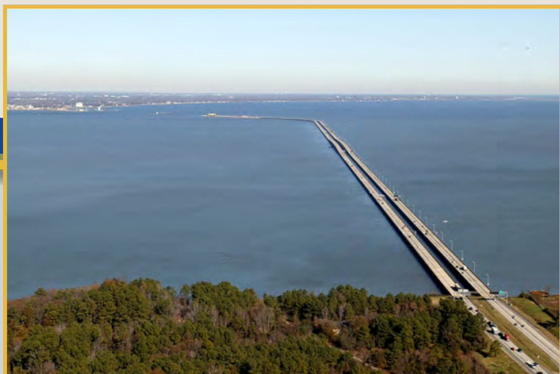
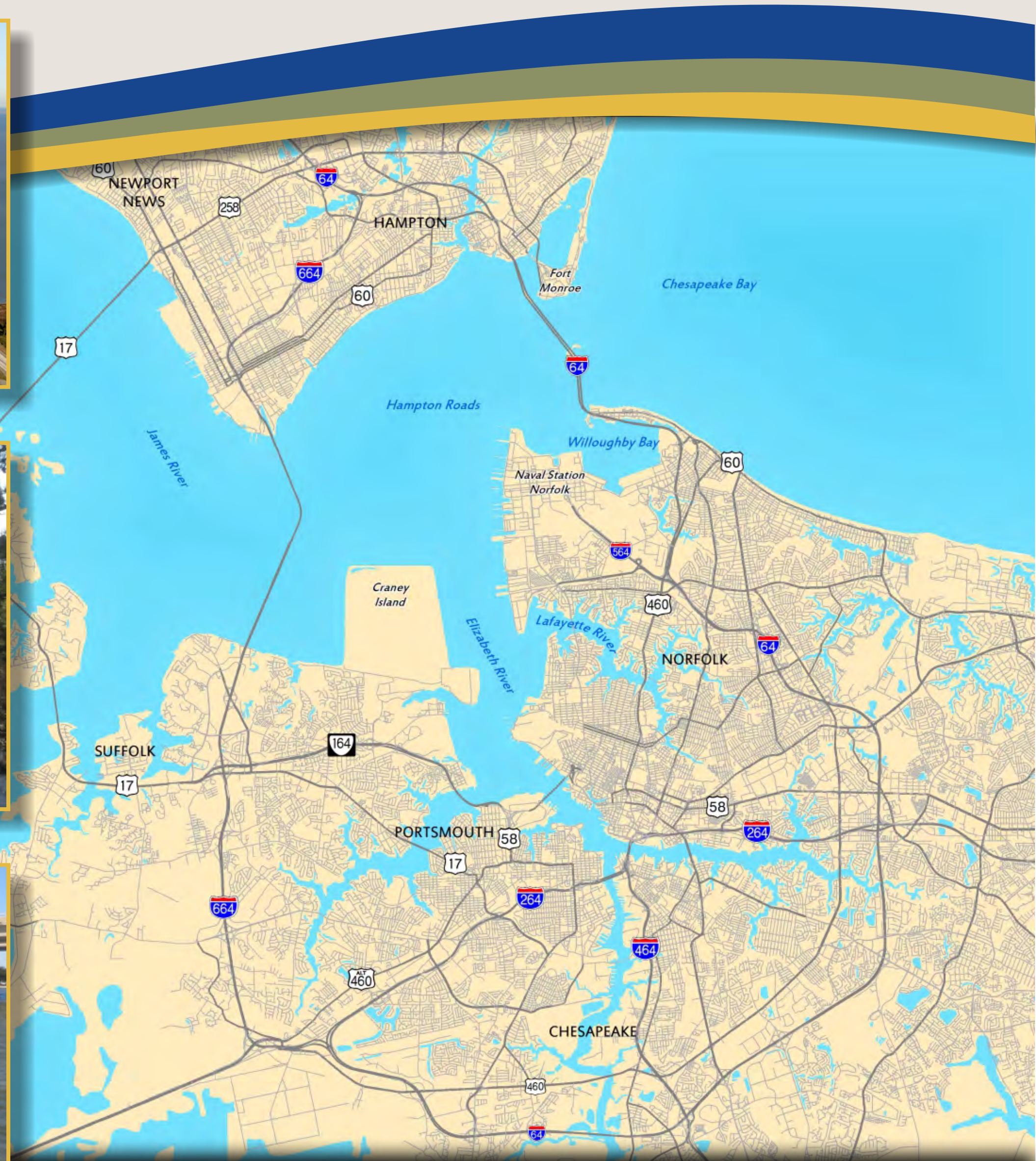
HRCS SEIS
Hampton Roads Crossing Study SEIS

Air Quality Technical Report

Prepared in Support of the Supplemental Environmental Impact Statement





VDOT
Virginia Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

July 2016

AIR QUALITY ANALYSIS TECHNICAL REPORT

HRCS SEIS
Hampton Roads Crossing Study SEIS

VDOT

Prepared in support of the Supplemental Environmental Impact Statement

VDOT Project #: 0064-965-081, P101

UPC#: 106724

July 2016

EXECUTIVE SUMMARY

The Virginia Department of Transportation (VDOT), in cooperation with the Federal Highway Administration (FHWA) as the lead federal agency, is preparing a Supplemental Environmental Impact Statement (SEIS) for the Hampton Roads Crossing Study (HRCS) located in the cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Suffolk, Virginia. Pursuant to the National Environmental Policy Act of 1969, as amended, (NEPA) and in accordance with FHWA regulations, the SEIS has been prepared to analyze the potential social, economic, and environmental effects associated with the proposed project[1,2]. The SEIS re-evaluates the findings of the 2001 HRCS Final Environmental Impact Statement (FEIS) and Record of Decision (ROD). The three alternatives retained for analysis in the 2001 FEIS, as well as input received from the public during initial scoping for the SEIS, were used to establish the Study Area Corridors.

NEPA requires consideration of whether the proposed action will have an adverse effect on air quality in the study area. Accordingly, quantitative carbon monoxide (CO) and Mobile Source Air Toxics (MSATs) analyses have been prepared. Additionally, qualitative analyses are provided for greenhouse gases as well as for indirect effects and cumulative impacts. For purposes of efficiency and quality control, all emission and dispersion modeling inputs (and worst-case traffic inputs for the CO analyses) were taken from or consistent with those specified in the VDOT Resource Document and associated online data repository[3,4].

The project was added to the Hampton Roads Transportation Planning Organization fiscal year (FY) 2012-2015 transportation improvement program (TIP) and the 2034 long range transportation plan (LRTP) as a study-only project on March 21, 2013 by the HRTPO Board.

Carbon Monoxide: Analyses for potential impacts for CO were conducted for the freeway, nearby intersections that might be impacted by the project, and the tunnels.

For the freeways and arterial street intersections, worst-case analyses for CO were conducted.

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[1] NEPA and FHWA's regulations for Environmental Impact and Related Procedures can be found at 42 USC § 4332(c), as amended, and 23 CFR § 771, respectively.

[2] The Hampton Roads region is currently in attainment of all of the National Ambient Air Quality Standards (NAAQS) established by the US Environmental Protection Agency (EPA) pursuant to requirements of the Clean Air Act (CAA). Note, effective April 6, 2015, EPA revoked the 1997 eight-hour ozone NAAQS for which the Hampton Roads region had previously been in attainment-maintenance. Therefore, the associated transportation conformity requirements that applied at the time that the FEIS was prepared no longer apply. See: https://www.gpo.gov/fdsys/pkg/FR-2015-03-06/pdf/2015-04012.pdf.

[3] The Resource Document was created by VDOT to facilitate and streamline the preparation of project-level air quality analyses. It is intended as a resource for modelers to help ensure that not only regulatory requirements and (as appropriate) guidance are met in all analyses but also high quality standards for modeling and documentation are consistently achieved. It addresses in a comprehensive fashion the models, methods and assumptions (including data and data sources) needed for the preparation of air quality analyses for transportation projects by or on behalf of the Department. It includes an associated online data repository to support project-level modeling.

[4] Copies of referenced VDOT documents (including the VDOT Resource Document and Programmatic Agreements) are available from the Department on request. Documents may also be obtained via the VDOT website: http://www.virginiadot.org/programs/pr-environmental.asp

- For freeways, interchanges are typically the focus for CO analyses. For this project, worst-case interchanges were identified based on Level of Service (LOS), traffic volumes, public access, and reasonableness. For the interchanges that were identified as the worst-case locations, CO concentrations were estimated using EPA models (MOVES2014a and CAL3QHC). A worst-case grade separation configuration was assumed that has receptors located in close proximity to the cross-over point (inside the right of way) where the highest modeled concentrations would be observed, i.e., representing worst-case placement of receptors. The results of the modeling for each of the short-listed (worst-case) interchanges indicate that, despite worst-case assumptions for traffic volumes, roadway configuration and receptor placement, the modeled worst-case CO concentrations remain well below the CO NAAQS at all receptor locations for each interchange.
- For intersections, worst-case locations for each alternative were identified from a list of 45 potential intersections that were ranked from worst to best based on peak volumes and LOS. The intersections that were identified as worst-case based on this ranking were then screened for modeling using the 2016 FHWA-VDOT "*Programmatic Agreement for Project-Level Air Quality Analyses for Carbon Monoxide*" (hereinafter "2016 Agreement"), which references screening criteria (primarily design year average daily traffic and intersection skew angle) that were previously established based on worst-case modeling for typical intersections. The worst-case modeling was conducted using EPA models and worst-case assumptions including peak hour traffic volumes, meteorology, receptor locations on the right of way edge, which together result in worst-case estimates for near-road concentrations. If the concentrations estimated using worst-case modeling for intersections still meet the applicable NAAQS, then the actual intersections would be expected to meet the NAAQS. For this project, all of the worst-case intersections for each alternative were found to meet the criteria for screening that were referenced in the 2016 Agreement, so it can be safely concluded that they would all meet the NAAQS.

Tunnels: The study evaluated the unique air quality issues associated with tunnels. The proposed project includes a series of new tunnels along the I-64, I-564 Connector, and I-664 Study Area Corridors. The tunnel air quality analysis addresses controlling the level of vehicle emissions to acceptable concentrations within the tunnel during normal conditions assuming the ventilation design is consistent with the normal ventilation air quantities as described and documented in the ASHRAE standards. The tunnel assessment would demonstrate that air quality in the new tunnels would be controlled consistent with current federal standards as well as FHWA/US EPA guidelines for CO concentrations[5] in tunnels. According to the ASHRAE standard, tests and operating experience have shown that when CO is adequately controlled, the other vehicle emission pollutants are likewise adequately controlled.

Mobile Source Air Toxics: The analysis also evaluated potential impacts from MSATs in the affected network which includes the Study Corridor. As the Study Alternatives are anticipated to add significant capacity to the existing and/or proposed new roadway networks where design year traffic is projected to be 140,000 to 150,000 annual average traffic (AADT) or greater, the Study Alternatives are best characterized as one with "High Potential MSAT Effects" under the 2012 FHWA interim guidance update document. Overall, the results of the MSAT analysis are consistent with the national MSAT emission trends predicted by MOVES and indicate that no meaningful increases in MSATs have been identified for any of the Build Alternatives and are not expected to cause an adverse effect on human health as a

[5] https://www.environment.fhwa.dot.gov/guidebook/vol1/doc1q.pdf

result of the Study Alternatives. There could be increases in MSAT levels in a few localized areas where VMT increases. However, EPA's vehicle and fuel regulations are expected to result in significantly lower MSAT levels in the future than exist today due to cleaner engine standards coupled with fleet turnover.

Greenhouse Gases: GHG emissions from vehicles using roadways are a function of distance traveled (expressed as vehicle miles traveled, or VMT), vehicle speed, and road grade. GHG emissions are also generated during roadway construction and maintenance activities.

While VMT will increase as a result of the project, the anticipated increase in GHGs will be mitigated by improvements in national fuel economy standards. The Energy Information Administration (EIA) projects that vehicle energy efficiency (and thus, GHG emissions) on a per-mile basis will improve by 28 percent between 2012 and 2040. This improvement in vehicle emissions rates will help to offset the increase in VMT. Nationally, the Energy Information Administration (EIA) estimates that VMT will increase by approximately 38 percent between 2012 and 2040. While VMT is expected to increase under the Build Alternatives, the increase is still at or below the projected national rate and much below the national rate when comparing the increase between the Build and No-Build Alternatives

In addition, the project Alternatives would improve vehicle speeds by constructing new roadway segments and increasing the capacity (i.e. lanes) in existing segments (providing an extra lane so that motorists can more easily pass slow-moving vehicles.) GHG emissions rates decrease with speed over the range of average speeds encountered in this corridor. Finally, the project Alternatives will decrease congestion and thereby reduce accident rates through improved access across the Hampton Roads waterway, dedicated transit facilities in specific locations along with Bus Rapid Transit (BRT), and converting existing lanes to dedicated transit lanes only; the safety improvements associated with the planned upgrades would produce emissions benefits by reducing vehicle delay and idling.

Indirect Effects and Cumulative Impacts: The CO and MSAT quantitative assessments are considered indirect effects analyses because they address air quality impacts attributable to the project that occur at a later time in the future. Those assessments indicate the potential for indirect effects associated with the project is not expected to be significant. They demonstrate that in the future: 1) air quality impacts from CO would not cause or contribute to violations of the CO NAAQS; and 2) MSAT emissions from the affected network would be significantly lower than they are today.

Regarding the potential for cumulative impacts, EPA's air quality designations for the region reflect, in part, the accumulated mobile source emissions from past and present actions. Since EPA has designated the region to be in attainment of all of the NAAQS, the potential for cumulative impacts associated with the project is not expected to be significant.

Overall, the potential for indirect effects and cumulative impacts associated with the project is not expected to be significant.

Construction Emissions: Emissions produced during the construction of the Preferred Alternative would be short-term or temporary in nature. In order to mitigate these emissions, construction activities will be performed in accordance with VDOT "*Road and Bridge Specifications*". The specifications require compliance with all applicable local, state, and federal regulations. Additionally, the following Virginia Department of Environmental Quality (VDEQ) air pollution regulations will be adhered to during the construction: 9 VAC 5-130 et seq., *Open Burning restrictions*, 9 VAC 5-45, Article 7 et seq., *Cutback Asphalt restrictions*, and 9 VAC 5-50, Article 1 et seq., *Fugitive Dust precautions*.

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1. INTRODUCTION

Potential air quality impacts associated with the proposed Hampton Roads Crossing Study (HRCS) in the Cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Suffolk (the Hampton Roads Area) were assessed. The purpose of the project is to relieve congestion at the I-64 Hampton Roads Bridge-Tunnel (HRBT) in a manner that improves accessibility, transit, emergency evacuation, and military and goods movement along the primary transportation corridors in the Hampton Roads region, including the I-64, I-664, I-564, and Route 164 corridors.

Federal funding is involved with the Study Alternatives; therefore, compliance with NEPA and the Clean Air Act and Amendments (CAA) is required. NEPA requires a discussion of the transportation-related air quality concerns in the study area and a summary of any carbon monoxide analysis performed. Note, as the Hampton Roads region is in attainment of all of the National Ambient Air Quality Standards (NAAQS)[6] established by the US Environmental Protection Agency (EPA) pursuant to requirements of the Clean Air Act (CAA), EPA transportation conformity rule requirements do not apply.

1.1 PROJECT DESCRIPTION

The Virginia Department of Transportation (VDOT), in cooperation with the Federal Highway Administration (FHWA) as the lead federal agency, is preparing a Supplemental Environmental Impact Statement (SEIS) for the Hampton Roads Crossing Study (HRCS). The Study is located in the cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Suffolk, Virginia. The SEIS re-evaluates the findings of the 2001 HRCS Final Environmental Impact Statement (FEIS) and Record of Decision (ROD). The three alternatives retained for analysis in the 2001 FEIS, as well as input received from the public during initial scoping for the SEIS, were used to establish the Study Area Corridors shown in **Figure 1-1**. The purpose and need of the SEIS is summarized below.

Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, FHWA is preparing an SEIS because of the time that has lapsed since the 2001 FEIS and new information indicating significant environmental impacts not previously considered. The SEIS, prepared in accordance with the implementing regulations of NEPA (23 CFR §771.130), is intended to aid in ensuring sound decision-making moving forward by providing a comparative understanding of the potential effects of the various options.

The purpose of this *HRCS Technical Report* is to provide documentation of the air quality assessments that have been performed to determine whether this project meets all NEPA and CAA requirements. Information in this report, described below, will support discussions presented in the SEIS.

- **Section 1** provides an overview of the study and outlines the methods used to assess air quality impacts from the project alternatives under consideration.

[6] EPA revoked the 1997 eight-hour ozone NAAQS in its entirety effective April 6, 2015, for which the Hampton Roads region had previously been in maintenance. Therefore, the associated transportation conformity requirements that applied at the time that the FEIS was prepared no longer apply.

- **Section 2** describes the air quality regulatory programs and standards to which the project is subject.
- **Section 3** presents the existing air quality conditions (affected environment) in the project area.
- **Section 4** assesses the potential impacts to air quality associated with the alternatives under consideration.
- **Section 5** assesses the potential impacts to air quality of a new tunnel under the Chesapeake Bay.
- **Section 6** is a qualitative assessment of greenhouse gas emissions resulting from the project.
- **Section 7** describes the indirect effects and cumulative impacts of the project.
- **Section 8** describes the potential air emissions resulting from project construction.
- **Section 9** presents proposed mitigation measures.

1.1.1 Purpose and Need

The purpose of the HRCS is to relieve congestion at the I-64 Hampton Roads Bridge-Tunnel (HRBT) in a manner that improves accessibility, transit, emergency evacuation, and military and goods movement along the primary transportation corridors in the Hampton Roads region, including the I-64, I-664, I-564, and Route 164 corridors. The HRCS will address the following needs (in the order of presentation in Chapter 1 of the Draft SEIS):

- Accommodate travel demand – capacity is inadequate on the Study Area Corridors, contributing to congestion at the HRBT;
- Improve transit access – the lack of transit access across the Hampton Roads waterway;
- Increase regional accessibility – limited number of water crossings and inadequate highway capacity and severe congestion decrease accessibility;
- Address geometric deficiencies – insufficient vertical and horizontal clearance at the HRBT contribute to congestion;
- Enhance emergency evacuation capability – increase capacity for emergency evacuation, particularly at the HRBT;
- Improve strategic military connectivity – congestion impedes military movement missions; and,
- Increase access to port facilities – inadequate access to interstate highway travel in the Study Area Corridors impacts regional commerce.

1.1.2 Alternatives

Five alternatives, including the No-Build Alternative, are under consideration for the Draft SEIS and are assessed in this Technical Report. The proposed limits of the four Build Alternatives are shown on **Figure 1-2**. Each Technical Report and Memorandum prepared in support of the Draft SEIS assesses existing conditions and environmental impacts along the Study Area Corridors (**Figure 1-1**) for each alternative. Each alternative is comprised of various roadway alignments, used to describe the alternatives and proposed improvements, shown on **Figure 1-3**.

The No-Build Alternative

This alternative includes continued routine maintenance and repairs of existing transportation infrastructure within the Study Area Corridors, but there would be no major improvements.

Alternative A

Alternative A begins at the I-64/I-664 interchange in Hampton and creates a consistent six-lane facility by widening I-64 to the I-564 interchange in Norfolk. A parallel bridge-tunnel would be constructed west of the existing I-64 HRBT. Alternative A begins at the I-64/I-664 interchange in Hampton and creates a consistent six-lane facility by widening I-64 to the I-564 interchange in Norfolk. A parallel bridge-tunnel would be constructed west of the existing I-64 HRBT. During the public review of the HRBT DEIS, there was a clear lack of public or political support for the level of impacts associated with any of the build alternatives. Specifically, potential impacts to the historic district at Hampton University, Hampton National Cemetery, and the high number of displacements were key issues identified by the public, elected officials, and University and Veterans Affairs officials. Given this public opposition, a Preferred Alternative was not identified and the study did not advance. On August 20, 2015, FHWA rescinded its Notice of Intent to prepare the HRBT DEIS, citing public and agency comments and concerns over the magnitude of potential environmental impacts to a variety of resources, such as impacts to historic resources as well as communities and neighborhoods. Consequently, VDOT and FHWA have committed that improvements proposed in the HRCS SEIS to the I-64 corridor would be largely confined to existing right-of-way. To meet this commitment, Alternative A considers a six-lane facility. Alternative A lane configurations are summarized in **Table 1-1**.

Table 1-1: Alternative A Lane Configurations

Roadway Alignments	Existing Lanes	Proposed Lanes
I-64 (Hampton)	4-6	6
I-64 (HRBT and Norfolk)	4	6

Alternative B

Alternative B includes all of the improvements included under Alternative A, and the existing I-564 corridor that extends from its intersection with I-64 west towards the Elizabeth River. I-564 would be extended to connect to a new bridge-tunnel across the Elizabeth River (I-564 Connector). A new roadway (VA 164 Connector) would extend south from the I-564 Connector, along the east side of the Craney Island Dredged Material Management Area (CIDMMA), and connect to existing VA 164. VA 164 would be widened from this intersection west to I-664. Alternative B lane configurations are summarized in **Table 1-2**.

Figure 1-1: HRCS Study Area Corridors

Table 1-2: Alternative B Lane Configurations

Roadway Alignments	Existing Lanes	Proposed Lanes
I-64 (Hampton)	6	6
I-64 (HRBT and Norfolk)	4	6
I-564	6	6
I-564 Connector	none	4
VA 164 Connector	none	4
VA 164	4	6

Note: The I-564 Intermodal Connector (IC) project is separate from HRCS that lies between the I-564 Connector and I-564. It would be constructed regardless of whether the HRCS improvements are made and therefore is included under the No-Build Alternative and is not listed with other proposed improvements.

Alternative C

Alternative C includes the same improvements along I-564, the I-564 Connector, and the VA 164 Connector that are considered in Alternative B. This alternative would not propose improvements to I-64 or VA 164 beyond the VA 164 Connector. Alternative C includes dedicated transit facilities in specific locations. DRPT completed a study in November 2015 that recommended high frequency bus rapid transit (BRT) service in a fixed guideway or in a shared high occupancy vehicle (HOV) or high occupancy toll (HOT) lanes (DRPT, 2015). Based on that recommendation, for the purposes of this Draft SEIS, transit assumes Bus Rapid Transit (BRT). In the Final SEIS, transit could be redefined or these lanes may be used as managed lanes. Alternative C converts one existing HOV lane in each direction on I-564 in Norfolk to transit only. The I-564 Connector and the I-664 Connector would be constructed with transit only lanes. This alternative also includes widening along I-664 beginning at I-664/I-64 in Hampton and continuing south to the I-264 interchange in Chesapeake. One new transit lane is included along I-664 between I-664/I-64 in Hampton and the new interchange with the I-664 Connector. Alternative C lane configurations are summarized in **Table 1-3**.

Table 1-3: Alternative C Lane Configurations

Roadway Alignments	Existing Lanes	Proposed Lanes
I-664 (from I-64 to the proposed I-664 Connector)	4-6	8 + 2 Transit Only
I-664 (from the proposed I-664 Connector to VA 164)	4	8
I-664 (from VA 164 to I-264)	4	6
I-564	6	4 + 2 Transit Only
I-564 Connector	none	4 + 2 Transit Only
VA 164 Connector	none	4
I-664 Connector	none	4 + 2 Transit Only

Note: The I-564 IC project is a separate project from HRCS that lies between the I-564 Connector and I-564. It would be constructed regardless of whether the HRCS improvements are made and therefore is included under the No-Build Alternative and is not listed with other proposed improvements.

Alternative D

Alternative D is a combination of the sections that comprise Alternatives B and C. Alternative D lane configurations are summarized in **Table 1-4**.

Table 1-4: Alternative D Lane Configurations

Roadway Alignments	Existing Lanes	Proposed Lanes
I-64 (Hampton)	4-6	6
I-64 (HRBT and Norfolk)	4	6
I-664 (from I-64 to VA 164)	4-6	8
I-664 (from VA 164 to I-264)	4	6
I-664 Connector	None	4
I-564	6	6
I-564 Connector	none	4
VA 164 Connector	none	4
VA 164	4	6

Note: The I-564 IC project is a separate project from HRCS that lies between the I-564 Connector and I-564. It would be constructed regardless of whether the HRCS improvements are made and therefore is included under the No-Build Alternative and is not listed with other proposed improvements.

Figure 1-2: Build Alternatives

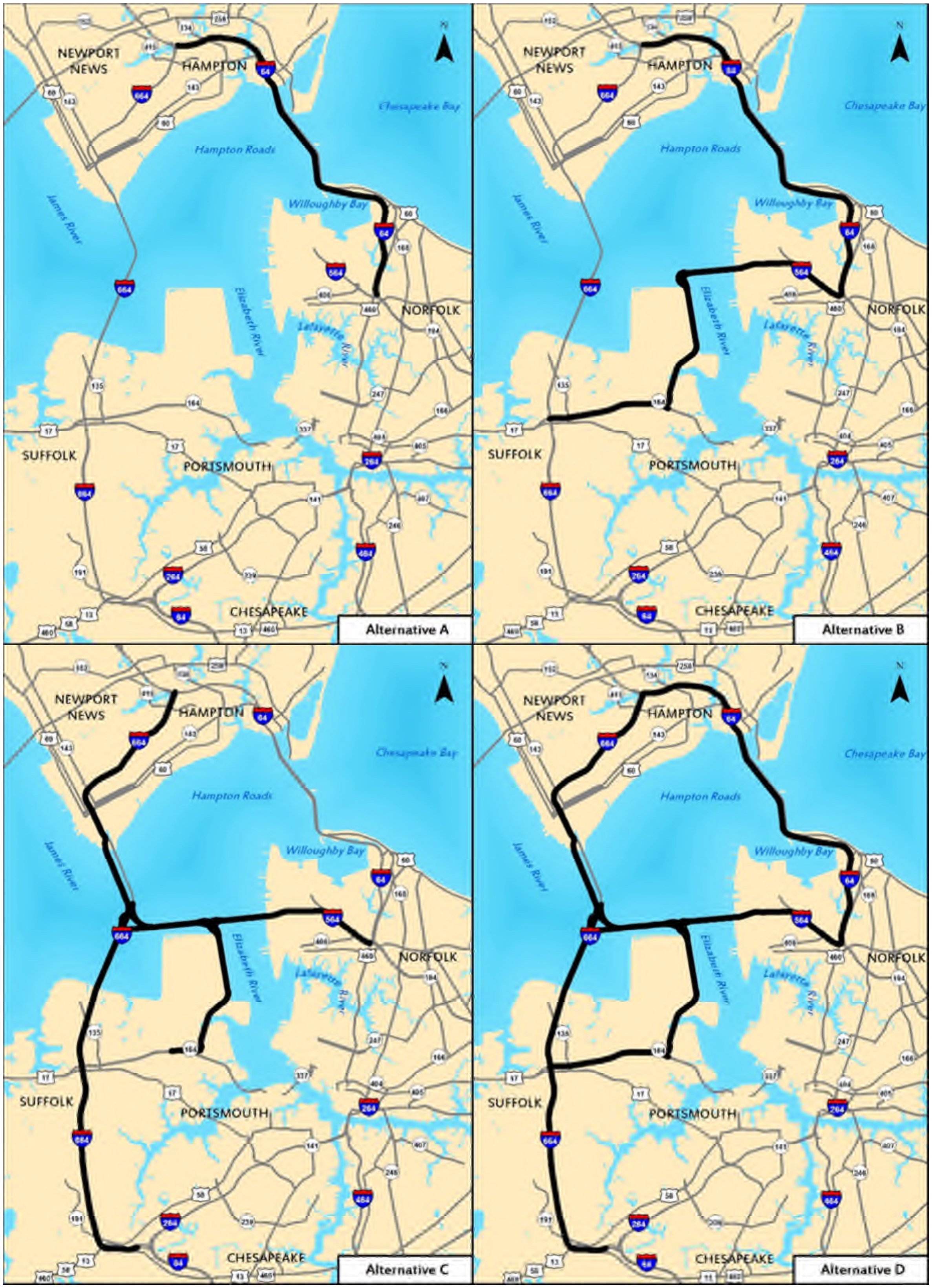
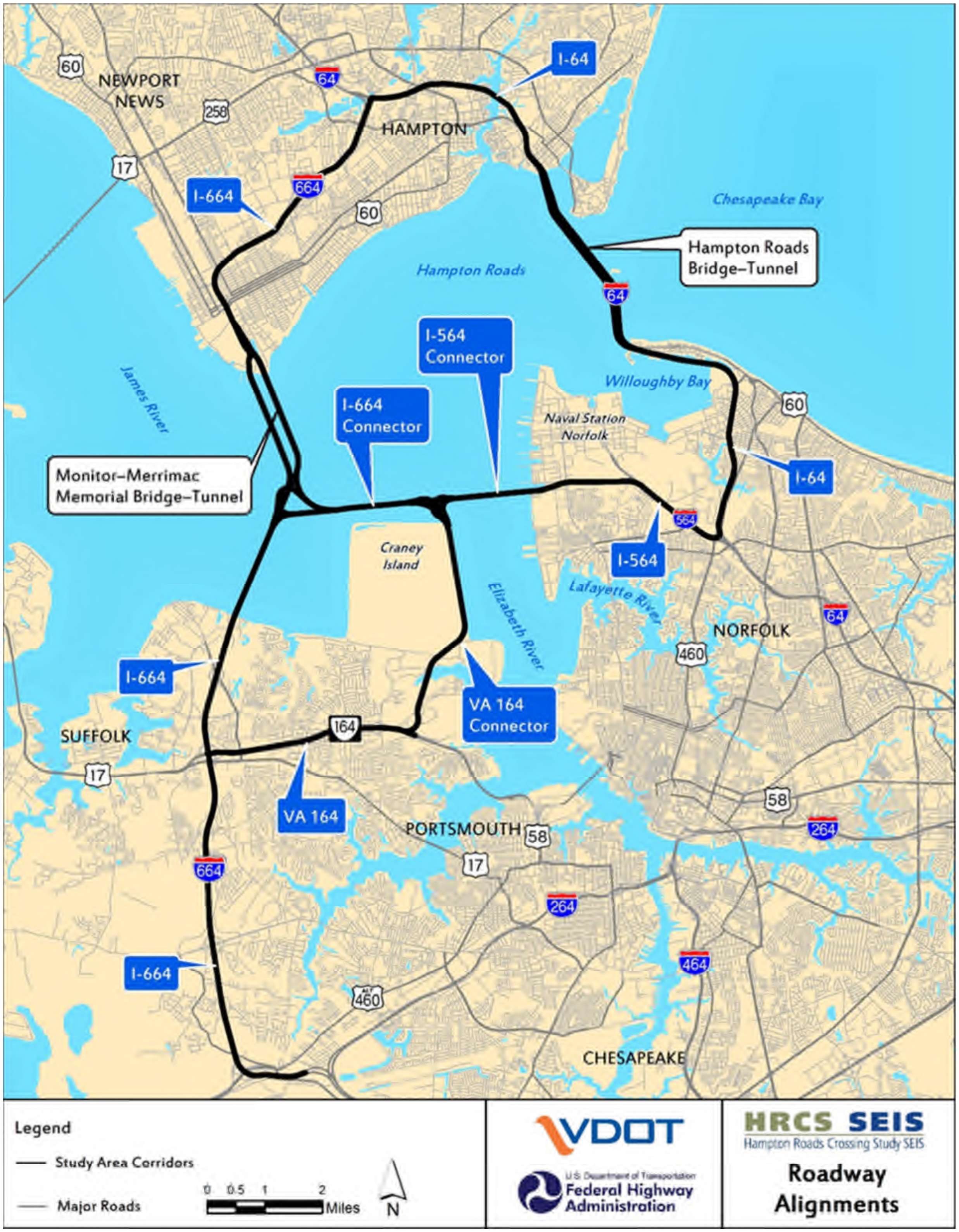


Figure 1-3: Roadway Alignments



1.1.3 Operationally Independent Sections

Given the magnitude and scope of the alternatives, it is expected that a Preferred Alternative would be constructed in stages or operationally independent sections (OIS). An OIS is a portion of an alternative that could be built and function as a viable transportation facility even if other portions of the alternative are not advanced. The OIS are comprised of various roadway alignments and were developed by identifying sections of roadway improvements that if constructed, could function independently.

1.2 METHODOLOGY

For the purposes of this analysis, the Study Area Corridors for detailed evaluation are generally defined as 250 feet on either side of the centerline of I-64, I-564, I-664, Route 164 and proposed new alignments (see **Figure 1-1**). Areas around the interchanges included in the Study Area Corridors vary based on the footprint of proposed modifications. For example, where proposed modifications would mainly consist of tying into existing ramps, the footprint of the interchange would be smaller and therefore the surrounding area around the interchange included for study would be smaller. The surrounding area included for study would be larger around the footprints of more extensively modified or newly proposed interchanges.

In this report, several individual air quality assessments are presented for different air quality pollutants. Carbon monoxide is in Section 4.1; particulate matter in Section 4.2; mobile source air toxics in Section 4.3; the tunnel assessment in Section 5; greenhouse gases in Section 6, and indirect effects and cumulative impacts in Section 7. The methodology for each analysis is presented in the applicable section.

For purposes of efficiency and quality control, all emission and dispersion modeling inputs (and worst-case traffic inputs for the CO analyses) were taken from or are consistent with those specified in the VDOT Project-Level Air Quality Analysis Resource Document and associated online data repository[7].

[7] The Project-Level Air Quality Analysis Resource Document was created by VDOT to facilitate and streamline the preparation of project-level air quality analyses. It is intended as a resource for modelers to help ensure that not only regulatory requirements and (as appropriate) guidance are met in all analyses but also high quality standards for modeling and documentation are consistently achieved. It addresses in a comprehensive fashion the models, methods and assumptions (including data and data sources) needed for the preparation of air quality analyses for transportation projects by or on behalf of the Department. It includes an associated online data repository to support project-level modeling.

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2. REGULATORY REQUIREMENTS

This section provides an overview of regulations and guidance applicable to the project-level air quality analysis. Copies of referenced VDOT documents (including the VDOT Resource Document and Programmatic Agreements) are available from the Department[8].

2.1 NATIONAL ENVIRONMENTAL POLICY ACT

NEPA applies to all federally-funded projects. Air quality is an environmental concern within the broad purview of NEPA. The requirements of NEPA have been defined in the Council of Environmental Quality's (CEQ) NEPA regulations that apply to all federal agencies and the FHWA/FTA joint NEPA procedures. The text of the NEPA statute, the CEQ NEPA regulations (40 CFR 1500) and FHWA's NEPA regulations (23 CFR 771) however do not contain specific requirements for air quality analyses. For air quality, FHWA has issued guidance for MSAT and CO analyses.

2.2 MOBILE SOURCE AIR TOXICS (MSATs)

In December of 2012, FHWA issued the Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA[9]. The update reflects the recent implementation of the EPA Motor Vehicle Emission Simulator (MOVES) model for estimating MSAT emissions from mobiles sources along with updating the scientific research in the MSAT arena.

The EPA identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer drivers from their 1999 National Air Toxics Assessment. The seven compounds identified were acrolein, benzene, 1, 3-butadiene, diesel particulate matter plus diesel exhaust organic gases, formaldehyde, naphthalene, and polycyclic organic matter (POM). While FHWA considers these the priority mobile source air toxics, the list is subject to change and may be adjusted in consideration of future EPA rules.

The FHWA guidance presents a tiered approach for assessing MSATs in NEPA documents and identified three levels of analysis. The three levels are for projects with no meaningful MSAT effects, low potential MSAT effects, and high potential MSAT effects respectively. The FHWA guidance defines the levels of analysis for each type of MSAT effect:

- No analysis for projects with no potential for meaningful MSAT effects;
- A qualitative analysis for projects with low potential MSAT effects; and
- A quantitative analysis for projects with high potential MSAT effects.

The Study Alternatives were evaluated against each threshold criteria in order to determine the type of MSAT analysis required to satisfy NEPA.

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8 Documents may also be obtained via the VDOT website: http://www.virginiadot.org/programs/pr-environmental.asp

9 FHWA (December 2012) http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/aqintguidmem.cfm.

2.3 CARBON MONOXIDE

In 1987, FHWA issued a Technical Advisory[10] providing guidance for preparing and processing of environmental impacts for Environmental Assessments (EA) and Environmental Impact Statements (EIS) under NEPA. Section V(G)(8) pertains to air quality including a summary of the project related carbon monoxide (CO) analysis. Two types of analyses are discussed: mesoscale and microscale. The mesoscale analysis is a regional analysis consisting of nitrogen oxide (NO_x), ozone (O_3) and hydrocarbons. Where these pollutants are an issue, a mesoscale analysis may be undertaken to evaluate the regional impacts of the project. A microscale analysis is a localized study where air quality dispersion modeling may be required to demonstrate that project related CO impacts are below the National Ambient Air Quality Standards (NAAQS). Over time, VDOT and FHWA have developed programmatic agreements to streamline the analysis requirements for projects using worst-case modeling results consistent with U.S. EPA and FHWA guidance. Section 2.6 presents a summary of the latest Programmatic Agreement which sets the procedures and thresholds recommended for a CO air quality study for projects in Virginia.

2.4 PARTICULATE MATTER

The Study Corridor is located in an area which is designated as attainment for the coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$) NAAQS; therefore, transportation conformity requirements pertaining to particulate matter do not apply for this Project. Regardless, the latest 2012-2014 monitoring data reported by the VDEQ show that the 24-hour and annual $PM_{2.5}$ background concentrations throughout the study corridor are 17 micrograms per cubic meter ($\mu g/m^3$) and 7.5 $\mu g/m^3$, respectively, which are both well below the respective $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$ and 12 $\mu g/m^3$.

2.5 EPA MOVES MODEL

On October 7, 2014, the EPA published a Federal Register Notice of Availability that approved the Motor Vehicle Emissions Simulator (MOVES2014) as the latest EPA tool for estimating emissions of volatile organic compounds (VOCs), nitrogen oxide (NO_X), CO, PM_{10}, $PM_{2.5}$ and other pollutants from motor vehicles. With this release, EPA started a 2-year grace period to phase in the requirement of using MOVES2014 for transportation conformity analyses. In July 2014, EPA issued guidance on the use of MOVES2014 for State Implementation Plan Development, Transportation Conformity, and Other Purposes. This guidance specifies that the same grace period be applied to project-level emissions analyses. At the end of the grace period, i.e., beginning October 7, 2016, project sponsors are required to use MOVES2014 to conduct emissions analysis. In March 2015, EPA published a new guidance document[11] for completing project-level carbon monoxide analyses using MOVES2014. CO and MSAT vehicle emission rates were estimated for this study using the latest official version of the EPA MOVES model (MOVES 2014a).

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[10] FHWA Technical Advisory, "Guidance for Preparing and Processing Environmental and Section 4(F) Documents", October 30, 1987. https://www.environment.fhwa.dot.gov/projdev/impta6640.asp

[11] EPA, "Using MOVES2014 in a Project-Level Carbon Monoxide Analysis", March 2015, EPA-420-B-15-028.

2.6 PROGRAMMATIC AGREEMENTS

Programmatic agreements are legal documents between the US Department of Transportation (DOT) and a state DOT that are designed to help streamline the environmental clearance process for transportation projects. Programmatic agreements can help focus limited resources on assessing larger projects with greater potential for air quality impacts.

On May 16, 2016, FHWA and VDOT implemented a "*Programmatic Agreement for Project-Level Air Quality Analyses for Carbon Monoxide*" (hereinafter "2016 Agreement") that was developed based on a national template that was created in a recently completed National Cooperative Highway Research Program (NCHRP) study[12]. The NCHRP template was designed to be applied using state-specific background concentrations and persistence factors, without the need to update the detailed worst-case CO modeling as presented in its Technical Support Document (TSD). The 2016 Agreement uses number of lanes and other criteria to screen projects involving highway links, unskewed intersections and interchanges with adjacent unskewed intersections.

As the new NCHRP template agreement does not include skewed intersections, the 2016 FHWA-VDOT Agreement incorporates by reference the previously existing 2009 FHWA-VDOT "*Project-Level Carbon Monoxide Air Quality Studies Agreement"* (hereinafter "2009 Agreement") that did include skewed intersections. Under the terms of the 2009 Agreement, project-level air quality (hot-spot) analyses are typically only conducted for CO for projects that exceed specified ADT and level of service thresholds or for any project for which an Environmental Impact Statement is being prepared. Different ADT thresholds are specified for different intersection skew angles. Worst-case ranked intersections and interchanges that cannot be screened using the Agreement are quantitatively assessed using worst-case modelling assumptions for CO consistent with the VDOT Resource Document.

Projects that meet the criteria specified in the 2016 Agreement (or by reference the thresholds from the 2009 Agreement) do not require project-specific modelling for CO. For those projects, the air quality analysis can simply reference as appropriate the 2016 Agreement and the worst-case modelling for CO on which its thresholds/criteria are based.

2.7 CLEAN AIR ACT

2.7.1 National Ambient Air Quality Standards

Pursuant to the Federal CAA of 1970, the EPA established National Ambient Air Quality Standards (NAAQS) for major pollutants known as "criteria pollutants." Currently, the EPA regulates six criteria pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter, and lead (Pb). Particulate matter (PM) is divided into two particle size categories: particles with a diameter less than 10 micrometers (PM_{10}) and those with a diameter of less than 2.5 micrometers ($PM_{2.5}$). **Table 2-1** shows the primary and secondary NAAQS for the criteria pollutants. The NAAQS are two-tiered: the first tier (primary) is intended to protect public health; the second tier (secondary) is intended to protect public welfare and prevent degradation of the environment.

[12] ICF International, Zamurs and Associates LLC, and Volpe Transportation Systems Center, "*Programmatic Agreements for Project-Level Air Quality Analyses*", NCHRP 25-25 (78), 2015. See: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3311

Table 2-1: National Ambient Air Quality Standards[13]

Pollutant	Averaging Time	Primary Standards [1,2]	Secondary Standards [1,3]
CO	8- hour	9 ppm (10 mg/m^3)	None
	1-hour	35 ppm	
Lead	Rolling 3-Month Average[5]	0.15 µg/m^3	Same as Primary
NO_2	Annual Arithmetic Mean	0.053 ppm (100 µg/m^3)	Same as Primary
	1-hour	0.100 ppm[6]	None
0_3	8-hour (2015 standard)[10]	0.070 ppm	Same as Primary
	8-hour (2008 standard)	0.075 ppm	Same as Primary
	8-hour (1997 standard)	0.08 ppm	Same as Primary
$PM_{2.5}$	Annual Arithmetic Mean	12 µg/m^3 [4,9]	15 µg/m^3
	24-hour	35 µg/m^3	Same as Primary
PM_{10}	24-Hours	150 µg/m^3[4]	Same as Primary
SO_2	1-hour	75 ppb[8]	None
	3-hour	None	0.5 ppm

Notes:
1. National standards (other than ozone, particulate matter, and those based on annual averages) are not to be exceeded more than once per year.
2. Primary Standards: Levels necessary to protect public health with an adequate margin of safety.
3. Secondary Standards: Levels necessary to protect the public from any known or anticipated adverse effects.
4. For PM_{10}, the 24-hour standard not to be exceeded more than once per year on average over 3 years. For $PM_{2.5}$, the 24-hour standard is attained when 98% of the daily concentrations, averaged over three years, are equal to or are less than the standard.
5. National lead standard, rolling three-month average: final rule signed October 15, 2008.
6. To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 0.100 ppm (effective January 22, 2010).
7. EPA revoked the 1-hour ozone standard in all areas; however, some areas have continuing obligations under that standard.
8. Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.
9. EPA updated the NAAQS for $PM_{2.5}$ to strengthen the primary annual standard to 12ug/m^3.
10. EPA updated the NAAQS for Ozone to strengthen the primary 8-hour standard to 0.07 ppm on October 1, 2015. An area will meet the standard if the fourth-highest maximum daily 8-hour ozone concentration per year, averaged over three years is equal to or less than 70 ppb.

Section 176(c) of the CAA requires federal agencies to ensure that all of their actions conform to applicable implementation plans for achieving and maintaining the NAAQS. Federal actions must not cause or contribute to any new violation of any standard, increase the frequency or severity of any existing violation, or delay timely attainment of any standard.

[13] https://www.epa.gov/criteria-air-pollutants/naaqs-table (accessed on May 23, 2016).

The NAAQS apply to the concentration of a pollutant in outdoor ambient air. If the air quality in a geographic area is equal to or is better than the national standard, EPA will designate the region as an attainment area. Areas where air quality does not meet the national standards are designated as non-attainment areas. Once the air quality in a non-attainment area improves to the point where it meets the standards and the additional redesignation requirements in the CAA [Section 107(d)(3)(E)], EPA may redesignate the area as an attainment/maintenance area, which are typically referred to as "maintenance areas."

The CAA requires EPA to designate the status of all areas as being in or out of compliance with the NAAQS. The CAA further defines non-attainment areas for ozone based on the severity of the violation as marginal, moderate, serious, severe, and extreme.

2.8 DESCRIPTION OF PROJECT-LEVEL CRITERIA POLLUTANTS

Carbon monoxide (CO) is a toxic colorless and odorless gas that results from the incomplete combustion of gasoline and other fossil fuels. Because CO disperses quickly the concentrations can vary greatly over relatively short distances. Relatively high concentrations of CO may occur near congested intersections, along heavily used roadways conveying slow-moving traffic, and in areas where atmospheric dispersion is inhibited by urban "street canyon" conditions.

Particulate matter (PM) is a broad class of air pollutants that exists as liquid droplets or solids, with a wide range of size and chemical composition. It is emitted by a variety of sources, both natural and man-made. Major man-made sources of PM include the combustion of fossil fuels in vehicles, power plants and homes, construction activities, agricultural activities, and wood-burning fireplaces. Smaller particulates less than or equal to 10 and 2.5 microns in size (PM_{10} and $PM_{2.5}$) are of particular health concern because they can get deeper into the lungs and affect respiratory and heart function.

2.9 TRANSPORTATION CONFORMITY

EPA promulgated the transportation conformity rule (40 CFR Parts 51 and 93) pursuant to requirements of the CAA. The rule **only** applies in EPA designated non-attainment or maintenance areas (40 CFR 93.102(b))[14]. As noted in the next section, the Hampton Roads area is in attainment of all of the applicable NAAQS; therefore, transportation conformity rule requirements do not apply for this region.

[14] See: https://www.gpo.gov/fdsys/pkg/CFR-2015-title40-vol20/xml/CFR-2015-title40-vol20-sec93-102.xml

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3. EXISTING CONDITIONS

3.1 AIR QUALITY ATTAINMENT STATUS OF THE PROJECT AREA

The EPA Green Book[15], which lists non-attainment, maintenance, and attainment areas, was reviewed to determine the designations for the jurisdictions within Hampton Roads in which the project is located. These include Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Suffolk.

The EPA Green Book shows that all of the jurisdictions in the region, including those spanning the entire project corridor, are designated as being in attainment for all of the NAAQS[16].

3.2 CLIMATE AND METEOROLOGY

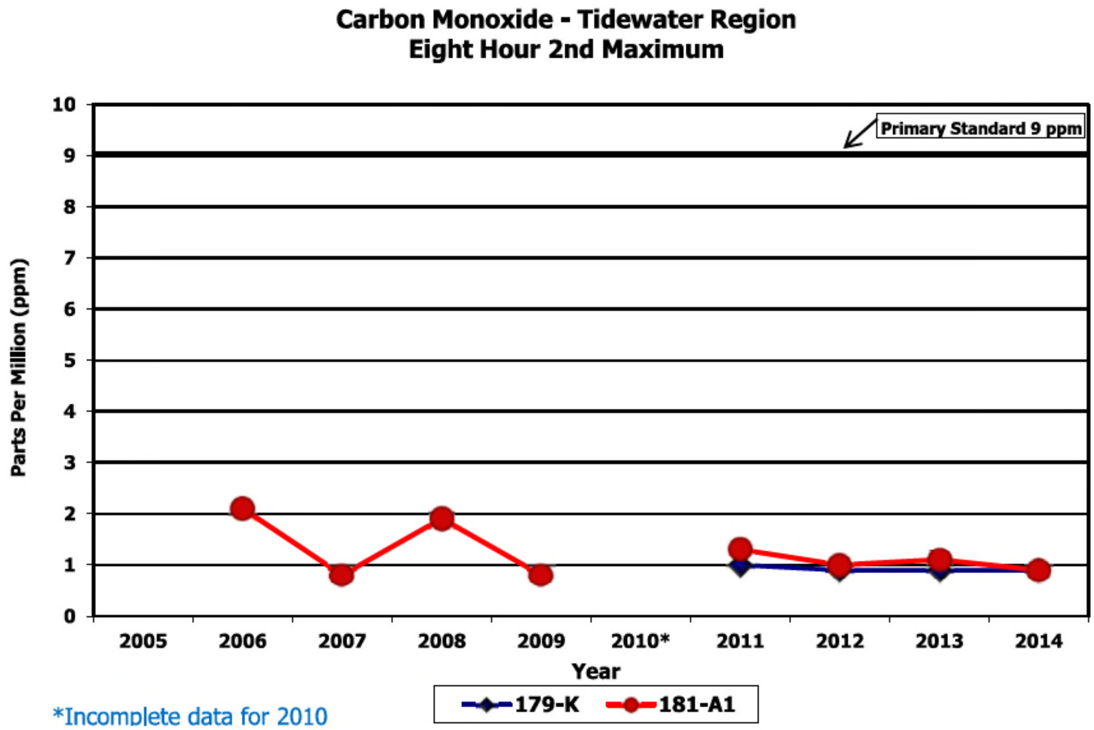
The climate of the area in which the project is located is influenced by the ocean with four distinct seasons. Winters are mild with limited snowfall and summers are hot and humid. Based on data provided by the National Weather Service, the average annual temperature for the Norfolk area is 60.3 degrees Fahrenheit. The area typically receives 48.8 inches of rainfall annually and up to 6.7 inches of snow.[17]

3.3 AMBIENT AIR QUALITY DATA AND TRENDS

VDEQ's annual air quality monitoring report shows that measured pollutant concentrations from all stations representative of the study area are below the NAAQS. As presented in **Figures 3-1 through 3-4**, VDEQ 10-year monitoring data indicates that most criteria pollutants concentrations have been decreasing since 2005. The reduction in CO, SO_2, NO_x, and ozone emissions is due to a variety of control measures that have been implemented over the last two decades, including motor vehicle engine controls, reductions in evaporative emissions from gasoline stations and consumer products, as well as reductions from power plants, businesses and residential combustion sources.

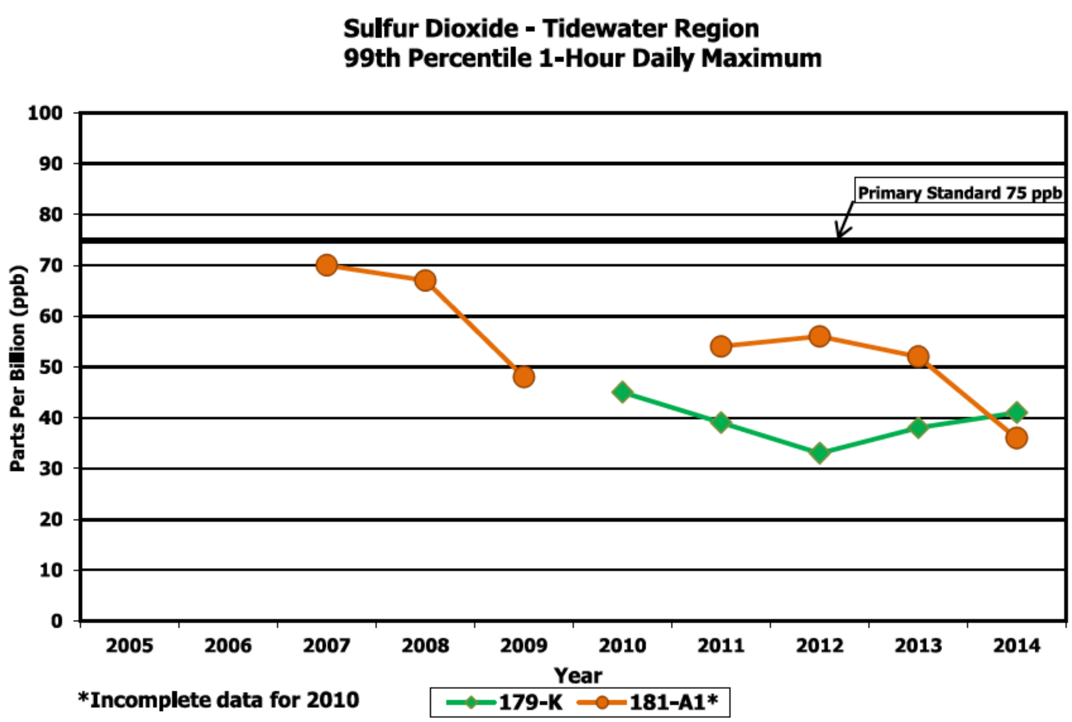
[15] EPA Green Book: https://www3.epa.gov/airquality/greenbook/faq.html
[16] Effective April 6, 2015, EPA revoked the 1997 eight-hour ozone NAAQS for which the Hampton Roads region had previously been in attainment-maintenance. Therefore, the associated transportation conformity requirements that applied at the time that the FEIS was prepared no longer apply. See: https://www.gpo.gov/fdsys/pkg/FR-2015-03-06/pdf/2015-04012.pdf.
[17] National Weather Service http://w2.weather.gov/climate/xmacis.php?wfo=akq (accessed on May 23, 2016)

Figure 3-1: VDEQ 10-YearTrend for 8-hour Carbon Monoxide (PPM) – Tidewater Region



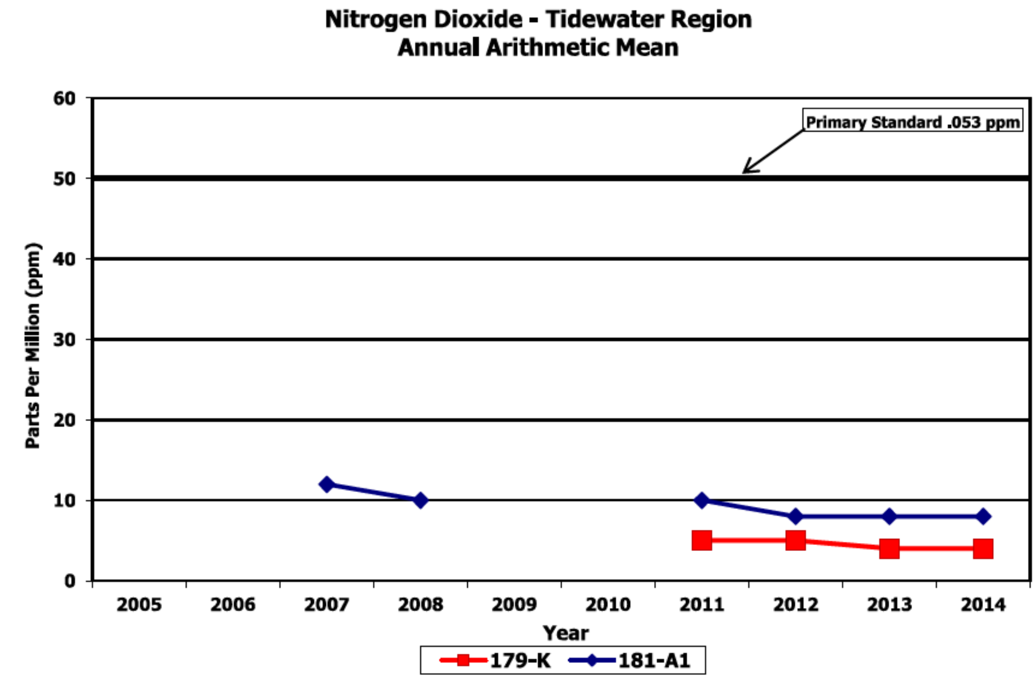
Source VDEQ: Virginia Ambient Air Monitoring 2014 Data Report

Figure 3-2: VDEQ 10-YearTrend for 1-hour Sulfur Dioxide (PPM) – Tidewater Region



Source VDEQ: Virginia Ambient Air Monitoring 2014 Data Report

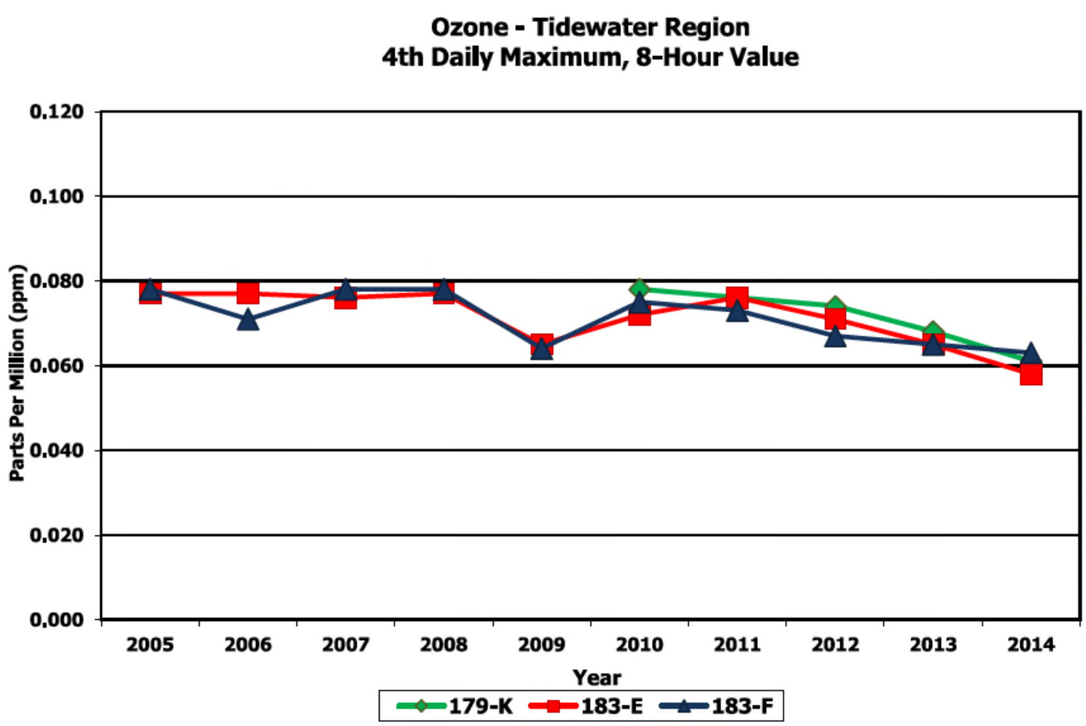
Figure 3-3: VDEQ 10-YearTrend for Annual Nitrogen Dioxide (PPM) – Tidewater Region



***Incomplete data in 2009 & 2010**

Source VDEQ: Virginia Ambient Air Monitoring 2014 Data Report

Figure 3-4: VDEQ 10-YearTrend for 8-hour Ozone (PPM) – Tidewater Region



Source VDEQ: Virginia Ambient Air Monitoring 2014 Data Report

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4. PROJECT ASSESSMENT

Project-level analyses for highway projects typically consist of evaluations of carbon monoxide (CO), particulate matter (PM), and Mobile Source Air Toxics (MSATs). The methodologies and assumptions applied for the analysis for each pollutant, which are discussed below, are consistent with FHWA and EPA guidance as well as the VDOT *Project Level Air Quality Analysis Resource Document*[18] including its associated on-line data repository.

Traffic forecasts for the Study Alternatives were developed for the Existing (2015), Interim Year Build and No-Build (2028) and Design Year Build and No-Build (2040) conditions. Traffic forecasts were performed for Alternative A, Alternative B, Alternative C, and Alternative D along with the No-Build Alternative.

4.1 CARBON MONOXIDE (CO) ANALYSIS

4.1.1 Methodology

The CO analysis included a review of both intersections and interchanges in the project area to identify the worst-case locations for assessment. Although not required as the region is in attainment of the NAAQS and therefore not subject to EPA transportation conformity rule requirements, EPA's detailed guidance[19] for CO analyses was applied to identify the worst-case intersections to consider for the analysis based on forecasts of peak volumes and intersection LOS. Short-listed intersections were then screened using the previously-referenced 2016 Agreement; by this Agreement, referenced thresholds or criteria for design year average daily traffic (ADT) must be exceeded before project-specific modeling for CO is required. The thresholds were originally established based on worst-case modeling for typical arterial intersections, with different thresholds applying for different intersection skew angles. The projected traffic volumes and intersection skew angles applied for the CO hot-spot analysis (i.e., for comparison to the applicable thresholds) are tabulated in **Appendix A**.

For locations for which project-specific modeling was determined to be required, a worst-case modeling approach was applied following FHWA guidance and using modeling inputs specified or referenced in the VDOT Resource Document. The microscale analyses were conducted using the latest version of the EPA emission model (MOVES2014a) and dispersion model (CAL3QHC) to estimate worst-case CO concentrations at individual receptor (i.e. receiver) locations. Peak CO concentrations modeled for each location were then added to the appropriate CO background concentrations (as specified in the VDOT Resource Document) to determine the worst-case CO impacts at each location. These values were then compared to the 1-hour and 8-hour CO NAAQS to show compliance.

[18] VDOT Project–Level Air Quality Analysis Resource Document, April 2016.
[19] U.S. Environmental Protection Agency, *Guideline for Modeling Carbon Monoxide from Roadway Intersections*, EPA-454/R-92-005, Office of Air Quality Planning and Standards, November, 1992.

4.1.2 Intersections/Interchanges Studied

Intersections

An analysis of the LOS and peak hourly volumes was evaluated for each Alternative to confirm the worst-case intersection locations for consideration under the 2016 Agreement. The intersections were ranked for each Alternative using peak AM and PM volumes and LOS criteria as specified in the EPA guidance as noted above. Traffic volumes used in the ranking of the signalized intersections are included in **Appendix A**. The intersection locations studied for each Alternative are shown in **Figures 4-1** thru **4-4**. The three highest ranked intersections by LOS and the higher of the AM or PM peak hourly ranked volumes were summarized for each Alternative. The top three ranked (i.e. worst-case) intersections are denoted in green in **Figures 4-1 through 4-4** and presented in **Appendix A**.

The 2016 Agreement was then applied to screen the worst case intersections for each Alternative. Based on the traffic forecasts presented in Appendix A, all of the worst-case intersections identified for each Alternative meet the design year ADT thresholds referenced in that Agreement. Project-specific CO hot spot modeling therefore is not needed for any of the intersections, as they can be cleared based on the Agreement and the worst-case CO hot-spot modeling for intersections on which it was based.

As the Project traffic study did not evaluate signalized intersections at the southern end of Alternative A along the I-64 mainline north of the I-564 and I-64 interchange as well as along the I-664 mainline north of the interchange at Route 164 and Route 17 toward the James River, the ranking of intersections for the CO analysis considered regional modeling results to identify worst-case intersections in these two areas. More specifically:

- A review of intersections along the I-64 corridor using Google Earth show there are two signalized intersections within 1,200 feet of the mainline at Granby Street and East Bayview Blvd and at Route 60 (West Ocean View Ave) and 4th View Street. **Figure 4-1** shows the location of these two signalized intersections. The output from the HRTPO regional traffic demand model, which was the basis for the Study Corridor traffic study, was reviewed for these signalized intersections for each Alternative for comparison to the ADT thresholds referenced in the 2016 Agreement. An evaluation of the traffic data for these intersections for each Alternative shows they are below the thresholds for a project-specific CO hot-spot analysis.
- For the I-664 mainline northward toward the James River, a review of signalized intersections along this corridor using Google Earth shows there is one large signalized intersection at College Drive and Hampton Roads Parkway approximately 2,600 feet to the south and east of Interchange 135 (e.g. interchange location 14 on Figure 4-3). **Figure 4-3** shows the location of the College Drive and Hampton Roads Parkway signalized intersection (e.g. intersection location 48). Similarly, the design year ADT from the HRTPO regional traffic model was reviewed for this signalized intersection for each Alternative for comparison to the applicable thresholds. As it is below the design ADT thresholds referenced in the 2016 Agreement, a project-specific CO hot-spot analysis is also not required for this location.

Figure 4-1: Alternative A Worst Case Interchange/Intersection Ranking

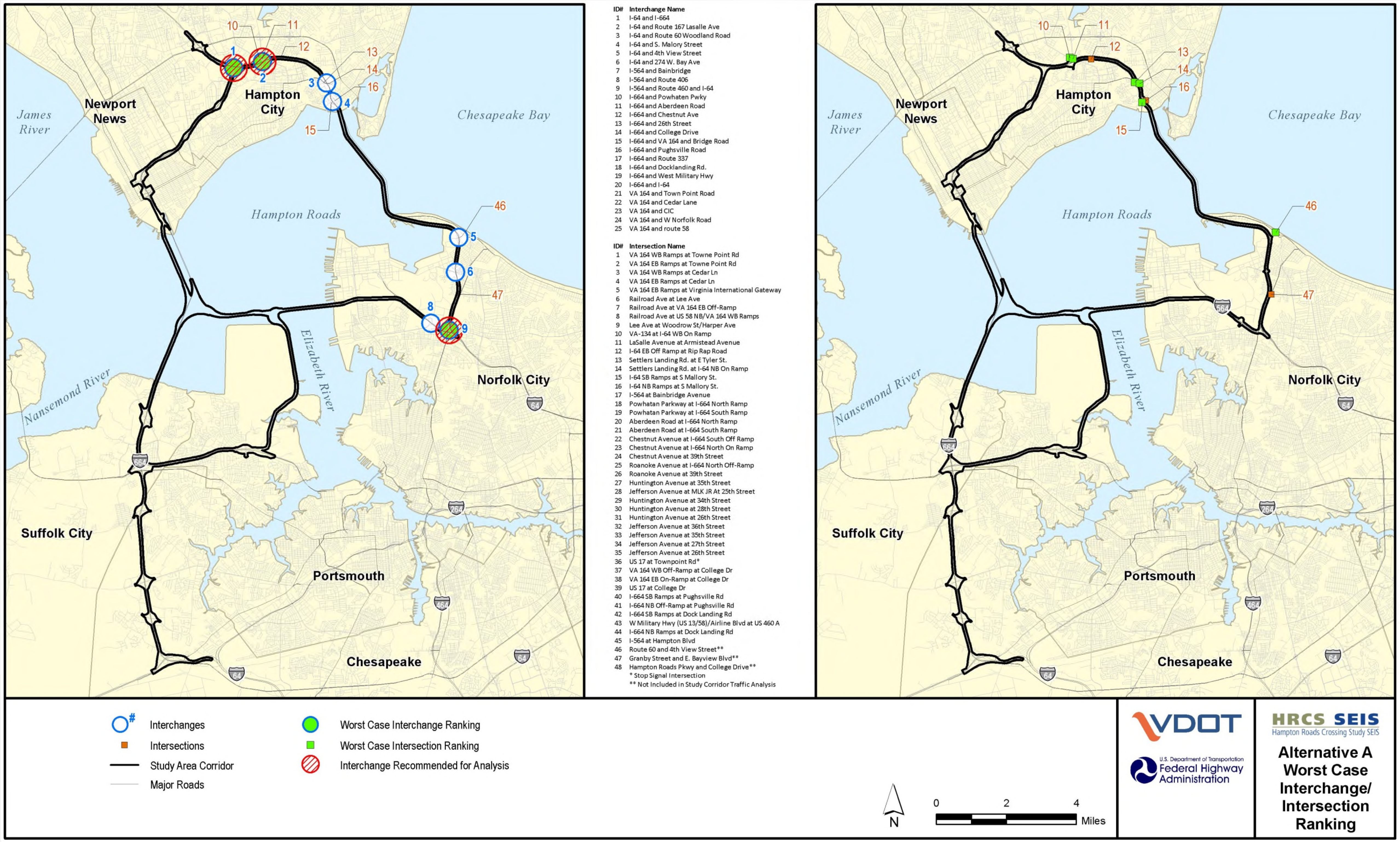

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Figure 4-2: Alternative B Worst Case Interchange/Intersection Ranking

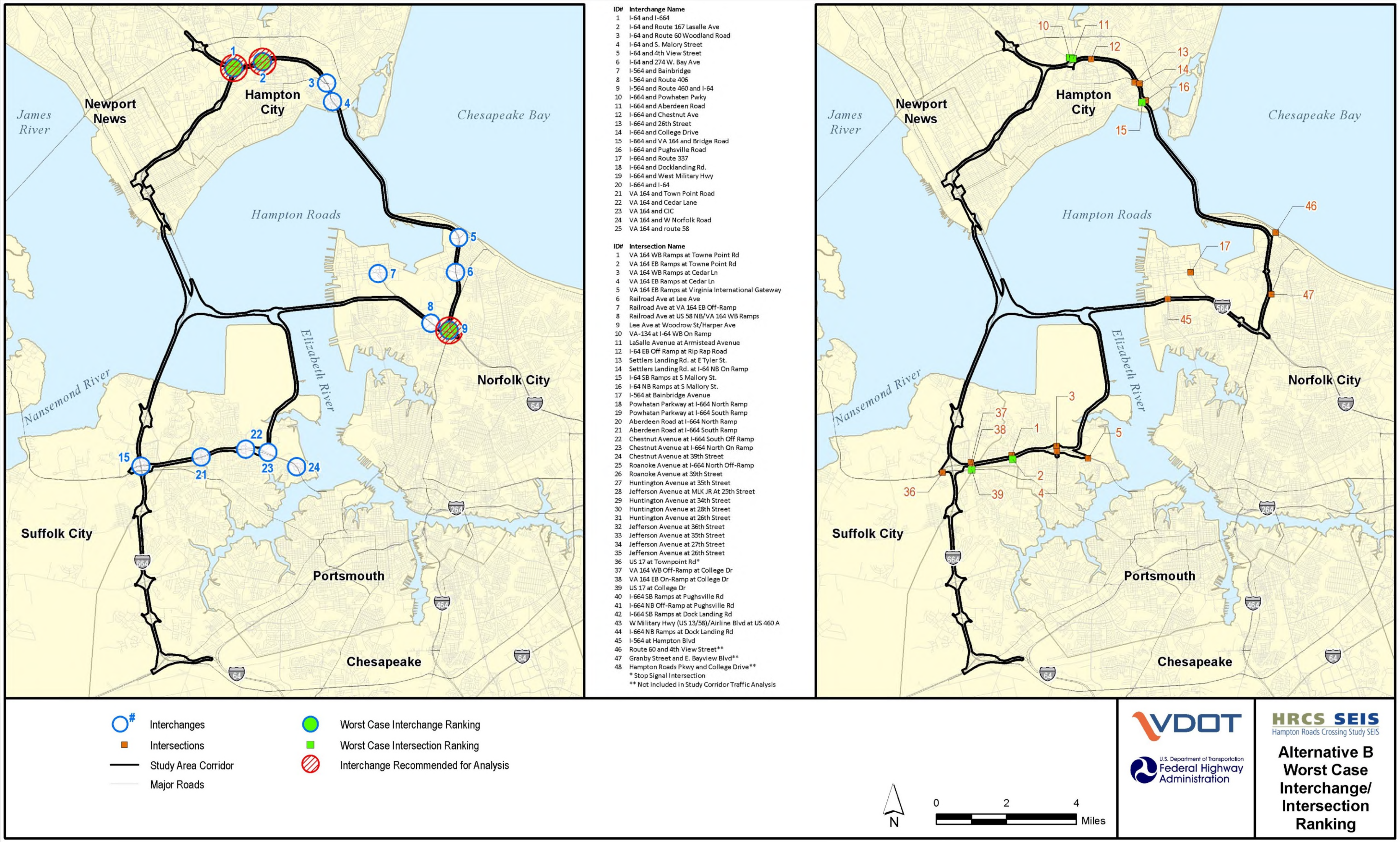

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Figure 4-3: Alternative C Worst Case Interchange/Intersection Ranking

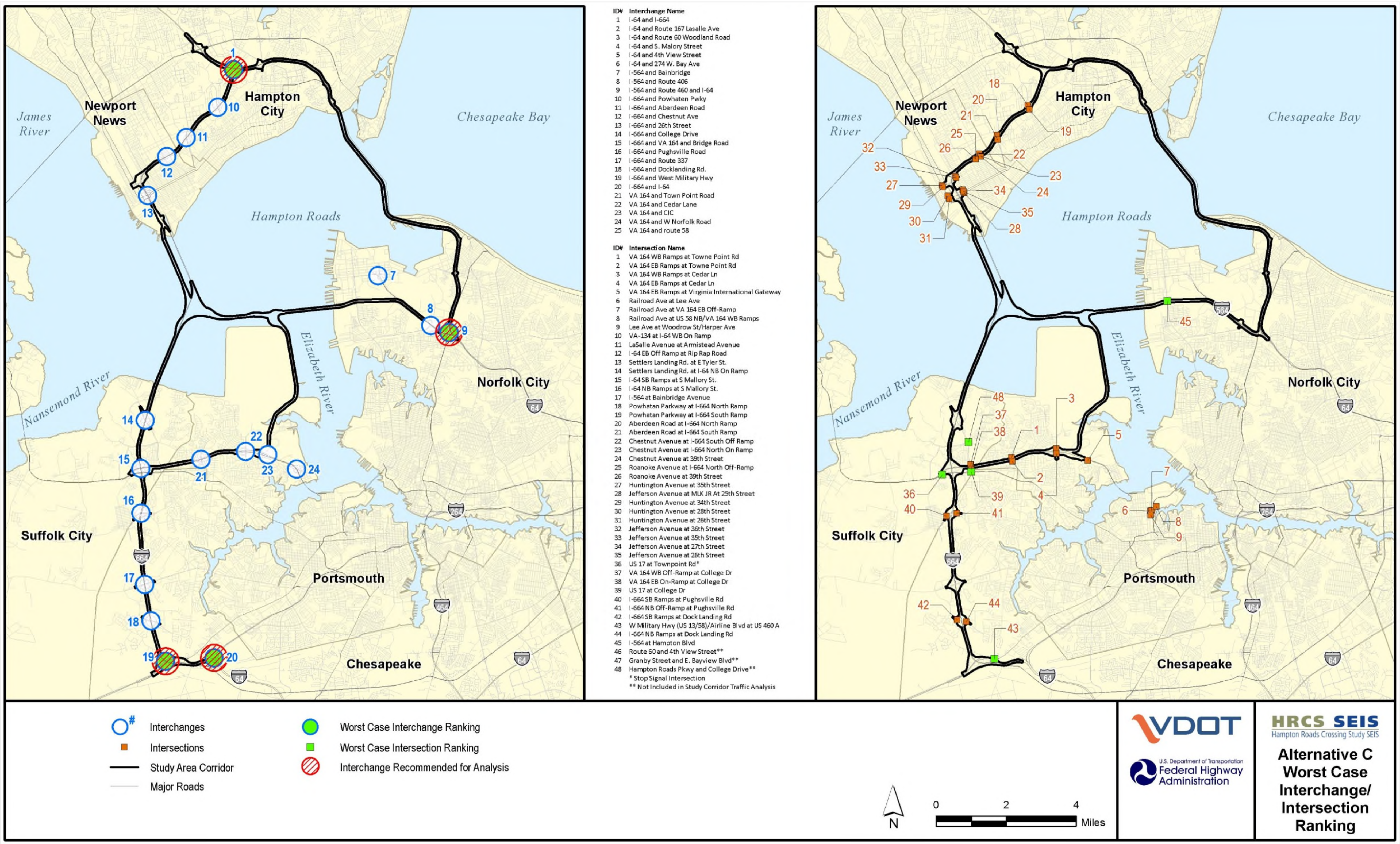

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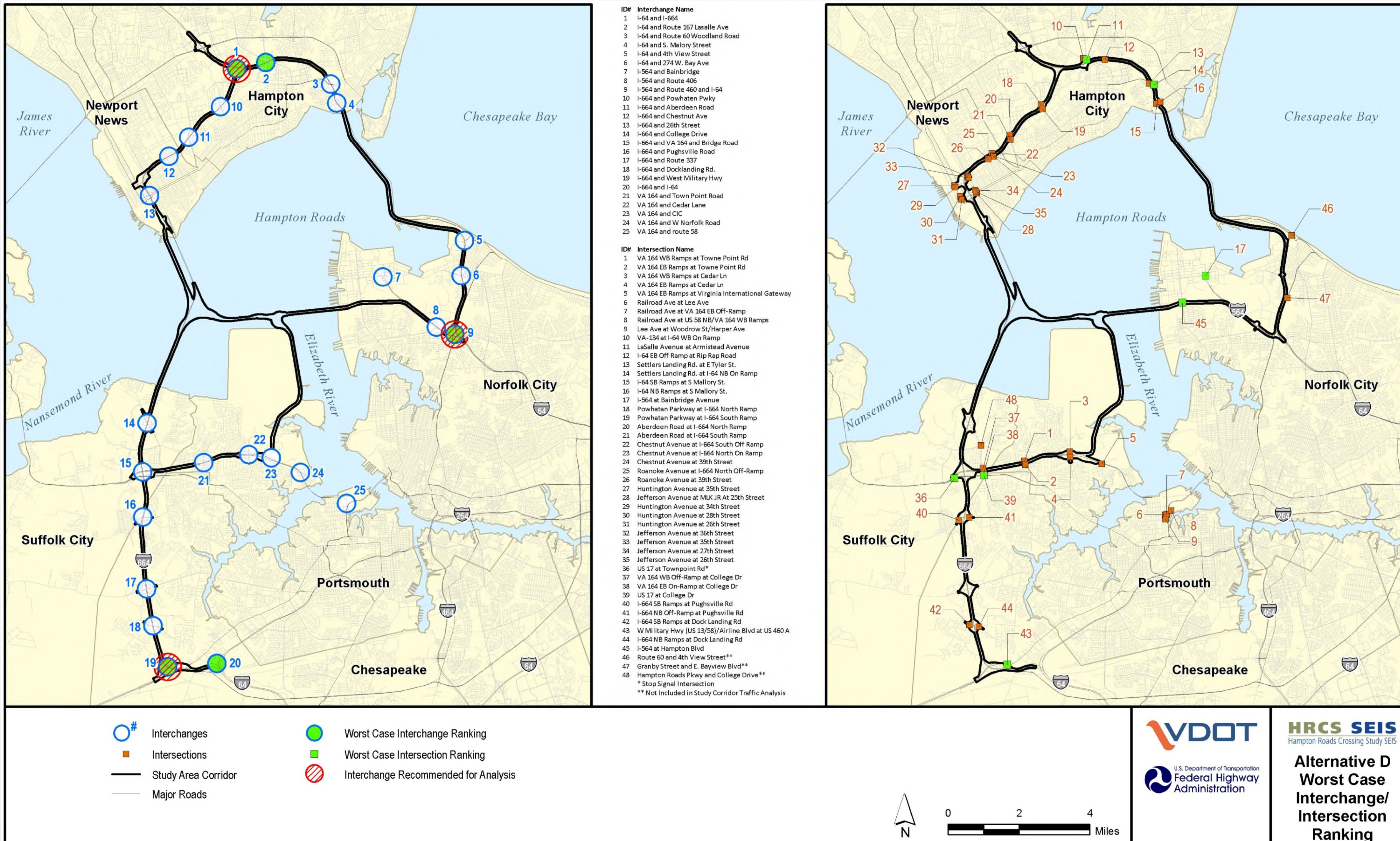
Figure 4-4: Alternative D Worst Case Interchange/Intersection Ranking



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Interchanges

Interchanges were ranked by worst-case volumes for the mainline traveling through each interchange. Traffic volumes used in the ranking of the interchanges are included in **Appendix A**. The interchange locations studied for each Alternative are shown in **Figures 4-1** thru **4-4**. The top five interchanges by volume for each Alternative were further analyzed to include skew angles, average speeds and LOS along the mainline for evaluation and justification for any additional interchanges for modeling beyond just worst-case traffic volumes. **Table 4-1** and **Table 4-2** presents the top five interchanges by volume for each Alternative for the 2028 and 2040 condition. A review of the worst-case interchanges show the top three interchanges for each Alternative clearly have the highest traffic volumes along with the worst-case LOS. In addition, one additional interchange for modeling (I-664 and I-64 Southern Termini) was included under Alternative C, which is forecast to have relatively high volumes and lower speeds along with a worst-case LOS of D. **Figures 4-1** thru **4-4** show the interchanges studied for each Alternative along with the interchange locations modeled denoted in red hatch green circles. It should be noted that locations that were modeled are common to one or more Alternatives (e.g. common interchanges).

In summary, the worst-case interchanges which were modeled based on the methodology described above are as follows:

- I-64 and I-664 (Northern Termini)
- I-564 and Route 460 and I-64
- I-64 and Route 167 Lasalle Ave
- I-664 and West Military Hwy
- I-664 and I-64 (Southern Termini)

The traffic analysis, as summarized above, demonstrates that the five interchanges selected for evaluation in the CO hot-spot analysis have the highest traffic volumes, lowest speeds and worst-case LOS within the study corridor for each Alternative, and therefore are representative of the locations where peak CO concentrations would be expected to occur throughout the corridor.

It is assumed that if these intersections/interchanges show peak ground level CO concentrations below the CO NAAQS, then all other locations in the study area would also be below the CO NAAQS.

For the highway interchanges, a worst-case analysis approach was taken using MOVES2014a and CAL3QHC (invoked via the latest version of the FHWA CAL3i interface software) to develop conservative estimates for CO concentrations. This approach is designed to overestimate the project impacts on CO emissions and produce worst-case results from the air quality/dispersion modeling. CAL3i provides a user-friendly interface for the EPA CAL3QHC model that serves to facilitate and streamline the modeling process, particularly for worst-case analyses. Details on the assumptions used for the worst-case modeling analyses are provided later in this report.

Table 4-1: 2028 Interchange Ranking

Alternative A						
Figure Interchange	Ranking	2028 Build Alt A	2028 Build Alt A ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
1	1	I-64 and I-664 (northern Termini)	**215,500**	**80**	54.1	D
9	2	I-564 and Route 460 and I-64	**203,500**	**65**	48.4	F
2	3	I-64 and Route 167 Lasalle Ave	**159,900**	**69**	48.0	F
3	4	I-64 and Route 60 Woodland Road	**143,300**	**51**	56.5	D
4	5	I-64 and S. Malory Street	**128,700**	**81**	47.1	E
Alternative B						
Figure Interchange	Ranking	2028 Build Alt B	2028 Build Alt B ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
9	1	I-564 and Route 460 and I-64	**214,500**	**65**	48.7	F
1	2	I-64 and I-664 (northern Termini)	**212,000**	**80**	54.1	D
2	3	I-64 and Route 167 Lasalle Ave	**156,000**	**69**	47.2	F
3	4	I-64 and Route 60 Woodland Road	**137,700**	**51**	56.5	D
4	5	I-64 and S. Malory Street	**123,900**	**81**	47.5	E
Alternative C						
Figure Interchange	Ranking	2028 Build Alt C	2028 Build Alt C ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
1	1	I-64 and I-664 (northern Termini)	**208,100**	**80**	54.1	C
9	2	I-564 and Route 460 and I-64	**207,200**	**65**	54.3	D
19	3	I-664 and West Military Hwy	**163,700**	**83**	59.7	C
20	4	I-664 and I-64 (Southern Termini)	**139,400**	**87**	59.5	C
15	5	I-664 and VA 164 and Bridge Road	**137,200**	**83**	60.4	C
Alternative D						
Figure Interchange	Ranking	2028 Build Alt D	2028 Build Alt D ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
9	1	I-564 and Route 460 and I-64	**223,600**	**65**	54.2	E
1	2	I-64 and I-664 (northern Termini)	**210,200**	**80**	54.1	C
19	3	I-664 and West Military Hwy	**159,400**	**83**	59.7	C
2	4	I-64 and Route 167 Lasalle Ave	**148,400**	**69**	54.3	D
15	5	I-664 and VA 164 and Bridge Road	**135,000**	**83**	59.7	D

Notes:

1. *Represents the lowest average AM or PM speed through the interchange.*
2. *Represents the worst-case LOS of either AM or PM through the interchange.*

Table 4-2: 2040 Interchange Ranking

Alternative A						
Figure Interchange	Ranking	2040 Build Alt A	2040 Build Alt A ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
1	1	I-64 and I-664 (northern Termini)	236,300	80	54.1	D
9	2	I-564 and Route 460 and I-64	219,900	65	43.2	F
2	3	I-64 and Route 167 Lasalle Ave	173,400	69	53.3	D
3	4	I-64 and Route 60 Woodland Road	158,600	51	54.5	D
4	5	I-64 and S. Malory Street	147,500	81	44.2	F
Alternative B						
Figure Interchange	Ranking	2040 Build Alt B	2040 Build Alt B ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
1	1	I-64 and I-664 (northern Termini)	235,900	80	53.9	D
9	2	I-564 and Route 460 and I-64	231,100	65	48.1	F
2	3	I-64 and Route 167 Lasalle Ave	172,700	69	45.4	F
3	4	I-64 and Route 60 Woodland Road	156,100	51	54.5	D
4	5	I-64 and S. Malory Street	142,900	81	44.5	F
Alternative C						
Figure Interchange	Ranking	2040 Build Alt C	2040 Build Alt C ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
1	1	I-64 and I-664 (northern Termini)	231,500	80	54.0	C
9	2	I-564 and Route 460 and I-64	227,000	65	50.2	F
19	3	I-664 and West Military Hwy	187,400	83	59.7	C
20	4	I-664 and I-64 (southern Termini)	164,400	87	59.4	D
15	5	I-664 and VA 164 and Bridge Road	160,400	83	60.3	C
Alternative D						
Figure Interchange	Ranking	2040 Build Alt D	2040 Build Alt D ADT	Effective Skew Angle	Average Speeds[1]	LOS[2]
9	1	I-564 and Route 460 and I-64	242,400	65	44.6	F
1	2	I-64 and I-664 (northern Termini)	234,500	80	54.1	D
19	3	I-664 and West Military Hwy	183,200	83	59.7	C
2	4	I-64 and Route 167 Lasalle Ave	162,900	69	54.3	D
20	5	I-664 and I-64 (southern Termini)	160,300	87	59.5	C

Notes:

1. *Represents the lowest average AM or PM speed through the interchange.*
2. *Represents the worst-case LOS of either AM or PM through the interchange.*

4.1.3 MOVES Emissions Estimation

Vehicle emission rates for CO were estimated using the latest version of the EPA Motor Vehicle Emissions Simulator model (MOVES2014a). The methodologies and assumptions used for the MOVES modeling were consistent with FHWA guidance as previously referenced as well as EPA guidance[20] and the VDOT Resource Document. All modeling inputs were from or otherwise consistent with the VDOT Resource Document. Specifically:

- Vehicle and fuels data required for input into the MOVES model was provided by VDOT (on-line data repository) for 2015, 2028 and 2040 conditions, consistent with the latest planning assumptions for the Study Corridor.
- Fuel data, vehicle population data, and age distribution data were provided by VDOT (on-line data repository) to populate the MOVES project data manager database for the areas where the worst-case interchanges are located (i.e. Hampton, Norfolk, and Chesapeake).
- Source type hour fractions for each link were derived using the link-source-type-hour calculation tool provided with the VDOT Resource Document (i.e., available in the on-line data repository). Project-specific data for cars and trucks volumes were applied along with the most recent VDOT DVMT 1236 report (2014) and source type population data for each source type.
- MOVES link files were developed for each worst-case interchange studied for each analysis year. The link file includes road type, peak-hour volumes, link lengths, roadway speed, and roadway grade.
- The roadway grades for the interchanges were derived from plans where available, or from profile data based on USGS elevation data from GIS files or Google Earth data.
- Worst-case meteorological data consistent with the VDOT Resource Document for the Study Corridor for the areas where the worst-case interchanges are located were also assumed in the project data manager database.

A summary of the MOVES inputs are presented in **Table 4-3**.

[20] EPA, "Using MOVES2014 in Project Level Carbon Monoxide Analyses", March 2015.

Table 4-3: Summary of MOVES Inputs

Parameter	Assumption
Scale Menu	"Project" Domain
	Calculation Type "Inventory"
Temperature	33°F[1]
Relative Humidity	Relative Humidity=76%[1]
Evaluation Month	January
Time Span	Year= (2015, 2028, 2040), AM Hour= 7AM to 8AM, Days=Weekdays
Geographic Bounds	Virginia, City of Norfolk, Hampton, Cheseapeake[2]
Vehicles Equipment[3]	All Vehicle Types for diesel and gasoline and CNG transit buses
Link Files	Roadway Specific developed by HMMH
Roadway Grade/Link Speeds	Roadway Specific developed by RKK and HMMH
Fuel and I/M Inputs	Fuels Data Provided by VDOT[1], No I/M program in study corridor[1,2]
Vehicle Population and Age Distribution	Provided by VDOT[2]
Pollutants and Process Panel	CO Running and CO Crankcase
Output Panel	Grams and Miles Selected as Units, Population and Distance traveled

Notes:
1. Data provided in the VDOT Project-Level Air Quality Analysis Resource Document, On-line repository.
2. Data for MOVES runs collected based on the location of the worst-case interchanges which are located in the Cities of Hampton, Norfolk, and Chesapeake. The MOVES Project database was populated for each interchange using city specific values relative to their locations.
3. Includes electric and ethanol E-85 light commercial trucks, passenger car and passenger trucks.

4.2 EMISSION FACTORS

Mobile source emission factors are calculated based on the actual peak-hour congested speeds at which vehicles travel through the interchanges. The MOVES runs were used to generate CO emission rates for input into the CAL3QHC dispersion model for the base (2015), opening (2028), and design (2040) years. For estimating CO emission rates for the interchange analysis, the following assumptions were made:

- An average vehicle speed of either 55 or 60 mph was assumed for each mainline link at each interchange
- Roadway ramp speeds ranged from 35 mph to 50 mph based on the traffic study results.
- The modeling assumed freeway links in an urban area type;
- Zero median width;
- At grade interchanges assuming no vertical separation;
- Receptor locations on the edge of the right-of-way assuming EPA guidance.

Emission rates were developed for freeway links with grades of +1 percent and +4 percent in the Cities of Hampton, Norfolk, Suffolk and Portsmouth. A maximum climbing grade of 4 percent was assumed on ramps that showed an incline. If this was the case, the entire approach leg was modeled as a 4 percent grade. If a ramp did not have an incline, a conservative 1 percent grade was used for the approach leg. Departure legs were modeled using a conservative 1 percent grade as well. The speeds, roadway grades, and emission factors for each of the legs are summarized in **Table 4-4**. As an example of the CO emission rates, **Table 4-4** summarizes the emission factors generated by MOVES for each year and vehicle speed for the five interchanges modeled using MOVES2014a. A sample MOVES input and output file is provided in **Appendix B**. A complete set of MOVES input/output files can be made available upon request.

Table 4-4: Summary of MOVES CO Emission Factors

	Approach	Vehicle Speed (mph)	Roadway Grade (%)	2015 (g/mile)	2028 (g/mile)	2040 (g/mile)
I-64 and I-664 (northern Termini[1])	South Leg Approach/Depart	55/55	4/1	8.81/4.19	4.20/1.91	2.38/1.02
	East Leg Approach/Depart	55/55	1/1	4.19/4.19	1.91/1.91	1.02/1.02
	West Leg Approach/Depart	55/55	4/1	8.81/4.19	4.20/1.91	2.38/1.02
I-564 and Route 460 and I-64[2]	North Leg Approach/Depart	55/55	4/1	8.02/3.81	3.91/1.76	2.25/0.96
	South Leg Approach/Depart	35/35	4/1	7.07/4.2	3.32/1.86	1.78/0.94
	East Leg Approach/Depart	55/55	4/1	8.02/3.81	3.91/1.76	2.25/0.96
	West Leg Approach/Depart	55/55	4/1	8.02/3.81	3.91/1.76	2.25/0.96
I-64 and Route 167 Lasalle Ave[1]	North Leg Approach/Depart	55/35	4/1	8.81/4.65	4.20/2.03	2.38/1.01
	South Leg Approach/Depart	55/45	4/1	8.81/4.32	4.20/1.91	2.38/0.99
	East Leg Approach/Depart	55/55	1/1	4.19/4.19	1.91/1.91	1.02/1.02
	West Leg Approach/Depart	55/55	1/1	4.19/4.19	1.91/1.91	1.02/1.02
I-664 and West Military Hwy[3]	North Leg Approach/Depart	50/50	4/1	7.70/3.81	3.68/1.69	2.10/0.91
	South Leg Approach/Depart	50/50	4/1	7.70/3.81	3.68/1.69	2.10/0.91
	East Leg Approach/Depart	60/60	4/1	8.42/4.02	4.05/1.85	2.34/1.02
	West Leg Approach/Depart	60/60	1/1	4.02/4.02	1.85/1.85	1.02/1.02
I-664 and I-64 (southern Termini)[3]	South Leg Approach/Depart	60/60	4/1	8.42/4.02	4.05/1.85	2.34/1.02
	East Leg Approach/Depart	60/60	4/1	8.42/4.02	4.05/1.85	2.34/1.02
	West Leg Approach/Depart	60/60	4/1	8.42/4.02	4.05/1.85	2.34/1.02

Notes:
1. MOVES generated CO emission rates for I-64 and I-664 and I-64 and Route 167 Lasalle Ave utilize the City of Hampton data in the MOVES file.
2. MOVES generated CO emission rates for I-564 and Route 460 utilize the City of Norfolk data in the MOVES file.
3. MOVES generate CO emission rates for I-64 and West Military Highway and I-664 and I-64 (southern termini) utilize City of Chesapeake data in the MOVES file.

4.3 DISPERSION MODELING SCENARIOS

A worst-case modeling approach was taken for the analysis. The worst-case assumptions applied together serve to overestimate the project CO emissions and concentrations. Worst-case traffic volumes (set at the theoretical per lane maximum for LOS E) were assumed for the CO analyses at the interchanges.

As the same worst-case volumes were applied for 2015, 2028 and 2040, and CO emission factors decline over time due to improved fuel quality and continued fleet turnover to vehicles constructed to more stringent exhaust emission standards for CO, the worst-case analysis for 2015 would have higher concentrations than those for 2028 and 2040. That is, as 2015 would have the same worst-case traffic but higher emission factors (as shown above in **Table 4-3**), it would have higher worst-case emissions than would later years. The screening analysis for 2015 therefore effectively covers both the 2028 and 2040 Build scenarios; however, all three years were modeled for comparison. For comparison, No-Build conditions were also analyzed for 2028 and 2040 using forecasted No-Build traffic volumes for each worst-case interchange.

4.3.1 Traffic Volumes for Interchange Scenarios

As part of the approach for worst-case screening modeling, default worst-case volumes were applied as specified in the VDOT Resource Document. For freeway links, the default worst-case volumes are 2400 vehicle per hour per lane (vphpl) [21]. The worst-case volumes are intended to reflect over-capacity operating conditions, which is taken as level of service (LOS) E. As shown in **Table 4-5**, the mainline freeway worst-case 2040 Build Alternative AM and PM peak volumes was estimated at 10,250 vehicles per hour (which translates to 1,708 vphpl for the 6-lane roadway) for Build Alternative D, compared to the worst-case value of 14,400 vehicles per hour (assuming the worst-case default value of 2,400 vphpl). Also as part of the worst-case modeling approach designed to overestimate concentrations, ramps were modeled as through lanes physically located adjacent to the through lanes.

Typically, the assumed worst-case traffic volumes tend to be significantly higher than the design (and opening) year modeled volumes. **Table 4-5** below summarizes the refined Build and No-Build traffic estimates developed by the project team along the five interchanges. It shows the per lane volume to be substantively lower in both the opening year (2028) and design year (2040) scenarios compared to the worst-case default. In addition, ramp lanes tend to accommodate fewer vehicles per hour, but this conservative approach assumes full utilization at a capacity of a mainline travel lane (2,400 vphpl). Overall the traffic volumes assumed are well over twice those forecasted for the corridor.

[21] VDOT Project-Level Air Quality Analysis Resource Document, Appendix G1.

Table 4-5: Comparison of Forecasted Traffic Volumes and Assumed Worst Case Volumes for Screening Modeling

Interchange	Direction	2028					2040					Worst-Case Volumes	Roadway Speeds	Lanes
		No Build	Alt A	Alt B	Alt C	Alt D	No Build	Alt A	Alt B	Alt C	Alt D			
I-64 and I-664 (northern Termini)	East	3,905	4,270	4,095	3,575	4,090	4,200	4,570	4,490	3,910	4,270	14,400	55	6
	West	3,960	4,355	4,260	3,715	4,065	4,370	4,695	4,700	4,065	4,470	14,400	55	6
	North	5,255	4,995	4,965	5,350	5,180	5,670	5,445	5,410	6,055	5,710	9,600	55	4
	South	4,920	4,685	4,690	4,970	4,805	5,345	5,090	5,065	5,585	5,280	9,600	55	4
	Total	**18,040**	**18,305**	**18,010**	**17,610**	**18,140**	**19,585**	**19,800**	**19,665**	**19,615**	**19,730**	**48,000**		
I-564 and Route 460 and I-64	East	8,230	8,885	9,380	8,800	9,690	8,635	9,440	9,775	9,615	10,250	14,400	55	6
	West	4,175	3,845	4,500	4,770	4,855	4,275	4,050	4,845	5,245	5,195	14,400	55	6
	North	5,370	5,820	5,810	4,870	5,550	5,835	6,270	6,155	5,205	5,790	9,600	55	4
	South	1,530	1,465	1,445	1,380	1,445	1,295	1,530	1,470	1,385	1,465	12,000	35	5
	Total	**19,305**	**20,015**	**21,135**	**19,820**	**21,540**	**20,040**	**21,290**	**22,245**	**21,450**	**22,700**	**50,400**		
I-64 and Route 167 Lasalle Ave	East	4,390	4,910	4,650	4,060	4,630	5,170	5,170	5,020	4,395	4,800	9,600	55	4
	West	5,130	5,570	5,455	4,805	4,920	5,915	5,920	5,915	5,105	5,345	9,600	55	4
	North	2,290	2,170	2,160	1,975	2,325	2,285	2,325	2,195	2,195	2,355	7,200	45	3
	South	1,100	950	1,090	995	980	1,075	1,035	1,115	1,040	1,020	7,200	35	3
	Total	**12,910**	**13,600**	**13,355**	**11,835**	**12,855**	**14,445**	**14,450**	**14,245**	**12,735**	**13,520**	**33,600**		
I-664 and West Military Hwy	East	4,560	4,295	4,410	3,970	4,135	4,975	4,825	4,565	4,610	4,575	9,600	60	4
	West	4,175	4,057	4,065	4,200	4,250	4,630	4,560	4,450	4,865	4,710	12,000	50	5
	North	975	1,015	1,045	945	955	1,120	1,090	1,190	1,135	1,140	12,000	60	5
	South	5,885	5,655	6,085	5,550	5,560	6,570	6,400	6,485	6,080	6,080	12,000	50	5
	Total	**15,595**	**15,022**	**15,605**	**14,665**	**14,900**	**17,295**	**16,875**	**16,690**	**16,690**	**16,505**	**45,600**		
I-664 and I-64 (southern Termini)	East	4,585	4,135	4,365	3,685	4,140	5,625	4,950	4,715	4,725	4,670	9,600	60	4
	West	2,295	2,000	2,265	2,000	1,805	2,640	2,315	2,285	2,280	2,160	9,600	60	4
	North	3,780	3,910	3,590	3,710	3,615	4,510	4,605	4,305	4,390	4,335	7,200	60	3
	South	4,185	4,080	4,065	4,045	4,085	4,730	4,830	4,650	4,775	4,690	7,200	60	3
	Total	**14,845**	**14,125**	**14,285**	**13,440**	**13,645**	**17,505**	**16,700**	**15,955**	**16,170**	**15,875**	**33,600**		

Notes: Default values based on number of lanes times 2,400 vehicles per hour per lane.

4.4 CAL3QHC

The latest version of the CAL3QHC model (04244)[22] was used to predict worst-case 1-hour CO concentrations from free-flow links using the latest version of the FHWA CAL3i[23]. CAL3i is a software package that incorporates the EPA CAL3QHC dispersion model and various worst-case default parameters per EPA guidance. The peak 1-hour concentrations from CAL3QHC were scaled by a persistence factor of 0.75[24] (as specified in the VDOT Resource Document) to estimate 8-hour concentrations. Travel speeds were estimated based on field observations and the traffic analysis. A summary of inputs used in the CAL3Interface model are shown in **Table 4-6.**

Worst-case modeled concentrations from CAL3QHC were added to appropriate background CO concentrations for comparison to the NAAQS. The default background CO levels specified in the VDOT Resource Document were 2.0 ppm (one-hour CO concentration) and 1.1 ppm (eight-hour concentration), which were the values observed at the monitor in the City of Norfolk. The corresponding persistence factor from the City of Norfolk was also selected.

Table 4-6: Summary of CAL3QHC Inputs

Description	Value[1]
Surface Roughness Coefficient	175 Centimeters
CO Background Concentrations (Hampton Roads)	2.0 ppm 1-hour, 1.1 ppm 8-hour (City of Norfolk)
Persistence Factor	0.75 (City of Norfolk)
Wind Speed	1.0 meter per second
Stability Class	Urban D
Mixing Height	1,000 meters
Wind Direction	5 degree increments (1 thru 36)
Receptor Height	5.9 feet

Note: CAL3QHC inputs were derived from the VDOT Project-Level Air Quality Analysis Resource Document, Appendix G1 and G2.

In keeping with the worst-case analysis approach, each interchange is modeled as a grade separation. This approach effectively concentrates the travel lanes, traffic and emissions in one location, i.e., at the center of the grade separation, versus being widely distributed or dispersed across the actual freeway ramps. Additionally, default receptor locations, which are summarized below, are close to the roadway edge and well inside the footprint or right of way for the actual interchange, which results in higher modeled estimates for ambient concentrations of CO than would occur for the actual interchange. The combination of the default worst-case configuration (grade separation for an interchange) and receptor locations (near the road way edge instead of being located much further away, at the actual right of

[22] "User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections", EPA-454/R-92-006 (Revised), EPA, September 1995.
[23] See CAL3Interface – A Graphical User Interface for the CALINE3 and CAL3QHC Highway Air Quality Models", Michael Claggett, Ph.D., FHWA Resource Center, 2016.
[24] Consistent with the Norfolk City monitor location derived from Appendix G2 of the VDOT Resource Document and was used for estimating 8-hour concentrations from 1-hour concentrations.

way edge) together result in much more conservatively high modeled estimates for ambient concentrations than would be expected to occur in practice.

CAL3QHC input and output files are provided in **Appendix C**.

4.4.1 Receptors

Receptor locations are placed in the vicinity of each intersection and interchange at worst-case locations such as sidewalks, property lines, and parking lots where the public generally has access. For worst-case analyses for freeways, receptors are placed twenty feet from the roadway edge; for arterial streets (including intersections), the receptors are placed ten feet from the roadway edge (i.e., at the nearest possible location for the model, which assumes a ten-foot mixing zone next to the roadway).

Receptor locations for each worst-case interchange were generated in CAL3i consistent with EPA modeling guidelines[25] where the receptors were located a minimum of 3 meters from the edge of the roadway and positioned at a height of 1.8 meters above the ground (5.9 feet). **Figures 4-5 through 4-9** shows the receptor locations at the five interchanges as displayed in the CAL3i interface. The modeled conditions are conservative as the theoretical worst-case traffic volumes along with other simplified assumptions were applied which together would serve to overestimate impacts and yield conservative results. If the peak CO concentrations at the worst-case areas selected in the analysis are below the NAAQS for CO, it is assumed that all other locations in the corridor would also remain below the thresholds.

[25] "Guidelines for Modeling Carbon Monoxide from Roadway Intersections", EPA-454/R-92-005, US EPA, 1992.

Figure 4-5: CAL3i Generated CAL3QHC Receptor Locations for I64 and I-664 (Northern Termini) Interchange

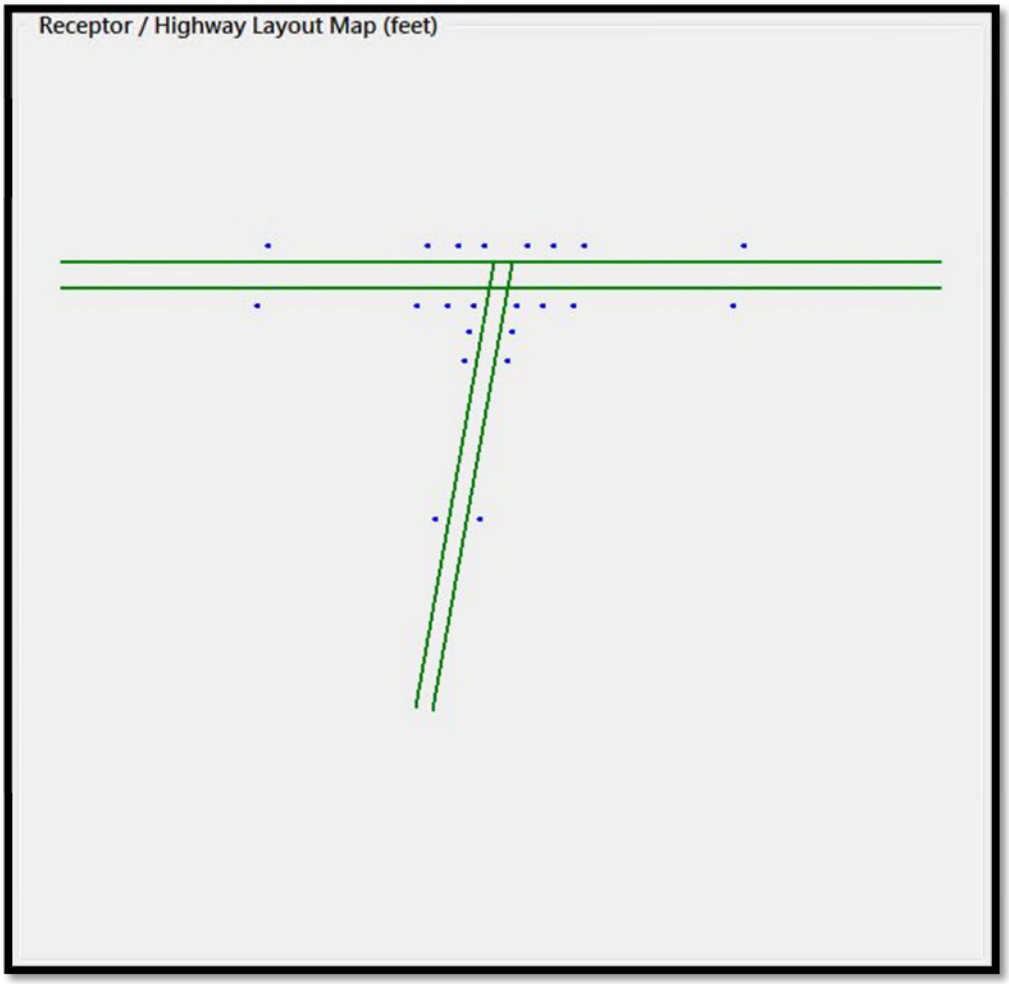


Figure 4-6: CAL3i Generated CAL3QHC Receptor Locations for I-564 and Route 460 and I-64 Interchange

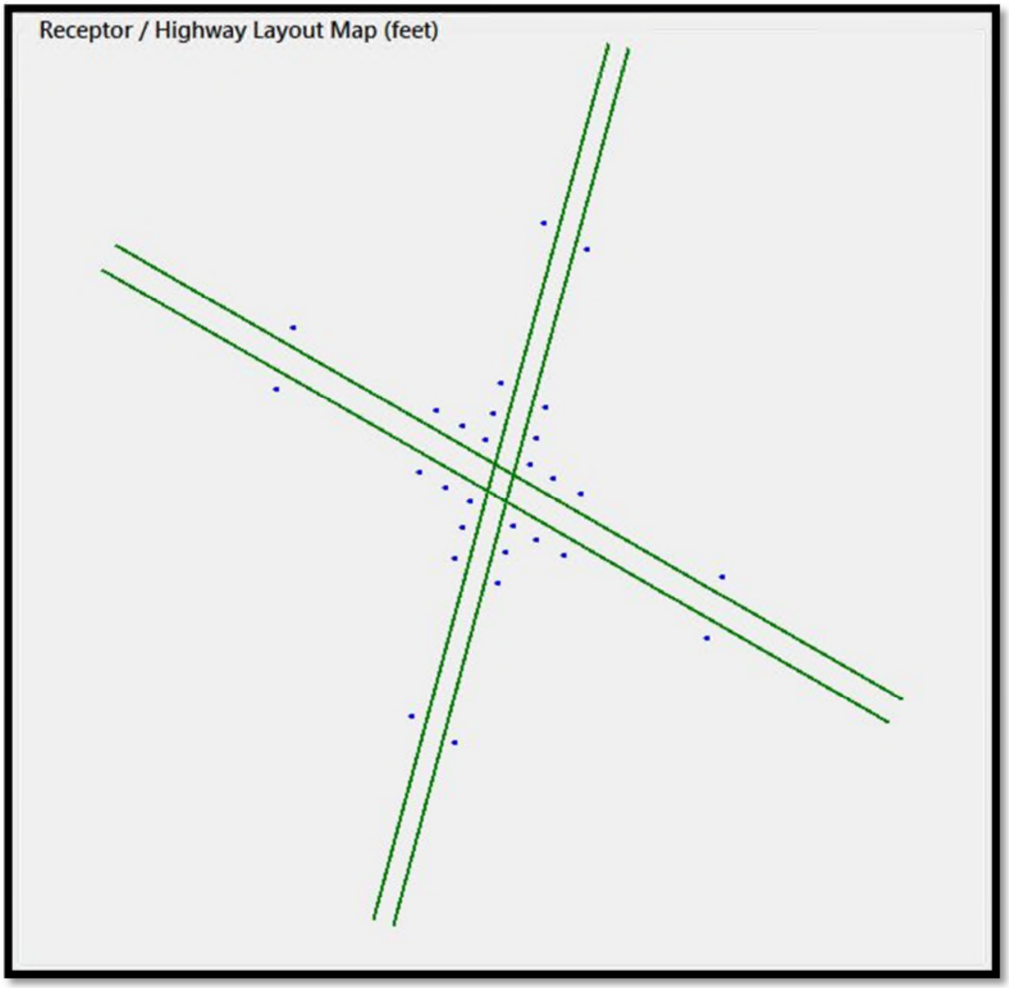


Figure 4-7: CAL3i Generated CAL3QHC Receptor Locations for I-64 and Route 167 Lasalle Avenue Interchange

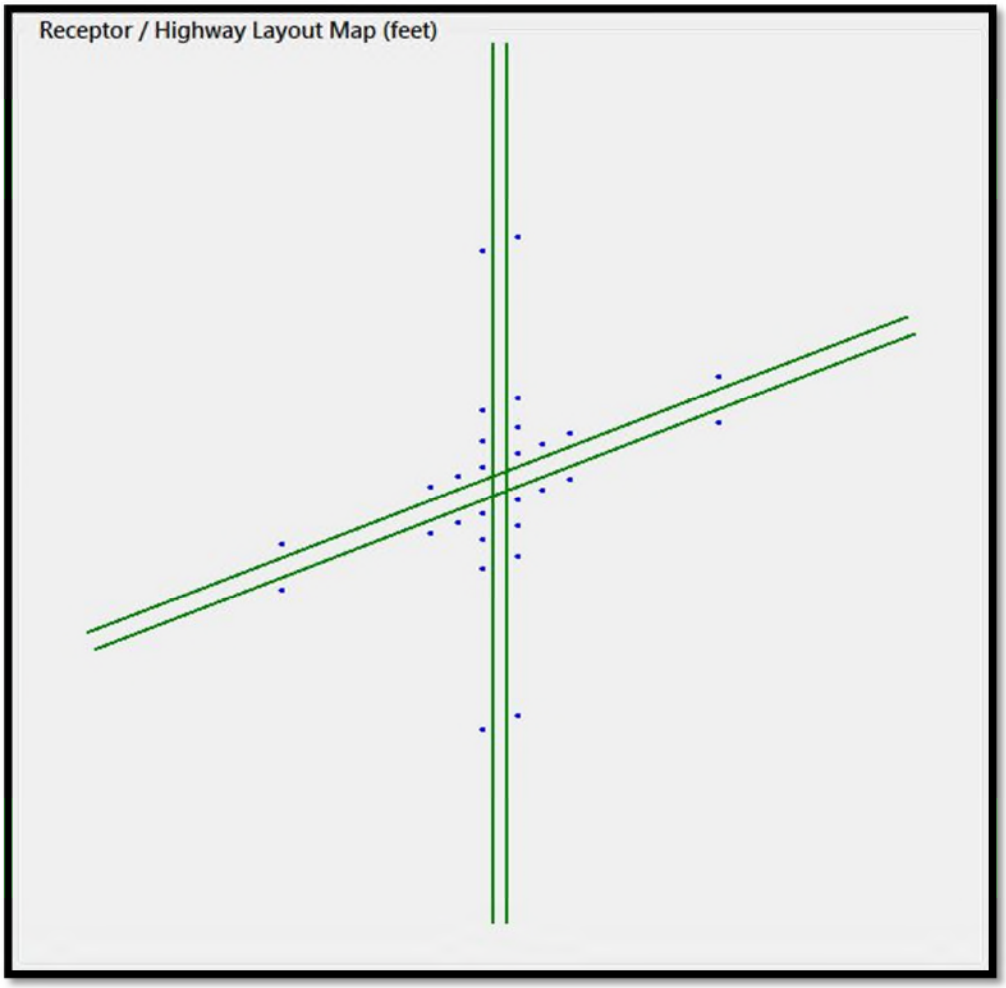


Figure 4-8: CAL3i Generated CAL3QHC Receptor Locations for I-664 and West Military Highway Interchange

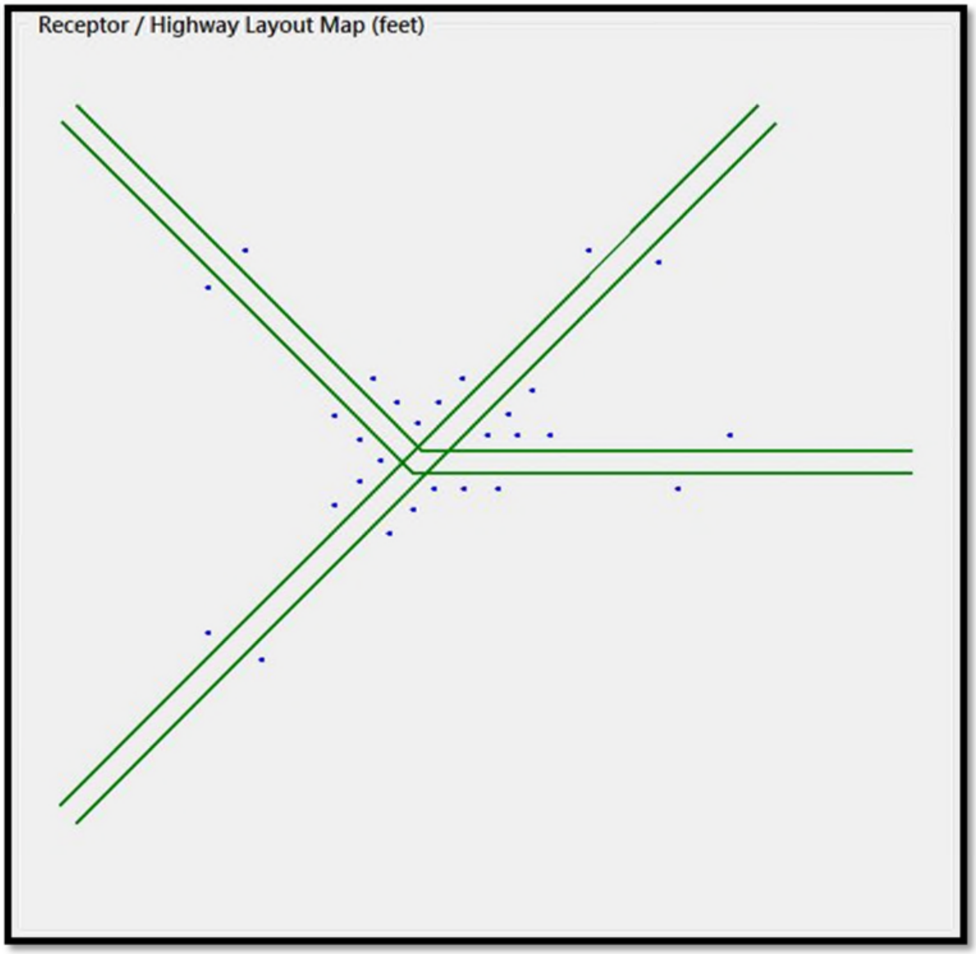
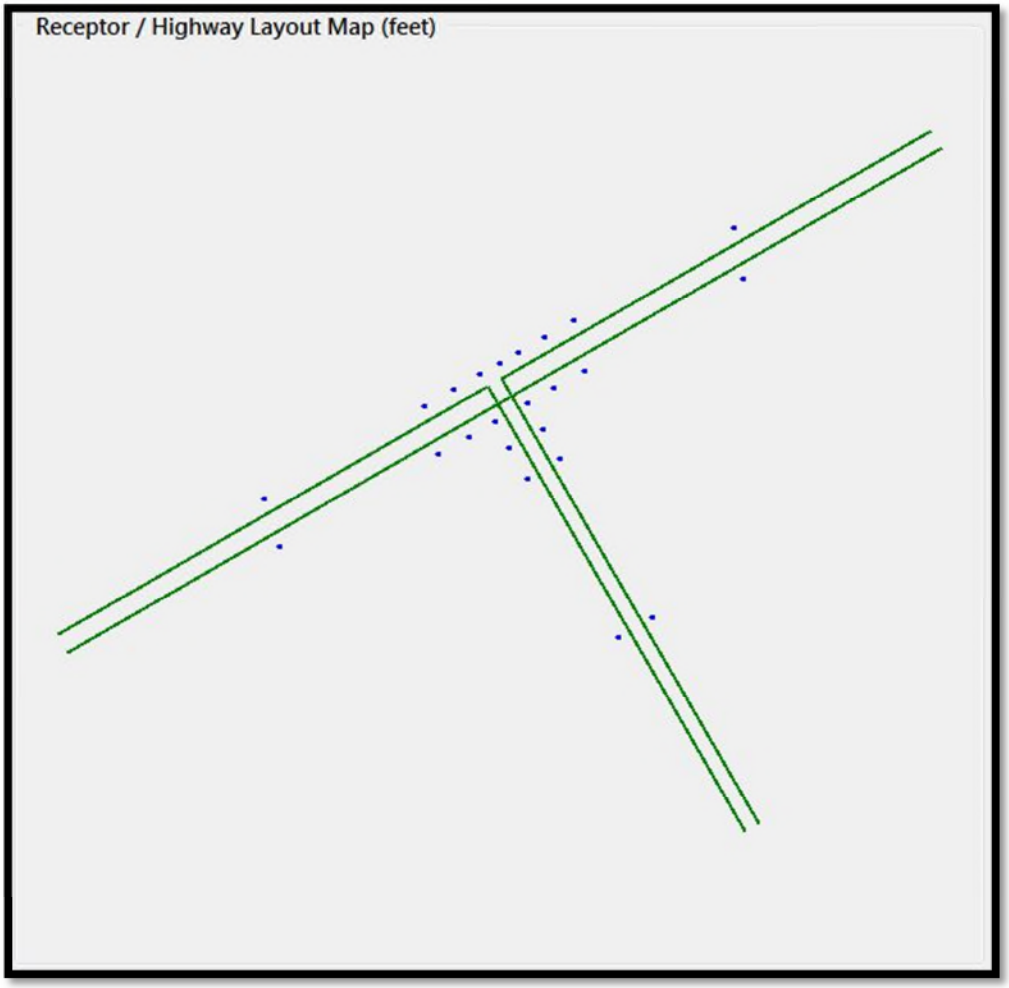


Figure 4-9: CAL3i Generated CAL3QHC Receptor Locations for I-664 and I-64 (Southern Termini) Interchange



4.4.2 CAL3QHC Modeling Results

The results of the 1-hour and 8-hour CO hot-spot analysis for the worst-case interchange locations is presented in **Table 4-7** for the base, opening and design year build and no-build conditions. The table includes the overall worst-case modeled concentrations for the AM and PM peak periods, and includes the modeled receptor number in parenthesis. The concentrations in **Table 4-7** also include the appropriate 1-hour and 8-hour background concentrations of 2.0 ppm and 1.1 ppm[26], respectively, for comparison to the CO NAAQS. The highest 1-hour predicted concentrations for the base, opening and design year build conditions were 11.5 ppm, 6.5 ppm and 4.6 ppm, respectively. The maximum 1-hour concentration for all base and future build and no-build conditions was predicted to occur at the I-64 and I-664 (Northern Termini) interchange. However, all predicted peak 1-hour CO concentrations are well below the 1-hour CO NAAQS of 35 ppm. A table of peak CO concentrations at all receptors at each of the worst-case interchanges for each scenario are included in **Appendix D**.

[26] Project Level Air Quality Analysis Resource Document, April 2016, Appendix H2.

The peak 1-hour values generated by CAL3QHC were scaled by a persistence factor of 0.75 to generate peak 8-hour CO concentrations, and these values were then added to the appropriate background concentration for comparison to the CO NAAQS. The highest 8-hour concentrations for the base, opening and design year build and no-build conditions were 8.2 ppm, 4.5 ppm and 3.1 ppm, respectively. Similar to the peak 1-hour concentrations, the maximum 8-hour CO concentration was also predicted to occur at the I-64 and I-664 (Northern Termini) interchange for the base and future build and no-build conditions. However, all predicted peak 8-hour CO concentrations are also below the 8-hour CO NAAQS standard of 9 ppm.

These results demonstrate that the worst-case interchanges for each existing, build and no-build alternative using very conservative assumptions would not cause or contribute to a violation of the CO NAAQS within the study corridor, and thereby satisfies all NEPA and CAA requirements pertaining to CO.

Table 4-7: CAL3QHC CO Modeling Results for the Worst-Case Interchanges

Intersection / Interchange	Averaging Period	2015[1, 2]	2028[1, 2]		2040[1, 2]		NAAQS (ppm)
		Base (No Build)	No Build Alternative	Build Alternative	No Build Alternative	Build Alternative	
		Peak (ppm)	Peak (ppm)	Peak (ppm)	Peak (ppm)	Peak (ppm)	
I-64 and I-664 (northern Termini)	1-Hour	11.5 (4)	3.7 (4)	6.5 (4)	3.0 (4)	4.6 (4)	35
	8-Hour	8.2 (4)	2.4 (4)	4.5 (4)	1.9 (4)	3.1 (4)	9
I-564 and Route 460 and I-64	1-Hour	10.7 (13)	3.8 (9)	6.2 (13)	3.1 (9)	4.4 (13)	35
	8-Hour	7.6 (13)	2.5 (9)	4.3 (13)	1.9 (9)	2.9 (13)	9
I-64 and Route 167 Lasalle Ave	1-Hour	8.0 (9)	3.0 (10)	4.8 (6)	2.6 (13)	3.6 (5)	35
	8-Hour	5.6 (9)	1.9 (10)	3.2 (6)	1.6 (13)	2.3 (5)	9
I-664 and West Military Hwy	1-Hour	10.3 (1)	3.5 (13)	5.9 (1)	2.9 (13)	4.2 (1)	35
	8-Hour	7.3 (1)	2.2 (13)	4.0 (1)	1.8 (13)	2.8 (1)	9
I-664 and I-64 (southern Termini)	1-Hour	8.9 (4)	3.6 (4)	5.4 (4)	3.1 (4)	3.9 (2)	35
	8-Hour	6.3 (4)	2.3 (4)	3.7 (4)	1.9 (4)	2.5 (2)	9

Notes:
1. Number in parenthesis represents the modeled receptor number of maximum modeled concentration from CAL3QHC. Please refer to Figures 4.5 through 4-9.
2. Modeled concentrations includes 1-hour Background Value of 2.0 ppm and 8-hour background value of 1.1 ppm

4.5 MOBILE SOURCE AIR TOXICS ANALYSIS METHODOLOGY

In December of 2012, the FHWA issued an interim guidance update[27] regarding the evaluation of MSAT in NEPA analyses and included projections utilizing the EPA MOVES emission model and updated research on air toxic emissions from mobile sources. The guidance includes three categories and criteria for analyzing MSATs in a NEPA documents:

1. No meaningful MSAT effects,
2. Low potential MSAT effects, and
3. High potential MSAT effects.

[27] http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/aqintguidmem.cfm

A qualitative analysis is required for projects which meet the low potential MSAT effects criteria while a quantitative analysis is required for projects meeting the high potential MSAT effects criteria.

Projects with Low Potential MSAT Effects are described as:

- Those that serve to improve operations of highway, transit, freight without adding substantial new capacity or without creating a facility that is likely to significantly increase emissions. This category covers a broad range of project types including minor widening projects and new interchanges, such as those that replace a signalized intersection on a surface street or where design year traffic is not projected to meet the 140,000 to 150,000 AADT criteria.

Projects with High Potential MSAT Effects must:

- Create or significantly alter a major intermodal freight facility that has the potential to concentrate high levels of diesel particulate matter in a single location;
- Create new or add significant capacity to urban highways such as interstates, urban arterials, or urban collector-distributor routes with traffic volumes where the AADT is projected to be in the range of 140,000 to 150,000 or greater by the design year; and
- Proposed to be located in proximity to populated areas.

In accordance with the MSAT guidance, the study area is best characterized as a project with "higher potential MSAT effects" since projected design year traffic is expected to reach the 140,000 to 150,000 AADT criteria. Specifically, the Design year Build Alternative D is expected to have ADT volumes at I-64 WB and EB West of I-64 of 212,300 ADT. A table summarizing the ADT throughout the project corridor for each alternative is presented in **Appendix A**.

The results demonstrate that the predicted ADT volumes would be greater than the 140,000 to 150,000 AADT MSAT criteria. As a result, a quantitative assessment of MSAT emissions projections was conducted for the affected network consistent with FHWA guidance.

4.5.1 MSAT Background

Controlling air toxic emissions became a national priority with the passage of the Clean Air Act Amendments (CAAA) of 1990, when Congress mandated that the EPA regulate 188 air toxics, also known as hazardous air pollutants (HAPs). The EPA assessed this expansive list in their 2007 rule on the Control of Hazardous Air Pollutants from Mobile Sources and identified a group of 93 compounds emitted from mobile sources that are listed in their Integrated Risk Information System (IRIS). In addition, EPA identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers from their 1999 National Air Toxics Assessment (NATA). The seven compounds identified were:

1. acrolein;
2. benzene;
3. 1,3 butadiene;
4. diesel particulate matter;
5. formaldehyde;
6. naphthalene; and
7. polycyclic organic matter.

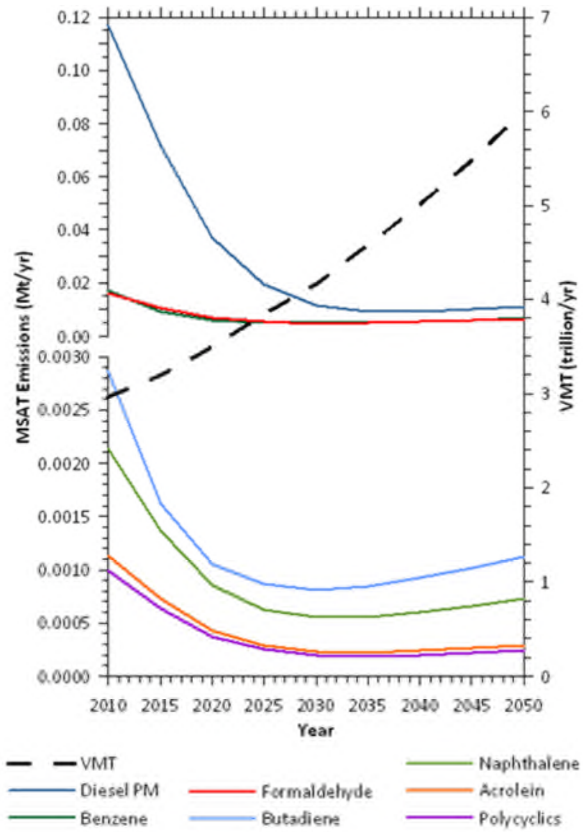
While FHWA considers these the priority mobile source air toxics, the list is subject to change and may be adjusted in consideration of future EPA rules. The 2007 EPA rule mentioned above requires controls that will dramatically decrease MSAT emissions through cleaner fuels and cleaner engines.

4.5.2 Motor Vehicle Emissions Simulator (MOVES)

According to EPA, MOVES improves upon the previous MOBILE mode in several key aspects. MOVES is based on a vast amount of in-use vehicle data collected and analyzed since the latest release of MOBILE, including millions of emissions measurements from light-duty vehicles. Analysis of this data enhanced EPA's understanding of how mobile sources contribute to emission inventories and the relative effectiveness of various control strategies. In addition, MOVES accounts for the significant effects that vehicle speed and temperature have on PM emission estimates, whereas MOBILE did not. MOVES2014a includes all air toxic pollutants in NATA that are emitted by mobile sources. EPA has incorporated more recent data into MOVES2014a to update and enhance the quality of MSAT emission estimates. These data reflect advanced emission control technology and modern fuels, plus additional data for older technology vehicles.

Based on an FHWA analysis using EPA's MOVES2010b model, even if vehicle-miles traveled (VMT) increases by 102 percent as assumed from 2010 to 2050, a combined reduction of 83 percent in the total annual emissions for the priority MSAT is projected for the same time period (see **Figure 4-10**).

Figure 4-10: National MSAT Emission Trends 2010-2050 for Vehicles Operating on Roadways Using EPA's MOVES 2010b Model



Source: FHWA 2012 Interim Guidance (EPA MOVES2010b model runs conducted during May-June 2012 by FHWA.)

Note: Trends for specific locations may be different, depending on locally derived information representing vehicle-miles travelled, vehicle speeds, vehicle mix, fuels, emission control programs, meteorology, and other factors.

The implications of MOVES on MSAT emissions estimates compared to MOBILE are lower estimates of total MSAT emissions, significantly lower benzene emissions, and significantly higher diesel PM emissions, especially for lower speeds. Consequently, diesel PM is projected to be the dominant component of the emissions total.

4.5.3 MSAT Research

Air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSAT exposure remain limited. These limitations impede the ability to evaluate how potential public health risks posed by MSAT exposure should be factored into project-level decision-making within the context of NEPA.

Nonetheless, air toxics concerns continue to be raised on highway projects during the NEPA process. Even as the science emerges, we are duly expected by the public and other agencies to address MSAT impacts in our environmental documents. The FHWA, EPA, the Health Effects Institute, and others have funded and conducted research studies to try to more clearly define potential risks from MSAT emissions associated with highway projects. The FHWA will continue to monitor the developing research in this field.

4.5.4 Project Quantitative MSAT Analysis

A quantitative MSAT analysis was conducted consistent with the latest guidance developed by FHWA. These include the Interim Guidance Update mentioned earlier, and the FHWA guidance for addressing a quantitative MSAT analysis using MOVES titled "Quick-start Guide for Using MOVES for a NEPA Analysis" along with training material developed by FHWA that provided detailed direction on the preparation of quantitative MSAT analyses as available from the VDOT On-line Data Repository.

- The affected network for the MSAT analysis was identified using the Hampton Roads Travel Demand Forecast Model for each Alternative and analysis year. The affected network extends well-beyond the study area as it captures changes in MSAT emissions due to changes in traffic volumes when comparing the No-Build to each Build Alternative condition.
- The latest Hampton Roads Travel Demand Model consist of modeling years 2009, 2028, and 2034; therefore, to remain consistent with the CO analysis study years, 2015 and 2040 year data sets were developed for use in the MSAT analysis. The 2015 AM, PM and daily base volumes for each link were developed by interpolating the 2009 base year and 2034 No-Build model output volumes to a 2015 value (the 2015 volume would be the 2009 volume plus 25 percent of the difference in 2034 and 2009 volume for each link).
- The 2040 volumes for each link were developed from 2034 model output volumes by growing the daily volume on each link by 7.0 percent, which is consistent with the growth applied to links during post-processing for the detailed traffic forecasting and analysis effort.
- The 2015 and 2040 vehicle speeds were estimated using the volume-delay functions contained in the TPO model, using the 2015 and 2040 volumes and recomputed volume/capacity (v/c) ratios for each link.
- The affected networks for each Alternative and analysis year were developed using FHWA criteria, namely daily volume change and travel time change for congested and uncongested links, for which reliable forecast data were available.
- Based on traffic projections for the base, opening year and design years, the segments directly associated with the Study Corridor and those roadways in the affected network where the AADT is expected to change +/- 5 percent or more and where there travel time is expected to change by +/- 10 percent for the Build Alternatives compared to the No-Build Alternatives were identified. The full affected network which includes the links affected by both volume and travel time changes (shown in red) is presented in **Figures 4-11 through 4-18** for each Alternative for the 2028 and 2040 conditions. Consistent with FHWA guidance, spurious results in the form of roadway links that would not be expected to be affected by the project (but otherwise met the change criteria) were treated as an artifact of the model and removed by the traffic analysis team. They reviewed the affected network and found it to be consistent with their overall understanding of the larger travel impacts of the Study Corridor.
- To streamline the analysis, and consistent with FHWA guidance, base and opening year No-Build networks are based on the design year (2040) No-Build networks for each Alternative.
- The EPA MOVES2014a model was utilized in order to obtain estimates for emissions for acrolein, benzene, 1, 3-butadiene, diesel PM, formaldehyde, naphthalene and polycyclic organic matter.

Figure 4-11: 2028 MSAT Affected Network for Alternative A

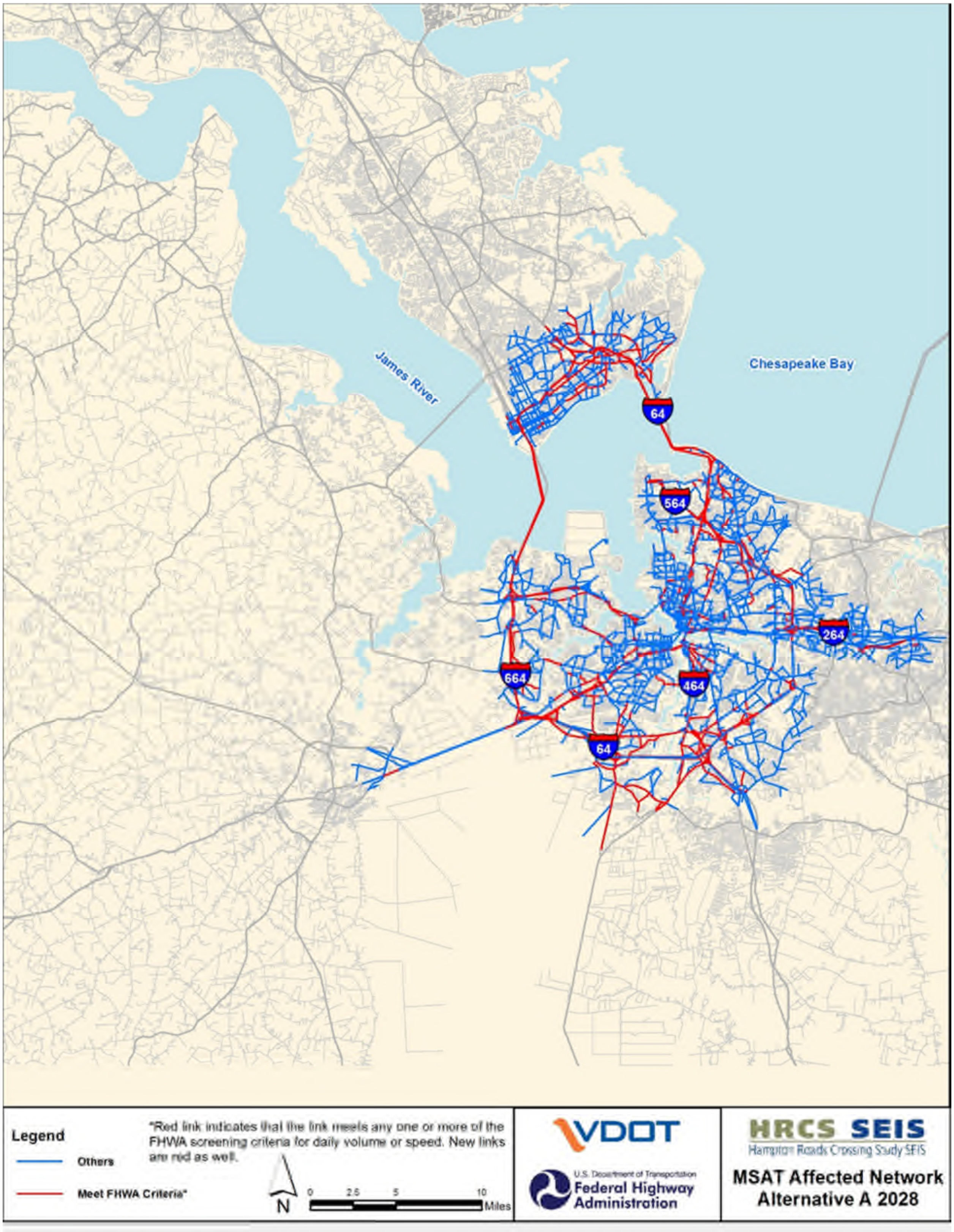


Figure 4-12: 2028 MSAT Affected Network for Alternative B

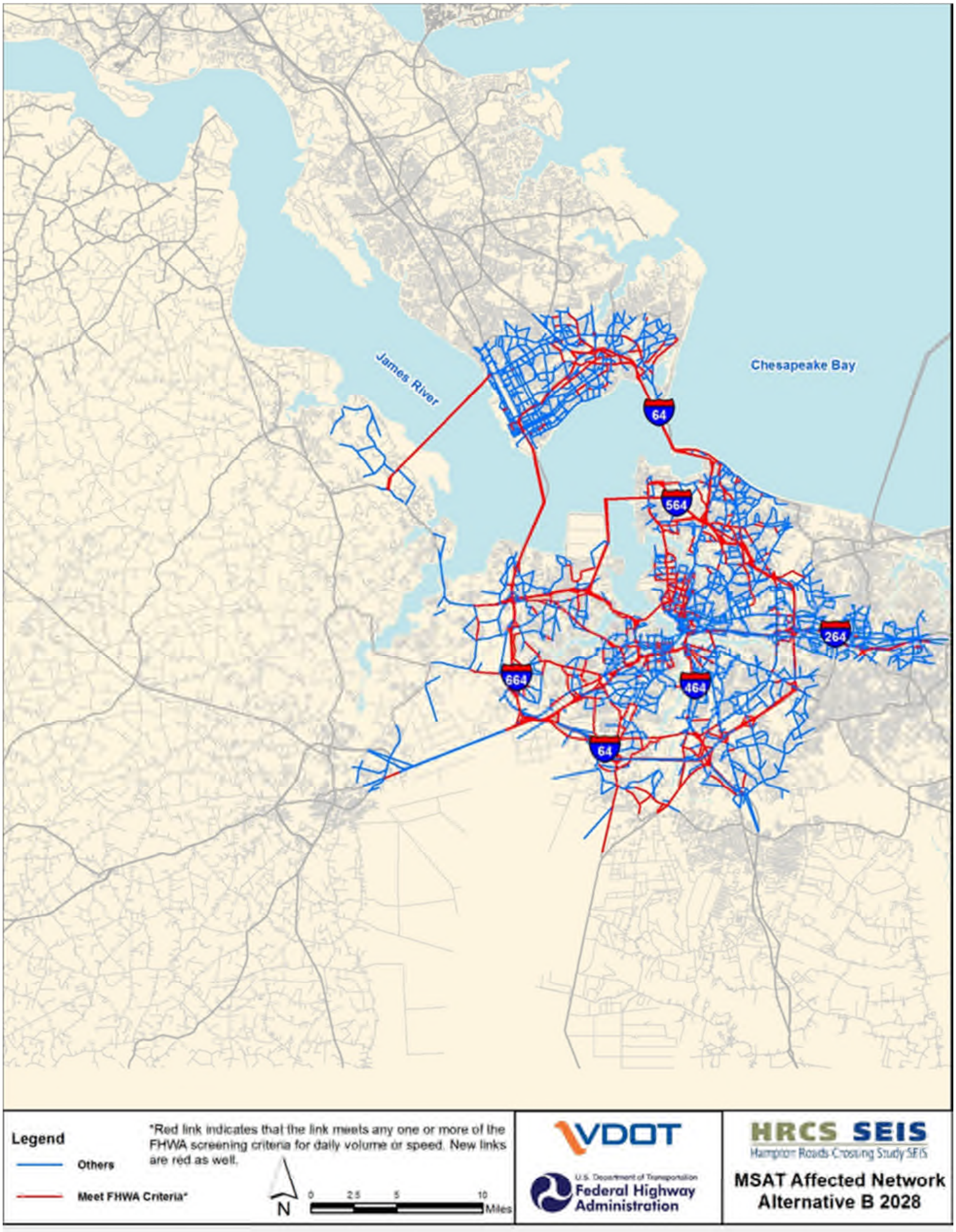


Figure 4-13: 2028 MSAT Affected Network for Alternative C

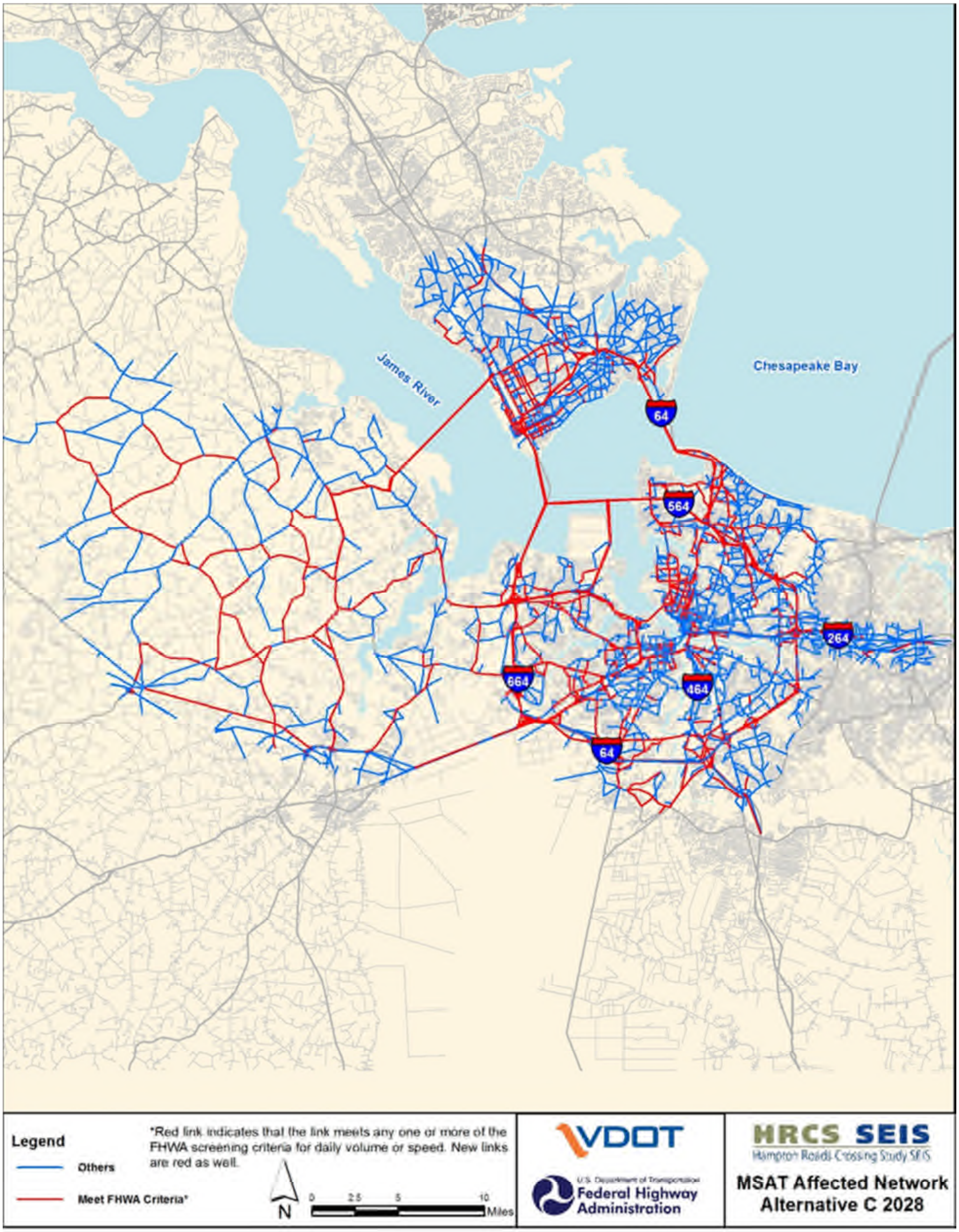


Figure 4-14: 2028 MSAT Affected Network for Alternative D

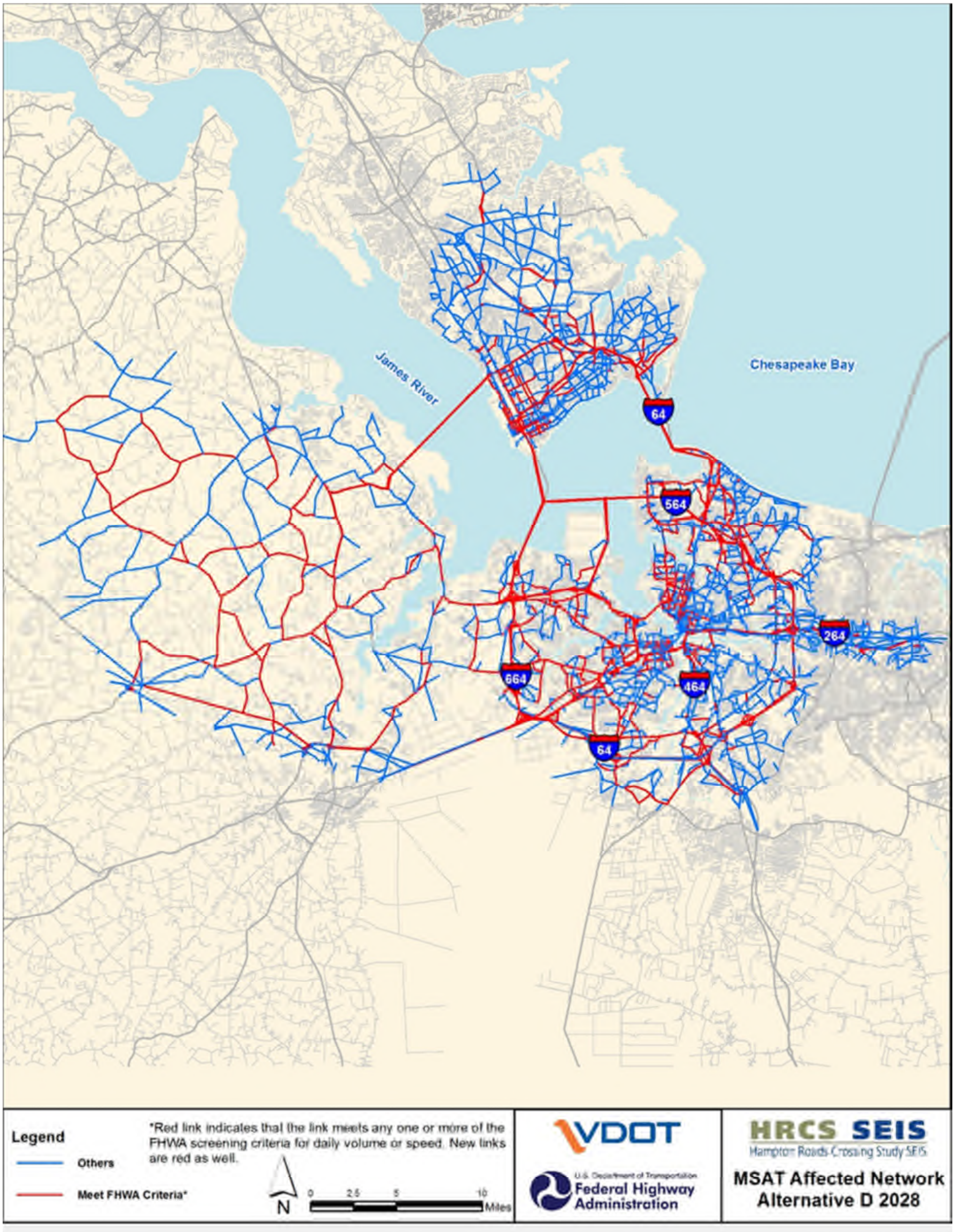


Figure 4-15: 2040 MSAT Affected Network for Alternative A

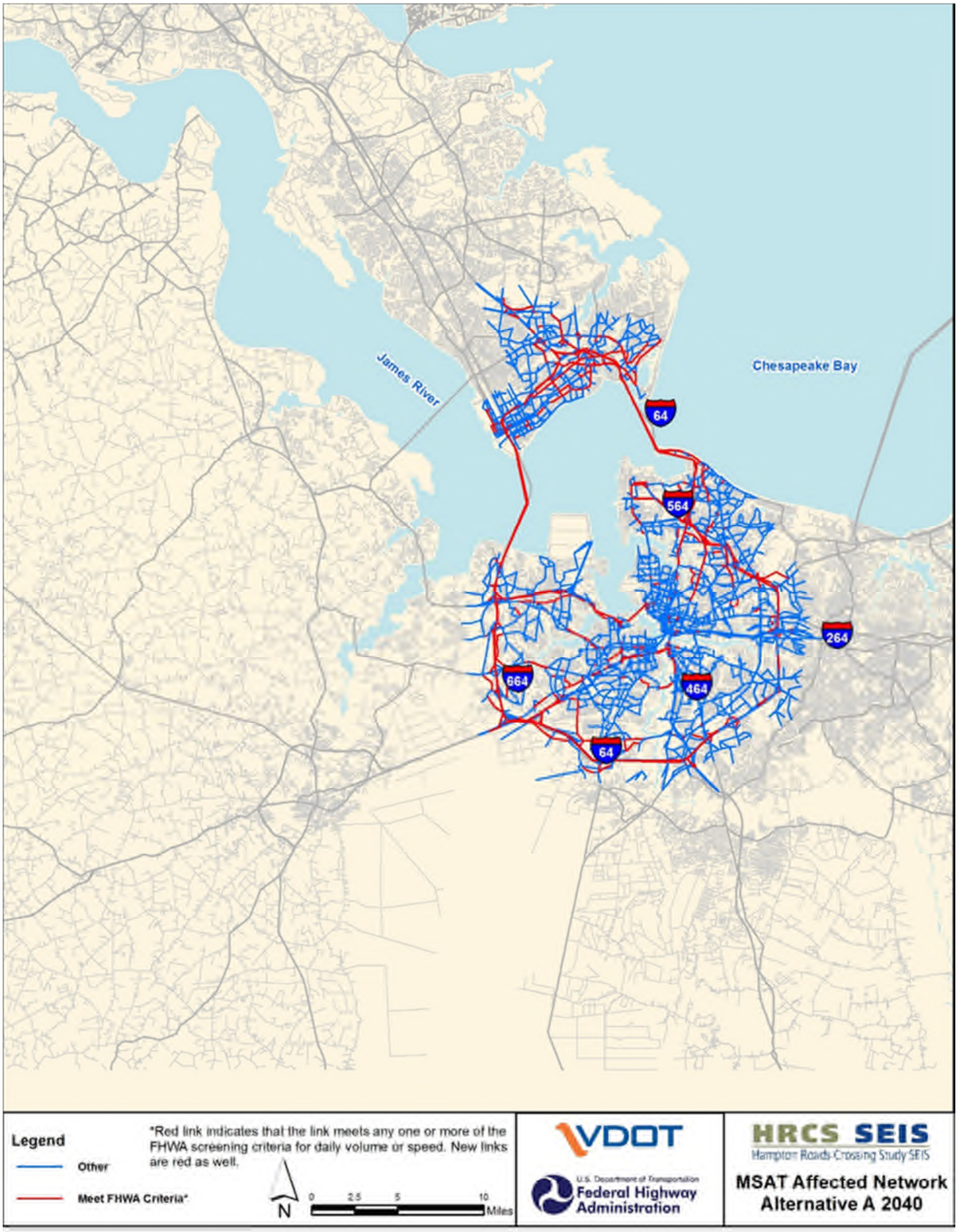


Figure 4-16: 2040 MSAT Affected Network for Alternative B

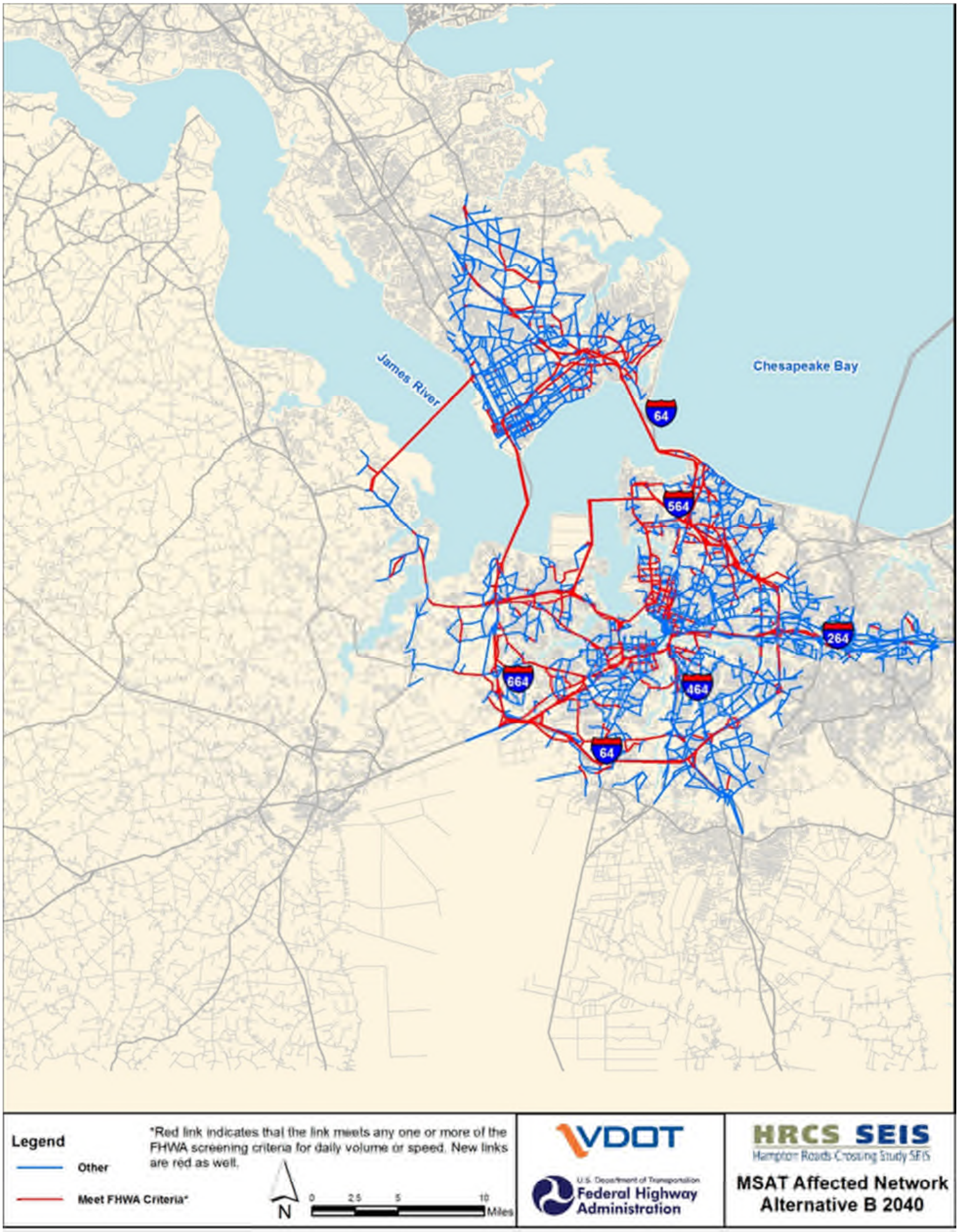


Figure 4-17: 2040 MSAT Affected Network for Alternative C

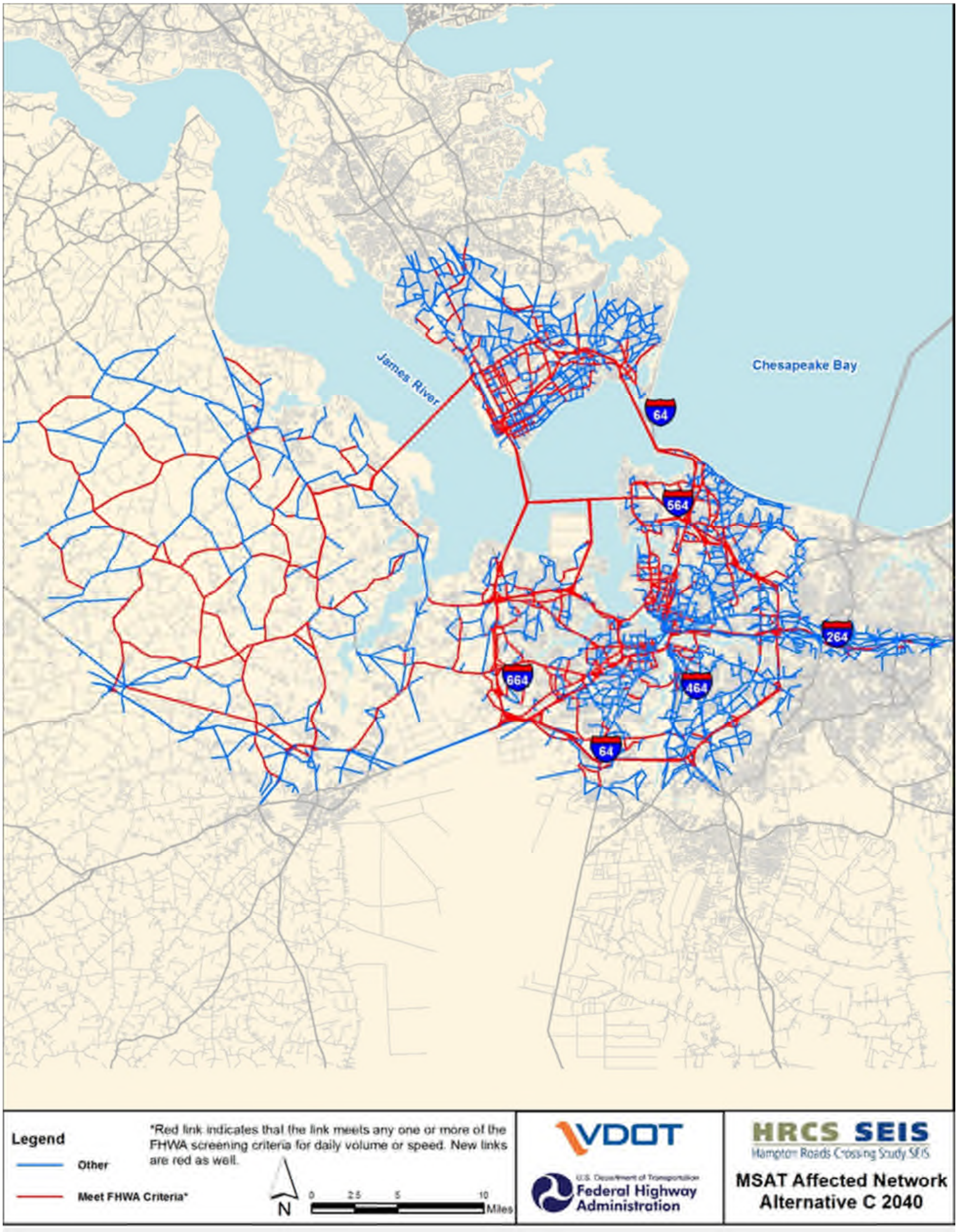
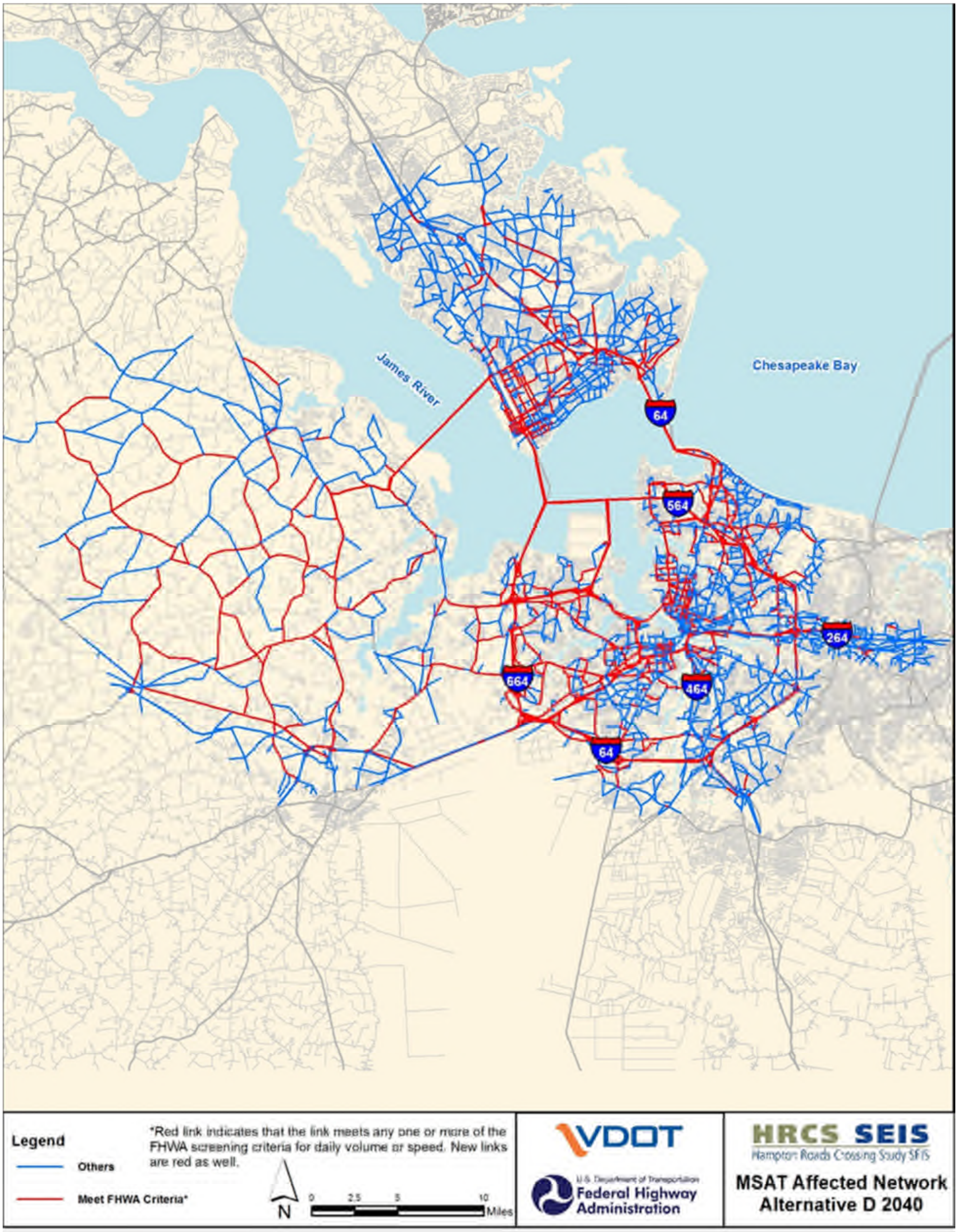


Figure 4-18: 2040 MSAT Affected Network for Alternative D



- The MOVES2014a Runspec and inputs were consistent with FHWA recommendations for conducting a quantitative MSAT analysis, including evaluating four months to represent the different seasons, averaging the resulting emissions for a typical day and multiplying by 365 to obtain average annual emissions for each pollutant.

- MSAT runs were developed for the base year, the opening year Build and No-Build conditions, and the Design year Build and No-Build conditions. A total of twelve scenarios were evaluated consisting of four base year runs for each Alternative, four Build and No-Build scenarios for each Alternative for the 2028 interim year and four Build and No-Build scenarios for each Alternative for the 2040 Design year.
- Age Distribution - Same for all runs, provided by VDOT Resource Document on-line database.
- Meteorology - Annual meteorological data provided by VDOT Resource Document on-line database for the City of Norfolk.
- I/M, Fuel Supply and Formulation - Same for all runs, provided by VDOT Resource Document on-line database. No I/M program in region.
- Annual VMT - The annual VMT was calculated from the regional traffic demand model output for the No-Build and Build Alternatives, for all links in the affected network where traffic volumes change by +/- 5 percent and travel time changes by +/- 10 percent as a result of each Alternative within the Study Corridor. The total VMT was apportioned into the six main MOVES source types for passenger cars, other 2-axle/4-axle vehicles, single unit trucks, buses, combination trucks and motorcycles. The 2014 VDOT 1236[28] report, which contains VMT by road type and source type for all Virginia jurisdictions, was used to apportion the VMT to each of the appropriate MOVES source types. In doing so, the analysis is project specific for each Alternative and condition.
- Day, Month, Hour VMT Fractions – These inputs are the same for all runs, based on the report titled VDOT Traffic Data for the 2014 Periodic Emission Inventory[29].
- Average Speed Distribution - Vehicle speed fraction was estimated from congested vehicle speeds contained in the regional traffic demand model output for each link included in the affected network and were apportioned using the MOVES AvgSpeedBin Table of bins (i.e., 1 through 16) for each road type consistent with the FHWA guidance training examples as described in the VDOT Resource Document. This approach provides project specific results for each Alternative and condition.
- Road Type Distribution - Project specific results are generated for each Alternative and condition based on the functional class of the roadways. Interstates were assigned to MOVES road type category 4 while other roads were assigned to MOVES road type category 5. The distributions of VMT by source type from the VDOT 1236 Report on each of these two road types along with the total VMT by road type from the TDM output files were used to develop evaluation year and Alternative specific road type distributions consistent with the FHWA guidance training examples as described in the VDOT Resource Document.
- Pollutant summary - Emissions from each of the MOVES runs for the Existing, Build and No-Build Interim year and Build and No-Build Design year for each Alternative were summarized for the following pollutants:

[28] http://www.virginiadot.org/info/resources/Traffic_2012/VMTReport_1236_2012.pdf
[29] Traffic Data for the 2014 Periodic Emissions Inventory, VDOT, November 2015.

1. acrolein;
2. benzene;
3. 1,3 butadiene;
4. diesel particulate matter;
5. formaldehyde;
6. naphthalene; and
7. polycyclic organic matter

- The analysis reflects only running exhaust and crankcase running exhaust, while diesel PM exhaust consists of diesel vehicles only. The polycyclic organic matter (POM) was summarized consistent with the pollutants listed in the FHWA guidance for POM.

The results of the quantitative MSAT analysis are presented in **Table 4-8** while changes in emissions compared to the 2028 and 2040 No-Build condition and between the Build and base year condition are provided in **Table 4-9**. A graphical representation of the projected annual MSAT emissions for the Base year, 2028 and 2040 No-Build and Build Alternatives by pollutant are presented in **Figures 4-19 and 4-25.** These tables and figures show that all of the MSAT emissions are expected to increase slightly for the Build Alternative scenario conditions when compared to the No-Build condition for 2028 and 2040. In addition, all MSAT pollutant emissions are expected to significantly decline in the Opening and Design years when compared to Existing conditions. These reductions occur despite projected increase in VMT from 2015 to the 2028 and 2040 Build scenarios. The increased emissions associated with each Build Alternative are generally consistent with the increased VMT associated with each Alternative.

Table 4-8: Projected Annual MSAT Emissions in tons per year (TPY) on "Affected Network"

		Annual Vehicle Miles Traveled (Millions of AVMT)	Acrolein (TPY)	Benzene (TPY)	1,3 Butadiene (TPY)	Diesel PM (TPY)	Formaldehyde (TPY)	Naphthalene (TPY)	Polycyclic Organic Matter (TPY)
2015 Base Year	Existing Alternative A	2,428.1	0.544	10.15	1.190	36.30	8.52	1.04	0.450
	Existing Alternative B	3,645.0	0.835	15.42	1.820	55.30	13.03	1.58	0.687
	Existing Alternative C	4,111.2	0.891	16.83	1.970	58.24	13.97	1.70	0.737
	Existing Alternative D	4,571.8	0.989	18.71	2.189	64.62	15.51	1.89	0.820
2028 Opening Year	Alternative A	3,564.9	0.196	4.05	0.049	8.94	3.66	0.373	0.154
	No-Build	3,492.8	0.187	4.04	0.046	8.42	3.50	0.360	0.152
	Alternative B	4,459.2	0.239	5.08	0.059	10.82	4.48	0.459	0.191
	No-Build	4,288.9	0.225	4.94	0.055	10.05	4.22	0.435	0.184
	Alternative C	5,274.1	0.275	6.00	0.068	12.36	5.16	0.531	0.223
	No-Build	5,064.6	0.274	5.67	0.067	12.00	5.00	0.528	0.212
	Alternative D	5,775.6	0.317	6.46	0.079	14.74	5.94	0.602	0.245
	No-Build	5,519.9	0.289	6.27	0.071	13.01	5.43	0.557	0.233
2040 Design Year	Alternative A	3,236.3	0.104	1.88	0.006	4.17	2.23	0.199	0.070
	No-Build	3,112.1	0.095	1.81	0.005	3.78	2.04	0.184	0.068
	Alternative B	4,859.9	0.145	2.82	0.008	5.71	3.10	0.281	0.105
	No-Build	4,647.8	0.139	2.70	0.008	5.49	2.97	0.269	0.100
	Alternative C	5,619.7	0.166	3.28	0.009	6.54	3.56	0.323	0.123
	No-Build	5,328.3	0.160	3.06	0.009	6.33	3.42	0.309	0.113
	Alternative D	6,385.6	0.189	3.67	0.010	7.46	4.04	0.366	0.136
	No-Build	5,972.6	0.183	3.45	0.010	7.29	3.91	0.352	0.129

Table 4-9: Projected Annual MSAT Change in Emissions on "Affected Network"

		Change in Annual Vehicle Millions of Miles Traveled (AVMT)	Acrolein (TPY)	Benzene (TPY)	1,3 Butadiene (TPY)	Diesel PM (TPY)	Formaldehyde (TPY)	Naphthalene (TPY)	Polycyclic Organic Matter (TPY)
2028 Opening Year	Difference (Build Alt A-No-Build)	72.10	0.01	0.01	0.00	0.52	0.16	0.01	0.00
	Difference (Build Alt A-Existing)	1136.8	-0.348	-6.1	-1.141	-27.36	-4.86	-0.667	-0.296
	Difference (Build Alt B-No-Build)	170.30	0.01	0.14	0.00	0.77	0.26	0.02	0.01
	Difference (Build Alt B-Existing)	814.2	-0.596	-10.34	-1.761	-44.48	-8.55	-1.121	-0.496
	Difference (Build Alt C-No-Build)	209.50	0.00	0.33	0.00	0.36	0.16	0.00	0.01
	Difference (Build Alt C-Existing)	1162.9	-0.616	-10.83	-1.902	-45.88	-8.81	-1.169	-0.514
	Difference (Build Alt D-No-Build)	255.70	0.03	0.19	0.01	1.73	0.51	0.04	0.01
	Difference (Build Alt D-Existing)	1203.8	-0.672	-12.25	-2.11	-49.88	-9.57	-1.288	-0.575
2040 Design Year	Difference (Build Alt A-No- Build)	124.20	0.01	0.07	0.00	0.39	0.19	0.02	0.00
	Difference (Build Alt A-Existing)	808.2	-0.44	-8.27	-1.184	-32.13	-6.29	-0.841	-0.38
	Difference (Build Alt B-No- Build)	212.10	0.01	0.12	0.00	0.22	0.13	0.01	0.00
	Difference (Build Alt B-Existing)	1214.9	-0.69	-12.6	-1.812	-49.59	-9.93	-1.299	-0.582
	Difference (Build Alt C-No- Build)	291.40	0.01	0.22	0.00	0.21	0.14	0.01	0.01
	Difference (Build Alt C-Existing)	1508.5	-0.725	-13.55	-1.961	-51.7	-10.41	-1.377	-0.614
	Difference (Build Alt D-No-Build)	413.00	0.01	0.22	0.00	0.17	0.13	0.01	0.01
	Difference (Build Alt D-Existing)	1813.8	-0.8	-15.04	-2.179	-57.16	-11.47	-1.524	-0.684

Figure 4-19: Acrolein MSAT Results for Existing, 2028 and 2040 Conditions

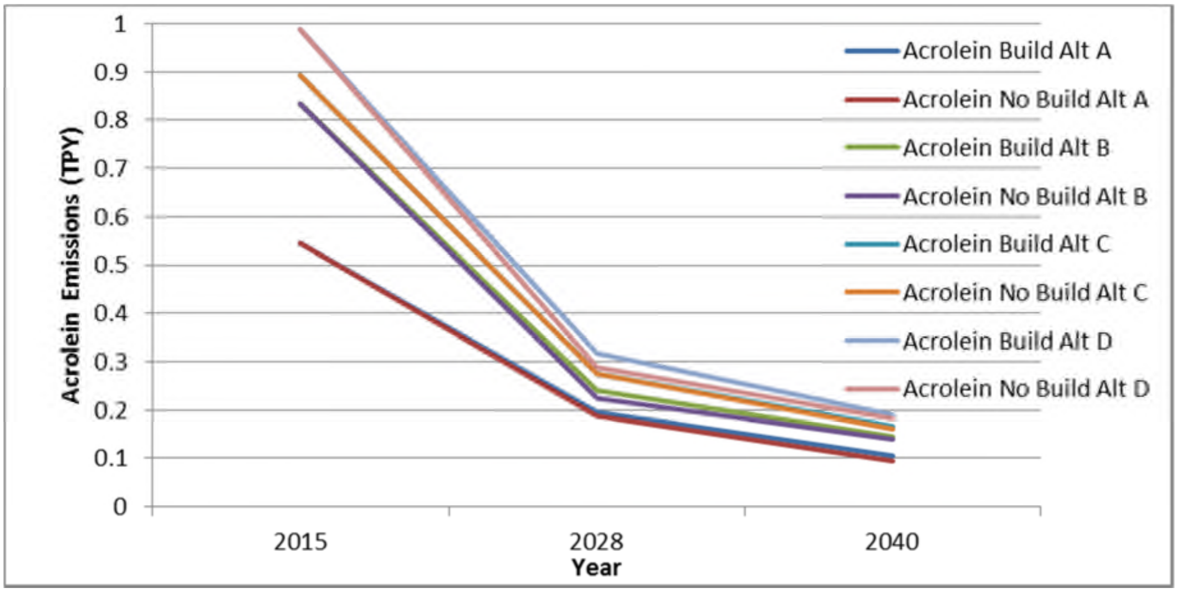


Figure 4-20: Benzene MSAT Results for Existing, 2028 and 2040 Conditions

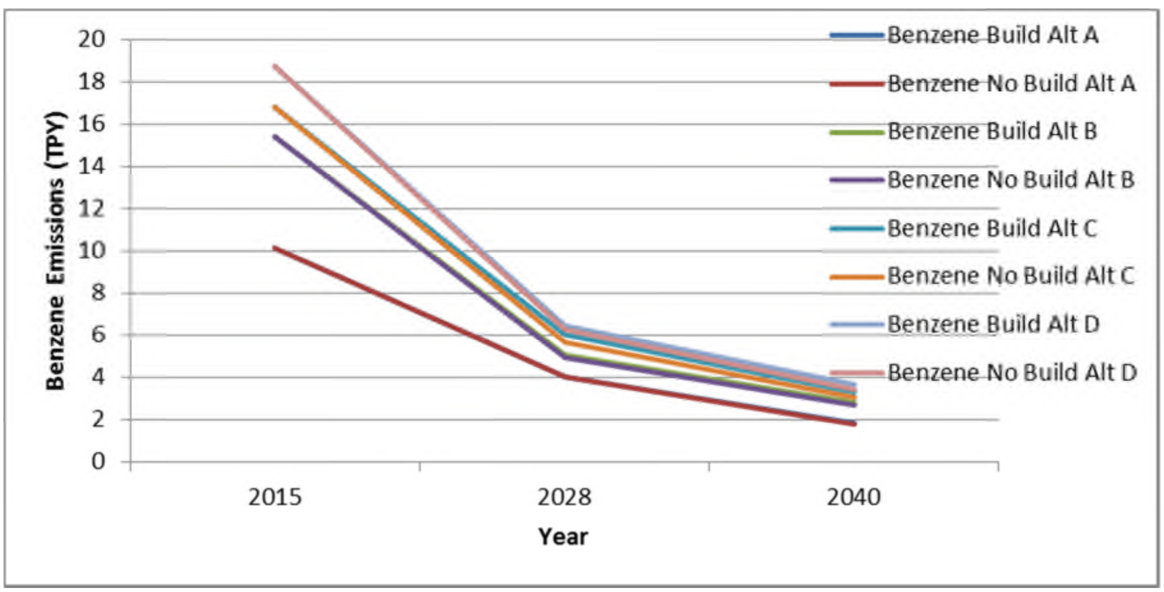


Figure 4-21: 1,3 Butadiene MSAT Results for Existing, 2028 and 2040 Conditions

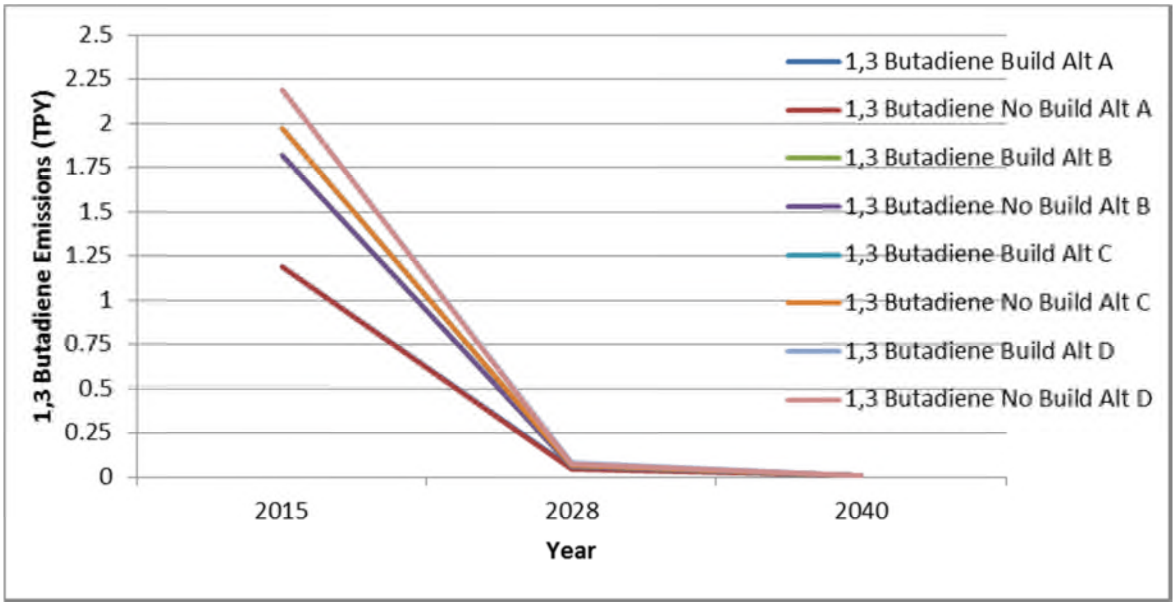


Figure 4-22: Diesel PM MSAT Results for Existing, 2028 and 2040 Conditions

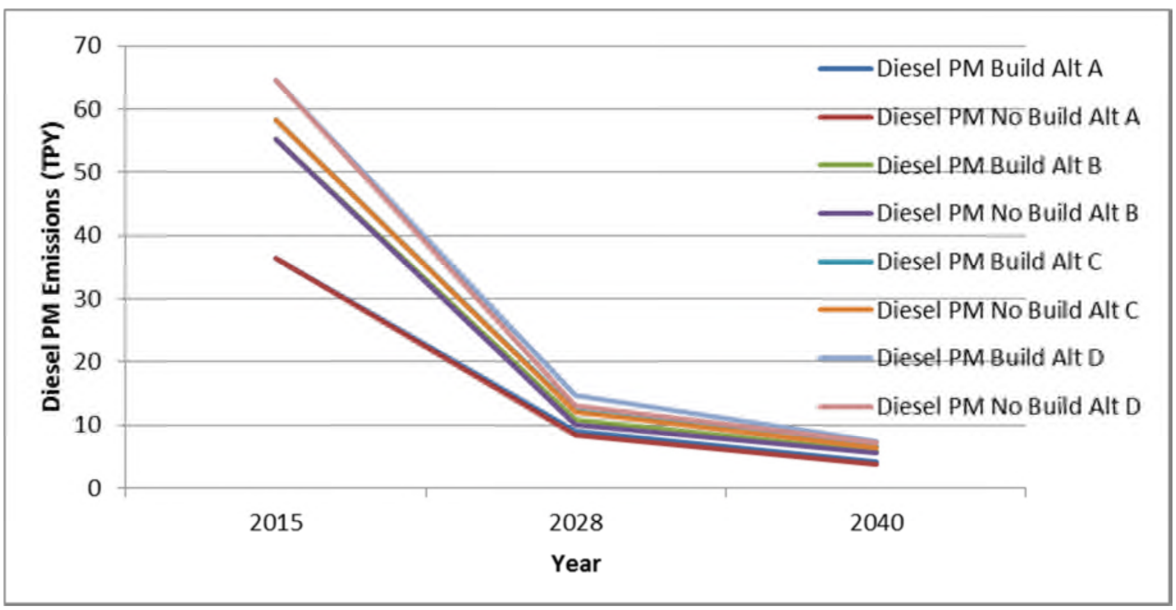


Figure 4-23: Formaldehyde MSAT Results for Existing, 2028 and 2040 Conditions

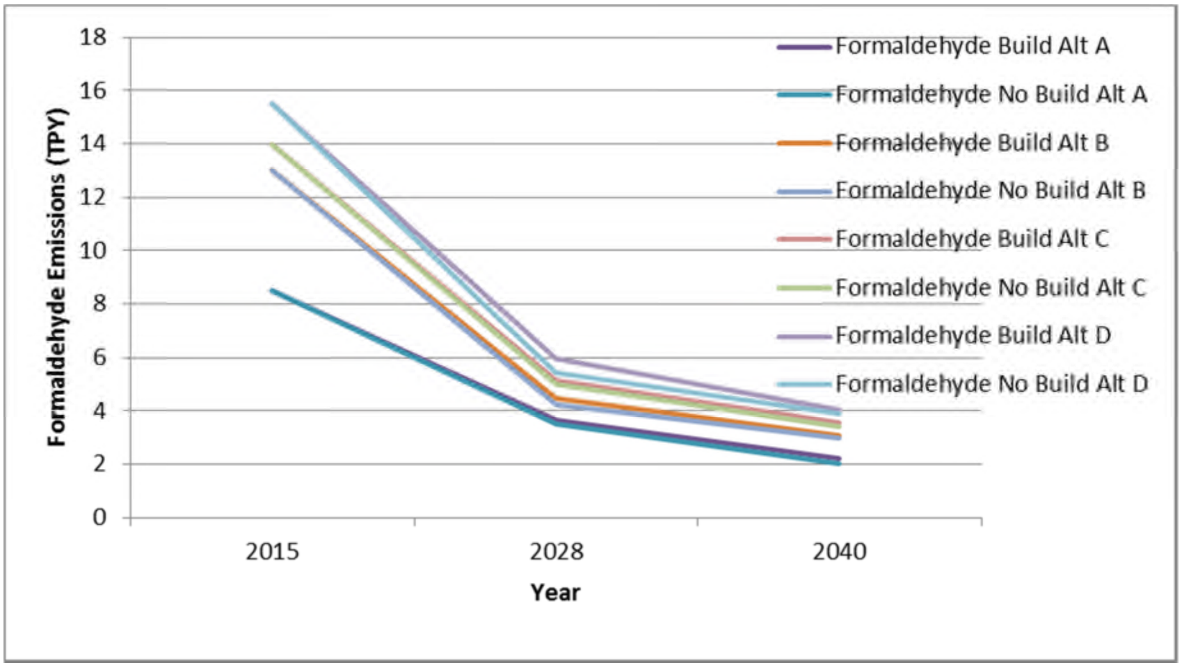


Figure 4-24: Naphthalene MSAT Results for Existing, 2028 and 2040 Conditions

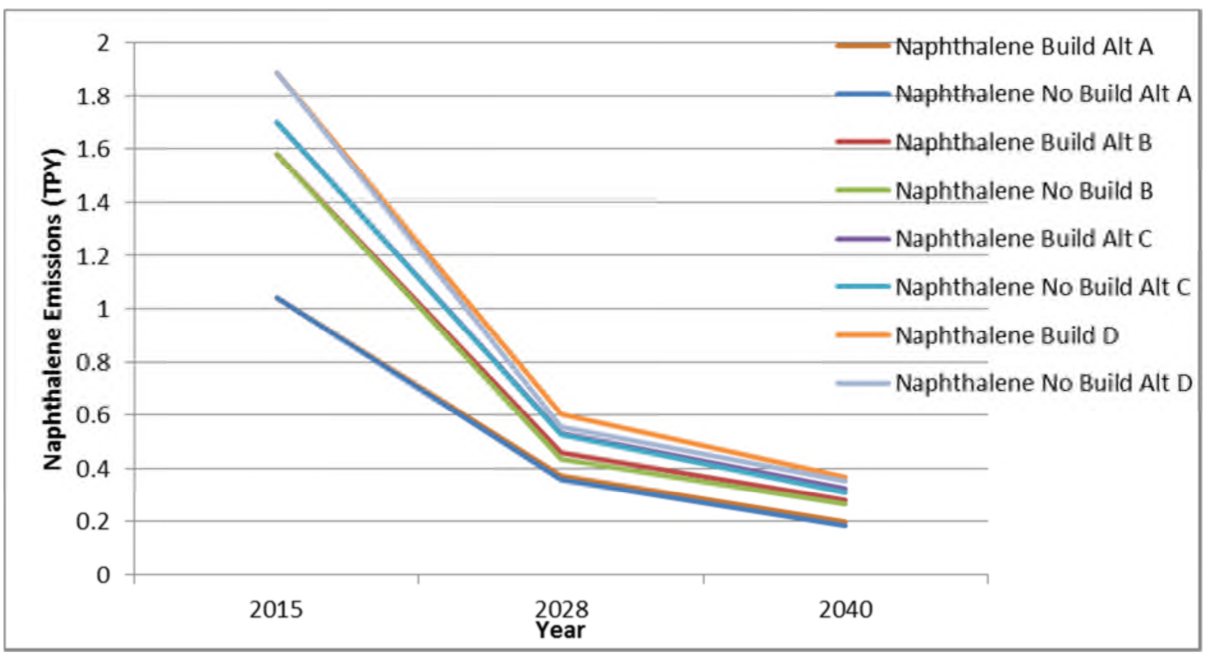
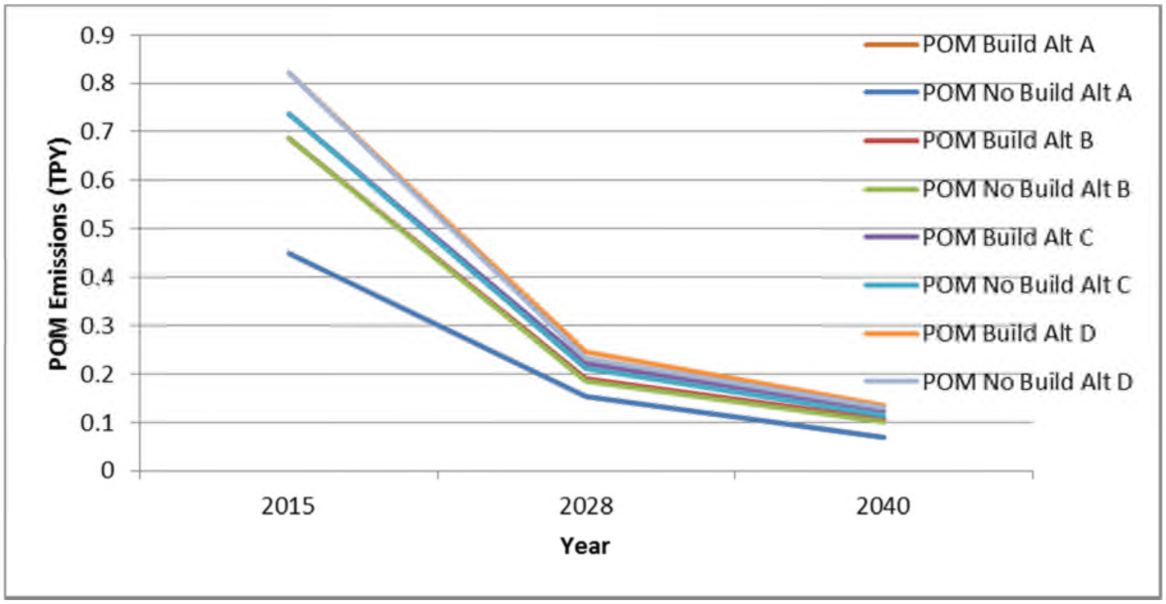


Figure 4-25: Polycyclic Organic Matter (POM) MSAT Results for Existing, 2028 and 2040 Conditions



In general:

- For each MSAT and alternative, the long-term trend in emissions is downward. The downward trend in emissions is a result of technological improvements, i.e., more stringent vehicle emission and fuel quality standards coupled with ongoing fleet turnover, and is achieved despite increased VMT in this period.
- For each MSAT and alternative, the forecast emissions for build and no-build are nearly coincidental, i.e., the differences in emissions between build and no-build are very small especially compared to the long-term downward trend in emissions for each MSAT.
- For each MSAT, emission estimates vary with alternative, which is expected given the substantial differences in the alternatives.

More specifically:

- All MSAT emissions for the Build Alternatives are expected to slightly increase between 0.01 tpy and 1.73 tpy in the Opening Year 2028, and between 0.01 tpy and 0.39 tpy during the Design Year 2040 when compared to the No-Build condition. Diesel PM generally had the highest increases in Build MSAT emissions compared to the No-Build, while 1,3 Butadiene and POV generally had the smallest increases.
- Of more significance is the Build Alternative conditions are expected to result in significant reductions in all MSATs compared to the Base Year in both the Opening and Design years as shown in Figures 4-19 to 4-25.
- MSAT emissions for the Opening year Build Alternative conditions are expected to decrease between 0.3 tpy and 50 tpy compared to the Base year conditions, and MSAT emission for the Design year Build Alternative conditions are expected to decrease between 0.4 tpy and 57 tpy compared to the Base conditions. Diesel PM generally had the highest decrease in MSAT emissions compared to the Existing conditions while POV generally had the lowest decrease in emissions.

- The highest increases in MSAT emissions are expected to occur with Alternative D, while the lowest increases are expected to occur with Alternative A.

In all cases, the magnitude of the MSAT emissions is small in the opening and design years and significantly lower than in the base year. Due to the small magnitude of projected MSAT emissions, the increase observed in 2028 and 2040 from the No-Build to the Build scenario are not considered significant, especially when considering that emissions from all MSATs are expected to be significantly lower in future years than in the base year.

Overall, the results of the MSAT analysis are consistent with national MSAT emission trends predicted by FHWA. No meaningful increases in MSATs have been identified and are not expected to cause an adverse effect on human health as a result of any of the Build Alternatives in future years.

4.5.5 Incomplete or Unavailable Information for Project-Specific MSAT Health Impacts Analysis

In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

The EPA is responsible for protecting the public health and welfare from any known or anticipated effect of an air pollutant. They are the lead authority for administering the CAA and its amendments and have specific statutory obligations with respect to hazardous air pollutants and MSAT. The EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. They maintain the Integrated Risk Information System (IRIS), which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects" (EPA, http://www.epa.gov/iris/). Each report contains assessments of non-cancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Other organizations are also active in the research and analyses of the human health effects of MSAT, including the Health Effects Institute (HEI). Two HEI studies are summarized in Appendix D of FHWA's Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA Documents. Among the adverse health effects linked to MSAT compounds at high exposures are cancer in humans in occupational settings, cancer in animals, and irritation to the respiratory tract, including the exacerbation of asthma. Less obvious is the adverse human health effects of MSAT compounds at current environmental concentrations (HEI, http://pubs.healtheffects.org/view.php?id=282) or in the future as vehicle emissions substantially decrease (HEI, http://pubs.healtheffects.org/view.php?id=306).

The methodologies for forecasting health impacts include emissions modeling, dispersion modeling, exposure modeling, and then final determination of health impacts, with each step in the process building on the model predictions obtained in the previous step. All are encumbered by technical shortcomings or uncertain science that prevents a more complete differentiation of the MSAT health impacts among a set of project alternatives. These difficulties are magnified for lifetime (i.e. 70 year) assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over that time frame, since such information is unavailable.

It is particularly difficult to reliably forecast 70-year lifetime MSAT concentrations and exposure near roadways to (1) determine the portion of time that people are actually exposed at a specific location; and (2) establish the extent attributable to a proposed action especially given that some of the information needed is unavailable.

There are considerable uncertainties associated with the existing estimates of toxicity of the various MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population, a concern expressed by HEI (http://pubs.healtheffects.org/view.php?id=282). As a result, there is no national consensus on air dose-response values assumed to protect the public health and welfare for MSAT compounds, and in particular for diesel PM. The EPA (http://www.epa.gov/risk/basicinformation.htm#g) and the HEI (http://pubs.healtheffects.org/getfile.php?u=395) have not established a basis for quantitative risk assessment of diesel PM in ambient settings.

There is also the lack of a national consensus on an acceptable level of risk. The current context is the process used by the EPA as provided by the CAA to determine whether more stringent controls are required in order to provide an ample margin of safety to protect public health or to prevent an adverse environmental effect for industrial sources subject to the maximum achievable control technology standards, such as benzene emissions from refineries. The decision framework is a two-step process. The first step requires EPA to determine an "acceptable" level of risk due to emissions from a source, which is generally no greater than approximately 100 in a million. Additional factors are considered in the second step, the goal of which is to maximize the number of people with risks less than 1 in a million due to emissions from a source. The results of this statutory two-step process do not guarantee that cancer risks from exposure to air toxics are less than 1 in a million; in some cases, the residual risk determination could result in maximum individual cancer risks that are as high as approximately 100 in a million. In a June 2008 decision, the U.S. Court of Appeals for the District of Columbia Circuit upheld EPA's approach to addressing risk in its two step decision framework. Information is incomplete or unavailable to establish that even the largest of highway projects would result in levels of risk greater than deemed acceptable.

Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits, such as reducing traffic congestion, accident rates, and fatalities, in addition to improved access for emergency response, that are better suited for a quantitative analysis.

4.5.6 MSAT Conclusions

What we know about mobile source air toxics is still evolving. Information is currently incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with each of the project Alternatives. Under each of the Build Alternatives, there may be slightly higher MSAT emissions in the design year relative to the No-Build Alternative due to increased VMT. There could also be increases in MSAT levels in a few localized areas where VMT increases. However, EPA's vehicle and fuel regulations are expected to result in significantly lower MSAT levels in the future than exist today due to cleaner engine standards coupled with fleet turnover. The magnitude of the EPA-projected reductions is so great that, even after accounting for VMT growth, MSAT emissions in the study area would be significantly lower in the future than they are today, regardless of the preferred Alternative chosen.

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5. TUNNEL ASSESSMENT

Included in the Study evaluation is the addition of new tunnels under Hampton Roads waterway to accommodate additional traffic. A series of new tunnels are proposed for each Alternative at I-64, I-564 and I-664 including two transit lane only tunnels for Alternative C. A description of the existing tunnel and proposed tunnels for each Alternative follows.

5.1 EXISTING TUNNELS

I-64

In Alternatives A, B, and D, the eastbound Hampton Roads Bridge Tunnel (HRBT) would be modified to carry two westbound lanes and both tunnels would be rehabilitated and upgraded.

The tunnel system upgrades would address the ventilation system and National Fire Protection Association (NFPA) 502 standards. In both tunnels, the existing transverse ventilation system would be converted to a longitudinal ventilation system with the addition of jet fans.

I-664

In Alternatives C and D, the southbound Monitor-Merrimack Memorial Bridge Tunnel (MMMBT) would be modified to carry two northbound lanes and both tunnels would be rehabilitated and upgraded as described for the HRBT above.

5.2 NEW TUNNELS

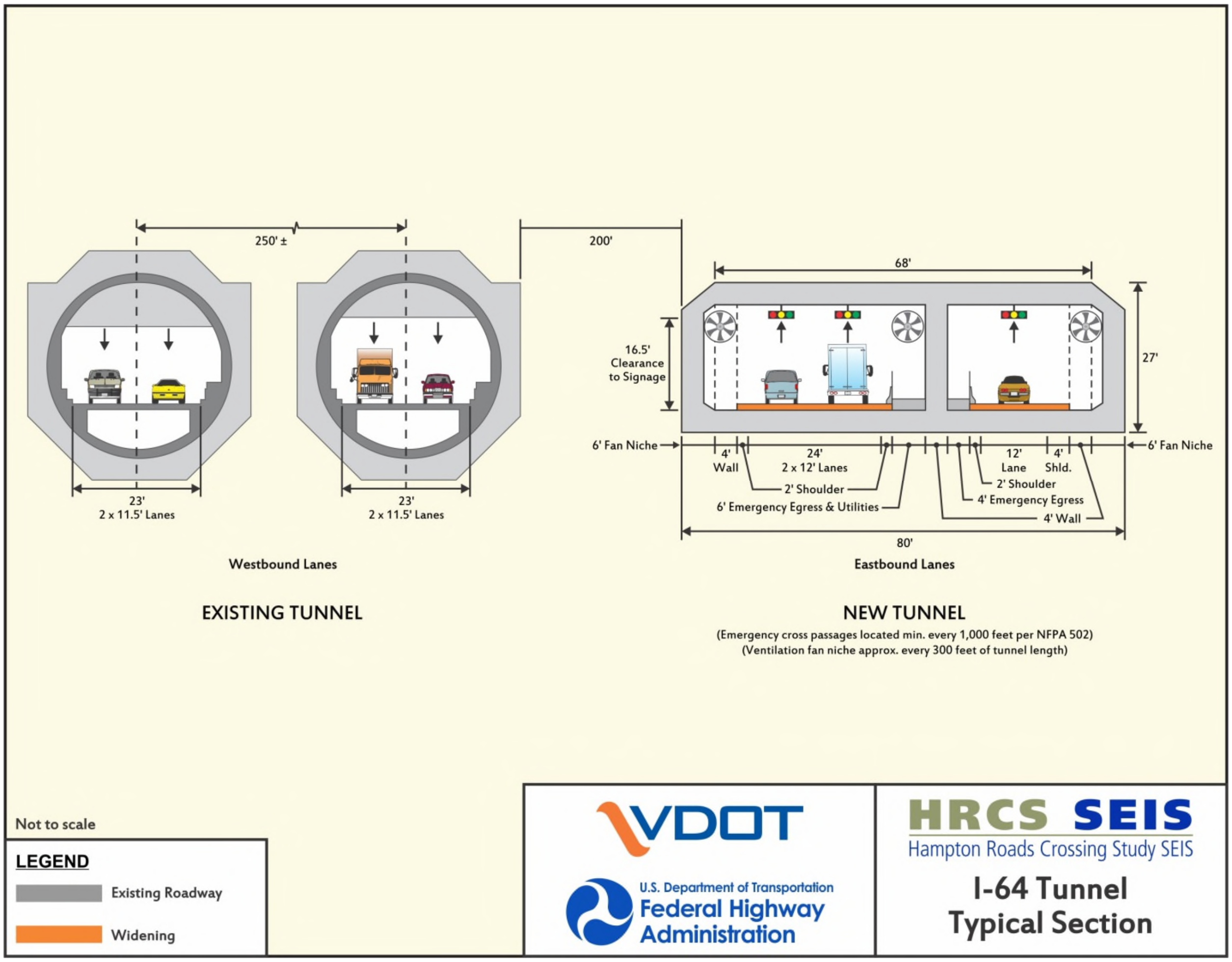
I-64

In Alternatives A, B, and D, a new tunnel carrying the eastbound lanes would be constructed approximately 200 feet (outside of tunnel to outside of tunnel) west of the existing tunnel. The tunnel profile would have a minimum grade of 0.5 percent and a maximum grade of 4.0 percent. The top of the tunnel armor would be 65 feet below the mean low water (MLW) level within the existing 1,000-foot wide Norfolk Harbor Entrance Reach.

The new tunnel would provide three travel lanes in two compartments at an estimated width of 40 and 28 feet, respectively. The two compartments would be separated by a 4-foot thick wall. The total width of the tunnel would be 92 feet. **Figure 5-1** provides the build typical sections for the I-64 tunnel. It was assumed the new tunnels would be equipped with a longitudinal jet fans ventilation system to move the air either during peak hour conditions or in the event of an accident or emergency

The proposed tunnel portals would not be located immediately adjacent to the existing tunnel portals due to the profile and the depth of the new tunnel; however, the new portals would be close enough to the existing portals to allow the existing islands to be expanded to receive the new tunnel and approach bridges without creating new islands.

Figure 5-1: Typical Build Section for the I-64 Tunnel

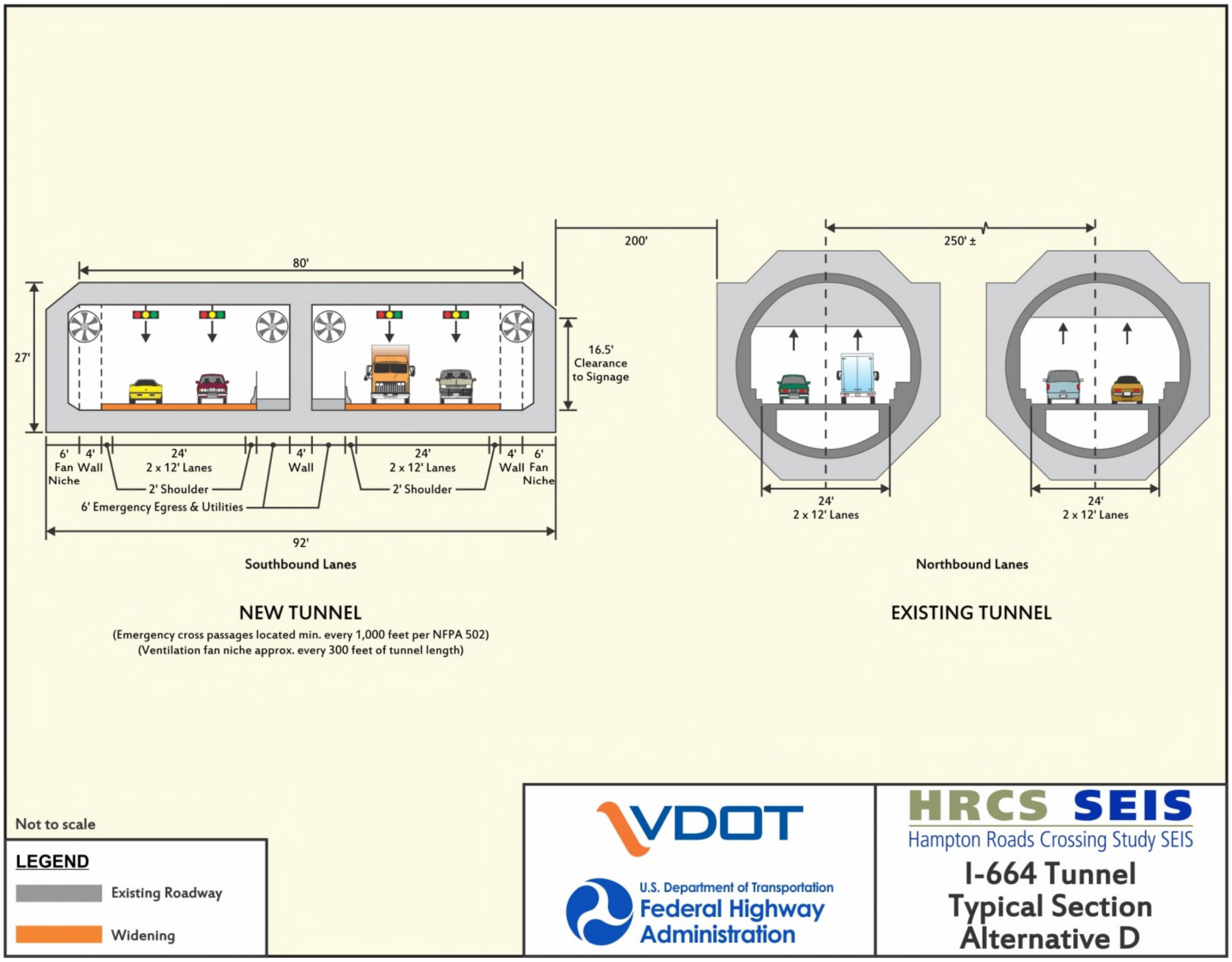


<u>I-664</u>

In Alternatives C and D, new tunnels carrying the eastbound lanes would be constructed approximately 1,200 feet (outside of tunnel to outside of tunnel) west of the existing tunnel. The tunnel profiles would have a minimum grade of 0.5 percent and a maximum grade of 4.0 percent. The top of the tunnel armor would be 65 feet below the mean low water (MLW) level within the existing 800-foot wide Newport News Channel.

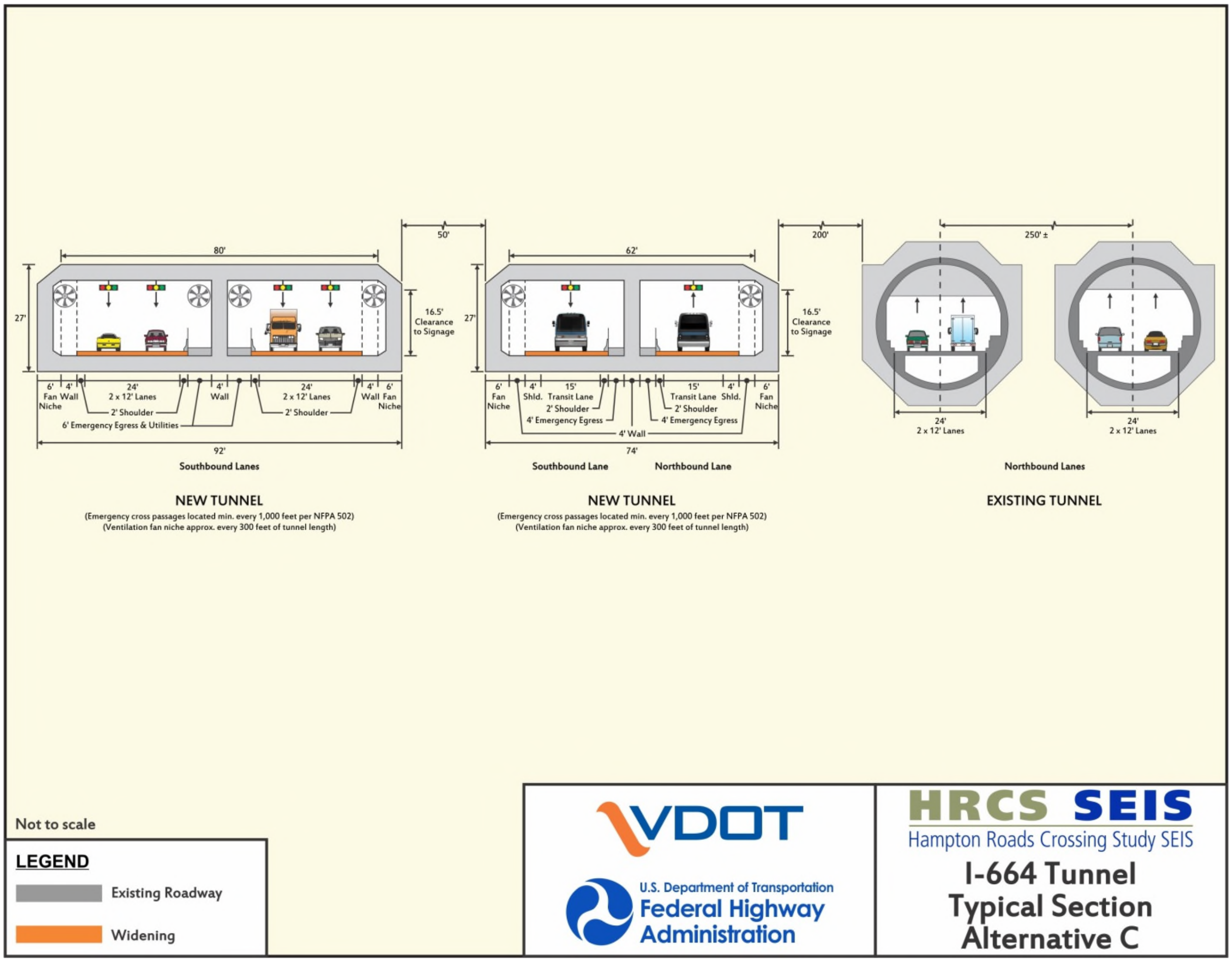
In Alternative D, one new tunnel is proposed. It would include four southbound general purpose travel lanes in two compartments at an estimated width of 40 feet each. The two compartments would be separated by a 4-foot thick wall. The total width of the tunnel would be 92 feet. **Figure 5-2** provides the build typical sections for the I-664 tunnel for Alternative D.

Figure 5-2: Typical Build Section for the I-664 Tunnel for Alternative D



In Alternative C, two new tunnels are proposed. The new tunnels would be constructed approximately 50 feet apart (outside of tunnel to outside of tunnel). One tunnel would include four southbound general purpose travel lanes in two compartments at an estimated width of 40 feet each. The two compartments would be separated by a 4-foot thick wall. The total width of the tunnel would be 80 feet. The other tunnel would include two transit lanes, one in each direction in two compartments at an estimated at width of 31 feet each. The two compartments would be separated by a 4-foot thick wall. The total width of the tunnel would be 74 feet. **Figure 5-3** provides the build typical sections for the I-664 tunnel.

Figure 5-3: Typical Build Section for the I-664 Tunnel for Alternative C



The proposed tunnel portals would not be located immediately adjacent to the existing tunnel portals because the alignment of southbound I-664 diverges from northbound I-664 in Newport News. The tunnel approaches would likely consist of new cast-in-place boat and cut-and-cover structures founded on piling or other suitable foundations. It was assumed the new tunnels for Alternatives C and D would be equipped with a longitudinal jet fans ventilation system to move the air either during peak hour conditions or in the event of an accident or emergency.

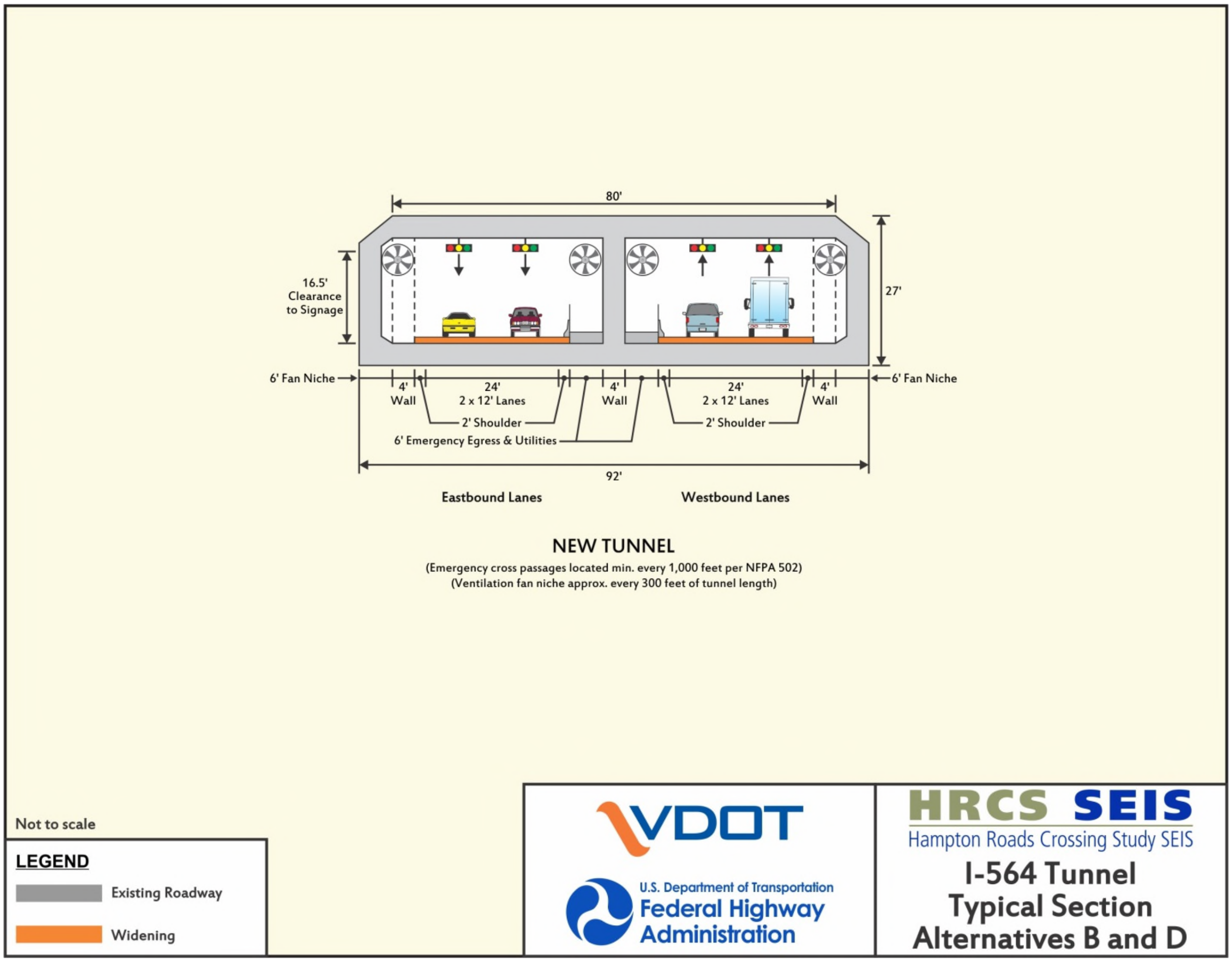
<u>I-564</u>

In Alternatives B, C, and D, new tunnels carrying the eastbound lanes would be constructed. The tunnel profiles would have a minimum grade of 0.5 percent and a maximum grade of 4.0 percent. The top of the tunnel armor would be 65 feet below the mean low water (MLW) level within the existing 1,250-foot wide Norfolk Harbor Reach.

In Alternatives B and D, one new tunnel is proposed. It would include two eastbound general purpose travel lanes in one compartment and two westbound general purpose travel lanes in one compartment at an estimated width of 40 feet each. The two compartments would be separated by a 4-foot thick wall.

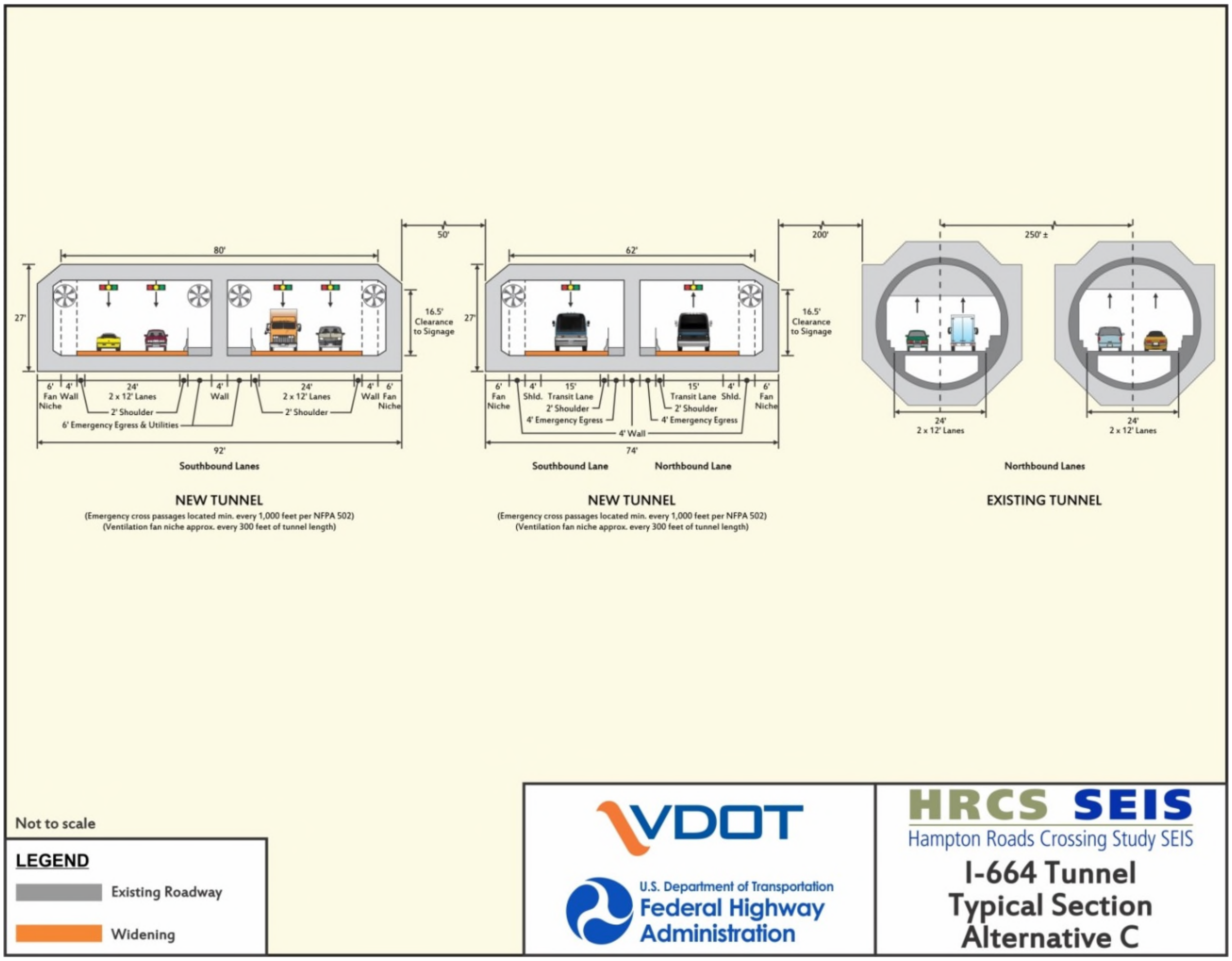
The total width of the tunnel would be 92 feet. **Figure 5-4** provides the build typical sections for the I-564 tunnel for Alternatives B and D.

Figure 5-4: Typical Build Section for the I-564 Tunnel for Alternative B and D



In Alternative C, two new tunnels are proposed. The new tunnels would be constructed approximately 50 feet apart (outside of tunnel to outside of tunnel). One tunnel would include two eastbound general purpose travel lanes in one compartment and one eastbound transit lanes in one compartment at an estimated width of 40 feet and 31 feet, respectively. The two compartments would be separated by a 4-foot thick wall. The total width of the tunnel would be 83 feet. **Figure 5-5** provides the build typical sections for the I-564 tunnel for Alternative C. It was assumed the new tunnels for Alternative B, C and D would be equipped with a longitudinal jet fans ventilation system to move the air either during peak hour conditions or in the event of an accident or emergency.

Figure 5-5: Typical Build Section for the I-564 Tunnel for Alternative C



5.3 TUNNEL ASSESSMENT

The ventilation system within the tunnels would be designed consistent with the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) Handbook, Chapter 15, Enclosed Vehicular Facilities -Tunnels. The ventilation system design is based on controlling the level of emissions to acceptable concentrations inside the tunnel during normal operations along with the capacity to remove smoke and gases during emergencies; and to assure both the traveling public as well as highway worker/emergency personal safety that air quality within the tunnel will be met consistent with normal ventilation air quantities as described in the referenced ASHRAE standard.

The tunnel assessment will demonstrate that air quality in the new tunnels will be controlled consistent with current federal standards as well as FHWA/US EPA guidelines for CO concentrations in tunnels. According to the ASHRAE standard, tests and operating experience have shown that when CO is adequately controlled, the other vehicle emission pollutants are likewise adequately controlled. Therefore, the analysis will demonstrate that the one-hour CO NAAQS of 35 ppm along with the FHWA/EPA 15-minute exposure level of 120 ppm will be met inside the new tunnels.

In order to demonstrate compliance with the 1-hour CO NAAQS and the FWHA/EPA 15-minute exposure level, the analysis had to address the worst-case scenarios that can be expected. This was generally considered to be (1) peak-hour traffic for routine tunnel operations and 2) an incident that stops traffic (e.g. accident or vehicle breakdown). In the case of peak hour traffic, this is normally one or two hours in the early morning and one or two hours in the late afternoon (i.e. rush-hour traffic) where congestion is higher corresponding with lower vehicle speeds compared to average conditions. For this analysis, peak hour traffic speeds are expected to range from 10 mph to over 40 mph depending on the location, therefore, a conservative speed of 10 mph was assumed for the worst-case peak hour speeds. The incident scenario is the other potential worst-case characterized by stopped vehicles, bumper-to-bumper vehicles in all lanes with engines idling. Under this scenario, the build-up of pollutant emissions in the tunnel could be maximized due to higher CO emission rates at lower vehicle speeds.

If the 35 ppm standard and the 120 ppm guideline are being met inside the tunnel, it can be concluded that emissions from the portals would also be below the CO standard and guideline levels in the ambient air outside the tunnel.

Aerial photography was examined for the areas of the existing and proposal tunnel portals to assess potential air quality impacts to adjacent land uses. This was conducted for the Hampton Roads Bridge Tunnel, the Monitor-Merrimac Memorial Bridge Tunnel, and a new Tunnel under the Elizabeth River.

The north portal to the Hampton Roads Bridge Tunnel is located south of the City of Hampton. The highway crosses from the mainland to a manmade island west of Fort Monroe where it enters the portal. The adjacent mainland areas are densely developed. As part of Alternative A of the HRCS, a new parallel bridge-tunnel with access to the new portal also being located south of the mainland is proposed. The south portal is located at a manmade island adjacent to Riggs Island north of and offshore from the mainland of Norfolk City. The proposed south portal will be located adjacent to the existing one which is remote and removed from the densely developed areas of Norfolk.

The north portal of the Monitor-Merrimac Memorial Bridge Tunnel is located on the mainland and southern tip of Newport News. A manmade spit was constructed extending from the existing shoreline to accommodate the entry into the tunnel. Adjacent land uses are primarily industrial seaport including working waterfront along Newport News Creek and a shipping facility to the west. As part of the HRCS Alternatives C and D, a new parallel bridge and tunnel would be constructed adjacent to the existing one. The south portal is located in the middle of Hampton Roads far from both the north shore in Newport News and the south shore in Chesapeake. Given the existing level of dense development and the remote location of the existing and new portals, impacts are expected to be limited.

As part of Alternative C, a new bridge-tunnel is proposed across the Elizabeth River from Norfolk to an area north of Craney Island in Portsmouth. For this east-west route, the east portal would be located just south of the Norfolk Naval Station in a densely developed area. The west portal would be located on a manmade island north of Craney Island. These areas are currently densely developed and therefore impacts are anticipated to be limited.

The methodology and assumptions for assessing the tunnel air quality analysis were consistent with the most recent Federal Highway Administration (FHWA) guidance (*Revised Guidelines for the Control of Carbon Monoxide (CO) Levels in Tunnels* [30]. The methodology included a series of calculations using the tunnel dimensions, ventilation system data, and traffic emissions and assumptions to estimate the CO concentration inside the tunnel including using 2040 Build Alternative traffic volumes with 2028 emission rates. This is a conservative assumption since 2040 traffic volumes within the tunnel are expected to be greater than 2028 volumes and 2028 will have higher vehicular emissions rates compared to 2040 since emission rates decline with time due to EPA's vehicle and fuel regulations (see Table 4-4 for example of 2028 and 2040 emission factors). EPA regulations are expected to result in significantly lower emissions in the future than exist today due to cleaner engine standards coupled with fleet turnover. **Table 5-1** presents the assumptions used for assessing CO concentrations in the tunnels for each Build Alternative along with the Existing and No-Build conditions.

[30] https://www.environment.fhwa.dot.gov/guidebook/vol1/doc1q.pdf

Table 5-1: Assumptions Used For Assessing CO Concentrations in the Tunnels for the Build, Existing and No-Build Alternatives

Parameter	Alternative A		Alternative B			
	HRBT I-64 Eastbound 1 & 2	HRBT I-64 Eastbound 3	HRBT I-64 Eastbound 1 & 2	HRBT I-64 Eastbound 3	I-564 Eastbound 1 & 2	I-564 Westbound 1 & 2
Length of Tunnel	7,400	7,400	7,400	7,400	5,100	5,100
2040 Average Daily Traffic (ADT)	45,866	22,933	44,666	23,333	25,900	25,900
2040 Peak Hour Traffic	3,313	1,657	3,243	1,621	2,155	2,145
Idle Traffic	740	370	740	370	510	510
Worst Case Peak Hour Speeds (mph)	10	10	10	10	10	10
2028 CO Emission Factor (10 mph) (g/mile)[1]	2.58	2.58	2.58	2.58	2.58	2.58
2028 CO Emission Factor (idle) (g/veh-hr)	1.85	1.85	1.85	1.85	1.85	1.85
Flow Rate (cfm)	771,042	385,000	771,042	385,000	771,042	771,042

Parameter	Alternative C							
	I-564 Eastbound 1 & 2	I-564 Westbound 1 & 2	I-664 Southbound 1 & 2	I-664 Northbound 1 & 2	I-664 Northbound Bus Only	I-664 Southbound Bus Only	I-564 Westbound Bus Only	I-564 Eastbound Bus Only
Length of Tunnel	5,100	5,100	5,100	5,100	5,100	5,100	5,100	5,100
2040 Average Daily Traffic (ADT)	44,800	44,800	63,300	64,400	300	300	300	300
2040 Peak Hour Traffic	2,645	2,815	4,640	5,095	18	18	18	18
Idle Traffic	510	510	510	510	255	255	255	255
Worst Case Peak Hour Speeds (mph)	10	10	10	10	10	10	10	10
2028 CO Emission Factor (10 mph) (g/mile)[1]	2.58	2.58	2.58	2.58	3.40	3.40	3.40	3.40
2028 CO Emission Factor (idle) (g/veh-hr)	1.85	1.85	1.85	1.85	14.3	14.3	14.3	14.3
Flow Rate (cfm)	771,042	771,042	771,042	771,042	385,000	385,000	385,000	385,000

Notes: 1. A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines.

Table 5-1: Assumptions Used For Assessing CO Concentrations in the Tunnels for Alternative (cont.)

Parameter	Alternative D					
	HRBT I-64 Eastbound 1 & 2	HRBT I-64 Eastbound 3	I-564 Eastbound 1 & 2	I-564 Westbound 1 & 2	I-664 Southbound 1 & 2	I-664 Northbound 1 & 2
Length of Tunnel	7,400	7,400	5,100	5,100	5,100	5,100
2040 Average Daily Traffic (ADT)	41,400	20,700	43,200	43,200	57,800	57,100
2040 Peak Hour Traffic	2,983	1,492	2,525	2,735	4,320	4,945
Idle Traffic	740	370	510	510	510	510
Worst Case Peak Hour Speeds (mph)	10	10	10	10	10	10
2028 CO Emission Factor (10 mph) (g/mile)[1]	2.58	2.58	2.58	2.58	2.58	2.58
2028 CO Emission Factor (idle) (g/veh-hr)	1.85	1.85	1.85	1.85	1.85	1.85
Flow Rate (cfm)	771,042	385,000	771,042	771,042	771,072	771,042

Parameter	Existing	
	HRBT I-64 Eastbound 1 & 2	HRBT I-64 Westbound 1 & 2
Length of Tunnel	7,400	7,400
Average Daily Traffic (ADT)	46,300	44,700
Peak Hour Traffic	3,445	3,370
Idle Traffic	740	740
Worst Case Peak Hour Speeds (mph)	10	10
2015 CO Emission Factor (10 mph) (g/mile)[1]	6.84	6.84
2015 CO Emission Factor (idle) (g/veh-hr)	18.3	18.3
Flow Rate (cfm)	771,042	771,042

Parameter	No Build	
	HRBT I-64 Eastbound 1 & 2	HRBT I-64 Westbound 1 & 2
Length of Tunnel	7,400	7,400
Average Daily Traffic (ADT)	56,200	56,000
Peak Hour Traffic	4,285	4,250
Idle Traffic	740	740
Worst Case Peak Hour Speeds (mph)	10	10
2028 CO Emission Factor (10 mph) (g/mile)[1]	2.58	2.58
2028 CO Emission Factor (idle) (g/veh-hr)	1.85	1.85
Flow Rate (cfm)	771,042	771,042

Notes: 1. A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines.

The analysis was conducted for the Existing, No-Build and each of the four Build 2040 Alternatives for two worst-case scenarios: 1) peak-hour conditions in order to address the worst-case scenario associated with routine peak hour traffic operations; and 2) an incident (idling) that stops traffic such as an accident or vehicle breakdown. The incident scenario may be the worst-case of the two scenarios as it is characterized by idling vehicles in bumper to bumper conditions where pollutant emissions tend to be at their highest. As a comparison, the No-Build Alternatives were also evaluated for each Alternative, which consisted of the existing HRBT I-64 tunnels.

Table 5-2 shows the calculations for the tunnel air quality analysis associated with the Existing and 2040 Build and No-Build Alternatives. The calculations are presented for the proposed travel lanes for each Alternative along with the worst-case peak hour and incident (i.e., idling) conditions.

Peak hour traffic volumes (i.e. worst-case volumes expected to occur during the early morning or late afternoon) were used to represent rush-hour traffic congestion where vehicle speeds are expected be much lower than average speeds during non-rush-hour conditions was assumed to be the worst-case hours. Incident condition, the other worst-case scenario, is assumed when vehicles are stopped bumper-to-bumper in both lanes with all engines idling. Each of these conditions was defined in terms of tunnel data/emission assumptions, and a set of calculations was developed for each to demonstrate that CO levels inside the tunnel will not exceed the 35 ppm threshold.

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Table 5-2: In-Tunnel Emission Analysis

	Alternative A				Alternative B					
	HRBT Eastbound 1 & 2	HRBT Eastbound Lane 3	HRBT Westbound 1 & 2	HRBT Westbound 3 & 4	HRBT Eastbound 1 & 2	HRBT Eastbound Lane 3	I-564 East Bound 1&2	I-564 West Bound 1&2	HRBT Westbound 1 & 2	HRBT Westbound 3 & 4
Tunnel Data										
Number of Lanes	2	1	2	2	2	1	2	2	2	2
Tunnel Length (ft.)	7,400	7,400	7,400	7,400	7,400	7,400	5,100	5,100	7,400	7,400
Tunnel Length (miles)	1.40	1.40	1.40	1.40	1.40	1.40	0.97	0.97	1.40	1.40
Tunnel Height (ft.)	16.5	16.5	14.5	13.5	16.5	16.5	16.5	16.5	14.5	13.5
Tunnel Width (ft.)	40	28	23	23	40	28	40	40	23	23
Tunnel Volume (cf^3)	4,884,000.00	3,418,800.00	2,467,900.00	2,297,700.00	4,884,000.00	3,418,800.00	3,366,000.00	3,366,000.00	2,467,900.00	2,297,700.00
Tunnel Volume (m^3)	138,299	96,810	69,883	65,064	138,299	96,810	95,315	95,315	69,883	65,064
Ventilation System Data										
Type of System	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal
Supply Air Capacity (cfm)	771,042	385,000	771,042	771,042	771,042	385,000	771,042	771,042	771,042	771,042
Air exchanges over 60-min	9	7	19	20	9	7	14	14	19	20
Traffic Assumptions										
AADT[1]	45,866	22,933	34,450	34,450	44,666	23,333	25,900	25,900	33,200	33,200
Worst Case Speeds[12]	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph
Peak Hour Fraction of ADT	0.072232155	0.072253957	0.07222061	0.072191582	0.072605561	0.069472421	0.083204633	0.082818533	0.07063253	0.07063253
CO Emission Factor -idle (g/veh-hour)[2]	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
CO Emission Factor - Peak Traffic (g/mile)[2]	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
Calculations for Peak Hour										
Peak Hour ADT from Traffic Report[3]	3,313	1,657	2,488	2,487	3,243	1,621	2,155	2,145	2,345	2,345
Vehicle Miles Traveled[4]	4,643.2	2,322.3	3,487.0	3,485.6	4,545.1	2,271.9	2,081.5	2,071.9	3,286.6	3,286.6
Emission rate (mg/hr)[5]	11,979,507	5,991,561	8,996,382	8,992,766	11,726,393	5,861,389	5,370,358	5,345,438	8,479,307	8,479,307
Static 60-min emission rate (mg/m^3)[6]	86.6	61.9	128.7	138.2	84.8	60.5	56.3	56.1	121.3	130.3
Diluted CO emission rate (mg/m^3)[7]	9.1	9.2	6.9	6.9	9.0	9.0	4.1	4.1	6.5	6.5
Converted to PPM[8]	8.0	8.0	6.0	6.0	7.8	7.8	3.6	3.5	5.6	5.6
Add ambient background values from VDOT (ppm)[9]	10.1	10.1	8.1	8.1	9.9	9.9	5.7	5.6	7.7	7.7
Percent of 120 ppm Tunnel Standard	8.38%	8.39%	6.73%	6.72%	8.24%	8.24%	4.72%	4.71%	6.44%	6.44%
Percent of 35 ppm 1-hr CO NAAQS	28.72%	28.76%	23.06%	23.06%	28.24%	28.26%	16.19%	16.14%	22.08%	22.08%
Calculations for Incident Idling										
Idle Vehicle Capacity[10]	740	370	510	510	740	370	510	510	510	510
Emission Rate (mg/hr)[11]	1,369,000	684,500	943,500	943,500	1,369,000	684,500	943,500	943,500	943,500	943,500
Static 60-minute CO concentration (mg/m^3)[6]	10	7	14	15	10	7	10	10	14	15
Diluted CO Concentration over 60 minutes (mg/m^3)[7]	1.05	1.05	0.72	0.72	1.05	1.05	0.72	0.72	0.72	0.72
Convert to ppm[8]	0.91	0.91	0.63	0.63	0.91	0.91	0.63	0.63	0.63	0.63
Add ambient background values from VDOT (ppm)[9]	3.01	3.01	2.73	2.73	3.01	3.01	2.73	2.73	2.73	2.73
Percent of 120 ppm Tunnel Standard	3%	3%	2%	2%	3%	3%	2%	2%	2%	2%
Percent of 35 ppm 1-hr CO NAAQS	9%	9%	8%	8%	9%	9%	8%	8%	8%	8%

Notes:

1. *Based on estimated AADT from traffic analysis for each Alternative in each direction.*
2. *Derived from MOVES2014a*
3. *Based on worst-case peak hour AM or PM from traffic analysis*
4. *Based on Peak Hour ADT x Tunnel Length*
5. *Based on Peak Hour ADT VMT x Peak Traffic CO emission factor x 1000 mg/g*
6. *Based on (CO emission rate in mg/hr)/(Tunnel Volume in m3)*
7. *Based on (CO concentration in mg/3)/Air exchanges per hour*
8. *Converted mg/m^3 to PPM*
9. *PPM concentration plus 1-hour VDOT CO background value of 2.1 ppm*
10. *Assumes 20 feet per vehicle per lane*
11. *Based on Idle VMT x Peak Traffic CO emission factor x 1000 mg/g*
12. *A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines*

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Table 5-2: In-Tunnel Emission Analysis (cont.)

	Alternative C									
	HRBT Eastbound 1 & 2	HRBT Westbound 1 & 2	I-564 Eastbound 1 & 2	I-564 Westbound 1 & 2	I-664 Southbound 1-2	I-664 Northbound 1 & 2	I-664 Northbound Bus Only	I-664 Southbound Bus Only	I-564 Westbound Bus Only	I-564 Eastbound Bus Only
Tunnel Data										
Number of Lanes	2	2	2	2	2	2	1	1	1	1
Tunnel Length (ft.)	7,400	7,400	5,100	5,100	5,100	5,100	5,100	5,100	5,100	5,100
Tunnel Length (miles)	1.40	1.40	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Tunnel Height (ft.)	14.5	13.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Tunnel Width (ft.)	23	23	40	40	40	40	31	31	31	31
Tunnel Volume (cf^3)	2,467,900.00	2,297,700.00	3,366,000.00	3,366,000.00	3,366,000.00	3,366,000.00	2,608,650.00	2,608,650.00	2,608,650.00	2,608,650.00
Tunnel Volume (m^3)	69,883	65,064	95,315	95,315	95,315	95,315	73,869	73,869	73,869	73,869
Ventilation System Data										
Type of System	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal
Supply Air Capacity (cfm)	771,042	771,042	771,042	771,042	771,042	771,042	385,000	385,000	385,000	385,000
Air exchanges over 60-min	19	20	14	14	14	14	9	9	9	9
Traffic Assumptions										
AADT[1]	51,800	51,800	44,800	44,800	63,300	64,400	300	300	300	300
Worst Case Speeds[12]	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph
Peak Hour Fraction of ADT	0.070173745	0.07007722	0.059040179	0.062834821	0.073301738	0.079114907	0.060	0.060	0.060	0.060
CO Emission Factor -idle (g/veh-hour)[2]	1.85	1.85	1.85	1.85	1.85	1.85	14.3	14.3	14.3	14.3
CO Emission Factor - Peak Traffic (g/mile)[2]	2.58	2.58	2.58	2.58	2.58	2.58	3.4	3.4	3.4	3.4
Calculations for Peak Hour										
Peak Hour ADT from Traffic Report[3]	3,635	3,630	2,645	2,815	4,640	5,095	18	18	18	18
Vehicle Miles Traveled[4]	5,094.5	5,087.5	2,554.8	2,719.0	4,481.8	4,921.3	17.4	17.4	17.4	17.4
Emission rate (mg/hr)[5]	13,143,830	13,125,750	6,591,460	7,015,108	11,563,091	12,696,972	59,114	59,114	59,114	59,114
Static 60-min emission rate (mg/m^3)[6]	188.1	201.7	69.2	73.6	121.3	133.2	0.8	0.8	0.8	0.8
Diluted CO emission rate (mg/m^3)[7]	10.0	10.0	5.0	5.4	8.8	9.7	0.1	0.1	0.1	0.1
Converted to PPM[8]	8.7	8.7	4.4	4.7	7.7	8.4	0.1	0.1	0.1	0.1
Add ambient background values from VDOT (ppm)[9]	10.8	10.8	6.5	6.8	9.8	10.5	2.2	2.2	2.2	2.2
Percent of 120 ppm Tunnel Standard	9.02%	9.01%	5.40%	5.63%	8.15%	8.77%	1.82%	1.82%	1.82%	1.82%
Percent of 35 ppm 1-hr CO NAAQS	30.93%	30.89%	18.50%	19.30%	27.93%	30.08%	6.22%	6.22%	6.22%	6.22%
Calculations for Incident Idling										
Idle Vehicle Capacity[10]	510	510	510	510	510	510	255	255	255	255
Emission Rate (mg/hr)[11]	943,500	943,500	943,500	943,500	943,500	943,500	3,646,500	3,646,500	3,646,500	3,646,500
Static 60-minute CO concentration (mg/m^3)[6]	14	15	10	10	10	10	49	49	49	49
Diluted CO Concentration over 60 minutes (mg/m^3)[7]	0.72	0.72	0.72	0.72	0.72	0.72	5.57	5.57	5.57	5.57
Convert to ppm[8]	0.63	0.63	0.63	0.63	0.63	0.63	4.85	4.85	4.85	4.85
Add ambient background values from VDOT (ppm)[9]	2.73	2.73	2.73	2.73	2.73	2.73	6.95	6.95	6.95	6.95
Percent of 120 ppm Tunnel Standard	2%	2%	2%	2%	2%	2%	6%	6%	6%	6%
Percent of 35 ppm 1-hr CO NAAQS	8%	8%	8%	8%	8%	8%	20%[13]	20%[13]	20%[13]	20%[13]

Notes:

1. *Based on estimated AADT from traffic analysis for each Alternative in each direction.*
2. *Derived from MOVES2014a*
3. *Based on worst-case peak hour AM or PM from traffic analysis*
4. *Based on Peak Hour ADT x Tunnel Length*
5. *Based on Peak Hour ADT VMT x Peak Traffic CO emission factor x 1000 mg/g*
6. *Based on (CO emission rate in mg/hr)/(Tunnel Volume in m3)*
7. *Based on (CO concentration in mg/3)/Air exchanges per hour*
8. *Converted mg/m^3 to PPM*
9. *PPM concentration plus 1-hour VDOT CO background value of 2.1 ppm*
10. *Assumes 20 feet per vehicle per lane*
11. *Based on Idle VMT x Peak Traffic CO emission factor x 1000 mg/g*
12. *A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines.*
13. *Bus emissions tend to be higher compared to the average vehicle fleet mix. Conservative assuming worst-case traffic speeds of 10 mph along with 2040 traffic volumes and 2028 emission rates. Expected in tunnel emissions using 2040 traffic volumes and 2040 emission rates would be lower.*

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Table 5-2: In-Tunnel Emission Analysis (cont)

	Alternative D							
	HRBT Eastbound 1 & 2	HRBT Eastbound Lane 3	HRBT Westbound 1 & 2	HRBT Westbound 3 & 4	I-564 Eastbound 1&2	I-564 Westbound 1&2	I-664 Southbound 1 & 2	I-664 Northbound 1 & 2
Tunnel Data								
Number of Lanes	2	1	2	2	2	2	2	2
Tunnel Length (ft.)	7,400	7,400	7,400	7,400	5,100	5,100	5,100	5,100
Tunnel Length (miles)	1.40	1.40	1.40	1.40	0.97	0.97	0.97	0.97
Tunnel Height (ft.)	16.5	16.5	14.5	13.5	16.5	16.5	16.5	16.5
Tunnel Width (ft.)	40	28	23	23	40	40	40	40
Tunnel Volume (cf^3)	4,884,000.00	3,418,800.00	2,467,900.00	2,297,700.00	3,366,000.00	3,366,000.00	3,366,000.00	3,366,000.00
Tunnel Volume (m^3)	138,299	96,810	69,883	65,064	95,315	95,315	95,315	95,315
Ventilation System Data								
Type of System	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal
Supply Air Capacity (cfm)	771,042	385,000	771,042	771,042	771,042	771,042	771,042	771,042
Air exchanges over 60-min	9	7	19	20	14	14	14	14
Traffic Assumptions								
AADT[1]	41,400	20,700	31,050	31,050	43,200	43,200	57,800	57,100
Worst Case Speeds[12]	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph
Peak Hour Fraction of ADT	0.07205314	0.072077295	0.068534622	0.068502415	0.058449074	0.063310185	0.074740484	0.086602452
CO Emission Factor -idle (g/veh-hour)[2]	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
CO Emission Factor - Peak Traffic (g/mile)[2]	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
Calculations for Peak Hour								
Peak Hour ADT from Traffic Report[3]	2,983	1,492	2,128	2,127	2,525	2,735	4,320	4,945
Vehicle Miles Traveled[4]	4,180.7	2,091.1	2,982.4	2,981.0	2,438.9	2,641.8	4,172.7	4,776.4
Emission rate (mg/hr)[5]	10,786,257	5,394,936	7,694,655	7,691,039	6,292,415	6,815,744	10,765,636	12,323,165
Static 60-min emission rate (mg/m^3)[6]	78.0	55.7	110.1	118.2	66.0	71.5	112.9	129.3
Diluted CO emission rate (mg/m^3)[7]	8.2	8.2	5.9	5.9	4.8	5.2	8.2	9.4
Converted to PPM[8]	7.2	7.2	5.1	5.1	4.2	4.5	7.1	8.2
Add ambient background values from VDOT (ppm)[9]	9.3	9.3	7.2	7.2	6.3	6.6	9.2	10.3
Percent of 120 ppm Tunnel Standard	7.72%	7.73%	6.01%	6.00%	5.23%	5.52%	7.71%	8.57%
Percent of 35 ppm 1-hr CO NAAQS	26.46%	26.49%	20.59%	20.59%	17.93%	18.93%	26.42%	29.37%
Calculations for Incident Idling								
Idle Vehicle Capacity[10]	740	370	510	510	510	510	510	510
Emission Rate (mg/hr)[11]	1,369,000	684,500	943,500	943,500	943,500	943,500	943,500	943,500
Static 60-minute CO concentration (mg/m^3)[6]	10	7	14	15	10	10	10	10
Diluted CO Concentration over 60 minutes (mg/m^3)[7]	1.05	1.05	0.72	0.72	0.72	0.72	0.72	0.72
Convert to ppm[8]	0.91	0.91	0.63	0.63	0.63	0.63	0.63	0.63
Add ambient background values from VDOT (ppm)[9]	3.01	3.01	2.73	2.73	2.73	2.73	2.73	2.73
Percent of 120 ppm Tunnel Standard	3%	3%	2%	2%	2%	2%	2%	2%
Percent of 35 ppm 1-hr CO NAAQS	9%	9%	8%	8%	8%	8%	8%	8%

Notes:

1. *Based on estimated AADT from traffic analysis for each Alternative in each direction.*
2. *Derived from MOVES2014a*
3. *Based on worst-case peak hour AM or PM from traffic analysis*
4. *Based on Peak Hour ADT x Tunnel Length*
5. *Based on Peak Hour ADT VMT x Peak Traffic CO emission factor x 1000 mg/g*
6. *Based on (CO emission rate in mg/hr)/(Tunnel Volume in m3)*
7. *Based on (CO concentration in mg/3)/Air exchanges per hour*
8. *Converted mg/m^3 to PPM*
9. *PPM concentration plus 1-hour VDOT CO background value of 2.1 ppm*
10. *Assumes 20 feet per vehicle per lane*
11. *Based on Idle VMT x Peak Traffic CO emission factor x 1000 mg/g*
12. *A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines*

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Table 5-2: In-Tunnel Emission Analysis (cont)

	Existing		No Build	
	HRBT Eastbound 1 & 2	HRBT Westbound 1 & 2	HRBT Eastbound 1 & 2	HRBT Westbound 1 & 2
Tunnel Data				
Number of Lanes	2	2	2	2
Tunnel Length (ft.)	7,400	7,400	7,400	7,400
Tunnel Length (miles)	1.40	1.40	1.40	1.40
Tunnel Height (ft.)	14.5	13.5	14.5	13.5
Tunnel Width (ft.)	23	23	23	23
Tunnel Volume (cf3)	2,467,900.00	2,297,700.00	2,467,900.00	2,297,700.00
Tunnel Volume (m3)	69,883	65,064	69,883	65,064
Ventilation System Data				
Type of System	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal	Jet Longitudinal
Supply Air Capacity (cfm)	771,042	771,042	771,042	771,042
Air exchanges over 60-min	19	20	19	20
Traffic Assumptions				
AADT[1]	46,300	44,700	56,200	56,000
Worst Case Speeds[12]	0 and 10 mph	0 and 10 mph	0 and 10 mph	0 and 10 mph
Peak Hour Fraction of ADT	0.074406048	0.075391499	0.076245552	0.075892857
CO Emission Factor -idle (g/veh-hour)[2]	18.3	18.3	1.85	1.85
CO Emission Factor - Peak Traffic (g/mile)[2]	6.84	6.84	2.58	2.58
Calculations for Peak Hour				
Peak Hour ADT from Traffic Report[3]	3,445	3,370	4,285	4,250
Vehicle Miles Traveled[4]	4,828.2	4,723.1	6,005.5	5,956.4
Emission rate (mg/hr)[5]	33,025,023	32,306,045	15,494,170	15,367,614
Static 60-min emission rate (mg/m^3) [6]	472.6	496.5	221.7	236.2
Diluted CO emission rate (mg/m^3) [7]	25.2	24.7	11.8	11.7
Converted to PPM[8]	21.9	21.4	10.3	10.2
Add ambient background values from VDOT (ppm)[9]	24.0	23.5	12.4	12.3
Percent of 120 ppm Tunnel Standard	20.02%	19.62%	10.32%	10.25%
Percent of 35 ppm 1-hr CO NAAQS	68.63%	67.27%	35.39%	35.15%
Calculations for Incident Idling				
Idle Vehicle Capacity[10]	740	740	740	740
Emission Rate (mg/hr)[11]	13,542,000	13,542,000	1,369,000	1,369,000
Static 60-minute CO concentration (mg/m^3)[6]	194	208	20	21
Diluted CO Concentration over 60 minutes (mg/m^3)[7]	10.34	10.34	1.05	1.05
Convert to ppm[8]	8.99	8.99	0.91	0.91
Add ambient background values from VDOT (ppm) [9]	11.09	11.09	3.01	3.01
Percent of 120 ppm Tunnel Standard	9%	9%	3%	3%
Percent of 35 ppm 1-hr CO NAAQS	32%[13]	32%[13]	9%	9%

Notes:

1. *Based on estimated AADT from traffic analysis for each Alternative in each direction.*
2. *Derived from MOVES2014a*
3. *Based on worst-case peak hour AM or PM from traffic analysis*
4. *Based on Peak Hour ADT x Tunnel Length*
5. *Based on Peak Hour ADT VMT x Peak Traffic CO emission factor x 1000 mg/g*
6. *Based on (CO emission rate in mg/hr)/(Tunnel Volume in m3)*
7. *Based on (CO concentration in mg/3)/Air exchanges per hour*
8. *Converted mg/m^3 to PPM*
9. *PPM concentration plus 1-hour VDOT CO background value of 2.1 ppm*
10. *Assumes 20 feet per vehicle per lane*
11. *Based on Idle VMT x Peak Traffic CO emission factor x 1000 mg/g*
12. *A worst-case speed of 10 mph was chosen and is on the lower end of expected peak hour speeds along the mainlines.*
13. *CO emission rates are higher in 2015 compared to future years assuming conservative worst case traffic speeds of 10 mph. CO emissions in future years are expected to be much lower compared to 2015.*

5.4 TUNNEL RESULTS

The results of the analysis show that CO levels in the tunnels are estimated to be below the one-hour CO NAAQS of 35 ppm and below the 15-minute FHWA/EPA guideline level of 120 ppm for both the peak hour and incident (idling) condition for all the Alternatives including the Build and No-Build conditions. The Existing and No-Build condition only includes the existing eastbound and westbound HRBT tunnels along I-64. The estimated worst-case CO concentration for the peak hour condition for the Existing condition is 24.0 ppm which is 20 percent of the FHWA/EPA guideline level and 68 percent of the CO NAAQS. The estimated worst-case CO concentration for the idling conditions is 11.1 ppm which is 9 percent of the FHWA/EPA guideline level and 32 percent of the CO NAAQS. Similarly, the estimated worst-case CO concentration for the peak hour condition for the No-Build condition is 12.4 ppm which is 10.3 percent of the FHWA/EPA guideline level and 35 percent of the CO NAAQS. The estimated worst-case CO concentration for the idling condition is 3.0 ppm which is 3 percent of the FHWA/EPA guideline level and 9 percent of the CO NAAQS.

For the peak hour condition for the Build Alternatives, the estimated worst-case CO concentration is 10.5 ppm (Alternative C I-664 Northbound) and is 30 percent of the CO NAAQS and 9 percent of the FHWA/EPA guideline level. For the incident idling condition, the estimated worst-case CO concentration is 7.0 ppm (Alternative C I-664 and I-564 Bus Only) and is 20 percent of the CO NAAQS and 6 percent of the FHWA/EPA guideline level. The calculations include the one-hour CO VDOT ambient background level of 2.1 ppm, which was assumed to exist in the tunnel ventilation supply air.

The tunnel air quality analysis addresses controlling the level of vehicle emissions to acceptable concentrations within the tunnel during normal conditions assuming the ventilation design is consistent with the normal ventilation air quantities as described and documented in the ASHRAE standards. The analysis also demonstrates the tunnels' capability to ensure the control of vehicle emission pollutants to appropriate levels and ensures both the traveling public's and highway worker's safety with respect to air quality. Specifically, the analysis demonstrates that air quality in the tunnels would be controlled in compliance with current FHWA/USEPA guidelines for CO concentrations in tunnels. According to ASHRAE standard, tests and operating experience show that, when CO is adequately controlled, the other vehicle emission pollutants are likewise adequately controlled.

In addition to the CO compliance calculation, the FHWA/EPA guidelines requires that tunnel incident management techniques be addressed as part of the environmental analysis to ensure CO exposure levels are kept to the minimum during accidents and breakdowns. Since the Study Alternatives are still in the study phase, no formal technical requirements or specifications have yet been developed by VDOT for operations and maintenance within the tunnel. Once the final Alternative is chosen and the design stage of the project commences, technical specifications will be prepared by VDOT and adhered to for operating and maintaining the tunnel including tunnel management techniques.

6. CLIMATE CHANGE AND GREENHOUSE GAS IMPACTS

Climate change is a critical national and global concern. Human activity is changing the earth's climate by causing the buildup of heat-trapping greenhouse gas (GHG) emissions through the burning of fossil fuels and other human activities. Carbon dioxide (CO2) is the largest component of human produced emissions; other prominent emissions include methane (CH4), nitrous oxide (N2O) and hydrofluorocarbons (HFCs). These emissions are different from criteria air pollutants since their effects in the atmosphere are global rather than localized, and also since they remain in the atmosphere for decades to centuries, depending on the species.

Greenhouse gas emissions have accumulated rapidly as the world has industrialized, with concentration of atmospheric CO2 increasing from roughly 300 parts per million in 1900 to over 400 parts per million today. Over this timeframe, global average temperatures have increased by roughly 1.5 degrees Fahrenheit (1 degree Celsius), and the most rapid increases have occurred over the past 50 years. Scientists have warned that significant and potentially dangerous shifts in climate and weather are possible without substantial reductions in greenhouse gas emissions. They commonly have cited 2 degrees Celsius (1 degree Celsius beyond warming that has already occurred) as the total amount of warming the earth can tolerate without serious and potentially irreversible climate effects. For warming to be limited to this level, atmospheric concentrations of CO2 would need to stabilize at a maximum of 450 ppm, requiring annual global emissions to be reduced 40-70% below 2010 levels by 2050. State and national governments in many developed countries have set GHG emissions reduction targets of 80 percent below current levels by 2050, recognizing that post-industrial economies are primarily responsible for GHGs already in the atmosphere. As part of a 2014 bilateral agreement with China, the U.S. pledged to reduce GHG emissions 26-28 percent below 2005 levels by 2025; this emissions reduction pathway is intended to support economy-wide reductions of 80 percent or more by 2050.

GHG emissions from vehicles using roadways are a function of distance traveled (expressed as vehicle miles traveled, or VMT), vehicle speed, and road grade. GHG emissions are also generated during roadway construction and maintenance activities. VMT derived from the MSAT Affected Network for each Alternative was used to characterize the VMT changes for the GHG discussion as the links identified in the Affected Network include only roadway links that could significantly impact the project Study Area (based on FHWA criteria) and excludes roadway links not affected by the Alternatives.

Under the No-Build Alternative, VMT would gradually increase in the Project Study area for each Alternative between 2015 and 2040 as employment and population in the area increases. Furthermore, under the Build Alternatives, increased capacity, less congestion, and improved transit access across the Hampton Roads waterway lead to an increase in VMT relative to the No-Build Alternative. The increase is similar because the project is anticipated to shift traffic to the mainlines from other roadways, not necessarily increase traffic on the roadways beyond the background growth between 2015 and 2040.

Under the No-Build Alternatives, VMT increases on average approximately 29 percent (the increase ranges from 28 percent to 31 percent depending on Alternative) between 2015 and 2040; under the Build Alternatives, VMT would increase on average approximately 36 percent compared to 2015 levels (the increases range from 33 percent to 39 percent depending on Alternative). For perspective, the

VMT increases on average 3.7 percent (range of 2 percent to 5 percent) from the No-Build to Build Alternatives in 2028 and on average 5.2 percent (range of 4 percent to 7 percent) in 2040 depending on Alternative. Nationally, the Energy Information Administration (EIA) estimates that VMT will increase by approximately 38 percent between 2012 and 2040, so the VMT increase under the Build Alternatives is still at or below the projected national rate.

A major factor in mitigating this increase in VMT is more stringent national fuel economy standards. EIA projects that vehicle energy efficiency (and thus, GHG emissions) on a per-mile basis will improve by 28 percent between 2012 and 2040. This improvement in vehicle emissions rates will help mitigate the increase in VMT for both the No-Build and Build Alternatives. Other factors related to the project would also help reduce GHG emissions relative to the No-Build Alternative. The project would reduce congestion and improve vehicle speeds by increasing regional accessibility through providing extra lanes so that motorists can more easily pass slow-moving vehicles, improve transit access across Hampton Roads waterway, dedicated transit facilities in specific locations along with Bus Rapid Transit (BRT), and converting existing lanes to transit only lanes.

The average travel speed across the mainlines within the Study Area would increase on average 49.4 miles per hour (range from 41 to 55 miles per hour) under the Build Alternatives compared to 44.7 miles per hour (range from 37 to 52 miles per hour) under the No-Build Alternatives. GHG emissions rates decrease with speed over the range of average speeds encountered in this corridor, although they do increase at very high speeds. Reduction of road grade also reduces energy consumption and GHG emissions. The proposed road widening under the various Alternatives would match existing roadway grades. Proposed grades for both mainline and interchanges at-grade and on structure range from 0 to 4 percent. EPA estimates that each 1% decrease in grade reduces energy consumption and GHG emissions by 7%, although the effect is not linear. The safety improvements associated with the proposed widening and new Elizabeth River crossings, which include better incident management capabilities, would produce emissions benefits by reducing vehicle delay and idling.

Construction and subsequent maintenance of the project would generate GHG emissions. Preparation of the roadway corridor (e.g., earth-moving activities) involves a considerable amount of energy consumption and resulting GHG emissions; manufacture of the materials used in construction and fuel used by construction equipment also contribute to GHG emissions. Typically, construction emissions associated with a new roadway account for approximately 5% of the total 20-year lifetime emissions from the roadway, although this can vary widely with the extent of construction activity and the number of vehicles that use the roadway.

The addition of new roadway miles to the study area roadway network would also increase the energy and GHG emissions associated with maintaining those new roadway miles in the future. Depending on alternative, the total roadway miles in the study area that need to be maintained on an ongoing basis would increase in the range of 0 to 18 miles, depending on the Alternative relative to the No- Build Alternative. The increase in maintenance needs due to the addition of new roadway infrastructure would be partially offset by the reduced need for maintenance on existing routes (because of lower total traffic and truck volumes on those routes).

7. INDIRECT EFFECTS AND CUMULATIVE IMPACTS

Effects of the project that would occur at a later date or are fairly distant from the project are referred to as indirect effects. Cumulative impacts are those effects that result from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions. Cumulative impacts are inclusive of the indirect effects. As summarized below, the potential for indirect effects or cumulative impacts to air quality that may be attributable to this project is not expected to be significant.

First, the CO and MSAT quantitative assessments can be considered indirect effects analyses because they look at air quality impacts attributable to the project that occur at a later time in the future. Those assessments indicate the potential for indirect effects associated with the project is not expected to be significant. They demonstrate that in the future: 1) air quality impacts from CO will not cause or contribute to violations of the CO NAAQS; and 2) MSAT emissions from the affected network will be significantly lower than they are today.

Second, regarding the potential for cumulative impacts, EPA's air quality designations for the region reflect, in part, the accumulated mobile source emissions from past and present actions. Since EPA has designated the region to be in attainment of all of the NAAQS, the potential for cumulative impacts associated with the project is not expected to be significant.

Overall, the potential for indirect effects and cumulative impacts associated with the project is not expected to be significant.

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8. CONSTRUCTION EMISSION ANALYSIS

The temporary air quality impacts from construction activities are not expected to be significant. Construction activities will be performed in accordance with VDOT's current "Road and Bridge Specifications." The specifications require compliance with all applicable local, state, and federal regulations.

This project is located within a volatile organic compounds (VOC) and nitrogen oxides (NOx) Emissions Control Area. As such, all reasonable precautions will be taken to limit the emissions of VOC and NOx. In addition, the following VDEQ air pollution regulations must be adhered to during the construction of this project: 9 VAC 5-130, Open Burning restrictions; 9 VAC 5-45, Article 7, Cutback Asphalt restrictions; and 9 VAC 5-50, Article 1, Fugitive Dust precautions.

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9. MITIGATION

Mitigation measures will be employed to minimize environmental impacts during construction activities to comply with all federal, state, and local regulations as discussed in Section 2 and Section 8.

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10. CONCLUSIONS

The Project Area is designated by the EPA as an attainment area for all of the NAAQS established by EPA, therefore transportation conformity requirements do not apply for this project for any pollutant.

For purposes of NEPA, quantitative analyses were conducted for CO and MSATs. Qualitative analyses were developed for greenhouse gases and indirect effects and cumulative impacts.

The CO analysis included a review of both intersections and interchanges in the project area to identify the worst-case locations for assessment. US EPA guidance[31] was applied to identify the worst-case intersections to consider for the analysis based on forecasts of peak volumes and intersection LOS. Short-listed intersections were then screened using the threshold referenced in the 2016 FHWA-VDOT Programmatic Agreement, which are based on worst-case modeling for typical arterial intersections.

- For this project, all of the worst-case intersections for each alternative were found to meet the criteria for screening that were specified in the 2016 FHWA-VDOT Agreement, so it can be safely concluded that they would all meet the NAAQS.
- For the interchanges that were identified as the worst-case locations, worst-case CO concentrations were estimated using EPA models (MOVES2014a and CAL3QHC). The results of the worst-case modeling for each of the short-listed (worst-case) interchanges indicate that, using worst-case assumptions for traffic volumes, roadway configuration and receptor placement, the modeled worst-case CO concentrations remain well below the CO NAAQS at all receptor locations for each interchange.

For MSATs, the Study Alternatives were evaluated following the latest FHWA guidance. As the Study Alternatives are anticipated to add significant capacity to the existing and/or proposed new roadway networks where design year traffic is projected to be 140,000 to 150,000 annual average traffic (AADT) or greater, the Study Alternatives are best characterized as one with “High Potential MSAT Effects”; therefore, a quantitative MSAT analysis was conducted consistent with the guidance. While there may be slightly higher MSAT emissions in the design year for each Build Alternative relative to the No-Build Alternative due to increased VMT, and there could also be small increases in MSAT levels in a few localized areas where VMT increases, EPA's vehicle and fuel regulations are expected to result in significantly lower MSAT levels in the future than exist today due to cleaner engine standards coupled with fleet turnover. The quantitative MSAT analysis demonstrated that there would be no long-term adverse impacts associated with the Build Alternatives, and that future MSAT emissions across the entire study corridor are expected to be significantly below today’s levels.

For GHGs, under the No-Build and Build conditions, VMT in the region is expected to increase between 2015 and 2040. Nationally, the Energy Information Administration (EIA) estimates that VMT will increase by approximately 38 percent between 2012 and 2040. While VMT is expected to increase under the Build Alternatives, the increase is still at or below the projected national rate. A major factor in mitigating this increase in VMT is more stringent fuel economy standards. EIA projects that vehicle

[31] U.S. Environmental Protection Agency, *Guideline for Modeling Carbon Monoxide from Roadway Intersections*, EPA-454/R-92-005, Office of Air Quality Planning and Standards, November, 1992.

energy efficiency (and thus, GHG emissions) on a per-mile basis will improve by 28 percent between 2012 and 2040. While VMT is expected to increase for both the Build and No-Build Alternatives, this improvement in vehicle emissions rates will help mitigate the increase in VMT. In addition, average vehicle speeds are expected to be higher for the Build Alternatives when compared to the No-Build in all scenarios. By reducing congestion and increasing speeds, vehicle travel duration and the associated amount of fuel combustion and associated emissions will decrease minimizing the impacts of GHGs. Regional accessibility will be increased through providing additional lanes so that motorists can more easily pass slow-moving vehicles along with improve transit access across Hampton Roads waterway and Bus Rapid Transit and converting existing lanes to transit only lanes. Thus, the project area would see a net reduction in GHG emissions under any of the Build Alternatives, even though VMT increases relative to the No-Build Alternative and 2015 levels.

For indirect and cumulative impacts, the quantitative assessments conducted for the project-specific CO and MSAT impacts were considered analyses of indirect effects. These analyses demonstrated that in the future, 1) air quality impacts from CO will not cause or contribute to violations of the CO NAAQS; and 2) MSAT emissions from the affected network will be significantly lower than they are today. Regarding the potential for cumulative impacts, EPA's air quality designations for the region (as attainment of all of the NAAQS) reflect, in part, the accumulated mobile source emissions from past and present actions. Therefore, the indirect and cumulative effects of the project are not expected to be significant.

The Project was added to the Hampton Roads Transportation Planning Organization fiscal year (FY) 2012-2015 transportation improvement program (TIP) and the 2034 long range transportation plan (LRTP) as a study-only project on March 21, 2013 by the HRTPO Board.

Construction activities will be performed in accordance with VDOT's "Road and Bridge Specifications" as well as any applicable VDEQ regulations. These specifications require compliance with all applicable federal, state, and local regulations.