacturers recommendations for placement and number of units. Minimum requirements of the units shall be as follows:

1. Embedded anodes shall be pre-manufactured and contain metallic zinc in compliance with ASTM B418-09 or better.

2. Zinc shall comply with the following limits of impurity:
   a. Copper (Cu) – 0.05% maximum
   b. Lead (Pb) – 0.006% maximum
   c. Iron (Fe) – 0.005% maximum

3. Plain steel wire shall comply with ASTM A82-09.

4. The anodes shall have a proven track record showing a minimum of five (5) years of satisfactory performance in a similar field environment. Records shall demonstrate satisfactory flow of protective current throughout this five-year period.

5. Anodes shall have a capacity of 780 Amp-hr/kg. Documentation shall be provided to confirm.

6. Anodes shall contain an amount of zinc sufficient to supply at least 0.20 milliamps of protective current per anode for a minimum of ten (10) years according to Faraday’s Law. Calculations, including anode efficiency, shall be provided to confirm.

C. All concrete substructure surface cracks measuring between 1/32” and 1/4” in width shall be repaired in accordance with the Special Provision Epoxy Injection Pressure Crack Sealing. All substructure surface repairs, including but not limited to scaling, delamination, spalls, and cracks greater than ¼” in width shall be repaired in accordance with Section 412 of the 2016 VDOT Road and Bridge Specifications.

### 21.3.6. Retaining Walls

#### 21.3.6.1. General Requirements

A. The retaining walls shall be designed using AASHTO LRFD Bridge Design Specifications; Interim Specifications; VDOT Modifications (IIM-S&B-80 VDOT Modifications to AASHTO LRFD Bridge Design Specifications); The VDOT Manual of the Structure and Bridge Division, Part 11 - Chapter 10 Earth Retaining Structures; and applicable sections of Road and Bridge Standards, Vol. I & II and as specified in the Technical Requirements.

1. Existing or new retaining walls shall be analyzed and designed for any additional loads imposed by sign structure supports or other structures.
2. Only retaining wall systems for which FHWA has developed guidelines will be permitted for this project. Reinforced Soil Slopes (RSS) are not allowed for use on the project.

3. Only retaining walls presenting an essentially vertical concrete face shall be used. Walls with vegetated and/or sloping faces shall not be allowed for this project.

4. In addition to cast-in-place reinforced concrete cantilever walls, the retaining wall systems indicated on the VDOT Approved Retaining Wall Systems List shall be allowed, except as noted above and as noted on the list itself.

5. Mechanically stabilized earth (MSE) walls shall be selected from the Department’s fully approved panel MSE wall systems.

6. Except for tie-backs and soil nails required for the support of retaining walls, all components of the retaining walls shall be contained within the Department’s right-of-way. Tie-backs for retaining walls may be located within permanent underground easements provided that such easements are approved by the Department.

7. MSE walls that require traffic protection at the top shall use railings on moment slabs.

8. Barriers, railings, and moment slabs located on top of retaining walls shall use low permeability concrete in accordance with current VDOT Specifications.

B. Concrete paved ditches shall be used behind retaining walls except where the top of the wall is located adjacent to a roadway shoulder in which case an approved concrete barrier system shall be used. Paved ditches shall extend to the back face of the retaining wall. For soldier pile retaining walls, where a post extends behind a retaining wall panel, the ditch shall be located adjacent to the post. The area between the edge of the ditch and the back of the retaining wall panel shall be paved with 4-inch-thick reinforced concrete graded to drain away from the wall. Reinforcement shall be in accordance with VDOT Standard PG-5.

C. For maintenance of the area at the top of a wall or working surface, a VDOT standard HR-1, or equivalent fencing system as approved by the Department, shall be required when the following condition exists:

1. Routine maintenance or inspection will be performed from the working surface or platform for which there is a 4-foot or greater distance above the next lower surface (OSHA 1910.23(c)1).

2. Retaining walls shall have metal railing except where top of wall is located adjacent to a roadway shoulder. Metal railing shall conform to VDOT Standard HR-1, galvanized and powder-coated (Black, Federal Color No. 37038) in accordance with the Special Provisions for Powder Coating.

D. All exposed, vertical faces of retaining wall elements shall receive Architectural Treatments in accordance with the Special Provision for Architectural Finish, Concrete Form Liners, and Color Stain Coating.

E. The following requirements in the VDOT Manual of the Structure and Bridge Division, Part 2 - File No. 17.01-7 Abutments, General Information and Selection Criteria, Use of MSE Walls shall not apply to this Project:

1. “MSE wall location for overpass structures shall accommodate a minimum of one future lane in each direction for the roadway below the overpass.”
2. “MSE wall limits shall extend sufficiently to allow future widening of the overpass by one lane in each direction.”

21.3.6.2. Modifications to Existing Retaining Walls

A. Retaining wall modifications shall be carried out in accordance with Section 21.3.6.1 General Requirements above.

B. If any work is to be performed on an existing retaining wall, the Design-Build shall ensure that all safety elements of existing retaining walls are brought up to current standards (example: railing). Work may include, but is not limited to, the following:
   1. Raising the existing retaining wall.
   2. Extending an Existing Wall.
   3. Adding a sound barrier wall or other feature to an existing retaining wall.
   4. Permanently increasing wall height through excavation at the front face.
   5. Placing permanent traffic lanes closer to the face of a retaining wall such that current safety requirements are not met.

21.3.6.3. Plan Submission

A. The Design-Build shall submit a preliminary plan for each new or modified retaining wall. Details provided in technical proposals are not considered the Preliminary Plans. After award and as part of the Preliminary Plans, each proposed retaining wall design shall be submitted by the Design-Build to the Department for review and approval for both proposed new construction and proposed modification. The Design-Build shall not advance the design beyond Preliminary Plans without Department approval.

B. A retaining wall preliminary plan submittal shall include:
   1. A plan and elevation view of the wall showing all existing and proposed design features associated with the project and including existing and future utilities, sound barrier walls, sign structures, landscaping, irrigation systems, barriers, existing and proposed drainage structures, adjacent bridges, etc.
   2. A preliminary geotechnical design memorandum which will include, at a minimum, the following technical information:
      a. Description of geology and geomorphology expected to be encountered along the alignment.
      b. A description of the geotechnical information that was collected and/or used in analyzing the geotechnical conditions and in developing the memorandum including locations of borings, rock coring, geophysical testing, and other in-situ testing.
      c. A description of subsurface conditions, including groundwater, and subsurface profiles.
      d. A summary of laboratory tests results.
      e. Assessment of the engineering properties of all soil and rock types.
      f. A narrative describing the basis for selection, design, and installation of the proposed foundation elements.
      g. Descriptions of geotechnical analyses and designs.
h. A description of the planned final subsurface investigation to be submitted prior to construction along with the Geotechnical Engineering Report (GER).

3. Where applicable, approval of the preliminary wall submittal shall be subject to the approval of an H&HA study and scour analysis.

C. If a retaining wall is located within 1.5 times the height of a bridge abutment or when integral to the performance of the abutment itself (including but not limited to a long wingwall), all retaining wall plans, including preliminary plans, shall be included in the bridge plan submittals for concurrent review and approval.

21.4. Requirements for Corrosion Resistant Materials in Retaining Walls Near the Hampton Roads Harbor.

If a retaining wall is required near the Hampton Roads Harbor, as determined by the Department, the following alternatives may be considered and corresponding criteria applied:

A. Cast in Place Wall Alternate. All wall reinforcing where part, or all, of the reinforcing is less than 5 feet above the Mean Higher High Water (MHHW) elevation shall meet or exceed the corrosion resistant requirements listed below.

1. Class I CRR steel (bars or mesh) as defined by VDOT IIM-S&B-81.
2. A minimum of 4 inches of clear concrete cover over principal main reinforcement shall be maintained for the entire wall regardless of whether reinforcement bar is CRR or conventional steel reinforcement.
3. Top of piling shall be a minimum of 4 feet below finished grade at the face of the wall.
4. Crack widths shall conform to Class 2 exposure as defined in AASHTO LRFD Article 5.7.3.4
5. Mechanical couplers shall not be used to connect conventional reinforcing steel with CRR steel.
6. Transition from CRR steel to conventional reinforcement shall only occur at construction joints a minimum of 5 feet above MHHW.

B. Mechanically Stabilized Earth (MSE) Alternate.

1. All wall reinforcement where part, or all, of the reinforcement is less than 5 feet above the MHHW elevation shall meet or exceed the corrosion resistance requirements listed below.
   a. Cast in Place (CIP) wall sections, footings, or step up sections below the precast panels shall meet the corrosion requirements for Cast in Place Wall Alternate presented above.
   b. Precast Facing Panel reinforcement, panel connections, and soil reinforcement inclusions shall be Class III CRR steel as defined by VDOT IIM-S&B-81 and maintain a minimum of 3 inches of concrete clear cover over reinforcement.
2. Wall elements (precast concrete panels, panel connections, soil inclusions, etc.) where all parts of the element are a minimum of 5 feet above the MHHW elevation shall meet or exceed the corrosion resistance requirements listed below.
   a. Class I CRR steel as defined by VDOT IIM-S&B-81.
C. Alternative Wall Designs

1. Precast Prestressed Concrete Piles/Posts shall have:
   a. Stainless-steel or CFRP strands and ties.
   b. Inserts shall be stainless-steel where available and hot dipped galvanized otherwise.
   c. A minimum concrete clear cover of 3 inches.

2. Steel Piles/Posts shall be hot dipped galvanized and oversized to account for 100 years of corrosion using the same equations required for MSE reinforcements. Surfaces in contact shall be considered to corrode at the same rate as surfaces which are not in contact.

3. Bolt holes and bolts at connections shall both be considered to corrode at the same rate as MSE reinforcements.

4. Permanent Concrete Wall Facing (precast or cast in place) shall meet the corrosion requirements for Cast in Place Wall Alternate presented above.

5. Tie backs where any part of the anchor system is less than 5 feet above MHHW shall utilize stainless-steel or CFRP strand.

21.4.1. Sound Barriers

Sound barrier wall posts shall not be spliced to soldier piles of retaining wall posts unless connection details are approved by the Department.

The requirements of VDOT Road and Bridge Specifications, Section 519.03(c)2 Structure-Mounted Barriers shall also apply to moment slab-mounted sound barrier walls.

Structure-Mounted Sound Barriers shall not exceed 10 feet in height as measured from the surface of the bridge deck or roadway.

21.4.2. Miscellaneous Structures and Foundations

21.4.2.1. Bridge Parapet Mounts/Sign Structures Mounted on Bridge Structures


Bridge parapet mounted sign structures shall not be allowed as outlined in current VDOT IIM-S&B-76, Adhesive Anchors for Structural Applications.

Overhead sign structures (span type only, non-cantilevers) shall be supported or directly mounted to the piers. If not feasible to mount at pier locations, overhead sign structures shall be mounted to the superstructure primary members or mounted to separate foundations. Where locating overhead sign structures at a pier is not feasible, proposed layout and justification shall be submitted for review by the Department. Sign supports shall be located a minimum 4 feet laterally from the top corner of the barrier on the side facing traffic. Sign panel face shall clear face of parapet/rail by a minimum of 12 inches, and located in accordance with the MUTCD clearance requirements for signs. The main bridge beams/girders shall be investigated for fatigue loading from the wind loads of the sign structure. The minimum vertical clearance between the bridge deck and sign shall be in accordance with the VDOT Road and Bridge Standards.
21.4.2.2. Existing Traffic Structures

A. The Design-Builder shall not relocate an existing traffic structure for proposed signs and ITS devices for reuse (new sign structures shall be required). Existing Traffic Structures may be reused in their existing location only when minor modifications to sign panels or other minor modifications are made and justified by the Design-Builder as not presenting a safety concern and as approved by the Department. VDOT structure identification and description of the structure are required for approval of removal or reuse of any existing traffic structure. The Department Structure ID for any existing traffic structure may be obtained by contacting the Department Hampton Roads District Structure and Bridge Section. The Department Hampton Roads Structure and Bridge Section shall be notified prior to the removal or reuse (as outlined above) of any existing traffic structure. Removed existing lighting poles shall not be relocated (new lighting poles shall be required).

B. Removal and Disposal of Existing Bridge-Mounted Sign Structures

All bridge-mounted sign structures located within the Project, which are in conflict, shall be removed and, if necessary, replaced with new signs mounted on independent sign structures. Bridge mounted signs shall be completely removed, including frames, sign panels, hardware, and incidentals. Removed materials shall become the property of the Design-Builder and shall be properly disposed of off-site. Connection bolts anchored into concrete parapets shall be mechanically cut flush with the surface of the parapet, and then removed by mechanical drilling to a depth of one-half inch below the surface of the parapet. The holes shall be patched to match the color and texture of the existing parapet surface with hydraulic cement mortar or grout conforming to Section 218 of the Road and Bridge Specifications. Connection bolts to steel beams shall be removed, and the affected areas of steel beams cleaned, primed, and painted in accordance with the requirements of Section 411 of the Road and Bridge Specifications to match the existing structure. Electrical service shall be disengaged at the nearest junction box, and all conductors shall be capped and sealed in place unless existing service is to be reused for lighting of replacement structures.

21.4.2.3. Acceptance for New or Modified Sign/ITS Structures

A. Acceptance of New or Modified Sign/ITS Structures will require an Initial Acceptance Inspection. The purpose of the initial acceptance inspection is to verify compliance with the requirements of VDOT IIM-S&B-82, Traffic Structures, and to identify deficiencies including incomplete work, and variances from approved plans and specifications and which must be rectified by the Design Builder before the structure can be accepted by the Department.

B. The Initial Acceptance Inspection shall be performed by the Department. The Design-Builder shall provide the Department with Released for Construction drawings, including all revisions at least two weeks prior to scheduling the inspections.

C. During the Initial Acceptance Inspection, data about location, date completed, description, horizontal/vertical clearances, structure element description and condition, and traffic safety features shall be documented in accordance with the manual, Procedures for Inventory and Inspection of Traffic Control Device Structure by the Design Builder, and verified by the Department.

D. The Design-Builder shall ensure that all structural elements are accessible for inspection of all structures. This requirement may dictate that the Design-Builder provide man-lifts, barges, remote operated vehicles, bucket trucks or other equipment necessary to inspect the...
structure and plans, personnel, and equipment to implement traffic control. Upon completion of the Initial Acceptance Inspection, the Department shall submit an inspection report to the Design-Builder within ten (10) days of the inspection recommending either acceptance of the structure or identifying deficiencies, including incomplete work, which must be rectified before the structure can be accepted. If a structure is not accepted, the Design-Builder shall rectify the deficiencies and notify the Department, in writing, certifying the deficiencies have been corrected. Within five (5) days of receipt of such certification, the Department may require that a follow-up inspection be performed to verify that the deficiencies have been corrected, or notify the Design-Builder that the structure is acceptable without a further inspection.

21.5. Deliverables

At a minimum, the deliverables shall include the items listed in Table 21.4-1 for the Department’s consultation and written comment.

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A. Working Drawings

The Design-Builder shall review and certify working/shop drawings and submit three sets to the Department for each structure. The working/shop drawings shall be certified by a registered, licensed, Professional Engineer in the Commonwealth of Virginia. Any details not previously included in the Released for Construction plans shall be documented by the Design-Builder for review and acceptance by the Department prior to commencing construction. This shall include, but not be limited to, all MSE walls, other specialty retaining structures (tieback, soil nail, etc.), overhead sign and other ancillary structures, and sound barrier walls.

B. FHWA Bridge Construction Unit Cost Report

For each bridge, the Design-Builder shall submit estimated quantities along with the associated unit costs for all standard and non-standard bridge items with the Working Drawing submittal. The bridge unit cost data is required to complete VDOT’s Annual Bridge Construction Unit Cost Report which is required by FHWA.

21.6. Miscellaneous

A. The parapet and barrier walls on structures may be constructed using slip-forming after the Department review and approval of the trial section. Where slip-forming is used, an additional 1” shall be added to the deck behind the parapet/barrier in accordance with the VDOT Standards. Slip-forming shall not be used for any parapet that requires a soundwall.
B. All temporary shoring and erection elements shall be dismantled and removed in their entirety following construction, unless otherwise approved by the Department.

C. The bridge shall be designed to support the following utilities to include their associated structural supports and/or hangers:
   1. Lighting on the bridge and under the bridge
   2. Conduit and cable as may be required in the overall project design and based upon coordination with VDOT Hampton Roads District Utilities Division.

D. As outlined above and in the Manual of the Structure and Bridge Division, Part 2, Chapter 30, pedestrian fencing shall be used on all overpass ramp structures over freeways (interstate) or railroad, regardless of whether the overpass structure provides pedestrian access (i.e., sidewalk, bikeway, etc.).

E. VDOT Standard BR27 bridge railing and pedestrian fencing BPF Type B and Type C shall be designed and constructed in accordance with the VDOT Manual of the Structure and Bridge Division for structures not on or over the interstate. The steel railing and fencing shall be galvanized and powder-coated (Black, Federal Color No. 37038) in accordance with the Special Provision for Powder Coated Galvanized Railing.

F. The outside of the BR27 rails, terminal walls, abutment elements and abutment retaining walls shall receive architectural treatment in accordance with the VDOT Manual of the Structure and Bridge Division, Part 2 - Chapter 5 (latest revision). The Design-Builder shall coordinate with the Department regarding the pattern and concrete staining required.
SECTION 22. TUNNEL APPROACH STRUCTURES

22.1. Scope

A. The requirements in this Section 22.1 apply to the design and construction of depressed roadways referred to as Tunnel Approach Structures, which include:
   1. U-Wall Sections (Boat section) of any type;
   2. Retaining walls of any type;
   3. Grade slabs of any type; and
   4. Cut-and-cover tunnel sections of any type.

B. Temporary support of excavation requirements is covered in Section 15.3.8 and not included in this section.

C. The following Appendices apply to this Section:
   1. Appendix A22-1 Waterproofing Membrane Systems for Tunnel Approach Structures

22.2. References

A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT Manual of Structure and Bridge Division; and
   2. VDOT Road and Bridge Standards, Vol. 1 and Vol. 2.
   3. VDOT S&B IIM

B. AASHTO Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. AASHTO LRFD Road Tunnel Design and Construction Guide Specifications;
   2. AASHTO Technical Manual for Design and Construction of Road Tunnels- Civil Elements;
   3. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications including all interim revisions and VDOT modifications; and
   4. AASHTO Manual for Assessing Safety Hardware (MASH).

C. NFPA 502 – Standards for Road Tunnels, Bridges and Other Limited Access Highways.

D. AWS Standards and Guidelines including:
   1. AWS D1.1M/D1.1 Structural Welding Code - Steel; and
   2. AWS D1.6M/D1.6 Structural Welding Code – Stainless Steel.

E. AISC Standards and Guidelines including:
   1. AISC Steel Construction Manual 14th Edition; and

G. 23CFR650 Subpart E – National Tunnel Inspection Standards (NTIS).
H. ACI 318-14 Building Code Requirements for Structural Concrete and Commentary.
J. fib Model Code for Service Life Design.
L. Virginia Construction Code.
M. Virginia Uniform Statewide Building Code (USBC)

22.3. Requirements

22.3.1. Performance Requirements

22.3.1.1. Functionality
A. Service and other installations shall not encroach into the clearance lines, and any doors of egress corridors, when open, shall not protrude into the tunnel clearance area above the roadway.

22.3.1.2. Durability and Service Life
A. The Design-Builder shall design and construct all reinforced concrete structures to achieve the required 100-year Service Life requirement. The Service Life, for reinforced concrete structures, is defined as the total duration to the initiation of steel corrosion plus five (5) years of propagation duration for carbon steel. The Design-Builder shall prepare a comprehensive durability report for all reinforced concrete structures and their associated metal components, if used, with regard to materials, additives, concrete strength, fabrication/euring techniques, cover to reinforcement, construction/erection expedients, climate parameters, carbonation, concrete diffusion coefficient, surface chloride concentration (loading rates) level, threshold value to initiate steel corrosion, cracking, etc., which will demonstrate how the Design-Builder intends to fulfill the Project durability and service life requirements. Proposed method of service life prediction shall incorporate the presence of cracks into the service life prediction model. The Design-Builder shall submit its proposed service life prediction software, such as the methodology adopted by the fib Model Code for Service Life Design, or equivalent, to the Department for approval. A minimum salinity magnitude of 35 parts per thousand shall be considered by the Design-Builder.

B. For reinforced concrete structures the Design-Builder shall verify the diffusion coefficient value used in the service life prediction model, based on actual concrete mixes used. Tests shall be conducted every [XXX]. The test results shall be submitted to the Department for review.

C. The Design-Builder shall also submit a Concrete Quality Control (QC) Protocol Report for the proposed concrete mixes to ensure the diffusion coefficient of the production concrete will be consistent with those being tested based on the testing method specified.

D. Analysis, modelling, and design shall include the considerations of pH level, chloride content, sulfates, and other contaminants in the soil/groundwater. The Design-Builder shall conduct all testing and analyses required to confirm the conditions and these conditions shall be used as parameters for Service Life Modeling.

E. Concrete
1. The Design-Builder shall use Concrete Class A4 (Low Shrinkage) for all retaining walls of any type, grade slabs of any type, U-Wall Sections (Boat section) of any type, cut-and-cover tunnel sections of any type, parapets/railings, sidewalks, medians, and ballast concrete. Trial batches shall be prepared with the project materials, at the anticipated temperatures (both concrete and ambient).

2. The design of the concrete mixes for all buried structures shall consider the chemical composition of the soil and groundwater.

3. The application of a waterproofing membrane, concrete surface impregnation coating, or other concrete surface coatings, corrosion inhibitors, etc. shall not be justification for a relaxation of the primary requirements for durability (i.e., cover, maximum chloride diffusivity, permeability, etc.) and Service Life. The application of waterproofing membranes and coatings are supplemental protective measures that shall not be considered as factors which impact Durability and Service Life.

4. The water/binder ratio shall be between 0.35 and 0.42, unless otherwise approved by the Department. The maximum water/binder ratio shall not exceed 0.42. The minimum water/binder ratio shall be selected to limit the adverse effects of autogenous shrinkage on early age cracking, but no less than 0.35 unless otherwise approved by the Department. Autogenous cracking, or “early age cracking” that typically occurs within the first seven (7) days, shall be limited with the use of shrinkage-reducing admixtures or internal curing.

5. The chloride diffusivity of the concrete at a concrete age of 28 maturity days shall not exceed 1,000 Coulombs. The diffusivity shall be determined by Virginia Test Method 112 and ASTM C1202.

6. For service life prediction purpose, the diffusion coefficient shall be derived based on ASTM C1556 “Standard Test Method for Determining the Apparent Chloride Diffusion Coefficient of Cementitious Mixtures by Bulk Diffusion.”

F. Pre-stressed Concrete

1. Structures with permanent pre-stressing shall be based on no tensile stress in the concrete in any Serviceability Limit State combination.

2. For tunnel approach structures below ground, a minimum specified cylinder compressive strength at 28 days of not less than 6,000 psi shall be used. Concrete cylinder compressive strength at 28 days in excess of 10,000 psi shall not be permitted.

G. Reinforcement

1. Piles: Reinforcement in any piles shall be in accordance with the Manual of the Structure and Bridge Division, Chapter 12.

2. Boat Sections: Reinforcing steel in boat sections shall be solid stainless-steel reinforcing bars conforming to AASHTO Designation MP 18M/MP 18-15; UNS Designation S30400, minimum Grade 60. Tie wires shall be Gage 16 stainless steel. Tie wires of other alloys or materials shall be submitted for review.

3. Cut-and-Cover: Reinforcing steel used in cut-and-cover sections shall be low-carbon, chromium, steel reinforcing bars conforming to the ASTM A1035A/A1035M Alloy Type 1035 CS with a minimum chromium content of 9.2%.

4. Retaining walls: reinforcing steel in retaining walls shall be in accordance with VDOT IIM-S&B 81 Corrosion Resistant Reinforcing Steels (CRR).
5. Grade slabs: Reinforcing steels in grade slabs shall be in accordance with IIM-S&B 81 Corrosion Resistant Reinforcing Steels (CRR).
6. Ordinary carbon steel and epoxy coated reinforcing steel shall not be permitted.
7. Mechanical couplers shall not be used to connect differing types of reinforcing steel.

H. Pre-stressing Strands
1. Precast, pre-stressed elements shall be reinforced with stainless steel or CFRP. Pre-stressing and post-tensioning strand for pre-stressed elements shall be 250 ksi low relaxation stainless steel, grade 2205, or carbon fiber reinforced polymer (CFRP).
2. Where stainless-steel strands and related stainless-steel bars for reinforcement of precast, pre-stressed members, are used in pre-stressed concrete elements, strands shall be in conformance with the Special Provision Copied Note for Stainless Steel Strand for Design Build and PPTA Contracts.

I. Steelwork
1. All parts and/or elements that are embedded or partially embedded for temporary works and for mechanical and electrical installations which are left in concrete and not replaceable shall be of the appropriate stainless-steel grade.

22.3.1.3. Structural Fire Resistance of Tunnel Approach Structures
A. Cut and Cover Tunnel Sections require passive fire protection. The design shall comply with fire life safety requirements described in Section 23.3.1.3.

B. [Local requirements]

22.3.1.4. Watertightness
A. Watertightness criteria for permanent structures are as follows:
1. Water ingress in any amount or in any location shall not be permissible;
2. Materials used in preventing or stemming water ingress shall not compromise the fire safety of the works or the durability of the structures in which they are used;
3. Embedded electrical boards, electrical conduits, and other similar elements shall be completely waterproofed and watertight; and
4. All joints, including construction joints, expansion joints, and joints between structure types, shall be totally watertight.

22.3.2. Design Requirements - General

22.3.2.1. Waterproofing
A. Provide external waterproofing membrane system for the Tunnel Approach Structures as specified in Section 22 Appendix A22-1 “Waterproofing Membrane Systems for Tunnel Approach Structures.”

B. The Design-Builder shall design appropriate protection measures for the waterproofing membrane including, but not limited to, chamfering corners of the structure, external protection, etc. All components of the waterproofing system shall comply with applicable Volatile Organic Compound (VOC) regulations.

C. Joints in sub-slab, main slab, or ballast concrete shall not be located such that joints are in the same vertical plane. i.e., Joints in different concrete pours shall be staggered.
22.3.3. Design Requirements - Structural Design

22.3.3.1. Introduction

A. The walls of retaining wall and U-wall approach structures shall be designed such that their interior faces shall be vertical after soil pressure and design hydrostatic pressure are applied, including consideration of long-term effect.

B. The use of temporary support of excavation as part of the permanent structure is not permitted.

C. All exterior slabs and walls shall have uniform thickness.

22.3.3.2. Loads and Forces

A. Tunnel Approach Structures shall be designed to sustain the most severe combination of loads to which they may be subjected to over their life, including temporary loads resulting from erection and any other temporary loads occurring during construction.

B. Load categories used in design shall be in accordance with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications. The loads and forces described in this Section represent minimum design values that will need to be considered. The loads and forces in this Section are un-factored service loads.

C. Permanent Loads (e.g., dead loads, earth pressures, etc.) shall be in accordance with Section 3.5 of the AASHTO LRFD Road and Tunnel Design and Construction Guide Specifications and the following:

1. Vertical uniform area surcharge load of not less than 600 psf applied at the ground surface over and adjacent to the structure; and

2. Dead loads from building or other structure foundations located above or near the structure.

D. Live Load shall be in accordance with Section 3.6 of the AASHTO LRFD Road and Tunnel Design and Construction Guide Specifications and the following:

1. Live loads from building or other structure foundations that are located within the zone of influence of the structure.

2. Vehicular collision force: design structures according to AASHTO LRFD Road Tunnel Design and Construction Guide Specifications as modified by VDOT Manual of the Structure and Bridge Division, Vol V.

E. Buoyancy

1. For permanent condition, buoyancy shall be calculated for all sections. Resistance to buoyancy calculations shall rely on the dead weight of structural components only. Overburden loads may be provided by extending the structure base slab beyond the permanent outer walls; shear strength/friction of overburden shall not be considered. The use of tie downs, tension piles, or other elements specifically designed to resist uplift forces is permitted. If tension piles are used, the maximum spacing in the longitudinal or transverse directions shall not exceed 10 feet. Auger cast piles are not permitted.

2. A minimum factor of safety of 1.1 shall be maintained at all times for the entire length of structure when applied to the structural dead weight ballast. The water elevation shall be assumed as the 100-year flood elevation plus an additional 5 feet. The unit weight of seawater shall be considered as 64.3 pcf. The dry unit weight of all concrete shall be as
determined by laboratory testing. The 600 psf area wide surcharge load shall not be included in the Buoyancy Factor of Safety.

3. For short term construction condition, buoyancy shall be calculated for all U-wall sections. A minimum factor of safety of 1.05 shall be maintained at all times for the entire length of structure.

4. All other load effects which may increase the uplift during the temporary and permanent stages shall be considered by the Design-Builder.

F. Seismic Effects

1. With reference to AASHTO LRFD, the importance category of the tunnel is defined as Critical. Design shall take account of seismic loadings, or demonstrate that such loadings are not significant in the designs; the Design-Builder shall design the Tunnel Approach Structures using peak ground acceleration of 0.03g. The structures and their associated facilities shall suffer only minimal damage, remain dry, and shall continue to function and operate during and after the earthquake. Soil liquefaction and slope movement shall be evaluated in accordance with the Technical Requirements in Section 15.3.4 Seismic Consideration. Watertightness shall not be compromised. The Design-Builder shall document the proposed design approach in the Design Development and Detailed Design.

G. Earth and Water Pressures

1. Vertical earth pressure occurs due to the backfill over the Cut and Cover Tunnel Structures. Its height and unit weight shall be determined by the Design-Builder based on the backfill material proposed.

2. Lateral earth pressures shall be calculated in accordance with AASHTO LRFD Road Tunnel Design and Construction Guide Specification. Wall Structures shall be designed for both short-term and long-term loadings. U-Wall and Cut and Cover Tunnel structures shall be designed for not less than at-rest earth pressures.

3. The Design-Builder shall determine earth pressures for temporary earth support; however, the earth pressures shall not be less than those calculated assuming active earth pressure.

4. The effect of hydrostatic water pressure shall be added to that of earth pressure, where ground water is present. Water pressures for U-Wall and Cut and Cover Tunnel Sections shall be based on the 100-year flood elevation plus an additional 5 feet.

H. Force Effects due to Superimposed Deformations

1. The effect of uniform temperature changes shall be included in the determining the final design of the tunnel approach structures in accordance with the AASHTO LRFD Road Tunnel Design and Construction Guide Specifications. All appropriate geometric effects shall be considered, including but not limited to profile grade, horizontal alignment, construction sequence and cross section geometry. Uniform temperature change analysis shall account for changes in element geometry both longitudinal and transverse. Both local and global effects of temperature changes shall be accounted for. Restriction or freedom of movement shall be considered in the analysis, including static friction and slippage.

2. Effects of temperature gradient shall be superimposed on uniform temperature analysis such that they exacerbate structural responses. A thermal analysis of each element shall be completed which accounts for thermal mass and insulation effects of non-structural
elements of the in-service structure, to include but not be limited to fire protection, non-structural and structural elements (walls, ceilings, flooring, etc.) used to define spaces such as evacuation corridors and shall include thermal influence of ballast. Structural effects due to gradients shall be accounted for in the design. Gradient effects shall be added to the uniform temperature effect on the driving side of a heat source and subtracted from the uniform temperature effects on the opposite face. Gradient effects shall be subtracted from the uniform temperature effect on the driving side of a cooling effect and shall be added to the uniform temperature effects on the opposite face.

3. Thermal forces between transverse joints shall be accounted for by the longitudinal reinforcement in walls and invert slabs. Provisions shall be made for movements and stresses resulting from temperature variations. Take into consideration any potential additional stresses imposed to the structure due to horizontal alignment impacts on thermal forces due to thermal gradient.

4. When appropriate, shrinkage and creep strains shall be determined in accordance with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications; in cases where the Guide Specifications silent LRFD Bridge Design Specifications shall be used. Shrinkage forces between transverse joints shall be accounted for by the longitudinal reinforcement in the walls roof slabs and invert slab. Differential shrinkage between portions of elements cast at different times shall be accounted for including but not limited to the effects of concrete ballast shrinking after being cast on a previously cast concrete surface and joint closures.

5. Force effects due to extreme values of differential settlements anticipated longitudinally and transversely across the tunnel approach shall be taken into consideration.

22.3.3.3.  Loading Combinations

A. Load combinations, load factors, and resistance factors used in the design shall comply with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications. Loading caused by construction and resulting from construction staging shall be included. Forces at the members of the partially completed structure, including individual members, shall be analyzed at each stage of construction.

22.3.3.4.  Structural Design

A. The tunnel approach structures shall be designed for the required 100-year Service Life, its proposed use, ground conditions, groundwater conditions, maximum flood water levels (defined as 100-year flood elevation plus an additional 5 feet), buoyancy, ground and groundwater chemistry, and proximity of the tunnel to the existing immersed tube tunnel and other structures. The design of the tunnel approach structures shall also consider any effects resulting from island expansion and construction staging for the islands at both tunnel portals.

B. The Design-Builder shall submit a structural design statement to demonstrate the proposed design of tunnel approach structures satisfies all the technical requirements herein for the Department’s approval before the advancement of the design. This submittal shall include all design basis, assumptions, demonstration plans, cross sections, minimum specification requirements, references, and standards to demonstrate the ability of such design to achieve the minimum requirements listed in this Technical Requirements.

C. Design Methods

1. The design of Tunnel Approach Structures shall be in accordance with the Technical Requirement herein and with the applicable provisions VDOT Manual of the Structure
and Bridge Division and AASHTO LRFD Road Tunnel Design and Construction Guide Specifications.

D. Reinforced Concrete Design

1. Design shall be in accordance with the more stringent of AASHTO LRFD Road Tunnel Design and Construction Guide Specifications and this Technical Requirement.

2. Control of cracking by distribution of reinforcement shall comply with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications, with an exposure factor corresponding to a maximum crack width of 0.004-inch.

3. The center-to-center spacing of main reinforcement shall not exceed 12 inches.

4. The minimum area of temperature and shrinkage reinforcement shall be calculated in accordance with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications.

5. Corners subjected to moments shall be reinforced such that sufficient development lengths are attained for moment capacity.

E. Foundation Pressures

1. Vertical pressures on base slabs include hydrostatic and earth pressure components. The hydrostatic component shall be distributed across the width of the slab in proportion to the depth of each portion of the base slab below the design groundwater table (defined as 100-year flood elevation plus an additional 5 feet). Distribution of the earth pressure component shall be based on the soil type and the specified construction procedures if condition affect the distribution, and shall include elastic foundation effects if significant changes in slab stresses are induced thereby.

F. Settlements

1. Structure design shall accommodate all anticipated settlement; all settlement analysis shall be in accordance with Section [X.XX], Design Requirements – Structural Settlements.

G. Openings

1. The effect of openings shall be analyzed and sections shall be strengthened where openings occur, by use of additional reinforcing, marginal framing members or other suitable means.

H. Fencing

1. The Design-Builder shall install a corrosion-resistant climb-resistant fence, such as BetaFence or Invisible Wall by Clear VU fence or approved equal, on the top of Tunnel Approach Structures beginning at the portal and extending for approximately 900 feet. The fence, fence poles, base plate and fasteners shall be as required in Section [XX.X] Permanent Fencing Gates and Ladders of these Technical Requirements.

22.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 22.4-1 for the Department’s consultation and written comment. All submittals shall be accompanied by appropriate level of analysis calculations to justify all engineering decisions made. The Department the right to reject incomplete submittals.
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Table 22.4-1 Deliverables
Appendix A22-1 – Waterproofing Membrane System for Tunnel Approach Structures

A22-1.1 General

A22-1.1.1 Description of Work

A. The work covered by this Supplemental Specification consists of furnishing all labor, equipment and material required to apply Waterproof Membrane and related work to the Tunnel Approach Structures, including all portal interfaces as described herein.

A22-1.1.2 Definitions

A. Waterproof Membrane: A layered system consisting of synthetic membrane(s), which prevents intrusion of groundwater into the interior of cast-in-place concrete below-grade and earth-retaining structures. Waterproof Membranes include: HDPE membranes designed to bond to concrete that is cast against it (integrated bonding systems); self-adhesive rubberized sheet membrane waterproofing systems designed to be applied to the exterior face of concrete structure after the concrete has cured; and other similar products. Bentonite based membranes and liquid applied membranes, excluding Liquid Membrane Seals, are not permitted.

B. Waterproof Membrane Protection: A layer of other protective material, as required by the membrane manufacturer, placed over the Waterproof Membrane to avoid damage during placement of concrete or soil backfill.

C. Liquid Membrane Seal: Two-component elastomeric, cold applied, trowel grade material designed for use with other membrane components.

D. Injection Grout: One or two component low viscosity hydrophilic polyurethane liquid of the type that is injected into joints or cracks to seal water leaks.

A22-1.1.3 Reference Standards

A. American Society for Testing and Materials (ASTM)
   10. E154 Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.
A22-1.1.4 Quality Control

A. Waterproof Membrane system shall be manufactured by a firm with five (5) years of experience in the production and sales of sheet membrane waterproofing. The waterproofing work shall be performed by an installer who is regularly engaged and specializes in work of the character required by this section and in the application of the materials specified here and is certified by the manufacturer as an acceptable applicator of its products.

B. The installer shall meet at project site with the membrane manufacturer, and other entities concerned with waterproofing installation performance, including test agencies, the Design-Builder and the Department to review procedures and conditions before installation of the waterproof membrane.

A22-1.1.5 Warranty

A. The manufacturer shall provide a warranty for the material and installation of the waterproofing 10 years beyond the Final Acceptance date. If leaks appear within the warranty period, attributable to waterproofing failure, based on the assessment of the Department, the Design-Builder shall be responsible for repair of the leaks, in a manner and to the extent acceptable to the Department, at no additional cost to the Department.

A22-1.1.6 Submittals

A. The Design-Builder shall submit the following in accordance with Section 2.2.4 of the Technical Requirements.

1. Complete Shop Drawings of typical installation details and non-typical details including, but not limited to, splices, penetrations, repairs, corner details and any other non-typical details; and engineering data in the form of manufacturer's installation instructions.

2. For interface condition such as the interface between the tunnel approach structures and the Ventilation Buildings and Tunnel and the Ventilation Buildings and similar non-typical conditions including penetrations, the Design-Builder shall provide detailed drawings showing beds, laps, terminations, injection ports and tube and similar components subject to the Department’s review and approval.

3. Manufacturer’s requirements including procedures, certifications and the plan for preventing damage to waterproofing components during construction.

A22-1.2 Products

A22-1.2.1 Materials

A. High Density Polyethylene (HDPE) Waterproof Membrane:

1. Type 1: Pre-applied integrally bonded sheet membrane for application on invert slabs: 0.069 inches (1.8 mm) nominal thickness composite sheet comprised of 0.048 inches (1.2 mm) minimum thickness HDPE and layers of synthetic adhesive. The membrane shall form an integral permanent bond to concrete poured against it to prevent water migration at the interface of membrane and structural concrete.

2. Type 2: Pre-applied integrally bonded sheet membrane for application on walls: same as Type 1 but with 0.069 inches (1.8 mm) nominal thickness and 0.048 inches (1.2 mm) minimum thickness of HDPE.

3. HDPE shall have the minimum properties shown in Table A22-1.
### Table A22-1: HDPE Membrane Minimum Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Typical Value (Type 1)</th>
<th>Typical Value (Type2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>ASTM D3767 Method A</td>
<td>1.8 mm (0.069 in.) nominal</td>
<td>1.8 mm (0.069 in.) nominal</td>
</tr>
<tr>
<td>Lateral Water Migration Resistance</td>
<td>ASTM D5385 Modified¹</td>
<td>Pass at 71 m (231 ft.) of hydrostatic head pressure</td>
<td>Pass at 71 m (231 ft.) of hydrostatic head pressure</td>
</tr>
<tr>
<td>Low Temperature Flexibility</td>
<td>ASTM D1970</td>
<td>Unaffected at -29°C (-20°F)</td>
<td>Unaffected at -29°C (-20°F)</td>
</tr>
<tr>
<td>Elongation</td>
<td>ASTM D412 Modified²</td>
<td>500%</td>
<td>580%</td>
</tr>
<tr>
<td>Crack Cycling at -23°C (-9.4°F), 100 Cycles</td>
<td>ASTM C836</td>
<td>Unaffected, Pass</td>
<td>Unaffected, Pass</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>ASTM D412</td>
<td>27.6 MPa (4,000 lbs./in.²)</td>
<td>27.6 MPa (4,000 lbs./in.²)</td>
</tr>
<tr>
<td>Peel Adhesion to Concrete</td>
<td>ASTM D903 Modified³</td>
<td>880 N/m (5.0 lbs./in.)</td>
<td>880 N/m (5.0 lbs./in.)</td>
</tr>
<tr>
<td>Lap Adhesion</td>
<td>ASTM D1876 Modified⁴</td>
<td>880 N/m (5.0 lbs./in.)</td>
<td>880 N/m (5.0 lbs./in.)</td>
</tr>
<tr>
<td>Resistance to Hydrostatic Head</td>
<td>ASTM D5385 Modified⁵</td>
<td>71 m (231 ft.)</td>
<td>71 m (231 ft.)</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>ASTM E154</td>
<td>1485 N (332 lbs.)</td>
<td>1485 N (332 lbs.)</td>
</tr>
<tr>
<td>Permeance</td>
<td>ASTM E96 Method B (Water)</td>
<td>0.01 perms</td>
<td>0.01 perms</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM D570</td>
<td>0.50%</td>
<td>0.50%</td>
</tr>
</tbody>
</table>

B. Rubberized Asphalt Waterproof Membrane:

1. Rubberized asphalt sheet membrane for application on top slabs of cut-and-cover tunnels: self-adhesive, cold applied composite consisting of 0.06 inches (1.5 mm) rubberized asphalt (covered with a release sheet that is removed during installation) and (0.0039 inches) 0.1 mm cross-laminated high-density polyethylene film.

2. Rubberized asphalt membranes shall have the minimum properties shown in Table A22-2.
Table A22-2: Rubberized Asphalt Membrane Minimum Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Typical Value –</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>ASTM D3767 Method A</td>
<td>1.5 mm (0.060 in.) nominal</td>
</tr>
<tr>
<td>Flexibility, 180° Bend over 25 mm (1 in.) mandrel at -43°C (−45°F)</td>
<td>ASTM D1970</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Tensile Strength, Membrane Die C Modified</td>
<td>ASTM D412</td>
<td>2240 kN/m² (325 lb./in.²) minimum</td>
</tr>
<tr>
<td>Tensile Strength, Film</td>
<td>ASTM D882</td>
<td>34 500 kN/m² (5 000 lb./in.²) minimum</td>
</tr>
<tr>
<td>Elongation, Ultimate Failure of Rubberized Asphalt</td>
<td>ASTM D412</td>
<td>300% minimum</td>
</tr>
<tr>
<td>Crack Cycling −32°C (-25°F), 100 Cycles</td>
<td>ASTM C836</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Lap Adhesion at Minimum Application Temperature</td>
<td>ASTM D1876</td>
<td>880 N/m (5 lb./in.)</td>
</tr>
<tr>
<td>Peel Strength</td>
<td>ASTM D903</td>
<td>1576 N/m (9 lb./in.)</td>
</tr>
<tr>
<td>Puncture Resistance, Membrane</td>
<td>ASTM E154</td>
<td>222 N (50 lb.) minimum</td>
</tr>
<tr>
<td>Resistance to Hydrostatic Head</td>
<td>ASTM D5385</td>
<td>70 m (231 ft.) of water</td>
</tr>
<tr>
<td>Exposure to Fungi in Soil, 16 weeks</td>
<td>GSA-PBS 07115</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Permeance</td>
<td>ASTM E96 Method B</td>
<td>2.9 ng/m² sPa (0.05 perms) maximum</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM D570</td>
<td>0.1% maximum</td>
</tr>
</tbody>
</table>

C. PVC Waterstops:

1. The PVC waterstop shall be extruded from an elastomeric plastic material of which the basic resin is prime virgin polyvinyl chloride. The PVC compound shall not contain any scrapped or reclaimed material or pigment.

2. PVC Waterstops shall have properties that meet or exceed U.S. Army Corps of Engineers CRD-C 572-74: Specifications for Polyvinylchloride Waterstop.

D. Hydrophilic Waterstops:

1. Use expandable, conformable polyurethane/butyl blended rubber based material that is free of sodium bentonite and is salt-water resistant.

E. Injection Grout

1. Provide water soluble, hydrophilic, acrylate ester resin. In the uncured state, resin shall be water soluble, non-water reactive and solvent free. Resin shall have viscosity of less than
40 mPas and be easily pumped, flushed and vacuumed during the injection process. All procedures shall be performed within the set time of the injected material. In the cured state, material shall be solid, hydrophilic, and flexible with reversible swelling action in excess of its initially installed volume. Cured material shall be resistant to common ground water contaminates, stable in the presence of acids, alkaline solutions, solvents and fuels, and resistant to permanent water pressure and salt-water environments.

2. Each joint shall include a FUKO re-injectable grout hose system or approved equal.

A22-1.3 Execution

A22-1.3.1 Preparation of Surface

A. Surface preparation shall be in strict compliance with the product manufacturer’s requirements.

A22-1.3.2 Installation of Waterproofing Membrane

A. Installation of HDPE Waterproof Membrane
   1. Installation shall be performed in accordance with the manufacturer’s requirements.

B. Installation of Rubberized Asphalt Membrane
   1. Installation shall be performed in accordance with the manufacturer’s requirements.

C. Installation of PVC Waterstops
   1. Forming and Positioning
      i. Prior to concrete placement, secure the waterstop by means of factory-applied grommets, pre-punched holes, or field-applied hog rings placed on twelve (12) inch centers between the two (2) outermost ribs of the waterstop, in accordance with the manufacturer’s published requirements.
      ii. Thoroughly consolidate concrete around the waterstop to prevent voids or honeycombing adjacent to the waterstop.

D. Splicing
   1. Butt-splice PVC waterstops with thermostatically controlled splicing iron equipped with peel-and-stick Teflon cover, in accordance with the manufacturer’s requirements.

E. Installation of Hydrophilic Waterstops
   1. Install in accordance with the manufacturer’s requirements.
A22-1.3.3 Protection of Waterproofing

A. Where reinforcement is placed prior to casting concrete, use methods approved by the Engineer of Record to achieve the required spacing between the membrane and reinforcement to ensure that the required clear cover to the reinforcement is achieved after the concrete has been cast.

A22-1.3.4 Leak Remediation

A. Observe structure and remedial grouting pipes by regular inspection for water leakage until the Final Acceptance date.

B. If structure walls, inverts, joints or remedial grouting pipes experience dripping water (leaks) undertake remedial measures consisting of:
   1. Grouting through remedial grouting pipes using suitable grouts, subject to Department approval, within the section that indicates the leak.
   2. Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of the structure.

C. Do not penetrate or puncture membrane except for permanent purposes using water tightness techniques required by the membrane manufacturer.

A22-1.4 Quality Control Plan

A. The Design-Builder shall prepare a Waterproofing Quality Control Plan and Program for the work described in this section prior to commencing installation. The Waterproofing Quality Control Plan and Program shall be prepared in accordance with Technical Requirements Section [X.XX] and shall include, but not be limited to, the following testing and inspection elements:

   1. Inspection Personnel
      i. The Design-Builder’s inspector shall have a minimum of five years of experience in the installation of flexible membranes in underground waterproofing installations and must be proficient in the supervision of testing procedures.

   2. Surface Inspection and Acceptance
      i. All surfaces to which waterproofing will be applied shall be inspected by the Design-Builder’s inspector in the presence of the waterproofing Installer’s quality control representative and approved by both parties in writing before placing concrete or soil against the waterproofing system.
      ii. Any deficiencies shall be corrected and re-inspected after corrective action has been taken before placing concrete or soil against the waterproofing system.
      iii. Waterproofing installation shall not be performed outside the approved area.

   3. Installation Inspection
      During installation of any element of the waterproofing system the Design-Builder and the Department shall inspect and record the following:
      i. Use of specified materials.
ii. Proper storing and handling of material in accordance with manufacturer’s recommendations.

iii. Ambient temperature.

iv. Seam direction and layout.

v. Number of attachments.

vi. Extent of overlap of membrane at seams for welding.

vii. Application of welds in accordance with manufacturer’s recommendations.

viii. Installation of any corner patches.

ix. Execution of penetrations and other details as per approved Shop Drawings.

x. Location and elevation of waterstops. Provide as-built documentation as specified herein.

xi. Location and elevation of remedial grouting pipes. Provide as-built documentation as specified herein.

xii. Installation of protective concrete or other material required by the membrane manufacturer.

4. Protection and Pre-Pour Inspection

i. Integrity of waterproofing during installation of rebar and formwork and during concrete pours shall be checked.

ii. A check for water build-up behind membrane will be performed and if necessary water pressure will be relieved in accordance with manufacturer’s recommendations prior to concrete pours.

iii. Penetration of waterproofing is not permitted except as outlined in A22-1.3.4 C.
SECTION 23. BORED TUNNEL

23.1. Scope

A. This Section 23 provides the requirements for tunnels constructed with a pressurized face Tunnel Boring Machine (TBM).

B. The following Appendix Specifications apply to this Section:
   1. Appendix A23-1 Excavation by Tunnel Boring Machine;
   2. Appendix A23-2 Precast Concrete Segmental Tunnel Lining;
   3. Appendix A23-3 Tunnel Boring Machine Data Acquisition and Monitoring.

23.2. Standards and References

A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT Manual of Structure and Bridge Division;
   2. VDOT Road and Bridge Specifications, including all revisions (excluding Section 103); and
   3. VDOT Road and Bridge Standards, Vol. 1 and Vol. 2.
   4. VDOT S&B IIMs

B. AASHTO Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   2. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, including all interim revisions and VDOT modifications (used for design requirements not addressed in 23.2.B.1); and

C. NFPA 502 – Standards for Road Tunnels, Bridges and Other Limited Access Highways

D. AWS Standards and Guidelines including:
   1. AWS D1.1M/D1.1 Structural Welding Code - Steel; and
   2. AWS D1.6M/D1.6 Structural Welding Code – Stainless Steel.

E. AISC Standards and Guidelines including:
   1. AISC Steel Construction Manual 14th Edition; and


G. 23CFR650 Subpart E – National Tunnel Inspection Standards (NTIS)

H. ACI 318-14 Building Code Requirements for Structural Concrete and Commentary
23.3. Requirements

23.3.1. Performance Requirements

23.3.1.1. Functionality

A. The Design-Builder is responsible for selecting the dimensions of the bored tunnel structures so that they comply with all Sections of these Technical Requirements and are able to house the required mechanical and electrical systems in the tunnel. Accordingly, the Design-Builder shall perform a space proofing study to establish the optimum internal diameter of the bored tunnel. The issues to be considered shall include, but not be limited to, the following:

1. Tunnel horizontal and vertical alignment; the finished elevation of the permanent tunnel structure including any earthwork or engineering fill and protection layers associated with the tunnel shall not extend above the horizontal projection of the existing ITT protection layers shown in the record drawings.
2. Required Static and Dynamic Clearance Envelope;
3. Emergency egress requirements;
4. Traffic barriers;
5. All in-tunnel facilities and equipment;
6. Required tunnel finishes;
7. Lining deflection; and
8. Construction tolerances for alignment and ring erection

B. In addition to the above requirements, service and other installations shall not encroach into the clearance lines, and any doors of egress corridors, when open, must not protrude into the tunnel clearance area above the roadway. The space proofing study shall be submitted to the Department for review and concurrence.

23.3.1.2. Durability and Service Life

A. The Bored Tunnel Structures’ durability and service life requirements shall follow those described in Section 22.3.1.2.

1. Reinforcement for precast concrete segmental lining shall consist of one of the following:
   a. Option 1: Reinforcement consisting of galvanized steel fibers of sufficient quantity to permit strain hardening of the concrete to keep the crack size ≤ 0.004 inches.
b. Option 2: Reinforcement consisting of deformed, chromium, steel reinforcing bars conforming to the ASTM A1035A/A1035M Alloy Type 1035 CS with a minimum chromium content of 9.2%.

c. Option 3: Blended reinforcement consisting of one of the following:

i. Option 3a:
- Stainless-steel fibers of sufficient quantity to permit strain hardening of the concrete to keep crack size < 0.004 inches
- Solid stainless-steel reinforcing bars conforming to AASHTO designation MP 18M/MP18-15, UNS designation S30400, minimum Gr. 60
- Gage 16, stainless-steel tie wires; tie wires of other alloys or materials shall be submitted for review.

ii. Option 3b:
- Galvanized steel fibers
- Deformed, chromium, steel reinforcing bars conforming to the ASTM A1035A/A1035M Alloy Type 1035 CS with a minimum chromium content of 9.2%.

2. Reinforcement, including deformed reinforcement and steel fibers, and concrete mixes proposed for precast concrete segmental lining shall be submitted to the Department for review.

3. Where blended reinforcement options are used, deformed reinforcing bars shall be required.

B. The Bored Tunnel Structures include the precast concrete segmental lining, internal structures, concrete roadway slab and the permanent foundation supports in the bored tunnel ground improvement areas. In addition, the following segmental lining components shall also satisfy the 100-year Service Life requirements: the permanent bolts and their associated inserts both in circumferential and radial joints of the segmental lining and the gaskets, which are defined and specified in Attachment Specifications A23-2 – Precast Concrete Segmental Tunnel Lining.

23.3.1.3. **Structural Fire Resistance of Tunnel**

A. The Design-Builders shall prepare a fire durability report for underground structures that demonstrates how the structure will comply with the Technical Requirements, subject to the Department’s review and approval. The tunnel structure above the roadway traffic barriers, including all overhead anchorages, shall be designed to resist structural failure when subjected to the fire size and fire growth requirements in Section [X.XX] Fire and Smoke Control, without consideration of any mechanical fire suppressing systems. Passive fire protection board is required and shall extend over the entire exposed traffic lane perimeter surface above the roadway tunnel traffic barriers. The fire protection board shall be designed in accordance with NFPA 7.3 so that the concrete temperature at the interface of concrete and fire protection board shall not exceed 250°C (482°F) for concrete 28-day strength (f'c) equal to or greater than 6,000 psi and 380°C (716°F) for concrete strength (f'c) less than 6,000 psi. The fire protection board and its anchors shall meet the performance requirements of NFPA 502.

B. Overhead anchors shall be cast into concrete.
23.3.1.4. Watertightness

A. The Design-Builder shall be responsible for designing, constructing, and maintaining the bored tunnels to meet the water-tightness criteria stipulated below:

1. For the tunnel lining elements, early age cracking resulting in through-section cracks shall not be allowed. The Design-Builder shall, through temperature and stress analysis, document that the planned risk of early-age cracking of the tunnel lining elements shall be acceptable for the full range of ambient climatic and weather conditions that may occur during hardening.

2. The tunnel shall be watertight with no visible leakage or seepage.

3. No material used in preventing or stemming water ingress shall compromise the fire safety of the works or the durability of the structures in which they are used;

4. Embedded electrical boards, electrical conduits and other similar elements must be completely waterproofed and watertight; and

5. The concrete in precast elements shall be provided with gaskets per A23-2.2.3.

6. Corrective measures for non-conforming infiltration rate shall not rely solely on injection of grout into the ground for reducing the permeability or otherwise change the ground condition.

B. The interface between the Bored Tunnel portal and Cut and Cover Tunnel Sections and other structures, shall be designed and constructed such that the joints are fully watertight over the range of movement predicted.

1. Each joint between cast-in-place interfaces with precast elements (e.g., cross-passages and tunnel approaches) shall include a FUKO re-injectable grout hose system or approved equal.

23.3.2. Design Requirements - Bored Tunnel

23.3.2.1. Materials

A. Selection of materials shall take into consideration the site conditions, exposure, and the durability requirements for this Project. As a minimum, materials shall meet the requirements of the VDOT Standard Specifications for Road and Bridge Construction, as well as Supplemental Specifications that are included in these Technical Requirements.

B. The Design-Builder shall propose concrete mix design and concrete 28-day compressive strength for the tunnel lining segments to meet both strength and durability requirements for the Department’s approval.

C. Due to the shallow soil cover anticipated over the tunnel in the vicinity of the islands, special tunnel lining segments made with heavy aggregate, and/or added ballast with heavy weight concrete, or other means to resist buoyancy may be needed.

23.3.2.2. Design

A. The design of the tunnel shall consider the performance requirements including the 100-year Service Life, the proposed use, ground conditions, groundwater conditions, depth of cover, maximum flood water levels, buoyancy, ground and groundwater chemistry, fire resistance, and proximity of the tunnel to the existing immersed tube tunnels. The design of the tunnels
shall also consider development and construction staging at the tunnel portals for all island expansions.

B. The Design-Builder shall submit a Structural Design Statement to demonstrate the proposed design satisfies all the technical requirements herein for the Department’s approval before the commencement of the design. This submittal shall include all design bases, assumptions, demonstration plans, cross sections, minimum specifications requirements, references, and standards to demonstrate the ability of such design to achieve the minimum requirements listed in the Technical Requirement.

C. The bored tunnel linings will provide a durable, structurally sound water-tight tube allowing safe operation of the new tunnel(s) for the durability and service life indicated in these Technical Requirements.

D. The permanent tunnel linings shall be comprised of bolted, gasketed, pre-cast concrete segmental lining. Radial joints shall be permanently bolted. Circumferential joints shall be permanently bolted or permanently doweled as approved by the Department. All permanent bolts shall be stainless-steel in accordance with Attachment Specifications A23-2 – Precast Concrete Segmental Tunnel Lining.

23.3.2.2.1. Tunnel Lining Thickness

A. The Design-Builder is responsible for determining the lining thickness and reinforcing for the Bored Tunnel. However, the thickness of lining shall not be less than 1’-6”.

23.3.2.2.2. Calculations

A. All design calculations shall be signed and sealed by a licensed Professional Engineer in the Commonwealth of Virginia.

B. Design calculations shall be carried out for all structural elements of the Bored Tunnel (including partition walls, roadway deck, etc.) and for the assessment of ground movements and their impact on the adjacent existing immersed tube tunnels, approaches, existing islands, and buildings. The Design-Builder shall be solely responsible for the accuracy of the calculations and the assumptions necessary to fully simulate the anticipated ground conditions (with consideration to proposed ground improvements and enabling works), and the proposed tunnel excavation methods and sequences. The Design-Builder shall provide in the design submission numerical simulations which are applicable to and reflect the work and construction stages proposed.

C. The Design-Builder shall use finite element or finite difference models such as PLAXIS, FLAC or other industry-recognized, English language software to predict ground movement due to tunnel construction, and all software utilized shall be fully validated for its intended use. State of the art modeling techniques, and simulation procedures, and appropriate material properties, and material definition shall be applied. The Design-Builder shall submit a licensed English version of the software, including all manuals, to the Department. License duration shall commence at [NTP], and finish at Final Acceptance of the Project. In addition, the Design-Builder, at a minimum, shall consider and submit calculations for the requirements as outlined below for the modeling process. The number and locations of design sections required for the tunnel design and for the assessment of surface settlements shall be the responsibility of the Design-Builder. The following design sections (including lining design and assessment of surface settlements) represent the minimum requirements that shall form part of the Design-Builder’s design:
1. One design section at the deepest tunnel location (for two cases: current seabed elevations and future dredging elevation);
2. One design section at the Northern tunnel portal(s);
3. One design section at the Southern tunnel portal(s);
4. One design section at the closest location to the Existing Immersed Tube Tunnels;
5. One design section at the location of lowest cover on top of the tunnel;
6. One design section at the location of lowest lateral pressure on the tunnel;
7. One design section at the location where the twin tunnel bores, if used, are closest to each other; and
8. One design section at each cross-passage location, if used.

D. In addition to the design sections defined above, the Design-Builder shall carry out case studies of all combinations of geological, hydrogeological, and geometrical conditions as defined in the GBR. Notwithstanding the calculations as requested above, the Design-Builder shall consider within the design submissions one numerical simulation of the tunnel construction of at least every 500 feet length of the bored tunnel section.

23.3.2.2.3. Segmental Design

A. The Design-Builder shall determine the configuration of the completed rings, individual segments, as well as details of joints and fixings, including water-tightness provisions, to suit ground and groundwater conditions, all handling, erection, stacking, transportation and TBM thrust loadings, methods and sequences of construction, tail void grout pressures distribution, and all functions in the completed works as described herein. The design shall address, among others, the following aspects, as applicable:

1. Ring configurations, including tapered rings to fit the alignment vertical and horizontal curvature and to correct line and level during construction whilst attaining the required degree of water tightness of the tunnel as specified in these Technical Requirements;
2. Segment size and form compatible with TBM and long-term structural requirements; and
3. Fixing details and other components, including circle (circumferential) joint fixings, cross (radial) joint fixings, holes, niches, recesses and fixtures for other system components, allowances for tolerances in segment production and in building the rings in the tailskin of the TBM.

23.3.2.2.4. Design Considerations

A. The Design-Builder shall, at a minimum, consider the following when designing of the tunnel linings:

1. Design shall consider all the loads likely to arise during the Service Life, including floatation and flooding;
2. The lining shall be capable of being erected, and of functioning properly, in all ground and groundwater conditions likely to be encountered;
3. Design shall include the consideration of pH level, chloride content, sulfates and other contaminants in the soil/groundwater/air, as well as effect of carbonation. The Design-Builder shall conduct its own testing to confirm its proposed design parameters;

4. Design shall provide drilling locators or other means for the attachment of the temporary and permanent tunnel services;

5. Design shall take account of short and long-term soil/structure interaction characteristics of the ground and the lining;

6. The lining form and material shall allow for the expected methods and sequences of the construction process;

7. Lining design for crack control by distribution of reinforcement shall comply with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications, with an exposure factor corresponding to a maximum crack width of 0.004-inch; and

8. Design shall take account of seismic effects; the Design-Builder shall design the tunnel lining for a Project design earthquake, using peak ground acceleration of 0.03g. Under the Project design earthquake, the tunnel structures and their associated facilities shall suffer no to minimal damage, and shall continue to function and operate during and after the earthquake. Soil liquefaction and slope stability for any protection elements and engineered berm fill around the tunnel shall be evaluated in accordance with Technical Requirements in Section 15.3.4 Seismic Consideration. Water-tightness shall not be compromised, and repairs shall be of a minor nature and not require long-term closure of the tunnel for implementation. The Design-Builder shall document the proposed design approach in the Design Development and Detailed Design.

9. Design shall consider any possible developed stresses due to seasonal temperature variation within the tunnel.

10. Design shall consider any possible developed stresses due to curvature of the tunnel alignment, especially in combination with any potential thermal gradient effects.

11. Design shall consider the penetrations and connections to the cross-passages. Tunnel liner segments of each ring at cross-passage penetration locations and for 2 complete rings each side of the penetrations shall be conventionally reinforced.

12. Design shall consider unbalanced loading conditions resulting from zones of improved ground.

13. Design shall consider loading and unloading from ground improvement installation, including freezing and thawing cycles if ground freezing planned for supporting cross-passage.

B. The minimum concrete cover for reinforced steel shall not be less than two inches (2") and shall satisfy all durability and service life requirements.

23.3.2.2.5. Loads

A. The Design-Builder shall justify all parameters adopted in the design. Analysis shall consider the geotechnical parameter and ground loads in accordance with Section [X.XX].

B. Tunnel linings shall be designed to fulfill the following requirements and to resist the following loadings:

1. Earth Pressures: The tunnel lining shall be designed to resist full overburden earth loads combined with the full range of possible lateral earth loads and water pressures;
2. Water pressures: The tunnel lining shall be designed to withstand water pressures assuming a water elevation equal to the maximum calculated by the [Tunnel Engineer of Record], and approved by the Department, and a unit weight of water of 64.3 pcf;

3. Superimposed surface loads from traffic (within the proposed island limits), existing and new structures over and adjacent to the tunnel, and any future loads specified in these Contract Documents;

4. Seismic loads;

5. Ship impact loads (refer to the Ocean Engineering Report for ship size and loads),

6. Sunken ship loads (refer to the Ocean Engineering Report for ship size and loads)

7. Surcharge loads, including a 600 psf area load at the ground surface at the islands where the tunnel is not below the waterway;

8. Vehicular loads within the tunnel;

9. Weight of ballast, barriers, and other tunnel appurtenances;

10. Unequal grouting pressures;

11. Adjacent excavation;

12. Long- or short-term loads induced by construction, including loads arising from measures to control ground movement;

13. Temperature, shrinkage and creep;

14. Handling, stacking and erection loads;

15. Jacking forces; and

16. Loading from suspended tunnel finishes, utilities, equipment, etc.

23.3.2.2.6. Load Combinations

A. The Design-Builder shall undertake a parametric study of ground parameters and loadings to determine combinations which give critical design conditions, taking into consideration different tunnel depths and critical groundwater elevations.

B. Load combinations, load factors, and resistance factors used in the design shall comply with AASHTO LRFD Road Tunnel Design and Construction Guide Specifications. Loading caused by construction and resulting from construction staging shall be designed for in cases where 600 PSF is not sufficient. Forces at the members of the partially completed structure, including individual members, shall be analyzed at various stages of construction.

23.3.2.2.7. Settlement of Permanent Structure

A. For the bored tunnel sections located on the Islands, the tunnel design shall address potential long-term ground movements that may result from island expansion performed as part of the Project. Ground movements shall be in accordance with Section [X.XX] Ground Movements Analysis, Damage Risk Assessment, Protection Measures and Repairs.

23.3.2.2.8. Buoyancy

A. General

1. The factor of safety against buoyancy shall be calculated for the entire length of the bored tunnel for both the long-term (final) condition and short-term (construction) conditions.
The minimum required factors of safety for both long term and short-term conditions are stated below.

2. Buoyancy calculations shall assume the tunnel is fully submerged at all locations; water elevation shall be assumed as the 100-year flood elevation plus an additional 5 feet.

3. Buoyancy calculations may account for resistance from the following items only: the dead weight of structural components; the dead weight of internal ballast; and the self-weight of overburden located directly above the tunnel springline unless otherwise stated below. The saturated unit weight of overburden assumed for the calculations shall be as determined by laboratory testing but not more than 115 pcf. The unit weight of all concrete and ballast assumed for the calculations shall be as determined by laboratory testing.

4. Buoyancy calculations shall not account for resistance from the following: weight of ancillary items; shear strength (friction or cohesion) of overburden; adhesion (e.g., between the tunnel liner and the overburden); live loads; any protection material/layers that are subject to dislocation and/or possible replacement; or the required 600 psf area-wide uniform vertical surcharge.

5. The use of tie-downs or other structural elements designed to resist uplift forces is not permitted.

B. Long-term (final) conditions:

1. For the entire length of the tunnel, a minimum factor of safety of 1.10 shall be maintained. For portions of the bored tunnel beneath the channel, the current bottom of channel elevation shall be assumed based on surveying data. The elevation of the existing ITT shall be based on existing record drawings.

C. Short-term (construction) conditions

1. A minimum factor of safety of 1.03 shall be maintained at all times for the entire length of tunnel.

23.3.3. Design and Construction Requirements - Bored Tunnel Enabling Works

23.3.3.1. General

A. The bored tunnel alignment will require the placement of tunnel enabling works which may include island expansions, engineered fill berms and ground improvement, the limits of which shall be determined by the Design-Builder. Refer to Section 15.3.5, Island Expansions; Section 15.3.6 Engineered Fill Berms; and Section 15.3.19 Ground Improvements, respectively for requirements.

B. Engineered fill berms shall be founded on stable, firm and clean ground with no debris from previous constructions. At a minimum, the top 15 feet of existing mudline shall be either dredged or modified and strengthened (through ground improvement) prior to the placement of the fill to mitigate future settlement and to maintain the geometry of the fill for the service life of the tunnel.

C. Island Expansions/Engineered fill berms shall be placed to the designed elevations prior to the start of the tunnel excavation.

D. Ground improvement is required at the launching and receiving pit excavations to facilitate TBM break-in and break-out, and to provide means of groundwater control at the base of the excavation. Ground improvement is also required for soft soils at significant depth as
described in the GBR, to prevent bearing capacity failure below the TBM cutterhead (thereby enabling the TBM to maintain the correct line and grade) and to mitigate settlement of the tunnel structure.

E. Ground improvement shall be performed immediately adjacent to the headwalls (for launching and receiving the TBM). This ground improvement shall be full face with dimensions meeting the following criteria:

a. Minimum length of improved zone shall be such that two full complete tunnel liner rings are installed and grouted in place prior to the TBM head breaking through the improved ground zone.

b. Minimum height and width of improved zone shall be such that improved zone is five feet greater than the excavated tunnel diameter.

23.3.3.2. Performance Requirements

A. The island expansions-engineered fill berms and ground improvement shall be suitable for bored tunneling operations including excavation (boreability), installation of backfill grout behind the lining and mucking operation, as determined by the Design-Builder’s means and methods.

B. Ground improvements performed adjacent to headwalls (for launching and receiving the TBM) at the base of the temporary launching and receiving pits and along the tunnel alignment shall provide adequate improvements to the stability, compressibility, and permeability of the in-situ soils in accordance with the Design-Builder’s design with a suitable factor of safety.

23.3.3.3. Minimum Strength Requirements

A. Minimum shear strength of the engineered berm fill will be required to stabilize the fill geometry during tunnel boring and to maintain stability against sliding of the fill as the TBM progresses along the tunnel alignment. The Design-Builder shall determine the shear strength and stability requirements against sliding along the tunnel axis and laterally (orthogonal to the tunnel axis) and shall be approved by the Department prior to start of construction.

23.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 23.4-1 for the Department’s consultation and written comment. All submittals shall be accompanied by appropriate level of analysis calculations to justify all engineering decisions made. The Department the right to reject incomplete submittals.

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Appendix A23-1 – Excavation by Tunnel Boring Machine

A23-1.1 General

A23-1.1.1 Description of Work

A. This Appendix Specification specifies the work required if the Design-Builder selects the bored tunnel option for the construction of a new parallel tunnel crossing under for Hampton Roads Bridge and Tunnel project by means of a Tunnel Boring Machine (TBM).

B. Use either an earth pressure balance (EPB) or Slurry TBM. Seepage of grout, bentonite slurry and/or polymer or other conditioning agents and/or slurry foam into the waterway shall not be allowed.

A23-1.1.2 Definitions

A. Tunnel Boring Machine (TBM) – a pressurized face tunneling machine, which will provide full excavation face support and refers to the total system of tunnel boring equipment and auxiliary and support equipment comprising the TBM, including systems, backup gear and all equipment and materials affixed thereto.

B. Slurry TBM - A TBM with a pressure bulkhead located behind the face to form a plenum under pressure. Bentonite slurry or other liquid medium is introduced into the plenum chamber under a controlled compressed air cushion to regulate the pressure. The support fluid is injected out into the ground at the face to form a semi-impermeable membrane at the face which transfers the support pressure from the plenum chamber into the ground to stabilize the face. The support fluid is mixed with material excavated by the rotary cutterhead and the resultant slurry, with cuttings, is removed by pumping. The cuttings are removed at the surface and the slurry is recirculated to the plenum chamber.

C. Earth Pressure Balance (EPB) TBM - A TBM with a pressure bulkhead located behind the face to form a plenum under pressure. Liquids and conditioners are injected into the plenum to be mixed with material excavated by the rotary cutterhead. The mix is extracted by means of a screw conveyor in an operation integrated with the TBM advance and discharged to atmospheric pressure in a controlled manner.

A23-1.1.3 Summary of Work

A. The Work consists of a TBM driven tunnel in site and subsurface conditions, including groundwater conditions, described in the GBR and the GDR, and interfaces with the portals at cut and cover and/or U-wall sections.

1. Providing a TBM capable of excavating and supporting the tunneling medium. The Design-Builder is responsible for the design of TBM system, all backup equipment, auxiliary systems, support equipment, and all and any other items necessary for the sustained operation of the TBM including tunnel spoil handling and reconditioning, water treatment and disposal systems and the slurry treatment plant (if applicable) to meet the requirements of this project and all Governmental Approvals.
2. Furnishing and installing the initial and permanent tunnel support consisting of bolted and gasketed precast concrete segments. The TBM excavation shall provide a tunnel of sufficient excavated diameter as required to provide the necessary interior space for the systems, roadway clearances, emergency egress walkway, and all Technical Requirements accounting for construction tolerances for all components.

3. The Design-Builder shall be responsible for identifying the legal disposal site, excavating, handling, transporting and disposing of excavated materials, encountered in accordance with the Technical Requirements and Governmental Approvals.

4. Furnishing and placing cementitious backfill grout continuously and immediately behind precast concrete lining to ensure the annular space between lining extrados and excavated surface is completely filled concurrently with the machine advance and considering grout flow into the surrounding ground.

5. Designing, furnishing and using slurries, conditioners, polymers, bentonite and/or other soil conditioning agents (all referred to herein as conditioners) at all times and of the types required to maintain face stability (with positive face support), reduce wear, advance the heading, and transport spoils in these ground conditions with the TBM and equipment selected.

6. All slurries, conditioners, polymers, bentonite and/or other soil conditioning agents shall be biodegradable.

7. Designing and furnishing slurry treatment plant as required for a Slurry TBM.

8. Installing and maintaining temporary drainage, lighting, power, water and ventilation in the excavations.

9. Drilling probe/grout holes or other means as determined appropriate by the Design-Builder, ahead of the tunnel as needed for ground and groundwater controls and before any personnel entry into the TBM pressure chamber or the tunnel face, as required by OSHA and other jurisdictional agencies.

10. Installing and removing temporary bulkheads and support members, stabilizing ground at portals, strengthening the ground along the tunnel alignment as required, and removing all existing piles, shallow foundations and obstructions.

11. Installing temporary and permanent engineered fill berms to provide medium for tunnel excavation at both ends of the tunnel alignment and stability against tunnel buoyancy per the RFC Documents.

12. Obtain all necessary Governmental Approvals.

13. Use equipment that meets requirements for Potentially Gassy ground, in accordance with 29 CFR 1926, including onboard electrical and mechanical systems.

**A23-1.1.4 Quality Control**

A. Design-Builder shall submit its quality control plan that includes but is not limited to the following requirements herein, which are in addition to any requirements listed in the Section [X.XX] of these Technical Requirements.
B. Worksite Personnel – Design/Builder shall submit qualifications for the following personnel:

1. Tunnel superintendents and tunnel foreman shall have successfully completed at least one tunnel project with similar tunnel size, ground conditions, and similar tunnel equipment within the last five years.

2. All TBM operators, master mechanics and electricians shall be trained and certified in writing as qualified by the machine manufacturer before start-up of TBM.

3. TBM Operators: Use only operators with prior experience on a similar project with a tunnel driven in soil with high ground water table (at least 3 bars) for at least three thousand (3000) feet in length and a minimum of thirty (30) feet in diameter.

4. Two technical representatives from the manufacturer, knowledgeable in the assembly, operation, maintenance and repair of the TBM, shall be on site throughout the entire duration of TBM assembly and tunnel driving. One technical representative shall have knowledge of all electrical aspects of the TBM and the second shall have knowledge in all mechanical aspects of the TBM.

C. Certification – Manufacturer certification that TBM, as assembled is complete and meets specification requirements, is ready for operation.

D. TBM assembly and demonstration tests: conducted at the factory in the presence of the Department before shipping to site and onsite before launch of machine. Onsite test shall also include a ring build cycle performance test demonstrating that the segmental ring can be constructed with no damage to the segments.

A23-1.1.5 Reference Standards

A. Occupational Safety and Health Administration (OSHA) OSHA 29 CFR 1926 Safety and Health Regulation for Construction

B. National Fire Protection Association NFPA 241 Safeguarding Construction, Alteration and Demolition Operations

A23-1.1.6 Submittals

A. The Design-Builder shall submit the items described in this Section in accordance with Section [X.XX] of the Technical Requirements. The submittals listed herein are required in addition to other submittals described in the Technical Requirements.

B. Submit the following for review and comment in a time frame sufficient to allow procurement of the TBM in accordance with the Design-Builder’s construction schedule.

1. Demonstrate that the TBM manufacturer has recently manufactured at least three (3) tunnel boring machines of similar type, size (more than 30 feet finished diameter), capability and complexity that were successfully used on projects in an environment similar to that in this Project.

2. Have machine manufacturer provide the following documentation for the three similar TBM projects cited above:
i. Features of each TBM, with a complete technical description and detailed general arrangement drawings of TBM and backup equipment, including but not limited to cutterhead and overcut, conditioner injection system (EPB) or slurry processing, integrated support pressure control system, thrust and steering systems, drive system, etc. The level of detail in the submittal shall be sufficient to demonstrate TBM(s) were similar to that proposed for this Work and operated in similar tunneling conditions for at least three thousand (3000) feet with each machine.

ii. Lengths and diameters of previous tunnel drives, geologic conditions for each project, including maximum groundwater pressure and ground support systems installed.

iii. TBM performance for each project, including face pressure control, average daily advance, average TBM penetration or excavation rate, utilization, reports on the extent and nature of segment damage and whether damage occurred during erection or due to other causes, how damage was corrected and descriptions of all major machine-related delays.

3. A complete technical description of the proposed TBM and all necessary backup equipment and systems for this project. Detail in submittal shall be sufficient to demonstrate that all aspects of the specification requirements are met. The proposed TBM manufacturer shall certify in writing that TBM and backup equipment and systems meet the project requirements.

C. Within sixty (60) days following the submittal in A23-1.1.6 B, submit the following, approved by the [Engineer of Record], to the Department for review and comment:

1. General arrangement drawings from TBM manufacturer showing details of TBM and backup equipment layout including detailed scale drawings with sufficient vertical and horizontal sections at tunnel axis and cross sections to clearly identify the different components of the TBM. Show the following features of TBM: a complete technical description and detailed general arrangement drawings of TBM and backup equipment, including cutterhead design, conditioning system, thrust, articulation, and steering systems, drive system, tunnel spoil system including means for detecting overexcavation, main bearing and seals, tail seals, guidance system, tunnel liner grouting system, compressed air locks, fire suppression system, schematic electrical system, ventilation system (including ventilation of plenum for hyperbaric intervention), segment erector and the interface of TBM with the segmental lining system elements, tunnel spoil transport system and slurry treatment facility (if applicable). Provide detailed narrative supported with sketches demonstrating the suitability of the TBM and backup for tunneling in the anticipated ground conditions. Provide a narrative description of how the working chamber is ventilated during hyperbaric intervention.

2. Written certification from TBM manufacturer of full and complete design coordination between TBM manufacturer and liner manufacturer. Include a written certification by both manufacturers affirming the compatibility of total TBM system and back-up equipment with lining, segment erector and backfill grout injection system.
3. A schedule allowing for a preventative maintenance plan and program for the full duration of tunnel excavation. The program shall include, but not be limited to, excavating tools and cutterhead, drive system, thrust and steering system, tunnel spoil system, seals, segment erection, guidance system, data acquisition system, tunnel ventilation, power supply, pumps, drainage, conveyors, track work and rolling stock.

4. Estimated delivery time, assembly time, start-up time, and on-site training period to reach planned sustainable tunneling capability for performing of the Work.

5. Estimated overall average daily advance for tunnel excavation, in feet/day, from start TBM to finish TBM excavation.

D. Within sixty (60) days following the submittal in A23-1.1.6 B, submit the following, approved by the Engineer of Record, to the Department for information:

1. Shop Drawings and specifications for TBM.
2. Details of spoils removal system through tunnels and shafts.
3. Method by which TBM will excavate through ground conditions.

E. Within ninety (90) days following the submittal in A23-1.1.6 B, submit the following, approved by the [Engineer of Record], to the Department for information:

2. Means and methods for drilling probe and grout holes from within the TBM.
3. Method of grouting ahead of the TBM in the case of intervention ahead of the cutterhead is needed, including methods of sealing the cutter head, drilling methods, planned grouting process, equipment and procedures to monitor quantities, pressures and design of admixtures to adjust setting or flash times to limit grout flow and prevent intrusion into the waterway.
4. Program for fire prevention and mitigation.
5. Permits for disposing of excavated material, dewatering fluids, conditioners and tunnel drainage in accordance with Governmental Approvals.
6. Location of nearest medical lock to be used for decompression of workers following entry into the pressure chamber of the machine under compressed air. Medical lock shall meet all requirements as defined by OSHA Regulations Standards – 29 CFR, 1926.803 Subpart S for working under compressed air.

F. At least one hundred twenty (120) days before start-up of TBM, submit a TBM Method Statement, approved by the Engineer of Record, to the Department for review and comment including:

1. Proposed method of calculating and measuring the face pressure required to maintain face stability and the logic and integrated computer systems that will be used to change the pressure as function of tunnel depth, ground water level, berm deformation (at location where engineered fill berm is used), and geologic materials and conditions encountered at the face.
2. A plan covering the intended machine parameters to achieve required pressure at the tunnel face for expected ground conditions and for the maintenance and stability of the engineered fill berms. Submit planned minimum and maximum face pressures to be maintained for different reaches which can be defined by stationing and tunnel face conditions, along with supporting calculations to maintain the stability for the engineered fill berm. Calculations for face pressures shall cover all expected ground conditions, low ground pressure at locations where engineered fill berms are used, low cover locations, partial safety factors for both water and ground pressures, fluctuation of face support inside the working chamber, and accounting for variations in groundwater levels influenced by tidal fluctuations.

3. A plan covering the start-up of TBM and the launch of TBM that prevents loss of ground and that provides total ground-water control before the TBM is safely in (or out of) the ground with several permanent tunnel lining rings installed. The work plan shall also include the following:

   i. Means for testing and verifying the effectiveness of ground treatment if and where used, including basis for design parameters.
   ii. Details of thrust frame or other means of providing reaction to start TBM into ground.
   iii. Details of the seals to be used at the structure walls and other measures to be taken to minimize loss of ground and to provide groundwater control while the TBM advances sufficiently to complete the installation of the first twenty (20) liner rings.

4. A plan covering special precautions and procedures to be used when stopping the machine for access to TBM face for inspection, intervention ahead of the face, maintenance or repair using compressed air, and/or other supplemental ground stabilization methods as required.

   i. Details of precautions to be taken for all stoppages or interventions including ventilation of plenum chamber for all conditions and for other stoppages such as weekends and holidays to prevent loss of face stability.
   ii. Contingency measures that would be implemented if problems are encountered with loss of ground or groundwater control.
   iii. Contingency measures if power is lost to the TBM for an extended period of time, due to a storm or other natural disaster.
   iv. Contingency measures to seal the tunnel section under construction during a storm surge to prevent flooding of the tunnel section.
   v. Contingency measures that would be implemented if a major TBM breakdown occurs under the navigational channel.

5. A plan for progressing the tunneling to include method(s) of stabilizing the TBM face in the event of loss of pressure during tunneling or during periods of no work such as over a weekend; also explain TBM shutdown and startup procedure after shutdown with specific description of procedure to prevent loss of face.
6. For Slurry TBM, details of slurry treatment plant and of treatment plant operations, disposal of slurry and conditioners; capabilities relative to anticipated ground conditions; and quality control testing program for slurry including a description of required tests and range of values considered acceptable for ground conditions anticipated for each tested parameter.

7. For an EPB TBM, details of the types of conditioners to be used, handling and disposal requirements, mixing methods, proposed tunnel spoil to conditioner ratios, results of soil conditioner testing program and quality control program, and a description of ground conditions in which they will be used, and the logic to be used in determining when, which, and how much conditioner to add, and description of computer controls to be used to adjust the above. The Design-Builder is required to submit a report demonstrating that the performance of selected conditioning agents can maintain a satisfactory ‘plug’ in the screw conveyor or alternative muck discharge system under all ground conditions and operating conditions described in the GBR.

8. Detailed description of proposed TBM guidance system including how guidance system interfaces with conventional laser, how the control is brought underground, how it is used by the TBM operator to monitor machine performance, how it interfaces with TBM operational systems (jack pressures and extensions, cutterhead and tailskin extensions and articulation) and lining ring placement and grouting sequence to minimize deviations from the theoretical tunnel alignment.

9. Detailed description of the annulus grouting proposed, demonstrating that it provides the required strength, deformation and set-up time characteristics to prevent grout seepage to the waterway and minimize grout takes while driving the tunnel, and including a description of the grouting system to demonstrate the capability of complete, immediate, and uniform filling of the tail void as the TBM advances, and how grout set time is designed to ensure consistency with the planned rates of advance of the TBM. Describe method of measuring grout volumes and logic used to determine grout composition and pressures as a function of tunnel depth, ground, and groundwater conditions, and describe interlock system to prevent shield advance without tail void grouting.

10. Methods of correcting tunnel alignment if the driving tolerance is exceeded.

11. Methods of measuring each ring and correcting lining ring non-planarity and/or non-circularity that may cause segment damage or gasket leakage if not detected and corrected, and measures to be taken should design tolerances be exceeded.

12. Methods and materials for repair of crack or spall damage to precast concrete segments should they be damaged during the erection or shovring process, and are not retrievable for replacement.

13. Details of the mechanisms by which the load distribution pads and the thrust jacks will be kept in their intended positions on the lining segments without introducing eccentric loads to the segments and creating a potential for segment damage, and intended corrective measures to be taken if jack misalignment should occur.

14. Methods to prevent conditioners from seeping into the waterway.
G. Submit certifications and records prior to start of tunneling, and as required during operations:

1. TBM Manufacturer: Written certification that all operators, electricians and master mechanics have completed training on similar equipment and at manufacturer’s plant for this project's equipment and are deemed qualified and ready for machine operation by the manufacturer.

2. Calibration certificates for pressure cells in excavation chamber, TBM guidance system, thrust jacks, and annular backfill grout pressure gauges. Provide these certificates prior to start of tunneling operation.

3. Continuous monitoring data of TBM performance as required in this Section: Submit to the Department on a real-time basis for the duration of TBM excavation via data logger. Submit data files in Microsoft Office spreadsheet file format within twenty-four (24) hours of occurrence.

4. Maintain daily reports for each manned shift, including periods when the TBM is not excavating. Daily reports shall include crew present, start and end station of the TBM, tunnel spoil volume (as applicable to EPB TBM excavation), lining ring data, deviations from work plan, or other unusual events.

5. For each erected ring, complete an individual record survey of all relevant construction information.

6. Records of deformation and/or damage for each lining element including repairs made, water inflows, etc.

7. Air quality and gas monitoring reports shall be maintained by the Design-Builder and submitted to the Department upon request. These shall include but not be limited to test and monitoring reports as required by OSHA and other jurisdictional agency requirements.

8. Results of strengths and/or accepted tests for the injected tail void grout.

9. Methods for monitoring and reporting deformation of each lining segment.

H. Submit as-built survey of the tunnel bore within thirty (30) days of completing each tunnel drive.

I. Immediately notify the Department of any tunnel misalignments or lining non-planarity and propose corrective action.

J. Ten (10) days before beginning any nonemergency remedial measures, submit a plan for information to the Department.

K. Submit daily to the Department and have in possession of TBM operator, a tabulation of the face support pressures by station that the Design-Builder has determined, based upon ground and groundwater conditions within and above the tunnel horizon, will be needed for that day’s tunnel drive.

L. Submit details of sprinkler systems as specified elsewhere in this Specification.
A23-1.1.7 Worksite Conditions

A. Tunnel Working Conditions - Maintain clean working conditions inside the tunnel. Remove tunnel spoil, grout spills, and all other material not to be used for tunneling. At completion of the Work, clean tunnel to the satisfaction of the Department.

B. Ground conditions are considered as potentially gassy. Use equipment that meets requirements for potentially gassy ground, in accordance with OSHA 29 CFR 1926, including onboard electrical and mechanical systems.

C. Emergency Work - Whenever there is an emergency or stoppage of work which is likely to endanger the excavation or adjacent structures, including over weekends and holidays, the Design-Builder shall continuously perform any work required until emergency or hazardous conditions are resolved and eliminated.

D. Polymers, Bentonite slurry, additives, and all other conditioners used for conditioning and face control, shall conform to all applicable regulations and not be hazardous, and shall not degrade the natural groundwater.

E. Use fire resistant hydraulic fluid in all hydraulically actuated underground equipment and machinery and equip with appropriate fixed fire suppression equipment in accordance with NFPA 241.

F. Provide and maintain at all times a continuous walkway in good repair from portal to the working face to allow emergency egress free of holes, obstructions and tripping hazards. Safety walkway in the tunnel shall be located out of the track area.

G. Equip TBM with a continuous flammable and toxic gas monitoring system capable of monitoring within the occupied working spaces. The monitoring system shall signal the heading and shut down electrical power, except for ventilation, lighting and life safety support systems, when concentrations of hazardous or toxic substances exceed the statutory limits.

H. The rear of the TBM shall be fitted with a suitable water smoke curtain.

I. Where belt conveyors are used either as part of the TBM trailing equipment or installed at any other underground location ensure that the following minimum requirements are met:

   1. Alarms shall alert personnel of starting up of any and all moving equipment.

   2. Outfit vertical and/or inclined conveyors at the portals with a deluge system. Protect the drive motor stations of horizontal conveyors either by water or dry chemical protection. Booster drives, splicing stations, tail pulleys and other fixed pieces of equipment on vertical conveyors shall be protected by fixed fire sprinklers.

   3. Test samples of conveyor belt to be used in the tunnels using a recognized testing laboratory in accordance with Mine Safety and Health Administration standards to determine the exact Fire Propagation Index. The results of the test shall be provided as part of the Design-Builder’s fire hazard analysis and shall be considered in the design of the fire protection system.

   4. Install and operate the conveyor in compliance with current federal, state, and local regulations and in accordance with the requirements of OSHA 29 CFR 1926.8 and NFPA 241.
5. Equip all belt conveyors whether on the TBM or any place underground with an approved slippage switch system design ("0" speed switch) to shut down the belt when sliding friction develops between the drive pulley(s) and the belt. The slippage switch system shall be inspected in accordance with the manufacturers' recommendations, and in accordance with NFPA 241. The most stringent shall apply.

6. Equip all conveyor belt systems with interlock systems that shut down belt conveyors when any conveyor in the system experiences an uncontrolled reduction in speed or upon activation of any fire protection system.

7. Protect or guard all fixed combustible materials from contact by the belt. Use metal or other non-combustible materials at distance of less than one-half (1/2) the width of the belt from any idler or pulley. Machinery guarding points along the belt shall also be non-combustible material.

8. Provide belt conveyors which utilize structures that do not provide a deck or platform between the upper and lower strands of belt except at necessary transfer points and belt splicing locations. Structure at transfer points and belt splicing locations shall not be constructed in a manner which will cause hazardous accumulations of materials.

9. Fire protection extinguishing equipment applicable to the hazard shall be provided at the head, tail, drive, and take-up pulley areas of belt conveyors and at intervals along belt conveyors not exceeding three hundred (300) feet (NFPA 241).

A23-1.2 Materials

A23-1.2.1 Precast Concrete Segments

A. As specified in Appendix Specification A23-2 – Precast Concrete Segmental Tunnel Lining.

A23-1.3 Tunnel Boring Machine

A. The TBM may be new or remanufactured. Remanufactured TBM shall be in accordance with the recommendations contained in the ITAtech Guidelines on Rebuilds of Machinery for Mechanized Tunnel Excavation (ITAtech Report No. 5, No ISBN 978-2-9700858-9-8, May 2015.) The firm remanufacturing the TBM shall be the original manufacturers.

B. General:

1. Design and supply a fully shielded pressurized face TBM, either EPB or Slurry TBM, for excavation of the ground and groundwater conditions described in the GDR and GBR. The groundwater shall be considered saline for purposes of equipment design including all electrical equipment. The TBM and back-up equipment shall be designed to operate in all conditions and capable of negotiating minimum curves in the alignment and meet the alignment tolerances as indicated in the RFC Documents.
2. Design, build and operate a TBM to maintain face stability and minimize engineered fill berm deformation at all times under all conditions during both excavation and periods of TBM shutdown or stoppage, including sudden losses of power.

3. Excavated diameter as produced by TBM shall be as required to produce minimal over-excavation, maintain line, grade, and the minimum necessary clearance for installation of segmental lining.

4. For access to the tunnel face and pressure chamber behind the cutterhead, fit TBM with a minimum of one compressed air lock and associated compressed air equipment designed for the maximum hydrostatic pressure to which the tunnel is exposed, but not less than five (5) bar (seventy-two (72) psi) air pressure.
   i. Provide feed-through into forward chamber independent of air lock for electrical power, water supply, high-and-low-pressure air, welding and other service lines required.
   ii. Supply low-pressure air in sufficient volume to maintain pressure in the forward chamber during all anticipated operations.
   iii. Design and operation of the airlock, medical lock and compressed air work and systems shall conform to the most stringent of all applicable local, state, and federal regulations for working in compressed air.
   iv. Provide efficient means of purging the forward chamber of hazardous gases and testing the air quality before entry.

5. Design the TBM and all of its components, to operate safely under continuous exposure to sea and/or contaminated water.

6. Implement a TBM inspection and maintenance program that shall include storage locations and site delivery plans for replacement parts and maintenance manuals with consideration to schedule limitations assumed by the Design-Builder’s work plan.

C. Excavating Tools and Cutterhead:

1. Design TBM cutterhead to have interchangeable excavation tools and cutters capable of cutting and removing hard materials including engineered fill berm material selected by the Design-Builder. Design cutter seals and bearings to perform in the full range of conditions indicated.

2. Design excavation tools and cutters to be removable from the holding blocks.

3. Provide and use conditioners required to stabilize face. Conditioners, either water, bentonite slurry, polymer or foam shall be used as required to control the movement of soils through the TBM. The Design-Builder is required to demonstrate that the performance of selected conditioning agents can maintain a satisfactory plug in the screw conveyor, if an EPB TBM is proposed, under all anticipated operating conditions or propose an alternative muck discharge system.
i. Develop a conditioner-testing program to demonstrate the satisfactory performance of proposed conditioners on deposits and the presence of seawater, during excavation to achieve the necessary consistency and to reduce stickiness, lumping, balling and abrasion. Adjust conditioners as required to optimize mining progress and transport of tunnel spoil.

ii. Provide product descriptions, dilution ratio, injection ratio, expansion ratio for polymers and other soil conditioners for ground conditions as determined by the Design-Builder.

4. Design and build the TBM for maximum abrasion resistance and durability. Design and use cutting tools and wearing surfaces for maximum life serviceability and for replacement from behind the cutterhead (back loading).

5. Provide TBM with access holes to permit drilling of probe holes and/or grouting ahead of the face in at least twelve (12) positions and through the machine skin in at least twelve (12) positions located equidistant around the circumference of the machine. Probe hole drilling and/or grouting may be required for intervention ahead of the TBM, cutterhead maintenance or on other occasions when it is necessary to access in front of the machine.

D. Thrust System and Steering:

1. Design TBM to provide forward thrust by thrust cylinders reacting against the installed segmental liner without damaging or overstressing either the liner or the thrust jacks at any time.

2. Provide thrust system that can advance machine under maximum combined reaction from earth and hydrostatic pressure, shield friction, face stabilization load, and disc or any other excavation tools. Provide jack shoes, load distribution pads, or full or partial jack ring(s) as required to obtain thrust by reacting on segmental liner without damaging the liner or thrust cylinders.

3. Provide thrust cylinders having individual actuation, synchronized actuation, and individual maximum thrust control. Thrust cylinders shall not permit displacements when idle or shut down for any reason. Provide elastic support of thrust cylinders to prevent jamming in curves and to transmit thrust force perpendicular to the segment face with minimal torque forces and minimal shear forces.

E. Drive System:

1. Provide TBM having sufficient drive motor power so the machine is not torque limited while operating TBM in ground conditions described in the GDR and GBR.

2. Provide TBM that can start cutterhead with at least one hundred twenty-five (125) percent of rated full load torque.

3. The design life of the main bearing shall be not less than ten thousand (10,000) hours with a sealing system providing protection against seawater and contamination for the same period.
4. TBM drive system shall operate the cutterhead equally in either direction of rotation (bidirectional).

F. Tunnel Spoil System (1 through 4, Not Applicable to Slurry TBM):

1. Fit and operate EPB TBM at all times with a screw conveyor (and pump system if alternative discharge to the surface is through a pipeline) to control the pressure at the face and to remove tunnel spoil from the cutterhead chamber. Design the screw conveyor for operation in abrasive and corrosive soils and for efficient replacement from within the tunnel.

2. Design the screw conveyor to be closed and sealed against maximum hydrostatic and earth pressure at both the front and the rear. Operation of the TBM in “open air or unpressurized mode” will not be permitted at any time.

3. Fit the end of the EPB TBM screw conveyor with a reliable positive displacement device (pressure lock out device) to separate the pressurized groundwater and tunnel spoil (and conditioners when used) at the end of the screw conveyor from atmospheric pressure. If the spoil is pumped to the surface the positive lock out device can be used in conjunction with the pump(s) to control the pressure on the face.

4. Design positive displacement device to operate at maximum hydrostatic and earth pressure in anticipated ground conditions. The positive displacement device shall be readily maintained or replaced from within the tunnel. Use a conveyor, rubber tired vehicles, rolling stock, or slurry pipe system as appropriate for tunnel spoil transport in the tunnel. Design the system selected for materials with abrasive fines and high water/conditioner content.

5. If a Slurry TBM is used, design the system to work under all conditions as determined by the Design-Builders. This includes the complete slurry system and conditioners required to stabilize the face and drive the tunnel.

6. Design slurry treatment plant to accommodate the types and quantities of geologic materials and soil conditioners anticipated and to remove the solids from suspension at a sufficiently fast rate so that slurry treatment does not limit the TBM advance rate. Replace or recondition slurry as needed with fresh slurry and/or conditioners when the properties are unsatisfactory.

G. Seals

1. Provide and use main bearing seals designed for the maximum pressure that can be achieved/experienced within the excavation chamber. Design the seals for the articulation joint (if applicable), tail shield and probe ports for maximum combinations of hydrostatic and earth pressure.

2. Design shield tail seals to comprise a redundant system of wire brushes to seal against maximum hydrostatic and backfill grout pressure. Also consider the liner segment design and the influence of annular grouting in seal design. There shall be a minimum of three (3) seals, which will be continuously fed with grease whenever the TBM is moving forward. All greases shall be biodegradable.

3. Tail seals other than the rear seal shall be replaceable from within the tunnel.
4. Provide an automatic system of seal lubrication with at least one (1) oil filled sealing chamber on each side of the main bearing. Equip oil system with monitoring of oil pressure and filters for cleanness to protect the main bearing. Oil and interior seals shall be capable of being changed from inside the TBM.

H. Segment Erector

1. Design the segment erector to be compatible with the weight of each segment and liner system(s) to ensure safe and efficient segment installation.

2. Design the erector to be actuated in the axial, radial, and circumferential directions and in the three (3) articulation angles corresponding to the six (6) degrees of freedom of the liner segments. Design the erector to grip and erect the segments properly such that they are positioned accurately, segments and gaskets are aligned within the required tolerances and gaskets are fully compressed, and no damage or distortion of the segments occurs.

3. Include in the erector a suitable gripping device for safely gripping and erecting the segments. Design and operate the gripping device consistent with the segment design.

4. Equip TBM with positioning device to indicate correct radial and circumferential location of the segments within the tail shield. This device shall continuously measure the gap between segments and tail shield to supply data for the ring orientation computer program which is linked to the guidance system. Equip TBM with a computerized ring selection system for determining ring type and orientation.

5. Design thrust cylinder jack shoes, load distribution pads or jacking rings to be consistent with segment and segment joint design and installation procedures, especially for installation of the key and requirements relative to advance of the machine. Do not introduce eccentric loads to the segments that create a potential for segment or jack damage, and take corrective action if jack misalignment should occur.

6. Provide special construction bars, framework, or other supports, as required, to assure safety for workers during erection of segments.

7. Provide an erector and segment installation system that installs tunnel rings in true shape and ensures tunnel segment faces are planar, and provides for mating of subsequent rings true and planar as well. This system shall include a ring orientation computer program that is linked to the TBM guidance system to optimize segment/curve alignment. Check and correct ring planarity and circularity indicated for segment tolerances.

8. Erector shall be capable of dismounting and disassembling the last fully erected ring to allow for repair and replacement of wire brush seals or of damaged segments.

I. Machine-Liner Interface

1. Maximum thrust pressure at any point and any time on the liner system shall not exceed the maximum allowable bearing pressure as indicated in the Plans approved by the Tunnel Designer.
2. Thrust pads shall not damage gaskets.

3. Equip TBM to allow continuous complete grouting (backfill) of the annulus between the concrete segments and excavated surface. Grout shall consist of a permanent, volume-stable, cementitious grout mixture. Adjust grout set-up times for compatibility with machine progress rates and planned or unplanned work stoppages. Continuously pump grout as the segment ring is pushed from the shield at sufficient pressure and volume to ensure: 1) complete and total filling of the annular void and 2) support of the surrounding ground. Provide a method of automatically controlling and measuring grout volumes and pressures. Provide grout of a type, consistency and with appropriate additives to limit its flow or the potential for connection or discharge into the waterway.

4. Grout the tail void from pipe installed along the tail shield. The grouting system and grout pipes are to be designed by the TBM manufacturer. Uniformly space grout pipes embedded in the tail shield with a redundant pipe at each location in the event that the first pipe becomes blocked. Use minimum of eight (8) sets of pipes during grout injections. Provide means of clearing blocked pipes of grout. Grouting through grout holes in segments will not be accepted as the primary method of backfill grouting.

5. Coordinate the shield tail seal and the liner system to ensure a competent seal.

6. Tail seal grease shall be compatible with the liner system gaskets and materials, shall be biodegradable, shall not contaminate the surrounding ground or groundwater and shall not in any way cause the long-term deterioration of the liner concrete, the joint connector, the gaskets, caulking, seals or joint packers. As the TBM advances, continuously inject tail seal grease under pressure to prevent groundwater or grout intrusion.

7. Provide a computer operated integrated annulus grouting system, which considers the rate of advance, grout quantities, prevailing pressures and other related variables to continuously adjust required volume of grout.

J. Provide a lock out device to prohibit tunnel advance unless annulus grouting systems are operational and providing the required grout. Guidance System and Alignment Control:

1. Equip TBM with a computerized laser guidance system capable of accurately tracking and continuously recording tunnel machine location and ring erection program permitting continuous control and setting of alignment and grade.

2. Design the guidance system to provide continuous location and position data in real time including comparison between design tunnel centerline and driven tunnel centerline and comparison of the projected tunnel location ten (10) rings ahead. The real-time comparison shall be graphically displayed to the machine operator at all times on an electronic display terminal. Data presented shall include, for every segment ring interval along tunnel centerline, design centerline stationing, as-driven coordinates and elevation, horizontal and vertical offsets from design tunnel centerline to the driven tunnel centerline, horizontal and vertical attitude of TBM compared to theoretical. Provide a comprehensive printout of displayed variables and messages that may be initiated on command or at determined intervals. Store and record data on suitable media for later use and data retrieval. Display of the information shall be made available in real time in the office of the Department.
3. Submit details of guidance system and use the system accordingly, to maintain alignment and correct any misalignment.

4. The Design-Builder shall not advance the TBM without the computerized laser system in operation and functioning correctly.

K. Other Features

1. Provide TBM with grout hole and probe drilling capability such that a minimum of fifty (50) feet of probe or grout hole can be maintained ahead of TBM cutterhead, when required. Equip probe hole penetrations with blow out prevention devices to prevent water intrusion into the tunnel.

2. Provide TBM with automatic data acquisition system in accordance with Appendix A23-3 Tunnel Boring Machine Data Acquisition and Monitoring to graphically display and record in real time at a minimum. Display information to a minimum of two (2) surface offices, one (1) of which shall be the office of the Department. Automatic data acquisition system is to be fully available for reading and recording of all data in the Department’s office in real time, twenty-four (24) hours per day.

3. Provide a minimum pumping capacity of water from the tunnel at the TBM heading during construction as determined by the Design-Builder.

4. Provide TBM trailing gear with rail mounted gantries or rubber wheels. Gantries riding on skids will not be permitted.

5. Provide a TBM with proof grouting drilling equipment. Drilling equipment and associated staging to enable recovery of tail void grout samples and proof grouting at any position around the ring.
A23-1.4 Procedures

A23-1.4.1 Construction

A. Tunneling

1. Perform tunnel construction, using and maintaining required products, to minimize movement of ground in front of, surrounding, and above the tunnel, to control water and water inflow and attendant soil transport, limit its flow or the potential for connection or discharge into the waterway above and to minimize subsidence of ground surface, waterway bottom, structures, and facilities above and close to tunnel for all ground conditions which are to be encountered as determined by the Design-Builder.

2. Notify the Department immediately upon detecting slurry or tunnel spoil spills. No work can be performed without implementing mitigation measure to prevent any further spills.

A23-1.4.2 Monitoring and Control

A. Engineered Fill Berms

1. Monitor the deformation and elevations of the engineered fill berms.

2. If the measurements indicate excessive deformations are occurring, take corrective measures, in accordance with procedures provided by the Design-Builder’s contingency plans. The Engineer of Record shall specify the limits of deformation for which actions are required.

3. If excessive deformations are occurring, take additional readings on affected sections of the berms. Take readings daily or more often if required, and after each shove of the shield if the tail shield is within one hundred (100) feet of the section exhibiting excessive deformation.

B. Segmental Ring

1. Monitor the deformation and convergence elevations of the tunnel liner segments.

2. If the measurements indicate excessive deformations are occurring, take corrective measures, in accordance with procedures provided by the Engineer of Record. The Engineer of Record shall specify the limits of deformation from the nominal ring diameter measured at the time of complete emergence from the TBM tailshield and completion of ring grouting.

3. If excessive deformations are occurring, take additional readings on affected sections of the liners. Take readings daily or more often if required, and after each shove of the shield if the tail shield is within ten (10) rings of the section exhibiting excessive deformation.
4. Take measurements of horizontal and vertical diameters for tunnel support ring. Complete record of measurements shall also include records of grouting for each ring daily.

5. For each erected ring, complete an individual record, of all relevant construction information, including but not limited to the following data:
   i. Time excavation started and finished.
   ii. Time lining erection started and finished.
   iii. Orientation of lining ring (position of key).
   iv. Grout pressures and quantities.
   v. Clearances between erected ring and the tailskin at crown and invert and at both springline locations. The distance between the tailskin and the backside of the segments shall be continuously measured and transmitted to the ring erection program.
   vi. Delays during shoving or lining erection.
   vii. Problems encountered, e.g. water seeps.
   viii. Damages to lining segments during erection or after start of shoving for the next ring.
   ix. Soil type/classification.

6. Replace segments that are damaged during the first twelve (12) inches of shove. Design the TBM segment erector that is able to retrieve segments in this position. Design segments to be removable under these conditions as well.

C. Water Inflow in Finished Tunnel

1. If water inflow into the tunnel exceeds that allowed per the Technical Requirements, undertake remedial measures as previously submitted and approved.

2. Establish grout injection pressure through the liner. Do not exceed the maximum grouting pressure as specified by the [Engineer of Record].
Appendix A23-2 – Precast Concrete Segmental Tunnel Lining

A23-2.1 General

A23-2.1.1 Description

A. The work specified in this Appendix consists of manufacturing, installing, erecting and performing operations necessary or incidental to provide complete precast concrete bolted, gasketed segments for final liner rings capable of rapid erection within the Tunnel Boring Machine, and resisting loads imposed during manufacture, handling and transport.

B. Design concrete segments, gaskets, and associated items for anticipated ground and water loads and environmental conditions on the completed tunnel. Design-Builder shall ensure that the segments are compatible with its selected construction equipment, means, methods, and procedures including, but not limited to, handling, erecting, jacking, and grouting.

C. Design rings to provide changes in tunnel alignment and elevation.

A23-2.1.2 Quality Control

A. Design-Builder shall submit its quality control plan that includes but is not limited to all of the following requirements. This quality control plan is in addition to the requirements in Project Management Technical Requirements.

B. Qualifications of manufacturer:

1. Tunnel segments shall be designed by a firm regularly engaged in the design of precast concrete bolted, gasketed tunnel lining segments of similar dimensions and tolerances to those required for the Project. The tunnel segment designer shall have designed bolted, gasketed tunnel lining segments installed as permanent lining below the groundwater table for at least three (3) projects comparable to the Work in size (more than 20-ft in diameter) and type (final lining) to be used for the Project.

2. The manufacture of tunnel segments shall be supervised during all facets (forming, casting, stripping, loading) of segment production by personnel experienced in the manufacturing of precast concrete segmented tunnel liner panels and installation of integral gaskets, having been employed on at least three (3) projects comparable to the Work in size and type (final lining) to be used for the Project.

3. The manufacturing plant shall be certified by the PCI Plant Certification Program prior to the start of the tunnel segment production.

C. Inspection and Testing:

1. Design-Builder shall employ an independent testing laboratory during manufacturing, certified by VDOT or equivalent governmental agency, to provide required inspection and testing.

D. Dimensional Tolerances:

1. Fabricate segments to design dimensions and tolerances as determined by the Design-Builder.
2. Provide labor, equipment, templates, and facilities necessary for inspecting manufactured segments.

3. Provide a tolerance measurement system, for segment acceptance, to account and adjust for thermal, moisture, and ambient temperature influences.

4. Manufacture similar segments with such accuracy and uniformity in dimensions that they will be entirely interchangeable not only within individual rings but with segments of other rings.

E. Demonstration Liner - Before installing precast liner rings in the tunnel, prepare one (1) demonstration liner comprising two (2) complete precast concrete segmented rings to demonstrate the proposed method of construction provides a liner within the tolerances required.

1. Furnish to the Department a thirty (30) day written notice prior to initiating assembly of the demonstration liner.

2. Assemble entire demonstration liner rings (test ring) above ground, with longitudinal axis vertical to demonstrate the accuracy of segments within the allowable tolerances. Provide temporary support structures, such as base cradle and lateral bracing, under cover, equipped with hoisting capacity.

3. For demonstration liner, select segments randomly from different lots and store until mock-up is assembled.

4. Maintain demonstration liner intact until tolerances of completed ring is verified.

5. If demonstration liner is not within tolerances, dismantle liner, adjust forms, cast new segments if necessary, and erect new demonstration liner.

6. Maintain one (1) ring of the demonstration liner as a master ring to ensure that tolerances are being maintained.

F. Production Units - Continue production of segments after successful completion of the demonstration liner.

1. At a minimum frequency of one (1) of every five hundred (500) castings from each mold, build rings from segments picked at random on the master ring to demonstrate interchangeability and ensure tolerances are being maintained.

G. Source Quality Control - Factory Tests:

1. Provide written notice at least thirty (30) days before starting manufacture of segments, to allow the Department to inspect place of fabrication.

2. Allow the Department access to work areas, and provide sufficient office space, workers, and equipment for performing inspections.

3. Provide equipment including master and working templates, gauges and calipers adequate to determine accuracy and tolerances in manufacture.
4. Obtain three (3) certified tests each, by a qualified independent laboratory, satisfactorily demonstrating the following: tensile capacity, shear capacity and maximum locking capacity of the joint connector assemblies with up to a 0.20-inch gap on longitudinal/circumferential joint; (yield) pullout capacity on radial joint bolt assemblies. Include actual joint connector assemblies.

H. Markings - Markings such as logos, trademarks and proprietary information, except panel identification markings, are prohibited on surfaces of tunnel liner segments.

I. Reference Standards:

1. American Concrete Institute (ACI):
   i. ACI 224R Control of Cracking in Concrete Structures;
   ii. ACI 503.4 Repairing Concrete with Epoxy Mortars; and
   iii. ACI 517 Recommended Practice for Atmospheric Pressure Steam Curing of Concrete.

   i. ASTM A36 Standard Specification for Carbon Structural Steel;
   ii. ASTM 1064 Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete;
   iii. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement;
   iv. ASTM C39, Compressive Strength of Cylindrical Concrete Specimens;
   v. ASTM C920 Standard Specification for Elastomeric Joint Sealants;
   vi. ASTM D395 Standard Test Method for Rubber Property – Compression Set;
   viii. ASTM D471 Standard Test Method for Rubber Property - Effect of Liquids;
   ix. ASTM D1171 Standard Method for Rubber Deterioration – Surface Ozone Cracking Outdoors and Chamber (Triangular Specimen);
   x. ASTM D638 Standard Test Method for Tensile Properties of Plastics;
   xi. ASTM D1149 Standard Test Methods for Rubber Deterioration - Surface Ozone Cracking in a Chamber;
   xii. ASTM D2240 Standard Test Method for Rubber Property - Durometer Hardness
xiii. ASTM F436 Standard Specification for Hardened Steel Washers;

xiv. ASTM F593 Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs; and


A23-2.1.3 Submittals

A. The Design-Builder shall submit the following in accordance with Section [X.XX] of the Technical Requirements:

1. Name of segment and gasket manufacturers, names and experience of personnel managing the precast concrete plant, and list of comparable tunnel projects and names of clients and contact information where manufacturer's segments have been used.

2. Shop Drawings of each type of segment showing complete details of formwork, reinforcing, mechanical joint connection assemblies, dowels and dowel connectors, joint relieves, gasket grooves, gaskets, grout/threaded lifting sockets and plugs, inserts, and accessories necessary as needed for manufacture, transportation and erection.

3. Structural design calculations, drawings and description of construction methods, to maintain and preserve integrity, strength and rigidity of formwork, lining and tunnel, prepared, signed and sealed by an engineer registered in the Commonwealth of Virginia with a minimum of ten (10) years of precast tunnel liner experience.

4. Concrete mix including ingredients, water tests, trial mixes, and results of concrete tests in accordance with the Technical Requirements Section [X.XX].

5. QC plan and protocol to ensure the production concrete can meet the Project Service Life requirement.

6. Name, location and qualifications of certified independent testing laboratory.

7. Material specifications for components of joint connection systems and specifications describing pullout capacity, material properties of the bolted and dowelled assemblies, methods to verify proper assembly during installation in tunnel, and demonstrations that these materials can satisfy project service life requirement.

8. Procedures:
   i. Detailed description of procedures for manufacturing, casting, curing, handling, transporting, storing, erecting and repairing segments, including calculations of stresses developed during handling, transporting, storing, erection and jacking.
   ii. Include plans to control shrinkage and temperature cracking of segments.
   iii. Detailed design for segment lifting devices, grout/threaded lifting sockets, grout plugs and reinforcing spacers and chairs. Allow for complete removal of lifting devices intruding into tunnel space.
   iv. Details showing layout of facilities for casting, curing and storing segments.
v. Details of joint connection pull-out capacity testing.

vi. Curing process for segment casting to twenty-eight (28) days after casting including:
   a. Test data including temperature gradient measurements from trial segments; and
   b. Data establishing the strength gain and curing time relationship at the raised temperatures anticipated during the curing process.

vii. Methods for testing and data to show the proposed consolidation and curing process will result in uncracked segments with the required strength and diffusion properties.

viii. Methods to verify design strength of the segments has been attained prior to use on site using a combination of in-place strength testing, and comparison with strength gain maturity curves, verified by test cylinders.

ix. Gasket manufacturer's quality control plan ensuring consistency of gasket material and dimensions.

x. Methods for identification of each segment including segment type with match marks, date and shift cast, and serial number including mold identity.

9. Samples of following:
   i. Compression (EPDM) gasket: five (5) linear feet and one (1) corner assembly;
   ii. Adhesive: one (1) pint each type used;
   iii. Joint connector assemblies: two (2) each set;
   iv. Compression packing: three (3) feet;
   v. Lifting sockets: two (2);
   vi. Reinforcement spacers and chairs: three (3) each;
   vii. Inserts: two (2) of each type proposed;
   viii. Foam strips used to prevent backfill grout from traveling along joints: two (2) feet; and
   ix. Segment bolts: two (2).

10. Manufacturer's product data and manufacturer’s certification that products used in segment production meet the requirements of this Section.

11. Notice of start of assembly of demonstration liners.
12. Methods to protect segments from direct sunlight and weather if stored outside.


15. Segment repair and rejection criteria.

A23-2.1.4 Product Delivery, Storage and Handling

A. Transport, store, and handle units to avoid damage and prevent excessive stresses in segments.

B. Use supports for storing segments to avoid damage; do not subject segments to undue strains.

C. Prevent damage to segment surfaces during handling and storage. Keep wire ropes, chains and hooks from direct contact with segment surfaces, joint assemblies, gaskets and joint packing.

D. Ensure selection of segments provides for required tunnel geometry, and for making alignment corrections as necessary during construction.

E. Demonstrate that storing of segments with joint compression packing and/or gaskets out-of-doors does not cause segments to materially deteriorate.

F. Inspect completed segments before loading. Discard defective and damaged segments; repair minor damage in accordance with procedures developed by the Design-Builder’s designer and accepted by the Department.

A23-2.2 Materials

A23-2.2.1 Precast Segments

A. Precast Segments shall meet all the requirements of the design and the durability requirements as required by the tunnel lining designer and as specified herein including gaskets, compression packing, mechanical joint connection systems, dowel connectors and other accessories required in the manufacture and erection of the tunnel lining. Manufacture of the precast concrete segments shall not commence until final review of the lining design; durability report and specification of materials and products has been accepted by the Department and until the concrete mix design has been tested and accepted by the Department.

A23-2.2.2 Miscellaneous Structural Steel

A. Provide seal plate, ring angles – Conform to Type 316/316L Stainless Steel.

A23-2.2.3 Gaskets

A. Segments shall be supplied with double EPDM water proofing gaskets on each segment piece at all four edges of each segment. All gaskets shall be anchored and cast directly into the concrete segment. EPDM gaskets shall be dense elastomeric synthetic rubber type, free of blisters, porosity, pitting, and other imperfections, manufactured as a continuous frame, with fully molded gasket corners mitered on each side, and vulcanized to provide uniform gasket thickness along entire length of mating surfaces. Segmental liner gaskets shall be designed to prevent the formation of an incompressible rubber hard-point at the gasket corners due to vulcanization of mitered joints.
B. Performance

1. Gasket Groove Loads - Demonstrate through a combination of engineering analysis and laboratory experiments that the EPDM gasket will not exert excessive loads on gasket groove of concrete tunnel liner under any possible combination of manufacturing and installation tolerances that can exist.

2. Groove Design - The Design-Builder shall design the grooves to suit the selected gaskets.

3. Water-tightness - Provide watertight seals even when complete closure of concrete tunnel liner segments is not possible because of manufacturing and installation tolerances. Prove by laboratory testing that at T-shaped joint between two (2) tunnel liner rings (three (3) liner segments) gasket will resist, without leakage, a minimum water pressure of twice the design pressure as determined by the Design-Builder under a combination of gasket differential gap and gasket bearing surface offset conditions. Gasket differential gap is defined as difference between gasket vertical deflection at optimum gasket compression and actual gasket vertical deflection as tested. Gasket differential gap and bearing surface offset conditions for testing are as described below. Resist twice the design water pressure as determined by the Design-Builder in the following configuration for four (4) continuous weeks without leakage:
   i. Along the longitudinal/circumferential joint, a differential gap of 0.08 inches on one (1) side of the longitudinal/circumferential joint, and a differential gap of 0.20 inch on the other side of the longitudinal/circumferential joint.
   ii. Along the longitudinal/circumferential joint, a differential gap of 0.20 inch, and a bearing surface offset of 0.40 inch.
   iii. Circumferential differential gap: 0.20 inch; and bearing surface offset of 0.40 inch.

4. Prediction of Future Performance - Demonstrate by combination of engineering analysis and measured performance of gasket that gasket can be expected to perform its intended function over a design life of one hundred (100) years for the ground conditions expected for this project. Use projected performance based on results of accelerated testing to demonstrate that the material properties specified will remain sufficient to seal the tunnel in similar or more damaging ground and groundwater conditions than anticipated. At a minimum, complete the following testing: load deflection test; watertightness test; short-term relaxation; and long-term relaxation.
5. Gasket material shall not suffer any adverse effects when exposed to groundwater at pressures up to a minimum of twice the design pressure calculated by the Design-Builder.

C. Experience with Gaskets - Demonstrate that tunnel liner gaskets have performed successfully in tunneling operations of similar applications.

D. The Design-Builder shall provide the gasket supplier’s detailed proposal for method of quality control to ensure consistency of material and dimensions of the gaskets. Before manufacturing gaskets in quantity, the manufacturer shall make trial units and fit them to actual segments so that the correct amount of stretch can be ascertained to ensure a secure fit to segment. The gasket supplier shall be present to oversee the gasket installation for the first twenty (20) rings of tunnel liner cast.
A23-2.2.4 Molds

A. Fabricate molds with machined steel mating surfaces to conform to the dimensions and tolerances required and provide segments with smooth casting faces such that a true, sound concrete surface is formed, free from irregularities, welding blemishes, or stains.

B. Segments of common dimensions but cast in different molds shall be interchangeable.

C. Provide molds with individual identifications to ensure that all segments cast are marked and fully traceable.

D. Form mold joint surfaces to provide flat planes. Joint planes shall lie perpendicular to the tangent or the surface of the segment at the joint.

E. Make all inserts to form bolt pockets, holes, grout holes, etc. of steel or materials having a coefficient of thermal expansion similar to that of concrete.

F. Provide steel templates, gauges, and a testing apparatus to enable the measurement of tolerances that ensure each segment falls within the maximum and minimum dimensions required. Keep protected from damage and distortion, free from dirt and corrosion and ready for use in checking the segments.

A23-2.2.5 Inserts, Anchors, Bolts, and Accessories

A. Inserts, bolts and anchors shall conform to ASTM F593 standard specifications for stainless steel bolts, hex cap screws and studs utilizing Type 316 Stainless Steel. All washers for bolt assemblies shall be manufactured of Type 316 Stainless Steel. All grout/threaded lifting sockets, grout plugs and related embedded items shall be either stainless steel conforming to ASTM F593 or plastic inserts conforming to ASTM D638 Test Method for Tensile Properties of Plastics.

A23-2.3 Procedures

A23-2.3.1 Workmanship

A. Furnish segments to be connected across radial joint and longitudinal/circumferential joints faces. Provide joint connection assemblies to facilitate structural performance, achieve and maintain maximum joint close down, required gasket compression, ring circularity and assist in ring stabilization. Design-Build shall design for loads across joint connections, along circumference, to maintain joint and installation performance and invert loads along longitudinal axis of tunnel derived from transport of equipment and materials, and loads generated by grouting, handling, erection and tunnel boring machine.

B. Provide gasket grooves and gaskets as designed. Joint surfaces upon or against which gasket can bear shall be smooth, free of spalls, fractures and imperfections that would adversely affect performance of joint. Design segment joints to withstand forces caused by compression of gasket, without cracking or fracturing.

C. Provide compression packing on longitudinal/circumferential joint faces. Design longitudinal/circumferential joint to provide full closure of gaskets with compression packing in place, and to prevent over compression and damage to gaskets from thrust loads and loads across mechanical connections. Design longitudinal/circumferential joints to provide full closure of gaskets when the segments are in contact. Compression packing on radial joints may be used but it is not required.
D. Provide each segment with a grout hole. These grout holes shall only be used in the event of temporary malfunction of tail shield grouting system and shall not be used as the primary grouting location and for performing annulus grout proof testing.

E. Identification of Segments

   1. Provide positive means of identifying each segment indicating the following information:
      
      i. Segment type designation;
      
      ii. Date of manufacture;
      
      iii. Serial number; and
      
      iv. Mold number.

   2. On tapered rings, indicate joint designation on inside face of liner segment and identify tapered side, or sides, by letter T.

F. Workmanship - Surface Finishes

   1. Ensure that the maximum local irregularity on formed surfaces does not exceed a rounded protrusion of 1/64 inch above the general concrete surface form.

   2. Segment casting and preparation shall include steel trowel finish for extrados of the segment such that the local maximum irregularity shall be a rounded protrusion of 1/16 inch above the general surface.

A23-2.3.2 Formwork and Finishing

A. Fabricate steel forms with machined steel mating surfaces to conform to the dimensions and tolerances required, ensure segments of common design and cast in different molds are interchangeable. Joints shall be watertight.

B. Provide steel templates, gauges and testing apparatus to enable the measurement of tolerances to ensure that each segment falls within two (2) concentric volumes in space represented at the maximum and minimum dimensions required. Keep suitably protected from damage and distortion, free from dirt and corrosion and ready for use in checking the segments.

C. Clean and coat forms with non-staining release agent before each reuse.

D. Ensure smooth surfaces for application of adhesive.

E. Accurately place any reinforcing steel with required tolerances. Cages shall be sufficiently rigid to prevent deformation during manufacturing process.

F. Securely anchor form inserts and embedded items to formwork.

G. Check each form before and after production pour to ensure tolerances are maintained.

H. Formed surfaces - Smooth form finish.
I. Back face - Segment shall be finished by a wood float or trowel. Provide a finish smooth and free from blemishes to ensure good surface contact is achieved with tailskin seal of tunneling machine.

A23-2.3.3 Segment Casting Preparation

A. Fix concrete spacers and chairs so that the reinforcement is held firmly in the correct position within the formwork with required cover. The spacers shall be rigidly fixed to the reinforcement to prevent displacement. If the spacers are wired on, the ends of the wires shall be turned into the unit.

B. Do not use spacers or chairs in the longitudinal/circumferential or radial joint regions. The joint regions are the areas up to four (4) inches from the joint surface.

C. Make mortar spacers and chairs compacted and cured to the same standards as the segments. Only mortar spacers and chairs shall be used.

D. Saturate all spacers and chairs with clean water prior to use. Spacers shall not be allowed to dry out after being fixed to reinforcement cages before the concrete is cast.

E. Cast dimples marks on the inside of segments to mark locations clear of reinforcing steel and any other items where holes can be drilled for attaching tunnel service utilities without interfering with reinforcement.

A23-2.3.4 Segment Casting

A. Produce segments under plant controlled conditions with production areas protected against rain, dust and direct sunlight.

B. Protect all segments from hot and cold weather at all times during production.

C. Ensure concrete is in complete contact with forms and embedded items. Consolidate concrete adjacent to side forms and along the entire length of forms to ensure a smooth surface finish after stripping of formwork.

D. Gauge the first segment cast in any form. Gauge one (1) in fifty (50) segments cast from each form, as a minimum, to ensure dimensions and tolerances of segments from all forms are maintained. If out of tolerance segment is found, do not use that segment in the work or any other segments from the form found to be out of tolerance. Check at least the previous fifty (50) segments from that form. When any variation in segment quality has occurred, the number of segments gauged shall be increased to that required to re-establish the accuracy and consistency of production.

E. Keep a record of all the units cast in each form and any form that becomes distorted or which casts faulty units shall be withdrawn from service until it is proved to be corrected.

F. All units of the same type shall be interchangeable and the required dimensions for each unit shall be accurately reproduced within the tolerances required.

G. Check reinforcement cages and other embedments within each mold.

H. Verify that the segments have attained the design strength prior to shipping through a combination of in-place strength testing and comparison with strength gain-maturity curves. Verify results with cylinder tests from concrete cured with segments.
I. The segments shall be delivered to the tunnel excavation sites in undamaged condition.

A23-2.3.5 Curing

A. If steam curing is used, conform to Section 3.04 of ACI 517 and meet the following additional requirements:

1. Immediately after segments have been cast, place forms in a sealed, vapor-tight enclosure to prevent escape of moisture and heat, but large enough to allow complete circulation of steam.

2. Do not attempt to remove segments from forms until adequate compressive strength is attained, as determined by test cylinders. Increased compressive strength will be required before removal of segments from forms if there is evidence of: distortion, cracking, spalling or similar damage that could have occurred during handling and storage of segments.

3. Enclosure Ambient Temperature - Do not exceed one hundred degrees (100°) F for first two (2) hours of curing; then maintain temperature between ninety degrees (90°) F and one hundred forty-five degrees (145°) F until required curing strength is achieved.

4. Segments shall be steam cured while in molds.

5. Segments shall be moist cured for a minimum of five (5) days after manufacture. After the steam curing the moist curing shall be achieved by placing the segments in a special area where water shall be continuously sprayed or atomized, to ensure a one hundred percent (100%) relative humidity environment.

6. Protect the segments from thermal shock. Utilize thermal blankets to minimize thermal shock. Do not allow rate of change of temperature to exceed thirty degrees (30°) F per hour. Do not allow a concrete temperature difference of more than fifty degrees (50°) F between any two (2) points of the segment at any time during the curing process. Trials of full sized segments shall be conducted with suitable instrumentation to demonstrate conformance with the above temperature gradients.

A23-2.3.6 Concrete Testing

A. Mix Design and Curing Strength Test

1. Before start of manufacture, establish concrete mix that will produce concrete of required compressive strength and other characteristics as required by tunnel lining designer.

2. After acceptance by the Department of the initial mix design has been obtained, make six (6) cylinders from a single batch of concrete.

3. Prepare cylinders before start of manufacture. Remove in pairs at appropriate time intervals during curing, and test immediately upon removal to establish correct curing duration.

B. Production Test Cylinders

1. Prepare three (3) cylinders and cure as required for each work shift or for everyone hundred (100) cubic yards of concrete used, whichever is more frequent.
2. At weekly intervals during segment manufacture, prepare two (2) cylinders from same concrete batch and cure in same manner as segments; demonstrate minimum strength for form removal is being attained. If average strength of two (2) cylinders is less than required, cure related tunnel liner segments for a longer time and demonstrate minimum cured strength is met.

A23-2.3.7 Delivery to Site

A. Provide the Department a complete copy of all Bills of Lading. The Bills of Lading shall show the number of segments, the date of manufacture, the identification markings of each segment and individual inspection certificates.

B. Ensure segments have attained the specified design strength prior to loading.

C. Inspect the segments, remove defective or damaged segments, and repair any minor damage, in accordance with specified procedures prior to loading segments.

D. Shipped segments shall be in units of complete rings, all properly identified.

A23-2.3.8 Erection of Tunnel Lining

A. Construct rings to correct line and grade, in true circular form to preserve the circular form of tunnel, and preserve true plane of face of rings, and in a manner which will not throw ring out of position or dislodge previously erected rings.

B. Provide continuous annulus grouting to prevent ring deflection after ring has left shield tail area.

C. Inspect concrete segments, joint connection assemblies, compression packing and gaskets before being taken underground and just before erection. Segments with imperfections and damage shall be repaired or replaced.

D. Install segmented tunnel lining system to dimensions and tolerances for line, grade and circularity indicated and required; within required design tolerances indicated for joint and structural performance.

E. Ensure tail seal grease used is compatible with gasket and concrete.

F. Keep shield invert clean and free of soil and water before erection of each ring. Ensure joint surfaces of segments are clean before erection.

G. Ensure gasket compression across longitudinal/circumferential joints meet requirements before jacking of shield ahead of segment ring. Maintain optimum joint closure tolerances during erection of subsequent rings.
H. Do not apply loads or eccentricities to segments or gaskets that are detrimental to lining system during erection sequence. Furnish and apply gasket lubricant (liquid soap) to gaskets prior to erection of segments.

I. Do not add packing or material to joints to adjust line and grade or negotiate curves.

J. Hangers for utility lines necessary for construction of tunnel may be connected to concrete segments; do not interfere with proper erection of each ring. Cast or drilled holes shall be placed only at locations where there is no reinforcement (as indicated by dimples).

K. Radial joints shall be staggered from ring to ring to avoid cruciformed joints.

A23-2.3.9 Repair of Defects

A. Prior to lining installation, repair minor damage to concrete segments before erection by removing defective/damaged area to sound concrete and patching with materials and procedures reviewed and accepted by the Department. Prepare a table covering procedures for repair of segment defects and acceptance criteria. Table shall include a description of the Type, and extent of damage, and repair procedure in accordance with ACI 224R and ACI 503.4, or basis for rejection of segment.

B. Report any segment that shows excessive cracking, change or defects to Department. Assess the cause of defects and their prevention mitigations, in a report, to the Department for review. Segregate and identify segments accepted for repair as to the class of defects(s). Mark and dispose of rejected segments immediately.

C. Major damage or irregularities to a concrete segment which impair structural integrity or performance will be cause for rejection of segment by the Department.

D. Clean and repair, before erection, all oil stained and unsightly rings that would otherwise visibly show after erection. Clean all rings that have been become stained during or after erection.

A23-2.3.10 Inspection of Precast Concrete Segments

A. To measure and determine accuracy of manufacture, provide and make available at all times, master templates and working templates, gauges, calipers and other equipment as may be required to inspect the segments.

A23-2.3.11 Proof Grouting

A. Proof Grouting includes drilling through segmental liner and Tail Void Grout and injection of grout through drilled hole. Proof Grouting shall be completed as follows:

1. At every 5th ring for the first 600 feet of tunnel.
2. At a maximum interval of 1000 feet at all other locations.
3. At up to 40 rings to be selected by the District. These locations are in addition to the proof grouting requirements listed above.
4. At ring(s) for which annular grouting warning levels and/or critical levels are triggered. Annular grouting warning and critical volumetric and pressure levels shall be established by the segmental liner EOR.

5. Proof Grout until volume specified by segmental liner EOR is injected at maximum pressure established for Tail Void Grouting in a two (2)-minute period.
Appendix A23-3 – Tunnel Boring Machine Data Acquisition and Monitoring

A23-3.1 Data Monitoring

The tunnelling process shall be monitored and documented in an adequate and state-of-the-art way to support a safe, controlled and undisturbed tunnelling operation.

a) The Client requests the Constructor to supply and maintain a Tunnelling Monitoring and Documentation System throughout the project.

It shall consist of the Software, Hardware and the relevant connections as described below.

The Client shall have full access to the Software with all functions.

b) The Constructor shall make available, maintain and keep permanently operational the necessary LAN to allow On-Site Access and Remote Access, as specified below.

The Constructor shall share this Tunnelling Monitoring and Documentation System with the Client. The access definitions support various levels of detail for Constructor’s and Client’s staff and representatives, depending on the project role, as to be determined.

A23-3.2 Definitions

For this tender, the following definitions shall apply in this section:

1.1.1 Software

Computer system to realise the monitoring and documenting task as described in the Specifications. The Software includes, but is not limited to, the data base software, database management system, front-ends, interfaces and back-up utilities.

1.1.2 Hardware

Describes the Data-Server, on which the Software is installed. The Data-Server is connected to LAN and Internet.

1.1.3 Real Time Data Transfer

Immediate and permanent data transmission of the raw sensor readings without delay or interruption. Transmission as soon as the data are generated by the installations.

Data retrieval frequency of a full set of Data shall be not larger than one (1) second, not limited by the number of indicators.

1.1.4 Data

None of the Data, whether generated manually or automatically by the Constructor’s installation and equipment, as listed in the relevant section, shall be withheld from the Software. The Constructor shall submit for acceptance, the list of items of data to the Client and the Construction Management.
1.1.5 **Local Area Network (LAN)**

The LAN is the fixed cable connection between Hardware, the Client’s and his representative’s work offices and locations, the TBM, and the access points for the tunnelling management to integrate the required data and to access the internet.

1.1.6 **On-site Access**

All connections to the Software via LAN with a transmission speed not less than 1 Gbit/s.

1.1.7 **Remote Access**

Uninterrupted access to the Software by Internet broadband. Connection shall permit for unlimited maximum licensed users (expected are up to (200) two hundred), parallel and simultaneously. Access shall be secured and encrypted (for example virtual private network, VPN).

1.1.8 **Time Stamp**

Time allocation for each set of data, set to indicate the time of measurement.

A23-3.3 **General Software Capabilities**

The Software shall permit at least the following general features as described in this section.

1.2.1 **Data Visualization**

The Software shall permit real-time display, in numerical form, of all data, such as trend indicators, status indicators and graphs or logic elements which are based on time, ring chainage, or tunnel meter and combinations there-of.

1.2.2 **Mathematical Module**

The Software shall offer a mathematical module to permit the individual creation of additional information/indicators, based on existing data. The additional information/indicators, together with all other data, shall be calculated and displayed in real time on the main Software and all Subsystems.

1.2.3 **Reporting**

The Software shall permit the individual user to design reports within the Software. The user shall be able to organise individually, the timing and distribution of reports, as well as the visibility of reports according to the individual user’s role.

1.2.4 **Monitoring and Notification**

The Software shall monitor the actual tunnelling process. It shall alert and notify if any parameters indicate deviation from the expected data range. The Monitoring and Notification system shall be fully customizable. It shall permit to select the data to be monitored on 24/7 basis and shall allow for individual trigger settings, depending on the TBM operation mode, the chainage and the time. The notifications shall be distributed according to user roles and the stage of escalation, and shall be sent by email, SMS and on special software screens.
1.2.5 Mobile Subsystem

The Software shall offer mobile solutions, preferably as Apps for mobile devices, to display and manage real-time data (continuous live stream or single screen shorts), historical data (incl. trend charts), notifications, shift reports (display, manipulation and sending), instrumentation data (incl. trend charts) and QM/QC for segmental lining including repair documentation.

A23-3.4 General Hardware Capabilities

The Hardware shall be designed, manufactured, installed and connected to support the Software during parallel operation of all users (number as specified).

It shall prevent data loss by supporting an adjusted back-up plan, (RAID 10) and shall be equipped with uninterruptible power supply (UPS).

The Hardware shall permit unimpeded data transmission and storage without data loss in critical situations, for example during link interruption between TBM and outside server.

The Hardware shall be designed for operation in the designated environment.

A23-3.5 Required Data and Transmission

The Contractor shall make available all data sources and sensors, provided in Real Time Data Transfer.

1.4.1 TBM and Tunnelling Data

Regardless of the TBM type, as a minimum the following Data shall be measured, digitalised and transmitted by LAN to be integrated into the Software.

These data incorporate, absolute and relative to advance and time, all respective concentrations, relations, weights, volumes, pressures, temperatures, rotation speeds, strokes, elongations and indications for all functions and machineries.

These requirements apply to the following tunnelling systems:

a) Excavation equipment machines and interrelated parts.

b) Material handling systems from the working chamber to ground surface, including separation plant.

c) Sealing systems.

d) TBM and back-up.

e) Thrust and steering systems.

f) TBM and tunnel guidance data.

g) Tunnel lining installation, including type and position, clearance inside shield tail before and after installation.

h) Temporary and permanent backfilling of tunnel lining.

i) All consumption materials.
j) Safety including breathable air components.

k) Ground probing and prediction systems.

l) Ground water management and discharge.

1.4.2 Settlement Measurements / Geo-Monitoring
According to the specification in the relevant section the manually or automatically acquired data must be made available, structured to be integrated into the Software. Automatic readings shall be available in real time. Manual readings shall be integrated into the Data Base no later than 6 hours after measurement. The measurement systematic and Software integration plan shall be submitted by the Constructor for acceptance by the Client, according to the submittal schedule in the relevant section.

1.4.3 Shift reports
According to the specification in the relevant section of this document the data from the shift reports must be integrated into the Software. Automatic readings shall be available in real time. Manual readings shall be integrated into the Data Base no later than 2 hours after end of shift. The reporting content, systematic and Software integration plan must be submitted by the Constructor for acceptance by the Client, according to the submittal schedule in the relevant section.

1.4.4 Quality Management Tunnel Lining
According to the specification in the relevant section of this document the data from the QM/QC of the tunnel lining must be integrated into the Software. This shall include all production data of the pre-fabricated lining elements supplied with electronically readable labels, such as bar codes. Data of the installation process, the position and possible damages and repair works must be integrated into the Software. Automatic readings shall be available in real time. Manual readings shall be integrated into the Data Base no later than 4 hours after end of shift.

The data integration plan for this requirement must be submitted by the Constructor for acceptance by the Client, according to the submittal schedule in the relevant section.

1.4.5 Air Quality – Tunnel
According to the relevant section of this document data of the air quality shall be collected in real time and monitored. Trigger levels shall be implemented for all individual sensor types to give a) alert, and b) warning by immediate notification when the specified pollution levels are reached (see relevant section). The Software shall send out the alarms as well as pass the information directly to the TBM operator.

Data, as well as the receipts of confirmation of warning, shall be recorded and stored. The data integration plan for this requirement must be submitted by the Constructor for acceptance by the Client, according to the submittal schedule in the relevant section.
A23-3.7 Data Integrity and Consistency

a) The Constructor shall ensure data integrity in every project phase.

b) The Constructor shall ensure that all provided data is consistent and accurate. All data must be non-contradictory to the project context.

c) The Constructor shall inform the Client immediately and in writing about possible failure to fulfil a) and b).

d) In case of data transfer failure, the Constructor shall re-establish the data transfer within 6 hours. The Constructor shall undertake all efforts as reasonably possible, to make available the missing data for enclosure into the Software.
SECTION 24. IMMERSED TUBE TUNNEL

24.1. Scope

A. This Section 24 provides the requirements for the Immersed Tube Tunnel (ITT).

B. The following Appendices apply to this Section 24:
   1. Appendix A24-1 Immersed Tube Tunnel Construction;
   2. Appendix A24-2 Immersed Tube Tunnel Backfill and Protection Layer;
   3. Appendix A24-3 Immersed Tube Trial Casting;
   4. Appendix A24-4 Immersed Tube Tunnel Foundation;
   5. Appendix A24-5 Immersed Tube Tunnel Joints;
   6. Appendix A24-6 Immersed Tube Tunnel Closure Joint Structure;
   7. Appendix A24-7 Immersed Tube Tunnel Waterproofing; and

24.2. Standards and References

A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT Manual of Structure and Bridge Division; and
   2. VDOT Supplemental Specifications.
   3. VDOT S&B IIM

B. AASHTO Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, in order of precedence:
   2. AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, including all interim revisions and VDOT modifications; and
   3. AASHTO Technical Manual for Design and Construction of Road Tunnels- Civil Elements

C. NFPA 502 – Standards for Road Tunnels, Bridges and Other Limited Access Highways;

D. AWS Standards and Guidelines including:
   1. AWS D1.1M/D1.1 Structural Welding Code - Steel; and
   2. AWS D1.6M/D1.6 Structural Welding Code – Stainless Steel.

E. AISC Standards and Guidelines including:
   1. AISC Steel Construction Manual 14th Edition; and

G. 23CFR650 Subpart E – National Tunnel Inspection Standards (NTIS);

H. ACI Standards and Guidelines including:
   1. ACI 201.2R-01 Guide to Durable Concrete; and
   2. ACI 318-14 Building Code Requirements for Structural Concrete and Commentary.

I. ASCE 37-02 Design Loads on Structures during Construction;


K. fib Model Code for Service Life Design;

L. ASTM American Society for Testing and Materials;


N. Occupational Safety and Health Administration (OSHA) Regulations;


P. Virginia Construction Code.

Q. Virginia Uniform Statewide Building Code (USBC)

24.3. Requirements

24.3.1. Performance Requirements

24.3.1.1. Functionality

A. The Design-Builder is responsible for selecting the dimensions of the Immersed Tube Tunnel (ITT) structures so that they comply with all Sections of these Technical Requirements and can house the required mechanical and electrical systems in the tunnel. Accordingly, the Design-Builder shall perform a space proofing study to establish the optimum dimension of the immersed tube tunnel. The issues to be considered shall include, but not be limited to, the following:

   1. Tunnel horizontal and vertical alignment; the finished elevation of the permanent tunnel structure including any earthwork or engineering fill and protection layers associated with the tunnel shall not extend above the horizontal projection of the existing ITT protection layers shown in the record drawings.

   2. Required Static and Dynamic Clearance Envelope;

   3. Emergency egress requirements;

   4. Traffic barriers;

   5. All in-tunnel facilities and equipment;

   6. Required tunnel finishes;

   7. Structural deflection; and

   8. Construction tolerances for immersed tube units.

B. In addition to the above requirements, service and other installations shall not encroach into the clearance lines, and any doors of egress corridors, when open, must not protrude into the
tunnel clearance area above the roadway. The space proofing study shall be submitted to the Department for review and concurrence.

24.3.1.2. Durability and Service Life

A. As specified in Technical Requirements Section 22.3.1.2 with the following exceptions:

B. Reinforcing for the Immersed Tube Tunnel shall be Deformed, chromium, steel reinforcing bars conforming to the ASTM A1035A/A1035M Alloy Type 1035 CS with a minimum chromium content of 9.2% or stainless-steel.

24.3.1.3. Structural Fire Resistance of Tunnel

A. The Design-Builder shall prepare a fire durability report for underground structures that demonstrates how the structures will comply with the Technical Requirements, subject to the Department’s review and approval. The tunnel structure above the roadway traffic barriers, including all overhead anchorages, shall be designed to resist structural failure when subjected to the fire size and fire growth requirements in Section [X.XX] Fire and Smoke Control, without the consideration to any mechanical fire suppressing systems. Passive fire protection board is required and shall extend over the entire exposed traffic lane perimeter surface above the roadway tunnel traffic barriers. The fire protection board shall be designed so that the concrete temperature at the interface of concrete and fire protection board shall not exceed 250°C (XXX°F) for concrete 28-day strength (f’c) equal to or greater than 6,000 psi and 380°C (XXX°F) for concrete strength (f’c) less than 6,000 psi. The fire protection board and its anchors shall meet the performance requirements of NFPA 502.

B. Overhead anchors shall be cast into concrete.

24.3.1.4. Watertightness

A. Immersed Tube Tunnel (ITT) elements shall be formed from continuous concrete cast in sections. Construction joints shall have full continuity of reinforcement such that each ITT element acts as a single structure with no articulation along its length.

B. The depth of the compression zone for members, which are designed to function as a watertight barrier shall be minimum 8-in. deep in the main load bearing direction for Service 1 load combination. In the calculation of the compression zone it shall be assumed that concrete has no tensile strength.

C. For the exterior walls, top and bottom slabs that form the shell of the tunnel, early age cracking resulting in through-section cracks shall not be allowed.

D. The provision of a waterproofing membrane shall not be considered as mitigation for the presence of through-section cracks in the tunnel concrete and therefore tunnel elements shall be watertight prior to the application of the mandatory external waterproofing membrane.

E. A steel membrane shall be used at the base and a spray applied membrane shall be used for the walls and roof with a suitable lap joint with the steel membrane at the base. The Design-Builder may propose alternative arrangements for approval by the Department.

F. The Design-Builder shall, through temperature and stress analysis, document that the planned risk of early-age cracking at the exterior walls, top and bottom slabs that form the shell of the tunnel shall be acceptable for the full range of ambient climatic and weather conditions that may occur during hardening. The documentation shall be certified by the [Engineer of Record] and submitted to the Department for review and approval.

G. The tunnel shall be watertight with no visible leakage or seepage.
H. Form ties through the external walls are not permitted. If the Design-Builder proposes to use form ties that penetrate external walls of watertight structures, the method and materials for restoring the external walls shall be documented in the design submittals, and the efficacy of the proposals demonstrated as part of the full-scale trial cast. The Department shall not be obligated to accept the use of form ties.

I. Prior to flooding the casting basin, the Design-Builder shall inspect the elements, including bulkheads, manholes and doors, and introduce temporary ballast such that the units remain on the casting basin floor during initial flooding. A continuous inspection shall be conducted of the structure for leaks during flooding. Flooding to be halted of the casting basin when the units are submerged a minimum of 3-ft above the top of the element and a full inspection of leaks shall be conducted. Remedial work, repairs or additional work that is required to ensure the water-tightness of the units shall be carried out. Dewatering of the casting basin shall be conducted as necessary to carry out remedial work. Removal of temporary ballast shall be done in a controlled and coordinated manner to float the New Immersed Tube Tunnel units. The Design-Builder may propose alternative method of water-tightness testing in the casting basin and shall submit this method for Department approval.

24.3.1.5. Design Considerations

A. Design for crack control by distribution of reinforcement shall comply with AASHTO Bridges, with an exposure factor corresponding to a maximum crack width of 0.004 in.

B. Nominal clear cover for all structural elements shall in accordance with IIM-S&B-80. Elements not facing traffic shall be considered a marine environment; elements facing traffic shall be considered normal.

C. The use of temporary support of excavation as part of the permanent structure shall not be permitted.

D. All exterior slabs and walls shall have uniform thickness.

24.3.2. Structural Analysis

A. The ITT analysis, as a minimum, shall consider the loads and load combinations included in Section 24.5 – Loads, Load Combinations and Resistance Factors.

B. For geotechnical design parameters, refer to Section [X.XX] GBR and GDR.

C. Cross Section

1. The ITT shall be designed to resist fabrication, flotation, immersion, backfilling, other applicable construction loads and staging, and all permanent loadings as specified. The maximum vertical and horizontal pressures (hydrostatic and soil) and maximum vertical pressure (hydrostatic) on the bottom slab shall be used for the design. In addition, a combination of maximum and minimum loads producing maximum demand shall be considered in the analysis. The bottom slab shall be designed as beam-on-elastic-foundation using subgrade reaction moduli. All ITT tunnel elements shall be designed for combined moment, shear and axial force.

2. 2-D analysis utilizing commercially available structural software capable of modeling bottom slab as a beam on elastic foundation shall be used for that purpose.

3. 3-D analysis should be used as warranted in areas of change in cross section, i.e. low point sump, and in areas of change in support and or loads introducing 3-D effects.

D. Longitudinal Design
1. Each ITT tunnel element and the entire tunnel may be designed longitudinally as beams or shells on elastic foundations. Since the tunnel alignment passes through different soil materials, entire tunnel alignment shall be analyzed to determine maximum shear forces at the joints and maximum bending moments in the tubes. Based on selected sequence of construction any hard spot reactions shall be modeled in the analysis. All permanent loads and their combinations shall be considered in the analysis. Each ITT element and its components shall be designed for temporary loads, as a minimum, during fabrication, floating, towing immersing, joining and ballasting.

2. Finite Element modeling utilizing commercially available software capable of analyzing soil-structure interaction shall be used.

24.3.3. **Loads, Load Combinations and Resistance Factors**

A. The Design-Builder shall consider all loads, including construction loads, which act on the ITT. As a minimum, the loads shall be those defined in AASHTO LRFD Road Tunnel Design and Construction Guide Specifications (Section [X.XX] Reference Standards).

B. ITT sections shall be designed to sustain the most severe combination of loads to which they may be subjected to over their life, including temporary loads resulting from erection and any other temporary loads occurring during construction.

24.3.3.1. **Loads and Forces**

A. Permanent Loads (i.e., dead loads, earth pressures, etc.) shall be in accordance with Section 3.5 of AASHTO LRFD Road and Tunnel Design and Construction Guide Specifications and the following:

1. Vertical uniform area surcharge of not less than 600 psf applied at the ground surface over and adjacent to the structure; and
2. Dead loads from building or other structure foundations located within the zone of influence of the structure.

B. Live Loads shall be in accordance with Section 3.6 of the AASHTO LRFD Road and Tunnel Design and Construction Guide Specifications and the following:

1. Live loads from building or other structure foundations that are located within the zone of influence of the structure.

C. Buoyancy for Permanent Conditions

1. Buoyancy shall be calculated for all sections. Resistance to buoyancy calculations shall rely on the dead weight of structural components only. Shear strength/friction of overburden shall not be considered. The use of tie-downs, tension piles, or other elements specifically designed to resist uplift forces shall not be permitted. Auger cast piles are not permitted.

2. The water elevation shall be assumed as the 100-year flood elevation plus an additional 5 feet. For the purposes of design, the unit weight of seawater shall be considered as 64.3 pcf. The dry unit weight of all concrete shall be as determined by laboratory testing. The 600 psf area wide surcharge load shall not be included in the Buoyancy Factor of Safety.
3. All other load effects which may increase the uplift during temporary and permanent stages shall be considered by the Design-Builders.

D. Seismic Effects

1. With reference to AASHTO LRFD, the importance category of the tunnel is defined as Critical. Design shall consider seismic loadings, or demonstrate that such loadings are not significant to the design; the Design-Builders shall design the ITT elements for the using peak ground acceleration of 0.03g. The structures and their associated facilities shall remain water-tight and shall continue to function and operate during and after the earthquake. Soil liquefaction and slope stability for ITT protection elements and any engineered berm fill around the tunnel shall be evaluated in accordance with Technical Requirements in Section [X.XX] Seismic Consideration.

E. Earth and Water Pressures

1. Vertical earth pressure occurs due to the backfill over the ITT Structures. Its height and unit weight shall be determined by the Design-Builders and shall be based on the backfill material used.

2. Lateral earth pressures shall be calculated in accordance with AASHTO LRFD Road Tunnel Design and Construction Guide Specification. ITT Elements shall be designed for both short-term and long-term loadings. ITT elements shall be designed for not less than at-rest earth pressures.

3. The Design-Builders shall determine earth pressures for temporary earth support; however, the earth pressures shall not be less than those calculated assuming the active earth pressure.

4. The effect of hydrostatic water pressure shall be added to that of earth pressure, where ground water is present. Water pressure for ITT elements shall be based on the 100-year flood elevation plus an additional 5 feet.

F. Force Effects due to Superimposed Deformations

1. The effect of uniform temperature changes shall be included in the determining the final design of the tunnel in accordance with the AASHTO LRFD Road Tunnel Design and Construction Guide Specifications. All appropriate geometric effects shall be considered, including but not limited to profile grade, horizontal alignment, construction sequence and cross section geometry. Uniform temperature change analysis shall account for changes in element geometry both longitudinal and transverse. Both local and global effects of temperature changes shall be accounted for. Appropriate consideration of restriction or freedom of movement shall be included in the analysis, include static friction and slippage.

2. Effects of temperature gradient shall be superimposed on uniform temperature analysis such that they exacerbate structural responses. A thermal analysis of each element shall be completed which accounts for thermal mass and insulation effects of non-structural elements of the in-service structure, to include but not be limited to fire protection, non-structural and structural elements (e.g., walls, ceilings, flooring) used to define spaces such as evacuation corridors and shall include thermal influence of ballast. Structural effects due to gradients shall be accounted for in the design. Gradient effects shall be added to the uniform temperature effect on the driving side of a heat source and subtracted from the uniform temperature effects on the opposite face. Gradient effects
shall be subtracted from the uniform temperature effect on the driving side of a cooling
effect and shall be added to the uniform temperature effects on the opposite face.

3. Thermal forces between transverse joints shall be accounted for by the longitudinal
reinforcement in walls and invert slabs. Provisions shall be made for movements and
stresses resulting from temperature variations.

4. When appropriate, shrinkage and creep strains shall be determined in accordance with
AASHTO LRFD Road Tunnel Design and Construction Guide Specifications; in cases
where the Guide Specifications silent LRFD Bridge Design Specifications shall be used.
Shrinkage forces between transverse joints shall be accounted for by the longitudinal
reinforcement in the walls roof slabs and invert slab. Differential shrinkage between
portions of elements cast at different times shall be accounted for including but not
limited to the effects of concrete ballast shrinking after being cast on a previously cast
cement surface and joint closures.

5. Force effects due to extreme values of differential settlements anticipated longitudinally
and transversely across the tunnel approach shall be taken into consideration.

G. Ship Loads and Vessel Traffic

1. Project-specific requirements, ship anchor, sunken ship loads, and vessel traffic shall be
determined and reported in the Ocean Engineering Report.

H. Fire Structural Loads

1. Passive fire protection is specified per Section [X.XX]. Structural analysis shall account
for any additional structural loads and/or stresses that may result from fire events as
described in Section [X.XX], and specified temperature in Section [X.XX]. No structural
damage is allowed.

I. Construction Loads

a. During the fabrication process, tunnel elements are subject to loads due to incremental
concrete placement during both outfitting and placing as a result of being afloat and from
settlement of the foundation.

b. The design of the tunnel elements shall include the analysis of stresses due to handling
loads such as lifting and transporting and environment produced loads such as waves and
wind. Design-Build shall design equipment for towing and lowering the tunnel
elements and develop procedures in accordance with the measured channel current
velocities. The wave height and length shall be considered for each stage of construction.
In addition, provide each tunnel unit with anchors and cables adequate for anchoring
against the stresses that occur as a result of waves and wind as defined in the TRs Section
[X.XX].

24.3.4. Stability Requirements

A. Design Builder shall submit detailed report for sequence of construction complying with all
Technical Requirements listed herein and other Sections of the Technical Requirements.

24.3.4.1. General

A. The positive and negative buoyancy analysis is critical for floatation, transportation,
immersing and final condition. In addition to buoyancy, the Design-Build shall check
tunnel elements for stability during floatation, transportation and immersion with attention
given to effects of variations in structural dimensions. All analyses shall be performed for
maximum and minimum densities of materials, soils and water, whichever creates the most unfavorable effect on stability of elements shall be used. Friction forces between element and surrounding soil shall not be included in stability analysis.

B. The Design-Builder shall establish criteria to ensure the stability of ITT elements during floatation, transport and immersion. The principles and parameters, and standards adopted by the Design-Builder shall be documented in the RFC Documents.

24.3.4.2. Buoyancy Requirements during Floating and Transportation

A. Buoyancy and lateral stability play an important role during the transportation and placement of immersed tunnel elements that may cause effects resulting in an unstable element. Depending on the shape of the element, an analysis is to be completed for both upper and lower bounds of freeboard. Sufficient freeboard for marine operation shall be provided to ease effect of waves during transportation. For the purposes of floating, transportation, and waterborne storage the unit weight of seawater shall be not less than 62.4 pcf (fresh water) and up to 64.3 pcf (ocean water).

24.3.4.3. Buoyancy Requirements during Immersion

A. The ballasting system for lowering the units shall be designed such that the unit will have sufficient negative buoyancy to:

1. Maintain stability;
2. Enable the unit to be lowered to its final position;
3. Ensure that the negative buoyancy with temporary ballast gives a minimum factor of safety against floatation of 1.025 immediately after lowering onto foundation; and
4. Maintain a minimum factor of safety of 1.03 at all stages of the work thereafter.

B. The effects of marine currents as stipulated in Section [X.XX] Current shall be taken into consideration.

24.3.4.4. Buoyancy Requirements at Final Placement

A. Completed immersed tunnels shall have a factor of safety against floatation equal to or greater than 1.10 including backfill and protection layer. Excluded from calculating the safety factor shall be siltation layer, roadway-wearing surface, and any removable mechanical, electrical items and not embedded piping. When backfill is not present, the minimum factor of safety against floatation and overturning shall be 1.06.

24.3.4.5. Temporary and Permanent Ballasting

A. Temporary ballast shall be provided for immersing the tunnel elements by the controlled and regulated pumping of water into the ballast tanks or alternative methods selected by the Design-Builder. The Design-Builder shall ensure that the distribution of the ballast is such that the tunnel element remains at the required orientation for joint connection. Provide for both addition and removal of ballast.

1. Design, construct, and install ballast tanks within each tunnel element prior to launching. Provide a means to monitor the water levels in each tank during immersion operations. Locations and minimum capacity requirements for the ballast tanks shall be designed to meet requirements outlined above. Ballast tanks may be removed from each tube element only upon completion of permanent ballast placement.

2. Uplift Factor of Safety. Ballast shall be provided for a minimum factor of safety against uplift of 1.06 during all phases of construction.
B. Permanent Ballasting and backfilling will follow completion of foundation. Precast concrete blocks could be selected as part of the permanent ballast; the Design-Builder may propose alternative methods for permanent ballast. The permanent interior walls, roadway slab, and barrier walks shall be included in the computation of the minimum factor of safety. Concurrently with permanent ballast placement, temporary ballast can be removed in such manner that at no time the factor of safety against floatation is smaller than 1.06.

24.3.5. Other Requirements

24.3.5.1. Immersion Joints

Seals for immersion joints shall include a Gina type gasket as the outer seal, and an omega-type replaceable seal as an inner seal, both as supplied by Trelleborg Bakker, based in the Netherlands, or an approved equal. Both seals shall have a design life equal to that of the tunnel. Details shall protect the seals from fire damage. The design of the seals shall consider long-term relaxation of seal material and the construction tolerances of the steel frames, the method of installation, and related tolerances.

24.3.5.2. Segment Joints

If segment joints are utilized in the construction of tunnel elements, they shall contain double protection against leakage. The requirements for water-tightness and exterior waterproofing shall apply. Segment joints shall be designed to transfer horizontal and vertical shear forces and total movement shall be restrained so as not to exceed the alignment and waterproofing system tolerances. Each joint shall include a FUKO re-injectable grout hose system or approved equal.

24.3.5.3. Closure Joint

A closure joint (final joint) shall be used if the last element is inserted rather than appended to the end of the previous element. Due allowances shall be provided in the design of the closure joint for potential misalignments of adjacent elements and for variation in the gap that is to be closed. The design of the joint and its construction shall ensure that the required compression to ensure that the joint is watertight shall not be compromised.

24.3.5.4. Exterior Waterproofing

All underground structures shall be waterproofed on the exterior side of the structure. Exterior waterproofing systems shall be watertight and must accommodate the anticipated movement of the structure. For structural steel membranes, appropriate corrosion protection and monitoring system shall be used to ensure that the minimum design thickness is maintained.

24.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 24.4-1 for the Department’s consultation and written comment. All submittals shall be accompanied by appropriate level of analysis calculations to justify all engineering decisions made. The Department the right to reject incomplete submittal.

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Appendix 24.1 – Immersed Tube Tunnel Construction

A24.1.1 ITT Method Statement

A. The Design-Builder shall produce a method statement to support the tunnel design. The ITT Method Statement shall be submitted in accordance with Technical Requirements Section [X.XX], at the start of the detailed design, and as part of the pre-construction planning process. The ITT Method Statement shall address the following aspects of construction that are required as a minimum:

1. Concrete works;
2. Concrete placement and curing;
3. Post-tensioning (if used);
4. Crack injection;
5. Marine works;
6. Dredging;
7. Maintenance dredging of tunnel trench;
8. Placing of tunnel foundation;
9. Float up and transportation of Immersed Tube Tunnel elements;
10. All required federal, state and local requirements regarding towing;
11. Mooring of Immersed Tube Tunnel elements;
12. Alignment control of Immersed Tube Tunnel;
13. Immersion of Immersed Tube Tunnel elements;
14. Sourcing, suitability and placing of tunnel backfills and protection;
15. Ballast exchange;
16. Formation of the closure joint (if used); and
17. Repairs of any damage prior to immersing.

B. The ITT Method Statement shall include weather windows and meteorological information for transport and immersion, water level, tidal conditions, water current, vertical seawater density and wave heights.

A24.1.2 Element Fabrication

A. Construct the Immersed Tube Tunnel elements to the dimensions as required by the RFC Documents.

B. Sequence of concrete placement for each tunnel element. Ensure that concrete placement and curing will minimize deformation of the steel plate waterproofing membrane and will minimize cracking.

C. Inspect each tunnel element prior to placement of the seamless elastomeric waterproofing membrane as specified in Tunnel Element Waterproofing, and make all corrections and repair all defects found to the satisfaction of the Department. Cracks that are greater in width than specified shall be repaired in accordance with the Design-Builder’s approved repair plan.

D. Ensure that placement of the four 4-in. deep concrete protection layer to the top slab of the tunnel elements does not damage the seamless elastomeric waterproofing membrane.

E. Construct and deliver a watertight structure. Correct all leaks, seepages or damp spots appearing on the interior surface of the concrete lining by means approved by the Engineer of Record.
F. Submit a detailed plan and proposed sequence of concrete placement for tunnel element construction. Submit a concrete heat of hydration analysis and detailed plan for each mix design indicating how concrete temperatures shall be monitored and how temperature restrictions for concrete placement, if required by the heat of hydration analysis, are to be achieved. Submit as-built locations of temperature sensors. Submit concrete temperature records.

A24-1.3 Towing
A. General
   1. Each tunnel element shall be equipped with towing hardware prior to launching. Ensure that all towing hardware is compatible with the selected method of towing and will not adversely affect the tunnel elements. Submit design to verify towing forces on tunnel elements.

A24-1.4 Immersing
A. Underwater Examination
   1. Prior to immersing each of the tunnel elements, the Design-Builder shall examine the joint components to ensure that they have not been fouled and are in working condition. Additionally, the Design-Builder shall visually inspect the excavated trench bottom and, if required, remove any silt or other materials before immersing the tunnel elements.

B. Lifting Lugs
   1. Detail and provide lifting lugs with sufficient capacity to withstand vertical, transverse and longitudinal surge loads acting simultaneously.

C. Ballast
   1. Provide ballast for the immersion of the tunnel elements by the controlled and regulated pumping of water into the ballast tanks. Ensure that the distribution of the ballast is such that the tunnel element remains at the required orientation for joint connection. Provide for both adding and removing ballast.
   2. Maintain negative buoyancy of the tunnel elements at the factor of safety as specified until permanent ballast is in place and secured.
   3. Ensure that water used for ballast does not contain any deleterious materials such as rubbish, sticks, grass, mud, stones, etc., which may create blockages in the inflow or outflow lines.

D. Two (2) active bulkheads shall always remain installed from the secondary end of Immersed Tube Tunnel element.

A24-1.5 Joining
A. Provide the equipment and materials necessary to obtain initial contact between the primary end of the tunnel element being placed and the secondary end of the previously placed tunnel element or the approach structure.

B. Check the alignment between the primary and secondary ends before initial contact is made to ensure that the Gina gaskets line up thereby resulting in an initial watertight condition.

C. Provide a minimum compressive force at the joint.
D. After initial contact of the tunnel elements, dewater the space between bulkheads.

E. After dewatering the space between bulkheads, and prior to entering this space, test the atmosphere to ensure that there are no noxious, toxic, flammable or explosive gases present. If noxious, toxic, flammable or explosive gases are detected, purge the entire atmosphere between the bulkheads.

**A24-1.6 Ballasting**

A. General

1. Prior to floating each Immersed Tube Tunnel element, calculate the flotation characteristics of the unit. Demonstrate by calculation that the proposed method of ballasting and placing each Immersed Tube Tunnel unit will accommodate the projected flotation characteristics and the actual flotation characteristics measured after floating each Immersed Tube Tunnel unit.

2. Take all measures necessary to protect tunnel access shafts from any damage by small craft or otherwise. Maintain a 24-hour surveillance of access shafts. As soon as practical after lowering, provide access to the interior of the tunnel units and maintain this access in a safe condition during and after backfilling operations.

3. Prior to launching, ensure and certify that all required testing has been performed, including testing of the temporary watertight bulkheads.

4. Fit any temporary openings with watertight covers prior to launching.

B. Ballasting

1. Design the ballasting system for lowering the units such that the unit will have sufficient negative buoyancy during the lowering to:
   
   i. Maintain stability;
   
   ii. Enable the unit to be lowered to its final position;

   iii. Ensure that the negative buoyancy with temporary ballast gives a minimum factor of safety against flotation of 1.025 immediately after lowering onto temporary supports or foundation; and

   iv. Increase the negative buoyancy with temporary ballast to give a minimum factor of safety against flotation of 1.06 after installation of permanent foundation as shown in the RFC Documents. Maintain a minimum factor of safety of 1.06 at all stages of the Work thereafter.

   v. The effects of ocean currents as stipulated in Section 1.4.19.6 Current, shall be taken into consideration.

C. Ballast Tanks

1. Design, construct and install ballast tanks within each tunnel element prior to launching. Provide a means to monitor the water levels in each tank during immersing operations. Ballast tanks may be removed from each tube element only upon completion of permanent ballast placement. Dispose of removed ballast tanks in an approved manner.

2. Uplift Factor of Safety: Provide ballast for a minimum factor of safety against uplift of 1.06 during all phases of construction.

**A24-1.7 Temporary Tunnel Bulkheads**

A. Temporary tunnel bulkheads shall be designed to enable a tunnel element to be floated into position over the tunnel trench and then lowered into position. The design of temporary
bulkheads shall include all temporary loads. In addition, the temporary bulkheads shall be designed for maximum hydrostatic pressure during immersion and joining.

B. Temporary bulkheads shall include watertight doors, valves, pressure sensors, distance-measuring device and any required devices for controlling elements joining. The bulkhead shall be watertight and a seal shall be provided all around bulkhead wall perimeter to withstand hydrostatic pressure.

C. Temporary waterproofing shall be provided for concrete bulkhead walls, if they are used. The type of waterproofing and application method shall not adversely affect surfaces of concrete required for completion of joint.

D. Removal of temporary bulkheads can be performed only upon completion of omega seal installation, permanent ballast placement and backfill placement.

A24-1.8 Locking and Ordinary Backfill

A. The following two (2) classes of backfill shall be used to backfill around and over the Immersed Tube Tunnel elements:

1. Locking Backfill: Consists of suitable materials to be placed only on sides of tunnel elements. Such backfill material to consist of free draining granular material such as sand or gravel mixture rationally without lumps of clay and organic matter with the specification and dimensions of it being determined by the Design-Builder.
   
   i. The placement of locking backfill to be performed only after completion of the foundation layer. To be placed in uniform layers and avoiding an unbalancing of side pressures, uplift and other conditions that may result in movement of tunnel elements. Furthermore, placement of locking backfill to be conducted in such manner that no damage is done to the Immersed Tube Tunnel waterproofing system.

2. Ordinary Backfill: Consists of suitable materials to be placed on the sides and if required on top of tunnel elements. Such backfill material to consist of free draining granular material such as sand or gravel mixture rationally without lumps of clay and organic matter with the specification and dimensions of it being determined by the Design-Builder.
   
   ii. Place ordinary backfill above the locking backfill and if required above Immersed Tube Tunnel elements. Place the ordinary backfill in uniform layers without creating unbalanced side pressures or other conditions, which would cause movement of the tunnel elements. Place the ordinary backfill in the sequence as approved by the Engineer of Record. Place ordinary backfill in a manner and with such equipment that will not damage the Immersed Tube Tunnel waterproofing system.

B. The locking fill and ordinary backfill shall have a grain size distribution such that liquefaction does not occur due to dynamic effects throughout the design life of the tunnel.

C. The locking fill and ordinary backfill and method of placement shall be in accordance with Governmental Approvals.

A24-1.9 Access

A. Access to the Immersed Tube Tunnel elements shall be provided during all stages of construction.
B. Underwater access is required during water-tightness testing in casting basin, and as soon as practical after lowering of the tunnel elements and it shall be maintained in a safe condition during and after backfilling operations.

C. Access, which includes access towers, watertight doors, watertight hatches, etc., shall be selected and designed by Design-Builder to meet OSHA, local, and state regulations. The access elements shall be designed for all temporary loads.

D. All penetrations in top slab, if used, shall be sealed and shall have the same water-tightness requirements as the tunnel element in which they are located. Minimizing interruption of shipping traffic shall be the important criteria for final determination of the access method.

A24-1.10 Ventilation during Construction

A. The Design-Builder shall be responsible for the supply of fresh air to work areas in sufficient quality and quantity to comply with all applicable laws, safety codes, and regulations. The Design-Builder shall maintain, at all times, the air in all confined or enclosed spaces in a condition suitable for the health of the personnel and for the proper performance of all required operations.

B. Temporary ventilation shall be maintained by the Design-Builder until tunnel construction is completed and has been accepted by the Department.

A24-1.11 Surveying

A. After the tunnel element load has been transferred to the foundations, the Design-Builder shall verify the alignment of the tunnel element utilizing survey towers or other methods.

B. The Design-Builder shall measure vertical alignment tolerances at the centerline of the tunnel and measure horizontal alignment tolerances at the tunnel element centerline at both ends of the tunnel element.

C. The Design-Builder shall measure horizontal and vertical alignments at the inboard end of the tunnel element with respect to the alignment of the previously placed tunnel element, at the joint to be connected. The Design-Builder shall measure horizontal and vertical alignment at the outboard end with respect to the theoretical alignment.

D. Tolerances:
   
<table>
<thead>
<tr>
<th></th>
<th>±1.5 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Alignment</td>
<td>±1.5 in.</td>
</tr>
<tr>
<td>Vertical Alignment</td>
<td>±1 in.</td>
</tr>
<tr>
<td>Maximum Differential</td>
<td>1 in.</td>
</tr>
</tbody>
</table>

E. Alignment Corrections. Where alignment must be corrected, and correction cannot be accomplished with the foreseen alignment equipment (i.e., jacks, etc.), the Design-Builder shall flood the space at the joint between the bulkhead plates, separate the tunnel elements, and correct the alignment deficiency. The Design-Builder shall notify the Department immediately upon determining that a tube element is misaligned.

A24-1.12 Transportation, Mooring and Immersion – Hydraulic Model Tests

A. Numerical hydraulic models of the ITT element shall be set-up for transportation, mooring, and immersion by the Design-Builder. Care shall be taken to accurately model the influence of the weather conditions existing at the time of the various marine operations. Similarly, the influence of immersion and transportation equipment that maybe present during these times shall be accurately modelled. Design-Builder’s numerical model tests shall determine:
1. Hydraulic stability of the ITT element and equipment; and
2. Towing capacity required and the loads actually applied to the ITT element.

A24-1.13 Weather Forecasting System

A. The Design-Builder shall establish a weather forecasting system to predict weather windows with acceptable wind, current, and wave conditions for safe marine operations of ITT elements.
Appendix A24-2 – Tunnel Backfill and Protection Layer

A. Within the Navigation Channel, the top of the tunnel stone protection layer shall not extend above the horizontal projection of the existing ITT protection layers shown in the record drawings and shall be located above the top of the tunnel waterproofing and extend vertically a minimum of 10 feet for the length of the tunnel.

B. The tunnel protection layer shall meet the following requirements:
   1. Protect the ITT elements and structural backfill from scour and erosion induced by ship's propellers;
   2. Protect the ITT elements and structural backfill for a one hundred (100) year scour event sea current per Section [X] of these Technical Requirements;
   3. Be designed to protect the ITT elements from damage caused by falling anchors and sunken or grounding ship as specified in Section [X] of these Technical Requirements; and
   4. Be designed to ensure that dragging anchors break free from the layer before reaching the ITT elements Refer to Section [X] of these Technical Requirements.

C. The Design-Builder shall produce As-Built records including the results of bathymetry carried out immediately post-construction.

D. The tunnel protection layer shall, as a minimum, extend the full width of the tunnel and backfill. Anchor loading shall be based on LRFD Road Tunnel Design and Construction Guide Specification.
Appendix A24-3 – Trial Casting

A. The trial casting shall be undertaken by the Design-Builder using the actual construction methods and equipment (i.e. batch plants, pumps etc.) and performed by operators and staff who will be involved in the permanent work.

B. The trial casting, as a minimum, shall include entire cross section with the following:
   1. For monolithic ITT elements: end frame, two (2) cast sections as proposed for permanent work including horizontal, and one (1) vertical construction joint.
   2. For segmental construction: end frame, the longest segment as proposed for permanent work, including all construction joints.

C. The Design-Builder’s trial casting shall demonstrate that all requirements of the concrete properties and all requirements for concreting and execution are fulfilled simultaneously, and shall be sufficient to demonstrate and validate:
   1. Measure to control early age cracking (concreting sequence, curing and cooling methodology); and
   2. Concreting and grouting at all joints (immersion, segment and construction).

D. The Design-Builder’s trial casting shall be comprised of typical structural parts of the tunnel and shall be sufficient to demonstrate the efficiency of the casting, cooling and curing methods. As a minimum, the trial casting shall include the entire cross section. The length of the trial casting in the longitudinal direction is to be agreed-upon with the Department. All elements of the trial casting shall be full size and not scaled such that they are representative of the intended permanent works structure. The Design-Builder’s trial casting shall also include horizontal and vertical construction joint between two segments, if applicable.

E. The Design-Builder’s trial casting structure shall be equipped with instrumentation to monitor concrete temperature against time. The temperature monitoring system shall be the same as the system used for tunnel production. Each trial casting shall be evaluated (i.e. back analyzed) to demonstrate that the evolution of measured temperatures correlates with those predicted by analysis.

F. The risk of cracking, taken as the ratio between the maximum principal tensile stress and the tensile strength, shall at all times be less than 0.70.

G. Pre-testing of concrete:
   1. Temperature and stress analysis shall be performed by the Design-Builder using a computer program based on the finite element method and proven for use in this application.
   2. Temperature simulation shall be based on documented values for the adiabatic heat development for the concrete that shall be used for the tunnel, and documented values of conductivity, formwork and insulating materials. The Design-Builder’s simulations of stresses shall be based on actual documented transient (time/age dependent) material properties.
   3. Based on stress analysis, the Design-Builder shall establish limiting temperature differences for each structural element to control the hardening process of the concreting works corresponding to:
      i. For all structural elements, the maximum allowable temperature difference within the same casting section shall be defined and not exceed 68 degrees Fahrenheit whichever is less. This normally corresponds to a temperature
difference between the central part and the surface of the structural element not exceeding 68 degrees Fahrenheit;

ii. For all structural elements, a maximum temperature difference between the mean temperature of the element and the temperature at the surface of the element shall be defined or shall be less than 59 degrees Fahrenheit whichever is less; and

iii. For structural elements which are restrained by adjacent elements, a maximum temperature difference between the mean temperature of the newly cast element and the mean temperature of previously cast elements shall be defined or shall be less than 59 degrees Fahrenheit, whichever is less.

H. The maximum temperature of the concrete shall not exceed 149 degrees Fahrenheit in the hottest part of the structural element.

I. Pre-testing of the injection of cast-in cooling pipes, if used, shall be performed for all types of pipes used. The length of the pipes shall, as a minimum, be of the same length as the maximum length used in production.

J. A program for the trial casting (including number of tests and the location of coring) shall be submitted to the Department for review a minimum of two (2) months before trial castings are performed. Each trial casting shall be evaluated in a report, which shall be submitted to the Department for review minimum of one month before execution of the corresponding permanent structure.
Appendix A24-4 – Tunnel Foundation

A. The Design-Builder shall install the Immersed Tube Tunnel (ITT) elements to such lines and levels within the dredged trench such that the geometry of the specified free envelope within each tube shall be available after settlements due to founding, backfilling, and ballasting have occurred and the roadway surfacing has been completed to specified levels.

B. Suitable tolerances shall be established for placing the foundation materials, compatible with the material beneath the foundation layer and the design of the tunnel elements.

C. The design of the Immersed Tube Tunnel foundation shall as a minimum include:
   1. Settlements or heave of the sub-soil;
   2. Prevention of soil liquefaction;
   3. Tolerances of the tunnel trench;
   4. Tolerances of the tunnel backfill and tunnel protection layer;
   5. Possible sedimentation above tunnel protection layer;
   6. Tolerances and settlements of the foundation layer;
   7. Effect of cumulative tolerances caused by design and construction processes; and
   8. All relevant loads.

D. The ITT shall be founded on suitable material. Unsuitable material below the base of the dredged trench shall be removed and replaced or improved as necessary. The possibility that overdredging may be required shall be considered when selecting the dredging equipment.

E. The Design-Builder shall undertake any ground improvement necessary to achieve the performance criteria. A suitable program of verification testing shall verify the effectiveness of any proposed ground treatment. Any assumptions regarding the performance of the ground improvement and how these assumptions are to be verified shall be documented in the Design Submittals. The methods used for the testing shall be in accordance with standards and requirements to be proposed by the Design-Builder.

F. The ITT shall be founded on a continuously-screeded gravel bedding. The foundation bedding shall consist of uncontaminated sound durable materials of uniform settlement characteristics, free of deposited sediments.

G. The foundation method shall have been proven and tested by successful utilization on similar projects. The use of individual supports as permanent foundation shall not be permitted.

H. Settlements shall be limited and shall mainly take place within a restricted period corresponding to the time lag between the placing of the foundation layer and the fixation of the immersion joints. The immersion joints shall be designed to resist the forces and moments resulting from the residual primary and secondary consolidation settlements, that could occur after fixation of the immersion joints.

I. Prior to founding the tunnel elements, the floor of the trench including the portion under the element shall be checked and if any sediments are encountered, appropriate cleaning procedures shall be performed, to avoid disturbance to the foundation layer or the trench bottom.

J. The method of placement of the foundation layer shall not cause segregation of the materials.

K. A screeded gravel bed shall be placed before immersion of the tunnel element. The gravel foundation material shall:
   1. Have a grain size such that liquefaction cannot occur due to dynamic effects throughout the design life of the Immersed Tube Tunnel; and
2. Have a grain size distribution such that the gravel foundation is stable and settlements will not exceed the settlements of the gravel foundation allowed for in the design.

L. The Design-Builder shall submit a Method Statement that includes information to support the design and documents the procedures, plant and equipment to be used to install the tunnel foundation layer. The Method Statement shall also include proposed method cleaning of the bottom of the trench bottom and sides, including provisions and precautions to prevent sedimentation below the tunnel elements.

M. The tunnel shall be analyzed based on the expected foundation conditions. The design shall consider potential variations in the thickness of the foundation layer taking into account likely dredging tolerances, and where applicable, tolerances on the surface profile prior to immersion (uneven or lack of support). The assumptions adopted in the design shall be documented in the Design Submittals.

N. Where new construction imposes loads or stress changes on any existing buildings, embankments, pavements, structures including the adjacent existing tunnel, utilities or the ground supporting such elements, appropriate measures shall be taken by the Design-Builder to prevent differential settlement or damage.

O. The Design-Builder shall document expected ground movements and movements of all tunnel structures in reports submitted to the Department as part of the Design Submittals. This documentation shall include movements that are expected to occur during construction, residual movements post construction and total movements. The analysis used to derive the estimates shall be consistent with the actual construction schedule (timing and sequence of work), and the material and methods to be used.

P. In its calculation of the settlement, the Design-Builder shall take into account the interaction between the soil and structures, and shall include any proposed ground improvement.

Q. Movements of the tunnel shall not compromise the tunnel traffic clearance envelope, pavement requirements or drainage and ducting. If estimated movements, calculated at the design stage, are likely to exceed limiting criteria during the tunnel design life, the Design-Builder shall undertake the following:

1. Design ground improvement to the tunnel foundation to limit estimated movements to acceptable values;

2. Document that sufficient tolerance exists within the tunnel clearance envelope to allow the roadway alignment to be adjusted by pavement overlay to accommodate estimated total and differential movements; or

3. Submit proposals for remedial works to the Department as part of the Preliminary and Detailed Designs.

R. Settlement of the new and existing tunnels, and approach structures shall be monitored and reported throughout construction in accordance with Section [X.XX].
Appendix A24-5 – Tunnel Joints

A. The tunnel joints including immersion joints, construction joints and movement joints, if used, shall conform to the following requirements as listed below in this section.

**A24-5.1 Immersion Joints**

A. The typical completed tube joint shall accommodate longitudinal movement and rotation due to temperature changes, and differential long-term settlement. Transverse movement (vertical and horizontal) shall be restricted by the keyed slabs and walls or shear pins. The transverse joint forces shall be obtained from longitudinal tunnel analysis.

B. The outer seal (Gina gasket) and inner seal (Omega seal) shall provide joint water-tightness.

C. The Gina gasket is the primary joint seal. It provides water-tightness of the joint during all stages of construction. The gasket must be manufactured in one piece and splicing shall not be permitted. The Gina gasket is clamped to the primary end frame of tunnel element.

D. The Gina gasket shall maintain sealing pressure over the design life of the structure allowing for relaxation of the gasket material. Longitudinal movement due to temperature changes and rotational movement due to differential settlement shall be accounted for in providing sealing capacities of the Gina gasket during low and high tides.

E. The Omega seal is the secondary joint seal. Field splicing of the Omega seal shall be permitted, but field splices shall be minimized. The seal shall be capable of absorbing all movements of the joint, and shall be designed to maintain water-tightness against the full water pressure over the service life of the structure.

F. The permanent drain/bleed pipes with valves from the space between Gina and Omega gaskets shall be provided for each Immersion Joint for testing, inspection and future leak remedial measures. A minimum of two pipes at top corners and two pipes at bottom corners shall be provided.

G. It shall be possible to inspect the Omega Seal including clamping system by video camera from two locations at each immersion joint during the design service life of the tunnel. Sufficient space shall be provided in front of the Omega Seal to be able to carry out the inspection. The Design-Build shall provide details of how this will be achieved.

H. The Gina gasket and Omega seal shall comply with Section A24-8.

**A24-5.2 Joint Design**

A. All joints shall be designed to be watertight without the need for replacement during the design life.

B. All joints shall be protected against the detrimental effects of spilled liquids and against a fire in the tunnel.

C. The immersion joints and the movement joints (if used) shall be able to transfer horizontal and vertical shear forces, prevent lateral and vertical differential movements, and shall have the ability to accommodate temperature, drying shrinkage, settlement, creep and any other movements which may occur for all relevant limit states to be defined by the Design-Build.

D. Construction joints and elements used for external walls and slabs shall have at least two (2) waterstops.
E. The systems for achieving water-tightness at movement and construction joints must have proven successful applications under similar conditions. The Design-Builder shall evaluate methods for achieving water-tightness as part of the Design Submittals.

F. All components requiring maintenance shall be designed and constructed to be easily accessible for monitoring, inspection, maintenance and replacement, without the need for demolition.

G. Readily accessible grouting tube shall be provided at immersion joints to allow grouting of the space between the primary and secondary gaskets.
Appendix A24-6 – Tunnel Closure Joint Structure

A. If required, the tunnel closure joint structure shall fill the gap between the final two (2) elements placed or between the final tunnel element placed and the cut-and-cover tunnel.

B. The tunnel closure joint structure shall match the properties of the surrounding tunnel after completion, including water-tightness properties.

C. The tunnel closure joint structure shall be provided with a minimum of two (2) waterstops in the joints around the entire structural perimeter.

D. The tunnel closure joint structure shall be able to transfer shear forces in both horizontal and vertical directions and shall have the ability to accommodate temperature, drying shrinkage, settlement, and creep movements, which may occur during the service life of the tunnel.

E. The tunnel closure joint structure construction shall be performed in the dry. A closure joint utilizing tremie concrete is not permitted.
Appendix A24-7 – Tunnel Waterproofing

A24-7.1 General
A. This Appendix specifies the furnishing and application/installation of waterproofing systems for the ITT elements. The waterproofing systems include the following:
   1. Seamless elastomeric waterproofing membrane system; and
   2. Steel plate waterproofing membrane system.
B. The waterproofing shall satisfy the following criteria:
   1. Provide and maintain a continuous water barrier; and
   2. Shall be chemically and biologically resistant to the marine environment.
C. The requirements that follow are to be considered minimum requirements. The requirements of the manufacturer shall be obtained and shall be followed unless otherwise directed by the Department.

A24-7.2 Systems Description
A. Seamless Elastomeric Waterproofing Membrane System
   1. The membrane shall be a minimum 120 mil thick acrylic-based methyl-methacrylate, cold liquid-applied, seamless elastomeric waterproofing membrane system.
   2. The membrane shall adhere to the entire surface so that waterflow between the membrane and the substrate is not possible.
   3. A reinforcing scrim shall be installed at cracks and construction joints where necessary.
B. Steel Plate Waterproofing Membrane System
   1. A minimum ½-inch thick steel plate shaped to fit the bottom and lower sidewalls exterior. All joints shall be continuously welded. The system shall include shear studs and is intended to be installed at the start of each tube element construction.
   2. Corrosion protection is not required but the thickness of the steel plates shall include a corrosion allowance and ensure a residual plate thickness after the 100-year Service Life sufficient to maintain the waterproofing function.

A24-7.3 Submittals
A. Submittals will be in accordance with Technical Requirements Section [X.XX].
B. Manufacturer's Literature. Submit the latest edition of the manufacturer's literature describing the seamless elastomeric waterproofing membrane including the following:
   1. Performance data;
   2. Application procedures;
   3. Durability and service life; and
   4. A list of references for similar projects completed during the last 10 years.
C. Samples
   1. Submit a sample of the seamless elastomeric waterproofing membrane as follows:
      i. An 8-in. high by 8-in. wide square sample. Color, texture, and thickness shall be representative of overall appearance.
D. Shop and Working Drawings
1. Submit shop and working drawings for the steel plate waterproofing membrane.

E. Welding Records and Data
   1. Submit welding records and data for the steel plate waterproofing membrane.

F. Certificates
   1. Seamless Elastomeric Waterproofing Membrane:
      i. Provide manufacturers’ certificates listing materials used and certifying compliance with the designated standards; and
      ii. Provide manufacturers’ certificates stating that waterproofing system is designed to be watertight at the depths indicated and capable of withstanding the indicated hydrostatic head.

   2. Steel Plate Waterproofing Membrane
      i. Provide mill certificates and certified copies of reports for all analyses and tests required by referenced ASTM and AWS specifications as specified.

G. Protection Methods and Repair Procedures. Submit plans, procedures and details for approved by the Engineer of Record for protecting the seamless elastomeric waterproofing membrane during launching, towing, immersing and placing operations for the Immersed Tube Tunnel elements. Submit procedures and details approved by the Engineer of Record for making repairs to the seamless elastomeric waterproofing membrane in both free air and underwater applications. Materials for underwater repair to the seamless elastomeric waterproofing membrane shall comply with all applicable federal, state and local regulations.

A24-7.4 Quality Assurance

A. Seamless Elastomeric Waterproofing Membrane
   1. Qualifications
      i. Manufacturer shall have a minimum of 10 years of experience in the production, sale, and technical support of seamless elastomeric waterproofing membranes and related materials, and shall have supplied waterproofing systems for similar applications.

B. Steel Plate Waterproofing Membrane
   1. Quality assurance shall be in accordance with the requirements stated in VDOT 2007 Road and Bridge Specification, Section 407- Steel Structures.

A24-7.5 Manufacturer’s Representative

A. A technical representative of the seamless elastomeric waterproofing membrane manufacturer shall monitor application of the waterproofing system and certify the proper application of the membrane. The technical representative shall be present during the entire application period, on a full-time basis.

A24-7.6 Project Conditions

A. Seamless Elastomeric Waterproofing Membrane
   1. Environmental requirements shall be in accordance with the manufacturer’s requirements.
2. Safety requirements shall be in accordance with the manufacturer’s requirements.

**A24-7.7 Warranty**

A. Seamless Elastomeric Waterproofing Membrane

1. The Manufacturer shall provide a minimum one (1) year warranty stating that the waterproofing system is free of defects in materials and workmanship upon Final Acceptance.

**A24-7.8 Products**

**A24-7.8.1 Materials**

A. Seamless Elastomeric Waterproofing Membrane

1. Primer

   i. One 100% solvent free reactive, elastomeric, two-component resin capable of full cure in 40 minutes at 68 degrees Fahrenheit.

2. Membrane

   i. One hundred 100% solvent free reactive, elastomeric, spray-applied material.

   ii. Membrane shall meet or exceed properties of laboratory-prepared samples tested at 68 degrees Fahrenheit and 24-hour cure where applicable as follows:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gel Time</td>
<td></td>
<td>6 – 11 minutes</td>
</tr>
<tr>
<td>Cure Time</td>
<td></td>
<td>30 minutes</td>
</tr>
<tr>
<td>Water Vapor Transmission</td>
<td>ASTM E96-14</td>
<td>4.3 g/m²/day</td>
</tr>
<tr>
<td>Adhesion to Concrete</td>
<td>ASTM D4541</td>
<td>100 psi or failure in concrete</td>
</tr>
<tr>
<td>Adhesion to Steel</td>
<td>ASTM D4541</td>
<td>290 psi</td>
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<td>Minimum Elongation</td>
<td>ASTM D638 Method A, Die C</td>
<td>80%</td>
</tr>
<tr>
<td>Minimum Strength</td>
<td>ASTM D638 Method A, Die C</td>
<td>435 psi</td>
</tr>
<tr>
<td>Crack Bridging</td>
<td>ASTM C836-12</td>
<td>Pass @ 25 cycles, 0.0625 in., -15°F</td>
</tr>
</tbody>
</table>

3. Steel Plate Waterproofing Membrane

   i. The steel plate membrane shall be fabricated from ASTM A36 steel.
### A24-7.9 Execution

#### A. General

1. Seamless elastomeric waterproofing membrane shall be applied to the exterior, exposed concrete and sides of steel surfaces of each tunnel element. A layer of minimum 4-in. deep protection concrete shall be installed on the top slab of each tunnel element.

2. At construction joints in the substrate and where construction joints are planned in the protective concrete layer, the membrane shall be strengthened by means of extra layers and/or reinforcing scrims.

3. Steel plate waterproofing membrane shall be installed at the bottom and the lower part of the external walls of each tunnel element. The concrete for the bottom slab of each tunnel element shall be placed within the steel plate waterproofing. The steel plate shall be bonded to the concrete with shear studs.

#### B. Seamless Elastomeric Waterproofing Membrane

1. **Preparation**
   - i. Surface preparation shall in accordance with the manufacturer’s requirements.
   - ii. Inspection: inspect the surface to receive the waterproofing system with the Department and the technical representative from the manufacturer of waterproofing system prior to starting any application procedures. Make all corrections and repair all defects found during the inspection to the satisfaction of the Department.

2. **Testing**
   - i. Conduct random tests for tensile bond strength on the surface receiving the waterproofing system using testing equipment as recommended by the manufacturer and approved by the Engineer of Record.
   - ii. Perform a minimum of three tests for tensile bond strength on each surface receiving the waterproofing system of each tunnel element.
   - iii. Ensure that each test for tensile bond strength meets or exceeds the minimums as recommended by the manufacturer. Should a test location indicate that tensile bond strengths are lower than the minimum recommended by the manufacturer, then perform additional surface preparation as recommended by the manufacturer and approved by the Engineer of Record. The Department may request additional random tests be made if one of the required tests indicates low bond strengths.

3. **Application**
   - i. Apply the waterproofing system as required by the manufacturer. Conform to all requirements of the manufacturer and all on-site recommendations of the technical representative.

4. **Field Quality Control**
   - i. Conduct tests and record relevant data as recommended by the manufacturer and as specified herein. Submit recorded data on a form acceptable to the Department. Minimum requirements for tests and data include the following:
     - a. Record the air and surface temperature before and after waterproofing system application. Calculate and record dew point for temperature and humidity using standard tables;
b. Perform adhesion tests of the cured membrane to the substrate. The tensile bond strength shall be checked by a minimum of three (3) tests per 1,000-square feet of area. The adhesion shall exceed minimum requirements as recommended by the Manufacturer and accepted by the Department. Record the tensile bond strength for each test performed and indicate the location where the test was performed; and
c. Test the wet film thickness of every 100-square feet of area the waterproofing system is applied to using a gauge pin or standard comb type thickness gauge. Record the wet film thickness and indicate the location where the test was performed.

5. Final Review
   i. Review the completed waterproofing system installation and the recorded test results for each tunnel element with the Department and the manufacturer's technical representative. Correct any irregularities or other items as recommended by the technical representative and as directed by the Department.

6. Place minimum four 4-in. deep protection concrete on top slab of each tunnel element after acceptance of seamless elastomeric waterproofing membrane by the Department.

7. Protect the seamless elastomeric waterproofing membrane from damage during launching, towing, immersing and placing operations. Inspect the membrane with divers after each tunnel element is towed to the site and prior to placement. Inspect the membrane again after each tunnel element has been immersed and placed. At any time should the inspections reveal damage to the waterproofing membrane, repairs shall be initiated in accordance with the Design-Builder’s approved plan and prior to the start of the next construction operation.

C. Steel Plate Waterproofing System

1. General
   i. Fabricate the steel plate waterproofing system to the shape and dimensions of the Immersed Tube Tunnel element. Fabrication of the steel plate membrane shall comply with the requirements of VDOT Road and Bridge Specification, Section 407- Steel Structures.
   ii. Provide shear studs to the size, shape and locations in accordance with the RFC Documents.
   iii. Provide compartments at the inner face of the membrane to the size, shape and locations required by the RFC Documents.

2. Assembly
   i. Assemble the steel plate waterproofing system at the location where the tunnel elements are to be constructed.
   ii. Use temporary bracing as necessary to accommodate loads to which the steel plate waterproofing system may be subjected during assembly and during construction of the tunnel elements.
   iii. Thoroughly clean surfaces to be joined.

3. Tests and Inspection
   i. Test and inspect all welded connections utilizing an independent testing laboratory and at no expense to the Department. Testing laboratory shall prepare
test and inspection reports and submit copies to the Department for acceptance by the Department.

4. In addition to normal testing of welds, all welds shall be tested for water tightness using the dye penetration procedure, which shall be approved by the Engineer of Record.
Appendix A24-8 – Immersed Tube Tunnel Joint Seals

A24-8.1 General

A. Description

1. This Appendix specifies furnishing and installing preformed seals, including the sealing system between the Immersed Tube Tunnel elements consisting of an outer (Gina) gasket and an inner (Omega) seal.

2. This Appendix also specifies furnishing, testing and installing the clamping system for both Gina gaskets and Omega seals.

B. Quality Control

1. Tunnel Sealing System

   i. A technical representative of the seals' manufacturer shall provide assistance during the installation and testing of the primary and secondary seals.

C. Submittals (in accordance with Section [X.XX] of these Technical Requirements)

1. Manufacturer's Literature

   i. Submit literature describing products, including the following:

      a. Quality control plan for manufacture of gaskets; and

      b. Reports regarding Durability/Service Life based on accelerated aging or similar test.

2. Shop Drawings

   i. Submit Shop Drawings showing types and configurations of compression seals selected, with supporting calculations demonstrating conformance with the RFC Documents.

   ii. Submit details of all bolt and bolt hole sizes and spacings approved by the Engineer of Record. Submit details of clamping bars and other fixings together with calculations justifying their design and approved by the Engineer of Record.

   iii. Submit details of the Gina gasket and Omega-seals including material properties, physical dimensions, seal joint details and locations, as approved by the Engineer of Record.

3. Submit calculations and/or tests demonstrating the adequacy of the seals to maintain water tightness exceeds the 100-year Service Life of the structure allowing for relaxation of the seal material, joint movement and construction tolerances. Include load-compression and water sealing-compression curve data for the Gina gasket. Calculations, tests and data shall be approved by the Engineer of Record.

4. Samples

   i. Submit two (2) samples of primary and secondary seal clamping assemblies.

   ii. Submit a typical vulcanized Gina seal.

   iii. Submit a typical molded corner for the Omega seal.

A24-8.2 Products

A24-8.2.1 Tunnel Sealing System – General

A. All seals shall be formed from materials of proven resistance against the following:
1. Fungi and micro-organisms; and
2. Oxygen, ozone, salt water, and heat.

B. All joint materials and components shall be protected against the detrimental effects of spilled liquids.

A24-8.2.2 Gina Gasket Type Seal

A. The primary compression seal shall be manufactured of natural or SBR or chloroprene rubber compounds to an overall cross-section corresponding to that known as a “Gina” section.

B. The overall cross-section of the Gina-type seal shall consist of a main body with an integral nose and seating ridge with load/compression characteristics as specified herein. The shape and material properties shall be designed to facilitate initial sealing and to suit the Design-Builder’s proposed method of tunnel section placement.

C. The rubber compound for the main body of the rubber seal shall have the following physical properties:
   1. Tensile strength, ASTM D412: 2500 psi (min.);
   2. Elongation at failure, ASTM D412: 450% (min.);
   3. Hardness, ASTM D2240: in the range of 40 to 65 shore A;
   4. Compression set, ASTM D395, Method B: 72 hours at 70 degrees Fahrenheit; 20% (max.);
   5. Change in tensile strength after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit; 15% (max.);
   6. Change in elongation at failure after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit; 20% (max.); and
   7. Change in hardness after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit, 5 shore A (max.).

D. The Gina-type seal shall be designed to maintain water tightness over the design life of 100 years. The following force compression characteristics shall be accommodated:
   1. The seal shall maintain a sealing pressure equal to 1.75 times the hydrostatic pressure for AASHTO Service I load combinations and 1.3 for relevant extreme load combinations at the maximum opening movements and construction tolerances specified over the design life of the structure allowing for relaxation of the seal material.

E. No field splices of the Gina-type seals shall be permitted unless authorized by the Department.

F. Corner pieces of the seal shall be molded to a radius.

A24-8.2.3 Omega-Type Seal

A. The secondary seal shall be manufactured of chloroprene or SBR rubber to an overall cross-section corresponding to that known as an “Omega” section.

B. The seal shall be reinforced with at least two (2) layers of nylon plies, which shall be turned back at the edges to provide at least four (4) layers at the flanges.

C. The rubber material of the seal shall have the following physical properties:
   1. Tensile strength, ASTM D412: 2100 psi (min.);
   2. Elongation at failure, ASTM D412: 400% (min.);
   3. Hardness, ASTM D2240: in the range of 50 to 60 shore A;
4. Change in tensile strength after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit: 15% (max.);
5. Change in elongation at failure after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit: 20% (max.); and
6. Change in hardness after aging in air, ASTM D573: 168 hours at 160 degrees Fahrenheit: 7 shore A (max.).

D. The Omega-type seal shall be designed to maintain water tightness against the full hydrostatic pressure over the 100-year Service Life. The seal shall be capable of absorbing all movements of the joint. The design shall include a safety factor of 2.5 for AASHTO Service I load combinations and 1.75 for relevant extreme load combinations on the sealing pressure, the clamping (pull out) strength and on the strength of the seal material. Relaxation of the rubber shall be considered in the design of the sealing pressure.

E. The stainless-steel plates and fasteners shall be used to fasten the Omega seal to ensure the 100-year Service Life of the seal.

F. A maximum of one (1) field splice shall be allowed for the Omega seal.

A24-8.3 Execution

A. Preparation of joint surfaces and Gina gasket protection shall be in accordance with the manufacturer’s requirements.

B. Installation of primary seal (Gina gasket) and secondary (Omega seal) shall be in accordance with the manufacturer’s requirements.

C. Testing of In-Place Gaskets

1. Test secondary gaskets for water leakage after each tunnel element has been placed, joined to the proceeding tunnel element and dewatered, in accordance with the following procedure:
   i. Pump clean water into space between primary and secondary gaskets using a lower drainpipe and bleeding air from the space by another permanently installed drain at the crown.
   ii. When water comes out of the upper drain, cap that upper drain and increase pressure to 150 psi. Maintain 150-psi pressure for a minimum of three (3) hours.
   iii. Examine gasket contact area for leakage prior to acceptance. Ensure that no water penetrates at any gasket contact area.
   iv. Alternatively: Pressure test the space between the primary and secondary gasket with air to a pressure 1.2 times the expected maximum service pressure at the joint location via a test pipe and valve to the manufacturers requirements. After pressurization, the valve shall be closed and pressure recorded at one (1) minute intervals for 10 minutes. At the end of this time, the recorded pressure shall be not less than 90% of the original pressure.

D. If the pressure test is unsuccessful, adjust clamping strips and bolts, retorque, and repeat the test procedures. If necessary, remove the seal, clean the mounting plates and check for dimensional and planeness tolerances.
SECTION 25. TUNNEL WALL FINISHES

25.1. Scope

A. The requirements in this Section apply to the design and construction of Tunnel wall finishes for:
   1. Tunnel Approach Structures as described in Section 22.1 of this Technical Requirements
   2. Bored Tunnel Structure as described in Section 23.1
   3. Immersed Tube Tunnel Structure as described in Section 24.1

25.2. References

A. VDOT Project Development Manual
B. VDOT Environmental Manual

25.3. Requirements

25.3.1. General

A. This Section pertains to the design of Tunnel Wall Finishes, including preparation of all specifications and drawings, for the cut and cover tunnel, the immersed tube tunnel, and the bored tunnel; and furnishing all material and equipment and performing all work required for installing Tunnel Wall Finishes as described herein.

25.3.2. Performance Requirements

A. Ceramic tile Tunnel Wall Finishes, shall meet the following functional requirements to ensure tunnel safety and ease of maintenance:
   1. Be compatible with tunnel lighting and in compliance with required minimum reflectance values;
   2. Be precluded from producing toxic fumes during a fire (Class A fire classification product); and
   3. Shall be durable and shall be provided with a 15-year warranty against failure, including detachment and material failure.

B. Tunnel ceramic tile shall not be attached to the fire protection board directly; the Design-Builder shall develop a ceramic tile wall system, which includes, fire protection board and appropriate attachment systems, ceramic tile and an intermediate component between ceramic tile and fire protection board that ensures long term reliable performance and integrity of the system including no detachment of the ceramic tile. Passive fire protection board is described in Sections 22 – Tunnel Approach Structure, Section 23 – Bored Tunnel and Section 24- Immersed Tube Tunnel. The ceiling (area above the top of the ceramic tile) shall be painted gloss white and have an initial surface reflectance of at least 50% or equivalent to that of the finished walls.

C. The Design-Builder may propose a tunnel finish alternative to ceramic tile, subject to Department review and approval; the alternative finishes shall be comparable to ceramic tile in terms of performance, durability, aesthetics, and maintainability. Possible acceptable alternative finishes include porcelain-enameled metal panels and pre-finished concrete panels.
D. The dynamic and static pressures and low-pressure loads acting on wall finishes shall be determined by the Design-Builder based on analysis and applicable national standards and directives. All anticipated loadings shall be considered, including but not limited to:

1. Pressure exerted by high pressure water cleaning apparatus shall be based on a nozzle pressure of 2,000-psi using a 25° nozzle held no further than 6 in. from the face of the tunnel finish. The Design-Builder shall confirm the adequacy of the proposed finish and its attachments by field testing said pressure on a mock-up area no smaller than 6-ft high by 6-ft wide that simulates proposed finish attachments.

2. Specific pressure loads associated with common traffic dynamic loads at the entrance and exit of the tunnel. The total negative load varies due to the dead load of the panel type selected plus the wind load. The total negative load is estimated at approximately 50 psf; and

3. The Design-Builder will determine all Loadings to which tunnel finishes will be subjected.

E. The Design-Builder shall inspect all parts of the tunnel above the roadway level for all water leaks prior to installation of passive fire protection boards, fans, finishes and any exposed conduit and piping. The inspection shall be recorded by photography and notation relative to project stationing and clock position looking up-station. All leaks identified will be repaired in a manner to be selected by the Design-Builder subject to review and approval by the Department.

25.3.3. Wall Finish

A. The ceramic tile wall system shall be erected to a height of 15 ft. 6 in. above the low-point of the tunnel roadway, excluding surfaces behind the roadway safety barrier. The minimum properties of ceramic tile shall be:

1. Color Uniformity: ASTM C609. The individual range of Delta L, Delta A and Delta B values of the sample shall fall within 1.5 units of the referenced standard. The average Delta E value of the sample shall not exceed 2.5;

2. Exposed face – Plain White smooth, reflective

3. Specular Gloss: 40 ± 5;

4. Reflectance: ASTM C609. Luminous reflectance Y value of 70 ± 5;

5. Water Absorption: ASTM 373 not to exceed average water absorption of 0.2%;

6. Mohs Hardness: minimum of 6;

7. Bond Strength: ASTM C482 – No sample less than 200 psi and average shall be greater than 250 psi;

8. Crazing: ASTM C424 – No evidence of crazing; and

9. Manufacturer must be G2, Green Squared.

B. The tunnel wall finish shall be ceramic tile, with appearance similar to the tile finish in the existing HRBT tunnel. The minimum properties of ceramic tile, in addition to minimum properties stated above, shall be:

1. Nominal tile size determined by the Design-Builder not to exceed 4-in. high x 4-in. wide as manufactured. Tiles shall not be cut from larger sizes;

2. Thickness: 5/16 in. to 7/16 in.;

3. Tile back: Raised rib back to provide satisfactory bond, minimum 1/4 in. rib;
4. Caliber Range (size): ASTM C502 ± 0.5\% of average facial dimension sample;
5. Warpage – Edge/Diagonal: ASTM C485. No individual value to exceed ± 0.4\%. The range of edge warpage not to exceed 0.5\%;
6. Wedging: ASTM C502 ± 0.5\%;
7. Breaking Strength: ASTM C648–Average breaking strength shall be 300 pounds-force or greater; and
9. Design Builder shall supply owner with a minimum of 10\% spare quantity of ceramic tiles.

C. The Design-Builder shall investigate and design a method of attachment of the ceramic tile wall finish system components including tile, intermediate component and fire protection board to the tunnel structure that will result in an ultimate pull-out capacity of 200 psi, confirmed by laboratory testing performed using the selected system, including proposed adhesive, mortar, and fasteners.

D. As an alternative to attachment of the ceramic tile to intermediate component and fire protection board, the Design-Builder may propose and, if approved, design a modular framing system that isolates the finish from the passive fire protection board, subject to the Department’s review and approval.

25.3.3.1. Submittals

A. The Design-Builder shall prepare a Tunnel Wall Finishes Design Statement Report that includes:

1. Specific design parameters to be used that address, at a minimum, the Performance Requirements and the strength and reflectivity properties;
2. A discussion of cleaning methods and finish durability; and
3. Ceramic tile type recommendation, subject to Department review and approval.

B. Design submittals shall include the following, subject to Department review and approval:

1. Detailed specifications for all products associated with the design, material and installation of selected Tunnel Wall Finish including, but not limited to: intermediate component, fire protection board, tile, primer, mortar, moisture barrier, grout, metal framing, metal panels, and fasteners; and
2. Detailed construction drawings showing the full extent of finish application including all necessary details including and details related to durability and achievement of the required Service Life.

25.3.4. Coating System for Exposed Fire Protection Board

25.3.4.1. General

A. This Section pertains to the coating system that will be applied to the surfaces of passive fire protection boards, including the edges of the fire protection boards, in the cut-and-cover tunnel, the immersed tube tunnel, and the bored tunnel. Requirements include: selection of appropriate system, preparation of specifications, and furnishing all material and equipment and performing all work required for installing the coating system as described herein.
25.3.4.2. Performance Requirements

A. The Coating System used shall have a demonstrable record of successful application in similar environmental conditions on fire protection board identical to the fire protection board used on this project. The Coating System shall meet the following requirements to ensure functionality, acceptable appearance, and ease of maintenance:

1. Shall be a two-component polymer based coating designed for application on fire protection board identical to the type used. Solvent-based epoxy-based paints are not permitted. Water dispersed epoxy paint systems, provided that they meet all of the other technical requirements of this section, are permitted.

2. Shall be gloss white and have an initial reflectance of not less than 50%.

3. Shall conform to all current API Standards and carry appropriate approvals for coatings and linings and shall meet all current U.S. EPA requirements for volatile organic compounds (VOC) Compliance Level.

4. Shall be resistant to water and carbon dioxide ingress and tested to anti-carbonization properties acceptable to the Department.

5. Shall be durable and shall be provided with a 15-year warranty against failure, including detachment and material failure.

6. Shall have a high degree of chemical inertness and fully resistant to sulphur laden atmosphere, salt sprays, motor vehicle exhaust fumes, oils, gasoline, and alkali detergents.

7. Shall remain adhered to the substrate without blistering or peeling. The manufacturer shall submit pull-off tests to demonstrate adhesion, results shall be subject to the Department’s review and approval.

8. When tested, bond between the coating system and fire protection board shall not break but the board itself separate at a depth of approximately 1 mm.

9. Shall not be penetrated by a load of 5,000 g when tested in accordance with ISO 1518 (scratch test).

10. Shall not cause chemical or other reaction that will reduce the effectiveness.

11. The Design-Builder shall supply the Department with a minimum of 10% of the required amount required to coat the tunnel, portal and approaches in a form suitable for storage and use in small quantities.

25.3.4.3. Preparation and Application

A. The Coating System shall be applied strictly in accordance with the manufacturer’s written requirements and instructions:

1. Apply one prime coat and two finish coats on the interior (traffic area side) of the fire protection board and one prime coat and one finish coat on the exterior (ground side) of the fire protection board and all of the edges of the fire protection board;

2. Provide a minimum dry film thickness of 60 microns per coat;

3. Following the application of the first coat, applied material should be allowed to become tacky or dry to touch prior to application of next coat; and
4. Monitor the humidity and dew point at all times. Cease application when conditions are unfavorable.

**25.3.4.4. Submittals**

A. The Design-Builder shall prepare a Coating System for Fire Protection Board Report that includes:

1. Comprehensive assessment of the coating system selected with regard to type, references from other similar project applications, proposed technical director, method of application, and warranty;
2. Examples of successful use; and
3. A discussion of recommended cleaning methods.

B. Design submittals shall include the following, subject to District review and approval:

1. Detailed product specifications.
2. Independent laboratory results that confirm properties stated in the specifications.
3. Tile samples to be used.

C. The Design-Builder shall prepare mock-up panels consisting of two panels, one attached to the wall and the other attached to the ceiling. Mock-up panels shall include, but not limited to, the furnishing and installation of tiles, adhesives, colors, coatings and finishes and any other manufacturer recommended treatments. If acceptable in the opinion of the Department, the mock-up panels may remain permanent; if unacceptable, the panels will be removed and the Design-Builder will repeat the process until acceptance is met. Approved mock-up panels will set the standard of subsequent production which shall be followed by the Design-Builder. This production process shall be documented and submitted to the Department by the Design-Builder.

**25.3.5. Tunnel Portal Wall Finish**

A. Tile shall also be applied on the faces of both portals of the tunnel. The portal tile area (extent) collar and appearance shall match precisely the area (extent) and appearance that exists on the existing tunnel portals for the Hampton Roads Bridge Tunnels. Any deviation from the extent or appearance of the Tunnel Approaches, Portals or Tunnel must be submitted for review and acceptance by the Department. The Design-Builder shall prepare and submit drawings of the portal tile configuration subject to review and acceptance by the Department.

**25.4. Deliverables**

At a minimum, the deliverables shall include the items listed above and in Table 25.4-1 for the Department’s consultation and written comment. All submittals shall be accompanied by appropriate level of analysis calculations to justify all engineering decisions made. The Department the right to reject any incomplete submittal.

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SECTION 26. MECHANICAL SYSTEMS

26.1. Scope
The scope of work is to provide complete working mechanical systems that include but are not limited to Design, Manufacturing, Testing, Installation and Commissioning of Mechanical and Fire Life Safety Systems. In addition, the Scope includes Training and requirements to develop Operations & Maintenance Manual and Emergency Response Plan.

26.2. References
A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   a. VDOT, Road and Bridge Standards
   b. VDOT, Road and Bridge Specifications
   c. VDOT, Project Development Manual
   d. VDOT, Environmental Manual
   e. VDOT, Drainage Manual
   f. VDOT, Instructional and Informational Memoranda

B. National Fire Protection Act (NFPA) Standards and Guidelines including:
   a. NFPA 502, Standard for Road Tunnels, Bridge and Other Limited Access Highways
   c. NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection
   d. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
   f. NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems
   g. NFPA 10, Standard for Portable Fire Extinguishers
   i. NFPA 14, Standard for the Installation of Standpipe, Private Hydrant and Hose Systems
   j. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances
   k. NFPA 72, National Fire Alarm Code
   l. NFPA 80, Standard for Fire Doors and Other Opening Protectives
   m. NFPA 92, Standard for Smoke Control Systems
   n. NFPA 252, Standard Methods of Fire Tests of Door Assemblies
   o. NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
   p. NFPA 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities
   q. NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems
   r. NFPA Fire Protection Handbook
   s. NFPA3: Recommended Practice for Commissioning of Fire Protection and Life Safety Systems

C. FHWA Tunnel Operations, Maintenance, Inspection, and Evaluation (TOMIE) Manual;

D. FHWA National Tunnel Inspection Standards (NTIS)
E. AASHTO Highway Drainage Guidelines.
F. Virginia Uniform Statewide Building Code (USBC);
I. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality
K. ASHRAE Guideline 1.5 - The Commissioning Process for Smoke Control Systems
L. ASTM A112.6.3-2001 Floor and Trench Drains;
M. National Electric Code (NEC);
N. FHWA Technical Manual for Design and Construction of Road Tunnels;
O. Air Movement and Control Association International, Inc. (AMCA) 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating;
P. AMCA 204, Balance Quality and Vibration Levels for Fans;
Q. AMCA 250, Laboratory Methods of Testing Jet Tunnel Fans for Performance;
R. AMCA 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data;
S. AMCA 500-D, Laboratory Methods of Testing Dampers for Rating;
T. AMCA 500-L, Laboratory Methods of Testing Louvers for Rating;
V. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless;
W. Sheet Metal and Air Conditioning Contractors’ National Association (SMACNA); and
X. International Fire Code.
Y. Underwriters Laboratories UL 10C - Standard for Safety – Positive Pressure Fire Test of Door Assemblies
Z. UL 555S Standard for Smoke Dampers
AA. UL 508, Industrial Control Equipment (ANSI);
BB. UL 723, Standard for Safety Test for Surface burning Characteristics of Building Materials
CC. OSHA Occupational Safety and Health Association
26.3. Requirements

26.3.1. General

This Section 26.3.1 provides the requirements for mechanical systems. These systems include but are not limited to the following:

A. Tunnel ventilation system;
B. Tunnel air monitoring system;
C. Tunnel drainage (including pump stations at portals and low point);
D. Tunnel fire protection system (fire detection, fire standpipe and water supply, deluge water-based fire-fighting system, i.e.);
E. Tunnel panels (including fire extinguishers);
F. Mechanical monitoring and control system;
G. Emergency exits;
H. Heating ventilating and air conditioning (HVAC) system;
I. Ventilation Buildings Mechanical Systems; and
J. Installation, Manufacturing, Testing and Commissioning
K. All mechanical piping and equipment located in the tunnel that is supported by post-installed anchors shall be mechanical undercut anchors. All mechanical piping and equipment located in the tunnel that is supported by cast in place anchors shall be “L”, “J” or plate type. Anchors shall be AISI Type 316/316L/316Ti stainless-steel. All anchors shall be designed for the temperature that they can be exposed to during a fire event. For additional criteria see structural sections on anchor bolt requirements.
L. All supports for mechanical equipment suspended within the tunnel shall be capable of maintaining support for not less than 2 hours at 600 degrees Fahrenheit or minimum values as developed by fire analysis.
M. The Design-Builder is alerted that the storage and transportation of equipment to be used on this project, shall be done so in an environment or method that is in accordance with the manufacturers recommendations and to provide the owner with assurance that the equipment will not be harmed to function appropriately for its intended use.

26.3.2. Coordination Requirements

A. The Design-Builder shall fully coordinate with all disciplines and agencies as necessary such that the mechanical systems are fully compatible with other tunnel systems and will function as intended. The Design-Builder shall submit a Space Proofing Report describing and showing mechanical and electrical systems to demonstrate available space meeting the most current version of NFPA 502.
B. The construction of the mechanical systems shall be coordinated with other construction works as necessary such that the design performance and assumptions are not compromised, impacted or degraded due to the final constructed conditions and that the mechanical systems will function as intended.
C. The Design-Builder shall hold, at a minimum, quarterly coordination meetings for design, construction, fire/life safety and other safety related issues throughout the design and
construction of the Project to ensure that all affected parties are made aware of the development of the tunnel and its facilities. During the design phase an opportunity for affected parties to comment on operational or standard practices shall be provided. The Design-Builder shall document agency comments and code requirements and provide a response to each. The primary focus of the meetings shall be on operational and safety issues as listed below:

a. All meetings shall be convened and recorded by the Design-Builder. Prior to advancement to detailed design of the principal safety related systems, the Design-Builder shall prepare a report documenting the agreed upon approach resulting from the meetings. This report shall be submitted to participants of the meetings and shall include but not be limited to the design of the tunnel and its systems and the proposed means of operation and emergency response.

b. The Design-Builder shall develop and provide a Fire Life Safety Procedure for First Responders and submit to the Department for review and approval. This procedure shall include but not be limited to:
   i. Proposed tunnel design and facilities for dealing with fires, spillages and road traffic accidents;
   ii. Fire Department procedures, roles and responsibilities;
   iii. Electrical, Controls and Radio communications requirements and procedures and;
   iv. Training requirements.

c. The Design-Builder shall conduct a combined First Responders Workshop(s) to discuss:
   i. Coordination of emergency response plans, roles and responsibilities;
   ii. Requirements for rendezvous and triage areas;
   iii. Risk level and response capacity as defined in NFPA 502; and
   iv. Proposals for emergency exercises.

26.3.3. Design Requirements – General

26.3.3.1. Design Principals

The mechanical systems design shall be governed by the following principles:

A. The Design-Builder shall perform engineering analyses in accordance with the most current version of NFPA 502, and apply other applicable project standards to provide an appropriate environment during all emergency and non-emergency operating modes. The Design-Builder shall submit a Fire Life Safety Compliance Report.

B. Critical power supply and control equipment shall be located in accordance with Section 27.

C. In accordance with VDOT Rules and Regulations Governing the Transmission of Hazardous Materials, hauling any explosive, flammable or other hazardous cargo is prohibited by the VDOT through any tunnel on Virginia’s highways the transportation of hazardous materials (HAZMAT) within or through Virginia must comply with Federal regulations promulgated by the Secretary of Transportation and set forth in Title 49 of the Code of Federal Regulations. Transport of hazardous materials through the
HRBT tunnel requires compliance with parts 100 through 180 of the Code of Federal Regulations Title 49 plus compliance with the restrictions listed in the tables. These tunnels are classified as urban/water proximate facilities. The tables list categories of materials grouped under the designations “Prohibited”, “No Restrictions” or “Restricted” and can be found in the document “Virginia’s Size, Weight and Equipment Requirements for trucks, trailers and towed vehicle” at https://www.dmv.virginia.gov/webdoc/pdf/dmv109.pdf

D. Bicycles, pedestrians and animals will not be allowed in the tunnel.

### 26.3.3.2. Environmental Design Conditions

A. The mechanical equipment and systems shall be designed, furnished, and installed/constructed with features necessary for suitable operation in a tunnel marine environment. The tunnel and other spaces therein such as the pump stations, egresses/exits, etc., contain environments with adverse conditions such as high humidity, high temperatures, potentially explosive atmospheres, and corrosive atmospheres. The equipment shall be selected, specified, designed, purchased, tested and installed with the full disclosure of the environments to the manufacturer. Mechanical piping, handrails and equipment located in the tunnel shall be of 316 stainless-steel unless specified differently throughout this document.

B. The road tunnel environment is harsh, consisting of vehicular emissions and fumes, etc. This is coupled with the amount of rainfall in the Hampton Roads area and vapors of salt from the ocean such that the mechanical systems need to be protected from corrosion.

### 26.3.3.3. Reliability and Availability

A. All mechanical equipment shall be designed to perform reliably in the intended application. All systems and equipment proposed for use shall have a proven track record of reliable service in a similar application.

B. Reliability evaluation of the fire life safety systems shall be performed. Failure or loss of availability of fire life safety equipment shall be considered in the evaluation. Evaluation shall address the following:

   a. Impact events
   b. Seismic events
   c. Redundancy requirements

C. The mechanical equipment and systems shall be designed, furnished, and installed/constructed with features necessary for suitable operation in a tunnel marine environment and within the manufacturer’s warranted ratings.

D. Mechanical systems shall be designed such that equipment maintenance will not require complete tunnel tube closure for traffic.

E. The Design-Builder shall supply a spare Jet Fan of exact size and type of those installed to the owner upon completion of the work.

F. The manufacturer shall guarantee that all spares and replacement parts shall be made available during the duration of the equipment’ life expectancy.
26.3.3.4. Protection against Environmental Conditions

A. All parts of the tunnel electrical and mechanical installations, including fasteners and support systems, shall be suitable for use under all reasonably foreseeable conditions in the environment in which they are installed.

B. Conditions to be considered shall include, but not be limited to the following:
   a. Ambient temperature and fire temperature;
   b. Humidity and vapors of ocean water;
   c. High winds;
   d. Immersion in water;
   e. Accumulations of ice or snow at portal areas;
   f. Tunnel washing;
   g. Vibration;
   h. Electromagnetic interference;
   i. Soot and smoke; and
   j. Vehicle emissions.

C. All parts of the tunnel mechanical installations, including fasteners and support systems, shall be adequately protected against corrosion before, during and after installation for the duration of their design life. Materials, paint systems and protective finishes shall be appropriate to the operating environment and shall be designed to inhibit the spread of corrosion should the protective layer be damaged. Suitable measures shall be taken to avoid direct contact between dissimilar metals exposed to the atmosphere. The design life of assets must be as specified in Table 26-1 below, except for listed asset sub-items which may have the specified lesser design life.

D. Equipment installed within the tunnel shall be designed to minimize the accumulation of dust and moisture on exposed surfaces, and, unless stated otherwise, shall have an ingress protection rating equivalent to IP65 as defined in ANSI/International Electrotechnical Commission (IEC) 60529.

E. All protective finishes shall be capable of repair on site to an equivalent level of durability and corrosion protection equivalent to the original finish, in accordance with the manufacturers’ recommendations, following mechanical or other damage.
### Table 26-1 Asset Items Specified Design Life

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<td>Bearings</td>
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<td>Drainage System</td>
<td>Pump Station</td>
<td>Level and other Sensors</td>
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<td>Pumps</td>
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<td>Tanks</td>
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26.3.3.5. Engineering Design Calculations

A. The Design-Builder shall submit engineering design analysis and calculations to the Department for review and comment, which shall include, the ventilation for the main tunnel and the egress/utility corridor, evacuation routes, drainage, fire suppression, and HVAC systems and components. The document shall provide the design approach, basis of design and complete sets of calculations and analysis assumptions, inputs and results, and demonstrate the ability of the systems and components to meet the design criteria specified within these Technical Requirements.

B. The Design-Builder shall utilize the software in the design of the tunnel mechanical systems as follows:

   a. Computational fluid dynamics flow modeling software (ANSYS FLUENT) or approved equal for the fire and ventilation system airflow modeling and fixed fire suppression system discharge modeling;
   
   b. United States Environmental Protection Agency’s (MOVES) software or approved equal to estimate the vehicle emissions;
   
   c. Hydraulic Analyzer of Sprinkler Systems (HASS) software or approved equal to perform hydraulic analysis in accordance with NFPA standards;
   
   d. Simulation of Transient Evacuation and Pedestrian Movements (STEPS) software or approved equal for evacuation modeling; and
   
   e. Peak stormwater runoff shall be analyzed in accordance with Section [X.XX].

C. If the Design-Builder shall submit a list of all software to be used to the Department for review and approve.

D. All software must use the English language.

E. To the extent the Design-Builder proposes the use software not currently available to the Department, the Design-Builder shall provide the Department the software for verification of models, computer runs and testing prior to approval.

F. The calculations, models, inputs and outputs of computer modeling files shall be in the English language and submitted to the Department for review and comment.

G. All final design calculations shall be certified by a Professional Engineer licensed in the Commonwealth of Virginia.

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<th>Asset Type</th>
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<th>Asset sub-item</th>
<th>Design Life (years)</th>
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<td>Valves</td>
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26.3.3.6. Training

A. The Design-Builder shall provide operation and maintenance training to the Department a minimum of ninety (90) days prior to Substantial Completion.

B. The Design-Builder shall provide a Tunnel O&M Training Syllabus, thirty (30) days prior to beginning training for review and approval by the Department. The training shall be conducted by the manufacturer’s technical service personnel or factory authorized representatives for all the mechanical systems installed.

C. The Design-Builder shall provide a minimum of forty (40) hours of training for each tunnel sub-system.

D. The Design-Builder shall include in the training: operation instructions, theory of operation, circuit description, preventive maintenance procedures, troubleshooting and repair of all mechanical systems equipment. The Design-Builder shall provide all participants material and manuals required for the training.

26.3.3.7. Warranty

A. A standard manufacturer’s warranty shall be furnished for each mechanical system component which is furnished and installed or otherwise provided to the Department. The effective beginning date of the Mechanical System Warranty Period (MSWP) shall be the date of the Final Acceptance of the Project and the MSWP shall end no less than two (2) years from this date, or the same as the manufacturer’s standard warranty, whichever is longer. The warranty documentation shall be provided to the Department and a copy shall be included in the Tunnel Operations & Maintenance Manual.

B. The Design-Builder shall be responsible for all costs associated with vendor or manufacturer warranty service during the MSWP.

26.3.4. Tunnel Ventilation

26.3.4.1. Design Requirements

A. General

a. The tunnel ventilation system shall be designed and constructed to provide a safe and tenable environment for motorists in the tunnel during all expected conditions including flowing traffic, stopped traffic, and congested traffic. The tunnel ventilation system shall also be designed and constructed to mitigate the effects of smoke and heat during an incident involving a fire to facilitate the safe evacuation of motorists and firefighting operations.

b. The tunnel ventilation system shall conform to the requirements of the most current version of the NFPA 502, Standard for Road Tunnels, Bridges, and Other Limited Access Highways.

c. The tunnel ventilation system shall be designed to provide the following minimum functions:

   i. Ventilation of tunnel vehicle emissions to maintain criteria limits for carbon monoxide (CO), nitrous oxides (NOx), sulfur dioxide (SO2) and particulate matter (PM); and

   ii. Removal of smoke and heat and providing a tenable environment for motorists and passengers evacuating the tunnel during a fire event. A tenable evacuation
route and means of accessing the fire for rescue and emergency services must be maintained supporting fire-fighting operations.

d. The design of the ventilation system shall assume uni-directional traffic operation in the tunnel during normal and fire emergency conditions. Contra-flow traffic or, in rare cases, bi-directional traffic operation will be a very infrequent operational need for a very short duration under special supervision. Traffic restrictions such as lane closure, restricted speed, escorting, and controlled access will be implemented during rare events and need to be addressed in the emergency response plan since the tunnel ventilation system will not be effective in a fire emergency event during bi-directional traffic operation.

e. The longitudinal tunnel ventilation system shall be designed with ability to reverse the tunnel airflow for emergency rescue services access the tunnel from the exit portal during fire emergency after complete evacuation of tunnel users.

f. The longitudinal tunnel ventilation system shall not be obstructed on the intake or discharge sides by other tunnel fixtures, lighting or signage.

g. The Design-Builder shall ensure that design, construction and installation of mechanical equipment, such as fans, is done in a manner to make regular/routine maintenance, removal, and/or replacement of equipment as efficient and accessible as possible with little to no disruption to traffic while maximizing the safety of Department personnel and contractors.

h. The ventilation design shall prevent the recirculation of smoke or exhaust fumes between the portals of the existing and proposed tunnels.

i. The portal design wind shall be determined based on typical winds in the Hampton Roads Bridge Tunnel area registered by the National Oceanic and Atmospheric Administration (NOAA) weather station. A 90th percentile of the winds impinging upon the exit portal shall be used for the tunnel ventilation analysis. The prevailing wind direction with respect to the tunnel axis shall be considered in calculating the portal design wind.

B. Control of Air Quality

a. Ventilation system shall be designed and constructed to comply with the in-tunnel air quality limits in accordance with the following requirements. Ventilation must dilute contaminants during normal and congested tunnel operations and control smoke during emergency operations.

b. The Design-Builder shall evaluate the type of vehicles for road tunnel usage and pollutions they produce to tunnel environment. The most common known emissions from spark-ignition engines, compression-ignition (diesel) engines and alternative fuel vehicles engines are:

   i. Carbon monoxide (CO);
   ii. Oxides of nitrogen (NOx);
   iii. Sulfur dioxide (SO2);
   iv. Haze and visibility; and
   v. Hydrocarbon emission from alternative fuel vehicles.

c. The following factors shall be evaluated as part of an engineering analysis of emissions and ventilation requirements to control air quality:
i. Type of vehicles: The calculation shall be based on the projected vehicle-fleet distribution based on the traffic forecast in 2040;

ii. Traffic operating mode;

iii. Tunnel Geometry: Determine the tunnel length, gradient and cross section;

iv. Vehicle speed;

v. Natural factors, including prevailing wind; and

vi. Traffic congestion: The calculation shall be based on a standstill traffic five-feet apart based on types of vehicle.

d. The following air quality parameters shall be continuously monitored. The ventilation system shall be designed and automatically controlled to maintain air quality below the following thresholds under all reasonably foreseeable traffic conditions:

   i. Carbon monoxide (CO). Provision shall be made for continuous monitoring of CO under stationary traffic conditions to ensure that the following exposure times are not exceeded:

      1. 120 ppm for 15-minutes;

      2. 65 ppm for 30-minutes;

      3. 45 ppm for 45-minutes;

      4. 35 ppm for 60-minutes; and

      5. Carbon Monoxide level shall be limited to 50 ppm for tunnel operators and maintenance workers exposure. Limits are time-weighted averages (TWAs) for eight-hours of exposure.

   ii. Oxides of Nitrogen (NOx). From compression-ignition (diesel) engines, the critical contaminants are nitrogen oxides (NOx), such as nitric oxide (NO) and nitrogen dioxide (NO2). Nitrogen dioxide NO2 shall be limited to three (3) parts per million (ppm). Nitric oxide (NO) shall be limited to twenty-five (25) ppm.

   iii. Sulfur dioxide (SO2). SO2 concentration level in the tunnel shall be limited to five (5) ppm for fifteen (15) minute exposure.

   iv. Haze and visibility. The presence of particulates leads to reduced visibility inside the tunnel. Haze and visibility measured using extinction coefficient which reflects the amount a light beam, is attenuated over a given distance. The extinction coefficients used for design of ventilation system shall be limited to 0.00152 ft-1 (0.005 m-1) for peak flow as well as for daily congested traffic.

   v. Hydrocarbon emission. Ventilation system shall be used to purge the tunnel of hydrocarbon gases in the event of the gas leak from compressed natural gas (CNG) vehicles. Design of ventilation system must be based on maintaining air quality below the lower flammable limit (LEL) in the event of a natural gas leak.

   vi. Accumulative effect of gases. Many gases may act additively, synergically or antagonistically as present in the tunnel air, and therefore their combined effect shall be evaluated.


e. Fresh air requirements shall be calculated based on predicted vehicle emissions for the year 2040, taking into consideration the likely spread of vehicle ages, standards of maintenance and traffic speeds.
H. Air Velocity
   a. Air Velocity in tunnels under normal operating conditions shall be controlled to reduce
dust dispersion and for comfort for motorists and workers. Air velocity within the tunnels
shall not exceed 2000-feet-per-minute except when 2000-feet-per-minute or greater
occurs naturally with piston effect of traffic and wind conditions.

I. Noise Level
   a. Noise levels during fire emergency shall comply with the requirements specified in the
Annex Material of the most current version of NFPA 502.

   b. When the mechanical ventilation system is operating at full load, and a tunnel roadway is
free of traffic, the sound level at five (5) feet above the center line of the road and thirty
(30) feet from the ventilation outlet at any point shall not exceed 85 dBA during normal
operations, congested operations and standstill operations. The sound power level ratings
of all fans shall comply with the latest revision of AMCA Standard 301, “Methods for
Calculating Fan Sound Ratings from Laboratory Test Data”.

   c. Fans shall be rated and tested in accordance with the latest edition of AMCA Standard
250, “Laboratory Methods of Testing Jet Fans for Performance”, or AMCA 300
“Reverberant Room Method for Sound Testing of Fans” as applicable.

J. Air Monitoring System
   a. The Design-Builder shall conduct all work necessary to complete the Air Monitoring
System for the tunnel.

   b. The tunnel ventilation control system shall be programmed to automatically operate and
efficiently maintain the tunnel air quality during normal flowing traffic, congested and
stopped traffic conditions; and semi-automatically to control heat and smoke during fire
emergency.

   c. The tunnel ventilation operating modes shall be determined by computer modeling of
anticipated environmental conditions.

   d. The tunnel shall be equipped with air quality monitoring equipment/sensors to monitor
and control carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and
visibility/haze levels collected at five sampling points approximately equally spaced
throughout the tunnel with the end points located within 150 feet from the portals or
closer supported by the air monitoring manufacturer specializing in road tunnels
installations and the middle point within approximately low point.

   e. Electrochemical type sensors for air quality analysis shall be provided suitable for tunnel
environment with a proven operation in road tunnels.

   f. The air monitoring system shall be maintained as efficient and accessible as possible with
little to no disruption to traffic while maximizing the safety of Department personnel and
contractors.

   g. Sensors shall be completely protected from traffic. Sensors operation shall not be
impacted by the tunnel power washing or scrub trucks, tunnel dust and by temperature
and air pressure changes.

   h. The sensors housing shall be made of stainless-steel and all its components shall be
corrosion, dust and moisture resistant.
i. Terminal box of each sensor shall be provided with local display indicating the measured values. The monitoring device shall report readings locally and send readings to the control room via the SCADA system. Readings shall be recorded and maintained by the system for one year. Refer to Section 29 SCADA and EPCS.

j. Air quality alarms shall notify the control room and not automatically activate the tunnel ventilation system.

k. Accuracy of measurements shall not exceed plus or minus two (2) percent of the full scale, while the full scale shall not exceed the values twice the maximum threshold values.

l. No humidifier or de-humidifier shall be required for air monitoring devices.

m. Monitoring devices for measuring air velocity and its direction in the tunnel shall be provided at within one hundred (100) feet from both portals for monitoring air flows. The devices must be suitable for tunnel environment and representative of and correlated with the average air flow across the tunnel cross section.

K. Fire and Smoke Control

a. The ventilation system shall be designed to control heat and smoke from a 100-megawatt (MW) fire peak heat release with an “ultra-fast” fire development rate of no less than fifteen (15) minutes.

b. The fire and smoke properties shall be based on a Heavy Goods Vehicle fire.

c. The effectiveness of the proposed design and compliance with the design requirements shall be demonstrated at an early stage in the design by computer modeling using suitable Computational Fluid Dynamics (CFD) software to identify any possible deficiencies and effectiveness of fire suppression system. In addition, analysis shall be repeated at RFC design stage to incorporate design changes and confirm compliance with the design requirements.

d. The longitudinal ventilation system shall be designed to move air in the direction of traffic flow during normal operation of the tunnel. The fans shall be able to reverse flow in the tunnel and individually controlled to enable performance to be optimized during reverse traffic flow and emergency conditions. The brake horsepower for reverse flow shall not exceed the brake horsepower for forward flow.

e. The design shall be determined by the longitudinal air velocity required in the tunnel to prevent backlayering from the design fire at any point in the tunnel under adverse wind conditions to allow for safe evacuation of occupants and access for emergency services.

f. The tunnel shall be assumed to be fully congested in the length of tunnel leading up to the fire.

g. Tunnel ventilation fans, such as jet fans, that can be directly exposed to fire within the tunnel roadway shall be considered expendable. The design of ventilation systems where fans can be directly exposed to a fire shall incorporate fan redundancy. Safety chains shall be installed to support each fan and sound attenuator.

h. Design for compliance with NFPA 502 shall allow for the eventuality that fans exposed to high temperatures exceeding the fan specified and tested temperature downwind from the fire location will be rendered inoperative by a fire, and that fans upwind of the fire are operating in relatively cool air and that all fans downwind will be operating in air at elevated temperatures.
i. In addition, the emergency ventilation system shall be designed to meet ventilation requirements with one critical fan being out of service due to maintenance.

j. The CFD model shall demonstrate that, for a design fire at any point in the tunnel, and subject to the stated traffic conditions, backlayering of smoke is controlled and a tenable environment is established to allow evacuation upstream of the fire without the longitudinal airflow velocity exceeding the limit permitted by NFPA 502 Annex B. In addition to steady-state CFD analysis as a minimum, time-dependent CFD modeling shall simulate the system performance from fire ignition, fire detection, systems activation to fully developed fire and airflow conditions for the following fire scenarios:

   i. Fire location (most critical) 100 feet in from the entrance portal, unidirectional traffic, tunnel clear ahead of the fire; If jet fan system is utilized row of fans closest to the entrance tunnel portal shall be considered expandable.

   ii. Fire location within 100 feet before the exit portal, unidirectional traffic, and tunnel filled with traffic behind the fire; and

   iii. Fire at the tunnel mid-point, or low point, whichever location is more critical, unidirectional operation, and tunnel filled with traffic behind the fire.

k. Results of time-dependent CFD analysis shall be compared against time-dependent evacuation modeling results to demonstrate tenability during the evacuation and rescue phase.

l. The calculation methods and formulae applied in the CFD model shall be checked and verified by an appropriately qualified independent checker. Modeler’s and the checker’s qualification shall be submitted to the Department for approval.

m. See Section [X.XX] for corridor ventilation requirements.

L. Control

A. Air quality sensors strategically located in the tunnel shall alert the operator when air quality levels fall below the thresholds stated above.

B. The direction and velocity of air flow through the tunnel shall be monitored to enable the control room operator to check that the air flow is neither insufficient nor excessive.

C. The control room operator shall have the means to override the control of individual ventilation fans at any time via the SCADA system.

D. Provision shall be made for the system to be controlled manually from a local control, when automatic control of the ventilation is either not possible or insufficient to maintain the required levels of air quality or for any other scenario.

E. The ventilation control system shall respond appropriately to the smoke control requirements for a fire at any given location, in accordance with a smoke control strategy to be reviewed by the Department and the First Responders.

F. Since it is highly probable that the control room operator will become aware of the existence of a small fire, either by observation of an incident on CCTV or by telephone, provision shall be made for the control room operator to call up and activate the appropriate ventilation plan by manually entering the location of a fire, or suspected fire, into the SCADA system.

G. All tunnel ventilation fan motors shall be continuously monitored for winding temperature and bearing vibration. If excessive temperature or vibration is detected, an
alert shall be raised via the SCADA system. However, in neither case should the motor be shut down automatically during a fire event, since motors must be allowed to run to destruction in the event of a serious fire.

26.3.4.2. Tunnel Ventilation Fan Assembly Manufacturing Requirements

A. Fan and Motor Manufacturer: All fans, provided for the Project shall be the product of the same manufacturer whose name appears on the theoretical fan performance curves. Furnish motors and drives for all tunnel ventilation fans supplied by either a single manufacturer or supplier.

B. Qualifications of Fan and Motor Manufacturer: The manufacturer of the fans to be provided for the Project shall be a manufacturer who for at least ten years has been regularly engaged in the production of tunnel ventilation fans of size capacity and thrust comparable to that specified.

C. Operating Environment
   a. Normal Operation - The entire fan-motor-sound attenuator assembly installed inside the tunnel shall be constructed such that it has industrial protection rating of IP 55, it is capable of withstanding water spray from tunnel washing vehicles, and suitable for the operating conditions that may be encountered in a vehicular tunnel.
   b. Fans shall have provisions for draining water that enters the fan assembly. Provide drain hole of 0.5-inch diameter minimum in the exterior casing of each sound attenuator, to drain water that may enter fan assembly.
   c. Emergency Operation - The entire fan-motor-sound attenuator assembly including hangers, supports, and cables, shall be constructed such that the components do not suffer mechanical, electrical, or structural failure when operating at full capacity with air flowing through the fan at the design temperatures.
   d. The entire fan-motor-sound attenuator assembly installed inside the tunnel or designed to exhaust hot air during fire emergency shall be rated to operate at full capacity at an ambient air temperature of 600 degrees F for a minimum period of one hour. (Note: The engineering analysis can be used to justify the ambient temperature reduction; however, it should not be less than 482 degrees F).
e. Equip motors with 120-volt anti-condensation motor winding heaters to prevent condensation of moisture in the motor windings. Energize heaters when the motor is not operating and de-energize the heaters when the motor is in operation. Terminate winding space heater leads in a separate NEMA 4X disconnect switch mounted on the exterior of the fan housing.

D. Material - Unless specifically stated otherwise, all material used in the construction and support of the Fan assembly shall be fabricated out of AISI Type 316/316L/316Ti stainless-steel. Common items such as motor windings, circuit boards, control systems, wiring, gaskets, sealants, lubricants and bearings are exempt from this requirement. Motor housing and impeller hardware are also exempt from this requirement. All exempt components shall have corrosion protection suitable to the humid, salt and corrosive environment. Fabricate access doors of steel construction with AISI Type 316 stainless-steel hardware and provide with not less than 1/8-inch-thick silicone base gasket suitable for the operating conditions specified to make airtight construction. Use AISI Type 304 stainless-steel bolts and stainless-steel support members to support fans, with rubber isolating material separating the stainless-steel from the fan’s steel attachment locations.

a. In selecting equipment, provide interchangeability of parts.

b. Clearance Limitations: The Design-Builder shall verify clearance and shall demonstrate on submittal drawings, that the clearance is sufficient for fan operation, maintenance with no need for tunnel closure and do not encroach into the vehicle dynamic clearance envelope.

c. Provide motors with a minimum of Class H insulation and rated for Class F temperature rise, when tested at the 1.15 service factor load.

d. Fabricate sound attenuators the exterior casing of stainless-steel, internally lined with inorganic mineral wool or glass fiber acoustic in fill covered with not less than No. 22 USSG stainless-steel perforated sheets. Select the acoustic in fill material, which is vermin free and moisture resistant. Select the facing on the in fill of the type that prevents erosion of the fibrous particles by the air stream under all conditions of operation specified. Select the acoustic fill material, which has the combustion rating Class A or class I when tested in accordance with Class A ASTM E 84, NFPA 255, or UL 723.

e. Provide means to protect tunnel ventilation system from birds and debris

E. Performance Requirements

a. Furnished fans shall be capable of delivering the required flow in the forward direction accelerating to full speed in 30 seconds or less. Reversible fans shall be capable of delivering the required thrust in the reverse direction in seventy-five seconds or less, from full speed forward to full speed reverse or vice versa with a maximum de-energized period of 30 seconds between reversals. All the fans shall reach full operating speed within 180 seconds. Permanently mark the forward direction of airflow in conspicuous location on the exterior of the fan housing.

i. Provide fans capable of being operated both manually and automatically, both locally and remotely. The operating procedures may require fans to be operated either individually or simultaneously.
ii. The fan performance requirements shall be determined by the Design-Builder and indicated in a design schedule and shall apply to fan operation with the standard air density of 0.075lb/cu ft.

iii. Select fan motor that operates in ambient air temperature of minus 5 degrees F to 104 degrees F and for fans used for smoke exhaust in emergency conditions with air temperatures of 600 degrees F for a period of not less than one hour. (Note: The engineering analysis can be used to justify the ambient temperature reduction; however, it should not be less than 482 degrees F).

iv. Furnish fans capable of satisfactorily withstanding the effect of all stresses and loads under starting and operating conditions.

v. Provide fans with a brake horsepower less than the nameplate rating of the motor.

vi. The capability of starting the fan at least four times (two cold and two hot starts) is required during any one hour of continuous operation. The capability of reversing air flow direction at least two times (one cold and two hot starts) is required during any one hour of continuous operation.

vii. Furnish fan having vibration velocity limits in compliance with AMCA 204 for fan application category BV-5 or AMCA 250 for Jet Fans.

viii. Furnish fans with a minimum reverse flow efficiency of not less than 90% of the forward capacity.

F. Design and construct motor bearings for maximum radial and thrust loads anticipated during starting and operating conditions. Furnish bearings having a minimum L-10 life rating equal to 40,000 hours as defined by the Anti-Friction Bearing Manufacturers’ Associations (AFBMA), which is an average bearing life of approximately 200,000 hours.

G. Bring lubrication lines from motor bearings to an easily accessible location for maintenance on the exterior of the fan housing and terminate in straight lubrication fittings. Terminate grease relief lines, if used, in spring loaded relief fittings. Provide grease fittings with covers to exclude water and dust. Select bearing lubricant, which provides the lubrication properties specified by the bearing manufacturer under conditions of operation for a minimum of one hour in design ambient air temperature.

H. Fabricate lubrication lines for motor bearings of high strength, seamless stainless-steel tubing without kinks or sharp bends. Secure lubrication lines rigidly to the housing with stainless-steel clamps and fasteners (cable ties are unacceptable) to prevent vibration of the lines and the leakage of air.

I. Monitoring Systems

   a. Each fan and motor bearing shall be furnished with a vibration monitoring system designed and installed for integration with the PLC remote I/O network through the distributed I/O cabinets (DICs). The vibration monitoring system shall be a two-wire, current-loop powered system operating on 24-volt, 4-20 mA base. The velocity sensor shall use solid-state, epoxy encapsulated circuitry with a piezoelectric crystal and output current proportional to velocity. The system shall have a frequency response range from 10 Hz to 10,000 Hz. The vibration monitoring components shall be designed, constructed, and capable of full operation from -20°F to +160°F, 100 percent humidity, and blowing rain. Encasements and enclosures shall be NEMA 4X.
stainless-steel. The 4-20 mA signal shall be connected to an analog input module in a DIC for processing at the PLC. The PLC shall be programmed to “alert” and “alarm” vibration levels as determined by the fan/bearing manufacturer. The alert level shall relate to general wear and/or minor defects indicating that maintenance is required. The alarm level shall relate to dangerous vibration caused by damage and/or sudden out-of-balance conditions.

i. Furnish motor bearing with a vibration monitoring system, complete with velocity pick-up transducer, for each motor bearing. Furnish the monitoring system that will trigger remote alarms for two levels of vibrations: “Alert” and “Alarm”. Provide measuring range that includes 0.2 inch per second RMS for alert and 0.4 inch per second RMS for alarm. Wire the transducer to the common monitoring terminal box mounted on the exterior of the fan housing.

b. Each fan shall be furnished with a flow switch. The flow switch shall be installed to detect air flow. The flow switch shall be wired so that one normally open contact closes when the flow switch is actuated. The electrical rating of the switch shall be 5A @ 125/250 VAC (minimum). The complete flow switch shall be designed to meet NEMA-4X watertight construction.

c. Each fan bearing and motor shall be furnished with two 100 ohm, three-wire, platinum RTD’s in the stator winding of each phase wired to a NEMA 4X terminal common junction box mounted on the outside of the fan housing. The PLC shall be programmed to monitor over-temperature levels as determined by the motor manufacturer.

d. All monitoring devices (motor winding RTD’s, velocity (vibration monitoring) sensors and air flow switches) shall have their leads terminated in a common junction box, separate from power or motor heater wiring, mounted on the fan. This junction box shall be a NEMA-4X junction box with threaded hubs for three ¾-inch and one 2-inch conduits.

J. Nameplates

a. Furnish nameplates for each fan assembly. On each nameplate, show the name and address of the fan manufacturer, the installer’s name and address, serial number of the fan, the maximum safe rotational speed of the fan in revolutions per minute in forward and reverse directions and the design operating conditions of the fan, airflow pressure, and density. Furnish an additional nameplate for each fan, which shows, in characters 3 inches high, the designated number of the fan as indicated on the RFC Documents. Rivet or screw nameplates to the fan housings. Make sure that nameplate is not hidden, visible and easily accessible.

b. Furnish two identical nameplates for each motor. On each nameplate, show the name and address of the motor manufacturer, the motor model number and serial number, motor speed in revolutions per minute, nominal horsepower, electrical characteristics (voltage, phase, frequency); no-load, full-load, and locked-rotor currents, NEMA code-letter designation, NEMA frame size, service factor, rating of space heater and the terminal connection chart for the motor. Securely fasten one of the two nameplates to the motor housing; rivet or screw the other to the fan housing adjacent to the fan nameplates.

c. Fabricate all nameplates of stainless-steel. Permanently mark the specified data on
26.3.4.3. **Equipment Installation and Testing Requirements**

The Design-Builder shall:

A. Provide lifting lugs of steel construction that are welded to the exterior of fan housing, motors and sound attenuators. Provide lifting lugs in sufficient number to facilitate on-site installation and removal of the fan, motor and sound attenuators.

B. Provide temporary supports and bracing as required during handling and erection.

C. Provide the services of a qualified erection superintendent who is competent and experienced with the work involved in the installation of ventilation equipment of this type. The erection superintendent shall, supervise the ventilation equipment installation, shall be available and at the site when any of the work in connection with the ventilation equipment installation is proceeding, and shall verify that the work is properly performed.

D. Design the support system to facilitate easy dismantling and reinstallation of fan and sound attenuators as required for maintenance.

E. Install fan assemblies in the space provided in such a manner as to be readily serviceable so that regular/routine maintenance, removal, and/or replacement of equipment does not disrupt traffic and maximizes the safety of Department personnel and contractors.

F. Adjust supports for fans, and for sound attenuators, such that they align accurately on the same horizontal plane.

G. Install fan assemblies as recommended by the fan manufacturer, using vibration isolators of adequate strength to minimize transmission of high frequency vibration to the structure.

H. Install the airflow indicating devices as follows:
   a. Differential pressure switches and relays in local instrument cabinet for each fan assembly.
   b. 3/8-inch copper tube for total and static pressure probes. Insert tubes through sound attenuators and extend into air stream approximately 8 inches. Tubing in contact with and inside the sound attenuator shall be AISI Type 316/316L/316Ti stainless-steel.
   c. Terminate total pressure probes facing inlet side of fan assembly.

I. Perform shop tests including:
   a. Test at the fan manufacturer’s facility or at a testing laboratory, which is suitable for all tests, specified. The motor manufacturer may perform the motor test at the manufacturer’s facility. Submit all testing standards and procedures for approval by the Engineer prior to proceeding with the tests. Notify the Engineer in writing, of all shop test dates not less than 14 days prior to all tests so that the Engineer may witness the tests.
   b. Test each fan motor in accordance with the following:
      1. Arrange for factory testing of each fan motor. Tests shall be witnessed (pre-production motors) and unwitnessed (production motors).
      2. Witnessed Tests (Pre-production Motors):
a. One motor of each nameplate horsepower rating and service factor shall be tested in the presence of the Engineer. The Engineer will designate motors for testing.

b. Tests shall be as follows:

i. Obtain actual fan motor performance curves verifying the theoretical fan motor performance curves and other data submitted as specified previously herein.

ii. Obtain values for the following electrical and mechanical characteristics with rated voltage and frequency applied to motor terminals:
   i. Full load current in amperes.
   ii. No load current in amperes.
   iii. Full load input in kilowatts.
   iv. No load input in kilowatts.
   v. Locked rotor current in amperes.
   vi. Locked rotor input in kilovolt amperes.
   vii. Locked rotor torque in pound feet.
   viii. Rotational moment of inertia of rotor in pounds feet squared (as determined by calculation).
   ix. Displacement power factor in percent at full load amperes and locked rotor amperes.
   x. Winding resistances.
   xi. Losses, no load and full load.
   xii. Vibration.

c. Test of each pre-production motor shall include the following:
   i. Performance speed current and speed torque tests.
   ii. Temperature test, full load.
   iii. Insulation resistance temperature test shall be taken following heat run, readings being taken in degrees F at 1-hour intervals for a period of 4 hours. Temperature shall be determined by the resistance method.
   iv. Cold and hot winding resistance measurement.
   v. Dielectric Test: (Voltage to be applied shall be based on the voltage rating of insulation plus 1000.)

d. Tests to determine:
   i. Winding resistances.
   ii. Losses, no load and full load.
   iii. Vibration.
3. Unwitnessed Tests (Production Motors):
   a. Each of the remaining production motors shall be tested at its rated synchronous speed unwitnessed.
   b. Tests shall be as follows:
      i. Winding resistances.
      ii. No load current in amperes.
      iii. Dielectric tests.
      iv. No load speed.
      v. Single or three phase locked rotor current in amperes (at full or reduced voltage).
      vi. Bearing installation and greasing verification.
      vii. Cold resistance measurement.
      viii. Insulation resistance and winding temperature at time taking insulation resistance.
      ix. Vibration check.
   c. Only those motors for which the Engineer has approved test reports and performance curves may be assembled into fan-motor units.
   d. Rerating and updating the nameplates of motors after testing will not be accepted under any circumstances.

c. Test the fans
   1. Balance each impeller statically and dynamically at the rated operating speed before spin testing. Spin test each impeller at 125 percent of design rotational speed for a period of not less than 5 minutes. Examine impellers for loose blades, hub surfaces, and other visual damages. Perform blade fastener torque test. Replace defective parts and repeat the spin test before further testing.
   2. Check each fan for obviously rough operation. Replace defective bearings and recheck fan operation. Test each fan for vibration, measured in two radial planes 90 degrees apart (front and rear), and in the axial direction. Compare the measured vibration levels with the acceptable vibration limits specified. If the measured vibration exceeds the specified limits, determine the cause(s), correct it and then retest the fan.
   3. Pre-Production Model Fan Tests
      a. Prior to commencing the manufacture of the production fans to be supplied under this Contract, testing as specified in the following Articles, on each pre-production model fan-motor-sound attenuator assembly unit shall be successfully completed and the test results reviewed by the Engineer.
      b. Run-in Test: Operate the fan assembly continuously for 24 hours and monitor the date, time, power (kW) to the fan, and motor frame
winding, ambient and bearing temperatures. Record above parameters every 30 minutes for the duration of the run-in test.

c. Performance Test: Test the fan assembly(ies) for performance in accordance with the requirement of AMCA, with and without sound attenuators. Test the fan assembly(ies) in forward and reverse direction of airflow to determine the fan performance, and motor brake horsepower (or input power). Adjust and repeat test as required until the specified requirements are satisfied. If the maximum horsepower listed on the schedule is exceeded when delivering the specified thrust, the fan shall be redesigned to meet the maximum horsepower (kW) requirements.

d. Noise Test: Test the fan assembly(ies) in forward and reverse direction of airflow in accordance with the requirements of IEEE 85 to obtain sound pressure data at eight-octave band center frequencies from 63 hertz to 8000 hertz. Record the measured data for each octave band and in the A-weighting (DBA).

e. High Temperature Test: Test a completely fabricated (as-installed condition) fan(s) designated for hot air removal (without the sound attenuators) to demonstrate the capability of the fan(s) to operate for one hour with 600 degrees F (or justified otherwise) air passing around (as applicable) and through the fan(s). Test with water droplets passing through the fan and as applicable spreading on its surface if fixed fire suppression system is considered to impact the fan. The fan(s) used for this test shall be considered a sacrificial unit(s) and not to be supplied for use under this Contract.

4. Production Fans

a. Production fans are the remaining fans of each type that are to be procured under this Contract.

b. Run-in Test: Operate each production fan assembly(ies) continuously for 24 hours with the predetermined required blade angle. Monitor the date, time, power (kW) to the fan, and motor frame and bearing temperatures and record these parameters every 30 minutes for the duration of the run-in test.

5. Material test

a. All material purported to be AISI Type 316/316L/316Ti stainless-steel shall be checked with a magnet. Failing the magnet test, materials found to comply with: magnetic properties shall be less than 1.02 at 200 H (Oersteds) for rolled products and 1.45 at 200 H (Oersteds) for cast products, shall be considered non-magnetic. Products found to be magnetic shall be replaced.
26.3.5. Tunnel Fire Protection Systems

26.3.5.1. Design Requirements

A. General

a. The requirements of this section shall apply to the Tunnel and Tunnel ancillary facilities (excluding the service building), including Tunnel ramps, pump stations, and emergency egresses. (See also Section [X.XX])

b. The fire protection system shall include a fixed fire-fighting system consisting of but not limited to fire pumps, a standpipe system with hose valves, deluge sprinkler heads, deluge valve cabinets, and portable fire extinguishers. The fire protection system, including all components of the system shall be protected from physical damage and shall be located outside the vehicle dynamic envelope.

c. All fire protection equipment, systems and components shall be designed in accordance with NFPA 502.

d. The tunnel fixed fire-fighting system shall be designed and constructed to provide safety for motorists in the event of a fire, and shall provide uniform suppression across the tunnel.

e. A combined standpipe/suppression system shall be designed, installed, inspected, and maintained as a Class 1 system(s) in accordance with NFPA 13, NFPA 14, NFPA 20, NFPA 25 and NFPA 502.

f. The fixed fire-fighting system (FFFS) shall be designed for a minimum of two (2) zones of activation. Fire suppression zones shall be a minimum of sixty-five (65) feet in length per zone. An engineering analysis shall be provided to justify the fire zone length and number of zones for FFFS activation. Analysis shall consider traffic type, wind and ventilation conditions.

g. All fire suppression pipes, fittings, elbows, connections, couplings, cabinets, anchors, bolts, accessories and supports shall be AISI Type 316, 316L or 316Ti stainless-steel unless specifically stated otherwise. Stated compliance with a code or standard that allows material other than 316 stainless-steel does not constitute “stated otherwise” and does not provide relief from the requirement of 316 stainless-steel materials. Weld fill material shall be 316L stainless-steel for all welding of 316 and 316L stainless-steel. For fire protection in this document “stainless-steel” and “316” shall mean AISI Type 316, 316L or 316Ti stainless-steel.

h. All fire-fighting system components except steel piping shall be UL listed. Steel piping components outside the tunnel shall meet the requirements of ASTM A312 – Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless-Steel Pipes.

i. All fire suppression valves four (4) inches and smaller shall be bronze or brass unless specifically stated otherwise or specifically not allowed by the stated code or standards for the specific application. The zone deluge valves shall be ductile iron in conformance to ASTM A536-77, Grade 65-45-12 and shall have a corrosion protective coating.

j. The fire suppression zones shall be controlled by automatic activation with time delay of one zone and manual activation of a second zone. The maximum number of active zones shall not exceed the capacity of the system; activation of additional zones shall require the shutdown of one of the zones prior to activation of an additional zone.
k. Linear heat detection system shall be used for automatic fire detection and system activation (see Section 28).

l. The fire pipe at the portals shall include a squelch-able alarm located in the control room, indicating when there is flow in a fire main.

B. The main fire pipe shall have a motorized valve located at each portal leading into the tunnel that can shut the flow of water off to the tunnel. The valve shall have a tamper switch and be tied into the FACP. The valve shall be operable from the tunnel operations building.

C. Hazard Classification

a. The tunnel fire-fighting system hazard classification is “Extra Hazard Group 2” and shall be designed in accordance with NFPA 13 Extra Hazard Group 2.

D. Design Fire Size and Growth Rate

a. Design fire size and fire growth rate requirements documented in Section [X.XX].

E. Water Source

a. The minimum suppression density shall be based on a single fire zone of activation and shall be designed in accordance with NFPA 13 density/area curves, and shall not be less than 0.4 gpm/sf.

b. The fire protection system shall utilize potable water; seawater shall not be utilized.

c. Both the north and south islands have existing water lines from the mainland that shall be utilized. At a minimum an 8-inch pipe shall be provided in the new tunnel that connects the north and south existing water supplies. Tapping into the existing fire loop system of existing tunnels shall not be permissible.

d. The quantity of water shall be designed for one-hour of water supply. The quantity of water required to meet the tunnel fire protection one-hour requirement shall be available at all times and shall not be diminished in any way.

e. The flow rate used for calculating the quantity of water for fire protection needs shall be a minimum of two (2) fixed fire suppression fire zones activated simultaneously along with utilization of three (3) hose valves at 250 gpm each.

f. Additional fire hydrants shall be provided. A minimum six (6) inch fire line shall connect from the fire department connection to the combination suppression stand pipe line for pressurization of the system. The fire department connection shall be protected with an inline check valve and shall be located within 100-feet of the fire hydrant. The fire hydrant shall be located such that access by the fire department fire truck shall not exceed ten (10) feet.

g. The fire department connections shall be a Siamese 2 ½” minimum connections. The connection configuration and treads shall be in accordance with the local fire department requirements.

h. Fire suppression zones shall be coordinated with tunnel ventilation zones and sized based upon NFPA requirements with isolation/zone control valves located and spaced appropriately.

F. Fire Pipe

a. All piping, joints and fittings shall comply with the International Fire Code (IFC). Steel piping components outside the tunnel shall meet the requirements of ASTM A312 –

b. All piping, joints and fittings shall be made of 316 stainless-steel at a minimum of Schedule 10.

c. Fire pipe located in the tunnel shall be installed exposed; it shall not be embedded or concealed. It shall be mounted outside of the vehicle dynamic envelope and be accessible for maintenance and inspection.

d. Piping from the water storage tank to the fire pump room as well as piping in the fire pumps room shall be made of 316 stainless-steel at a minimum of Schedule 40.

e. All pipes that have water in them and are exposed to freezing environments shall be protected against freezing. For the combined standpipe/suppression system, a minimum of the first 1,000 feet of pipe, from the portal into the tunnel shall be insulated and provided with heat tracing. For deluge cabinets located within 1,000 feet of the portal freeze protection shall be provided inside the cabinet for all piping and trim: wet and dry pipe. Freeze protection shall be calculated using ASHRAE 99.6% heating design temperatures less 20 degrees Fahrenheit. If air duct is utilized, piping located in the air duct shall be considered a freezing environment for its entire length within the air duct.

f. Hydraulic calculations shall be provided justifying the size of the designed pipe and pump system.

G. Sprinkler Heads

a. Sprinkler heads shall be made of 316 stainless-steel and shall be deluge open type heads suitable for tunnel environment.

b. Sprinkler heads shall be uniformly spaced along and across the tunnel in accordance with NFPA 13.

c. The maximum allowable coverage shall be based on “obstructed noncombustible” as defined in NFPA 13. Under no circumstance shall a single head coverage exceed 260 sf.

H. Deluge Valves

a. Deluge valves shall be provided for each fire deluge zone.

b. Deluge valves shall be equipped with an integrated pressure reducing valve or have pressure reducing valve prior to the deluge valve.

c. Isolation valves shall be provided just before and just after the deluge valve.

d. Drain and test connections shall be provided in accordance with NFPA 25 for required testing of the system. Drains shall be piped to outside the deluge valve cabinet.

e. The deluge valve and trim shall be UL listed for the intended purposes.

f. The deluge valve shall be configured such that the first deluge valve is activated automatically with a time delay for operator verification and the second valve can be manually activated. Activation shall be capable either at the valve station or remotely at the Control Room. Provisions shall be made to prevent accidental sprinkler activation.

g. The deluge valve shall be capable of being operated remotely and manually. A local manual override for opening and closing the valve shall be provided.

h. The deluge valve shall be capable of opening and closing under full system pressure in both manual operation and remote operation. This shall allow for the activation and
deactivation of a fire zone during a fire event. The fire zone may move during a fire event and the system shall be capable of deactivation of one of the two (2) zones and activating another zone while keeping the second zone operating.

i. The deluge valve(s) shall be contained within a cabinet.

I. Deluge Valve Cabinet
   a. The cabinet shall be made of 316 stainless-steel.
   b. The deluge valve cabinet shall be located in the egress/utility corridor. All access to the cabinet shall be from the egress/utility corridor.
   c. Access doors shall be provided for each deluge valve and shall be of adequate size for maintaining the equipment and for removal of the deluge valve. The access door shall be equipped with security annunciation system. The access doors shall be lockable and have latch for holding the door in the open position.
   d. An alarmed and unlocked door shall be provided for access to the manual on/off valve.
   e. The cabinet shall be permanently labeled. Lettering shall be a minimum of one (1) inch high in red color.
   f. Labeling shall identify the deluge valve(s) that are in the cabinet and the fire zone that they serve.
   g. The manual on/off access door shall be labeled “Manual Override”.
   h. The cabinet shall be bolted to the wall.
   i. Power and controls into and out of the cabinet shall be in accordance with NFPA 72.

J. Portable Fire Extinguishers
   a. Portable fire extinguishers and spacing shall be provided in accordance with NFPA 502.
   b. Portable fire extinguisher shall be contained in an NFPA 10 compliant cabinet.
   c. Portable fire extinguishers shall be visible and accessible from the tunnel.

K. Hose Valves
   a. Hose valves and spacing shall be provided in the tunnel in accordance with NFPA 502.
   b. Hose valves shall be provided at each portal and along the tunnel at locations easy for access, testing and maintenance and protected from traffic.
   c. Each hose valve niche shall contain two (2) fire hose valves.
   d. Hose connections shall have 2-½” valves and shall be of the pressure reducing type.
   e. Threads shall conform to local fire department requirements.
   f. A chain and a cap shall be provided.
   g. The hose valves shall be made of brass.

L. Fire Pumps
   a. Each island shall have a minimum of two (2) fire pumps. One (1) shall be a primary pump and the second shall be a backup or redundant pump.
b. The minimum water flow that each fire pump shall be designed for shall be in accordance with NFPA 25 and shall not be less than 100% of the required fire flow for two (2) zones of suppression activation simultaneously with 750 gpm of hose valves water discharge.

c. Fire pumps shall be installed with all required trim – isolation valves, check valves, test connection, jockey pumps, fire department connections, and pressure sensors in accordance with NFPA 20.

d. The fire pump system at each portal island shall include a jockey pump. The jockey pump shall operate at 10 gpm and have a minimum available head pressure of 110% of the design fire pump pressure.

e. A minimum 8” diameter pipe shall be installed from the north water supply to the south water supply and from this common header to each fire pump room.

f. All fire pumps shall be provided with normal and emergency power. A maximum of one (1) fire pump at each ventilation building shall be permitted to operate at a time.

g. An automatic transfer switch (ATS) shall be provided adjacent to the fire pumps for automatic transfer from normal power to emergency power.

26.3.6. Tunnel Drainage

26.3.6.1. Design Requirements

A. General

a. The tunnel drainage system shall be designed and constructed to provide a safe and tenable environment for motorists in the event of a fire, rain fall event, fuel spill or hazardous spill.

b. At a minimum pipes and fittings for tunnel drainage shall be suitable for a tunnel environment and meet the most current versions of NFPA 502, NFPA 820 and International Plumbing Code (IPC) requirements and in accordance with the additional requirements of this document.

c. Drainage system features shall include but not be limited to portal trench drains, drain inlet boxes, gravity drainage pipe, pressurized drainage pipe, portal pump stations, low point pump station, and drainage pumps.

d. Corrosion control measures shall be provided for buried pipes in accordance with the National Association of Corrosion Engineers (NACE) corrosion control standards.

e. The tunnel drainage conveyance and collection system shall have sufficient capacity to receive and convey, as a minimum, the rate of flow from all roadway sources without causing flooding. For the purposes of this project flooding is defined as no standing water on either lane of traffic under normal circumstances and no standing water on a minimum of one (1) lane under emergency conditions.

f. For emergency circumstances the minimum roadway water sources used for designing the tunnel drainage system shall include but not be limited to simultaneous discharge from two (2) zones of activation from the fixed fire-fighting system, three (3) hoses at 250 gpm each, and a 100-year 24-hour storm event.

g. For normal circumstances, the minimum roadway water sources used for designing the drainage system shall include but not be limited to simultaneous flow from infiltration, tunnel washing and a 100-year 24-hour storm event.
h. An engineering analysis shall be provided to justify the sizes for gravity and pressurized drainage pipes. Analysis shall consider the road geometry, road slope and cross slope.

i. Where drainage cannot be directed to a gravity system, drainage shall be directed to a pump.

j. Pump stations shall be classified per NFPA 70. Pump station equipment shall be suitable for the applicable space hazardous classification (e.g., equipment located in wet wells or spaces that potentially will have explosive levels of hydrocarbons shall be explosion proof). Equipment and components installed in wet wells shall be designed to fully exclude moisture, abrasive material, corrosive gases, and all other matter that may contribute to wear.

k. All pump stations shall be monitored at the Control Rooms. The tunnel Control Room shall have override control for all pumps.

l. Wet well atmospheric monitoring systems, ventilation, station telemetry systems and other elements for a complete and operable pumping system shall be provided.

m. A ventilation system for the drywell, wetwell and grit chambers, designed in accordance with NFPA 820, suitable for a moist and corrosive environment shall be provided. The dry well, wetwell and grit chamber shall be equipped with a hydrocarbon detection system for operating the ventilation system automatically, based on concentration levels of hydrocarbon vapor and shall be equipped with a manual local override. Ventilation rates shall not be less than 6 air changes per hr. continuous in the dry well and 12 air changes per hr. when in alarm HC in any locations, wet and dry wells.

n. A hydrocarbon-based vapor detection system shall be provided with two alarm levels – high HC and high-high HHC. In the event hydrocarbon vapors exceed the required limits in the drainage system (high HC level), the hydrocarbon detection system shall start the exhaust fan(s). Upon high-high HHC level in the dry well the drainage pumps shall be shut down. For a high-water level alarm in the wet well, all pumps shall remain operable and be controlled by the level controllers regardless of the hydrocarbon levels. The alarm shall annunciate locally and be connected to the SCADA system for remote annunciation to a “remote” control location. High-high HHC levels in any location shall activate an alarm. All drainage equipment, systems and components shall be UL listed. Drainage pipes are not required to be UL listed.

B. Pumps

a. The pumps shall be submersible, non-clogging, non-overloading, chopping, centrifugal type.

b. The automatic pump control system shall provide for equal operating time for each pump and prevent pumps from overheating.

c. Installation and configuration shall be drywell type.

d. The low point pump station shall have a minimum of three (3) pumps.

e. The portal pump stations shall have a minimum of three (3) pumps.

f. Each pump shall be designed to handle 100% of the total pumping requirement.

g. Pumps shall be mounted on housekeeping pads, be accessible and maintainable.

h. All pumps shall be from a single manufacturer.
i. Pump controls shall be automatic control and shall be located in a 316 stainless-steel NEMA 6P water proof box within twenty-five (25) feet of the pumps they serve. Electrical power and control for the pumps shall be hardened so that all pumps shall remain operable even when the tunnel is 100% submerged. A light will illuminate on the pump control panel to indicate the operation of each pump. A flow meter will indicate the pumping rate for each pump. A squelch-able alarm will sound in the tunnel control room if a second pump starts, and will sound again if a third pump starts. The tunnel control room shall include manual on & off switches to allow personnel to operate the pumps and bypass the automatic switches.

j. A minimum of three (3) foot service area around all pumps and six (6) foot clearance from the walls to the pumps shall be maintained.

k. Pumps shall be installed such that any single pump can be removed from the pump station without disconnecting any other pump. The Design-Builder shall include illustrated study showing how equipment can be installed originally, removed and replaced through structure doorways and openings in accordance with Section 34.3.3.

l. All pumps shall be provided with isolation valves on both the suction and discharge side of the pump for 100-percent isolation of each pump.

C. Low Point Pump Station

a. The low point pump station (LPPS) shall consist of a maintainable/cleanable wetwell and dry well and shall be located at the lowest point in the tunnel. The pumps shall be located in the dry well with piping protruding into the wet well. The wet well shall be a single cell sizes at a minimum of thirty (30) minute run time with two (2) pumps operation and no inflow between pump on and pump off (i.e. a 1,500 gpm design pump capacity requires 45,000 gal between the pump on and pump off elevation in the wet well). To facilitate maintenance and cleaning, the minimum dimension inside the wet well shall be six (6) feet – neither the height, length nor width shall be less than six (6) feet. Contiguous piping and chambers shall not be counted or used for sizing the wet well.

b. Maintenance access to the LPPS dry well shall be from the egress/utility corridor via access hatch and standard stairs or, for a room at the same level as the egress/utility corridor through a man door. Access from the egress/utility corridor shall be configured to allow for easy maintenance ingress and egress as well as pump removal. The access hatch or man door shall be configured such that the pumps can be rigged into the egress/utility corridor.

c. Access to the LPPS wetwell shall be through a minimum three (3) foot diameter manhole with ships ladder. The manhole shall be located in the egress/utility corridor or centered in the travel lane. Manholes located in the travel lane shall comply with the load requirements of ASME A112.6.3 – 2001 (airport load), with other manhole requirements of AASHTO, and VDOT standards, will require a minimum of Type 316/316L stainless-steel frame, must be flush with the road and shall be bolted down with recessed bolts.

d. Access hatches and manholes located in the egress/utility corridor shall be designed such that they do not create a slip trip or fall hazard in the egress/utility corridor and comply with the egress floor requirements.

e. The LPPS shall have a minimum head clearance of six (6) feet.

f. The LPPS shall be capable of discharging to the portal pump grit chambers at both portals simultaneously and/or individually.
g. The drywell shall be equipped with a sump and pump that keeps water from accumulating on the floor from leaks and or seepage. This sump pump shall discharge to the wetwell.

h. The wetwell shall have level detection that controls the pumps.

i. The drywell shall have wetwell level indication either by means of a site glass or level sensor with digital readout and display.

j. The drywell and wetwell chambers shall have hydrocarbon detection in accordance with NFPA 502. The detector shall be located in the drywell.

k. The gravity discharge to the wet well shall be equipped with a 316 stainless-steel trash basket. The basket mesh shall not exceed two (2) inches by two (2) inches.

l. Level control: the pumps shall be set up as lead/lag with automatic rotation of which pump is the lead pump after each activation. The water high level alarm shall be set 6 inches from the inside tip of the wet well. The level controls shall be lead pump on at 18”, lag at 12”, and 3rd pump at 9” down from the inside top of the wet well.

D. Portal Pump Stations

a. The portal pump stations (PPS) shall be located at the tunnel portals and shall consist of an oil water separator that has a dry well and a grit/sludge oil separation chamber. The oil separation compartment shall remove Total Suspended Solids and floatable free oil by way of two baffles. The grit/sludge oil separation chamber shall have an oil baffle followed by a grit baffle that maintains the level of fluid in this chamber at all times. The clear water shall overflow the second baffle into the clear water wet chamber where it is pumped out by the pumps in the dry well. Discharge from the LPPS and surface runoff collected at the portal drain will discharge into the oil water separator at a point that results in a minimum of a ten (10) minute dwell time. Dwell time shall be based on inflow from the LPPS or 2 fixed firefighting system zones +750 gpm, whichever flow is highest. The portal pumps shall be located in the dry well with piping protruding into the wetwell section of the oil water separator.

b. Access to the PPS dry well shall be from the ventilation building via a standard stair tower. The access from the service building shall be configured to allow for easy maintenance ingress and egress. Access hatches shall be configured for pump removal. The access hatch shall be configured such that the pumps can be rigged to the egress/utility corridor. All access hatches located in the roadway shall be bolted down with recessed bolts.

c. Access to the PPS oil water separator (grit/sludge oil separation and wet well chambers shall be through a minimum three (3) foot diameter manhole with ships ladder located over each chamber. Where possible the access hatches shall be configured such that they are located in the egress/utility corridor. Where it is not possible to locate the access hatches in the egress/utility corridor they shall be located and meet the same requirements that are required in Section 26.3.X Low Point Pump Station.

d. The PPS shall provide means for settling of sediment and skimming of floating materials; shall have an automatic pump operating control system, water level detection and control, and alarm signals to annunciate locally and at a “remote” control location in the event of water level being too low or too high. The water level detection system installed in the wet well shall be intrinsically safe, mercury free and suitable for the wet well environment.
e. The PPS shall have a minimum head clearance of six (6) feet.

f. The drywell shall be equipped with a sump and pump that keeps water from accumulating on the floor from leaks and/or seepage. This pump shall discharge into the wet well.

g. The pumps shall discharge water from the PPS in compliance with VDOT specifications and in accordance with the VDEQ requirements.

h. The grit/sludge oil separation chamber shall have a weir and baffle wall for holding back grit/sludge oil in this chamber of the oil water separator. The Design-Builder shall design the oil water separator to meet the regulatory requirements of the Virginia Department of Environmental Quality’s General VPDES Permit for Industrial Activity Stormwater Discharges. The chamber shall be configured for a minimum of two (2) feet high of grit/sludge accumulation and a minimum of 5,000-gallons of oil and shall be designed such that from the point of entry to the point of discharge a minimum of ten (10) minutes of dwell time shall be achieved. Dwell time shall be based on inflow from the LPPS or 2 fixed firefighting system zones +750 gpm, whichever flow is highest. The oil water separator shall be designed to intercept and store oil, fine sands, clays, organic particles and silt in addition to larger floatables and gravel particles. The only permissible flow into the grit chamber shall be from the trench drain and the low point pump station, no other discharges are permitted.

i. The grit, drywell and wetwell chambers shall have hydrocarbon detection in accordance with NFPA 502. The detector shall be located in the drywell.

j. The wetwell shall have level detection that controls the pumps.

k. The drywell shall have wetwell level indication either by means of a site glass or level sensor with digital readout and display.

l. The wetwell shall be sized for a minimum thirty (30) minute run time with two (2) pumps operating simultaneously and no inflow and with a capacity of no less than 60,000 gallons.

m. The grit chamber, wetwell and drywell shall be provided with mechanical ventilation designed in accordance with NFPA 820, suitable for a moisture and corrosive environment.

n. Level control: the pumps shall be set up as lead/lag with automatic rotation of which pump is the lead pump after each activation. The high-level alarm shall be set 6 inches down from the grit chamber top of wall. The level controls shall be lead pump on at 30”, lag at 24”, 3rd pump at 18” down from the grit chamber top of wall.

E. Trench drain

a. A ductile iron trench drain grate shall be provided across the roadbed at each portal.

b. Frame of the trench drain shall be made of stainless-steel.

c. The trench drain shall be capable of capturing storm water from a twenty-four (24) hour - 100-year storm event, in accordance with VDOT drainage manuals. The trench drain shall prevent any water from the design event from entering the tunnel. A maximum of 100 feet of the boat section shall be permitted to flow to the trench drain.

d. The trench drain inlet shall comply with ASME A112.6.3 – 2001 (airport load), VDOT standards and shall be bolted down with 316 stainless-steel recessed bolts or approved equal.
e. All embedded support framing and anchorage shall be a minimum of Type 316/316L stainless-steel.

f. The trench drain shall discharge to the portal pump stations grit chamber.

g. No pipes shall be permitted to drain into the trench drain.

F. Access hatches and manholes

a. Access hatches located in the egress/utility corridor shall be hinged, nonskid surface that does not impede the corridor in any way. The hatches shall be framed such that the lid is flush with the egress/utility corridor floor. The minimum loading for the hatch shall be 100 psf with an additional 500 lb. point load at the center.

b. Hatches and manholes in the roadway shall be centered in the travel lane, shall be bolted down with recessed bolts, and shall be in compliance with ASME A112.6.3 – 2001 (airport load requirements).

c. The access hatches and manholes shall comply with AASHTO, ASME, and VDOT standards and shall be bolted down with recessed 316 stainless-steel bolt system and cast-iron grates or approved equal. The frame shall be a minimum of Type 316/316L stainless-steel. Weld fill material shall be 316L stainless-steel for all welding of 316 and 316L stainless-steel.

G. Drainage pipes

a. Pressurized drainage pipe located in the tunnel shall be installed exposed; it shall not be embedded or concealed. Neither the pipe, fittings or and accessories shall be installed within six (6) inches of the vehicular dynamic envelope.

b. The piping system shall be designed to provide scour velocities with a single pump running and shall be designed to handle the flow from all pumps running at the same time. For the low point pump station scour velocity shall be considered running in only one direction not to both portals at the same time.

c. All exposed pressurized drainage pipes, fittings, elbows, connections, couplings, anchors and supports shall be made of 316 stainless-steel. Pressurized drainage pipe shall be schedule 40. Weld fill material shall be 316L stainless-steel for all welding of 316 and 316L stainless-steel.

d. All gravity drainage pipes below the road surface shall be reinforced concrete pipe (RCP). RCP shall be certified in compliance with ASTM and AASHTO standards and shall be installed in accordance with VDOT standards for drainage pipe within a roadway.

e. Gravity discharge to the LPPS shall be from a single pipe. Multiple gravity connections to the LPPS wetwell are not permitted.

f. Discharge pipe from the LPPS shall be plumbed to both portals. Isolation valves in the LPPS drywell shall be provided such that the discharge can be isolated to either portal.

g. Exposed pressurized drainage pipe within 1,000 feet of the portals shall be insulated and provided with heat tracing.

H. Drain Inlets

a. Inlets shall be designed to accommodate regular maintenance and cleaning with grate openings that have not less than two (2) feet by three (3) feet inside dimensions and shall not protrude into the travel way, excluding the portal trench drain.
Technical Requirements
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b. Grate inlets shall be cast iron designed in accordance with VDOT Standards, AASHTO requirements and shall be bolted down. Minimum dimensions shall be two (2) feet by three (3) feet clear inside dimensions for access and shall be designed for a minimum loading of HS-20. All hardware, frame with recessed bolts, and anchors shall be Type 316 stainless-steel. All grates located in the tunnel shall be bolted down with recessed bolts.

c. Inlets shall be spaced in conjunction with the fire zones and shall be sized such that not more than two (2) inlets (one at the end of the fire zone and the next downstream inlet) are capable of arresting and capturing 100% of the required inflow.

d. The drain inlet box shall have a minimum of eighteen (18) inch sediment trap in the bottom of each box.

e. The drain inlet box shall be in accordance with VDOT Standards for highway drainage structures and AASHTO requirements.

26.3.7. Emergency Exits

26.3.7.1. Design Requirements

A. The primary means of egress in the tunnel shall be via an enclosed, fire-protected egress/utility corridor which leads to grade.

B. The Design-Builder shall provide egress/utility corridor along the entire length of the tunnel from entrance to exit portals.

C. The egress/utility corridor shall be designed for emergency personnel and emergency evacuation of tunnel occupants and routine use by maintenance staff and patrol.

D. Emergency egress/maintenance corridor and egress stairs shall be designed in accordance with NFPA 502 and NFPA 101 requirements and shall lead to the area outside the tunnel protected from tunnel smoke. A total of four exits from each corridor - two points of exit discharge for maintenance staff and emergency responders - one (1) at each end of the tunnel protected from traffic, and two points of egress using stairs leading to the ventilation building and to the islands away from the smoke contaminated air protected from traffic, shall serve the egress/utility corridor.

E. The clear width of the egress/utility corridor shall not be less than three (3) feet, eight (8) inches. The clear height of the egress/utility corridor shall be seven (7) feet, six (6) inches. No obstructions shall project into this clear distance, including equipment cabinets or their doors or hardware, whether doors are in open or closed position.

F. The Design-Builder shall perform evacuation modeling to verify width of the egress/utility corridor, spacing between exit doors to the corridor not exceeding 250 feet apart, size of the exit doors and to determine time needed for evacuation and rescue, while comparing results against tenability analysis. Evacuation modeling shall determine the number of open doors for pressurization system calculations to prevent smoke from entering the corridor when doors are open considering a bus with at least fifty (50) passengers just behind the fire and other vehicles stopped leading back to the entrance portal.

G. The evacuation modeling shall simulate tunnel occupant movements as a function of time and shall account for various types of tunnel occupants. Tunnel occupants of the same type shall include gender and age variations, differences in body dimensions, travel speed and pre-movement time (lapse before tunnel occupants begin evacuation).
H. Spacing between exits shall not be further than 250 feet apart and shall be coordinated with emergency response plan and firefighting procedures. Precise locations and design of doors shall be reviewed by the Department.

I. Emergency exit doors shall comply with the requirements of NFPA 502. Emergency escape doors exposed to the tunnel shall be minimum 1½-hour fire rated based on the design time-temperature curve. Doors for egress enclosure access from the roadway shall be of the sliding type. All doors shall be self-closing, able to be opened from either side and fitted with alarm contacts connected to the SCADA system.

J. Where swing doors are used in other locations, they shall open in the direction of evacuation direction and shall comply with NFPA 101 requirements. Additional doors shall be provided at the extreme ends of the emergency egress/utility corridor for First Responders’ and maintenance access. These doors shall be fitted with access control.

K. The sliding mechanism shall be the level, open track type, with suspended counterweights, closed box tracks shall not be permitted. The door operating mechanism, including counterweights, shall be provided with a stainless-steel cover system which is easily cleaned and removed for maintenance. The door shall be free of protuberances that may inhibit operation.

L. All doors shall be clearly marked on both sides with an agreed code to indicate the location in the tunnel. The location codes on the road side of the doors shall be large enough to be read clearly by the nearest CCTV camera, to enable it to be used by the control room operator to identify the location of an incident.

a. The emergency egress/utility corridor shall be independently supplied with fresh air from outside the tunnel (protected from the tunnel smoke) and pressurized to prevent the ingress of smoke while the tunnel ventilation system is operating in fire and smoke control mode.

b. The egress/utility corridor pressurization system shall initially pressurize the corridor during a fire event to minimum design pressure differences across smoke barriers according to NFPA 92, and prevent smoke from entering the corridor, but shall not over-pressurize so that the force required to open the egress doors fully when applied to the latch side be as low as possible but shall not exceed fifty (50) pounds under the worst-case ventilation differential pressure.

c. A tenable environment shall be provided in the means of egress during the evacuation phase in accordance with the emergency response plan.

d. At no time shall the air velocity at any point in the corridor exceed 2200 fpm.

M. Provide duty and stand-by pressurization fans equipped with adjustable speed drives (ASD) to adjust speed of pressurization fans with emergency exit doors opened and closed. Provide pressure sensors and barometric relief dampers in the egress/utility corridor.

a. A permanently lit ‘Emergency Exit’ sign shall be provided above the center of every escape door with additional downward illumination to highlight the door.

N. Symbol and font height shall be at least six (6) inches and white contrast luminance thirty (30) foot Lambert.

O. The style and color of the symbols and legends on the signs shall be agreed with the Department. Signs need to be clearly visible both when back-lit in poor ambient light and when front-lit if bright ambient light predominates.
P. Permanently lit or reflective ‘Nearest Emergency Exit’ signs shall be provided at intervals in accordance with NFPA 502 requirements and at five (5) foot height, with two (2) directional arrows pointing towards the nearest door or portal in both direction, and supplementary text giving the distances to the nearest door or portal in feet.

Q. Additional Emergency Exit signs shall be installed in the emergency egress/utility corridor indicating the shortest way out and the distance to the exit.

R. The walking surfaces of the emergency exits and walkways shall be slip resistant. Provide trough drains along the walls of egress/utility corridor to collect condensing and fire water. Slot drains shall be used at each door threshold and shall comply with walking surface for slip resistance and maximum slot dimensions.

26.3.8. Ventilation Buildings – Mechanical

26.3.8.1. Design Requirements

A. This section applies to Heating Ventilation and Air Conditioning (HVAC), plumbing and drainage, and fire protection systems, as required for the ventilation buildings.

B. The mechanical systems shall be designed in accordance with all applicable ASHRAE documents, NEC Standards, NFPA standards and VA USBC (Building, Mechanical, Plumbing, Fire Prevention).

C. The Design-Builder architectural design shall identify and define the Project’s ancillary facilities and other spaces required. The Design-Builder shall identify and describe these spaces, including their type, function, equipment content, and occupancy status to determine the necessary HVAC, plumbing, and fire protection system design requirements. Table 26-2 is a guide for the application of HVAC systems for types of ancillary spaces anticipated, however the Design-Builder’s design will ultimately determine the HVAC system applicability for these ancillary spaces. Where required by code, rooms shall be provided with anti-condensation heating, fresh air ventilation and air conditioning. The systems shall be designed for suitable operation in the marine environment.
Table 26-2 HVAC Systems by Type of Ancillary Space

<table>
<thead>
<tr>
<th>Space Description</th>
<th>Heating</th>
<th>Ventilation(^1)</th>
<th>Air Conditioning</th>
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</thead>
<tbody>
<tr>
<td>Rooms</td>
<td></td>
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<tr>
<td>Battery Rooms</td>
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<tr>
<td>Electrical Equipment Rooms</td>
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<tr>
<td>Fire Pump Room</td>
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</tr>
<tr>
<td>Generator Room</td>
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<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Lobby/Corridor</td>
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<td>X</td>
<td></td>
</tr>
<tr>
<td>Mechanical Equipment Rooms</td>
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<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Switchgear Room</td>
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<td></td>
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<tr>
<td>Bathroom</td>
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<td>Control Room</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Break Room</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Quantity of air changes shall be determined based upon the Virginia USBC requirements and occupancy either by personnel or equipment within the space.
2. Ventilation or air conditioning as required to maintain a maximum temperature of 104 °F within the space.

D. If lead-acid batteries are selected for the UPS, ventilation to the battery room shall be provided by a duty/standby fan arrangement to ensure continuous ventilation at all times and to prevent any accumulation of hydrogen gas from the batteries.

E. Rooms containing heat-emitting or heat-sensitive equipment shall be provided with cooling by fresh air or air conditioning as appropriate.

F. The ambient outdoor design conditions documented in the ASHRAE “Fundamentals” Handbook shall be used based upon the 0.4-percent summer and 99.6-percent winter, annual frequency of occurrence.

G. General conditions shall be 72 °F summer and 70 °F winter unless specifically stated otherwise. The following indoor design temperatures shall be used. Humidity control shall be provided per equipment manufacturer’s recommendations:

a. Summer Season:
   iii. Control Rooms: 72 °F db.
   iv. Electrical rooms: 104 °F db maximum.
   v. Battery rooms: 78 °F db.
   vi. Equipment/storage/janitor rooms: 104 °F db.

b. Winter Season:
   viii. Control Rooms: 70 °F db.
   ix. Electrical rooms: 55 °F db.
x. Battery rooms: 77 °F db.

xi. Equipment/storage/janitor rooms: 55 °F db.

xii. Corridors/toilets/locker rooms: 70 °F db.

H. Sheet metal ducts in the service building HVAC system shall be constructed of lock formed quality galvanized steel with joints that are air tight. Duct gauges and fabrication methods shall comply with the Sheet Metal and Air Conditioning Contractor’s National Association, Inc. (SMACNA.) The ducts shall be sized by the static regain method or for an equal pressure drop of not more than 0.10 in wg per 100 feet of duct. Test wells and plugged openings shall be provided in ducts for air balancing. Access doors shall be provided in ductwork at all apparatus requiring service and inspection in the duct system. Access doors shall be two gauges heavier than the duct gauge in which they are installed. Air ducts on the roof or outside shall be of Type 316 stainless-steel and shall be designed / supported for hurricane forces.

I. Fire dampers as required by the Virginia USBC shall be UL listed.

J. Splitters and dampers shall be provided with accessible operating mechanisms. Splitters shall be operated by quadrant operators. Manual control dampers shall be operated by locking type quadrant operators. Dampers and splitters shall be two (2) gauges heavier than the duct in which installed. Multi-leaf dampers shall be opposed blade type with maximum blade width of twelve (12) inches.

K. The supply air registers and diffusers shall be selected to provide the required throw and spread with the least amount of draft and noise. Registers shall be provided with adjustable and double deflection louvers and opposed-blade adjustable volume dampers. Ceiling diffusers shall be with adjustable throw opposed-blade adjustable volume dampers. The volume dampers shall be key operable through the face of the diffuser.

L. Hurricane type Louvers shall be provided for installation in exterior walls. Louver blades shall be fabricated from Type 316 stainless-steel sheets or approved equal means of protection from corrosion and protected with a weather-resistant protective coating. Louvers shall be provided with Type 316 stainless-steel bird screens.

M. Variable volume, single duct, low and medium pressure terminal units shall be provided with a calibrated air volume sensing device, damper, actuator and accessory relays. Units shall control air volume to within five (5) percent of each set point volume.

N. Electric unit heaters shall be provided to supplement or replace the heat supplied by the air conditioning units during the cold season. The heaters shall be the industrial type and shall meet all the requirement of the National Electrical Code (NEC). The heaters shall be UL listed. Suitable stationary or rotating air deflectors shall be provided to assure proper heat distribution. The electric unit heaters shall be provided with a built-in or surface mounted high limit thermostat interlocked electrically so the heater cannot be energized unless the fan and fan motor are running. The heaters’ operation shall be controlled either by a built-in or remote thermostat and have protective devises as required by the NEC.

O. Due to the ventilation buildings’ proximity to the ocean, the HVAC equipment shall be protected with a multiple-coat, weather-resistant protective coating which shall be certified as passing a minimum one hundred twenty-five (125) hour salt spray fog test in accordance with ASTM Standard.

P. Ventilation building plumbing and drainage shall be designed in accordance with the requirement of the Virginia USBC. The plumbing systems shall be capable of supplying the
required quantity of domestic (hot and cold) water for the various utilities, provide disposal of sanitary waste and storm water, and shall include any sanitary water treatment if necessary. The plumbing system shall include various plumbing fixtures, piping, valves, backflow preventers, water meters, hose bibs, strainers, domestic water heaters and other accessories as needed for a complete system that meets the Virginia USBC requirements.

Q. The Design-Builder shall provide the ancillary facility fire protection systems that shall be comprised of sprinkler and standpipe systems, clean agent systems, and portable fire extinguishers.

R. The sprinkler systems for ancillary buildings and facilities shall conform to the requirements of NFPA 13, the Virginia Statewide Fire Prevention Code (SFPC) and the Virginia USBC.

S. Clean agent fire suppression systems shall be provided for server rooms and critical electronic equipment rooms. The system shall be provided in accordance with the requirements of NFPA Standards 72 and 2001, the Virginia Statewide Fire Prevention Code (SFPC) and the Virginia USBC.

T. Portable fire extinguishers shall be provided for each space in accordance with the requirements of NFPA 10, the Virginia Statewide Fire Prevention Code (SFPC) and the Virginia USBC.

26.4. **Deliverables**

At a minimum, the deliverables shall include the items listed in Table 26.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
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<td>Hardcopy</td>
<td>Electronic</td>
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</tr>
<tr>
<td>Proposed software for tunnel mechanical systems design</td>
<td></td>
<td>1</td>
<td>60 days after NTP</td>
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<tr>
<td>Qualification of CFD modeler and independent Checker</td>
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<td>Design Calculations</td>
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<tr>
<td>Fire Life Safety Compliance Report</td>
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<td>Ventilation and Fire Protection CFD Modeling Report</td>
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<td>Design Drawings and Specifications</td>
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<td>Emergency Response Plan</td>
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</tbody>
</table>
26.5. Mechanical Testing and Commissioning

A. The Design-Builder shall prepare testing and commissioning plan that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing plan that assures that the systems functions and operates as intended.

B. Field testing of the mechanical systems shall be performed to verify that all system operating modes function as intended and comply with the Technical Requirements. The Design-Builder shall be responsible for performing field testing procedure in accordance with standard manufacturer’s test procedures for all operable equipment. The Design-Builder shall prepare field test procedures and submit to the Department for review prior to commencement of any testing.

C. The Department or its duly recognized representative shall be given the opportunity to witness any or all tests at their discretion, and will provide the Design-Builder with a list of tests that the Department would like to witness. Coordination with the Department shall be performed so that field measurements are witnessed. Final testing of safety systems will be witnessed and accepted by the Department.

D. Testing for the mechanical equipment shall not be undertaken until the permanent electric service and local controls are established and can be used for testing.

E. The Design-Builder shall submit to the Department, a written test program/procedure for each of the field tests identified in this Section at least 21 calendar days before the scheduled date of test initiation. This test program shall contain, as a minimum, the resumes of the key personnel participating in the test phase, the specific make and model numbers of the test equipment to be used, and a general procedure to be followed for the set-up of equipment and for the sampling, recording, and production of the test data. In addition, pass/fail criteria shall be included in the test program/procedure for comparison to test results.

F. For each test, a test report shall be provided to include the following:

1. Test methodology;
2. Relevant codes or standards;
3. Specific details of the equipment or system tested;
4. Full record of measurements taken, with locations;
5. Evidence of calibration of test equipment;
6. Applicable acceptance criteria;
7. Test results; and

8. Any further actions or re-testing required.

G. Where airflow measurements are required, the number and location of points traversed shall conform to AMCA and ASHRAE, modified for the shape of the tunnel.

H. The Design-Builders shall perform fan airflow performance tests:

1. At each service building, and for each fan after all construction and other work involving the air pathways from the roadway level to fan and to ambient have been completed, and all fans have been installed and run-in, the Design-Builders shall conduct tests to determine actual airflow under operating conditions as specified below.
   a. Each fan shall be tested at the design blade angle.
   b. For each service building fan, the Design-Builders shall measure and record the following:
      i. Power consumed
      ii. Dry bulb and wet bulb temperature of the air passing through the fan.
      iii. Simultaneously record the outdoor ambient barometric pressure.
   c. For each tunnel fan the Design-Builders shall perform vibration tests, run-in tests; starting tests; performance tests and noise measurements.
   d. The tunnel fans shall be tested and rated in accordance with the latest edition of Air Movement and Control Association (AMCA) Standard 250, “Laboratory Methods of Testing Jet Tunnel Fans for Performance” or other as applicable. The sound power level ratings of the jet fans shall comply with the latest revision of AMCA Standard 310, “Methods for Calculating Fan Sound Ratings from Laboratory Test Data.”

2. Using the recorded data in conjunction with the certified operating fan and motor data and curves derived from the shop tests, the air delivery and static pressure of each fan under all provided operating conditions shall be determined.

3. Brake Horsepower (BHP), airflow and thrust shall be corrected to the design air density before use with the fan performance curves and all calculations shall be shown in the report.

4. For each fan the Design-Builders shall perform air velocity traverses with all fans operating, at locations determined by the Design-Builders to confirm fan airflow delivery. For each measurement location, a minimum of three air velocity traverses of the entire duct/cross section shall be taken and averaged, and the average shall not vary from the measurements by more than five percent. If measurements vary by more than five percent, additional measurements shall be taken until three consecutive sets of measurements do not vary from the average by more than five percent.

5. If the air delivery is less than the design output, the Design-Builders shall perform all work necessary to achieve the design airflow. This may include adjusting the fan blade angle or VFD set point to bring the fan airflow to the design level. In this instance, the design BHP shall not be exceeded.

6. The Design-Builders shall, following any change in air delivery of any fan, repeat the tests to determine actual air output of each of the fans. Both the Department and the field service engineer shall be present at these tests. The Design-Builders shall promptly (within 21 calendar days) submit to the Department copies of the test results. The reports shall show all test results including those from initial and subsequent tests. The reports shall clearly indicate, with sketches, if necessary, the initial and subsequent blade setting angle of the fan and VFD set points.
7. The fan vendor shall provide the Design-Build Contractor, following any blade angle adjustment, with replacement fan nameplates to reflect the latest blade angle setting and re-issue the Operations and Maintenance Manual for the fan-motor units. The Design-Builder shall replace the fan nameplates.

I. The Design-Builder shall perform the following egress corridor pressurization system tests:

1. Test each fan for its actual performance
2. Verify that the pressurization control sequence is initiated under the design conditions.
3. Verify that all dampers open and close fully, cycle smoothly through their full range of operation and react correctly to commands from the control system and to the pressure changes
4. Operate system under automated control and witness, measure and make adjustments to confirm that the specified range of differential pressure is maintained between the egress corridor and the roadway with the doors closed, within the required interval. Adjust and limit fan to speed required under this condition.
5. Test duct pressures, differential pressures across equipment, air moving devices, outdoor areas, stairwells and tunnels pressure (forces) to open the egress doors. Adjust fan pressures such that passageway doors shall open with less than 50 lb. force.
6. Confirm fans achieve specified speed (volume) over the specified intervals.
7. Operate, adjust and limit fan speeds to maintain the schedule velocity through the tunnel and exit doors. The velocity shall be maintained across the open-door area to prevent smoke from getting into the egress corridor.

J. The Design-Builder shall perform tunnel airflow performance tests:

1. The tunnel ventilation control system shall be tested for proper functionality. Each ventilation operation mode shall be tested via the tunnel ventilation control system to confirm proper performance of the control system.
2. All modes of tunnel ventilation: normal operations, congested operations, standstill operations and fire emergency operations, shall be tested for conformance with airflow requirements.
3. Airflow calculations shall be performed to determine the airflow that will be moving through the tunnel at commissioning test locations under commissioning conditions (i.e. no fire, no traffic). These calculations shall account for changes in fan operating point due to the lack of resistance that the design fire would generate.
4. The field tests shall include the measurement of air movement within the tunnel produced by the ventilation system. These measurements made by the Design-Builder shall serve as verification that the tunnel ventilation system produces sufficient velocity in the roadway during a fire to satisfy emergency ventilation criteria. The Design-Builder shall conduct an airflow test for at least three representative fire locations. In addition, all operating modes for non-fire emergency shall be tested.
5. The Design-Builder shall determine and provide the Department for Review and Comments, details on all tests for the measurements, the testing conditions (such as ventilation system operating requirements), the acceptance criteria, and the test results required for each location at least 21 calendar days before the scheduled date of testing.

6. Air velocity traverses of the entire tunnel roadway shall be performed to determine the average airflow through the cross section. For each measurement location, a minimum of three air velocity traverses of the entire cross section shall be taken and averaged, and the average shall not vary from the measurements by more than five percent. If measurements vary by more than five percent, additional measurements shall be taken until three consecutive sets of measurements do not vary by more than five percent.

7. In addition, air velocity traverses of the entire tunnel roadway shall be performed to assess the average airflow without the tunnel ventilation system operating. The airflow generated by wind conditions only need to be determined before and after the airflow tests performed with tunnel ventilation system operation.

8. The Design-Builder shall provide the Department with the measured test results. If the measured air velocities are less than the required Design-Builder’s design "cold" air velocities, Design-Builder shall make adjustments to the system to produce the required tunnel airflow velocities. The field measurements shall then be repeated to verify that the required tunnel airflows have been achieved. The increased fan airflows shall not cause overloading of the fan motors. The tunnel ventilation system shall be modified by the Design-Builder to the extent required to provide the minimum airflows specified. In addition, the fan nameplates shall be updated and replaced.

K. The Design-Builder shall perform the following noise tests:

1. For each tunnel ventilation fan room, the sound levels, measured in dB(A) shall be recorded at three locations upstream, and three locations downstream, of the fans. Terms upstream and downstream are with respect to fan forward airflow.
   a. One measurement location shall be in the air plenum connecting the roadway (egress corridor) to the service building.
   b. One measurement location shall be in the air duct and three feet from the fan’s connection to atmosphere.
   c. One measurement location shall be on the roadway, three feet from the barometric relief damper closest to the service building.
   d. Background sound levels shall be recorded before and after any fan sound measurement.
   e. Sound power levels shall be recorded in each band of the octave band (8 bands).
   f. These tests shall be performed by a qualified Professional Engineer. The overall responsibility for this measurement program shall belong to the Design-Build Contractor.

2. For each bank of fan, the Design-Builder shall record sound levels, measured in dBA at several locations upstream and downstream of the fans. First with a single fan operated at
high speed and repeated with all fans operation under design fire emergency modes. The test measurement locations shall be:

a. Directly under the fans discharge at a height of 5 feet above the road surface

b. At 15 feet and at 30 feet from the outlet of the fan discharge away in both directions and at a height of 5 feet above the road surface

c. At the entrance/exit portal, depending on which is nearer the fans

L. The Design-Builder shall perform air monitoring system testing:

1. The Design-Builder shall prepare a commissioning plan memo that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing plan that confirms that the systems functions and operates as intended.

2. Equipment installed by or under direction of the Design-Build Contractor, which is found to be defective in material or workmanship, shall be repaired or replaced. The Design-Builder shall bear all costs necessary to achieve these repairs or replacements including parts, labor, travel and living expenses.

3. Operation Tests: Each air monitoring location shall be field tested under operating conditions to determine that all parts of the system function properly. All defects shall be corrected and necessary adjustments made to satisfy the requirements. The Design-Builder shall submit three certified copies of results obtained from field tests to the Engineer, indicating the total response time for each system.

4. Before final acceptance and after testing the Design-Builder shall show by in-service demonstration that the equipment and all associated accessories are in good operating condition and properly performing their intended function.

5. The following Operational Test Reports are required:
   a. Confirming that operational units have remained within specifications for 24 hours during the full range of temperature and humidity testing.
   b. Interfering gases do not affect the air monitoring system analysis.
   c. Data reading reports within the control room are accurate.

M. The Design-Builder shall perform the following service building HVAC, plumbing, drainage and fire protection systems tests and commissioning:

1. The Design-Builder shall develop a commissioning plan that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing and commissioning plan that assures that the system functions and operates as intended.

2. The Design-Builder shall prepare a commissioning plan and field test procedures and submit to the Department for review prior to commencement of any testing.

N. The Design-Builder shall perform drainage pumping plant tests that shall include but not be limited to testing the pump flow rate and pressure, controls sump pump operation levels and ventilation fans operation.
O. The Design-Builder shall test the drainage pipes by the lapped or laser method and shall compile with the Virginia State Plumbing code for alignment.

P. The Design-Builder shall hydrostatically test the drainage discharge force main. Pressure test shall be 150% of pump normal operating pressure for 1 hr. without any leakages or additional water added to the system. Test pressure shall not exceed +/- 5 psi over the test period. The Design-Builder shall perform the following fire suppression system tests

1. End-to-end time for detection, alarm, location and confirmation of a fire, with a reasonable allowance for any human intervention;
2. Times to charge the system.
3. Time to establish full operation of the system; and
4. Rate of water consumption under full availability and pump failure conditions.

Q. The Design-Builder shall perform the following fire suppression system tests

1. End-to-end time for fire detection, fire alarm, location and confirmation of a fire, with a prescribed allowance for any human intervention;
2. Times to fully charge the system;
3. Time to establish full operation of the system;
4. Rate of water consumption under full availability and pump failure conditions and;
5. Deluge valve test in accordance with NFPA 25. In addition to NFPA 25 requirements the deluge valves shall be tested for open and close remotely and manually under full system pressure. Also, the time from detection to full flow release from the sprinkler heads shall be tested.
6. Each deluge zone shall be tested with single zone activation for water density. A minimum of 20 receptacles evenly spaced shall be placed in the zone being tested and the density at each location reported.
7. A minimum of three (3) different location shall be tested for combination tests for water density. A minimum of 20 receptacles evenly spaced shall be placed in each of the two zones being tested and the density at each location reported. The test shall have 2 deluge zones and 3 hose valves (250 gpm each) activated at the same time for these tests. Test locations shall be at the two most hydraulically remote locations and at the lowest elevation in the system.
8. Fire pumps shall be tested in accordance with NFPA 25.
9. The freeze protection system shall be tested by disconnecting each circuit and confirming that an alarm is activated in the control room. If the freeze protection system is shut down automatically for any reason or operation it shall be tested to confirm that it is automatically reactivated as well.

R. The Design-Builder shall perform the fire hydrants flow tests for flow and pressure in accordance with NFPA 25 requirements.
SECTION 27. ELECTRICAL POWER AND DISTRIBUTION

27.1. Scope

To provide minimum technical requirements to a Design-Builder to install an IEC 61850 compliant Substation Automation System and Electrical Distribution System for the Project.

A. This Section provides the Electric Service, Power and Distribution requirements for the following:
   1. Descriptions of existing utility service and existing power distribution to the existing HRBT facility
   2. 13.2kV, 480V and 208VElectric Distribution Equipment, Emergency Generators, and Uninterruptible Power Supplies (UPSs) on the existing and new HRBT Facility
   3. Substation Automation Systems
   4. 13.2kV feeder(s) from the Hampton Shore-gear to the North Island;13.2kV feeder(s) from the Norfolk Shore-gear to the South Island, Tunnel Tie Feeders
   5. Switchgear, Motor Control Centers (MCC), Panelboards, and Transformers;
   6. Manholes, Hand-holes, Junction Boxes, Cabinets, and Enclosures
   7. Raceways, Wiring, and Cables
   8. Calculations
   9. Lightning Protection, Grounding, and Bonding
   10. Temporary Electric Power
   11. Installation
   12. Testing
   13. Integration with existing electrical system

27.2. References

A. Department Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. Department, Project Development Manual
   2. TBD
B. Virginia Uniform Statewide Building Code (USBC)
C. National Fire Protection Act (NFPA) Standards and Guidelines including:
   1. NFPA 502, Standard for Road Tunnels, Bridge and Other Limited Access Highways
   2. NFPA 70 – National Electric Code (NEC)
   6. NFPA 780 – Standard for the Installation of Lightning Protection Systems
   7. NFPA 70E – Standard for Electrical Safety in the Workplace
   8. NFPA 820 – Standard for Fire Protection in Wastewater Treatment and Collection Facilities, specifically Chapter 7
D. National Electric Safety Code (NESC)
E. FHWA Tunnel Operations, Maintenance, Inspection, Evaluations (TOMIE) Manual; and
F. FHWA National Tunnel Inspection Standards (NTIS)
G. IEC 61850 Communication Networks and Systems for Power Utility Automation
27.3. Requirements

27.3.1. Existing Department 34.5kV/23kV and 13.2kV Electric Service and Distribution Description

The existing facility is powered from a Norfolk utility from the south and a Hampton utility from the north.

On the south shore, there is a 34.5kV/13.2kV Dominion substation that supplies the Department’s south shore GIS switchgear. The Department’s south shore switchgear has two (2) 500 Kcmil bridge feeders, one for each south vent building. Each one of the south vent buildings have an outgoing 4/0 tunnel tie feeder that supplies power to the north vent building in the same tunnel.

On the north shore, there is a 23kV/13.2kV Dominion substation that supplies the Department’s north shore GIS switchgear. The Department’s north shore switchgear has two (2) 500 Kcmil bridge feeders, one for each north vent building. Each one of the north vent buildings have an outgoing 4/0 tunnel tie feeder that supplies power to the south vent building in the same tunnel.

Each Island has a 2000 kW, 13.2kV generator which is the primary backup source to a utility loss from the closest shore. For example, the North Island generator is the backup to a Hampton utility and the South Island generator is the backup to a Norfolk utility. The secondary backup to each utility is the other utility. In each vent building, there are medium voltage cross-building-ties between the medium voltage Norfolk fed and Hampton fed buses and serve the purpose of supplying power to the other medium voltage bus in the same vent building during a generator failure.

Each vent building has two (2) switchgear lineups, a Norfolk lineup and a Hampton lineup. These switchgear lines are roughly 55’ to 60’ long and they face each other with roughly 10’ between the two lineups. The medium voltage switchgear is in the center of the lineup. Each medium voltage switchgear has two (2) 1000/1333 kVA 13.2 kV/480V substation transformers; one on each side. On each low voltage side of the substation transformers is a Low Voltage Switchgear (LVSG) with roughly 4 to 6 low voltage feeder breakers. Each LVSG lineup is connected to the opposite facing low voltage switchgear in the other lineup from across the room through a low voltage bus and tie breaker. The feeder breakers in the low voltage switchgear supply power to Motor Control Centers (MCC) associated with that end of the lineup and other various loads throughout the HRBT Facility.

27.3.2. New Substation

The Design-Builder shall determine the existing tunnel’s worst-case load demand through a Department approved method; the Design-Builder shall determine the load demand for the new tunnel. The Design-Builder shall then submit to Department the calculations for the worst-case-scenario being powered from one shore substation. The Design-Builder shall coordinate with Department and Dominion to ensure that both the Norfolk and Hampton Dominion substations have sufficient capacity to supply the entire facility (new and existing) from one shore substation with the fire mode with the largest load being run during peak demand plus 25% additional capacity. The existing shore switchgear shall be relocated to accommodate the new construction roadway alignments. Department’s Engineer shall approve the new location. The new Dominion shore substation and the Department’s shore switchgear shall be physically hardened which would include the following:

1. No overhead lines to the switchgear.
2. The fenced in area and the switchgear enclosure shall be locked and secured from any access by all unauthorized personnel.

3. 24/7 CCTV security cameras monitoring the Department’s switchgear.

### 27.3.3. New 13.2 kV Service

The Design-Builder shall provide a new 15 kV switchgear shore substation and coordinate with Dominion to provide the utility service to the new tunnel facility. The existing Department shore switchgear will remain separate from the new Department shore switchgear. The existing Department shore switchgear shall be relocated to accommodate the traffic lanes needed for the new tunnel/bridge facilities. The new shore switchgear shall be SF6 gas-insulated switchgear (GIS) enclosed in outdoor enclosure. Only one utility shall be out of service at any given time. The outdoor enclosure shall set on top of a vault of minimum height of five foot-six inches (5’6”). All switchgear equipment shall be capable of being monitored and controlled on the facility’s SCADA network. The shore switchgear shall also be automated through a substation automation system (SAS) using IEC 61850 standards to communicate to protective relays and at a minimum have the same functionality and capabilities as the existing shore switchgear for the existing HRBT Facility. The new shore switchgear shall at a minimum have four (4) breakers. One breaker shall be the Main, Tunnel Support Building’s feeder, the second shall be for bridge lighting and the third shall be a spare.

### 27.3.4. Emergency Generators

The new Tunnel Support Building on each island shall have at least one medium voltage generator as an emergency backup power in case of a utility failure. The generator shall be connected to paralleling-switchgear. The parallel-switchgear will feed the switchgear that is powered by the incoming utility service via the bridge feeders in the Tunnel Support Building. The emergency generators shall have a storm anticipation mode function allowing a closed transition paralleling with the utility. In addition, it allows the capability of close transition back to the utility. The generators shall have sufficient capacity to power the fire mode with the largest load in one tunnel plus normal conditions in the other tunnel with an additional 10% spare capacity. The generator shall transfer automatically in less than 10 seconds from the moment a utility failure has been detected. The generator shall be monitored on the facility’s SCADA system. The generator set shall meet all requirements for Level 1 systems per NFPA 110.

A. Provide at a minimum a microprocessor-based generator set.

B. The paralleling control functions shall be integrated with the generator set control functions.

C. Local Generator Operator Panel

1. A graphical display with a minimum of up to 9 lines of data with approximately 27 characters per line.

2. Analog AC metering panel

3. OFF/MANUAL/AUTO Mode Control Switch

4. MANUAL RUN/STOP Control Switch and Indicating LED

5. EXERCISE Control Switch and Indicating LED

6. Operator adjustments that allow for many set up and adjustment functions via raising and lowering switches on the operator’s panel.

7. EMERGENCY STOP Control Switch
8. PANEL LAMP/LAMP TEST Control Switch

9. AC Metering

10. Internal Controls - The following internal control components and functions shall be at the minimum has the same functions as the existing equipment for the existing HRBT Facility.
   a. Emergency Start Mode.
   b. Non-Emergency Start Mode
   c. Screen-Saver Mode
   d. Data Logging
   e. Fault Simulation Mode
   f. Built In Test
   g. First Start Sensor System
   h. Synchronizer
   i. Load Share Mode
   j. Load Demand Mode
   k. Load Govern Mode
   l. Manual (Semi-Automatic) Parallel Mode

11. Engine Control - The following engine control components or functions shall be provided for each generator set in the system.
   a. Engine Starting
   b. Cycle Cranking
   c. Programmable Idle Speed Control
   d. Time Delay Start and Stop (cool down)

12. Alternator Control - The following alternator control components or functions shall be provided for each generator set in the system
   a. Digital Output Voltage Regulation
   b. Torque-Matched Volts/Hz Overload Control
   c. Fault Current Regulation

13. Protective Functions - The following generator set protective functions shall be provided for each generator set in the system.
   a. Alternator Protection
      i. Generator set relaying shall be utility grade equipment.
      ii. Supplier shall demonstrate that the relays and settings are coordinated with the alternator thermal damage curve.
   b. The following relay functions shall be included:
      i. Over Current Warning
      ii. Over Current Shutdown (51)
      iii. Short Circuit Shutdown
      iv. High AC Voltage Shutdown (59)
      v. Low AC Voltage Shutdown (27)
      vi. Under Frequency Shutdown (81u)
      vii. Over Frequency Shutdown/Warning (81o)
      viii. Over Load (kW) Warning
      ix. Reverse Power Shutdown (32)
      x. Sync Check (25)
      xi. Fail to Synchronize Warning or Shutdown
      xii. Phase Sequence Sensing Shutdown
      xiii. Reverse VAR Shutdown
   c. Engine Protection
Each generator set shall be provided with the following engine protection functions that are integral to the generator set monitoring, metering, protection and control system.

i. Over-speed Shutdown

ii. Low Lube Oil Pressure Shutdown

iii. Low Lube Oil Pressure Warning

iv. High Coolant Temperature Shutdown

v. High Coolant Temperature Warning

vi. Low Coolant Pressure Warning/Shutdown

vii. Low Coolant Level Warning/Shutdown

viii. Low Coolant Temperature Warning.

ix. Low and High Battery Voltage Warning

x. Discharged Battery Protection.

xi. Weak Battery Warning

xii. Fail to Start (Over-crank) Shutdown

xiii. Fail to Crank Shutdown

xiv. Redundant Starter Disconnect

xv. Redundant Speed Sensors

xvi. Low Fuel-Day Tank and Low Fuel-Main Tank warning.

xvii. Cranking Lockout.

xviii. Sensor Failure Indication.

xix. High Crankcase Blow-by Level warning.

xx. High Fuel Temperature Warning.

xxi. High Intake Manifold Temperature/Pressure

xxii. Aftercooler Cooler Inlet Over Temperature

14. Alarm and Status Indication (Local and SCADA)

15. Control Power

27.3.5. Uninterruptable Power Supplies

A. Provide high efficiency Uninterruptible Power Supplies (UPS)

1. Provide two (2) Lighting UPS that shall function as a Stored Emergency Power Supply System (SEPPSS), one in each Tunnel Support Building for all designated lighting to be connected to a SEPPSS. Each UPS will serve the designated loads on the respective Tunnel Support Building to the tunnel midpoint.

2. Provide two (2) Electronic Equipment UPS, one in each Tunnel Support Building for all electronic equipment designated to be connected to a UPS. Each UPS will serve the designated loads on the respective Portal Island to the tunnel midpoint.

3. Provide a UPS within the Department Hampton Shore and Norfolk Shore new 13.2KV switchgear enclosure for all substation loads designated to be connected to a UPS under Section 27.3.5.D, E and F.

4. All Lighting UPSs will be part of the respective Tunnel Support Building Stored Emergency Power Supply System (SEPPSS), as defined in NFPA 111.

5. Each Lighting UPS shall be listed and rated as a Type O, Class X (1.0), Level 1 SEPSS, as defined and described in the current edition of NFPA 111.

6. Each Lighting UPS and Electronic Equipment UPS shall have an efficiency rating greater than ninety-seven (97) percent at eighty (80) percent load.
7. Each Lighting UPS and Electronic Equipment UPS shall be provided with a manual make before break by-pass isolation switch that is located in separate cabinet from the UPS to allow UPS replacement without interrupting the function and operation of the manual bypass switch.

B. The SEPSS provided under this Project shall comply with all requirements as stated in the current editions of NFPA 70 and NFPA 111 and all requirements described and/or identified in these Technical Requirements.

C. Provide all UPS batteries in enclosed metal cabinets, separate from the UPS, with provisions of direct exhaust venting of the battery cabinet to the building exterior.
   1. Batteries shall have capacity to support one hundred (100) percent of each UPS-rated load for two (2) hours and a seven (7) year warranty.

D. The following loads shall be powered by Lighting UPSs:
   1. All lighting identified in Technical Requirements Section 31, and serving:
      a. Tunnel Egress Corridor
      b. Stairs
      c. Tunnel Support Buildings Interior Spaces
      d. Tunnel Roadway lighting required by NFPA 502
      e. Open Approach (U-Wall) Lighting
   2. An additional ten (10) percent spare capacity based on the total highest calculated demand load connected to each UPS.

E. The following loads shall be powered by Electronic Equipment UPSs:
   1. Traffic and Lane Use Signs;
   2. Dynamic Message Signs;
   3. CCTV Equipment;
   5. All fire alarm, detection, and control systems;
   6. All SCADA EPCS and ITS equipment, servers, Programmable Logic Controllers (PLCs), Remote Control Units (RCUs), and Remote Input/Output Units (RIOs);
   7. All Intrusion Detection equipment;
   8. All Control Room workstation computers, monitors, printers, and other electrical operation loads;
   9. An additional ten (10) percent spare capacity based on the total highest calculated UPS demand load connected to each UPS.
   10. All UPS’s located in non-condition environments shall be hardened appropriately for environment in which they are located with summer and winter design conditions and calculations to be approved by the Department.
F. The following loads shall be powered by the Norfolk and Hampton Shore Substations UPS:

1. All substation and switchgear interior and exterior lighting;
2. Switchgear enclosure interior ventilation;
3. All switchgear interior convenience receptacles;
4. All substation and switchgear SCADA equipment and components; and
5. An additional ten (10) percent spare capacity based on the total highest calculated UPS demand load connected to the UPS.

27.3.6. Substation Automation System(s) and Protective Relaying

A. The Design-Builder shall provide a Substation Automation System (SAS) that is in compliance with IEC 61850 standard. The automation system at a minimum shall have the same functionality, operations and capabilities as the existing automation system in the existing HRBT Facility. The existing SAS includes intelligent electronic devices (IEDs), protective relays, and other field devices up to and including the station unit with local process visualization as well as communication interfaces to supervisory, control and data acquisition (SCADA) systems. The SAS system shall be selective in identifying faults and limiting them to their place of origin so that they can be eliminated rapidly. All relevant data must also be transmitted, recorded and evaluated. It is the task of the substation automation system to gather the data of the substation, plant or field (commands, events, counters and measured values), to pre-process this raw data and to forward the resulting information on. The data of the substation, plant or field must therefore be gathered by the decentralized substation automation system via connected IEDs and the relevant transmission protocols. The SAS shall be configured in such a way, that appropriate relevant information is passed to the applicable observation, monitoring or control centres. A major central task of the substation automation system is the execution of automation tasks, such as logical operations and switching sequences. Additionally, a local human machine interface (HMI) shall be required to perform control and monitoring tasks. The Design-Builder shall be responsible for engineering and furnishing protection system IEDs, programming of all relay settings, programming of virtual logic Lockout relays, programming of all protective relay logic control functions including peer-to-peer messages for tripping and control interlocks, all required fiber optic switches, fiber optic switch configuration/settings, fiber optic cable (within the substation), fiber optic connectors, fiber optic termination racks.

B. This existing system includes the following individual components:

1. Relay Manager
2. Multi-function Overcurrent Protection Relay
   a. At a minimum shall be installed on all main feeders, tie feeders, and branch feeders.
   b. Shall have at a minimum, the following functions:
      i. Phase Fault Overcurrent Protection.
      ii. Ground Fault Overcurrent Protection.
      iii. Negative Sequence Protection (Unbalanced Load Protection ANSI #46).
      iv. Breaker Failure Protection.
      v. Cold Load Pickup.
      vi. Trip Circuit Supervision.
      vii. Thermal Overload Protection. (ANSI#49)
      viii. Event and Fault Recording.
      ix. Auto Reclosure
x. Start-up Time Monitoring.

xi. Intermittent Earth Fault Protection.

xii. HMI, PC-software and SCADA Control.

xiii. The overload protection shall be provided and can function with or without thermal input.

xiv. The relay shall provide functionality that allows for RTD inputs for measuring external equipment temperatures.

xv. Programmable protective functions.

xvi. Reverse power (ANSI 32) Flexible Function protection.


xviii. Restricted earth fault protection (87N).

xix. Sensitive ground-fault protection (50Ns/51Ns).

xx. Sensitive directional ground-fault detection (67N/67Ns).

xxi. Trip via displacement voltage $V_0$

xxii. Two independent stages or one single independent stage and one user-defined characteristic

xxiii. Each element can be operated optionally in forward/backward direction or non-directionally.

xxiv. The function can also be operated insensitively as an additional, directional short-circuit protection.

xxv. Synchronism check (ANSI 25) (function utilized on Mains and Ties only)

xxvi. Lockout (86)

xxvii. Overvoltage protection (59)

xxviii. Under-voltage protection (27)

xxix. Fault locator (21FL)

c. The relay shall have the capability to integrate into the SCADA system. The communication protocol shall be IEC 61850 modular in design available in Fiber connections.

3. Line Differential Relay

a. The relay shall provide the following protection functions: 87, 21, 21N, 50/51, 50N/51N, 67N, 49, 78/68, 85, 50BF, 27, 59, 81, 25 and 79. The 87 Differential function and the distance protection shall be phase segregated. The relay should also allow an ability to include a transformer in the differential zone. The relay shall provide the transformer inrush blocking and fault locator capability from both sides.

b. The relay shall have the capability to be used in ring topology or chain topology

c. The relay shall have the capability to provide two communication channels.

4. All required SAS computer hardware and software

5. Fiber Optic Switches

C. Protection and control as well as SAS data acquisition and control shall be based upon the IEC-61850 protocol. The communications architecture shall employ fiber optic Ethernet switches that support rapid spanning tree technology and ring architecture.

D. Provide a logical and functional description of the SAS and submit to the Department for approval.
E. The equipment manufacturer shall have at least 10 years minimum of producing similar electrical equipment. The Design-Builder shall at a minimum provide a testing procedure to test the functional and logical description of the SAS to be accepted and approved by Department.

F. Equipment on this job shall be installed new and undamaged condition. This equipment shall be maintained in new condition until the end of the project.

G. The substation automation system serves as a control and monitoring device for the switchgear operators. The operator must be able to detect the substation status and carry out switching commands from an HMI, which must be connected to the station unit via the TCP/IP station bus. The substation automation system must record and processes all switchgear events. Each event must be accompanied by a real time-time stamp. The origin of this time stamp must be in the device which acquired the event. Functions of the SAS are:

1. Communicate to Protective Relays using IEC 61850
2. Monitoring
3. Automation
4. Online configuration
5. Local and remote control / control with switchgear interlocking / switching sequences
6. Serial connection of IEDs and field devices
7. Connection to a local HMI
8. Archiving and logging of operation and disturbance data
9. Open communication channel using OPC client / server mechanisms

H. The communication architecture shall employ fiber optic Ethernet switches that support rapid spanning tree technology and shall be designed to have a high degree of reliability. A single break in the fiber optic cable shall not cause a disruption of communication with any device on the IEC-61850 network. A star topology will not be accepted.

I. SAS system design shall be capable of growth and contain provision for future expansion.

J. Redundant SAS servers (referred to as Data Collector in the Contract Drawings) shall be supplied to ensure high system reliability.

K. The SAS servers shall share data with the site wide SCADA system via OLE for Process Control (OPC)

L. The SAS server and HMI server software must run on Station Unit computers that are industrial grade. The SAS server has no moving parts and a MS Windows embedded operating system less than two (2) years old.

M. The SAS shall communicate with all protective relays and remote I/O devices using the IEC-61850 standard via a fiber optic backbone.

N. The Design-Builder shall develop functional specifications or logic descriptions to Department for approval prior to building any of the switchgear equipment. The functions shall at a minimum include:

1. IEC 61850 GOOSE messaging for breaker tripping, breaker failure initiation, breaker backup tripping, and lockout of breaker closing.
2. GOOSE messaging paths shall be monitored and shall alarm for functional path failures with information available to support troubleshooting without network tools in hardware failure situations.

3. Distributed lockout implementation shall be consistent with functional and operations of the existing equipment in the existing HRBT Facility.

4. Maintenance tagging scheme shall include:
   a. Multiple tag types or colors for different maintenance use cases – do not restore once tripped, maintenance in process.
   b. Tag management and data entry via HMI display pages.
   c. Close blocking or operation blocking for selected tag types.
   d. Nonvolatile protection against operation of tagged equipment.
   e. Tag indications on one-line or control display pages, and in remote data to SCADA.

5. Data Collector function with dual redundant HMIs for polling or gathering of metering and status values from relays, IEDs, and remote I/O.

6. HMI with displays shall have at a minimum the same function and capabilities as the existing equipment in the existing HRBT Facility.

7. System Security
   a. Safety functions such as a hardware self-test and the general interrogation, both done at start up as well as cyclically in the background during system operation, must ensure prompt error or fault signals.
   b. The SAS shall be designed to be maintenance free, i.e. batteries requiring replacement, the hard drive shall be an SSD and the fan cooling system must utilize a heat sink with no cooling fan.

8. INTERLOCKS
   a. Shall be implemented locally in the respective IEDs, protective relays and/or station unit (relay manager).
   b. Substation station interlocking shall be done by using a generic object-oriented substation event (GOOSE) mechanisms between IEC 61850 IEDs.

9. AUTOMATION AND INTERLOCKING FUNCTIONS
   a. The functionality of this system shall be approved by Department prior to the Design-Builder programming the system.

27.3.7. Switchgear, Motor Control Centers, Panelboards and Transformers

A. Each of the 15-kV metal-clad switchgear and all components shall be designed, manufactured and tested in accordance with the latest applicable industry standards, including but not limited to ANSI/IEEE 37.20.2, C37.04, C37.06. The medium voltage configuration shall be in such a fashion that one shore can provide power to the other shore switchgear. The medium voltage configuration shall be configured so that each shore utility will feed one-half (1/2) of the new Tunnel Support Buildings in the normal configuration. In the case of a utility failure from either shore, the system shall automatically transfer to one of the two (2) backup systems; either generator (primary) or the other utility (secondary). Each of the medium voltage switchgear in the Tunnel Support Buildings shall have a main-tie-main circuit that are electrically interlocked.
Both main circuit breakers shall operate in the normally closed position and the tie breaker shall operate in the normally open position. The switchgear shall be furnished with communication cabling from relays to communication gateways to support remote monitoring of device data and status plus remote ON and OFF control.

B. Medium Voltage (MV) Switchgear

1. Each Tunnel Support Building shall have at least two separate lineups and a minimum of four (4) substation transformers; two (2) substation transformers per lineup. One MV switchgear shall be normally powered by the bridge feeder from the shore and the other shall be powered by the tunnel tie feeder from the other island.

2. Each lineup shall have MV primary breakers for each substation transformers.
   a. In addition to the MV primary breakers, the MV switchgear normally powered by the bridge feeder shall have a main breaker, an outgoing tunnel tie feeder, a generator breaker, cross-island tie breaker and a spare.
   b. In addition to the MV primary breakers, the MV switchgear normally powered from the switchgear in the other building shall have at the minimum an incoming tunnel tie breaker, a MV bus tie breaker (connected to the bus in lineup in the same room) and a spare.
   c. All MV Breakers shall be drawout breakers and have a minimum rating of 1200 amperes.

C. The switchgear assembly shall consist of individual vertical sections housing various combinations of circuit breakers and auxiliaries, bolted to form a rigid metal-clad switchgear assembly. Metal side sheets shall provide grounded barriers between adjacent structures and solid removable metal barriers shall isolate the major primary sections of each circuit. Hinged rear doors, complete with provisions for padlocking, shall be provided.

D. The stationary primary contacts shall be silver-plated and recessed within insulating tubes. A steel shutter shall automatically cover the stationary primary disconnecting contacts when the breaker is in the disconnected position or out of the cell. Provide rails to allow withdrawal of each 15-kV circuit breaker for inspection and maintenance without the use of a separate lifting device.

E. The circuit breakers shall be horizontal draw-out type, capable of being withdrawn on rails. The breakers shall be operated by a motor-charged stored energy spring mechanism, charged normally by a universal electric motor and in an emergency by a manual handle. The primary disconnecting contacts shall be silver-plated copper.

F. Each circuit breaker shall contain three vacuum interrupters separately mounted in a self-contained, self-aligning pole unit, which can be removed easily. The vacuum interrupter pole unit shall be mounted on glass polyester supports. A contact wear gap indicator for each vacuum interrupter, which requires no tools to indicate available contact life, shall be easily visible when the breaker is removed from its compartment. The current transfer from the vacuum interrupter’s moving stem to the breaker main conductor shall be a non-sliding design. The breaker front panel shall be removable when the breaker is withdrawn for ease of inspection and maintenance.

G. The secondary contacts shall be silver-plated and shall automatically engage in the breaker operating position, which can be manually engaged in the breaker test position.

H. Interlocks shall be provided to prevent closing of a breaker between operating and test positions, to trip breakers upon insertion or removal from housing and to discharge stored energy mechanisms upon insertion or removal from the housing. The breaker shall be secured positively in the housing between and including the operating and test positions.
I. The breakers shall be electrically operated by the following control voltages:
   1. 125-volt DC charge, close and trip.
   2. Each breaker shall be complete with control switch and LED type red and green indicating lights to indicate breaker contact position. The control switch shall have three positions, pull to lock, OFF, and ON.

J. Breaker shall be controlled both manually and automatically through the protective relay.

K. The 125-volt DC control voltage shall be supplied by the Design-Builder from a remote battery and charger system.
   1. 86 device for trip and lockout, with extra auxiliary contacts not used in breaker scheme.
   2. 43 control switch, with extra auxiliary contacts, wired to each relay to Enable Remote ON and OFF control of the breaker.
   4. 2 NO and 2 NC auxiliary contacts (may be MOC type) not used in the breaker scheme.
   5. 2 NO and 2 NC cell contacts (may be TOC type) not used in the breaker scheme.
   6. SEL351S relays wired for networked and remote OFF / ON control.
   7. Separate 125 Vdc control circuit over-current protection (3) for charge, close and trip circuits.

L. Each relay shall utilize digital inputs wired from device contacts as follows:
   1. 52 breaker auxiliary contact, type “a”.
   2. 52 breaker TOC contact, type “a”.
   3. 52 breaker 43 L/R Switch, Remote Mode, contact type “a”.
   4. 52 breaker 86 Trip and Lockout Relay, contact type “a”.
   5. 52 Control Switch, Off after Close, contact type “a”.
   6. 52 Control Switch, Off after Trip, contact type “a”.

M. The control functions of all the new switchgear shall have at the minimum the same functionality, operations, and capabilities as the existing switchgear in the existing HRBT Facility.

Cross Island Tie

1. On the North Portal Island, provide a tie feeder between H11/H12(North Island) medium voltage bus to the new medium voltage bus powered by the North shore. The feeder shall be the same size as the largest shore feeder. The feeder shall be connected to the spare breaker in the H11/H12 on one end. The other end of the feeder shall be connected to a new breaker in the new MV switchgear in the new North Tunnel Support Building. The feeder breakers under normal operation conditions shall be in the open position, locked from being closed automatically in SAS, and locked from being closed by any unauthorized personnel. These breakers shall be manually operated only.

2. On the South Portal Island, provide a tie feeder between N15/N16(South Island) medium voltage bus to the new medium voltage bus powered by the South shore. The feeder shall be the same size as the largest shore feeder. The feeder shall be connected to the spare breaker in the N15/N16 on one end. The other end of the feeder shall be connected to a new breaker in the new medium voltage switchgear in the new South Tunnel Support Building. The feeder breakers under normal operation conditions shall be in the open position, locked from being
closed automatically in SAS, and locked from being closed by any unauthorized personnel. These breakers shall be manually operated only.

3. Provide a 2-way medium voltage switch either in the new Tunnel Support Building Switchgear Room or on an outdoor pad-mounted for a Cross Island Tie Feeder on each island. The MV switches shall be installed between a medium voltage breaker in the new Tunnel Support Buildings and a new breaker in the existing ventilation building. The switches will act as an extra precautionary method to prevent closing the breakers and closing two different sources on each other. The switches will be manually operated only. There shall be a way to physically lockout unauthorized personnel from operating the switch.

N. Low Voltage Switchgear

i. Voltage rating shall be 480VAC, 3-phase, 4-wire, 60Hz. The entire assembly shall be suitable for 600 volts maximum ac service.

ii. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of 100,000 amperes symmetrical at rated voltage.

iii. The bus system shall have a minimum ANSI short-circuit withstand rating of 65,000 amperes symmetrical tested in accordance with ANSI C37.20.1 and UL1558.

iv. All circuit breakers shall have a minimum symmetrical interrupting capacity of 100,000 amperes. To ensure a fully selective system, all circuit breakers shall have 30 cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 amperes, regardless of whether equipped with instantaneous trip protection or not.

v. All ratings shall be tested to the requirements of ANSI C37.20.1, C37.50 and C37.51 and UL witnessed and approved.

1. Construction of Low Voltage Switchgear shall be:

i. The switchgear shall consist of the required number of vertical sections bolted together to form a rigid assembly. The sides shall be covered with removable bolt-on covers. All edges of front covers or hinged front panels shall be formed. Provide ventilators located on the top of the switchgear over the breaker and bus compartments to ensure adequate ventilation within the enclosure. Hinged rear doors, complete with provisions for padlocking, shall be provided.

ii. The assembly shall be provided with adequate lifting means and shall be capable of being moved into installation position and bolted directly to Design-Builder supplied floor sills to be set level in concrete per manufacturer’s recommendations. Provisions shall be made for jacking of shipping groups, for removal of skids or insertion of equipment rollers. Base of assembly shall be suitable for rolling directly on pipes without skids. The base shall be equipped with slots in the base frame members to accommodate the use of pry bars for moving the equipment to its final position.

iii. Each vertical steel unit forming part of the switchgear line-up shall be a self-contained housing having one or more individual breaker or instrument compartments, a centralized bus compartment and a rear cable compartment. Each individual circuit breaker compartment, or cell, shall be segregated from
adjacent compartments and sections by means of steel barriers to the maximum extent possible. It shall be equipped with drawout rails and primary and secondary disconnecting contacts. Removable hinge pins shall be provided on the breaker compartment door hinges. Current transformers for feeder instrumentation, where shown on the plans, shall be located within the appropriate breaker cells and be front accessible and removable.

iv. The stationary part of the primary disconnecting devices for each power circuit breaker shall be breaker mounted and consist of a set of contacts extending to the rear through a glass polyester insulating support barrier; corresponding moving finger contacts, suitably spaced, shall be furnished on the power circuit breaker studs which engage in only the connected position. The assembly shall provide multiple silver-to-silver full floating high pressure point contacts with uniform pressure on each finger maintained by springs. Each circuit shall include the necessary three-phase bus connections between the section bus and the breaker line side studs. Load studs shall be equipped with insulated copper load extension buses terminating in solderless type terminals in the rear cable compartment of each structure. Bus extensions shall be tin-plated where outgoing terminals are attached.

v. The circuit breaker door design shall be such that the following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

vi. The secondary disconnecting devices shall consist of floating terminals mounted on the stationary unit and engaging mating contacts at the front of the breaker. The secondary disconnecting devices shall be gold-plated and engagement shall be maintained in the “connected” and “test” positions.

vii. The removable power circuit breaker element shall be equipped with disconnecting contacts and interlocks for draw-out application. It shall have four positions, “connected,” “test,” “disconnected” and “removed.” The breaker draw-out element shall contain a worm gear levering “in” and “out” mechanism with removable lever crank. Levering shall be accomplished via the use of conventional tools. Mechanical interlocking shall be provided so that the breaker is in the tripped position before levering “in” or “out” of the cell. Interlocking that trips the breaker will not be accepted. The breaker shall include an optional provision for key locking open to prevent manual or electric closing. Padlocking shall provide for securing the breaker in the connected, test, or disconnected position by preventing levering.

viii. An insulating flash shield shall be mounted above each circuit breaker to prevent flashover from the arc chutes to ground. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

ix. Provide a rear compartment barrier between the cable compartment and the main bus to protect against inadvertent contact with main or vertical bus bars.

x. Provide in the cell when the circuit breaker is withdrawn, a safety shutter which automatically covers the line and load stabs and protects against incidental contact.
xi. Provide a metal barrier full height and depth between adjacent vertical structures in the cable compartment

xii. Provide a glass polyester full height and depth barrier between adjacent vertical structures in the bus compartment with appropriate slots for main bus.

xiii. Provide close-coupled connection to medium voltage step-down transformers. Provide connection box with coordinated size to match low voltage throat provided by transformer manufacturer. Provide busway that has the following:

- All bus bars shall be tin-plated (10 microns) copper. Main horizontal bus bars shall be mounted with all three phases arranged in the same vertical plane. Bus sizing shall be based on ANSI standard temperature rise criteria of 65 degrees C over a 40 degrees C ambient (outside the enclosure).

- Provide a full capacity neutral bus.

- A copper ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchgear. The ground bus short-time withstand rating shall meet that of the largest circuit breaker within the assembly.

- All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with Belleville-type washers.

- Copper bus shall have a maximum current density of 800A per square inch and 200A per square inch for busbar contact surface area.

xiv. Each of the 480V Switchgear units located in the new Tunnel Support Buildings shall have main and tie circuit breakers that are electrically interlocked. Both main circuit breakers shall operate in the normally closed position and the tie circuit breaker shall operate in the normally open position and closes when one of the main circuit breakers trips or loses power. If a 480V Switchgear has lost power, and detects that the medium voltage bus that was supplying it is still energized, then the system shall automatically transfer to another 480V source fed by the other utility with sufficient capacity to handle the entire load demand of the 480V switchgear.

xv. All Switchgear, Motor Control Centers (“MCC”) and Panelboard bus shall be tinned copper.

xvi. All Switchgear, MCC, and Panelboard circuit breakers and components shall be one hundred (100) percent rated.

xvii. All Low Voltage Switchgear circuit breakers shall be draw-out power circuit breakers.

2. All MCC starters or individually mounted starters serving motors 40hp or larger shall be Electronic Soft Start or Adjustable Speed Drive starters, except pump starters. The type of pump starters selected shall be appropriate for the respective pump operation and control.

3. Use MCCs to feed all fans and pumps serving the Tunnel.

4. Fans using Variable Frequency Drives (VFD) shall be powered from an MCC with no other loads.
5. Where Switchgear has been identified in this Technical Requirement, Switchboard construction is not acceptable.

O. All transformers:
   1. Installed outdoors or anywhere within the tunnel shall be dry resin encapsulated type in a Type 316 Stainless Steel NEMA 4X enclosure;
   2. Shall have copper windings;
   3. Serving any electronic equipment shall have a K13 or higher rating, based on the electronic equipment served; and
   4. Shall be high efficiency.

P. Provide at least two (2) MCCs in each of the new Tunnel Support Buildings Electric Rooms. Each MCC shall be fed from separate sides of the respective Unit Substation 480V Switchgear.
   1. In each of the Tunnel Support Buildings, one MCC fed from one utility shall feed one-fourth (1/4) of the Tunnel Roadway jet fans, another MCC in the same building shall feed another one-fourth (1/4) of the Tunnel Roadway jet fans.

Q. All panel boards shall be provided with a minimum of 20% spare circuit breakers and all spaces shall be populated.

27.3.8. Hangers and Supports
   A. All hangers, supports, hardware and anchors installed within the Tunnel, Tunnel Egress Corridor, Tunnel Stairs, Horizontal/Vertical Ventilation/Utility Shafts/Spaces/Plenums, exposed to the outdoors, or indoors non-conditioned spaces open to outdoors shall be Type 316 Stainless Steel.
   B. All anchors installed within the Tunnel above the Tunnel Roadway Clearance Envelope to support Electrical, SCADA or ITS Equipment and conduit shall be Type 316 Stainless Steel mechanical undercut anchors.
   C. Provide dielectric isolation between dissimilar metals.

27.3.9. Manholes, Hand-holes and Junction Boxes
   A. All manholes, hand-holes, and pull/junction boxes installed in paved areas or areas that can be subject to vehicle traffic shall have H-20 rated bolt-down covers. Bolts shall be Type 316 Stainless Steel.
   B. All manholes, hand-holes and pull/junction boxes installed within Roadways and the Tunnel Roadway shall have the center line of cover in line with the center of traffic lanes to minimize vehicle tires from riding over covers.
   C. All manholes, hand-holes and pull/junction boxes installed within the Tunnel Roadway shall have covers provided with gaskets to prevent fuel and oil spills from entering the manhole, hand-hole or pull/junction box. Cover gasket material shall be Nitrile-Buna Rubber (Butadiene Acrylonitrile) (NBR) or similar material approved by the Department.
   D. All manholes, hand-holes, and pull/junction boxes installed within the Tunnel Roadway shall be provided with a drain pipe that drains directly into the Tunnel Roadway Drainage System.
   E. All pull/junction boxes or concrete cavities installed within the Tunnel Roadway side barriers shall be provided with a drainpipe that drains directly into the Tunnel Roadway Drainage System.
F. All pull/junction boxes installed within the Tunnel, Tunnel Egress Pathways, Stairs and Horizontal/Vertical Ventilation Shafts/Spaces, exposed outdoors or in non-conditioned spaces open to the outdoors shall be Types 316 Stainless Steel NEMA 4X.

G. All electrical pull/junction boxes installed within the Tunnel Support Building's interior in conditioned spaces shall be hot dipped galvanized steel.

H. All manhole and hand-hole covers shall have cast-in lettering identifying manhole or hand-hole service function.

I. All manhole and hand-hole hardware, cable support brackets, ladder, sump drain grate, etc. shall be Type 316 stainless steel.

J. All Stainless-Steel junction/pull box covers shall have machine printed Type 316 Stainless Steel name plates attached to the cover to identify the junction box service function. All other junction box covers shall have machine printed synthetic name plates attached to the cover to identify the junction box service function.

K. All electrical pull/junction boxes larger than 24” X 24” shall have hinged covers.

27.3.10. Equipment Cabinets and Enclosures

A. ITS and SCADA cabinets and enclosures in all locations except in the Server and Control Rooms shall be Type 316 Stainless Steel NEMA 4X enclosures with a full-length hinge and three-point latch recessed handle key door lock system.

B. All electrical panelboards, cabinets, and enclosures installed within the tunnel, Tunnel Egress Pathways, Stairs and Horizontal/Vertical Ventilation/Utility Shafts/Spaces, exposed to the outdoors or in non-conditioned spaces open to the outdoors shall be Types 316 Stainless Steel NEMA 4X enclosures with a full-length hinge and three-point latching door lock system with key lock and recessed door handle.

C. All electrical panelboards, cabinets, and enclosures installed within the Tunnel Support Building’s interior in conditioned spaces shall be NEMA 12 hot dipped galvanized steel. All electrical panelboards, cabinets, and enclosures installed within the Tunnel Support Building’s interior in non-conditioned spaces or below grade shall be Type 316 Stainless Steel NEMA 4X.

D. All Electrical, SCADA EPCS and ITS panelboards, cabinets, and enclosures that require operable doors and are installed within the Roadway Tunnel, Tunnel Egress Corridor, Utility Spaces created within the Tunnel Egress Corridor, and all outdoor locations shall be provided with magnetic door switches to monitor the door open/close status through the SCADA System. Activation of the door magnetic switch “door open alarm” shall automatically adjust the closest CCTV camera to view the specific device that initiated the Door Open Alarm Signal, and display the closest CCTV camera video image on the Control Room video monitors.

E. All Electrical, SCADA EPCS and ITS panels, cabinets, and enclosures shall have machine-printed synthetic nameplates adhered to the front of the unit door with epoxy resin to identify the unit’s unique identification name.

F. All Electrical, SCADA, and ITS panelboards, and cabinets located within the Roadway Tunnel shall be enclosed within a two (2) hour fire rated enclosure that provides direct access to the entire panelboard or cabinet it encloses through operable two (2) hour fire rated doors.
27.3.11. Grounding, Bonding, and Lightning Protection

A. Grounding and Bonding Requirements:

1. Provide a ground grid under the entire new fenced area and three (3) feet beyond the entire fence perimeter for the Department Hampton Shore and Norfolk Shore new and existing 13.2KV switchgear.
   a. Maximum measured grounding system resistance at each transformer, switchgear and structure connection point to the ground mat shall be less than three (3) ohms.
2. Provide a ground loop around the entire new Tunnel Support Buildings and all other Facility Buildings.
   a. The ground loop includes crossing below the new tunnel portal entrances.
   b. The maximum measured grounding system resistance at each Electric Distribution and Generator Room Main Ground Bus shall be less than five (5) ohms.
3. Provide a separate insulated ground conductor with all 600V and below feeders and branch circuits.
4. Provide a separate insulated ground conductor within each raceway for all parallel 600V and below feeders.
5. Provide a separate insulated ground conductor with all 15kV feeders for the entire length of each 15kV feeder.
6. All building ground rings and exterior switchgear buried ground grids shall utilize a minimum of #4/0 bare tinned copper encased in a conductive concrete, Grounding Enhancement Material (GEM).
7. The grounding electrode on each island shall be paint and corrosion free H-pile of a minimum length of 20’ below finish grade.
8. All connection to grounding electrode(s), ground electrode conductors and building steel shall be exothermic welds.
9. Provide a #4/0 bare tinned copper ground conductor on top (outside the concrete encasement) of all 15kV buried concrete encased duct banks. Bond #4/0 ground conductor to ground inside all manhole and handholes connected through the duct bank and when the duct bank crosses the grounding grid.
10. In all manholes, hand-holes, and junction/pull boxes bond all metal components with a minimum #6 AWG bare copper bonding conductor. This includes but is not limited to covers, frames, pulling eyes, conduits, cable shields, ground rods and ground conductors.
11. Bond all metal raceways to all metal junction/pull boxes.
12. Provide bonding jumper for all cable trays and metal conduits across the cable tray gap or exterior of the conduit expansion fitting that have been installed to accommodate thermal or structure expansion/movement.
13. Bond every other pedestal/foundation pier in every direction of all raised access floors.
14. Provide a Ground Bus in the new Tunnel Support Building Electric Distribution, Emergency Generator, UPS, SCADA/ITS Server, and Communication Equipment rooms connected to the Tunnel Support Building ground grid on each portal island.
15. Provide bonding of all fence posts, bonding of the fence top rail to each fence post, each fence leaf gate and entire perimeter fence wire mesh at maximum twenty-five (25) foot intervals to the substation ground grid.

16. Provide ground inspection and test wells at each location that the Department Hampton Shore and Norfolk Shore new and existing 13.2KV switchgear connects to the substation ground mat.

17. Provide ground inspection test wells on both portal islands at each location that the Tunnel Support Building Main Electric Room ground bus is connected to the ground loop around the building.

B. Lightning Protection Requirements:

1. Lightning protection systems and components shall comply with the requirements of NFPA 780.

2. Provide a lightning protection system for the Department Hampton Shore and Norfolk Shore new and existing 13.2KV switchgear. The lightning protection shall consist of a minimum of two (2) high mast poles with single lightning arrestors within the new substation fenced area, one (1) pole on the east side and one (1) pole on the west side of the new and existing 15kV switchgears. The height of each pole and lightning arrestor shall extend above the highest structure in the new and existing 15kV switchgear areas. Connect the new substation lightning protection system down conductors to the new and existing 15kV substation ground grids. Provide a test and inspection well at each location that the high mast pole mounted lightning arrester down conductor connects to the substation ground grid.

3. Provide lightning protection systems for the new Tunnel Support and all Facility Buildings. At a minimum, provide lightning protection down conductors at each of the four (4) building corners for each building. Where the lightning protection system down conductors connects to the Tunnel Support Building ground loop at each of the four (4) building corners provide a test and inspection.

4. The new lightning protection system for the Department Hampton Shore and Norfolk Shore new and existing 13.2KV switchgear shall be connected to the 13.2KV switchgear ground grids.

5. The lightning protection systems shall be designed, inspected and tested following the criteria described in NFPA 780 Annex D and UL’s Master Label Certification program. The Master Label Certificate shall be published to UL’s Public Directory.

6. All lightning protection components shall be U.L. listed for lightning protection service.

7. All lightning protection conductors shall be tinned copper.

8. All lightning protection hardware shall be compatible with copper conductors and the material and/or structure the lightning protection components are attached or connected to.

9. Provide lightning surge protection devices on the line side of all 480V and 208V Power feeder conductors entering or leaving the Tunnel Support Buildings inside the buildings at the line side of the panelboard or equipment point where the power feeder terminates.

10. Provide lightning surge protection devices on all copper Signal, Data, and Communication circuit conductors or cables entering or leaving the Tunnel Support Buildings inside the buildings at the point of entry or exit of the Signal, Data, and Communication circuit conductors. The surge protection shall be provided for each conductor of each cable.
27.3.12. Raceways

A. All raceways installed exposed in the Tunnel, Tunnel Egress Pathways, Tunnel Stairs, Tunnel Horizontal/Vertical Ventilation/Utility Shafts/Spaces, and/or concealed behind finish panels and/or fireproofing panels shall be Type 316 Stainless Steel Electric Metallic Tubing or Type 316 Stainless Steel Rigid Metal Conduit.

B. All raceways containing 15kV feeders, fiber optic backbone cables and emergency circuit wiring serving any of the systems identified in NFPA 502-2017, Article 12.4.1 that are routed through the Roadway Tunnel, Tunnel Egress Corridor or Cross-passages, Tunnel Egress Corridor Plenum, and/or access stairs and Shafts form the Tunnel Support Buildings to the Tunnel shall be installed and constructed as a UL Listed 2-hour fire rated raceway assembly. All raceways installed concealed with at least four-inches of concrete cover in the Tunnel, Tunnel Egress Corridor, Stairs and Horizontal/Vertical Ventilation/Utility Shafts/Spaces shall be Schedule 40 Rigid Polyvinyl Chloride Conduit (PVC) or Reinforced Thermosetting Resin Conduit (RTRC).

1. Any raceway having less than four (4) inches of concrete cover shall be Type 316 Stainless Steel Rigid Metal Conduit.

2. Where concrete encased PVC or RTRC raceways exit concrete, and connect to exposed conduit the last six (6) inches of the raceway shall be converted to Type 316 Stainless Steel Rigid Metal Conduit before exiting the concrete.

C. All raceways that are installed exposed outdoors or indoors in non-conditioned spaces that are open to the outdoors shall be Type 316 Stainless Steel rigid metal conduit.

D. All raceways installed indoors in conditioned spaces exposed or concealed within walls or above suspended ceilings shall be galvanized steel rigid metal conduit.

E. All Stainless Steel Electric Metallic Tubing fittings and connectors shall be waterproof Type 316 Stainless Steel compression.

F. Use only Type 316 Stainless Steel supports and mounting hardware with Stainless Steel electric metallic tubing and Stainless Steel rigid metal conduit.

G. For indoor conditioned spaces, use galvanized steel supports and mounting hardware with galvanized steel rigid metal conduit.

H. In Tunnel, Tunnel Egress Corridor, Stairs and Horizontal/Vertical Ventilation Shafts/Spaces all raceway connections to motors, damper actuators, adjustable light fixtures, lane use signs, traffic signals, cameras and any other equipment or component that requires adjustment or can vibrate shall be made using weatherproof, fire rated Type MC Cable complying with UL System No. 120, FHIT.120, Electrical Circuit Integrity System.

I. For indoor locations in conditioned spaces use liquid-tight flexible (galvanized steel) metal conduit (LFMC) for connection to motors, damper actuators, adjustable light fixtures, lane use signs, traffic signals, cameras and any other equipment or component that requires adjustment or can vibrate located.

J. Use marine-grade 6063 T6 aluminum ladder cable trays with 6063 T6 aluminum support brackets and Type 316 Stainless Steel mounting hardware to support all 15kV feeder cables and communication cables installed along the Trestles.

K. Use Schedule 40 PVC conduits encased in a minimum of three (3) inches of concrete (duct bank) on all sides for all underground raceways. All multiple underground concrete encased conduits shall have a minimum of 1 ½-inch separation between each conduit in all directions. The
installation of direct buried underground cable is not acceptable, except for underground ground grids and/or mats.

L. All underground duct banks for 15kV cables shall be constructed with five (5) inch (minimum) diameter Schedule 40 PVC conduits.

M. All 15kV duct banks shall be constructed with a minimum of two (2) spare five (5) inch PVC conduits.

N. All spare conduits and/or ducts shall have all ends capped with a removable cap and have a minimum of 3/8-inch wide flat Dacron true tape installed end to end.

O. All underground duct banks, except 15kV duct banks, shall be constructed with twenty-five (25) percent spare ducts/conduits based on the total number of live ducts/conduits within the duct bank. The size of the spare ducts/conduits shall be equal to the diameter of the largest duct/conduit within the duct bank. No duct bank shall have less than one (1) spare duct/conduit.

P. Provide colored warning tape twelve (12) inches above the top of all underground duct banks.

Q. All underground duct banks installed for fiber optic cables shall be provided with a tracer cable system above the duct bank for the entire length of the duct bank.

R. Provide flexible and/or expansion type fittings with bonding jumpers in all raceway systems crossing expansion joints, crossing between different types of structures and/or crossing between a rigid structure and a structure that may have movement.

S. The minimum diameter conduit for all conduit types is ¾-inch.

T. All exposed raceways shall be installed parallel or perpendicular to and follow the contour of the surfaces where the raceway is installed.

U. All power and communication conductors and cables installed with any cable tray shall be individually secured to the cable tray using marine grade, ultraviolet and weather resistant synthetic cable ties, at five (5) foot intervals.

V. Provide dielectric isolation between all dissimilar metals.

27.3.13. Wire and Cable

A. All 600-volt and less feeders, branch circuit, and control wiring shall use tinned copper conductors.

1. Minimum conductor size #12 AWG for power wiring.

2. Minimum conductor size #14 AWG for control and signal wiring.

3. All 600 volts and less feeders and branch circuit wiring conductors shall have 600 volts insulation Types XHHW, XHHW-2, RHW or RHW-2 INSULATION, shall be listed for wet locations, shall be of the low smoke zero halogen type, and shall comply with the requirements of NFPA 502.

B. All 15kV cables shall be of the single conductor type with tinned copper conductor, Ethylene Propylene Rubber (EPR) insulation, 133 percent insulation level, one hundred (100) percent foil copper shield, MV-105 classification with low-friction, flame retardant, and a moisture and sunlight resistant outer jacket. Cable shall be listed for wet, aerial, and underground in ducts and cable tray (CT) use. Minimum conductor size shall not be less than #4/0 AWG. Minimum conductor size for the bridge feeders shall be 500 MCM.
C. All conductors and cables shall be labeled at all termination points, splices, taps, and at boxes where the conductors or cables pass through uninterrupted. All conductor and cable labels installed in manholes, hand-holes, and in below ground locations shall be machine printed wrap around, marine grade, waterproof, ultraviolet (UV) resistant and fabricated from low smoke zero halogen synthetic material.

D. The installation of all conductors and cables shall comply with NFPA 70 and IEEE Standard 576-2000, IEEE Recommended Practice for Installation, Termination and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications.

E. All machine and/or equipment assisted conductor or cable pulls shall utilize an in-line calibrated dynamometer that is set at the maximum pull tension specified by the conductor or cable manufacturer that has been submitted and accepted by Department. If during any conductor or cable pull the conductor or cable maximum pull tension is exceeded the pulling operation shall stop, the conductor or cable shall be removed, the removed conductor or cable shall be disposed, and the conductor or cable shall be replaced with a new conductor or cable. The tension gauge calibration shall be certified by a qualified testing laboratory within one (1) year of use at all times. Pulling tension and sidewall pressure shall not exceed the manufacturer’s allowable values. If the pulling tension or sidewall pressure is exceeded during a pull, the cable shall be considered damaged and shall be replaced by the Design-Builder. Record all cable pull tensions and submit a report.

F. When installing and routing cables and conductors through manholes and hand-holes the cable shall not be installed utilizing the shortest route, but shall be routed along those walls providing the longest route and the maximum spare cable lengths. All cables installed in manholes and hand-holes shall be formed closely parallel to the walls, shall not interfere with duct entrances, and shall be supported on brackets and cable insulators, spaced at a maximum of four (4) feet. In existing manholes and hand-holes where new ducts are to be terminated or where new cables are to be installed, the existing installation of cables, cable supports, and grounding shall be modified as required in accordance with applicable codes and standards with all cables properly arranged and supported.

G. Provide at least one (1) complete loop of slack cable around all walls in every manhole and hand-hole for all 13.2kV feeders and cables.

H. Each phase conductor of all 13.2kV feeders shall be individually wrapped (by phase) with arc-proofing tape in every manhole, hand-hole, and junction box. Extend the arc-proofing tape on each phase conductor or cable a minimum of four (4) inches into all conduits and ducts at all manholes, hand-holes, and junction boxes. To prevent unraveling, the arc-proofing tape shall be random wrapped the entire length of the arc-proofing tape with pressure sensitive glass cloth tape.

I. Each phase conductor of all 480V and 208V feeders or cables serving pumps, fans, transformers and/or panelboards anywhere within the tunnel shall be individually wrapped (by phase) with arc-proofing tape in every manhole, hand-hole, and junction box within the tunnel. Extend the arc-proofing tape on each phase conductor a minimum of four (4) inches into all conduits and ducts at all manholes, hand-holes and junction boxes. To prevent unraveling, the arc-proofing tape shall be random wrapped the entire length of the arc-proofing tape with pressure sensitive glass cloth tape.

J. SPlicing AND TERMINATING PRODUCTS

1. A. Comply with the following standards:
a. IEEE 48: "IEEE Standard Test Procedures and Requirements for High Voltage Alternating Current Cable Terminations".


c. IEEE 404: "Standard for Power Cable Joints".

d. IEEE 592: "Standard for Exposed Semiconducting Shields on Pre-Molded High Voltage Cable Joints and Separable Insulated Connectors".

e. UL 486A: "Wire Connectors and Soldering Lugs for Use with Copper Conductors".

f. IEEE 386: "Separable" insulated connectors for power distribution systems above 600 volts.

2. All current carrying components shall be copper.

3. All connectors/lugs shall be compression type, two-hole, long barrel, seamless, tin plated copper, listed per UL 486A.

4. All splicing and termination kits shall be as recommended by the manufacturer, in writing for the specific sizes, ratings and configurations of cable conductor, splices and terminations specified. Kits shall contain all components required for a complete splice or termination including detailed instructions and shall be the product of a single manufacturer. Completed splices and terminations shall provide insulation equivalent to the insulation class of the cable it connects.

5. Splices shall be made with standard splicing kits and shall be one of the following types:

   a. Heat shrink splice kit of uniform cross-section polymeric construction with outer heat shrink jacket.

   b. Pre-molded, cold shrink rubber, in-line splice kit.

   c. Separable insulated splice, 600 amp, 3-phase rated, with capacitive test print on molded T-body. Voltage rating of separable splice shall be 13.2 KV for use on all MV circuits.

6. Deadbreak junctions shall have four 13.2 KV, 600A deadbreak interfaces bused together with copper bus and encapsulated in a precision molded peroxide cured EPDM insulated rubber body with a semi-conductive outer shield. Junctions shall meet the requirements of ANSI/IEEE 386, and be equipped with stainless steel mounted bracket with 2 parking stands. When mated with a compatible product, the junction shall provide a completely shielded, submersible threaded connection. Unused interfaces shall be covered with insulated protective caps of the same manufacturer as the junctions.

7. Conductor Terminations shall comply with Class I, IEEE Standard 48. insulation class shall be equivalent to that of the cable upon which they are installed. Terminations for shielded cables shall include a shield grounding strap. Include an effective moisture seal for the end of the insulation regardless if this item is included in termination kits. Seal shall be silicone rubber tape, cold shrink rubber sleeve, or heat shrink plastic sleeve as recommended by the kit manufacturer. Termination kits shall be performance tested for compliance with IEEE Standard 48 and shall be of the following types:

   a. Class I Termination for Shielded Cable: Modular type, furnished as a kit, with stress relief tube, multiple molded silicone rubber insulator modules, shield ground strap, and compression type connector.
b. Class I Termination for Shielded Cable: Heat shrinkable type with heat shrinkable inner stress control and outer non-tracking tubes, multiple molded non-tracking skirt modules, and compression type connector.

c. Separable Insulated Elbow Connectors: Modular system, complying with IEEE Standard 386. System shall consist of disconnecting, 600A, 3-phase rated single pole, cable terminators and matching stationary, plug-in, dead front terminals. System components shall be designed for the system voltage and for sealing against moisture. Elbows shall include voltage test points on molded connector body. Voltage rating of separable elbow connectors shall be 13.2 KV for use on all MV circuits.

K. Provide dielectric separation between all dissimilar metals.

27.3.14. Calculations

A. Requirements for Sizing of the new 13.2kV feeders:

1. Bridge feeders shall be a minimum of 500 MCM
2. Tunnel feeders shall be a minimum of 4/0

B. Requirements for Electrical Calculations for All Components of the Electric Distribution System at all voltages shall be as follows:

1. The use of demand or diversity factors less than unity in any calculation MUST be substantiated by published documentation that validates the use of the demand and/or diversity factor of less than unity and approved by the Department.

2. Provide ten (10) percent additional spare capacity added to the total maximum calculated demand load for all switchgear, panelboards, motor control centers, generators, UPSs, transformers, feeders, and any other electrical equipment serving electric power loads provided under this Project. The current kW and kVA rating of all equipment shall be based on the standard size rating larger than the respective calculated total demand load after adding the required ten (10) percent additional spare capacity.

C. Provide detailed load analysis and calculations for the entire electrical distribution system including engine-generators and UPS’s at all voltage levels for the system and equipment provided under this Project:

1. The load analysis and calculations shall include the first existing circuit breaker downstream of all connection points at all voltage levels to the new electric distribution system provided under this Project.

2. The load analysis and calculations shall be performed using SKM Systems Analysis, Inc. Power Tool Software (SKM) or approved equal software.

3. Detailed SKM one-line diagrams showing all nodes shall be submitted with each calculation submittal.

D. Provide detailed voltage drop analysis and calculations for the entire electrical distribution system at all voltage levels for the system provided under this Project:

1. The voltage drop analysis and calculations shall include the first existing circuit breaker downstream of all connection points at all voltage levels to the new electric distribution system provided under this Project.

2. The voltage drop analysis and calculations shall be performed using SKM or approved equal software.
3. Detailed SKM one-line diagrams showing all nodes shall be submitted with each calculation submittal.

E. Provide detailed engine-generator starting analysis and calculations for each engine-generator and for all operating load conditions based on the approved load starting sequences.
   1. The engine-generator starting analysis and calculations shall be performed using the furnished engine-generator manufacturer.
   2. The engine-generator starting analysis shall be based on transient motor starting with fire pump running and considering that all tunnel jet fans must be running at rated speed within a maximum of one hundred eighty (180) seconds per NFPA 502.

F. Provide detailed short circuit analysis and calculations for the entire electrical distribution system at all voltage levels for the system provided under this Project:
   1. The short circuit analysis and calculations shall include the first existing circuit breaker downstream of all connection points at all voltage levels to the new electric distribution system provided under this Project.
   2. The short circuit analysis and calculations shall be performed using SKM or approved equal software.
   3. Detailed SKM one-line diagrams showing all nodes shall be submitted with each calculation submittal.

G. Provide detailed coordination study analysis and calculations for the entire new electrical distribution system at all voltage levels for the system provided under this Project:
   1. The coordination study analysis and calculations shall include the first existing circuit breaker downstream of all connection points at all voltage levels to the new electric distribution system provided under this Project.
   2. The coordination study analysis and calculations shall be performed using SKM or approved equal software. Detailed SKM one-line diagrams showing all nodes shall be submitted with each calculation submittal.

H. Provide detailed arc-flash hazard analysis and calculations for the entire new electrical distribution system, at all voltage levels:
   1. The arc-flash hazard labeling, analysis and calculations shall include all new and existing switchgear, switchboards, panelboards, motor control centers, industrial control panels, disconnect switches, and enclosed circuit breakers at all voltage levels for the new and existing electric distribution system.
   2. The arc-flash hazard analysis and calculations shall be performed using SKM or approved equal software. The arc-flash hazard analysis detailed SKM one-line diagrams showing all nodes shall be submitted with each calculation submittal.
   3. The arc-flash analysis shall be performed in accordance with the current edition of NFPA 70E Appendix D and IEEE 1584. All electrical equipment shall be provided with the appropriate arc-flash hazard-warning label as required by the current edition of NFPA 70 - National Electric Code (NEC). The arc-flash hazard-warning label shall also identify the Incident Energy, Working Clearance, and required Personal Protection Equipment (PPE) for every new piece of equipment provided under this Project.
I. Provide detailed calculations for ground grids at the Department Hampton Shore and Norfolk Shore new 13.2kV switchgear and at the Tunnel Support Buildings in accordance with IEEE Standards 80 and 81 using SKM software.

J. Provide conductor and cable pull tension calculations for all 15kV, 480V and 208V conductors and cables having conductors #2 AWG and larger for all fiber optic cables, coax cables, and multi-conductor communication cables installed in conduit or ducts:
   1. Provide a detailed description and/or explanation of the complete conductor or cable installation and pulling operation and all assumptions used in the calculations.
   2. The pull tension calculations must demonstrate the conductor or cable manufacturer maximum pull tension is not exceeded.
   3. The conductor and cable pull tension calculations must be submitted with the RFC Documents Submittal for Department approval.
   4. All conductor and cable pull tension calculations must be resubmitted for Department approval as shop drawings to include all conduit or duct as installed conditions prior to the installation and pulling of any conductors or cables in any conduit or ducts.

K. Provide detailed calculations verifying the size and ampere-hour capacity selection for all batteries and battery systems.

27.3.15. Monitoring and Control

A. Provide all 13.2kV fused switches and circuit breakers with:
   1. CTs and PTs;
   2. Digital Voltage Meter and Selector Switch to read each phase line-to-line voltage;
   3. Digital Ammeter and Selector Switch to read each phase current;
   4. Provisions for remote Open/Close control and status;
   5. Provision for remote monitoring of each phase current, each phase line-to-line voltage, kW, kVA, and power factor;
   6. All remote features shall be monitored and controlled through the SCADA System; and
   7. All 13.2kV Switchgear shall communicate with the SCADA System through a network connection utilizing Modbus, Profibus, PROFINET, Ethernet/IP or Ethernet protocols.

B. Provide all 480V Switchgear main power circuit breakers and tie power circuit breakers with:
   1. CTs and PTs;
   2. Digital Voltage Meter and Selector Switch to read each phase line-to-line voltage;
   3. Digital Ammeter and Selector Switch to read each phase current;
   4. Provisions for remote Open/Close control and status;
   5. Provision for remote monitoring of each phase current, each phase line-to-line voltage, kW, kVA, and power factor;
   6. All remote features shall be monitored and controlled through the SCADA System; and
   7. All 480V Switchgear shall communicate with the SCADA System through a network connection utilizing Modbus, Profibus, PROFINET, Ethernet/IP or Ethernet protocols.
C. Provide all 13.2kV to 480V transformer auto voltage regulators with remote monitoring of the automatic voltage regulator operation. The remote monitoring of each transformer automatic voltage regulator operation shall be monitored by the SCADA System.

D. Provide all engine generators with auxiliary input and output contacts connected to the SCADA System to allow the SCADA System to Start/Stop the engine generator and to monitor all the NFPA 110 required engine generator status points.

E. Provide all Automatic Transfer Switches with auxiliary output contacts connected to the SCADA System to allow the SCADA System to monitor Transfer Switch Normal/Emergency sources available, and Transfer Switch Load connected to Normal/Emergency source.

F. Provide all UPSs with the following:
   1. Auxiliary outputs to allow all UPS standard output data to be remotely monitored by the SCADA System; and
   2. All UPSs shall communicate with the SCADA System a network connection utilizing Modbus, Profibus, PROFINET, Ethernet/IP or Ethernet protocols.

G. Provide all Motor Control Centers with:
   1. Auxiliary inputs and outputs to allow all MCC starters to be monitored and controlled by the SCADA System; and
   2. All MCC starters shall communicate with the SCADA System a network connection utilizing Modbus, Profibus, PROFINET, Ethernet/IP or Ethernet protocols.

27.3.16. Temporary Electric Power for Construction –

Temporary power to install, construct, or bore the new tunnel shall be the responsibility of the Design-Builder. Design-Builder shall not use power dedicated to the existing tunnel for any reason without prior approval from Department’s Resident Electrical Engineer. Design-Builder shall not tap off of any Dominion shore substations directly feeding the existing tunnel.

It is the responsibility of the Design-Builder to coordinate with Dominion to put into place the necessary infrastructure to deliver sufficient power to the temporary equipment and any temporary substation. The temporary power connection to any transmission lines shall be made upstream of any Dominion shore substation feeding the HRBT and shall not affect any power requirements or load demands for the existing HRBT facility. After coordinating with Dominion, the voltage drop calculations, short-circuit and coordination study details shall be submitted to Department for approval by Department’s Resident Electrical Engineer prior to any temporary power construction.

27.3.17. Installation

A. To de-energize any 13.2kV feeder the Design-Builder must give Department a minimum of 14 days calendar notice. Only one (1) of the existing 13.2kV feeders can be de-energized at any point in time. The maximum time duration that any one (1) existing 13.2kV feeder can be de-energized is eight (8) consecutive hours. The existing 13.2kV feeders can only be de-energized between the hours of 8:00am to 4:00pm, unless approved by Department.

B. Provide one (1) complete set of draw out circuit breaker lifting equipment in each of the Tunnel Support Building Electric Rooms on both islands.

C. All Electrical, Communication, SCADA EPCS and ITS equipment, enclosures and raceways that are located within and/or penetrate the walls or ceiling of the Tunnel Egress Stairs or Egress Pathway Corridor that do not serve the Tunnel Egress Stairs or Egress Pathway Corridor MUST
be separated from the Tunnel Egress Stairs or Egress Pathway Corridor by Fire Barriers having a minimum two (2) hour Fire Resistance Rating in accordance with the requirements of NFPA 101, Chapter 8, Section 8.3 or as modified by the current applicable edition of NFPA 101.

D. The new control room shall be designed and constructed as a Designated Critical Operations Area (DCOA) as defined in the 2014 NEC 708. All power and control systems connected to the new control room shall be installed under the Critical Operations Power System as defined in the 2014 NEC 708. The new control room construction shall comply with all requirements of NFPA 502-2017, Article 13.5 for an Operations Control Center and with all requirements of NFPA 72-2016, Article 26.4 for a Proprietary Supervising Station Alarm Systems.

E. The Tunnel Control Room, Tunnel Egress Corridor and/or Cross Passages, Tunnel Egress Corridor Plenum, and any shaft connecting the Tunnel Support Buildings to the Tunnel shall be considered Tunnel Ancillary areas/spaces. All systems installed in Tunnel Ancillary areas/spaces that are required to be connected to emergency circuits per NFPA 502-2017, Article 12.4.1 are also classified as Critical Operation Power Systems and shall comply with all the requirements of NFPA 70 (NEC), Article 708.

F. The electrical work and equipment in all pump rooms shall be in accordance with NFPA 70 (NEC) requirements for Class 1, Division 2 spaces.

27.3.18. Testing

A. Provide the following Testing and Inspection for Electrical Equipment:

1. Factory Test
   a. Department Hampton Shore and Norfolk Shore new 13.2kV switchgear Unit Substations (15kV Switchgear, Transformers with automatic voltage regulators, and 480V Switchgear)
   b. 15kV Cable
   c. Motor Control Centers
   d. Diesel Generators and Automatic Transfer Switches
   e. UPSs
   f. Fire Rated MC Cable
   g. Individual mounted Adjustable Speed Drives
   h. Automation controls logic and the hardware

2. Pre-Startup Inspection
   a. All items listed under Factory Test
   b. Panelboards, Individual Motor Starters, Individual Transformers
   c. All feeder conductors (all conductor sizes)
   d. All branch circuit conductors (all conductor sizes)
   e. Grounding mats, loops, grids, and individual ground busses
   f. Lightning Protection System

3. Startup Test
   a. All items listed under Pre-Startup Inspection
4. System Function Test  
   a. All items listed under Startup Test  
   B. Submit Detailed Test and Inspection Procedures for the Factory Test, Pre-Startup Inspection,  
      Startup Test, and System Function Test.  
   C. Submit detailed Test and Inspection reports for all Tests and Inspections.  
   D. Factory Test can utilize Manufacturers’ Standard Factory Tests.  
   E. Pre-Startup Inspections, and Startup Tests shall follow all the Inspection and Tests listed in  
      Power Equipment and Systems, Section 7 Inspection and Test Procedures.  
      1. To demonstrate that all equipment operates as specified.  
      2. Thermographic survey shall be performed with the conductor, equipment and/or system  
         operating at a minimum of fifty (50) percent of the rated load capacity of the conductor,  
         equipment and/or system being surveyed. Provide the following Testing and Inspection for  
         Electrical Equipment:  
   G. The Testing and Inspection organization performing the Startup and System Function Tests shall  
      be independent of the installing Design-Builder and shall be a NETA accredited company.  
   H. Testing and Inspection personnel for all Tests shall be Technicians certified in accordance with  
   I. Testing instruments used for all Tests shall be calibrated and certified within one (1) year of the  
      date used for the specific test performed.  

27.4. Deliverables  
At a minimum, the deliverables shall include the items listed in Table 27.4-1 for Department consultation  
and written comment.

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SECTION 28. FIRE ALARM, DETECTION, AND CONTROL

28.1. Scope

A. The Design-Builder shall provide a UL Listed Fire Alarm, Detection, and Control System throughout the Project as described in this Section of the Technical Requirements and as required by all applicable Codes and Standards. The system shall include an automatic heat detection system in the tunnel roadways, manual fire detection in the tunnel roadways, suppression release for the tunnel deluge system, automatic fire detection in ancillary spaces, monitoring of fire suppression system valves and piping, a mass notification system, a fire alarm network including an interface to the ventilation control building fire alarm and detection systems and off-site monitoring and control. Do not provide any visual and/or audible Fire Alarm Notification appliances anywhere within the Tunnel. Fire alarm system to include but not limited to following main components as required by code:

i. Fire alarm control panel.
ii. Remote annunciator[s]
iii. Intelligent initiating fire detectors [linear heat detection system, heat detectors, smoke detectors, etc.]
iv. Conventional initiating fire detectors [heat detectors, smoke detectors, etc.]
v. Signaling devices [horns, strobes, bells and combination horn/strobe, etc.]
vi. Addressable input (monitor) modules.
vii. Addressable output (control) modules.
viii. Control units and Field Mountable Modules.
ix. Fault isolator modules.
x. Fire pump monitoring.
xi. Fire protection water flow switches.
xii. Fire protection valve tamper switches
xiii. Auxiliary control relays for ventilation equipment shutdown.
xiv. End of line devices.
xv. Auxiliary relay contacts for: [fuel dispenser, automatic doors, remote alarm & trouble signals, etc.]


28.2. References

A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:

i. VDOT Road and Bridge Standards;
ii. VDOT Road and Bridge Specifications;
iii. VDOT Project Development Manual; and
iv. VDOT Instructional and Informational Memoranda.


C. NFPA 502 – Standards for Road Tunnels, Bridges and Other Limited Access Highways.


E. Virginia Uniform Statewide Building Code (USBC).


G. FHWA National Tunnel Inspection Standards (NTIS).


28.3. Requirements

28.3.1. General

A. The fire alarm and detection system equipment and service provider shall be a nationally recognized company specializing in fire alarm and detection systems. This provider shall employ factory trained and NICET Level IV certified technicians and shall maintain a service organization within 50 miles of the Project location. The equipment and service provider shall have a minimum of 20 years of experience in the fire alarm industry. The local office of the fire alarm and detection system installer shall be U.L. listed under UUJS category as a qualified system provider. The fire alarm and detection system equipment and service provider shall have single-source responsibility for all components that make up the system and shall assume responsibility for compatibility of all system components.

B. Each and every item of the fire alarm and detection system shall be listed under the appropriate category by UL and shall bear the UL label.

C. All equipment and components shall be new, and the manufacturer’s current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approval agency for use as part of a protected premise protective signaling (fire alarm) system. The authorized representative of the manufacturer of the major equipment, such as control panels, shall be responsible for the satisfactory installation of the complete system.

D. All equipment and components shall be installed in strict compliance with each manufacturer’s recommendations. Consult the manufacturer’s installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.

E. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., detectors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

28.3.2. Addressable Fire Alarm System:

A. The system shall be electrically supervised and monitor the integrity of all conductors.
B. The system specified shall provide a digital alarm communicator capable of transmitting alarm, trouble and supervisory conditions. These conditions shall automatically be transmitted to the local tunnel control center, the VDOT secondary control center, or to an approved central station.

C. The system shall be an active/interrogative type system where each initiating device and notification appliance circuit is repetitively scanned, to ensure that the devices and wiring are functional. Loss of signal at a local FACP shall result in a trouble indication on all remaining FACP displays.

D. Sequence of Operation: The following sequence of operations is not intended to be comprehensive listing of all actions that might initiate an ALARM, TROUBLE or SUPERVISORY condition or list all activities as a result of a given condition. All manufacturer standard and code required actions that generate an ALARM, TROUBLE or SUPERVISORY condition shall be included as well.

i. The following operations shall occur within the evacuation zone in alarm as the result of an ALARM condition:
   a. Indicate location of individual alarm device in English on 80 character displays on the fire alarms control panel that the device is connected. The alarm will also be displayed at the network annunciators.
   b. Printing and history storage equipment shall log the information associated with the fire alarms control panel condition, along with the time and date of occurrence.
   c. All system output programs assigned via control-by-event interlock programming to be activated by the particular point in alarms shall be executed, and the associated system outputs shall be activated on either local outputs or points located on other network nodes to include the following activities:
      ii. Initiate visual alarms strobes via addressable control relays and remote power supplies throughout all levels of the fire zone.
      iii. A device malfunction or loss of signal as determined in the monitoring of the signaling line circuits causes system to enter TROUBLE condition, which includes the following operations:
           a. Indicate location of individual malfunctioning initiated device in English on 80 character displays on the fire alarm control panel that the device is connected. The alarm will also be displayed at the network annunciators.
           b. Printing and history storage equipment shall log the information associated with the fire alarm control panel condition, along with the time and date of the occurrence.
           c. Initiate TROUBLE signal transmission.

E. System Wiring:

i. All transmission shall be hard wired. The fire alarm network that interconnects the FACPs together shall be Class A circuit and shall utilize fiber optic cable. A minimum of two conduits located in separate areas of the tunnel shall be utilized.
ii. The linear heat detectors shall be configured as a Class B circuit.

iii. Other signaling Line Circuits (SLC) continuing alarms, trouble and supervisory signals form all intelligent reporting devices shall be Class B (NFPA Style 4).

iv. Notification appliance Circuits shall be wired Class B (NFPA Style Y).

F. Interface to SCADA System

v. Each FACP location shall be connected to the SCADA System PLC via an Ethernet type connection at an Ethernet Switch provided by others. Each FACP shall report all alarm, trouble, supervisory and status conditions to the SCADA system. The SCADA system will use this information to operate other tunnel fire and life safety systems. In addition, the FACP network shall be able to accept commands from the SCADA system to acknowledge alarms and to turn on and off the deluge valves and to abort deluge dumps.

G. Conductors

i. A Wire and cable shall be type listed for its intended use by an approval agency acceptable to the Department. Obtain from manufacturer written instructions regarding the appropriate wire/cable to be used for the installation. Wire and cable shall be low smoke, zero halogen type in accordance with NFPA 502 and shall meet the requirements of IEEE 1202.

ii. The fire alarm network that connects the various FACPs shall utilize a single mode fiber optic cable for communication. Cable shall be as specified in Section 2.42 SCADA System. Minimum fiber count shall be 12 fiber.

A. Manual Deluge Control Panel

i. Graphic annunciator of all tunnel lanes and deluge zones with manual deluge and abort switches. Alarm LED shall be included per zone.

ii. Operator switches shall be key switch enabled to prevent unauthorized use. The key shall only be removable in the disabled position. Lamptest shall also be provided.

iii. All switches and LEDs shall be controlled by driver board located in the manual deluge control panel connected via data and power cabling to the FACP.

iv. Enclosure to match the Fire Alarm Control Unit. Locking cover /display and hinged. Key and lock shall be common to all Fire alarm system enclosures.

B. Tamper and Pressure Switches

v. Made for NFPA 72 and NFPA 13 service use in weatherproof NEMA 4 enclosure and compatible with fire protection system valves and piping.

vi. Provide addressable module for each device or group of devices at a single location.

C. Manual Pull Stations: Single action type, fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color. Stations requiring the breaking of a glass panel are not acceptable. Stations requiring the breaking of a concealed glass rod may be provided with approval by the Department. Provide addressable modules for all manual pull stations.
i. Station reset: Key- or wrench-operated, double-pole, double-throw, switch-rated for the voltage and current at which it operates. Stations have screw terminals for connections.

ii. Weatherproof Housing: Provide a weatherproof, hinged, clear-lexan housing suitable for the location for all pull stations mounted in unprotected spaces, including but not limited to, locations in the tunnel cells and on the exterior. Provide tamperproof clear lexan shield.

H. Signaling Devices

i. Combination Horn/Strobe Devices: Shall consist of factory-combined speaker and visual alarm units in a single assembly. Each speaker and visual component shall meet the same requirement for separate fire alarm speakers and visual alarm devices indicated above. Audible/Visual unit shall be UL listed for its intended use.

ii. Visual Alarm Devices: Electronic, xenon flashtube type, designed for operation from 20 to 24 volts DC. Power connections shall be by means of a terminal block. Device shall comply with ADA requirements and be listed to UL 1971 and marked as such. Flash rate shall not exceed two per second nor be less than one per second. Light output shall be rated at a minimum intensity of 15/75 candelas per UL 1971 over the entire design voltage range, or as indicated on the drawings, whichever is greater. Mount lenses on an aluminum face plate. Units shall have synchronization capability for uniform flashing of visual alarm units.

iii. System Printer

iv. Provide a desk top, 80 column system printer at the ventilation building Control Room. The printer shall be enclosed in a separate cabinet suitable for placement on a desktop 7 or table. Printer(s) shall receive English language text from the fire control panel in an industry standard ASCII format that complies with Electrical Industries Association (EIA) standard EIA-232D. The printer shall provide a hard-copy printed on standard pin feed paper of system events.

a. Printer(s) shall be capable of printing the following:
   - Log in/out
   - Alarm, trouble and supervisory historical logs
   - Current alarms, troubles, and supervisory conditions
   - Acknowledging of alarms, troubles, and supervisory conditions
   - Alarm silencing
   - System reset
   - All printed information shall include time and date.
28.3.3. Fire Alarm, Detection and Control Requirements by Location

28.3.3.1. Tunnel Roadway

The Design-Builder shall:

A. Provide waterproof NEMA 4 single action manual pull station with waterproof NEMA 4 back box at both ends of the Tunnel, adjacent to every fire hose cabinet, adjacent to each Tunnel Egress Corridor Door (tunnel side), and adjacent to each Tunnel Egress Stair Door (tunnel side). Adjacent shall mean not more than five (5) feet away. Provide an Underwriters Laboratories (UL) listed pull station clear polycarbonate removal protective cover, without horn sounder, over every manual pull station located within the Tunnel and Tunnel Egress Corridor.

B. Provide a double looped zoned linear heat detector system throughout the Roadway Tunnel to be used for a fire detection, alarm, and automatic control of the corresponding Fire Protection Deluge zone.

   i. Linear heat detection cable shall be fiber optic.

   ii. One hundred ninety degree F alarm temperature sensor cable capable of initiating an alarm once its rated activation temperature is reached. Maximum ambient temperature up to 150 degrees Fahrenheit. The cable shall detect the specified temperature anywhere along the detector length. Averaging, analogy integrating, or thermistry-type detection cables are not acceptable.

   iii. UL listed spacing of 50 feet without any derating for ceiling height.

   iv. The detection cable shall be capable of withstanding the tunnel environment including structural vibrations. Provide proof that the linear heat detection cable has been used successfully in other roadway tunnel applications.

   v. All brackets and fittings used to support the linear heat detector in the tunnel shall be Type 316 stainless steel.

C. Provide required interface modules to monitor and control all Roadway Tunnel Deluge zones through the Fire Alarm System.

D. Provide waterproof fire protection water flow and tamper switches with waterproof monitor modules.

E. Coordinate Tunnel ventilation zones and fire detection and FFFS zones per NFPA 502.

F. Provide the LHD control panel with the same system power supply, supervision, and alarm features as specified for the FACP. The LHD control panel shall be mounted in the new control room.

28.3.3.2. Tunnel Egress Corridor, Egress Stairs and Utility Stairs

The Design-Builder shall:

A. Provide multiple Fire Alarm Control Panels (FACPs) within the Egress Corridor to function as the FACPs for all Fire Alarm, Detection, and Control equipment throughout the Egress Corridor. Connect FACPs to new dedicated fiber optic network loop.

B. Provide waterproof NEMA 4 single action manual pull station with waterproof NEMA 4 back box adjacent to every Egress Corridor Door (egress corridor side).
C. Provide individual weatherproof heat detectors throughout the Egress Corridor that are UL listed for outdoor use.

D. Provide waterproof fire protection water flow and tamper switches with waterproof monitor modules.

28.3.3.3. Substation Switchgear Enclosure

The Design-Builder shall:

A. Provide a FACP within the Substation Switchgear enclosure to function as the FACP for all Fire Alarm and Detection equipment in the Switchgear enclosure center corridor. Connect FACP to the District’s existing SCADA System to allow this FACP to be monitored by all District SCADA monitoring locations.

B. Provide two (2) smoke detectors within the Switchgear enclosure center corridor.

C. Provide two (2) double action manual pull stations with the Switchgear enclosure, one (1) at each center corridor exit doors.

28.3.3.4. Ventilation Buildings Interior

The Design-Builder shall:

A. Provide an addressable fire-alarm system in these building(s). The system consists of:
   
   i. Fire-alarm unit.
   
   ii. Manual fire alarm box.
   
   iii. System smoke detectors.

   
   v. Notification appliance.
   
   vi. Addressable interface device.
   
   vii. Digital alarm communicator transmitter.

   viii. System printer.

B. Provide fire-alarm component in Fire Protection Room:

   i. Clean agent system control module.
   
   ii. Pre-action sprinkler system control modules.

   iii. Monitor module (tamper switch, pressure flow switch and wet system tamper switch).


   v. Wall-mounted fire alarm horn/strobe.

C. Provide fire-alarm component in Control Room:

   i. Area photo smoke detector for activation of clean agent system.

   ii. Ceiling-mounted fire alarm horn/strobe.

   iii. Fire alarm control panel.

D. Provide fire-alarm component in Electrical Room:
i. Area photo smoke detectors for activation of pre-action sprinkler system.

ii. Wall-mounted fire alarm horn/strobes.

28.3.3.5. Existing Ventilation Buildings

The Design-Builder shall:

A. Provide an addressable fire-alarm system in this building. The system consists of:
   i. Fire-alarm unit.
   ii. Manual fire alarm box.
   iii. System smoke detectors.
   v. Notification appliance.
   vi. Addressable interface device.
   vii. Digital alarm communicator transmitter.
   viii. System printer.

B. Provide fire-alarm component in Storage Room:
   i. Clean agent system control module.
   ii. Pre-action sprinkler system control modules.
   iii. Monitor module (tamper switch, pressure flow switch and wet system tamper switch).
   v. Wall-mounted fire alarm horn/strobe.

C. Provide fire-alarm component in Control Room:
   i. Area photo smoke detector for activation of clean agent system
   ii. Ceiling-mounted fire alarm horn/strobe.
   iii. Fire alarm control panel.

D. Provide fire-alarm component in Electrical Room:
   i. Area photo smoke detectors for activation of pre-action sprinkler system.
   ii. Wall-mounted fire alarm horn/strobes.

28.3.3.6. New Control Rooms

A. The Design-Builder shall design and construct a new control room that shall be the main fire alarm command center for all the new system installed in tunnel and control building. The existing room will be the secondary fire alarm command center be located. The control panels for LHD in tunnel, fire alarm in tunnel egress corridor/stair and utility stair and fire alarm system in the new ventilation building and existing ventilation building.
28.3.4. Installation

The Design-Builder shall install:

A. Fire Alarm, Detection, and Control System in accordance with NFPA 70, NFPA 72, and NFPA 502 and other standards referenced in this section.

B. The components in conjunction with Section 27 Technical Requirements for additional related requirements.

C. All Fire Alarm, Detection and Control wiring, cables and/or conductors serving the Tunnel and Tunnel Egress Corridor and Stairs shall be considered “Emergency Circuits with respect to NFPA 502” and MUST comply with the requirements of NFPA 502-2014, Chapter 12 by the current applicable edition of NFPA 502.

D. Equipment:
   i. Equipment mounting heights shall be in accordance with the State and local Fire Alarm Codes and ADA Guidelines.
   ii. Provide interconnecting wire and cable between the various system devices for proper system operation as recommended by the manufacturer’s representative.
   iii. Connect Fire Alarm System control modules to devices to be controlled by Fire Alarm.
   iv. Linear Heat Detectors: Match fire suppression zones and install the cable over the 13 center of each lane in a Class A cross-zone configuration. Install in accordance with the manufacturer recommendations. The manufacturer technical representative shall be on site during the entire installation of the new system. The technical representative shall be on site with the Design-Builder during the entire time of final connections and testing of the linear heat detection system. The cost of the technical representative shall be responsibility of the Design-Builder. The cable shall be located at not more than 20 inches from the ceiling. The cable shall be installed by hand. Mechanical devices shall not be applied. All bending and fitting shall be done by hand. Pliers and other hand tools shall not be used to form the cable. Observe minimum bending radius. All mounting and fastening hardware shall be stainless steel and approved by the manufacturer. Use stainless steel messenger wire, eyebolts, turnbuckles to support the cable. Support messenger wire in accordance with the manufacturer recommendations. Fire proof all penetrations where cable or conduit is used to penetrate a wall. Provide bushings at all open ends of conduit. All cable shall be wired in a series loop configuration. Circuits with T taps and Y branches shall not be accepted.
   vi. Automatic Detectors: Install ceiling detectors indicated to be ceiling mounted not less than 4 inches from a side wall to the near edge. For exposed solid joist construction, mount detectors on the bottoms of the joists. Install detectors no closer than 5 feet from air registers.
   vii. Tamper and Flow Switches: Connect for each tunnel fire suppression system valves and piping. Provide addressable modules.
   viii. Horn/Strobe and Strobe: Install 80 inches above finished floor or 6 inches below the ceiling whichever is lower.
ix. Fire Alarm Control Panel (FACP): Locate in vicinity of deluge valves with tops of cabinets not more than 6 feet above the finished floor.

x. Monitor Modules: Locate within standard junction box of size recommended by manufacture with appropriate cover plate.

xi. Control Modules: Locate within standard junction 1 box of size recommended by manufacturer with appropriate cover plate.

E. INSTALLATION OF CONDUCTORS

i. Wiring Within Enclosures: Install conductors paralleled with or at right angle to the side and back of enclosure. Bundle, lace and train the conductors to terminal points. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

ii. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.

iii. Color Coding: Color-code all fire alarm conductors differently from the normal building power wiring. Provide one color code for alarm circuits wiring and different color code for supervisory circuits. Provide a color code for audible alarm indicating circuits different from alarm initiating circuits. Use different colors for visual alarm indicating devices.

iv. Paint fire alarm system junction boxes and covers and conduit as indicated in Section 27 Identification for Electrical Systems.

v. Wiring for 24 volt control, alarm notification, emergency communication and similar power-limited auxiliary functions may be run in the same conduit as initiating and signaling line circuits. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.

vi. Wiring shall be in accordance with local, state and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the Fire Alarm System. Number and size of conductors shall be as recommended by the Fire Alarm System manufacturer, but not less than 16 AWG for signaling line circuits, 16 AWG for speaker circuits and 12 AWG for strobe circuits.

vii. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.

viii. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NFPA 70 (e.g., FPLR), and shall be installed within communications cable tray (CCT). All wiring not in CCT shall be in conduit.

ix. Wiring used for the SLC multiplex communication loop shall be twisted and shielded and installed in conduit unless specifically excepted by the Fire Alarm equipment manufacturer and approved by the Department.
F. Connection
   i. Verify that hardware and devices are NRTL listed for use with fire-alarm system before making connections.

G. Grounding
   ii. Ground equipment and conductor and cable shields. All pair shields shall be grounded at one point only. Cable that originates from equipment in the New Control Room and serves field devices shall be grounded to the signal ground terminal in the New Control Room.

28.3.5. Testing

The Design-Builder shall:

A. Test the entire Fire Alarm, Detection, and Control System including all equipment devices and wiring in accordance with all requirements and procedures identified in NFPA 72, Chapter 14-2013 or as modified by the current applicable edition of NFPA 72.

B. Provide service of a factory-authorized service representative to supervise the field assembly and connection of components and the pre-testing, testing and adjustment of the system.

C. Upon completing installation of the system, align, adjust, and balance the system and perform complete pre-testing. Determine, through pre-testing, the conformance of the system to the requirements. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

D. Provide a letter, after pre-testing is complete, certifying the installation is complete and fully operable. The letter shall include the names of the witnesses to the preliminary tests.

E. Provide ten Calendar Days minimum notice in writing when the system is ready for final acceptance testing.

F. Test the system according to the procedures outlined in NFPA 72. Minimum required tests are as follows:

   i. Verify the absence of unwanted voltages between circuit conductors and ground.
   ii. Megger test all conductors other than those intentionally and permanently grounded with electronic components disconnected. Test for resistance to ground. Report readings less than 1 megohm for evaluation.
   iii. Test all conductors for short circuits utilizing an insulation-testing device.
   iv. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on the record drawings.
   v. Verify the control unit is in the normal condition as detailed in the manufacturers operating and maintenance manuals.
   vi. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
vii. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.

viii. Test the system for all specified functions according to the manufacturer’s operating and maintenance manual. Systematically initiate specified functional performance items at each station including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.

ix. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the period and in the manner specified.

x. Test operation of the tunnel deluge valve controls.

G. Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the specifications and complies with applicable standards.

H. Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests. Submit NFPA 72 Record of Completion at Project completion to the Department.

I. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

Acceptance will be withheld until the following activities have been successfully completed:

i. Delivery and acceptance of all submittals.

ii. System testing.

iii. System demonstration, including operation of systems using manuals.

iv. The Department training.

v. Delivery and acceptance of final documentation.

28.3.6. Maintenance

A. Design-Builder shall provide maintenance of fire alarm systems and equipment for a period of 12 months, using factory-authorized service representatives.

28.3.7. Training

A. Design-Builder shall provide the services of a factory-authorized service representative to demonstrate the system and train the owners maintenance personnel. Provide minimum of 16 hours of training and provide DVD of training session.
Deliverables

At a minimum, the deliverables shall include the items listed in Table 28.4-1 for the Department’s consultation and written comment.

Table 28.4-1 Deliverables

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
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<tr>
<td></td>
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<td>Electronic</td>
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<td>Fire Alarm, Detection, and Control System Plan</td>
<td>5</td>
<td>1</td>
<td>60 days after NTP</td>
</tr>
<tr>
<td>Mass Notification System</td>
<td>5</td>
<td>1</td>
<td>60 days after NTP</td>
</tr>
<tr>
<td>Install Fire Alarm, Detection and Control System</td>
<td>5</td>
<td>1</td>
<td>15 days before start of investigation work</td>
</tr>
<tr>
<td>Testing of Fire Alarm, Detection and Control System</td>
<td>5</td>
<td>1 and 5 CDs</td>
<td>60 days after completion of investigation, including testing</td>
</tr>
</tbody>
</table>
SECTION 29. SCADA SYSTEM

29.1. Scope

A. The scope of this section is to provide a new Supervisory Control and Data Acquisition (SCADA) system that will provide monitoring and control capabilities of electrical and mechanical systems for the existing and new tunnel facility. The new SCADA systems shall consist of new hardware/software and integrate with the Department’s other existing systems. The new SCADA systems shall consist of the following major components:

1. Existing Programmable Logic Controllers (PLC) and Substation Automation System (SAS) for the existing tunnel facility
2. New PLC’s and SAS for the new tunnel facility
3. New Computer and Server Hardware
4. Expansion of the existing ventilation and power fiber architecture to include the new tunnel facility.
5. New SCADA Human Machine Interface (HMI) to manage the electrical and mechanical systems of the existing and new tunnel facility.

29.2. References

A. VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT, Project Development Manual
   2. TBD
B. Virginia Uniform Statewide Building Code (USBC)
C. National Fire Protection Act (NFPA) Standards and Guidelines including:
   1. NFPA 70 – National Electric Code (NEC)
   2. NFPA 502, Standard for Road Tunnels, Bridge and Other Limited Access Highways
   4. NFPA 1221 – Standards for the Installation, Maintenance and Use of Emergency Services Communications Systems
D. ANSI/TIA/EIA 607 – Grounding and Bonding Requirements for Telecommunications in Commercial Buildings;
E. ANSI/TIA/EIA 569 – Commercial Building Standards for Telecommunication Pathways and Spaces;
F. ANSI/TIA/EIA 568 – Commercial Building Standard Telecommunication and Cabling Standard;
G. ANSI/TIA/EIA 758 – Customer Owned Outside Plant Telecommunications Cabling Standard;
H. IEC 61131 – Standard for Programmable Controllers; and
I. ISA/IEC 62443 – Standards on the Cyber Security of Industrial Controls
J. ANSI/TIA/EIA 455 – Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components;
K. ANSI/TIA/EIA 604 – Optical Fiber Cabling Color Coding;
L. NEMA IA 2.1-8 – Programmable Controllers;
M. NEMA ICS 5 – Control Circuits and Pilot Devices;
N. NEMA ICS 6 – Industrial Control and System Enclosures;
O. TSB 140 – Additional Guidelines for Field Test Length, Loss and Polarity of Optical Fiber;
29.3. **Requirements**

29.3.1. **General**

This section provides the requirements for the SCADA system for the various Tunnel electrical, mechanical and security systems. Primary and Secondary Control Rooms and Server Rooms.

29.3.2. **Primary and Secondary Control Rooms and Server Rooms**

The physical requirements for the Primary and Secondary Control Room and Server Rooms are specified in Section 35, Buildings. These rooms shall be sufficiently sized to support and contain the equipment prescribed herein.

29.3.3. **SCADA System Hardware and Software**

A. The new SCADA system will provide monitoring and control capabilities of the existing tunnel facility and the new tunnel facility. This system shall be a combination of existing and new control hardware. The following major components will be integrated to form a new HRBT SCADA system:

1. Existing Ventilation Control Hardware: NWVB, NEVB, SEVB and SWVB Building programmable logic controllers (PLC) and Master PLC
2. Existing Substation Automation Hardware: Existing Siemens SICAM units
3. Existing Generator Controller
4. Existing Drain Pump Controller
5. New Ventilation Control Hardware
6. New Substation Automation Hardware
7. New Generator & Drain Pump Controller.
8. New SCADA HMI Interface: The existing SCADA HM Interface will be replaced with a new SCADA HMI that will manage existing and new facility.

B. The new SCADA system shall be able to control and monitor the following major systems of the new tunnel:

1. Power
   a. Medium Voltage Gear
   b. Shore Gear
   c. Low Voltage Gear
   d. Motor Control Centers
   e. Generators
   f. Uninterruptible power supplies
   g. Automatic Transfer Switches
2. Ventilation
   a. Tunnel Support Building Fans & Dampers
b. Ventilation Instrumentation (Sensors, limit switches etc.)

3. Pump
   a. Drain Pumps
   b. Fire Pumps
   c. Pump Instrumentation (level sensors, etc.)

4. Fire System (Monitor Only)

C. The following existing SCADA hardware equipment located in the existing facility is to be upgraded to match the new SCADA hardware:

1. NEVB Building SCADA Workstation
2. SEVB Building SCADA Workstation
3. SWVB Building SCADA Workstation
4. NWVB Building SCADA Workstation
5. Control Room Workstations
6. SCADA Servers

D. The new SCADA hardware shall consist of the following:

1. Hot Standby PLC - The Hot Standby PLC system shall consist of two (2) PLCs, PLC 0 (Primary) and PLC 1 (Backup), as well as power supplies, communication cards and other components for a fully operational system. Each Hot Standby PLC shall also be capable of exchanging information with the existing facility wide SCADA System. In the event of a failure in the primary (PLC 0), there shall be a seamless transfer of control and monitoring capabilities to the backup (PLC 1). The Hot Standby PLC system shall be used as a data concentrator, collecting information from all associated devices and receiving commands from the new SCADA HMI.

2. Remote IO racks – All field devices shall be connected to a remote IO rack. Rack location shall be near the device locations.

3. Remote IO racks shall have the necessary communication modules and power supplies to provide the operator with the full functionality of the tunnel systems.

4. The SCADA PLC software shall be a commercial off-the-shelf (COTS) package. This program creation and editing software shall allow the functional program to be edited both "online" and "offline."

5. Provide new separate and independent SCADA operating HMI software for the entire new and existing HRBT facility. Replace each of the existing SCADA operating HMI software with new SCADA HMI software. The new SCADA HMI software shall be fully tested and debugged to HRBT’s satisfaction prior to the replacement of each of the existing SCADA HMI software. The Design-Builder shall perform screen design workshops with the owner during the development of the SCADA HMI. These workshops shall focus on screen layout and functions. The replacement of each of the existing SCADA HMI software with the new SCADA HMI software shall be coordinated with HRBT and so scheduled to provide a seamless transition between the new and existing operating SCADA HMI software, and to minimize the disruption of HRBT operations.
29.3.4. Workstation Computer & Server Hardware

A. All existing SCADA servers and workstations will be replaced with new SCADA servers and workstations. The new SCADA servers and workstations will allow the operators to manage the existing and new tunnels systems associated with the SCADA system.

B. The SCADA servers shall be redundant servers. The redundant servers will consist of a Primary and Backup server. In the event of a failure of the primary server transition to the backup server will be seamless without any disruption to the operations. The SCADA Servers shall meet at a minimum the following requirements:

1. Latest Windows OS compatible with the SCADA HMI Software.
2. Quad core processors
3. 16GB or more of RAM.
4. 100MB/1GB Ethernet is required for networking.
5. RAID drives – Shall be Fast Solid-State Drives (SSD).
6. Furnish all necessary communication cards in the server required for connection to the network and any other devices to be connected to the SCADA HMI.
7. Sound card and speakers required for local alarm annunciation.
8. Rack Mounted

C. Dedicated server will be provided for each of the following:

1. Alarming
2. Reporting
3. Domain Management
4. Virtual Machine Server
5. The above servers will at a minimum meet the requirements of the SCADA server.

D. The SCADA client:

1. Latest Windows OS compatible with the SCADA HMI Software.
2. Quad core processors
3. 16GB or more of RAM.
4. 100MB/1GB Ethernet is required for networking.
5. Furnish all necessary communication cards in the server required for connection to the network and any other devices to be connected to the SCADA HMI.
6. Sound card and speakers required for local alarm annunciation.
7. All external ports (e.g., Network, USB, HDMI) not used shall be secured or disabled.

29.3.5. FHWA Rule 940 Compliance

A. The Design-Builder shall follow the System Engineering Process as defined by Federal Highway Administration (FHWA) 23CFR, Part 940, commonly referred to as Rule 940. The Design-Builder shall go through and comply with the entire process including, but not limited to:

1. Providing all documentation, such as an updated regional architecture, Concept of Operations, Requirements Documents, etc., required under Rule 940;
2. Developing Test plans and procedures; and
3. Verifying all Test plans and procedures.

B. System Architecture
1. The following systems all interact together to control and monitor tunnel traffic and incidents and must be included with and part of the Intelligent Transportation System documentation requirements of Rule 940:
   a. SCADA System Electrical Power Control Systems (EPCS) and Intrusion Detection System (IDS);
   b. Ventilation;
   c. Pumping;
   d. Electrical;
   e. Lighting;
   f. Fire Protection;
   g. Fire Alarm, Detection and Control System;
   h. Communication Systems;
   i. Traffic Signals;
   j. Security
   k. CCTV systems;
   l. Message and Traffic Control Signs;
   m. Gates; and
   n. Air Quality.

2. The Design-Builder shall coordinate with the Department to review and verify the existing regional architecture, including all components in the existing HRBT and supply documentation to the Department summarizing the review. The Design-Builder shall update the existing regional architecture to include any additional components required to meet Rule 940. After which, the Design-Builder shall include all new market packages, equipment, systems, functionality and data flows in the updated regional architecture and demonstrate the proposed systems interface and functionality with all the new and existing systems required in the HRBT to satisfy Rule 940. The Design-Builder shall use the latest version of “Turbo Architecture” to update the regional architecture.

C. Concept of Operation

1. Provide a detailed Concept of Operations document that complies with requirements of Rule 940, and IEEE 1362 or the current Standard that replaces IEEE 1362. The Concept of Operations shall describe in general all systems components associated with the new tunnel and how those systems shall interface and function with all the Department existing systems and components.

2. The Concept of Operations document shall be submitted to the Department and accepted by the Department prior to submitting for Department review and acceptance of any related Released for Construction documents.

D. System Engineering Analysis

1. Provide a detailed System Engineering Analysis document that complies with requirements of Rule 940 and describe in detail with specific information all systems and components
associated with the new tunnel and how those systems shall interface and function with all the Department existing systems and components.

2. The System Engineering Analysis document shall be submitted to the Department and accepted by the Department prior to submitting for Department review and acceptance of any related Released for Construction documents.

E. System and Component Traceability Matrix

1. Provide a detailed System and Component Traceability Matrix document that complies with requirements of Rule 940. The Traceability Matrix shall identify all the systems and components associated with the new tunnel, how those systems and components operation and function shall be tested, and how the tests results are documented.

2. The Traceability Matrix document shall be submitted to and accepted by the Department prior to the testing and/or commissioning of system and component covered under or with the Traceability Matrix.

29.3.6. Graphics

A. Furnish and install a complete software package to provide detailed, full-color animated displays of the RCU status and operating conditions for the workstations.

B. Develop and implement the graphic views as applicable. Each view shall show current, real-time conditions of the system. The SCADA System HMI/GUI graphic screens shall include the following, as a minimum:

1. Tunnel and Facilities menu screens with system login passwords for the various Operators access levels system;
2. Tunnel and Facilities Graphic Overview screens;
3. Tunnel Jet Fan screens with individual Operator and automatic control Modes of Operation;
4. Tunnel Egress Passage screens with individual Operator and automatic control Modes of Operation;
5. Tunnel Lighting screens with individual Operator and automatic control Modes of Operation;
6. Pump Station screens with individual Operator and automatic control Modes of Operation;
7. Intrusion Detection and Access Control screens with individual Operator and automatic control Modes of Operation;
8. Diesel Engine/Generator(s) screens with individual Operator and automatic control Modes of Operation as defined in the Tunnel SCADA “SC” drawings, the Tunnel Electrical Service “EP” drawings and elsewhere in the Specifications;
9. Tunnel Air Quality Monitoring screens;
10. Fire Protection and Fire Pump screens with individual Operator and automatic control Modes of Operation;
11. Fire Alarm, Detection, and Control screens with individual Operator and automatic control Modes of Operation;
12. Tunnel and Facilities Electrical Distribution screens with individual Operator and automatic control Modes of Operation;
13. Tunnel Motorist Aid Call-box screens;
14. Tunnel Fire Zone screens;
15. UPS System(s) screens;
16. Tunnel and Facilities SCADA System screens;
17. Building HVAC screens with individual Operator and automatic control Modes of Operation;
18. Alarm with acknowledgement screens with individual Operator and automatic control Modes of Operation; and
C. Coordinate with the Department for the specific criteria for each screen to be created.
D. Coordinate with the Department on the look, configuration and Operator interaction requirements of all graphic screens for all workstations.

29.3.7. Network
A. The existing SCADA network comprises of two independent networks; the power network and the ventilation network. The ventilation network is a dual redundant ring fiber optic network. The power network is a single ring fiber optic network.
B. Expand existing power and ventilation ring network to integrate all power and ventilation fire and life safety systems for the new tunnel.
C. All network switches in the existing power and ventilation network will be upgraded to be identical to those network switches to be installed to incorporate the new tunnel facility.
D. The new network switches shall meet the following requirements:
   1. All switches shall be managed network switches.
   2. Provide 1000Mbit/s Ethernet communication between the servers, workstations, touch panels and PLCs in a self-healing ring configuration.
   3. Provide a dual redundant ring configuration. There shall be four (4) (two sets of transmit and receive) single mode fiber-optic cable ports to support Ethernet at 1000 Mbit/s up to 10km. Fiber shall use SC connectors.
   4. Provide twenty-four (24) IE FC RJ45 ports to support Ethernet at 100 Mbit/s over IE FC TP Standard cable. Provide additional POE ports as needed to integrate POE devices.
   5. Switches shall be 19" rack mounted and have an Operating temperature: -4 °F (-20 °C) to 158 °F (70 °C).
E. The power network and switches shall meet criteria defined in NERC CIP -007. Any exceptions will require approval by the authority.
F. All network ports on the new network switches shall support port lock utility. The utility shall scan all network ports to identify attached devices and enable selection of specific devices to communicate on each port as an authorized device. It shall prevent unselected or unauthorized devices from communicating through the network ports.
G. All existing systems will be kept operational during the expansion of power and ventilation network. The operators shall be able to perform their tasks through existing SCADA system.
H. All new fiber optic cable to be furnished and installed shall be single mode. All necessary connectors shall be provided and terminated on new and existing fiber optic cable to be connected to the new network switches. All new and existing fiber optic cable shall be tested with an optical power meter. The optical power meter results shall be in accordance to the following; 0.5 dB loss per km for 1310 nm sources, 0.4 dB loss per km for 1550 nm. 0.3 dB for each splice loss.

29.3.8. Mechanical and Electrical Control Monitoring
A. Provide all 13.2kV fused switches and circuit breakers with:
   1. Provisions for remote Open/Close control and status;
2. Provision for remote monitoring of each phase current, each phase line-to-line voltage, kW, kVA, and Power Factor (PF);
3. All remote features shall be monitored and controlled through the SCADA System; and
4. All 13.2kV Switchgear shall communicate with the SCADA System through a network connection utilizing Controlnet, Modbus, Profibus, PROFINET, EtherNET/IP or Ethernet protocols.

B. Provide all 480V Switchgear main power circuit breakers and tie power circuit breakers with:
   1. Provisions for remote Open/Close control and status;
   2. Provision for remote monitoring of each phase current, each phase line-to-line voltage, kW, kVA, and PF;
   3. All remote features shall be monitored and controlled through the SCADA System; and
   4. All 480V Switchgear shall communicate with the SCADA System through a network connection utilizing Controlnet, Modbus, Profibus, PROFINET, EtherNET/IP or Ethernet protocols.

C. Provide all 13.2kV to 480V transformer auto voltage regulators with remote monitoring of the automatic voltage regulator operation. The remote monitoring of each transformer automatic voltage regulator operation shall be monitored by the SCADA System.

D. Provide all engine generators with auxiliary input and output contacts for connection to the SCADA System to allow the SCADA System to Start/Stop the engine generator and to monitor all the NFPA 110 required engine generator status points.

E. Provide all Automatic Transfer Switches with auxiliary output contacts connected to the SCADA System to allow the SCADA System to monitor Transfer Switch Normal/Emergency sources available, Transfer Switch Load connected to Normal/Emergency.

F. Provide all UPSs with:
   1. Auxiliary outputs to allow all UPS standard output data to be remotely monitored by the SCADA System; and
   2. All UPSs shall communicate with the SCADA System through a network connection utilizing Controlnet, Modbus, Profibus, PROFINET, EtherNET/IP or Ethernet protocols.

G. Provide all Motor Control Centers with:
   1. Auxiliary inputs and outputs to allow all MCC starters to be monitored and controlled by the SCADA System; and
   2. All MCC starters shall communicate with the SCADA System through a network connection utilizing Controlnet, Modbus, Profibus, PROFINET, EtherNET/IP or Ethernet protocols.

H. Provide all Jet Fans with:
   1. Forward and reverse operation monitoring and control for all inputs and outputs;
   2. Fan inboard and outboard vibration indication as analog inputs direct from sensor furnished with fan, and fan shutdown through SCADA;
   3. Fan winding temperature status for each phase as analog temperature inputs direct from sensor furnished with fan, and fan shutdown through SCADA;
   4. Fan inboard and outboard bearing temperature status as analog temperature inputs direct from sensor furnished with fan, and fan shutdown through SCADA;
   5. Fan running status based on fan motor full load current draw under normal operation as analog inputs obtained from current sensors installed in fan MCC starter;
   6. Fan control selection in local or remote-control status indication, and fan H-O-A in hand, off or auto position status indication;
7. Fan start-stop control local at MCC and remote through SCADA;
8. Fan safety shutdown control automatic override during Tunnel fire;
9. Fan runtime;
10. Fan starter fault/failure status; and
11. Fan speed control local at MCC and remote through SCADA.

I. Provide all Pumps with:
1. Pump moisture status direct from sensor furnished with pump;
2. Pump thermal overload status direct from sensor furnished with pump;
3. Pump running status based on pump motor full load current draw under normal operation obtained from current sensors installed in pump MCC starter;
4. Pump control selection in local or remote-control status indication, and pump H-O-A in hand, off or auto position status indication;
5. Pump start-stop control local at MCC and remote through SCADA;
6. Pump sump liquid level as an analog;
7. Pump sump multiple level sensor for pump on-off control;
8. Pump sump level sensor for sump high level alarm;
9. Pump runtime;
10. Pump starter fault/failure status; and
11. Pump sump hydrocarbon detection for gasoline, methane, and diesel alarm.

J. Provide Tunnel Roadway Lighting Control

K. Provide Tunnel Air Quality Monitoring and Control
1. Monitor all outputs for all Tunnel sensors and controllers associated with the Tunnel Air Quality monitoring and control as described in Section 26 Mechanical Systems.
2. Provide automatic and remote manual control of all Tunnel Ventilation equipment to maintain Tunnel Air Quality as described in Section 26 Mechanical Systems.

L. The SCADA System shall include and provide all monitoring and control functions required under Technical Requirements Section 26 Mechanical Systems and Section 27 Electric Power and Distribution that has not been specifically identified in Items A through K above.

29.3.9. Intrusion Detection and Card Access

The Design-Builder shall coordinate with the Department for procurement and installation of all access control hardware and software and provide intrusion detection and card access in accordance with the Appendix A29-1 requirements for the following locations:

A. All exterior doors to the new Traffic Operations Center Building, Tunnel Support Buildings, Server Room, Control Room and Duct Doors, shall be provided with waterproof, corrosion resistant, industrial grade magnetic switches to monitor door open/closed status.

B. All Roadway Tunnel, Tunnel Egress Corridor, and Tunnel Egress Stair doors shall be provided with waterproof, corrosion resistant, industrial grade magnetic switches to monitor door open/closed status.

C. All equipment cabinet doors located within the Roadway Tunnel, Egress Corridor, Egress Stair, Tunnel Plenum, and outdoors shall be provided with waterproof, corrosion resistant, industrial grade magnetic switches to monitor door open/closed status. This includes, but not limited to, all fire protection deluge cabinets, fire hose cabinet, motorist aid call box, Program Logic Controller cabinet, Remote Input/Output cabinet, Fire Alarm Control Panel, Panelboard, and Junction Box cabinet doors.
D. All North and South Island access road security gates. Each gate shall be provided with
waterproof, corrosion resistant, industrial grade switches and controls and CCTV security camera.

29.3.10. Fiber Optic Cable

29.3.11. Installation

A. Install SCADA in accordance with VDOT Standards, NFPA 70, and NFPA 502.
B. All associated wiring, cables and/or conductors serving the Tunnel and Tunnel Egress Corridor
and Stairs shall be considered “Emergency Circuits with respect to NFPA 502” and MUST
comply with the requirements of NFPA 502-2014, Chapter 12, Sections 12.1.2 and 12.2.1.3 or as
modified by the current applicable edition of NFPA 502.

29.3.12. Testing

A. Provide detailed test plans for all testing. The test plans must test the entire SCADA Systems,
including all equipment devices, software and wiring.
B. Provide detailed test plan for testing each of the new SCADA operating HMI software.
C. Provide a detailed procedure and test plan for implementing the replacement of each of the
existing SCADA operating HMI software.
D. The Design-Builder shall perform screen design workshops with the owner during the
development of the SCADA HMI. These workshops shall focus on screen layout and functions.
SCADA HMI screen layouts and functions must be approved by the Department during the
workshops.
E. Submit Detailed Procedures for all inspections and tests to be performed.
F. Testing and Inspection for all components (equipment and cables) of the SCADA and ITS system
shall progress through four stages of testing as described below:

1. Factory Acceptance Test (FAT): The first test shall be the Factory Acceptance Test. As part
of their submittals, the Design-Builder shall develop a plan which assembles, configures and
connects all equipment in a manner which simulates the complete Project. The Design-
Builder shall then perform extensive testing to demonstrate that the hardware and system
work as intended. The factory test shall have an un-witnessed phase, where the Design-
Builder shall perform the tests themselves and submit signed test forms documenting the
results. After certifying that the test has passed, a witnessed test shall be scheduled with the
Department. The FAT must take place within the continental United States.

2. Local Equipment Test: Once the equipment has been fully exercised as part of the FAT and
installed according to the Contract Documents, the Design-Builder shall perform a local site
test. This test shall verify that the equipment has not been damaged in shipment and has been
installed properly. To the extent possible, the equipment shall be exercised locally to
demonstrate full functionality. This test shall be witnessed by the Department.

3. Remote Equipment Test: After passing the Local Equipment Test, the Design-Builder shall
demonstrate that the equipment can function as a part of a complete system. From a
designated control point, the Design-Builder shall exercise the remote equipment and
demonstrate full functionality. This test shall be witnessed by the Department.
4. Final System Acceptance Test: The final test of the system shall be a Final System Acceptance Test. This test shall be an endurance test, requiring flawless operation for the designated time period as described below.

G. Factory Tests can utilize Manufacturers’ Standard Factory Tests or be developed by the Design-Builder and submitted to the Department for acceptance.

H. Local Equipment Tests and Remote Equipment Tests shall be developed by the Design-Builder and submitted to the Department for acceptance.

I. Final System Acceptance Test shall follow all Inspection and Tests listed in ANSI/NETA ATS (current edition) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, Section 8 System Function Tests, and shall be developed by the Design-Builder and submitted for Department acceptance to demonstrate that all equipment and systems operate as specified.

J. Submit Detailed Certified Inspection and Test Reports for all inspections and tests performed.

K. The Testing and Inspection organization performing the Local Equipment Tests shall be independent from the installer and shall be a NETA accredited company.

L. Testing and Inspection personnel for all Tests shall be Technicians certified in accordance with ANSI/NETA ETT, Standard for Certification of Electrical Testing Technicians.

M. Testing instruments used for all Tests shall be calibrated and certified within one (1) year of the date used for the specific test performed.

N. All Software Testing shall be performed by personnel trained and certified by the Software Vendor.

29.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 29.4-1 for the Department’s consultation and written comment.
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SECTION 30. COMMUNICATIONS SYSTEMS

30.1. Scope

A. Provide Communication Systems consisting of Department UHF/VHF 2 Way Radio Systems, AM/FM Rebroadcast System, Telephone System, Mass Notification System (MNS), and Motorist Aid Call Box System as described in this Section and as required by all applicable Codes and Standards.

B. The 2-Way Radio Enhancement Communication System for Emergency Responders for the new Tunnel and associated new Tunnel Support Buildings will be the Virginia State Police System known as STARS. The STARS for the new Tunnel and associated new Tunnel Support Buildings will be furnished and installed by the Virginia State Police.

30.2. References

A. VDOT Design Manuals Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT Instructional and Informational Memoranda (IIM) Requirements;
   2. VDOT Construction Instructional and Informational Memoranda;
   3. VDOT Traffic Engineering Division Instructional and Informational Memoranda;
   4. VDOT Structure and Bridge Division Instructional and Informational Memoranda;

B. National Fire Protection Act (NFPA) Standards and Guidelines including:
   1. NFPA 70 – National Electric Code;
   2. NFPA 502, Standard for Road Tunnels, Bridge and Other Limited Access Highways; and
   4. NFPA 1221 – Standards for the Installation, Maintenance and Use of Emergency Services Communications Systems

C. Virginia State Police Statewide Agencies Radio System (STARS)

D. ANSI/TIA/EIA 607 – Grounding and Bonding Requirements for Telecommunications in Commercial Buildings

E. ANSI/TIA/EIA 569 – Commercial Building Standards for Telecommunication Pathways and Spaces

F. ANSI/TIA/EIA 568 – Commercial Building Standard Telecommunication and Cabling Standard

G. ANSI/TIA/EIA 758 – Customer Owned Outside Plant Telecommunications Cabling Standard

H. IEC 61131 – Standard for Programmable Controllers

I. ISA/IEC 62443 – Standards on the Cyber Security of Industrial Controls

J. ANSI/TIA/EIA 455 – Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components

K. ANSI/TIA/EIA 604 – Optical Fiber Cabling Color Coding
L. NEMA IA 2.1-8 – Programmable Controllers
M. NEMA ICS 5 – Control Circuits and Pilot Devices
N. NEMA ICS 6 – Industrial Control and System Enclosures;
O. TSB 140 – Additional Guidelines for Field Test Length, Loss and Polarity of Optical Fiber
Q. FHWA National Tunnel Inspection Standards (NTIS)

30.3. Requirements

30.3.1. Design Requirements – Communication Systems by Location

A. Tunnel Roadway
   1. Provide transmitter antenna, all equipment, cable, and hardware to allow Department UHF/VHF 2 Way Radio System to provide 100% coverage.
   2. STARS furnished and installed by Virginia State Police.
   3. Provide all equipment, cable, and hardware for Motorist Aid Call Boxes.
   4. Provide Mass Notification System. Provide all equipment as part of the appropriate Fire Alarm Control Panels (FACPs).

B. Tunnel Egress Corridor, Egress Stairs and Utility Stairs
   1. Provide transmitter antenna, all equipment, cable, and hardware to allow Department UHF/VHF 2 Way Radio System to provide 100% coverage.
   2. STARS furnished and installed by Virginia State Police.
   3. Provide all equipment, cable, and hardware for Motorist Aid Call Boxes/Emergency Phones.

C. Substation Switchgear Enclosure
   1. Provide Telephone inside Switchgear enclosure center corridor connected to the existing Department Telephone System.

D. Island Tunnel Support Buildings Interior
   1. Provide Telephones connected to the existing Department Telephone System.
   2. Provide transmitter antenna, and all front end transmitting equipment, and hardware to allow Department UHF/VHF 2 Way Radio System to provide 100% coverage.
   3. STARS furnished and installed by Virginia State Police.
   4. Provide PBX and all front-end equipment for Motorist Aid Call Boxes.
   5. Provide all equipment as part the appropriate FACPs for Mass Notification System.

E. The Primary and Backup Control Rooms
   1. Provide two (2) dedicated Telephone lines and handset equipment to allow Operator to notify Fire Department.
   2. Provide desk station to allow Operator to communicate and interact with all Motorist Aid Call Boxes.
3. Provide desk station to allow Operator to activate and communicate over the Mass Notification System through the Main Fire Alarm Command Center (MFACC) and Secondary Fire Alarm Command Center (SFACC).

30.3.2. Design Requirements – Communication Systems Components

A. Mass Notification System

1. Provide a Mass Notification System throughout the Tunnel that will be operated from both the Primary Control Room and the Secondary Control Room.

2. The Mass Notification System MUST comply with the requirements of NFPA 72-2013, Chapter 24, Section 24.4.3 and 24.4.4 or as modified by the current applicable edition of NFPA 72.

3. Provide all Mass Notification System primary front-end equipment in the Primary Control Room. Provide complete redundant Mass Notification front end equipment in the Secondary Control Room.

4. The Mass Notification System shall only provide one-way voice communication messages, which are spoken by the operator through a microphone or are manually activated pre-recorded messages from either the Primary or Secondary Control Rooms. Both Control Rooms shall have system control capability.

5. The Mass Notification System shall accommodate both Operator voice message and pre-recorded messages that are selected by the Operator.

6. In addition to NFPA 72 requirements the Mass Notification System wiring, cables and/or conductors serving the Tunnel and Tunnel Egress Pathway Corridor loudspeakers shall be considered “Emergency Circuits with respect to NFPA 502” and MUST comply with the requirements of NFPA 502-2017, Chapter 12. The Mass Notification System shall be designated an Emergency Communication and Signaling System per NEC 708.14.

7. The Mass Notification System equipment, loudspeakers and loudspeaker circuiting MUST be monitored and supervised by the Tunnel Fire Alarm System and monitored by the SCADA System.

8. All the Mass Notification System loudspeakers MUST be alternately wired on separate circuiting and amplifier equipment so any equipment or wiring malfunction does not impact adjacent loudspeaker operation.

9. Provide and locate an audio detector within the Tunnel Roadway for each speaker to automatically adjust the output volume individually of the loudspeaker associated with each audio detector to at least 15 dB above the Tunnel ambient noise level at that speaker location associated with the audio detector sensing the high ambient noise level.

10. Provide detailed computer software generated models and calculations with the design document submissions to validate all speaker selections, speaker locations, audio detector locations, amplifiers capacities and speaker dB settings. Submit software type to be used for calculations for approval prior to starting any modeling and calculations.

11. All loudspeakers shall be waterproof and corrosive resistant to a saltwater environment.

B. Telephone System

1. Provide a wall telephone in every room within the new Tunnel Support Buildings connected to the existing Department telephone system. Coordinate hardware requirements, connection points and telephone system interface requirements with the Department.
C. Motorist Aid Call Box System

1. Provide a Motorist Aid Call System using call boxes located within the Tunnel and Tunnel Egress Corridor.

2. The Motorist Aid Call Boxes (call box) shall include a handset and hand set receiver cradle behind a weatherproof latched hinged door. The entire call box and door assembly shall be a NEMA 4X enclosure constructed of Type 316 Stainless Steel.

3. When any call box hand set is removed from the handset receiver cradle a call with a unique station call number shall be automatically initiated to the Primary and Secondary Control Room workstation telephone console. When the hand set is returned to the receiver cradle the call shall automatically be ended. When successive call box calls are received by the Tunnel Operator either another Operator can receive the call, or one Operator can answer the call and advise the person on the other end that the call is being placed on hold.

4. The Tunnel Motorist Aid Call Box System shall automatically record all call box calls with a time and date stamp.

5. The Tunnel Motorist Aid Call Box System shall be provided with monitoring/diagnostic hardware and software that will automatically poll each call box to verify the call box is in service, functioning and report a call box malfunction to the system front end equipment. The Tunnel Motorist Aid Call Box System equipment availability to operate and/or equipment malfunctions shall be monitored by the SCADA System.

6. The Tunnel Operator from either the Primary or Secondary Control Room workstation telephone console shall be able to receive or initiate a call from or to any Motorist Aid Call Box.

7. The Motorist Aid Call Box System shall expand the existing Department PABX. The final capacity of the PABX shall be at least 10% greater than the total number of combined existing and new Motorist Aid Call Boxes. The dedicated PABX shall be monitored for Alarm and Trouble conditions through the SCADA System.

8. The call box hinged door shall be provided with an internal magnetic door switch that automatically activates an Alarm signal to both the Primary and Secondary Control Rooms through the SCADA System indicating the unique call box door has been opened. The Alarm Signal shall require the SCADA Operator to acknowledge the alarm. Activation of the magnetic switch on the call box door “door open alarm” shall automatically adjust the closest Camera to view the specific device that initiated the Door Open Alarm Signal and display the camera video image on both Primary and Secondary Control Room video monitors.

9. All Tunnel and Tunnel Egress Corridor Motorist Aid Call Boxes shall use analog phones with digital converters, compatible with the existing PABX, located in the existing ventilation buildings. The call boxes shall be manufactured by a vendor such as Talkaphone or equivalent, subject to Department approval.

10. All wiring, cables and/or conductors serving the Tunnel and Tunnel Egress Corridor call boxes shall be considered “Emergency Circuits with respect to NFPA 502” and MUST comply with the requirements of NFPA 502-2017, Chapter 12.

11. All call box system wiring, cables and/or conductors must be installed in a raceway system complying with the Raceway Requirements identified under Section Raceway.
12. Locate all Tunnel call boxes at both ends of the Tunnel, adjacent to each Tunnel Fire Hose Cabinet, adjacent to each Tunnel Egress Door (Tunnel side), and adjacent to each Tunnel Egress Stair Door (Tunnel side). Adjacent shall mean not more than 5-ft away.

13. Locate all Tunnel Egress Corridor call boxes adjacent to each Tunnel Egress Pathway Corridor Door (Pathway side), not more than 300 feet apart for the entire length of Tunnel Egress Pathway Corridor and inside at the top and bottom of all egress stairways.

14. All Tunnel and Tunnel Egress Corridor call boxes shall be alternately wired to separate front end equipment such that loss of the equipment or call box wiring will not cause all call boxes to be inoperative.

15. Provide two (2) fifty (50) line pushbutton telephone desk sets on the workstation in both the Primary and Secondary Control Rooms for Tunnel Operator use to communicate with the Motorist Aid Call Boxes.

16. Mount top of call box 48 inches above top of user floor elevation where the call box is located.

17. Provide a wall mounted self-illuminating reflective sign above each Motorist Aid Call Boxes at all locations.

18. All Motorist Aid Call Box wiring, cables and/or conductors serving the Tunnel shall be considered “Emergency Circuits with respect to NFPA 502” and MUST comply with the requirements of NFPA 502-2017, Chapter 12.

D. Virginia State Police STARS

1. The Design-Builder shall coordinate the Project Design and Construction with Virginia State Police to accommodate all Virginia State Police requirements.

2. The Design-Builder shall provide space within and on the new Tunnel Support Buildings on the islands to accommodate STARS equipment and antennas in accordance with Virginia State Police requirements.

3. The Design-Builder shall provide the size and quantity of empty conduits with pull strings to accommodate the STARS at the locations designated by the Virginia State Police between:
   a. The new Tunnel Support and existing Ventilation Buildings on the islands. At a minimum provide one (1) 4-inch empty conduit between each new Tunnel Support Building and the existing Ventilation Buildings on both islands
   b. The new Tunnel Support Building Roof and the building interior. At a minimum provide one (1) 2-inch diameter empty conduit
   c. The new Tunnel Support Buildings and the Tunnel Egress Corridor. At a minimum provide two (2) 2-inch diameter empty conduits between each new Tunnel Support Buildings on both islands and the Tunnel Egress Corridor
   d. The Tunnel Egress Corridor and the Tunnel. At a minimum provide two (2) 2-inch empty conduits in the Tunnel Egress Corridor from the south island to the north island with access pull boxes at four locations (both ends and at the 1/3 and 2/3 distance locations). At each of the four pull box access points provide two (2) 2-inch diameter empty conduits to the Tunnel

4. The Design-Builder shall provide the infrastructure throughout the Roadway Tunnel and Tunnel Egress Corridor to accommodate the STARS equipment and antenna supports at the locations designated by the Virginia State Police.
5. All conduit infrastructures provided to accommodate STARS shall utilize conduit bends with a minimum conduit radius of 24-inches and not more than a total of 270 degrees of conduit bends between pull boxes and/or pull points.

6. The Design-Builder shall provide electric power to all STARS equipment in accordance with Virginia State Police requirements.
   a. To accommodate the electric power requirements for the STARS equipment the Design-Builder may be required to provide a dedicated UPS and batteries that only serve the STARS equipment. UPS capacity and battery would be in accordance with Virginia State Police requirements.
   b. If Virginia State Police does not require a dedicated UPS and batteries to power the STARS equipment the Design-Builder shall power the STARS equipment from a dedicated panelboard that is fed from the Lighting UPSs that are designated as Stored Emergency Power Supply System (SEPSS) and that are also connected to the Emergency Power Supply System (EPSS). The Lighting UPSs total capacities must be increased to include the addition of the STARS equipment.
   c. At a minimum provide two (2) 20 ampere, 120-volt power feed circuits, each circuit having a connected load of 16 amperes to power STARS equipment at the following locations:
      i. At STARS equipment location within each new Tunnel Support Building on the south and north islands;
      ii. At each of the four pull box access points within the Tunnel Egress Corridor identified in Item D.3.d above; and
      iii. At the STARS roof antennas on new the Tunnel Support Buildings on the north and south islands. Each roof antenna locations only requires a minimum of one (1) 20 ampere, 120-volt power feed circuit.

7. Provide a Two-Way Radio Communication Enhancement System that will allow all Department Radios and Radio Operating Frequencies to function within the Tunnel, Tunnel Egress Pathways, Tunnel Stairways, Tunnel Horizontal and Vertical Ventilation Shaft/Spaces, new Tunnel Support Buildings, and new Control Rooms.

**30.3.3 Installation**

A. Install all Communication Systems in accordance with the current version of NFPA 70, NFPA 72, NFPA 502 and NFPA 1221.

B. Refer to Section 27, Electric Power and Distribution for additional related requirements.

**30.3.4 Testing**

A. Provide the following Testing and Inspection for all Communication Systems provided:
   1. Factory Test;
   2. Pre-Equipment Startup Inspection;
   3. Equipment Startup Test; and
   4. System Function Test.

B. Submit Detailed Test and Inspection Procedures for all Communication Systems for each of the four (4) stages of Testing and Inspection.
C. The Mass Notification System, including all equipment devices and wiring, MUST also be tested in accordance with all requirements and procedures identified in NFPA 72-2013, Chapter 14 or as modified by the current applicable edition of NFPA 72.

D. Submit detailed Testing and Inspection reports for all Tests and Inspections.

30.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 30.4-1 for the Department’s consultation and written comment.

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SECTION 31. LIGHTING

31.1. Scope
The Design-Builder shall provide and or maintain Lighting conditions that conform to the VDOT’s standard lighting requirements for freeway operations and shall be subject to the Department’s approval.

31.2. Standards and References
A. VDOT and Virginia Design Manuals, Road and Bridge Specifications and Standards drawings to include Special Provisions, Supplement Specifications and other reference documents listed herein, which are not all inclusive:
   a. VDOT Traffic Engineering Design Manual
   b. Virginia Uniform Statewide Building Code (USBC)
   c. Commonwealth of Virginia Energy Conservation Code
   d. FHWA Roadway Lighting Handbook
B. AASHTO, FHWA Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   a. AASHTO Roadway and Lighting Design Guide;
   b. AASHTO Technical Manual for Design and Construction of Road Tunnels – Civil Elements
   c. NFPA 70, National Electrical Code;
   d. NFPA 502 Standards for Road Tunnels, Bridges and Other Limited Access Highways;
   e. ANSI/IES RP-22 Tunnel Lighting;
   f. ANSI/IES RP-8 Roadway Lighting;
   g. ANSI/IES RP-1 Office Lighting;
   h. ANSI/IES RP-20 Lighting for Parking Facilities;
   i. ANSI/IES RP-33 Lighting for Exterior Environments;

31.3. Requirements

31.3.1. General
A. A lighting warrant analysis will be performed and submitted as part of the lighting design documentation to the Department for review and approval.
B. All new lights shall be light emitting diode (LED).
C. The LED luminaires shall be warranted by the manufacturer for a minimum of 10 years from date of installation against any failure resulting from materials, defects, and workmanship.
D. All new conventional and high mast fixtures shall be equipped with individual photoelectric control and prewired 7-pin twist lock ANSI C136.41-compliant receptacle and a rain-tight shorting cap. LED luminaires for inside the tunnel and other location as shown on the plans and/or as directed by the Engineer.
E. Temporary and permanent lighting facilities for the project shall be installed to ensure lighting facilities meet current VDOT Lighting Design Standards and Guidelines (found in Chapter 2 of the VDOT Traffic Engineering Design Manual) and ANSI/IESNA RP-8 requirements.

F. Roadway light poles shall be LP-2 offset design.

G. Dedicated load centers or disconnects shall be provided for roadway lighting.

H. All lighting design shall:
   a. Be prepared in accordance with the USDOT Roadway Lighting Handbook and the AASHTO Roadway and Lighting Design Guide;
   b. Be performed using AGI-32 computer software;
   c. Include point-to-point lighting analysis and calculations submitted to the Department for review and approval;
   d. Be required at all entrances to the general purpose or managed lanes.

31.3.2. Roadway Lighting

A. The Design-Builder shall maintain Lighting conditions that conform to the VDOT’s standard lighting requirements for freeway operations and shall be subject to the Department’s approval.

B. At all other locations where, existing lighting standards are present and impacted by construction, the Design-Builder shall relocate existing light poles on new foundations if existing poles meets VDOT Standards or provide new light poles. Existing LP-1 conventional design poles shall be converted to LP-2 offset design. The Design-Builder shall complete a lighting analysis for these locations and provide to the Department for review. No action is required at locations where construction does not impact existing lighting assets.

C. All new lights shall be Light Emitting Diodes (LED) in accordance with Part 2, Section [X.XX].

D. All new conventional pole luminaires shall be equipped with individual photocells and nodes. This does not include under bridge lights, tunnel lights, high mast lights, and aerial/marine navigation lights.

E. The Design-Builder shall install continuous freeway lighting for the entire length of the Hampton Roads Bridge Tunnel Expansion project. The Design-Builder shall design and construct the permanent roadway lighting system to properly illuminate all road, bridge, and tunnel segments in accordance with ANSI/IESNA RP-8, RP-20 and RP 22. The Design-Builder shall also be required to illuminate the emergency pull-off/truck inspection areas on I-64 EB and I-64 WB, as well as the parking lot and circulatory roadway areas of the north and south islands.

F. At all other locations where, existing lighting standards are present and impacted by construction, the Design-Builder shall relocate existing light poles on new foundations. The Design-Builder shall complete a lighting analysis for these locations and provide to the Department for review. No action is required at locations where construction does not impact existing lighting assets.

G. Temporary and permanent lighting facilities for the project shall be installed to ensure lighting facilities meet current VDOT Lighting Design Standards and Guidelines (found in
Chapter 2 of the VDOT Traffic Engineering Design Manual) and ANSI/IESNA RP-8 (roadway), RP-20 (parking lots), and RP-22 (tunnels) requirements.

H. All lighting design shall:
   1. Be prepared in accordance with the USDOT Roadway Lighting Handbook and the AASHTO Roadway and Lighting Design Guide;
   2. Be performed using AGI-32 computer software;
   3. Include point-to-point lighting analysis and calculations submitted to the Department for review and approval;
   4. Be required near all entrances to the HOT lanes.

I. For I-64 overpasses over city-maintained streets that currently have under-bridge lighting and are being modified or replaced by the project, the Design-Build shall design and install new under-bridge lighting systems with LED luminaires.

J. LED lights shall use LEDs with a Color Temperature (CCT) of 4000K at all interchanges and within the tunnels. LEDs that illuminate continuous section of freeway between interchanges shall be 3000K.

31.3.3. Bridge Lighting

A. The Design-Build shall install continuous freeway lighting for the entire length of all new bridges. The Design-Build shall design and construct the permanent roadway lighting system to broadcast sufficient lumens as required by VDOT’s standard lighting requirements for freeway operations for the full width of the bridges.

31.3.4. Tunnel Lighting

A. Luminaires shall be surface or adjustable bracket-mounted that utilize 4000K Correlated Color Temperature (CCT) LED as the light source, and be provided with an electronic driver to allow remote dimming to control luminaire light level output.
B. Luminaires shall be fabricated from Type 316 stainless-steel, minimum twenty (20) gauge, with welded seams and joints, Type 316 stainless-steel hardware.
C. Luminaires shall be corrosion resistant to salt water, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.
D. Luminaire lens shall be clear flat tempered glass, minimum 0.25-inches thick. If luminaire cannot be installed at least twelve (12) inches beyond the tunnel clearance envelope, luminaire lens shall be minimum 0.25-inches thick poly-carbonate.
E. Luminaires shall use multiple rotary draw compression cam latches to provide access to the fixture interior for servicing.

31.3.5. Trestles

A. Luminaires shall be pole-mounted with a Type II or III asymmetric roadway optical distribution that utilizes 4000K CCT LED—as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.
   a. Luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet salt water environment. Refer to Specification section 31.5 for luminaire testing.
b. Luminaires shall be fabricated from one-piece heavy wall die cast salt water marine grade T6 aluminum with Type 316 stainless-steel hardware. The finish color of the luminaire housing shall be selected by the Department.

c. Luminaires shall be provided with electronic driver, surge protection, vibration isolation and power compartment removable access door.

31.3.6. **Tunnel Open Approach Sections**

A. Luminaires shall be surface or wall mounted and use 4000K CCT LED as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.

B. Luminaires shall be corrosion-resistant to salt water, waterproof and listed per UL 1598A for outside wet salt water environment. Refer to Specification section 31.5 for luminaire testing.

C. Wall-mounted luminaires shall be fabricated from Type 316 stainless-steel, minimum 20 gauge, with welded seams and joints, and Type 316 stainless-steel hardware.

D. Luminaire lens shall be tempered glass, minimum 0.25-inches thick.

31.3.7. **Tunnel Egress Corridor, Egress Stairs and Utility Stairs**

A. Luminaires shall be surface or bracket mounted that use 4000K CCT LED as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.

B. Luminaires shall be fabricated from Type 316 stainless-steel, minimum 20 gauge, with welded seams and joints, and Type 316 stainless-steel hardware.

C. Luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.

D. Luminaire lenses shall be tempered glass, minimum 0.25-inches thick.

E. Luminaires that require latches shall use multiple rotary draw compression cam latches to provide access to the fixture interior for servicing.

31.3.8. **Tunnel and Building Horizontal Air Plenums**

A. Luminaires shall be surface or bracket-mounted that use 4000K CCT LED as the light source.

B. Luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.

C. Luminaire lens shall be tempered glass, minimum 0.25-inches thick with Type 316 stainless-steel hardware and metal lens guard.

31.3.9. **Islands Service Roads and Parking Areas**

A. Luminaires shall be pole-mounted with a Type II, III or IV wide asymmetric optical distribution that utilizes maximum of 4000K CCT LED as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.

B. Luminaires shall be provided with electronic driver, surge protection, vibration isolation and power compartment removable access door.
C. Luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.

D. Luminaires shall be fabricated from one-piece heavy wall die cast saltwater marine-grade T6 aluminum with Type 316 stainless-steel hardware. The finish color of the luminaire housing shall be selected by the District.

E. Luminaire lens shall be tempered glass, minimum 0.25-inches thick.

F. Existing luminaires and poles shall be replaced to match the new poles, luminaires and illumination configuration.

31.3.10. Norfolk and Hampton Shore Switchgear

A. Exterior fenced area luminaires shall be pole or surface wall-mounted full cut-off that utilizes maximum of 4000K CCT LED as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.

B. All luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.

C. Exterior luminaires shall be fabricated from one-piece heavy wall die cast saltwater marine grade T6 aluminum with Type 316 stainless-steel hardware, finish color selected by the Department or shall be fabricated from Type 316 stainless-steel, minimum 20 gauge, with welded seams and joints, and Type 316 stainless-steel hardware.

D. Exterior luminaire lens shall be tempered glass, minimum 0.25-inches thick.

E. Pole-mounted luminaires shall be provided with surge protection.

F. Interior Switchgear Enclosure luminaires shall utilize 4000K CCT as the light source.

31.3.11. Tunnel Support Building Interior

A. Interior luminaires shall be surface, pendant or recessed that use 4000K CCT LED as the light source.

B. North island and south island existing Control Room luminaires shall be provided with dimming drivers.

31.3.12. Tunnel Support Building Exterior Perimeter

A. Luminaires shall be surface wall-mounted full cut-off with a Type II, III or IV wide asymmetric area optic distribution that utilizes 4000K CCT LED as the light source and be provided with an electronic driver to allow remote dimming to control luminaire light level output.

B. Luminaires shall be corrosion-resistant to saltwater, waterproof and listed per UL 1598A for outside wet saltwater environment. Refer to Specification section 31.5 for luminaire testing.

C. Luminaire housing shall be fabricated from one-piece heavy wall die cast saltwater marine-grade T6 aluminum with all Type 316 stainless-steel hardware, finish color selected by the District or shall be fabricated from Type 316 stainless-steel, minimum 20 gauge, with welded seams and joints, and Type 316 stainless-steel hardware.

D. Luminaire lens shall be tempered glass, minimum 0.25-inches thick.
31.3.13. **Pump Stations**

A. Luminaires shall be surface or bracket-mounted that use 4000K CCT LED as the light source.

B. Luminaires shall be corrosion-resistant to saltwater, waterproof and UL listed for use in a Class 1, Division 2, wet saltwater location. Refer to Specification section 31.4 for luminaire testing.

C. Luminaires shall be fabricated from one piece of heavy wall die cast saltwater marine-grade T6 aluminum with Type 316 stainless-steel hardware.

D. Luminaire lens shall be tempered glass with a Type 316 stainless-steel hardware and metal lens guard.

E. All luminaires shall have luminaire efficacy greater than 65.5 percent.

F. All luminaire drivers shall be high efficiency electronic having a power factor greater than 0.91.

G. Spring-type clamp latches shall not be used for securing any exterior and tunnel luminaire lens frame doors.

31.4. **Design Requirements – Light Levels**

A. Tunnel, Tunnel Open Approach Sections and Trestles
   
   a. Provide roadways with luminance levels in candela per square meter (cd/m²) in compliance with RP-8 and RP-22 for expressways having a posted speed limit of 55-miles-per-hour.
   
   b. Provide emergency illumination levels in compliance with NFPA 502, where applicable.
   
   c. Provide tunnel exit zone luminance levels in candela per square meter (cd/m²) that is based on treating the tunnel exit the same as the tunnel entrance including transition zone and threshold zone lighting.

B. Tunnel egress corridor, egress stairs and utility stairs lighting

   a. Provide an average foot-candle illumination level equivalent to not less than 10fc at the floor or walking surface with an average-to-minimum fc ratio of 2:1.
   
   b. When any electrical, mechanical, SCADA or ITS equipment, panels or cabinets are located within the egress corridor, provide an average foot-candle illumination level equivalent to not less than 30fc for the equipment, panels, cabinets, and associated work space clearance areas.

C. Tunnel and building horizontal air plenums lighting

   a. Provide an average foot-candle (fc) illumination level equivalent to not less than 5fc at the floor with a maximum-to-minimum fc ratio of 10:1.
   
   b. When any electrical, mechanical, SCADA or ITS equipment, panels or cabinets are located within the horizontal plenum, provide an average foot-candle illumination level equivalent to not less than 30fc for the equipment, panels, cabinets, and associated work space clearance areas.

D. Island roads
a. Provide roadways with luminance levels in candela per square meter (cd/m²) in compliance with RP-8 for expressways having a posted speed limit of 55-miles-per-hour.

E. Island parking areas
   a. Provide an average foot-candle illumination level equivalent to not less than 5fc at the parking surface with a maximum-to-minimum fc ratio of 10:1 and an average-to-minimum fc ratio of 4:1.
   b. Provide an average vertical illuminance of not less than 2.5fc at five-feet above finished grade, with calculations in accordance with RP-20.

F. Norfolk and Hampton shore switchgear
   a. Exterior fenced area: provide an average illumination equivalent to not less than 20fc at washed river rock level with a maximum-to-minimum fc ratio of 10:1 and less than 0.02fc of spill-over light at any point along adjacent property lines.
   b. Interior switchgear enclosure: provide an average illumination level equivalent to not less than 30fc at floor level with a maximum-to-minimum fc ratio of 6:1.

G. Islands Ventilation Building Interior Lighting
   a. Provide all rooms an average illumination level equivalent to not less than 30fc at floor level with an average-to-minimum fc ratio of 3:1, unless otherwise noted.
   b. Provide all corridors, stairs, general use, and toilets an average illumination level equivalent to 10fc with an average-to-minimum fc ratio of 2:1 for stairs and 3:1 for all other spaces.
   c. Provide existing north island and south island control rooms with an average illumination level of not less than 50fc at desk top work surface with an average-to-minimum fc ratio of 3:1.

H. Islands ventilation building exterior perimeter lighting
   a. Provide an average illumination level equivalent to not less than 10fc at ground level with a maximum-to-minimum fc ratio of 10:1 for an area around the entire building for a distance of 15-feet from the building wall.
   b. Additionally, provide a minimum foot-candle level equivalent to not less than 2fc at the ground level for an area that is ten (10) feet, in all directions in front of all building swing and overhead doors.

I. Pump stations
   a. Provide an average foot-candle illumination level equivalent to not less than 30fc at the pump station bottom with a maximum-to-minimum fc ratio of 10:1, in each pump station pit section.

J. All light levels provided in this section are maintained light levels, not initial light levels.

31.4.1. Design Requirements – Calculations
A. All lighting calculations shall be performed using AGi32 software. Lighting calculations shall be performed and submitted for all areas, locations and spaces without exception.

B. A detailed lighting analysis report identifying all assumptions shall be submitted with all design submissions, in accordance with Technical Requirements, using manufacturer data for
each luminaire. The reports shall include the actual AGi32 software calculations in electronic format, and printouts from AGi32 including the luminaire schedule and all calculation summary sheets.

C. Prior to fixture installation, an updated lighting analysis report shall be submitted based on the results from the independent laboratory test results and report.

D. The reflectance values used in all lighting calculations shall be the reflectance values for the finished construction.

E. Computerized horizontal illuminance levels in foot-candle taken at two-foot increments longitudinally for one fixture cycle and a maximum of three (3) feet transversely across the finished surface. Include average maintained, maximum, and minimum values. Also include average/minimum and maximum/minimum uniformity ratios. Sample calculation areas shall be submitted for each area and are defined as areas with significant geometric differences that will make each test area unique to itself and/or common to others.

F. Calculations for the tunnel roadway and side walls shall be performed in accordance with ANSI/IES RP-22.

    a. The following criteria shall be used in preparing computerized calculations:
        i. Specific IES file submitted for each lighting fixture type to be clearly referenced;
        ii. Tunnel Roadway Type Reflectance (r-Table);
        iii. Tunnel Walls Reflectance;
        iv. Roadway Barriers Reflectance;
        v. Ceiling Reflectance;
        vi. Light Loss Factor (LLF);
        vii. Specific Tunnel Geometry;
        viii. Luminance levels in cd/m² for each tunnel lighting zone based on the Lseq method described in RP-22;
        ix. Distribution data according to ANSI/IESNA classification type, as defined in IESNA Lighting Handbook; and
        x. All resultant luminance levels in cd/m² converted to illuminance levels in fc.

G. The following formula shall be used for determining the LLF for all interior and exterior lighting calculations for all areas and all individual spaces:

    a. \[ \text{LLF} = (\text{LAT}) \times (\text{VF}) \times (\text{RSDD}) \times (\text{BO}) \times (\text{LLD}) \times (\text{LDD}) \]
        i. LLF = Light Loss Factor
        ii. LAT = Luminaire Ambient Temperature Factor
        iii. VF = Voltage Factor
        iv. RSDD = Room Surface Dirt Depreciation Factor
        v. BO = Burn Out Factor
        vi. LLD = Lamp Lumen Depreciation
vii. LDD = Luminaire Dirt Depreciation Factor (Use LDD = 0.85 for all calculations)

b. The minimum LLF used for all interior lighting calculations shall not be higher than 0.85.

c. The minimum LLF used for all exterior lighting calculations shall not be higher than 0.70.

d. The minimum LLF used for tunnel roadway and egress corridor shall not be higher than 0.65.

31.4.2. Design Requirements – Installation

A. Temporary Lighting

a. Provide and maintain temporary lighting for all construction work areas.

b. All existing lighting serving all roadways available for Department operation and use must remain in operation, unless temporary lighting is provided.

B. Immersed Tube Tunnel (ITT)

a. Mount all tunnel roadway luminaires to tunnel ceiling directly above the roadway pavement line that defines the separation from the roadway and the shoulder on both sides of the tunnel. The luminaire installation cannot extend into and must be at least twelve (12) inches from the tunnel clearance envelope.

b. As a guide, every third luminaire on both sides of the tunnel roadway shall be connected to branch circuits that are connected to the new lighting Stored Emergency Power Supply System (SEPSS). The actual quantity of luminaires connected to branch circuits that are connected to the new lighting SEPSS shall be increased or decreased to meet the foot-candle requirements along the roadway surface as specified in NFPA 502 for emergency lighting. All other lighting serving the Tunnel Roadway shall be connected to branch circuits that are connected to the new Emergency Power Supply System (EPSS).

c. Provide a minimum of two (2) wall or ceiling surface-mounted luminaires adjacent to each jet fan to service lighting for each jet fan. The service lighting installed at each jet fan location shall be controlled by a local on/off switch at each location.

d. Tunnel roadway lighting control

i. The lighting control system shall incorporate the following features:

1. Fully automatic dimming of all roadway lighting in response to external luminance as measured by two (2) luminance photometers at each end of the tunnel.


3. Alarming of control system faults (including loss of communication with luminaires) and failure of complete lighting power supply circuits.

4. Override to increase or decrease tunnel lighting from the lighting control panel.
5. Links to the SCADA system to permit remote indication of system status and alarms, and to increase and decrease lighting.

6. Provide a minimum of five (5) lighting control levels through SCADA.

7. Provide analog luminance photometers as follows: one (1) in the tunnel entrance, one (1) in the tunnel threshold zone, one (1) in the tunnel transition zone, three (3) in the tunnel interior zone (equally spaced), one (1) in the tunnel exit zone, and one (1) in the tunnel exit portal. The portal luminance photometer shall be located at a site that is a safe stopping distance from the entrance portal on north island and aimed at the tunnel portal in accordance with RP-22; this photometer will be used by SCADA to automatically control the tunnel roadway lighting based on daylight. The remaining photometers will be used to monitor the actual light levels at any location at any point in time.

   ii. Include a dimming system controlled through SCADA that will adjust the light level output of each tunnel roadway luminaire to achieve uniform light levels throughout the tunnel for each lighting zone for each control level.

C. Bored Tunnel

   a. Mount all tunnel roadway luminaires on the tunnel side curved wall outside the tunnel clearance envelope on both sides of the tunnel roadway. The luminaire installation cannot extend into and must be at least twelve (12) inches from the tunnel clearance envelope.

   b. Provide adjustable mounting brackets for each luminaire to allow individual aiming of each fixture such that the fixture light distribution is optimized to the roadway surface.

   c. As a guide every third luminaire on both sides of the tunnel roadway shall be connected to branch circuits that are connected to the new lighting SEPSS. The actual quantity of luminaires connected to branch circuits that are connected to the new lighting SEPSS shall be increased or decreased to meet the foot-candle requirements along the roadway surface as specified in NFPA 502 for emergency lighting. All other lighting serving the tunnel roadway shall be connected to branch circuits that are connected to the new System EPSS.

   d. Tunnel roadway lighting control (See Section Immersed Tube Tunnel (ITT) in this section, for Requirements).

D. Trestles

   a. Mount trestle luminaire on reinforced spun-cast concrete poles. The luminaire mounting/attachment to the pole, poles fabrication material, height, shape, taper, and outer diameter, and pole mounting/attachment to the Trestle shall be similar to the existing poles, with any additional modifications to accommodate current wind load, vibration, and seismic requirements as described elsewhere in these Technical Requirements.

   b. The branch circuits that feed the pole-mounted luminaires installed on the new trestles shall be connected to the existing trestle lighting power distribution system.
E. Tunnel open approach sections
   a. Luminaires shall be pole-mounted and/or surface-mounted to tunnel open approach sections side walls. Luminaire branch circuit conduit shall be concealed within the open approach side wall construction.
   b. The wall mounted luminaires illuminating the tunnel island shall be connected to branch circuits that are connected to the new lighting SEPSS.

F. Tunnel egress corridor, egress stairs and utility stairs
   a. All luminaires and branch circuit wiring raceway shall be surface-mounted.
   b. All luminaires shall be connected to branch circuits that are connected to the new lighting SEPSS.

G. Tunnel and building horizontal air plenums
   a. All luminaires and branch circuit wiring raceway shall be surface-mounted.
   b. All luminaires shall be connected to branch circuits that are connected to the new EPSS.
   c. All plenum lighting shall be remotely controlled through SCADA and local single switches at all of the entrances to the plenum.

H. Islands service roads and parking areas
   a. All new and existing north island and south island service roads and parking areas light poles shall be new with new luminaires and new branch circuit wiring and raceway.
   b. All light poles shall be fabricated from reinforced spun-cast concrete and be equivalent to the new spun-cast concrete poles that shall be utilized for the trestle luminaire poles.
   c. All light poles shall be mounted on reinforced concrete piers behind the portal walls. Light pole piers must be at least twenty-four (24) inches in diameter and the top of the concrete pier must be thirty (30) inches above finished grade at the location of the light pole. All light pole piers must be protected by bollards in accordance with the criteria in Technical Requirement Section 1.8.3.
   d. The light pole luminaires illuminating all island service roads providing access to and from the island new and existing ventilation buildings shall be connected to branch circuits that are connected to the new EPSS.
   e. The light pole luminaires illuminating the island parking areas shall be connected to branch circuits that are originating from the respective new island normal power distribution system.
   f. All light pole luminaires shall be controlled by photoelectric control controllers.

I. Norfolk and Hampton shore switchgear
   a. Install new lighting within substation fenced area on poles and on the exterior walls of the switchgear enclosure. Poles shall be fabricated from reinforced spun concrete and be equivalent to the new spun-cast concrete poles that shall be utilized for the trestle luminaire poles.
b. All substation exterior lighting shall be controlled by a local common photo cell controller, and a weatherproof toggle switch located on the inside of the substation fenced area adjacent to the substation fenced area man gate. The toggle switch shall be used to keep the exterior lighting off when the area is not occupied.

c. The exterior luminaires located above both substation switchgear enclosure doors shall be provided with two (2) hours of battery back-up power.

d. All interior luminaires located with the substation switchgear enclosure shall be provided with two (2) hours of battery back-up power.

e. Substation switchgear interior lighting shall be controlled by interior three-way switches located adjacent to each entrance door.

f. Power all Substation exterior and interior lighting from the substation switchgear power panels.

J. Islands ventilation building interior

a. All luminaires shall be recessed, surface-mounted and/or pendant-mounted. All luminaires shall be controlled by local on/off switches.

b. Fifty (50) percent of all new luminaires shall be connected to branch circuits that are connected to the new SEPSS. The remaining additional fifty (50) percent of all new luminaires shall be connected to branch circuits that are connected to the new EPSS.

c. Provide new recessed indirect luminaires in the existing north island control room. Provide dimming control for the new lighting such that the lighting over each of the two (2) workstations can be separately dimmer-controlled from the workstation directly below the respective lighting. All new luminaires shall be connected to branch circuits that are connected to the new SEPSS.

K. Islands ventilation building exterior perimeter

a. All new luminaires shall be wall surface-mounted and connected to branch circuits that are connected to the new EPSS.

L. Pump stations

a. All luminaires shall be ceiling surface-mounted and controlled by a local on/off switch.

b. All lighting branch circuit wiring shall be suitable for a Class 1, Division 2 location and connected to branch circuits that are connected to the new EPSS.

M. All branch circuit conductors serving the tunnel emergency lights, tunnel egress corridor and stairs lights shall be considered “Emergency Circuits with respect to NFPA 502” and shall comply with the requirements of NFPA 502-2014, Chapter 12, Sections 12.1.2 and 12.2.1.3, or as modified by the current applicable edition of NFPA 502.

N. All luminaire mounting hardware and support brackets shall be Type 316 stainless-steel unless the luminaires are installed within temperature or humidity controlled spaces within the portal.

O. All luminaires, luminaire poles, and luminaire mounting brackets shall be designed for applicable wind loads, vibration and seismic requirements.
P. All tunnel roadway, trestle, open approach section and roadway luminaires, luminaire poles, and luminaire mounting brackets, shall be designed to accommodate the fatigue load that would be imposed on a light fixture by a large truck or bus traveling at the posted speed limit plus ten (10) mph, in accordance with AASHTO bridge fatigue loading requirements.

31.5. Testing

31.5.1. Lighting Testing

A. All luminaires utilizing LED light source must have one (1) fixture randomly selected from the fixture production run sent to an independent nationally recognized testing laboratory to have the luminaire IES light distribution measured and verified.

B. IES LM-79, IES LM-80 and an In-situ Temperature Measurement Test (ISTMT) report shall be submitted to the Department for each LED luminaire.

C. The Department shall randomly select two (2) luminaires of each light distribution from the Project's production lot at either the manufacturer's plant or job site; this choice shall be of sole discretion of the Department. The Design-Builder shall then deliver the luminaire(s) to a recognized independent testing laboratory that is acceptable to the Department. The luminaires shall be tested at an independent testing laboratory for compliance with illumination, efficiency, and uniformity ratios of illumination depicted on the design documents. The results of these tests shall be forwarded to the Department directly. If one (1) or more in each group fails to meet the criteria, the Design-Builder shall deliver two (2) additional luminaires for testing. Additional groups of two (2) luminaires shall be delivered until one (1) group fully passes all tests. No rejected luminaires may be used on this Project. All testing shall be at the sole expense of the Design-Builder.

D. Water spray test:

   1. Water spray tests shall be conducted on luminaires selected at random by VDOT, by an independent testing laboratory engaged by the fixture manufacturer. The tests shall be witnessed by VDOT. The test results shall include a detailed description of the test, observations and results. The test results shall be submitted to VDOT for review.

   2. Test Procedure: The completely assembled and operable luminaire shall be mounted on a rack with the lens side of the fixture facing the spray nozzles. Either the rack mounted luminaire or the spray nozzles can be adjustable to provide various angles of water spray to luminaire lens. The spray apparatus shall consist of four (4) spraying nozzles, spaced twenty-four (24) inches apart attached to a two (2) inch pipe header, with each nozzle delivering twelve (12) gallons per minute at one hundred (100) pounds-per-square-inch, in a ninety (90) degree cone. A water pressure gauge shall be installed after the last spray nozzle.

   3. The luminaire assembly shall be positioned centered between two (2) nozzles at a distance of eighteen (18) inches from the nozzles. The assembly shall be rotated so that the water spray is directly aimed at a point twenty-five (25) degree over from the bottom of the lens assembly.
4. Energize the luminaire for a minimum of thirty (30) minutes before turning on the water spray. Turn on the water spray and apply the spray to the energized luminaire for fifteen (15) minutes. After the fifteen (15) minutes, de-energize the luminaire and continue to apply the water spray for fifteen (15) minutes. After the second fifteen (15) minute water spray interval turn off the water spray and wipe dry the outside of the luminaire. Within fifteen (15) minutes or less after turning off the water spray open the luminaire and inspect for water infiltration into all interior areas of the luminaire.

5. Photographs of the test luminaire shall be taken throughout the entire test process and included in the report documenting the interior and exterior conditions of the luminaire before, during and after testing.

6. The luminaire assembly shall not show any signs or evidence of water infiltration into the luminaire interior housing after the completion of the test.

7. During the water spray test, no luminaire lens frame latch shall release. A releasing latch is an indication of test failure regardless of water infiltration into the luminaire interior housing.

E. Vibration testing for tunnel roadway and trestle:

1. Vibration tests shall be conducted on ten (10) fixtures selected at random by the Department, by an independent testing laboratory engaged by the fixture manufacturer. The tests shall be witnessed by the Department. The test results shall be submitted to the Department for review. Testing shall be in accordance with ANSI 136.31.

F. Tunnel roadway luminaire test procedure:

1. While the luminaire is attached to the mounting bracket that would be used to attach the luminaire to the tunnel concrete structure the completed luminaire, lamped and energized, shall successfully pass a vibration test at a 2G loading for 100,000 cycles in each of the three (3) major axes followed by a 4G test for 5,000 cycles along the same axis.

G. Trestle luminaire test procedure:

1. Similar to tunnel roadway test procedure except test at 3G for 100,000 cycles.

31.6. Deliverables

At a minimum, the deliverables shall include the items listed in Table 31.6-1 for the Department’s consultation and written comment.

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SECTION 32. AESTHETICS

32.1. Scope

Aesthetic treatments shall be designed to be consistent with the local landscape and architecture, as well as the developed themes of the local setting. The Design-Builder shall coordinate with local and state agencies to develop an aesthetic concept, including any necessary coordination with agencies such as the State Historic Preservation Office, as applicable, while maintaining applicable design standards.

32.2. References

VDOT Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:

A. VDOT Manual of the Structure & Bridge Division Part 2 Design Aids and Details – Chapter 5
B. VDOT Manual of the Structure & Bridge Division Part 12 Sound Walls Architectural Treatment

32.3. Requirements

32.3.1. General

A. The following items will be considered in defining the aesthetics concepts for the Project when these features will be visible to the public upon completion:

1. material, finish, color, and texture of sound barrier walls, retaining walls (including MSE walls, soil nail walls, tieback walls, and gravity walls), bridge elements (barriers, railings, parapets walls, abutments, wingwalls, and piers);
2. paved slope treatments and hardscape at interchanges and intersections;
3. median or other specialty paving, including material, finish, and color;
4. fencing;
5. signage (including overhead, attached, ground-mounted, and gantries);
6. lighting poles and lamps; and
7. any permanent building construction for the Project, including ancillary support, operational, and toll collections.

B. All permanent structures shall be carefully detailed to achieve the greatest level of aesthetic quality and fit in accordance with (A) above. All permanent structures shall be proportioned to avoid excessive size, bulk and mass.

C. Graphics, signage, and lighting shall be consistent along the entire length of the Project.

D. Aesthetic elements shall be easy to maintain and resistant to vandalism and graffiti.

E. Aesthetics elements shall be fully integrated with the overall landscape design.

F. Use of form liners shall meet geometric requirements of VDOT Volume 5 Part 2 Chapter 5. Shoulder widths and horizontal clearances shall take into consideration relief of form liner.
G. Where existing structural elements that are to be incorporated into the Project have aesthetic treatments, the surface finish and color for sound walls, retaining walls, bridge parapets and walls, and bridge abutments shall match existing.

H. Where structural elements have no aesthetic surface, treatments specified, elements shall receive a smooth concrete finish in accordance with the VDOT Road & Bridge specifications.

32.3.2. Specific Requirements

A. Sound Barrier Walls: Architectural treatment shall be provided for both the roadway and the landowner side of all sound barrier walls. Architectural treatment details shall be in accordance with the requirements of the Manual of Structure and Bridge Division, Part 12 “Sound Walls – Architectural Treatment” and approved aesthetic concept. Pattern and relief to be approved by Department.

B. Retaining Walls: Architectural treatment details shall be in accordance with the requirements of the Manual of Structure and Bridge Division, Part 2 Chapter 5. Pattern and relief to be approved by Department.

C. Bridges:

1. Bridges over I-64: For bridges which cross-over I-64, the bridges shall include the following:
   a. Barriers and Railings: VDOT Std. form liners applied to outboard face of barriers conforming to VDOT Volume 5 Part 2 Chapter 5 (pattern and relief to be approved by the department).
   b. Abutment Walls: VDOT Std. form liners and medallion on breastwall and wingwalls (pattern and relief to be approved by the department).
   c. Piers: Any wall piers or piers with rectangular or square columns adjacent to roadway (shoulder or median) shall have form liners in accordance with VDOT Volume 5 Part 2 Chapter 5 (pattern and relief to be approved by the department).

2. Approach bridges: For new bridges immediately approaching the tunnel shall include the following:
   a. Barriers and Railings: VDOT Std. form liners applied to inboard face of barriers conforming to VDOT Volume 5 Part 2 Chapter 5 (pattern and relief to be approved by the department).

D. Tunnel and Tunnel approach sections (boat sections): Tile shall also be applied on the faces of both portals of the tunnel. The portal tile area (extent) collar and appearance shall match precisely the area (extent) and appearance that exists on the existing tunnel portals for the Hampton Roads Bridge Tunnels. Any deviation from the extent or appearance of the Tunnel Approaches, Portals or Tunnel must be submitted for review and acceptance by the Department. The Design-Builder shall prepare and submit drawings of the portal tile configuration subject to review and acceptance by the Department.

E. Landscape Architecture:

1. The Design-Builder shall develop a landscape plan incorporated into the final roadway plan for the project. The Design-Builder shall furnish and install all landscaping according to their approved landscaping plan. Reforestation areas are generally located between the interstate and private properties, screening noise walls, screening stormwater management facilities, between frontage roads and the interstate, and adjacent to...
2. A landscaping plan will be developed by the Design-Builder’s landscape architects and shall examine various landscaping opportunities and treatments for the project area that could be implemented to maintain the aesthetics of the corridor. The landscape plans shall be developed in concert with input from the Department, the National Park Service and the Cities of Hampton and Norfolk. A final planting plan for the project shall be prepared by a Virginia licensed Landscape Architect and shall be submitted to the Department for review and approval.

3. Topsoil and seeding for soil stabilization and E&S control for the Project shall be performed in accordance with Sections 602 and 603 of the VDOT Road and Bridge Specifications.

4. Planting for bioretention swales or other proposed water quality features shall be developed in accordance with the Department of Environmental Quality’s (DEQ) criteria for appropriate species, density, and planting zones for developing water quality features. The cost for any plantings for proposed stormwater management facilities required to meet the DEQ criteria shall be included in the Design-Builder’s bid. Stormwater management facilities planting plans shall be developed as part of the overall planting plan for the project.

5. All landscaping shall be in accordance with the Memo for Guidance for Planting in the Clear Zone and Landscaping for VDOT Projects, dated November 2, 2000, Guidelines for Context Sensitive Solutions/Design, dated February 25, 2004, and FHWA 23 CFR 752 Landscaping and Roadside Development and the attached Special Provisions for Section 605 and 244 of the VDOT 2016 Road and Bridge Standards. A majority of the plant materials should be native or indigenous to the area and can adapt and survive in roadside environments.

6. The planting plans shall be designed and constructed to require minimal maintenance and be compatible with the existing landscape adjacent to the Project and may reflect historic and cultural features of the area.

Plant stock shall be specified with the following species, minimum sizes and spacing:

- **Street Tree Selections:** Columbia Sycamore, Allee Elm, Darlington Oak, 2.5-inch Caliper (Spacing between 25 feet and 50 feet).
- **Flowering Trees:** Kwanzan Cherry, Capital Pear, 1.5-inch Caliper (Spacing between 15 feet and 25 feet)
- **Multi-stem Trees:** William Toovy Crape Myrtle, Acoma Crape Myrtle, 8 feet Height (Spacing between 12 feet and 15 feet, in groups)
- **Evergreen Trees:** Nellie Stephens Holly, Hollywood Juniper, 8 feet Height (Spacing between 8 feet and 25 feet)
- **Ornamental Shrubs:** “Carissa” Holly, No. 3 Containers (Spacing between 2 feet and 2.5” O.C.)
- **Perennials:** “Happy Returns” Daylily, No. 1 Cont., 18” O.C.
- **Narcissus Sp. Bulb:** Top Size DN-II (space groups of 5 bulbs 18” O.C. or individual Bulbs at 6”-8” O.C.)
- Native Grasses: “Cloud Nine” Switch Grass, Regal Mist Muhly Grass, No. 1 to No. 3 Containers (Spacing between 2 feet and 3 feet O.C. – medians and interchange loop areas)
- Seedlings: Tulip Poplar, Red Maple, Serviceberry, No. 3 Cont. (8’ centers for Interchange loop no-mow area)
- Native Shrubs: Groundsel Shrub, No. 3 to No. 5 Containers (Spacing between 2.5 feet and 3 feet O.C. for use in Interstate Loop no-mow area)

7. Spacing of other plant material shall be in accordance with accepted horticultural and landscape architectural design principles based upon species selection. Planting plans shall provide for screening where appropriate and for replacement of trees impacted by the Project in accordance with VDOT IIM-LM-253.1 dated December 18, 2014. All plants shall conform to the American Standard for Nursery Stock (ANSI-Z60.1-2004), container grown or balled and burlapped.

8. For plant beds, soil shall be prepared and amended per Section 605 of the Road & Bridge Specifications throughout the limits of the planting bed or as detailed on the plans. Street Trees shall be planted in individual oversize planting pits providing a minimum of 200 Cubic Feet of planting medium per tree. Groups of flowering trees shall be planted in linear planting pits and detailed on the plans as to the length, 7’ width and 15” minimum depth of the amended soil mixture for the planting pits. Daffodils shall be added in a 10” wide strip centered on the median beneath all median tree plantings. Amendments shall be in accordance with Section 605 of the Specifications or as detailed and denoted on the plans.

9. Landscaped areas outside of interstate median and stormwater management facilities shall be planted with larger plant stock. Landscape plans shall provide for screening and for replacement of trees impacted by the Project outside the interstate roadway. The Design-Build shall plant a tree two (2) inches in caliper for every increment of six (6) inches in caliper of a tree that is removed. For example, if the Design-Build removes a twenty-four (24) inch red oak, they should plant four (4) two (2) inch caliper trees. When planted, shade trees should be two (2) inch in caliper and spaced twenty (20) to thirty (30) feet on center, flowering trees six (6) to eight feet in height and spaced ten (10) to fifteen (15) feet on center, evergreen trees seven (7) feet in height and spaced fifteen (15) to twenty-five (25) feet on center, shrubs two (2) to four (4) feet in height and spaced three (3) to five (5) feet on center, depending on the species. Where areas are too small or steep (slopes at 2H: 1V) for adequate tree growth, the Design-Build shall provide densely planted shrubs. Vines can be planted on walls and where there are areas too narrow for any other plants. All plants shall conform to the American Standard for Nursery Stock (ANSI-Z60.1-2004), container grown or balled and burlapped.

10. Trees of significant aesthetic or historic value, such as the Emancipation Oak on Hampton University, should be identified and considered for preservation if they can be located at least five (5) feet outside of the grading limits and not become a future safety hazard as determined by the Engineer.

11. All planting operations and holes will use Improved Backfill as the medium for installing plants per Department approved planting details provided on the plans. This includes lay down restoration areas. The improved backfill will be 2/3 Class B Topsoil and 1/3 organic compost.
12. The roadside development sheet should not include tall fescue. It shall include native and low-growing grasses and groundcovers both for erosion and sediment control and permanent seeding.

13. Four specific “ecotypes” are to be addressed, and a rough estimate of these quantities, by acre, shall be provided by the Department in sketch plan form prior to developing final plans for approval.

   a. Special Seeding Overlays will consist of three types: Wetland, Intermediate, and Dry Conditions. These seeding overlays are in addition to the VDOT roadside development sheet.

   b. Reforestation: As defined above under “larger plant stock” and to include native hardwoods and evergreens planted 15-20’ O.C.

   c. Native small tree large shrub mix

   d. Special landscape areas that address best management practices for all storm water management areas.

   These ecotypes may overlap.

14. The Design-Builder’s price proposal shall include all landscaping and other related incidental costs; based on their anticipated clearing limits, proposed lay down areas, and impacts to locations requiring screening.

15. The Project shall have a minimum one-year plant establishment (warranty) period applicable to all plantings.

### 32.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 32.4-1 for the Department’s consultation and written comment.

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SECTION 33. DEMOLITION

33.1. Scope
An essential component of the project is the removal of permanent structures, including bridges. The Design-Builder shall perform all execution of the work in accordance with VDOT’s Standard Specification and modified as stated herein.

33.2. References
A. VDOT and Virginia Design Manuals, Road and Bridge Standards, Specifications, and Reference Documents listed herein, which are not all inclusive:
   1. VDOT 2016 Road & Bridge Specifications
   2. SPCN Demolition Notification for Structures Not Requiring Asbestos Removal, June 25, 2009

33.2.1. General
A. Detailed demolition and erection plans shall be included with the final design plan submittal. The demolition and erection plan shall include, but not be limited to, details of protection of the underlying roadway, wetlands and users. The stage construction plans shall outline expected methods of protecting roadway users during each stage.
B. It is the Design-Builder’s responsibility to obtain and/or verify any required As-Built field dimensions and locations needed for the purposes of design and construction.
C. An existing sign inventory shall be completed prior to site demolition in accordance with the VDOT Traffic Engineering Design Manual. This existing information shall be submitted at the same time as the first plan submittal for proposed signing.
D. Total closures of Interstate 64 for such work as installation and removal of overhead sign structures, demolition of existing bridges, erection of bridge members or with substantiation of need by the contractor will require coordination with appropriate stakeholders, public notice and only with the Departments concurrence and approval. Any proposed closures will be identified as an item in the Traffic Management Plan cited in Section 13 of these Technical Requirements.
E. The Design-Builder shall perform asbestos inspections on all structures (including bridge structures) and, as applicable, perform asbestos abatement, abatement monitoring, notifications and demolition in accordance with VDOT procedures and specifications. Prior to demolition, asbestos abatement shall be performed for all structures found to contain regulated asbestos materials (RACM) and non-RACM that is expected to become friable (i.e. RACM) during demolition. The Design-Builder shall make all appropriate abatement and demolition notifications as required by Federal and State regulations.
F. Asbestos inspection, abatement and project monitoring shall be performed by individuals and firms licensed by the Virginia Department of Professional and Occupational Regulation. Asbestos abatements shall not be performed by an asbestos contractor who has
an employee/employer relationship with, or financial interest in, the laboratory utilized for asbestos sample analysis nor shall the asbestos contractor have an employee/employer relationship with, or financial interest in, the asbestos inspector and project designer working on the project. Copies of all asbestos inspection, monitoring and disposal records shall be provided to the Department.

G. For any asbestos waste and other non-hazardous waste, the Design-Builder shall have the signatory responsibility for the waste shipping manifest(s) and/or bill(s) of lading. For hazardous waste the Design-Builder shall be considered the co-generator and shall be responsible for preparing the hazardous waste shipping manifest(s) for the Departments representative’s signature and as otherwise consistent with the signatory requirement under Section 411 of the VDOT Road and Bridge Specifications.

33.3. Deliverables

At a minimum, the deliverables shall include the items listed in Table 33.4-1 for the Department’s consultation and written comment.

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SECTION 34. COMMISSIONING, OPERATIONS, AND MAINTENANCE

34.1. Scope
The Design-Builder shall prepare a commissioning plan that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing plan that assures that the systems function and operates as intended.

34.2. References
B. NFPA 25 Water-Based Fire Protection
C. ASHRAE SPC217P Non-Emergency Ventilation in Enclosed Road, Rail and Mass Transit Facilities

34.3. Requirements

34.3.1. General
A. Field testing of the mechanical systems shall be performed to verify that all system operating modes function as intended and comply with these Technical Requirements. The Design-Builder shall be responsible for performing field testing in accordance with standard manufacturer’s test procedures for all operable equipment. The Design-Builder shall prepare field test procedures and submit to the Department for review and approval prior to commencement of any testing.
B. The Department shall be given the opportunity to witness any or all tests at their discretion, and will provide the Design-Builder with a list of tests to be witnessed. Coordination with the Department shall be performed so that field measurements are witnessed. Final testing of safety systems will be witnessed and accepted by the Department.
C. Testing for the mechanical equipment shall not be undertaken until the permanent electric service and local controls are established and can be used for testing.
D. The Design-Builder shall submit to the Department, a written test program/procedure for each of the field tests identified in this Technical Requirement at least thirty (30) days before the scheduled date of test initiation. This test program shall contain, as a minimum, the resumes of the key personnel participating in the test phase, the specific make, model numbers and calibration certifications of the test equipment to be used, and a general procedure to be followed for the set-up of equipment and for the sampling, recording, and production of the test data. In addition, pass/fail criteria shall be included in the test program/procedure for comparison to test results.
E. For each test, a test report shall be provided to include the following:
   1. Test methodology;
   2. Relevant codes or standards;
   3. Specific details of the equipment or system tested;
4. Full record of measurements taken, with locations;
5. Evidence of calibration of test equipment;
6. Applicable acceptance criteria;
7. Test results; and
8. Any further actions or re-testing required.

F. Where airflow measurements are required, the number and location of points traversed shall conform to AMCA and ASHRAE, modified for the shape of the tunnel.

G. The Design-Builder shall perform fan airflow performance tests:

1. After all construction and other work involving the air pathways from the roadway level to fan and to ambient at the ventilation building have been completed, and all fans have been installed and run-in, the Design-Builder shall conduct tests to determine actual airflow under operating conditions as specified below for each ventilation building, and jet fan.
   a. Each fan shall be tested at the design blade angle.
   b. For each ventilation building fan the Design-Builder shall measure and record the following:
      i. Power consumed;
      ii. Dry bulb and wet bulb temperature of the air passing through the fan; and
      iii. Simultaneously record the outdoor ambient barometric pressure.
   c. For each jet fan the:
      i. Design-Builder shall perform vibration tests, run-in tests; starting tests; performance tests and noise measurements.
      ii. The tunnel jet fans shall be tested and rated in accordance with the latest edition of Air Movement and Control Association (AMCA) Standard 250, “Laboratory Methods of Testing Jet Tunnel Fans for Performance”. The sound power level ratings of the jet fans shall comply with the latest revision of AMCA Standard 310, “Methods for Calculating Fan Sound Ratings from Laboratory Test Data.”

2. Using the recorded data in conjunction with the certified operating fan and motor data and curves derived from the shop tests, the air delivery and static pressure of each fan under all provided operating conditions shall be determined.

3. Brake Horsepower (BHP) and thrust shall be corrected to the design air density before use with the fan performance curves and all calculations shall be shown in the report.

4. For each fan the Design-Builder shall perform air velocity traverses with all fans operating, at locations determined by the Department to confirm fan airflow delivery. For each measurement location, a minimum of three air velocity traverses of the entire duct/cross section shall be taken and averaged, and the average shall not vary from the measurements by more than five (5) percent. If measurements vary by more than five (5) percent, additional measurements shall be taken until three (3) consecutive sets of measurements do not vary from the average by more than five (5) percent.
5. If the air delivery is less than the design output, the Design-Builder shall perform all work necessary to achieve the design airflow. This may include adjusting the fan blade angle or VFD set point in order to bring the fan airflow to the design level. In this instance, the design BHP shall not be exceeded.

6. The Design-Builder shall, following any change in air delivery of any fan, repeat the tests to determine actual air output of each of the fans. Both the Department and the manufacturer field service engineer shall be present at these tests. The Design-Builder shall promptly (within 21 calendar days) submit to the Department copies of the test results. The reports shall show all test results including those from initial and subsequent tests. The reports shall clearly indicate, with sketches, if necessary, the initial and subsequent blade setting angle of the fan and VFD set points.

7. The fan vendor shall provide the Design-Builder, following any blade angle adjustment, with replacement fan nameplates to reflect the latest blade angle setting and re-issue the Operations and Maintenance Manual for the fan-motor units. The Design-Builder shall replace the fan nameplates.

H. The Design-Builder shall perform the following egress corridor pressurization system tests:

1. Test each fan for its actual performance.
2. Verify that the pressurization control sequence is initiated under the design conditions.
3. Verify that all dampers open and close fully, cycle smoothly through their full range of operation and react correctly to commands from the control system and to the pressure changes.
4. Operate system under automated control and witness, measure and make adjustments to confirm that the specified range of differential pressure is maintained between the egress corridor and the roadway with the doors closed, within the required interval. Adjust and limit fan to speed required under this condition.
5. Test duct pressures, differential pressures across equipment, air moving devices, outdoor areas, stairwells and tunnels pressure (forces) to open the egress doors. Adjust fan pressures such that passageway doors shall open with less than fifty (50) lb. force.
6. Confirm fans achieve specified speed (volume) over the specified intervals.
7. Operate, adjust and limit fan speeds to maintain the schedule velocity through the tunnel and exit doors. The velocity shall be maintained across the open door area to prevent smoke from getting into the egress corridor.

I. The Design-Builder shall perform tunnel airflow performance tests:

1. The tunnel ventilation control system shall be tested for proper functionality. Each ventilation operation mode shall be tested via the tunnel ventilation control system to confirm proper performance of the control system.
2. All modes of tunnel ventilation: normal operations, congested operations, standstill operations and fire emergency operations, shall be tested for conformance with airflow requirements.
3. Airflow calculations shall be performed to determine the airflow that will be moving through the tunnel at commissioning test locations under commissioning conditions (i.e. no fire, no traffic). These calculations shall account for changes in fan operating point due to the lack of resistance that the design fire would generate.
4. The field tests shall include the measurement of air movement within the tunnel produced by the ventilation system. These measurements made by the Design-Builder shall serve as verification that the tunnel ventilation system produces sufficient velocity in the roadway during a fire to satisfy emergency ventilation criteria. The Design-Builder shall conduct an airflow test for at least three (3) representative fire locations. In addition, all operating modes for non-fire emergency shall be tested.

5. The Design-Builder shall determine and provide the Department for review and comments, details on all tests for the measurements, the testing conditions (such as ventilation system operating requirements), the acceptance criteria, and the test results required for each location at least thirty (30) days before the scheduled date of testing.

6. Air velocity traverses of the entire tunnel roadway shall be performed in order to determine the average airflow through the cross section. For each measurement location, a minimum of three air velocity traverses of the entire cross section shall be taken and averaged, and the average shall not vary from the measurements by more than five (5) percent. If measurements vary by more than five (5) percent, additional measurements shall be taken until three consecutive sets of measurements do not vary by more than five (5) percent.

7. In addition, air velocity traverses of the entire tunnel roadway shall be performed to assess the average airflow without the tunnel ventilation system operating. The airflow generated by wind conditions only need to be determined before and after the airflow tests performed with tunnel ventilation system operation.

8. The Design-Builder shall provide the Department with the measured test results. If the measured air velocities are less than the required Design-Builder's design "cold" air velocities, the Design-Builder shall make adjustments to the system to produce the required tunnel airflow velocities. The field measurements shall then be repeated in order to verify that the required tunnel airflows have been achieved. The increased fan airflows shall not cause overloading of the fan motors. The tunnel ventilation system shall be modified by the Design-Builder to the extent required to provide the minimum airflows specified. In addition, the fan nameplates shall be updated and replaced.

J. The Design-Builder shall perform the following noise tests:

1. For each tunnel ventilation fan room the sound levels, measured in dB(A) shall be recorded at three (3) locations upstream, and three (3) locations downstream, of the fans. Terms upstream and downstream are with respect to fan forward airflow.
   a. One (1) measurement location shall be in the air plenum connecting the roadway (egress corridor) to the Ventilation Building.
   b. One (1) measurement location shall be in the air duct and three (3) feet from the fan’s connection to atmosphere.
   c. One (1) measurement location shall be on the roadway, three (3) feet from the barometric relief damper closest to the Ventilation Building.
   d. Background sound levels shall be recorded before and after any fan sound measurement.
   e. Sound power levels shall be recorded in each band of the octave band (8 bands).
   f. These tests shall be performed by a professional engineer.
2. For each bank of jet fans, the Design-Builder shall record sound levels, measured in dBA at several locations upstream and downstream of the fans in addition to at the jet fan bank. First with a single fan operated at high speed and repeated with all fans operation under design fire emergency modes. The test measurement locations shall be:
   a. Directly under the jet fans at a height of five (5) feet above the road surface;
   b. At fifteen (15) feet and at thirty (30) feet from the outlet of the jet fan away in both directions and at a height of five (5) feet above the road surface; and
   c. At the entrance/exit portal, depending on which is nearer the fans.

K. The Design-Builder shall perform air monitoring system testing:
   1. The Design-Builder shall prepare a commissioning plan memo that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing plan that confirms that the systems functions and operates as intended.
   2. Equipment installed by or under direction of the Design-Builder, which is found to be defective in material or workmanship, shall be repaired or replaced.
   3. Operation Tests: Each air monitoring location shall be field tested under operating conditions to determine that all parts of the system function properly. All defects shall be corrected and necessary adjustments made to satisfy the requirements. The Design-Builder shall submit three certified copies of results obtained from field tests to the Department, indicating the total response time for each system.
   4. Before final acceptance and after testing the Design-Builder shall show by in-service demonstration that the equipment and all associated accessories are in good operating condition and properly performing their intended function.
   5. The following Operational Test Reports are required:
      a. Confirming that operational units have remained within specifications for twenty-four (24) hours during the full range of temperature and humidity testing;
      b. Interfering gases do not affect the air monitoring system analysis; and
      c. Data reading reports within the control room are accurate.

L. The Design-Builder shall perform the following ventilation building HVAC, plumbing, drainage and fire protection systems tests and commissioning:
   1. The Design-Builder shall develop a commissioning plan that consists of individual equipment performance and quality assurance tests, as well as a complete installation testing and commissioning plan that assures that the system functions and operates as intended.
   2. The Design-Builder shall prepare a commissioning plan and field test procedures and submit to the Department for review and approval prior to commencement of any testing.

M. The Design-Builder shall perform drainage pumping plant tests that shall include but not be limited to testing the pump flow rate and pressure, controls sump pump operation levels and ventilation fans operation.

N. The Design-Builder shall test the drainage pipes by the lamped or laser method and shall compile with the Virginia State Plumbing code for alignment.

O. The Design-Builder shall hydrostatically test the drainage discharge force main. Pressure test shall be 150% of pump normal operating pressure for one (1) hour without any leakages or
additional water added to the system. Test pressure shall not exceed +/- 5 psi over the test period.

P. The Design-Builder shall perform the following fire suppression system tests:
   1. End-to-end time for fire detection, fire alarm, location and confirmation of a fire, with a prescribed allowance for any human intervention;
   2. Times to fully charge the system;
   3. Time to establish full operation of the system; and
   4. Rate of water consumption under full availability and pump failure conditions and;
   5. Deluge valve test in accordance with NFPA 25. In addition to NFPA 25 requirements the deluge valves shall be tested for open and close remotely and manually under full system pressure. Also, the time from detection to full flow release from the sprinkler heads shall be tested.

Q. The Design-Builder shall perform the fire hydrants flow tests for flow and pressure in accordance with NFPA 25 requirements.

34.3.2. Testing

A. The Department will verify that the completed systems conform to the functionality, performance and safety requirements, as in accordance with these Technical Requirements.

B. Specific performance tests shall include, but not necessarily be limited to:
   1. Tunnel ventilation;
      a. Air velocity and uniformity;
      b. Noise levels; and
      c. Efficiency of smoke extraction.
   2. Tunnel lighting;
      a. Luminance levels.
   3. Drainage pumping plant;
      a. Pump discharge flow and pressure.
   4. Fire suppression system;
      a. End-to-end time for detection, alarm, location and confirmation of a fire, with a reasonable allowance for any human intervention;
      b. Times to charge the system.
      c. Time to establish full operation of the system; and
      d. Rate of water consumption under full availability and pump failure conditions.
   5. Fire hydrants;
      a. Flow and pressure.
   6. EC and traffic control systems.
      a. Comprehensive functional tests.
C. For each test, a test report shall be provided to include the following:
   1. Test methodology;
   2. Relevant codes or standards;
   3. Specific details of the equipment or system tested;
   4. Full record of measurements taken, with locations;
   5. Evidence of calibration of test equipment;
   6. Applicable acceptance criteria;
   7. Test results; and
   8. Any further actions or re-testing required.

34.3.3. Materials Handling Report for Equipment

A. The Design-Builder shall ensure that design, construction and installation of Work is done in a manner to make regular/routine maintenance, removal, and/or replacement of equipment as efficient and accessible as possible. The Design-Builder will detail this approach in a Materials Handling Report (“MHR”) for all equipment that will be included into the final project. This report shall be comprehensive in detailing:
   1. Material handling for all mechanical and electrical equipment requiring routine maintenance (as identified by the manufacturer);
   2. All mechanical and electrical equipment with service life less than 100 years. All Design-Builder installed equipment with service life less than 100 years shall be removable with existing Department maintenance equipment and tools unless otherwise provided to the Department by the Design-Builder. Removal of the equipment must not require extensive disassembly of equipment and shall have minimal impact to the remaining operations of the facility and shall not require removal and replacement of any permanent construction work such as walls, doorways or windows; and
   3. Access, transport, and lifting procedures for all mechanical and electrical equipment weighing in excess of 50 lbs.

B. Materials Handling Report (MHR) shall include, at a minimum, the following:
   1. A Space Utilization Plan that reflects optimal placement of equipment for ease of maintenance with little to no disruption to traffic while maximizing the safety of Department personnel and contractors;
   2. Material selection that reflects the best effort to standardize materials and minimize differing parts to be maintained in the inventory;
   3. Demonstration of how the proposed equipment can be accessed for maintenance and removal within the considerations in this section of the Technical Requirements. The Design-Builder must identify the ability for equipment to be removed and replaced within the finished building interior including tools and equipment needed for removal and transport of existing material highlighting requirements for passage through doorways, around pieces of equipment and access via maintenance elevator or other means of access; and
   4. A listing of all equipment and major tools needed for access, maintenance, and removal/replacement for each installed piece of equipment which includes hand trucks,
boom trucks, cranes, etc. This listing shall indicate if the Department currently owns such
equipment or tools or if the maintenance equipment will be provided as part of the
Design-Builder’s final work product. If new maintenance equipment will be provided to
the Department, the MHR must detail size, storage requirements, and/or means of
movement from maintenance storage buildings to individual pieces of equipment.

C. The Department reserves the right to reject:

1. Any Material Handling or installed equipment that did not receive prior Department
approval as part of a MHR detailed in this Section of the Technical Requirements;

2. A Maintenance Plan requiring demolition of permanent structure or portions thereof to
gain access to equipment;

3. A MHR requiring use of extraordinary, non-typical maintenance equipment requiring
excessive Department storage or non-routine maintenance; and

4. Substantially complete work failing to meet the requirements of the Department approved
MHR or these Technical Requirements. Any reconfiguration, replacement, demolition or
new construction to comply with the MHR and/or Technical Requirements will be
considered rejected work.

34.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 34.4-1 for the Department’s
consultation and written comment.

Table 34.4-1 Deliverables

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SECTION 35. TUNNEL SUPPORT AND FACILITY BUILDINGS

35.1. General
A. The Design-Builder shall provide the following buildings associated with the Project:
   1. Tunnel support buildings;
   2. Traffic operations center building;
   3. Facility maintenance building;
   4. New garage building;
   5. Crash house (wrecker trucks) buildings (one per island);
   6. Island inspection booths.

35.2. Standards and References
A. The applicable Standards and References as defined in Section [X] of these Technical Requirements are as follows:
   1. Construction and Professional Services Manual (CPSM);
   2. Virginia Uniform Statewide Building Code (USBC);
   3. Virginia Plumbing Code;
   4. Virginia Mechanical Code;
   8. Virginia Energy Conservation Code;
   9. ADA Standards for Accessible Design;
   10. 28CFR35 – Title II of the Americans with Disabilities Act (ADA); and
   11. 28CFR36 – Title III of the Americans with Disabilities Act (ADA).

35.3. Design Requirements

35.3.1. Tunnel support buildings
35.3.1.1. Building size and configuration
A. The new tunnel support buildings shall be located near each portal, over the tunnel. Each tunnel support building shall be designed to facilitate the electrical switchgear and communications equipment in separate rooms. The tunnel support buildings shall house rooms for the flood gates and necessary equipment, stairs and equipment elevators, storm drainage pumps, and fire pumps (as necessary). No personnel spaces are intended for the tunnel support buildings.

B. The exterior architectural design and materials shall complement the existing HRBT facility ventilation buildings.

35.3.1.2. Ancillary Building System Requirements
A. The new tunnel support buildings shall include UPS/battery backup rooms and a server room.

B. A minimum of one (1) bathroom facility shall be located in each tunnel support building.
C. An equipment closet, for use by state police or other state agencies, shall be provided. Coordinate with state police as necessary.

35.3.1.3. Other Requirements

A. The design of the interior of the tunnel support buildings shall be such that a pathway, for equipment and materials to be removed for maintenance or replacement, can be utilized as needed. A common loading bay may be used in lieu of individual loading bays for the various equipment rooms.

B. Man doors and rollup doors for occupant and equipment access shall be provided. Equipment hatches, with lifting points, shall be provided for equipment on lower levels of the tunnel support buildings to be moved to upper levels.

C. The equipment elevators shall be able to transport occupants and equipment to each level, including the tunnel, of the tunnel support buildings.

D. The design of the interior of the tunnel support buildings shall be such that routine maintenance and inspections of the building and systems can be accommodated.

35.3.2. Traffic operations center building

35.3.2.1. Building size and configuration

A. The new traffic operations center building shall be a one story building sized to house the control room for the complete facility, that being the existing HRBT facility and the proposed expansion, and provide offices for the existing operations staff personnel and additional personnel required for the expanded facility, as determined by the Department.

B. The new control room shall be of sufficient size to facilitate the daily operational duties and functions of the control room personnel for the complete facility.

C. The office portion of the new traffic operations center building shall be designed to house the existing HRBT operations staff as well as additional staff required to manage/operate the complete facility, as determined by the Department.

D. The new traffic operations center building shall be located on the north end of the north island. It shall be in-between the existing eastbound and westbound tubes or in-between the existing eastbound tube and new facility, whichever space can accommodate the new building and associated parking.

35.3.2.2. Ancillary building system requirements

A. The new control room shall include a video wall.

B. A dedicated server room shall be provided in the new traffic operations center building.

C. In addition to offices, the new traffic operations center shall include the following:

1. Meeting spaces;
2. Computer room with raised floor;
3. Restrooms; and
4. Locker rooms, including showers and change rooms.
35.3.2.3. **Other requirements**

A. The traffic operations center buildings shall also be equipped with the following systems:

1. Applicable security access (internal and external);
2. Applicable fire detection and alarm systems;
3. Appropriate HVAC systems; and
4. Emergency and backup power.

B. Other rooms, as required, for regular and daily maintenance/janitorial, storage, and mechanical equipment shall be included in the new building.

35.3.3. **Facility maintenance building**

35.3.3.1. **Building size and configuration**

A. The existing maintenance building, on the north island, shall be expanded to include three (3) more bays.

1. The new bays shall be consistent in size and architectural as the existing bay.

35.3.4. **New garage building**

35.3.4.1. **Building size and configuration**

A. A new garage building shall be constructed on the north island. It shall be located in-between the existing eastbound tube and new facility, near the south side of the island. The dimensions, architecture, and size (i.e. number of bays) shall match the existing garage building on the south island.

35.3.4.2. **Ancillary building requirements**

A. Other rooms, as required, for regular and daily maintenance/janitorial, storage needs, and mechanical equipment for the new building shall be included.

B. The new garage building shall also include:

1. Restrooms;
2. Applicable fire detection and alarm systems;
3. Appropriate HVAC systems; and
4. Emergency and backup power.

35.3.5. **Crash house buildings**

35.3.5.1. **Existing crash houses building size and modifications**

A. If the new traffic control center building is to be located in-between the existing eastbound and westbound tubes, then the existing crash house on the north island shall be demolished. A new crash shall be constructed in-between the existing eastbound tube and the new facility.

B. If the new traffic control center building is to be located in-between the existing eastbound tube and the new facility, then the existing crash house on the north island shall remain and be modified as follows:
1. Its capacity shall be doubled. The existing building shall be expanded to accommodate three (3) more vehicle bays, for a total of six (6). The new bays shall be consistent in size and architectural as the existing bays.

2. The office portion shall be expanded to accommodate twice the existing personnel.
   i. Additional restrooms, rooms for regular and daily maintenance/janitorial, storage, and mechanical equipment shall be included in the expanded building.
   ii. All existing systems (i.e. electrical, HVAC, fire detector, security, etc.) shall be upgraded to accommodate the larger building.

C. The existing crash house on the South Island shall be expanded to double its existing capacity.
   1. The new bays size, architectural design, and materials shall complement the existing bay.
   2. The office portion shall be expanded to accommodate twice the amount of existing personnel.
      i. Additional restrooms, rooms for regular and daily maintenance/janitorial, storage, and mechanical equipment shall be included in the expanded building.
      ii. All existing systems (e.g. electrical, HVAC, fire detector, security, etc.) shall be upgraded to accommodate the larger building.

35.3.5.2. New crash house building size and configuration

A. If a new crash house is to be constructed, on the north island, then it shall be designed to provide twice as much capacity as the existing building.
   1. The new crash shall have a minimum of six (6) large vehicle bays and an appropriate number of offices to house the assigned personnel. The new bays shall be no smaller than the bays of the existing building.
   2. Other rooms, as required, for regular and daily maintenance/janitorial, storage, and mechanical equipment for the new building shall be included.
   3. The new crash house building shall include:
      i. Restrooms;
      ii. Locker rooms, including showers and change rooms;
      iii. Applicable fire detection and alarm systems;
      iv. Appropriate HVAC systems; and
      v. Emergency and backup power.

35.3.6. Island inspection booth buildings

35.3.6.1. Building Size and Configuration

A. North island inspection booths.
   1. The existing inspection booth shall be demolished and removed.
   2. A new inspection booth shall be located on the north side of the north island, near the trestle abutment on the island. The location shall be close in proximity to the new tunnel to allow safe access to the new facility by VDOT personnel.
   3. The inspection booth shall be designed to house two (2) VDOT personnel.
   4. The booth shall include the following:
      i. One (1) restroom;
ii. Applicable fire detection and alarm systems;
iii. Appropriate HVAC systems; and
iv. Emergency and backup power.

B. South island inspection booths.

1. The existing inspection booth shall be demolished and removed.
2. A new inspection booth shall be located in the vicinity of the existing (westbound) inspection booth. The inspection booth shall be designed to house one (1) VDOT personnel.
3. A new inspection booth shall be located near the trestle abutment of the existing eastbound lanes. The inspection booth shall be designed to house one (1) VDOT personnel.
4. Both new booths shall include the following:
   i. One (1) restroom;
   ii. Applicable fire detection and alarm systems;
   iii. Appropriate HVAC systems; and
   iv. Emergency and backup power.

35.4. Deliverables

At a minimum, the deliverables shall include the items listed in Table 35.4-1 for the Department’s consultation and written comment.

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Number of Copies</th>
<th>Delivery Schedule</th>
<th>Reference Section</th>
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<tr>
<td></td>
<td>Hardcopy</td>
<td>Electronic</td>
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<tr>
<td>Exterior architectural design plan</td>
<td>5</td>
<td>1</td>
<td>60 days after NTP</td>
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