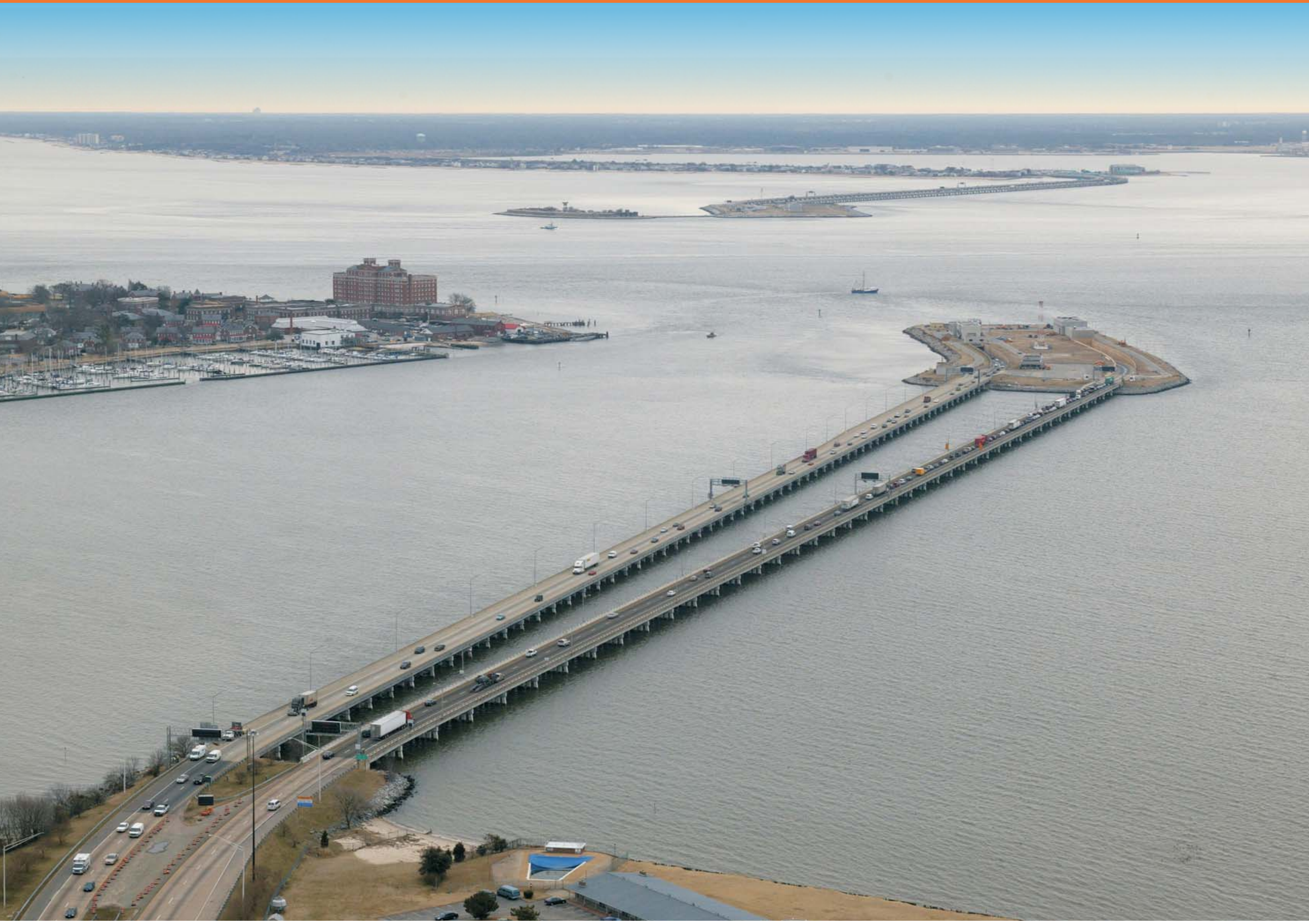
I-64 HAMPTON ROADS BRIDGE TUNNEL

HRBT
Hampton Roads Bridge Tunnel EIS

ALTERNATIVES TECHNICAL REPORT



VDOT Virginia Department of Transportation

U.S. Department of Transportation Federal Highway Administration

November 5, 2012

TABLE OF CONTENTS

LIST OF FIGURES

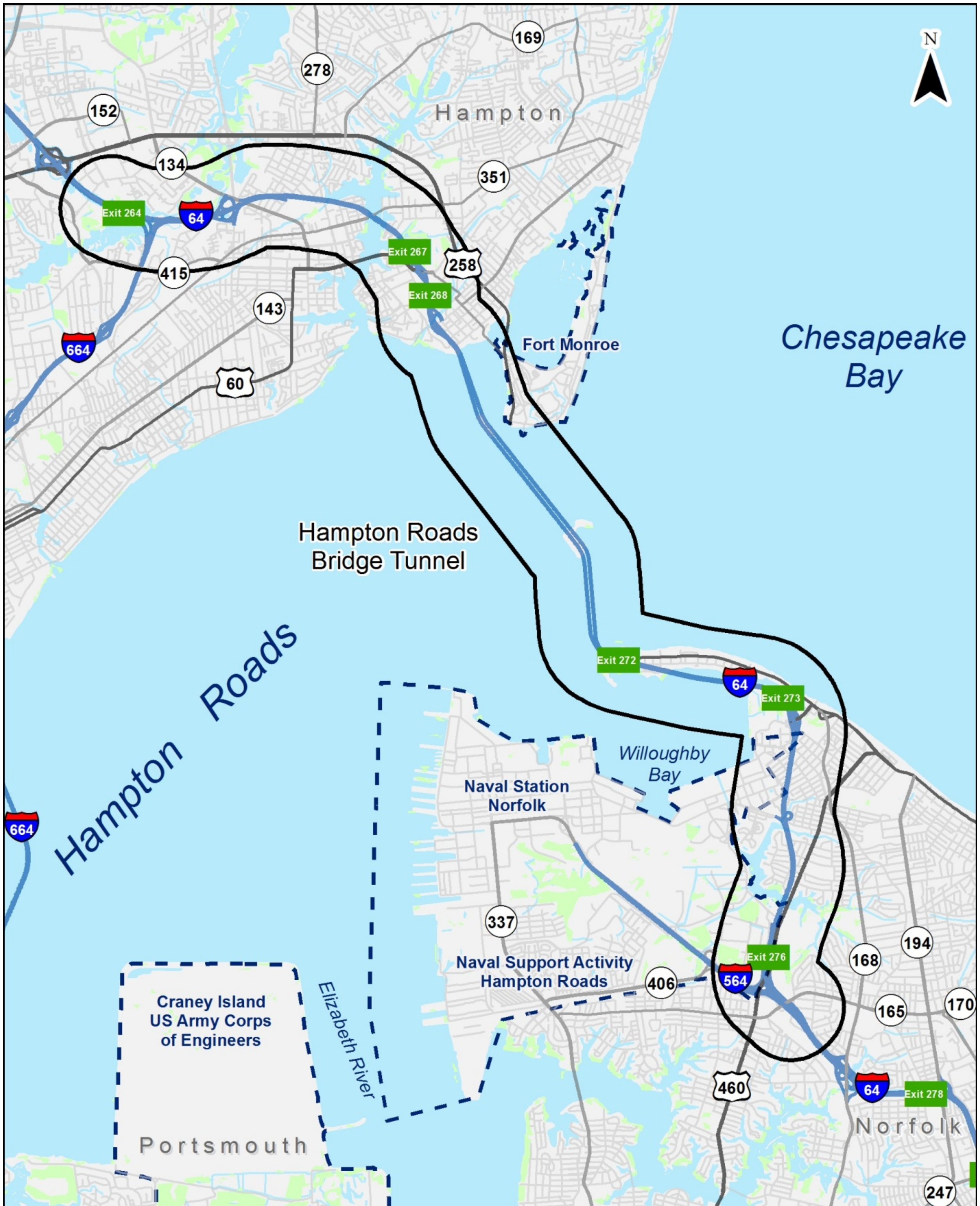
LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

The Virginia Department of Transportation (VDOT), in cooperation with the Federal Highway Administration (FHWA), is studying the environmental consequences of transportation improvements along Interstate 64 (I-64) and the Hampton Roads Bridge Tunnel (HRBT). **Figure 1** shows the study location, from the I-64 interchange with I-664 in the City of Hampton to the I-64 interchange with I-564 in the City of Norfolk, a distance of approximately 13.1 miles, including the 3.5-mile-long HRBT. The study area encompasses lands and waterbodies within or adjacent to the I-64 corridor that could potentially incur direct or indirect impacts as a result of the proposed study.

This report describes the alternatives development process and screening criteria approach for the I-64 HRBT Environmental Impact Statement (EIS), including the identification of an initial range of alternatives considered and alternatives retained for detailed evaluation. With the exception of the No-Build Alternative, build alternatives that do not address the stated purpose and need were determined to be not reasonable and were not advanced for detailed evaluation. The remaining alternatives were retained for detailed evaluation and environmental analysis. The results of this Technical Memorandum will be summarized in the EIS.



Legend

Study Corridor

0 0.5 1 2 Miles

Study Location

U.S. Department of Transportation Federal Highway Administration

VDOT

Figure 1

2. EXISTING CONDITIONS

I-64 consists of three sections within the study limits, the Peninsula (Hampton), the Hampton Roads Bridge Tunnel (HRBT), and the Southside (Norfolk).

Within the Hampton section of the study I-64 is predominantly three lanes per direction, with auxiliary lanes (acceleration and deceleration lanes) at the interchanges. The mainline typical section includes 12-foot travel lanes, 12-foot right shoulders, and 4-foot left shoulders. The lane and right shoulder widths meet current interstate design standards; however, the left shoulder width does not meet current interstate design standards per AASHTO's *A Policy on Geometric Design of Highways and Streets*. In the eastbound direction, the three lanes are reduced to two lanes at the Settlers Landing Road interchange (Exit 267) prior to the HRBT, which violates AASHTO's lane continuity guidelines. This lane reduction exacerbates the bottleneck at the tunnel due to reduced capacity. In the westbound direction, the two lanes from the HRBT widen to three lanes at the South Mallory Street interchange (Exit 268), which is approximately one-third mile west of the approach bridges. The posted speed limit is 55 miles per hour (mph). The following interchanges are located west of the HRBT:

- Exit 264 – I-664
- Exit 265 – Route 167/Route 134/LaSalle Avenue, North Armistead Avenue, and Rip Rap Road
- Exit 267 – US 60/Route 143/Settlers Landing Road and Woodland Road
- Exit 268 – Route 169/South Mallory Street

The 3.5-mile HRBT connects Hampton and Norfolk by spanning Hampton Roads, the confluence of the James River, Nansemond River, and Elizabeth River. The structure is composed of the 0.6-mile western approach bridges, two 1.4-mile-long tunnels, and 1.2-mile eastern approach bridges with 0.15-mile portal islands at the transitions between the bridges and the tunnels.

The two existing HRBT west approach bridges are 3,225 feet long and the two east approach bridges are 5,925 feet long. The bridges consist primarily of 75-foot long spans with a deck width of 44 feet. The bridge superstructure consists of simple span AASHTO prestressed beams and cast-in-place concrete deck. The bridge piers were constructed with a concrete cap supported on either 24 inch prestressed concrete piles or 54 inch prestressed concrete cylindrical piles.

The approach bridges between the tunnels and the land-side roadways have 12-foot-wide lanes with 10-foot-wide right shoulders and 4-foot-wide left shoulders. The shoulders do not meet current design standards. Additionally, these approach bridges have a low vertical clearance above the water that does not meet the latest clearance specifications in AASHTO's *Guide Specifications for Bridges Vulnerable to Coastal Storms*, 2009.

The two existing tunnels are double shell steel, immersed tube tunnels. The westbound tunnel has 12-foot-wide lanes and no shoulders. The vertical clearance is 13'-6" inches, which does not meet AASHTO or VDOT standards. The vertical clearance is problematic for some trucks. An average of 80 to 90 over-height trucks per month must be stopped and inspected on the HRBT, which causes disruption to traffic flow; all traffic is stopped when trucks are pulled from I-64 for inspection and then stopped again to allow trucks to re-enter I-64 following inspection. The eastbound tunnel has 12-foot-wide lanes and no shoulders. The vertical clearance is 14'-6", which does not meet AASHTO or VDOT standards.

Within the Norfolk section of the study, I-64 has two lanes per direction. The travel lanes are 12 feet wide, right shoulders are 12 feet wide and left shoulders vary from 2 to 6 feet wide. The lane and right shoulder widths meet current interstate design standards; however, the left shoulder width does not meet current interstate design standards. I-64 is on structure across Willoughby Bay south of the West

Ocean View Avenue/Bayville Street interchange; over wetlands surrounding West Ocean View Avenue/West Bay Avenue; and across Mason Creek south of West Bayview Boulevard where an entrance ramp is provided for Granby Street. The Willoughby Bay Bridges are 4,991 feet long and have a similar design to the approach bridges. They have a deck width of 44 feet and most spans are approximately 63 feet long. The bridge superstructure consists of prestressed concrete beams and cast-in-place concrete deck. The deck was built continuous for live load to minimize the number of deck joints. The substructure consists of 24 inch square prestressed piles and pile cap.

The following interchanges are located east of the HRBT:

- Exit 272 – Route 168/West Ocean View Avenue/Bayville Street.
- Exit 273 – US 60/4th View Street.
- Exit 274 – Entrance ramp from eastbound West Bay Avenue to I-64 east and exit ramp from westbound I-64 to westbound West Ocean View Avenue.
- Westbound Entrance Ramp from Granby Street to I-64 just north of Norfolk Naval Station Gate 22 and the Forest Lawn Cemetery.
- Eastbound Entrance Ramp from Norfolk Naval Station Gate 22 to I-64.
- Exit 276 – I-564 and Granby Street (Route 460). Southbound Granby Street cannot be accessed from westbound I-64 and northbound Granby Street is not accessible from eastbound I-64.

3. PREVIOUS STUDY

In 2008, VDOT prepared the *HRBT Expansion Feasibility Study*. The goal of the study was to review alternatives; develop concept-level drawings; develop general construction cost estimates for each alternative; identify potential right-of-way impacts; develop estimates of congestion-reduction benefits of the alternatives through traffic analysis; and provide policy-level guidance on the feasibility and long-term benefits of the alternatives.

The feasibility study assessed the following six I-64 widening alternatives to address recurring congestion at the HRBT, which included the addition of two or four lanes to I-64 on either a high bridge structure or a combination bridge and tunnel:

- Alternative 1 included two additional lanes of bridge-tunnel capacity providing a contiguous, six-lane facility;
- Alternative 2 included the addition of two reversible bridge-tunnel lanes throughout the corridor to increase peak hour and evacuation capacity;
- Alternative 3 included the addition of four bridge-tunnel lanes;
- Alternative 4 included the addition of four bridge-tunnel lanes including two multimodal lanes;
- Alternative 5 included a high bridge at the Hampton Roads crossing, rather than including any new tunnel segments; and
- Alternative 6 included four additional lanes of bridge capacity.

The feasibility study was completed following a public comment period in December 2008. The study concluded that capacity improvements within the HRBT corridor were feasible by widening I-64 and the widening should occur outside of existing lanes. The following three build alternatives were recommended for dismissal because they did not address the recurring congestion in the corridor or presented safety concerns with two-way operations: Alternatives 1, 2, and 5.

The feasibility study was not completed pursuant to the National Environmental Policy Act (NEPA); thus, the conclusions reached by the study were not directly incorporated into the I-64 HRBT EIS. However, the alternatives analysis in the feasibility study served as a precursor to the alternatives development for this study. It also provided a preliminary indication of which alternatives may be reasonable or unreasonable.

4. DESIGN CRITERIA

Where applicable, alternatives were developed using current design guidelines and structural design parameters. All guidelines were based on the American Association of State Highway and Transportation Officials (AASHTO) *A Policy on the Geometric Design of Highways and Streets, 2004* (Green Book), the VDOT *Road Design Manual*, and VDOT *Bridge Design Manual*. Structural design parameters guided the design of new structures crossing Hampton Roads and were based on the Port of Virginia's requirements for vertical clearances and channel width for shipping as provided during scoping. Roadway geometric design guidelines used in the development of alternatives are presented in **Table 1**, and structural design parameters are presented in

Table 1. Roadway Geometric Design Guidelines

Design Element	Mainline	Interchanges
Functional Classification	Urban Freeway	N/A
Design Speed	Minimum: 60 mph Desired: 70 mph	Directional Ramp: 50 mph Diamond Ramp: 50 mph Loop Ramp: 30 mph
Horizontal Alignment	Minimum Radius: 1,204' (60 mph) Minimum Radius: 1,810' (70 mph)	Directional Ramp Min. Radius: 760' Diamond Ramp Min. Radius: 760' Loop Ramps Minimum Radius: 215'
Vertical Alignment	Minimum Grade: 0.5% Maximum Grade: 4%	Minimum Grade: 0.5% Maximum Upgrade: 5% Maximum Downgrade: 4%
Stopping Sight Distance	Minimum: 570' (60 mph) Minimum: 730' (70 mph)	Directional Ramp Minimum: 425' Diamond Ramp Minimum: 425' Loop Ramp Minimum: 200'
Lane Width	12'	Single lane: 16' Two lanes: 12'
Shoulder Width	Mainline: Right: 17' (12' paved); 14' paved with concrete barrier Left (median): 12' paved Tunnel: Right: 2' offset from barrier Left (median): 2' offset from barrier Bridge (crossing): Right: 14' Left (median): 6'; 14' with 3 or more lanes	Right: Directional Ramp: 11' (8'paved) Diamond Ramp: 11' (8' paved) Loop Ramp: 11' (8' paved) Left: 9' (4' paved)

Table 1. Roadway Geometric Design Guidelines, continued

Design Element	Mainline	Interchanges
Structure Width	Match clear roadway width	Match clear roadway width
Cross Slope / Superelevation	Normal: 2% Maximum: 8%	Normal: 2% Maximum: 8%
Vertical Clearance	Mainline: 16'-6" Tunnel: 16'-6"	16-'6"
Clear Zone Width	30'-34'	Desired: 14' from edge of traveled way to protective barrier Minimum: typical section shoulder width from edge of pavement to face of protective barrier
Roadside Barrier	National Cooperative Highway Research Program (NCHRP) approved Guiderail, Concrete Barrier, End Treatment, and Impact Attenuating Devices	NCHRP approved Guiderail, Concrete Barrier, End Treatment, and Impact Attenuating Devices
Median Barrier	NCHRP approved Concrete Barrier, End Treatment, and Impact Attenuating Devices	N/A
Side Slopes	Desired: 6 Horizontal (H): 1 Vertical (V) or flatter Minimum: 4H:1V w/o barrier 2H:1V w/ barrier	Desired: 6H:1V or flatter Minimum: 4H:1V w/o barrier 2H:1V w/ barrier

Table 2. Structural Design Parameters

Design Parameter	All Bridge Crossing	Bridge Tunnel Crossing
Clearance Over Channel	250’ above mean high water (MHW) across main channel	N/A
Clearance Under Channel	N/A	Desired: 65’ to top of tunnel armor from mean low water (MLW) Minimum: 60’ to top of tunnel armor from MLW[2]
Vertical Clearance Above Water for Approach Bridges	Elevation of Bottom of Superstructure: 18’ relative to NAVD 88[1]	Elevation of Bottom of Superstructure: 18’ relative to NAVD 88[1]
Width of Channel	Minimum: 1,000’ (per Port of Virginia) Desired: VDOT Structure and Bridge (S&B) Division requirement based on future hydraulic study	Minimum: 1,000’ (per Port of Virginia)[3] Desired: VDOT S&B requirement based on future hydraulic study
Horizontal Offset from Existing Tunnel/Bridge	200’ minimum (outside of structure to outside of structure)	200’ minimum (outside of structure to outside of structure)

[1] Elevation 18 feet includes 1 foot of clearance above the 100-year design wave crest elevation (elevation 12 feet relative to North American Vertical Datum [NAVD] plus 1 foot) per AASHTO’s *Guide Specifications for Bridges Vulnerable to Coastal Storms*, 2009, plus an assumed 5 feet for potential sea level rise over the next century per VDOT Structure and Bridge Division standard practice.

[2] Clearance under channel from existing top of tunnel to MLW is ±55 feet.

[3] Width of existing 35-foot-deep channel between islands is 3,700 feet.

5. INITIAL RANGE OF ALTERNATIVES

Fourteen initial alternatives were considered as part of the study. The proposed range of reasonable alternatives included the No-Build Alternative and a range of Build Alternatives, as described below.

A. No-Build Alternative

Under the No-Build Alternative, I-64 would remain predominantly three lanes per direction within the Hampton section of the study area, with auxiliary lanes (acceleration and deceleration lanes) at the interchanges. The 3.5-mile HRBT would continue with current operations. Within the Norfolk section of the study, I-64 would remain two lanes per direction, including the I-64 bridges across Willoughby Bay. Under the No-Build Alternative, VDOT would continue maintenance and repairs of I-64 and the HRBT as needed, with no substantial changes to current management activities. Specifically, there would be no rehabilitation or reconstruction of the HRBT. The No-Build Alternative would include those projects funded for construction in HRTPO's 2034 Long Range Transportation Plan.

B. Transportation System Management / Transportation Demand Management

Transportation System Management / Transportation Demand Management (TSM/TDM) improvements maximize the efficiency of the current transportation system or reduce the demand for travel on the system through the implementation of low-cost improvements. Examples of TSM activities that could be utilized in the I-64 corridor include Intelligent Transportation System (ITS) measures such as active traffic management and enhanced driver information; expanded auxiliary lanes along I-64; lengthening acceleration and deceleration lanes along I-64; addition of turn lanes at ramp terminal intersections; and optimized signalization at ramp terminal intersections and cross roads. Examples of TDM activities that could be used in the I-64 corridor include ride sharing, van and carpooling, installation of park and ride facilities, and encouragement of telecommuting.

C. Rehabilitation or Reconstruction of the Existing HRBT

This alternative would include rehabilitation to the existing tunnels and either rehabilitation of the approach bridge superstructure or reconstruction of the approach bridge substructure and superstructure. Tunnel rehabilitation would likely include replacement of the wall tiles, wearing surface, and structural slab; upgrades to utilities; upgrades to the ventilation system to increase vertical clearance; and upgrades to the safety system to improve compliance with NFPA 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways (2011). The existing transverse ventilation systems in both existing tunnels would be converted to longitudinal ventilation systems with the addition of jet fans, which would increase the vertical clearance. Additionally, NFPA 502 requires upgrades to the fire detection and protection systems, means of egress, and electrical systems. Better compliance with NFPA 502 would improve the safety systems in the tunnels to meet the standards that all new tunnels must meet.

Bridge rehabilitation would consist of the removal and replacement of the existing superstructure, crack sealing, repair, jacketing existing piling, replacement of piling, and the replacement of parapets. Dredging of a ten-foot deep channel for barges would be required outside of both existing structures in areas where the water depth is less than ten feet with the rehabilitation option. Reconstruction would consist of complete substructure (piers/foundations) and superstructure replacement, including raising and widening the structures to meet the current design standards. Bridge reconstruction would require that the ten-foot deep dredged channel include the entire area between the existing approach bridges as well as 150 feet east of the westbound structure and 50 feet west of the eastbound structure.

D. Replacement of the Existing HRBT

This alternative would include the complete removal of one or both existing bridge-tunnels in conjunction with construction of a new crossing facility in the same location. New bridge construction would consist of complete substructure (piers/foundations) and superstructure replacement, including raising and widening the structures to meet the current design standards. Tunnel reconstruction would consist of complete replacement of the existing structures to meet current design standards. In addition, bridge reconstruction would require that a ten-foot deep channel be dredged to include the entire area between the existing approach bridges as well as 150 feet east of the westbound structure and 50 feet west of the eastbound structure.

E. Reversible Lanes

This alternative would include adding one or two reversible travel lanes to I-64. At the HRBT crossing, the additional lanes would be constructed west of the existing crossing to prevent disturbance to the existing bridge-tunnels during construction. However, the reversible lanes would operate in the center of the roadway and eastbound traffic would use the new lanes. The reversible lanes would connect to the mainline of I-64 west of I-664, and connect to the existing reversible lanes on I-64 east of I-564. The lanes would either be completely barrier-separated from both directions of traffic, similar to the reversible lanes east of I-564, or a moveable-barrier system would be used to separate opposing traffic.

F. Build-6 Alternative

This build alternative would include construction of two additional lanes of capacity on I-64 at the Hampton Roads crossing and within the Norfolk section of the corridor, so that a continuous six-lane facility would extend from I-664 to I-564. Through the Hampton section of the corridor no additional through lanes would be constructed as the corridor currently includes six travel lanes, three in each direction. The typical section would include 12-foot travel lanes and 12-foot shoulders. The total mainline pavement width would be 122 feet and the eastbound and westbound directions would be separated by a concrete traffic barrier. The inside shoulder would be widened from 8 feet to 12 feet to meet the geometric design criteria. In Norfolk, the Build-6 Alternative would require 5 feet of outside widening on both sides of the highway and widening into the existing 36-foot grass median.

The existing bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new two-lane bridge-tunnel at the Hampton Roads crossing and would require two-way traffic to operate on the existing eastbound approach bridges and tunnel.

G. Build-8 Alternative

The Build-8 Alternative would provide four continuous mainline lanes in each direction of I-64 throughout the limits of the study. Through the Hampton section of the study, this alternative would require one lane of widening in each direction of I-64. Through the Norfolk section, this alternative would require the addition of two lanes in each direction of I-64. The typical section would include 12-foot travel lanes and 12-foot shoulders. The eastbound and westbound directions would be separated by a concrete traffic barrier. The total width of the Build-8 Alternative mainline pavement would be 146 feet and would require 16 feet of outside widening on both sides of the highway through Hampton. In Norfolk, the Build-8 Alternative would require 17 feet of outside widening on both sides of the highway and widening into the existing 36-foot grass median.

The existing bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new four-lane bridge-tunnel at the Hampton Roads crossing.

H. Build-8 Managed Alternative

The Build-8 Managed Alternative would be similar to the Build-8 Alternative, providing four continuous mainline lanes in each direction of I-64. However, some or all of the travel lanes would be managed using tolls and/or vehicle occupancy. The Build-8 Managed Alternative could include tolling of all I-64 mainline lanes, or a combination of managed and general purpose (GP) lanes, such as high occupancy vehicle lanes where there are 2 or more occupants per vehicle (HOV-2); high occupancy toll (HOT) lanes where HOV users could use the lanes for free, but single occupancy vehicles (SOV) would pay a toll; or express toll lanes, where all traffic in the managed lane would be tolled. Additionally, expanded local/express bus service or bus rapid transit could be accommodated with this alternative in the general purpose lanes or the managed lanes.

As with the Build-8 Alternative, the typical section would include 12-foot travel lanes and 12-foot shoulders to meet current design criteria. The eastbound and westbound directions would be separated by a concrete traffic barrier. The typical section would also include an approximate four-foot buffer separation between the general purpose lanes and any managed lanes. The total width of the Build-8 Alternative mainline pavement would be 154 feet, and would require outside widening on both sides of the highway in Hampton. In Norfolk, the Build-8 Managed Alternative would require outside widening on both sides of the highway and would include widening into the existing grass median. The managed lanes would tie to the high occupancy vehicle (HOV) lanes on I-64 on both ends of the study area.

Similar to the Build-8 Alternative, the existing bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new four-lane bridge-tunnel at the Hampton Roads crossing.

I. Build-10 Alternative

The Build-10 Alternative would provide five continuous mainline lanes in each direction of I-64 throughout the limits of the study. Throughout the Hampton section of the study, this alternative would require widening in both directions of I-64 by two lanes. In the Norfolk section of the study, this alternative would require widening in both directions of I-64 by three lanes. Similar to the Build-8 Alternative, the typical section would include 12-foot travel lanes and 12-foot shoulders to meet current design criteria, and the eastbound and westbound directions would be separated by a concrete traffic barrier. The total width of the Build-10 Alternative mainline pavement would be 170 feet, and would require 28 feet of outside widening on both sides of the highway through Hampton. In Norfolk, the Build-10 Alternative would require 29 feet of outside widening on both sides of the highway and widening into the 36-foot existing grass median. Through Willoughby Spit, the mainline widening would occur on the south side of the existing roadway.

Similar to the Build-8 Alternative, the existing bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new six-lane bridge-tunnel at the Hampton Roads crossing.

J. Build-12 Alternative

The Build-12 Alternative would provide six continuous mainline lanes in each direction of I-64 throughout the study limits. The alternative would construct six additional lanes of capacity on I-64 within the Hampton portion of the corridor and eight additional lanes of capacity on I-64 on the Hampton Roads Bridge-Tunnel and within the Norfolk section of the corridor. Similar to the Build-8 and Build-10 Alternatives, the typical section would include 12-foot travel lanes and 12-foot shoulders to meet current design criteria, and the eastbound and westbound directions would be separated by a concrete traffic barrier. The total width of the Build-10 Alternative mainline pavement would be 194 feet, and would require 40 feet of outside widening on both sides of the highway through Hampton. In Norfolk, the Build-10 Alternative would require 41 feet of outside widening on both sides of the highway and widening into the 36-foot existing grass median. Through Willoughby Spit, the mainline widening would occur on the south side of the existing roadway.

The existing bridges and tunnels would be rehabilitated, as described in Section 5.C, and would include a new eight-lane bridge-tunnel at the Hampton Roads crossing.

K. High Bridge Crossing

A high bridge would not be a stand-alone alternative, but rather an option to address the crossing type for the Hampton Roads channel. The option would involve either a cable-stayed or suspension bridge upstream of the existing facility. Both types could provide long main spans with high clearance to accommodate the Hampton Roads shipping channel. Both bridge types would have the same typical section, which would consist of the total number of lanes for each build alternative (six, eight, ten or twelve) 14-foot outside and median shoulders, a two-foot median traffic barrier, and two-foot outside parapets. Using the criteria described in **Table 1**, the total deck width would range between 134 feet and 206 feet. The bridge would be built to carry all lanes of I-64 over Hampton Roads, not just the widening. Under this option, the new bridge would have full shoulders, no vertical clearance issues, and meet or exceed the minimum height above mean high water (MHW). The bridge lanes would be designed to meet the capacity needs for the corridor.

Depending on the bridge type, a high bridge would require a new and/or significantly expanded islands to accommodate new bridge piers. These new or expanded islands have a high potential to infringe on the existing channel and would introduce a height restriction over the shipping channel. It would also require 500-foot to 800-foot tall towers that would be obstructions to FAA controlled air space for nearby Chalmers Field and Langley Air Force Base. Additional information on the high bridge option is included in the *HRBT High Bridge Technical Memorandum* (July 2012) and is included in Appendix A.

L. Light or Heavy Rail

This alternative would include dedicated light or heavy rail transit on a new structure across Hampton Roads. The existing bridge-tunnels would remain, however, rehabilitation of the superstructure or reconstruction of the substructure and superstructure of the approach bridges would be completed, as described in Section 5.C. Routine maintenance of the existing tunnels would continue as required. This alternative would not address geometric deficiencies of existing facilities as no improvements would be made to the existing bridge-tunnel to address current design standards for shoulders, vertical clearance in tunnels, or vertical clearance above water.

There is currently no rail transit service connecting Hampton to Norfolk, nor comprehensive transit service within the larger region. The nearest rail transit service is "The Tide," which is a light rail line located approximately 5.5 miles from the study area and operates on the Southside from Fort Norfolk Station to Newtown Road Station. For a rail transit crossing at the HRBT to be viable, a new rail transit route or system would be necessary on both the Peninsula and the Southside.

The Hampton Roads Transportation Planning Organization (HRTPO) and Virginia Department of Rail and Public Transportation (DRPT) recently completed the *Hampton Roads Regional Transit Vision Plan (Vision Plan)*. The *Vision Plan* was prepared in two phases. Phase I, the Tran*sit Vision Plan for Hampton Roads*, was completed in April 2009 by the HRTPO. Phase 2, the *Hampton Roads Regional Transit Vision Plan Final Report*, was completed in February 2011 by DRPT. Together, these two documents provide a strategic approach for the development and implementation of a regional mass transit system. The *Vision Plan* offers short-term recommendations to address current regional transit inadequacies and long-term strategies to achieve the goals of reduced traffic congestion and increased transit use. The Vision Plan proposes a dedicated light rail transit connection across Hampton Roads in the long term (beyond 2034), although specific corridor recommendations are not provided. Several alternative locations for this facility are identified, with the preferred potential crossing located approximately four miles west of the HRBT. Potential transit improvements across Hampton Roads are not funded for study, design or construction in the HRTPO's 2034 *Long Range Plan*; therefore, they are not reasonably feasible.

Further information regarding consideration of light and heavy rail is included in the *HRBT Transit Technical Memorandum* (2012), prepared by VDOT and included in Appendix B.

M. Bus Transit

This alternative would include expansion of existing bus transit services within the study corridor and across Hampton Roads. This service change could be in the form of an increase in bus service or inclusion of a dedicated (express bus or bus rapid transit) facility, as recommended for study in the *Vision Plan*. A Bus Transit Alternative could be considered as a stand-alone build alternative or in conjunction with other retained alternatives. Regardless, the existing bridge-tunnels would remain, however, rehabilitation of the superstructure or reconstruction of the substructure and superstructure of the approach bridges would be completed, and routine maintenance of the tunnels would continue as required, as described in Section 5.C.

If bus transit were implemented as part of other retained build alternatives, the expanded service could travel more freely within alternatives that provide additional lane capacity and improve capacity for trips across Hampton Roads. Build alternatives that include managed lanes could include bus transit and/or dedicated bus lane as part of the management strategy. Thus, expanded bus transit is included as a component of other alternatives.

Further information regarding consideration of bus transit is included in the *HRBT Transit Technical Memorandum* (2012), prepared by VDOT and included in Appendix B.

N. Ferry Service

During scoping, various public agency comments suggested consideration of hydrofoil or ferry service as part of the I-64 HRBT Draft EIS. This alternative would provide a ferry service to carry vehicles across Hampton Roads via water transport. The existing bridge-tunnels would remain; however, rehabilitation of the superstructure or reconstruction of the substructure and superstructure of the approach bridges would be completed, and routine maintenance of the tunnels would continue as required, as described in Section 5.C.

6. ALTERNATIVES SCREENING APPROACH AND CRITERIA

Following the initial scoping process for the project, the purpose and need for the study was established. The I-64 HRBT study focuses on two primary need items: inadequate capacity and geometric deficiencies of the existing facilities. The alternatives were evaluated for their ability to address the purpose and need:

Capacity: the alternative should address inadequate capacity of existing facilities to accommodate existing and forecasted travel demand at acceptable levels of traffic service and travel reliability.

Geometric deficiencies of existing facilities: the alternative should address geometric deficiencies that currently impede operating efficiency and contribute to decreased levels of traffic service.

Screening criteria were derived from each of the need elements. These screening criteria were used to determine the ability of each build alternative to address the identified needs. These screening criteria are described in the following sections.

Except for the No-Build Alternative, if a build alternative was deemed not feasible or reasonably capable of meeting the needs, then consideration of the alternative ceased and the alternative was eliminated from further consideration; the remaining build alternatives were retained.

A. Capacity

The screening criteria to measure capacity included level of service and travel reliability.

Level of Service

Level of service (LOS) is a measure of the quality of traffic flow, and is one measure of the ratio between roadway capacity and traffic volume. LOS ranges in grade from A to F. LOS A indicates free-flow conditions where the effects of incidents or breakdowns are easily absorbed; traffic operates well below capacity and at or close to free-flow speeds without delay in travel time. Off-peak speed studies through the HRBT showed free-flow speeds of approximately 55 to 60 miles per hour (MPH). LOS F indicates stop-and-go conditions with queues forming behind bottlenecks. Traffic operates at or above capacity and is substantially below free-flow speeds, which subsequently causes a substantial delay in travel time. LOS was identified using Highway Capacity Software (HCS) and is established using generally-accepted analysis methods to determine roadway capacity. The LOS standard is LOS C for interstates; however, this LOS may not be attainable in this urban environment.[1] Thus, VDOT has identified LOS D as the screening threshold used for the study alternatives.

Travel Reliability

Build alternatives were evaluated and compared for their ability to improve travel reliability. Travel reliability is not a criterion that can be quantitatively measured. However, it is possible to identify factors that impact the reliability of travel conditions, which provides for a qualitative assessment. These factors include the ability to move traffic incidents to the shoulders and out of travel lanes to avoid increased traffic delays; the ability of emergency response providers to reach incident scenes, via adequate shoulders and/or clear zone widths when GP lanes are queued; adequate overhead clearance to reduce the need for overheight trucks to turn around; and other physical deficiencies. Travel reliability also includes the ability of an alternative to provide predictable service during routine maintenance or construction. The ability of each alternative to address these reliability factors was

[1] Per Meeting with FHWA Virginia Division, January 20, 2012

considered during the alternatives screening process. If an alternative did not address these factors, it was eliminated.

B. Geometric Deficiencies of Existing Roadway

I-64 was originally constructed in the late 1950s in Hampton and in the early 1970s in Norfolk. The westbound lanes of the HRBT were opened to traffic in 1957, and the eastbound lanes of the HRBT were opened to traffic in 1976. The mainline, interchanges, bridges, and tunnels do not meet current design standards. Identified geometric deficiencies include narrow median shoulders on the mainline, low vertical clearance within the existing tunnels, and low vertical clearance above the water for the approach bridges over Hampton Roads. Additionally, the tunnels do not meet the current National Fire Protection Agency (NFPA) 502 fire and safety codes. The screening criteria derived from the deficiencies need are primarily based on the design guidelines presented in **Tables 1** and **2**.

Three key issues are representative of the geometric deficiencies of existing facilities in the study corridor and these have been identified as screening criteria, specifically: shoulders, vertical clearance in tunnels, and vertical clearance above the water.

Shoulders

In the Hampton section of the study area, left shoulders are generally eight feet wide and do not meet current 12-foot interstate design standards provided by AASHTO in *A Policy on Geometric Design of Highway and Street* (Green Book) and VDOT in the *Road Design Manual*. The bridges between the tunnels and the land-side roadways have ten-foot-wide right shoulders and 4-foot-wide left shoulders that do not meet current design standards as provided by AASHTO and VDOT. The roadways through the tunnels do not have shoulders consistent with current standards. Within the Norfolk section of the study area, right shoulders are 12 feet wide and left shoulders vary from two to four feet wide and do not meet current interstate design standards.

As described in the purpose and need, the lack of adequate shoulder widths result in roadway congestion and management problems during incidents or minor construction/inspection because one or more of the travel lanes must be closed to through traffic. Providing adequate shoulder widths that meet design standards would allow emergency vehicles to use shoulders to access incidents; allow vehicles involved in an incident to pull out of the travel lane; and allow additional roadway width for maintenance of traffic during construction, maintenance, and inspection activities. Thus, each alternative was evaluated for its comparative ability to address existing geometric deficiencies and provide shoulder widths that meet current design standards.

Vertical Clearance in Tunnels

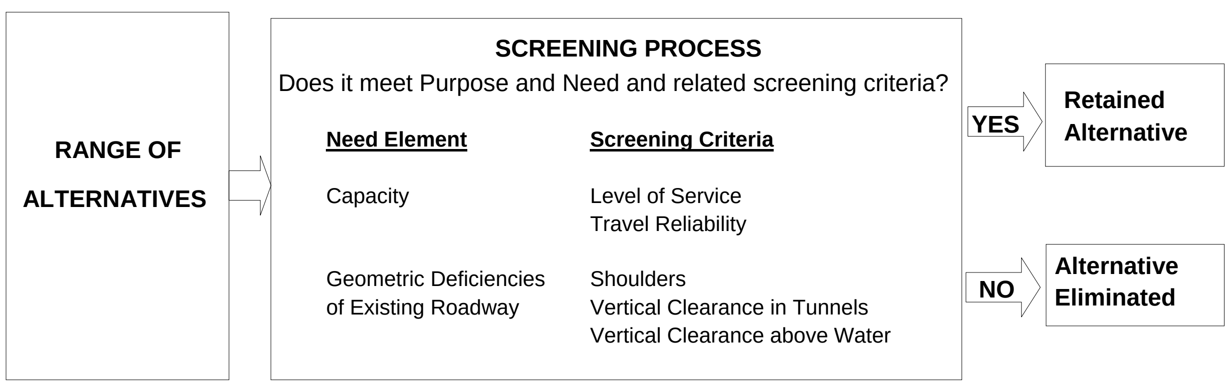
The existing vertical clearance is 13’-6” for the westbound tunnel and 14’-6” for the eastbound tunnel, both of which are substandard. The VDOT *Road Design Manual* establishes a vertical clearance of 16’-6” for interstates. This limited vertical clearance is problematic for some trucks. According to the VDOT *Hampton Roads Bridge/Tunnel Quarterly Tunnel Operations Reports*, an average of 80 to 90 potentially overheight trucks per month must be stopped and inspected on the HRBT tunnel portal islands, causing roadway congestion because all traffic must also be stopped on the crossing to remove the potentially overheight truck from the roadway. Providing adequate vertical clearance in the tunnel would allow all standard height trucks to cross the HRBT and eliminate the need to remove potentially overheight vehicles from the traffic stream. Accordingly, build alternatives were evaluated for their comparative ability to provide vertical clearances in the tunnel that meet current design standards.

Vertical Clearance above Water

The approach bridges have a vertical clearance above the water that does not meet the clearance specifications in AASHTO's Guide Specifications for Bridges Vulnerable to Coastal Storms, 2009. Consequently, during a storm event, the saltwater could contact the bottom of the girders, thus causing deterioration over time. In more severe storm events, water could overtop the bridge deck and potentially shift the bridge off its bearings. Alternatives were screened for their comparative ability to meet the following AASHTO clearance specifications: "vertical clearance of highway bridges should be sufficient to provide at least 1 foot of clearance over the 100-year design wave crest elevation, which includes the design storm water elevations." It is the preference of the VDOT Structure and Bridge Division's standard practice to add five feet of additional clearance to account for potential sea level rise.

C. Summary

The flowchart below illustrates the steps in the alternative development and screening criteria process.



7. ALTERNATIVES ELIMINATED FROM DETAILED STUDY

At the conclusion of the screening process, ten of the fourteen alternatives were eliminated from further study. The justification for the elimination of alternatives is summarized below.

A. TSM/TDM Alternative

TSM/TDM alternatives, by their nature, do not include the addition of single occupancy vehicle (SOV) lanes and involve only minor work outside the existing right-of-way. Therefore, because of the limited scope of these types of improvements, TSM/TDM improvements alone would not address the capacity or roadway geometric deficiency needs. Notwithstanding, the retained build alternatives do not preclude TSM/TDM elements, should they be considered in the future.

B. Rehabilitation or Reconstruction of the Existing HRBT

Rehabilitation or reconstruction of the existing HRBT would not increase roadway capacity to alleviate current or future unacceptable and unreliable levels of traffic service, operating speeds, or travel times. Although the current deficiencies of the existing facilities could be addressed with rehabilitation/ upgrades to the tunnels and reconstruction of the approach bridges, it would not be feasible to address them with the rehabilitation of the approach bridges because simply replacing the superstructure would not allow for the height of the approach bridges to be raised nor shoulders to be widened. The existing tunnels could be used for another 75 to 100 years[2] assuming routine maintenance of the tunnels would continue and rehabilitation/upgrades were addressed as described in Section 5.C.

Travel lanes would need to be taken out of service or replaced with temporary structures during the rehabilitation or reconstruction effort, thus affecting the travel capacity throughout the construction period which could extend beyond three years. To minimize potential construction-related cost, transportation, and environmental impacts, HRBT traffic could be detoured; however, this detour would convey additional traffic to already congested routes such as the Monitor-Merrimac Memorial Bridge-Tunnel (I-664) or James River Bridge, or continue to utilize the HRBT with a reduced number of lanes. As these facilities are already at or near capacity, the conveyance of additional detoured traffic from HRBT during the construction period would only increase congestion and gridlock at these locations.

Because this alternative would not address the purpose and need of the study, it was eliminated from further consideration as a stand-alone alternative; however, it has been included as a component of the retained build alternatives.

C. Replacement of the Existing HRBT

Replacement of the existing HRBT bridge is not reasonable and has been eliminated because the existing tunnels have a remaining life span of 75 to 100 years[2], and it would be less costly to rehabilitate the existing approach bridges and tunnels than to completely replace them. This alternative would result in a minimal achievement of benefits relative to an unreasonably high level of disruption to regional travel during the construction period which could extend beyond three years.

Additionally, removal of two lanes of the existing bridge-tunnels would be necessary prior to constructing the new facility. The number of lanes crossing the HRBT during construction would be reduced by one half from four lanes to two lanes. This would result in increased delays within the I-64 HRBT corridor for drivers that continue to use the HRBT or additional traffic on other regional routes such as I-664 and the James River Bridge.

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[2] Per meeting with VDOT HRBT Study Team and VDOT Structure and Bridge Engineer, August 18, 2011.

This alternative would not address the identified capacity needs as it only replaces the existing HRBT, additional capacity is not contemplated with this alternative. Geometric deficient roadway infrastructure would be replaced by a new facility that would meet current design standards for shoulder widths and vertical clearance above water for approach bridges. If only one of the existing bridge-tunnels were removed, the remaining bridge-tunnel would have the same geometric deficiencies as the current facility.

D. Reversible Lanes

Construction of reversible lanes would partially address deficiencies at the existing crossing, because the reversible lanes would be on a new bridge-tunnel that would meet current design standards for shoulders, vertical clearance in tunnels, and vertical clearance above water. However, the existing bridge-tunnels would continue to be used without improvements; therefore, geometric deficiencies at these facilities would not be addressed. Additionally, the travel patterns along I-64 through this study area do not allow for effective operation of reversible lanes. Reversible lanes would add capacity in one direction during any given peak period, but the capacity needs in the opposite direction would not be met. It is also noted that the 2008 *HRBT Expansion Feasibility Study* also recommended elimination of the reversible lane alternative for similar reasons.

E. Build-6 Alternative

The Build-6 Alternative would not provide adequate congestion relief for current or future traffic within the study corridor. As discussed in the *Traffic and Transportation Technical Report* (2012), LOS E or worse would generally still occur on the HRBT and its approaches in the future with this alternative. Therefore, the alternative would not meet the capacity need and the LOS screening threshold for this study. This alternative would require two-way traffic to operate on the existing eastbound approach bridges and tunnel. Due to the narrow typical section in the eastbound tunnel, a concrete traffic barrier could not be placed between the travel lanes; therefore, there would be no means to minimize potential head-on collisions at highway speeds. Because of this safety concern, the speed limit could be reduced; however, this reduction would further lessen the capacity of this improvement.

F. Build-12 Alternative

The Build-12 Alternative would draw traffic from other Hampton Roads crossings, in particular the Monitor-Merrimac Memorial Bridge-Tunnel (I-664), even though the total traffic volume crossing Hampton Roads would not substantially increase in the Build-12 compared to the Build-10 Alternative. As a result, capacity on parallel facilities would likely become underutilized in the future. The additional capacity provided by the Build-12 Alternative would result in an LOS that exceeds the minimum level preferred by FHWA. Since the additional capacity would exceed the LOS standard criteria for the study it is unnecessary based on the marginal transportation benefit provided beyond the Build-10 Alternative. Furthermore, the Build-12 Alternative would result in increased environmental and right-of-way impacts not realized by either the Build-8, Build-8 Managed, or Build-10 Alternatives. The alternative was eliminated from further study because it would provide excessive capacity at a greater cost and greater potential impacts than the other build alternatives.

G. High Bridge Crossing

As discussed in the *High Bridge Technical Memorandum* (Appendix A), the anticipated bridge height would create a visual impact to nearby communities and historic properties. As discussed with agency representatives during the study scoping effort, a new or expanded island could have a detrimental impact on the hydrodynamic characteristics of Hampton Roads. A high bridge could be vulnerable to natural hazards and manmade threats, including ships colliding with bridge piers and high winds affecting bridge operations. Additionally, the tall towers required by the structure would be considered obstructions to FAA controlled air space for Chambers Field and Langley Air Force Base. Therefore, although a high bridge option over Hampton Roads would address the stated transportation needs, the option would incur additional problems that make it unreasonable to carry forward.

H. Light or Heavy Rail

As discussed in the *Transit Technical Memorandum* (Appendix B), light and heavy rail ridership projections were evaluated for future services that cross Hampton Roads. The findings indicated that rail transit would accommodate approximately ten percent of the existing HRBT users and eight percent of the year 2040 users on the HRBT. The alternative would require substantial new rail transit connections on the Peninsula and Southside, and it would have limited ability to accommodate existing and future traffic volumes on the HRBT. Based on the projections and the necessary rail connections, the Light or Heavy Rail Transit Alternative was eliminated from further consideration because it would not address the roadway deficiency or capacity needs identified by this study.

I. Bus Transit

As discussed in the *Transit Technical Memorandum* (Appendix B), as a stand-alone alternative, bus transit would not involve roadway or bridge-tunnel improvements; therefore it would not address the identified capacity and roadway geometric deficiencies of the existing facility. Expansion of the existing bus transit network alone would likely not attract enough riders to substantially address the capacity need within the I-64 HRBT corridor because there is currently a lack of bus ridership potential across Hampton Roads. This fact is demonstrated by recent recommendations by Hampton Roads Transit (HRT) to eliminate five current weekday trips across HRBT due to low ridership (*Service and Schedule Efficiency Review*, HRT, March 2011). All bus routes across Hampton Roads accommodated approximately 900 passengers per day in 2011, which is less than one percent of the existing HRBT daily traffic volume. Any increased bus service would also continue to rely on the existing HRBT facility, and its operation would be hampered by current capacity and deficiencies of existing facilities.

J. Ferry Service

The Ferry Service Alternative would not address the geometric deficiencies of the existing facilities, because no improvements would be made to the I-64 roadway or existing bridge-tunnel to address current design standards for shoulders, vertical clearance in tunnels, or vertical clearance above water. Ferries would require that vehicles arrive at least 20 minutes prior to departure to load and would travel at maximum speeds less than 40 miles per hour. This speed may not be reasonable across Hampton Roads where ferries would have to traverse shipping lanes and adhere to speed restrictions. The total trip length (including loading and unloading) would be approximately 30 minutes across Hampton Roads only. This represents an average increase in the travel time across Hampton Roads of approximately 20 minutes as compared to the current average peak hour travel time across the bridge-tunnel of 9.5 minutes. Even in 2040 the predicted travel time across Hampton Roads would exceed the predicted travel time for the ferry alternative. In both scenarios the ferry alternative is less effective than traversing Hampton Roads using the bridge-tunnel.

Further, as cited in the *Vision Plan*, total average weekday ferry ridership between downtown Hampton and the Norfolk Naval Station in the year 2034 are expected to range from 600 to 1,100 vehicles, or about one percent of the existing traffic volume and less than one percent of the projected 2040 No-Build volume on the HRBT. The Ferry Service Alternative would not address geometric deficiencies of the existing facilities or capacity needs of the HRBT.

8. ALTERNATIVES RETAINED

Four alternatives were retained for detailed study: No-Build, Build-8, Build-8 Managed, and Build-10. This chapter provides a complete description of these build alternatives and justification for why they were retained.

A. No-Build Alternative

Under the No-Build Alternative, I-64 would remain predominantly three lanes per direction within the Hampton section of the study area, with auxiliary lanes (acceleration and deceleration lanes) at the interchanges. The 3.5-mile HRBT would continue with current operations. Within the Norfolk section of the study, I-64 would remain two lanes per direction, including the I-64 bridges across Willoughby Bay. Typical sections are shown on **Figure 2**.

VDOT would continue with maintenance and repairs of I-64 and the HRBT as needed, with no substantial changes to current management activities, specifically, there would be no rehabilitation or reconstruction of the HRBT. The No-Build Alternative would only include those projects funded for construction in HRTPO's *2034 Long Range Transportation Plan.*

The No-Build Alternative would not address the purpose and need of the study because routine maintenance of the HRBT corridor and other programmed projects would not improve capacity or address geometric deficiencies of existing facilities. However, it has been retained for evaluation to serve as a benchmark and comparison for other retained build alternatives.

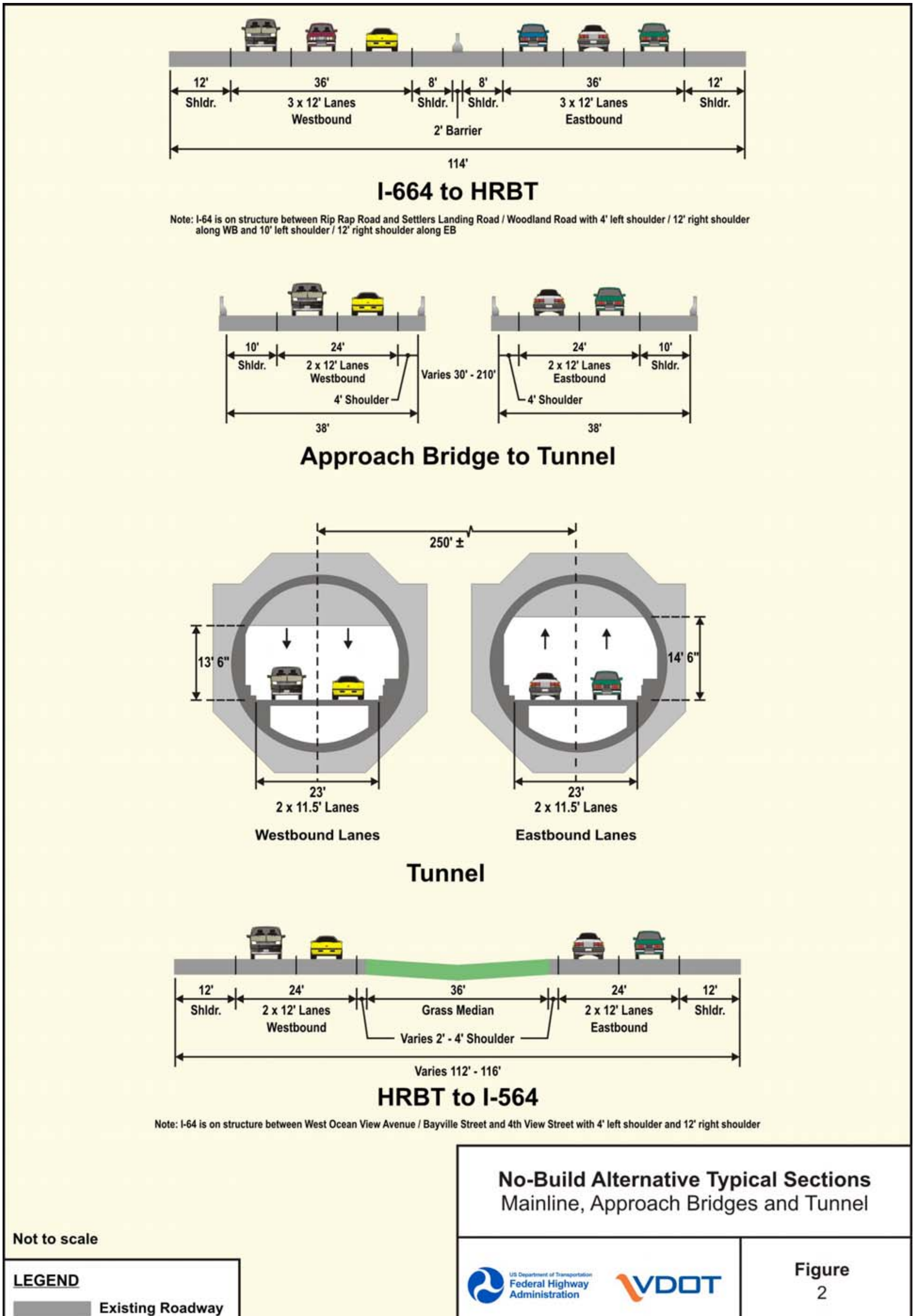
B. Build-8 Alternative

The Build-8 Alternative would provide four continuous mainline lanes in each direction of I-64 throughout the limits of the study. Through the Hampton section of the study, this alternative would require one lane of widening in each direction. Through the Norfolk section, this alternative would require two lanes of widening in each direction. Typical sections are shown in **Figure 3** and plan sheets are provided in Appendix C.

The typical section would include 12-foot travel lanes, 12-foot shoulders, and a concrete barrier between the eastbound and westbound lanes. The total pavement width of the Build-8 Alternative mainline would be 146 feet and would require 16 feet of outside pavement widening on both sides of the highway through Hampton. In Norfolk, the Build-8 Alternative would require 17 feet of outside pavement widening on both sides of the highway and widening into the existing 36-foot grass median.

The Build-8 Alternative was assumed to include an open roadside section that would consist of a clear zone; roadside grading to tie the proposed slope to existing ground; and an a offset to the limit of disturbance (LOD) to accommodate elements such as drainage, utilities, and stormwater management. The additional details on the roadside design are provided in Section 9.A. Based on those assumptions, the calculated limit of disturbance of the Build-8 Alternative, including the full open roadside section, would be approximately 326 feet. However, due to the preliminary level of engineering assessments completed for this planning study, a consistent LOD was established for the corridor and is described in Section 9.B.

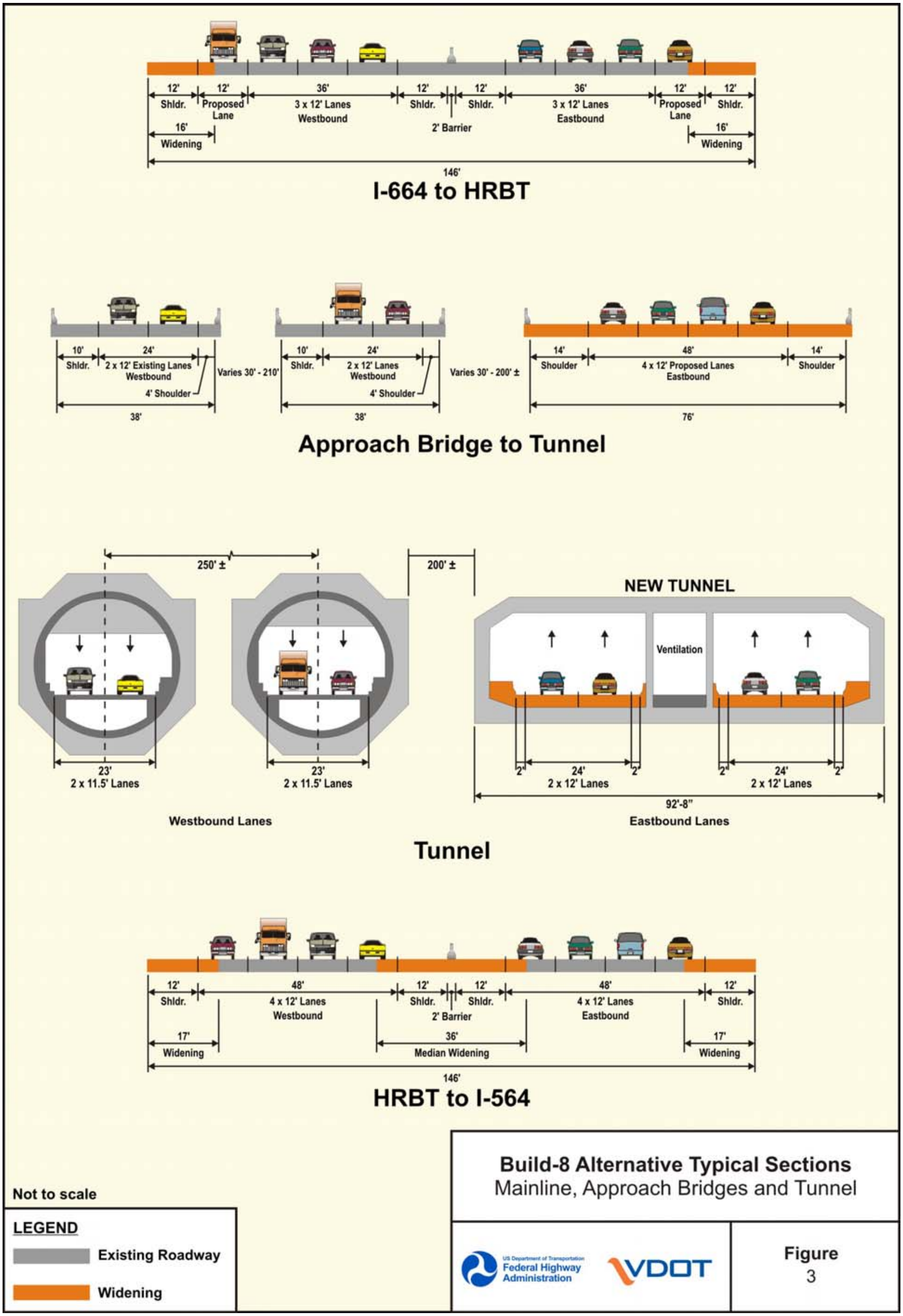
At the western study limit (west of the I-664 interchange), the Build-8 Alternative mainline would tie to the existing mainline typical section of twelve lanes at the Pine Chapel Road Bridge. At the eastern study limit (east of the I-564 interchange), the mainline would tie into the existing I-64 mainline typical section of four lanes.



No-Build Alternative Typical Sections
Mainline, Approach Bridges and Tunnel

US Department of Transportation Federal Highway Administration | VDOT

Figure 2



Build-8 Alternative Typical Sections
Mainline, Approach Bridges and Tunnel

Figure 3

The existing approach bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new four-lane bridge-tunnel at the Hampton Roads crossing. Additional details of the new approach bridges and tunnel are provided in Sections 9.E and 9.F.

The Build-8 Alternative was retained because it would meet the capacity needs of the study by providing two additional lanes in each direction between the east side of the HRBT and the I-564 interchange and one additional lane in each direction between the I-664 interchange and the HRBT. The additional lanes would result in an acceptable average LOS of D or better throughout the corridor, which meets the minimum LOS threshold. The elimination of mainline lane drops through the corridor would eliminate the need for through lanes to merge and minimize reduction of travel speeds and delay. Travel reliability would be addressed with added space for traffic incidents to be moved to shoulders or into additional lanes, allowing traffic flow to continue and providing easier access for emergency vehicles.

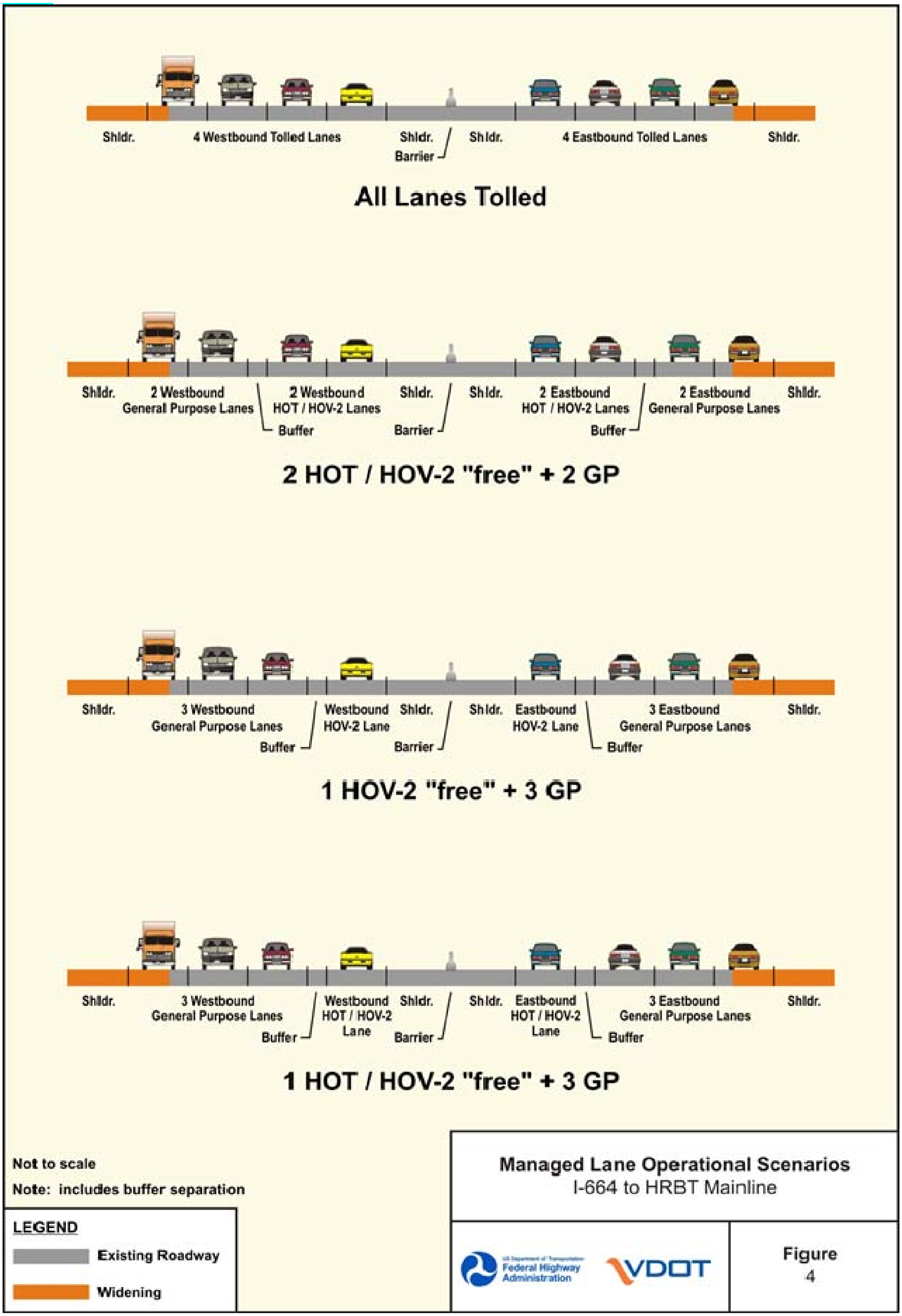
In addition, the Build-8 Alternative would address geometric deficiencies by improving the I-64 roadway and the HRBT to meet current design standards. Shoulders would be 12 to 14 feet wide to allow space for breakdowns and incident management. Vertical clearance in the new tunnels would be 16’-6” to meet current VDOT and AASHTO standards; the existing tunnel clearance would be increased with the ventilation system upgrade. These changes would reduce the number of truck turnarounds caused by low clearance in the existing tunnels. Vertical clearance above the water would be 18 feet for new tunnel approach bridges to reduce the risk of exposure to storm surges and salt corrosion.

C. Build-8 Managed Alternative

The Build-8 Managed Alternative would be similar to the Build-8 Alternative, providing four continuous mainline lanes in each direction of I-64. However, some or all of the travel lanes would be managed using tolls and/or vehicle occupancy. The Build-8 Managed Alternative could include tolling of all I-64 mainline lanes, or a combination of managed and general purpose (GP) lanes, such as high occupancy vehicle lanes where there are 2 or more occupants per vehicle (HOV-2); high occupancy toll (HOT) lanes where HOV users could use the lanes for free, but single occupancy vehicles (SOV) would pay a toll; or express toll lanes, where all traffic in the managed lane would be tolled. Additionally, expanded local/express bus service or bus rapid transit could be accommodated with this alternative in the general purpose lanes or the managed lanes.

Due to the number of possible managed lane scenarios, there were no specific operational scenarios identified at this stage of the study. However, the following four operational scenarios were evaluated as part of the traffic analysis to bracket a sample range of travel demand conditions for this build alternative. **Figure 4** presents a typical section for the managed lane operational scenario through Hampton.

1. **All lanes tolled:** All HRBT users would have to pay a toll. The tolls could be varied to maintain a desired level of service on the HRBT, with higher tolls during periods of higher demand and lower tolls during periods of lower demand.
2. **Two HOT Lanes + Two General Purpose Lanes** ***(2 HOT / HOV-2 “free” + 2 GP)*****:** This scenario would include two general purpose lanes and two HOT lanes in each direction. The HOT lanes would be restricted to HOV-2 vehicles that would travel for free and SOVs that would pay a toll to use the lane.
3. **One HOV Lane + Three General Purpose Lanes** ***(1 HOV-2 “free” + 3 GP)*****:** This scenario would include three general purpose lanes and one HOV lane in each direction. The HOV lane would be restricted to HOV-2 vehicles that would travel for free.



Managed Lane Operational Scenarios
I-664 to HRBT Mainline

Figure 4

4. **One HOT Lane + Three General Purpose Lanes** ***(1 HOT / HOV-2 "free" + 3 GP)*****:** This scenario would include three general purpose lanes and one HOT lane in each direction. The HOT lanes would be restricted to HOV-2 vehicles that would travel for free and SOVs that would pay a toll to use the lane.

As with the Build-8 Alternative, the typical section would include 12-foot travel lanes, 12-foot shoulders, and a concrete barrier between the eastbound and westbound directions. The typical section would also include a four-foot buffer separation between the general purpose lanes and any managed lanes. The total pavement width of the Build-8 Alternative mainline would be 154 feet and would require 20 feet of outside pavement widening on both sides of the highway in Hampton. In Norfolk, the Build-8 21 feet of outside widening on both sides of the highway and would include widening into the existing 36-foot grass median. Typical sections are shown in **Figure 5** and plan sheets are provided in Appendix D.

The Build-8 Managed Alternative was assumed to include an open roadside section that would consist of a clear zone; roadside grading to tie the proposed slope to existing ground; and an a offset to the limit of disturbance (LOD) to accommodate elements such as drainage, utilities, and stormwater management. The additional details on the roadside design are provided in Section 9.A. Based on those assumptions, the calculated limit of disturbance of the Build-8 Managed Alternative, including the full open roadside section, would be approximately 334 feet. However, due to the preliminary level of engineering assessments completed for this planning study, a consistent LOD was established for the corridor and is described in Section 9.B.

At the western study limit (west of the I-664 interchange), the Build-8 Managed Alternative mainline would tie to the existing twelve lanes at the Pine Chapel Road Bridge and the managed lanes would tie to the existing HOV lanes. At the eastern study limit (east of the I-564 interchange), the mainline would tie into the existing four lanes and the managed lanes would tie to the reversible HOV lanes.

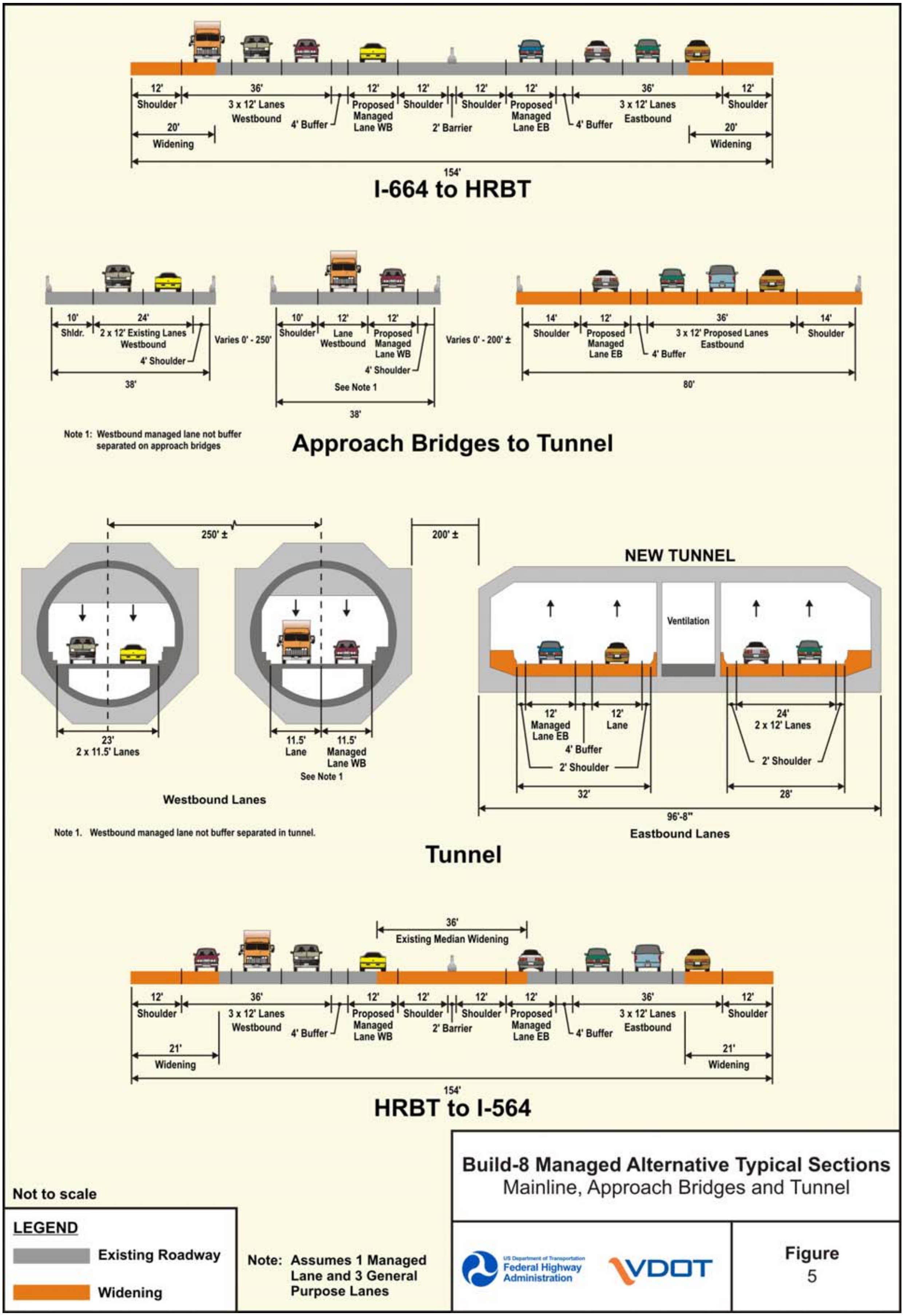
Similar to the Build-8 Alternative, the existing approach bridges and tunnels would be rehabilitated as described in Section 5.C. The alternative would include a new four-lane bridge-tunnel at the Hampton Roads crossing. Additional details of the new approach bridges and tunnel are provided in Sections 9.E and 9.F.

The Build-8 Managed Alternative was retained for similar reasons as the Build-8 Alternative. The addition of travel lanes to provide a continuous eight-lane facility through the study area allows it to meet the capacity needs of the study. Likewise, existing geometric deficiencies would be improved with the additional lanes and wider shoulders built to current VDOT and AASHTO design standards.

D. Build-10 Alternative

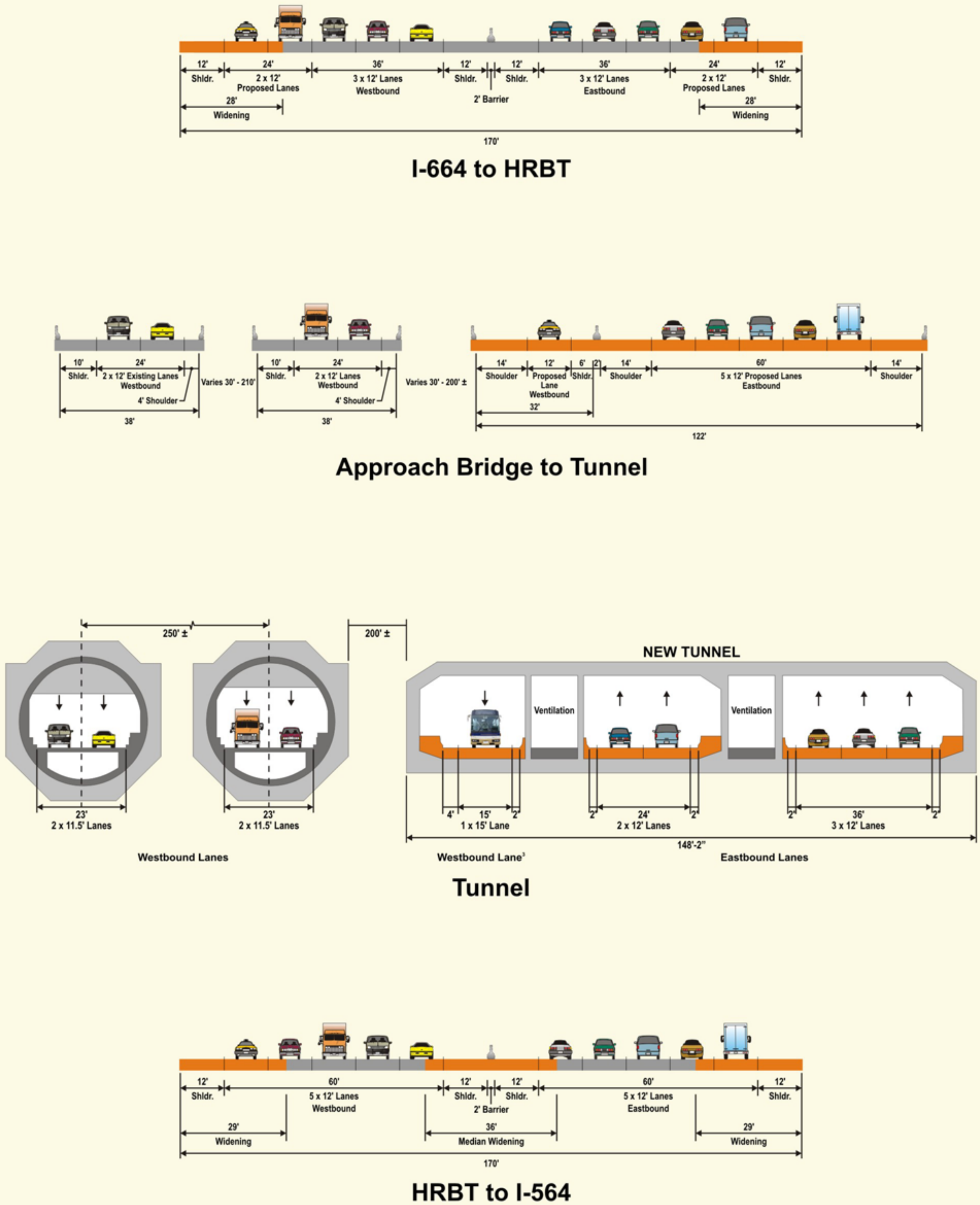
The Build-10 Alternative would provide five continuous mainline lanes in each direction of I-64 throughout the limits of the study. Throughout the Hampton section of the study, this alternative would require widening in both directions of I-64 by two lanes. In the Norfolk section of the study, this alternative would require widening in both directions of I-64 by three lanes. Typical sections are shown in **Figure 6** and plan sheets are provided in Appendix E.

Similar to the Build-8 Alternative, the typical section would include 12-foot travel lanes, 12-foot shoulders, and a concrete barrier between the eastbound and westbound lanes. The total pavement width of the Build-10 Alternative mainline would be 170 feet and would require 28 feet of outside pavement widening on both sides of the highway through Hampton. In Norfolk, the Build-10 Alternative would require 29 feet of outside pavement widening on both sides of the highway and widening into the 36-foot existing grass median.



Build-8 Managed Alternative Typical Sections
Mainline, Approach Bridges and Tunnel

Figure 5



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LEGEND

- Existing Roadway
- Widening

Build-10 Alternative Typical Sections
Mainline, Approach Bridges and Tunnel

US Department of Transportation Federal Highway Administration

VDOT

Figure
6

The Build-10 Alternative was assumed to include an open roadside section that would consist of a clear zone; roadside grading to tie the proposed slope to existing ground; and an a offset to the limit of disturbance (LOD) to accommodate elements such as drainage, utilities, and stormwater management. The additional details on the roadside design are provided in Section 9.A. Based on those assumptions, the calculated limit of disturbance of the Build-10 Alternative, including the full open roadside section, would be approximately 350 feet. However, due to the preliminary level of engineering assessments completed for this planning study, a consistent LOD was established for the corridor and is described in Section 9.B.

At the western study limit (west of the I-664 interchange), the mainline would tie to the existing mainline typical section of twelve lanes at the Pine Chapel Road Bridge. At the eastern study limit (east of the I-564 interchange), the mainline would tie into the existing I-64 mainline typical section.

The existing approach bridges and tunnels would be rehabilitated, as described in Section 5.C. The alternative would include a new six-lane bridge-tunnel at the Hampton Roads crossing. Additional details of the new approach bridges and tunnel are provided in Sections 9.E and 9.F.

The Build-10 Alternative was retained because it would meet the capacity needs of the study by providing three additional lanes in each direction between the east side of the HRBT and the I-564 interchange. Two additional lanes in each direction would be provided between the I-664 interchange and the HRBT. This improvement would generally result in LOS C throughout the corridor, which would exceed the screening threshold for this study. The elimination of mainline lane drops through the corridor would eliminate the need for through lanes to merge, thereby minimizing travel time delay. Travel reliability would be addressed with added width for traffic incidents to be moved to shoulders or into additional lanes, allowing traffic flow to continue and easier access for emergency vehicles.

Furthermore, similar to the Build-8 Alternative, the Build-10 Alternative would address geometric deficiencies by improving the I-64 roadway shoulder widths and the HRBT vertical clearances to meet current design standards. Shoulders would be 12 to 14 feet wide to allow space for breakdowns and incident management. Vertical clearance in the new tunnels would be 16’-6” to meet current VDOT and AASHTO standards and the existing tunnel clearance would be increased with the ventilation system upgrade. These changes would reduce the number of truck turnarounds caused by low clearance in the existing tunnels. Vertical clearance above the water would be 18 feet for new tunnel approach bridges to reduce the risk of exposure to storm surges and salt corrosion.

9. ENGINEERING DETAILS OF ALTERNATIVES RETAINED

The three retained alternatives include elements that create the end-to-end alternatives including the roadside design, limits of disturbance (LOD), interchanges, landside structures, approach bridges to tunnel, tunnel, and Willoughby Spit and Willoughby Bay bridges. These elements are explained below.

A. Roadside Design

Three roadside design options were developed for the build alternatives, as shown in **Figure 7**. The widest typical section would include a full open section with 18 feet of clear zone from the edge of the shoulder; roadside grading at a 3-to-1 slope to tie to the existing ground; and a 35-foot offset to the LOD to accommodate drainage, utilities, and stormwater management, and construction easements. To determine an approximate width of roadside grading, it was assumed that I-64 was approximately 15 feet above the surrounding ground. The roadside grading, along with the other roadside design criteria would result in a total distance of approximately 90 feet from the outside edge of shoulders to the LOD.

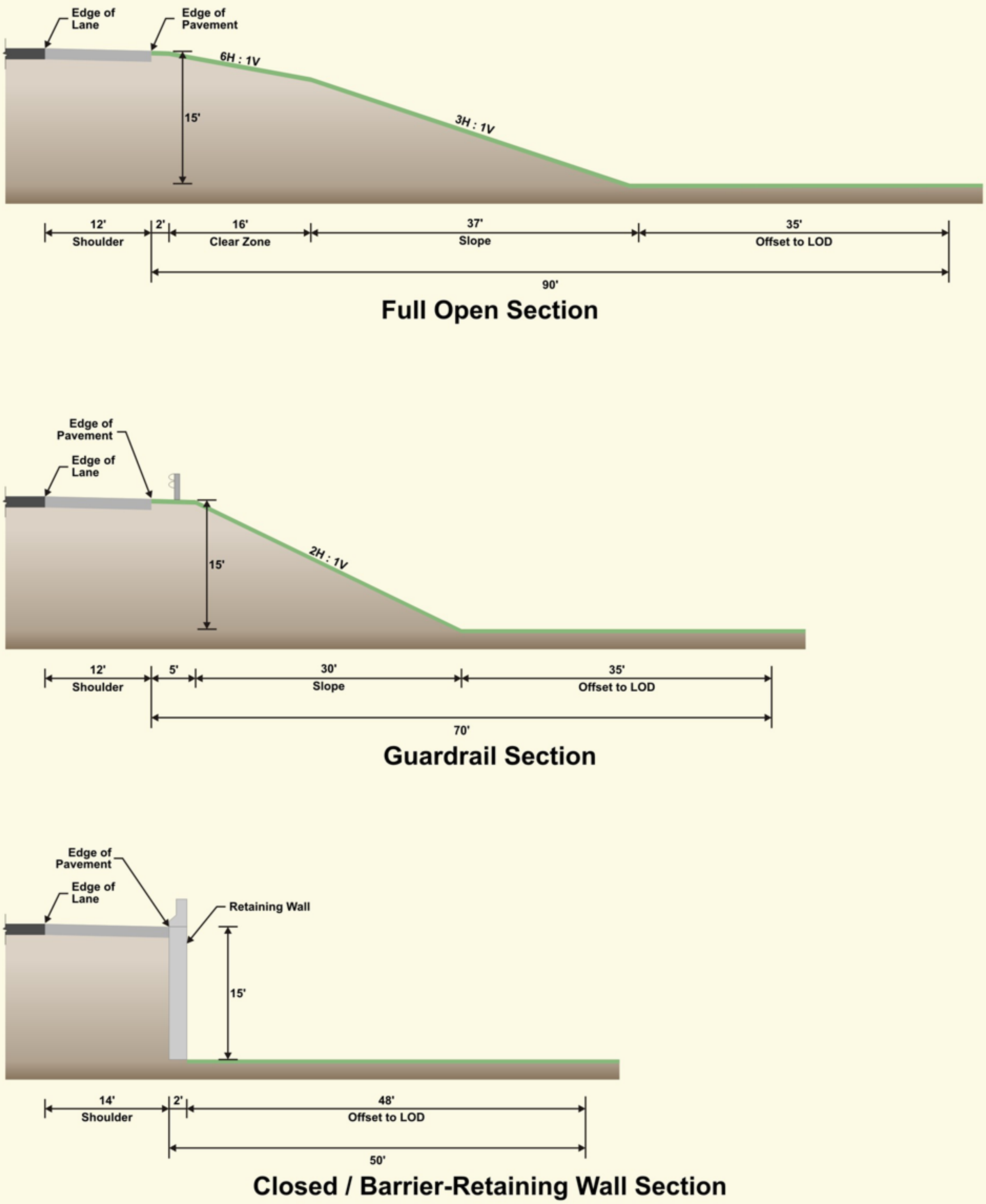
In general, the roadside design was assumed to include the full open section; however, a second and third option were also developed for a potentially narrower footprint. The second roadside option would include guardrail that would allow for a 2-to-1 slope to tie to existing ground, and a 35-foot offset to the LOD. With the assumption that I-64 sits 15 feet above the surrounding grade, this option would provide an approximate distance of 70 feet from the outside edge of shoulder to the LOD. The third option would include a closed roadway section with a retaining wall at the edge of the shoulder and would have a total distance of approximately 50 feet from the outside edge of shoulder to the LOD. These values meet VDOT design standards.

B. Limit of Disturbance

The calculated LOD was developed for the mainline of the three alternatives retained using the proposed pavement width and the preliminary roadside design as described in Section A above. Due to 1) the preliminary level of engineering assessments completed for this planning study; 2) the number and location of the auxiliary lanes to/from interchange ramps; 3) limited available survey information; and 4) topographic variability throughout the existing corridor, an additional buffer was added to provide a more consistent LOD to ensure that there would be adequate width to accommodate detailed design and construction in the future. Consequently, the resulting LOD for the mainline for the alternatives retained was the following:

- Build-8 Alternative: 360 feet or 425 feet
- Build-8 Managed Alternative: 370 feet or 435 feet
- Build-10 Alternative: 400 feet or 465 feet

An additional LOD buffer was also added around the interchanges in the form of a consistent radius circle. At each interchange, the LOD was either a 600-foot or 800-foot radius around the interchange, depending on the size and scale of the existing interchange and the potential improvements. This LOD would provide enough flexibility during the design stage to accommodate other possible improvements. The preliminary interchange concepts described in Section 9.C were considered when selecting the radius for the LOD for each interchange.



Not to scale

Notes:

1. Offset to LOD includes roadside drainage
2. Offsets assume highway is 15' above roadside

Roadside Design Options

US Department of Transportation Federal Highway Administration

VDOT

Figure 7

The LOD varies in width across Hampton Roads due to the varying distance between the existing and proposed approach bridges and the amount of dredging potentially required to accommodate the construction of the new approach bridges and tunnel and rehabilitation/reconstruction of the existing approach bridges. The LOD for the mainline across Hampton Roads was provided as follows:

- Build-8 Alternative: 520 feet to 930 feet
- Build-8 Managed Alternative: 540 feet to 930 feet
- Build-10 Alternative: 560 feet to 970 feet

Additionally, the LOD around the portal islands was estimated using a radius of 1,200 feet to ensure that there would be adequate space to accommodate detailed design and construction of the enlarged islands in the future.

The LOD was assumed to be the proposed right-of-way line where it was located outside of the existing right-of-way line. The LOD for the mainline and the interchanges for the retained alternatives is shown on the plan sheets in Appendix C, D, and E. The environmental impact analysis in the EIS considers the entire area within the LOD assuming it would be impacted.

C. Interchanges

Preliminary concepts were investigated for the ten interchanges within the study area to accommodate the build alternatives. The interchange concepts could include adjustments to ramp gore areas to tie-in to the wider mainline, addition of lanes to accommodate future traffic volumes, realignment of ramps to meet the current VDOT and AASHTO design standards, and the removal of ramps to eliminate mainline weaving areas.

The plan sheets in Appendices C, D and E present a potential edge of pavement and LOD for the preliminary interchange concepts. The edges of pavement shown represent one or two interchange options that could accommodate the widened mainline. The concepts were used to develop approximate interchange LODs that would allow enough flexibility during the design stage to accommodate other possible improvements. During the Interchange Modification Report (IMR) process, each of the interchange configurations will serve as a starting point for further study and a more in-depth examination of the needs at each location. Operational and geometric improvements were not considered for the cross roads, but would need to be addressed during detailed design. The interchange assumptions were intended for environmental impact analysis and should not be considered as specific proposals for design.

The ten interchanges within the study corridor include:

- Exit 264 – I-664
- Exit 265 – Route 167/Route 134/LaSalle Avenue, North Armistead Avenue, and Rip Rap Road
- Exit 267 – US 60/Route 143/Settlers Landing Road and Woodland Road
- Exit 268 – Route 169/South Mallory Street
- Exit 272 – Route 168/West Ocean View Avenue/Bayville Street
- Exit 273 – US 60/4th View Street
- Exit 274 – Entrance ramp from eastbound West Bay Avenue to I-64 east and exit ramp from westbound I-64 to westbound West Ocean View Avenue
- Westbound Entrance Ramp from Granby Street to I-64 just north of Norfolk Naval Station Gate 22 and the Forest Lawn Cemetery
- Eastbound Entrance Ramp from Norfolk Naval Station Gate to I-64

- Exit 276 – I-564/Granby Street (Route 460). Southbound Granby Street cannot be accessed from westbound I-64 and northbound Granby Street is not accessible from eastbound I-64

Exit 264 – I-664

The I-64/I-664 interchange (Exit 264) is a semi-directional interchange located at the western limit of the study area. The three build alternatives would require the reconstruction of the two flyover ramps (westbound I-64 to southbound I-664 and northbound I-664 to westbound I-64) because the mainline widening would impact the piers of the existing structure. In addition, the ramp from I-664 northbound to I-64 eastbound would have to be shifted east from its current alignment to accommodate a relocated northbound I-664 to westbound I-64 ramp. The gore area (area between the mainline and ramp) for the I-64 eastbound exit ramp to southbound I-664 would be modified to accommodate the wider mainline.

Exit 265 – Route 167/Route 134 – LaSalle Avenue, North Armistead Avenue, and Rip Rap Road

The partial cloverleaf interchange with North Armistead Avenue/Route 134, Lasalle Avenue/Route 167, and Rip Rap Road (Exit 265A/B/C) includes seven ramps that would be modified to accommodate a widened mainline section. Currently, westbound I-64 traffic can exit to either North Armistead Avenue or southbound Lasalle Avenue. Eastbound I-64 traffic can exit to southbound Lasalle Avenue and Rip Rap Road via a ramp east of the main interchange. Traffic can access westbound I-64 via North Armistead Avenue and eastbound I-64 via two separate ramps along Lasalle Avenue. Traffic cannot access I-64 directly from Rip Rap Road. The interchange modifications would require reconstruction of the two loop ramps at North Armistead Avenue and Lasalle Avenue to maintain current ramp terminal intersections on the local roads and merge into the widened mainline. In addition, adjustments to the gore areas on four diamond ramps would provide a smooth transition to the mainline. The fifth diamond ramp in the southwest quadrant would be realigned near the ramp terminal to accommodate the new loop ramp.

Exit 267 – US 60/Route 143 – Settlers Landing Road and Woodland Road

The ramp gore areas in the Settlers Landing Road/Woodland Road/US 60 and Route 143 diamond interchange (Exit 267) would be modified to accommodate the widened mainline. The ramp in the northwest quadrant would be lengthened to diverge from I-64 north of the expected queuing from the ramp terminal intersection.

Exit 268 – Route 169 – South Mallory Street

The interchange at South Mallory Street (Exit 268) is a partial diamond interchange with a loop in the northeast quadrant. Two options for modifying the interchange were considered. For Option 1, the loop ramp would be enlarged to meet current design criteria. Consequently, the diamond ramp adjacent to the loop ramp would be shifted east. The shift of the diamond ramp would push the ramp terminal intersection with Mallory Street closer to Libby Street/Downes Street. The proximity of these intersections may cause operational problems. To address this issue, Option 2 was developed to replace the loop ramp with a diamond ramp from westbound I-64 to South Mallory Street. In this option, the existing westbound entrance diamond ramp would remain in place.

A commercial vehicle inspection station currently exists between the eastbound entrance ramp and the mainline in the southwest quadrant. The associated inspection area would be shifted to the west to accommodate the widened mainline in both options.

Exit 272 – Route 168/West Ocean View Avenue/Bayville Street

The West Ocean View Avenue and Bayville Street interchange (Exit 272) includes right-in/right-out ramp movements along both eastbound and westbound I-64. The Build-8 Alternative has two options at this interchange. Option 1 would include relocating the entrance ramp to eastbound I-64 from the western end of the Peninsula closer to Willoughby Bay and adjusting the other three ramps to accommodate the widened mainline. Bayville Street would retain its existing alignment. Option 2 would include shifting segments of Bayville Street south and removing the existing eastbound Bayville interchange ramps. In addition, the ramps to/from westbound I-64 would be adjusted to accommodate the widened mainline.

Additionally, this interchange has two options for the Build-10 mainline that differ from the Build-8 Alternative. Option 1 would include shifting Bayville Street to the south, requiring the acquisition of most residential properties and removing the existing eastbound Bayville Street ramps. Option 2 would shift Bayville Street south, but reduce the roadway width from 36 to 24 feet to fit it within the remaining land area adjacent to the highway. In addition, the ramps to/from westbound I-64 would be adjusted to accommodate the widened mainline.

Exit 273 – US 60/4th View Street

The 4th View Street interchange (Exit 273) is a diamond interchange with 900 to 1,000-foot long ramps. The ramp gore areas would be adjusted to accommodate the widened mainline.

Exit 274 – Entrance ramp from eastbound West Bay Avenue to I-64 east and exit ramp from westbound I-64 to westbound West Ocean View Avenue

The partial interchange at West Bay Avenue and West Ocean Avenue (Exit 274) contains a loop ramp in the northeast quadrant that provides access from westbound I-64 to westbound West Bay Avenue and a direct access ramp from eastbound West Bay Avenue to eastbound I-64. Two options were considered for this interchange. Option 1 would maintain the exiting ramp configurations. The direct access ramp would be widened to two lanes to accommodate increased traffic and shifted to the west side of the existing ramp to accommodate the widened mainline and meet current design standards. The loop ramp would be enlarged to meet the current design criteria.

Option 2 could be implemented in conjunction with the closing of the entrance ramp from Granby Street to Westbound I-64 near the Forest Lawn Cemetery (see Granby Street entrance ramp below). This option would include the construction of a diamond exit ramp from westbound I-64 to West Bay Avenue and a diamond entrance ramp from West Ocean Avenue to I-64 westbound. The loop ramp in the northeast quadrant would be removed. The direct access ramp from eastbound West Bay Avenue to eastbound I-64 would be modified as described above. The addition of an entrance ramp to westbound I-64 would permit the closing of the entrance ramp from Granby Street by allowing traffic that currently uses that access point to travel approximately one mile north on Granby Street to West Ocean Avenue to access the new westbound entrance.

Westbound Entrance Ramp from Granby Street to I-64 just north of Norfolk Naval Station Gate 22 and the Forest Lawn Cemetery

The Granby Street entrance ramp is a short slip ramp that runs parallel to westbound I-64 near the Forest Lawn Cemetery. Traffic from both northbound and southbound Granby Street can access the ramp; however, due to the 50-foot radius of the U-turn movement from southbound Granby, large trucks cannot access it from that direction. The radius of the entrance ramp does not meet current design criteria due to the close proximity of I-64 to Granby Street (approximately 180 feet from the outside edge of travel lanes). Option 1 would include adjusting the ramp gore area to accommodate the widened mainline. Option 2 would eliminate the entrance ramp, and in conjunction with the second option at Exit 274, reroute traffic to the West Ocean Avenue / West Bay Avenue interchange where a partial diamond would provide access to westbound I-64.

Eastbound Entrance Ramp from Norfolk Naval Station Gate to I-64

The entrance ramp from Norfolk Naval Station Gate 22 to westbound I-64 would be adjusted to provide adequate length for the grade change and to accommodate the widened mainline.

Exit 276 – I-564 and Granby Street (Route 460)

The I-64/I-564 interchange (Exit 276) is located at the eastern limit of the study area. The semi-directional interchange also connects I-64 with Granby Street (Exit 276A). Currently, two eastbound through lanes and an auxiliary lane approach the interchange with the auxiliary lane dropping at the exit to southbound Granby Street/westbound I-564. Prior to the two mainline lanes merging with the two lanes of I-564 to create a four-lane roadway, a left exit provides access to the I-64 HOV lanes. After passing through the E. Little Creek Road interchange, one lane is dropped at the exit to Tidewater Drive and the three remaining lanes continue east of the study area.

The Build-8 and Build-8 Managed Alternatives would have the same lane configuration through the interchange. Both alternatives would have four eastbound through lanes and an auxiliary lane approaching the interchange. The auxiliary lane would be dropped at the exit to southbound Granby Street/westbound I-564 and the ramp would be widened to two lanes by converting the outside through lane to a through-exit choice-lane. The innermost mainline lane would be dropped via an exit to the I-64 HOV facility and three lanes would continue to the I-564 merge to become a five-lane roadway. One lane would be dropped past the E. Little Creek Road interchange at the exit to Tidewater Drive. The remaining four mainline lanes would continue approximately one mile east where the fourth lane is dropped, via an exit to southbound Chesapeake Boulevard (Exit 278).

The Build-10 Alternative would include five eastbound through lanes and an auxiliary lane approaching the interchange. The auxiliary lane and one mainline lane would be dropped at the exit to southbound Granby Street/westbound I-564. East of this exit, the lane configuration would be the same as the other two build alternatives as described above.

Along westbound I-64, all three build alternatives would widen the mainline by one lane west of the Tidewater Drive interchange (Exit 277). In the Build-8 and Build-8 Managed Alternatives, the ramp to I-64 from the HOV facility would continue as the interior lane and ramp from I-564 would be adjusted to accommodate to wider mainline before merging as it currently does. In the Build-10 Alternative, both the ramp from the HOV facility the ramp from I-564 would continue as mainline lanes.

The ramp gore areas to/from Granby Street, East Little Creek Road (Exit 276C), and Tidewater Drive would be adjusted to accommodate the widened mainline for all three alternatives.

D. Landside Structures

The landside structures include all bridges located in Hampton or Norfolk along I-64 or crossing I-64 that are not part of the main Hampton Roads crossing structures. The improvements to the structures would consist of widening the existing I-64 mainline bridges and replacing existing cross road bridges to accommodate the widened mainline of I-64. There were 36 existing bridges within the study corridor. Thirty-two (32) bridges were I-64 bridges and four were local roads or direct access ramps crossing I-64. The existing dimensions and structural details were obtained from as-built plans. **Table 3** summarizes the existing bridge information for the structures that would be widened as part of these improvements.

Table 3. Landside Structures

Bridge	No. of Spans	Length	Width	Superstructure			Substructure		Recommended for Approval
				Girder Type	Girder Spacing	Overhang	Abutment	Pier	
I-64 over Newmarket Creek within I-664 Interchange	1	52'-6"	56'-11" EBL 56'-11" WBL	18 - Precast Beam Lines	varies (4'-0" to 7'-8")	2'-5"	Stub Abutment	N/A	October 1976
I-64 over Lasalle Avenue	3	140'-8"	133'-11"	10 - Precast Beams & 10 - Precast Box beams	7'-4 1/2"	N/A	Stub Abutment	2-Column Piers	May 1980
I-64 over N. Armistead Avenue	4	236'-10 5/8"	123'-10"	10 - Precast Beams & 9 - Precast Box beams	7'-4 1/2"	N/A	Stub Abutment	Hammerhead	May 1980
I-64 over Rip Rap Road	3	144'-6 5/8"	113'-10"	10 - Precast Beams & 9 - Precast Box beams	7'-4 1/2"	N/A	Stub Abutment	Hammerhead & 3-Column Piers	February 1981
I-64 over N. King Street	3	168'-5 1/2"	113'-10"	16 - Prestressed Concrete Girders	7'-4 1/2"	3'-0"	Stub Abutment	Hammerhead & 3-Column Piers	February 1981
I-64 over River Street / E. Pembroke Avenue / Hampton River	18 spans EBL 38 spans WBL	1455'-2" EBL 2782'-0" WBL	61'-10" EBL 55'-10" WBL	WBL - 7-Steel Plate Girders, 7 to 9-Prestressed Concrete Beams; EBL - 10-Steel Plate Girders	WBL varies (6'-2" to 8'-3") 6'-6" EBL	varies WBL 2'-6" EBL	Stub & Full Height Abutment	3, 4-Column Piers, Pile Bents, Hammerheads	January 1980 EBL July 1983 WBL

Table 3. Landside Structures, continued

Bridge	No. of Spans	Length	Width	Superstructure			Substructure		Recommended for Approval
				Girder Type	Girder Spacing	Overhang	Abutment	Pier	
I-64 over S. Boxwood Street / East Branch Creek Viaduct	7 EBL only	714'-0" EBL	63'-0" EBL	2 - Steel Plate girders with floor system	6'-0"	Varies (2'-6" avg)	Cantilever Abutment	Single Column Piers	Dec. 1955 & raised in Oct. 1979
I-64 over Settlers Landing Road / Woodland Road	4	255'-5"	113'-10"	18 - Rolled Beam lines	6'-4 1/2"	2'-11"	Stub Abutment	4-Column Piers	August 1979
I-64 over 13th View Street / Bayville Street	3	130'-6"	44'-0" EBL 44'-0" WBL	12 - Rolled Beam lines	7'-8"	2'-10"	Stub Abutment	3-Column Piers	May 1966
I-64 over Willoughby Sound	78	4991'-11" EBL 4990'-7" WBL	44'-0" EBL 44'-0" WBL	12 - Prestressed Concrete Girders	7'-3"	3'-10 1/2"	Stub Abutment	Pile Bents	October 1966
I-64 over 4th View Street	3	174'-5" EBL 183'9" WBL	44'-0" EBL 44'-0" WBL	Rolled Beams & Steel Plate Girders. 12 lines total	7'-8" ±	Varies (2'-10" avg)	Stub Abutment	3-Column Pier	September 1969
I-64 over Mason Creek Road	3	179'-0"	44'-0" EBL 44'-0" WBL	14 - Rolled Beams lines	6'-6" ±	2'-6"	Stub Abutment	3-Column Pier	April 1969
I-64 over 1st View Street	3	173'-0" EBL 169'-0" WBL	44'-0" EBL 44'-0" WBL	14 - Rolled Beams lines	6'-6" ±	2'-6 1/2"	Stub Abutment	3-Column Pier	April 1969
I-64 over W. Ocean Avenue / W. Bay Avenue / Oasts Creek	28 spans EBL 27 spans WBL	1751'-2" EBL 1675'-8" WBL	varies (43'-4" to 49'-8")	6 to 9 - Prestressed Beams	varies (6'-3" to 7'-6")	varies (3'-0" avg)	Stub Abutment	Pile Bents	July 1969

Table 3. Landside Structures, continued

Bridge	No. of Spans	Length	Width	Superstructure			Substructure		Recommended for Approval
				Girder Type	Girder Spacing	Overhang	Abutment	Pier	
I-64 over W. Evans Street	3	128'-1" EBL 127'-11 1/2" WBL	44'-0" EBL 44'-0" WBL	12 - Rolled Beam lines	7'-8" ±	Varies (2'-10" avg)	Stub Abutment	3-Column Pier	March 1972
I-64 over W. Bayview Boulevard	3	137'-0" EBL 141'-0" WBL	44'-0" EBL 44'-0" WBL	14 - Rolled Beam lines	6'-7"	Varies (2'-6 1/2" avg)	Stub Abutment	3-Column Pier	April 1969
I-64 over Mason Creek	13 spans WBL 18 spans EBL	832'-2" WBL 1152'-2" EBL	49'-8" WBL 43'-4" EBL	7 - WBL, 6 - EBL Prestressed Concrete Girders	7'-3 1/4 WBL 7'-5 1/2" EBL	3'- 1/4"	Stub Abutment	Pile Bents	July 1969
I-64 over Patrol Road Access Road	2	156'-0"	44'-0" EBL 44'-0" WBL	14 - Rolled Beams lines	6'-6"	2'-6"	Stub Abutment	3-Column Pier	April 1969
I-64 over Granby Street within I-564 Interchange	4	244'-0" EBL 208'-0" WBL	54'-8" EBL 42'-8" WBL	EBL - 8-Rolled Beam Lines WBL - 6-Rolled Beam Lines	varies (4'-10" to 7'-11")	varies (2'-11" to 3'-4")	Stub Abutment	3,4-Column Piers, Hammerhead	February 1990 EBL July 1967 WBL
I-64 EB over I-564 within I-564 Interchange	4	416'-1 3/4"	38'-0"	5-Steel Plate Girders	varies (8'-0" avg)	varies (2'-0" avg)	Stub Abutment	2, 3-Column Pier	May 1965
I-64 over E. Little Creek Road within I-564 Interchange	7	819'-6 3/4"	35'-4"	4 - Continuous Steel Plate Girder lines	9'-5"	3'-6 1/2"	Stub Abutment	2-Column Piers	August 1990

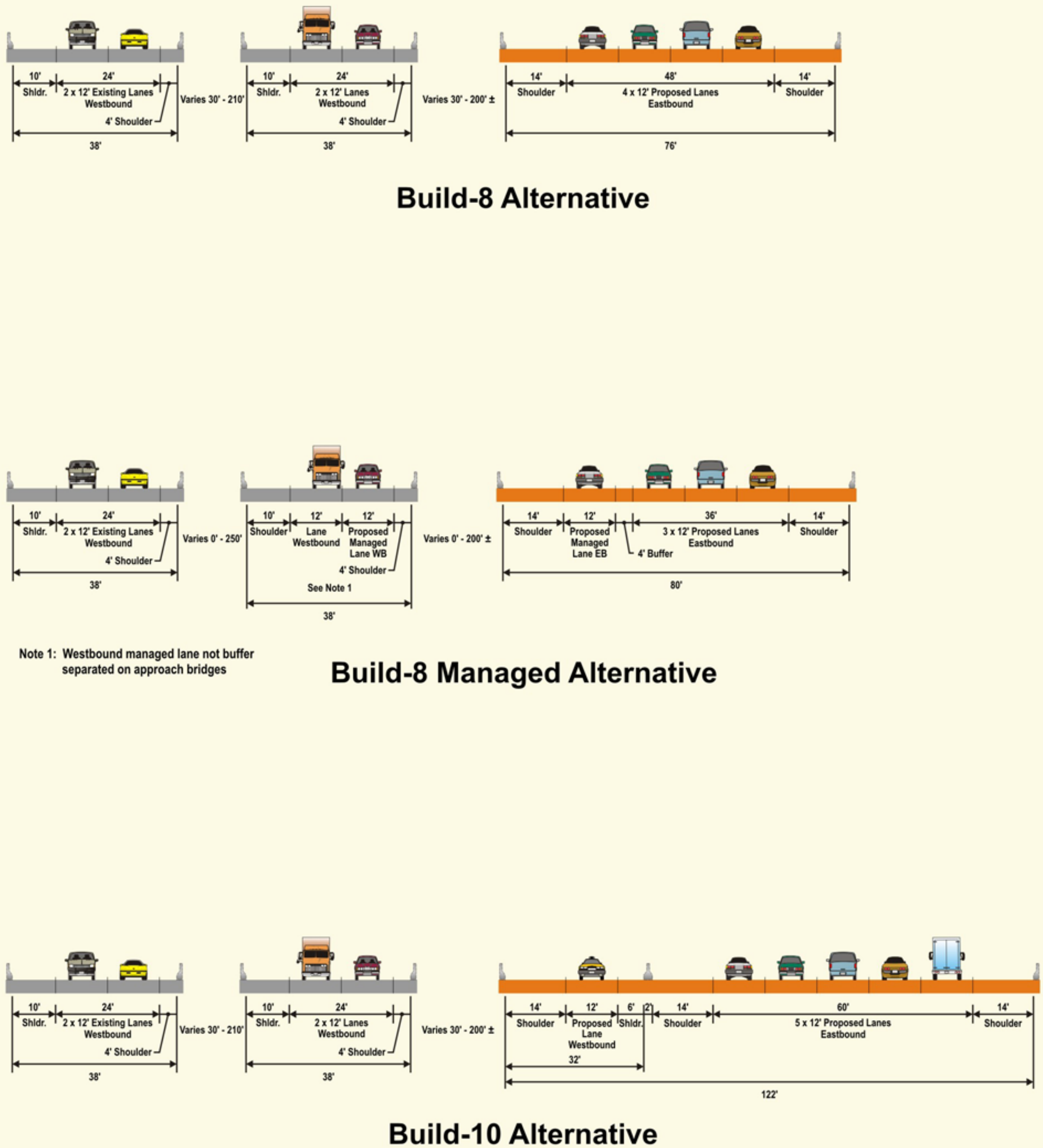
E. Approach Bridges to Tunnel

The two existing approach bridges currently carry two lanes per direction, as shown in the typical sections in **Figure 8**. In the three build alternatives that were retained, the eastbound bridge would be modified to carry two westbound lanes. In the Build-8 Managed Alternative, the westbound managed lane(s) would not be separated from the adjacent general purpose lane due to the lack of width on the existing eastbound structure. To meet current design standards, the new bridge would be constructed to the west (upstream) of the existing bridges to carry the eastbound lanes. For the Build-8 Alternative and Build-8 Managed Alternative, the new bridge would carry four travel lanes. For the Build-10 Alternative, the new bridge would carry six travel lanes, which would include five eastbound lanes and one westbound lane. The westbound lane would be barrier separated from the eastbound traffic. Construction of the new approach bridges would require dredging of a ten-foot deep channel, with four-to-one side slopes, extending both below and 150 feet outside the footprint of the proposed structure.

Two improvement options would be considered for the existing approach bridges: major rehabilitation or total reconstruction. The rehabilitation option would retain the existing 12-foot lanes, four-foot left shoulders, and 10-foot right shoulders while the reconstruction option would widen the structure to include a six-foot left shoulder and 14-foot right shoulder.

Major rehabilitation would consist of superstructure work only and would require a ten-foot deep, 150-foot wide channel with four-to-one side slopes, to be dredged adjacent to the outer edge of the bridges to allow adequate width for construction barges because the water is less than ten feet deep. Rehabilitation would include the removal and replacement of the existing superstructure, crack sealing, repair, jacketing existing piling, replacement of piling, and the replacement of parapets. The rehabilitation would not address the existing roadway geometric deficiency of narrow shoulders; therefore, design exceptions may be necessary. In addition, the bridges would not be raised from their existing elevation (10.35 feet relative to North American Vertical Datum [NAVD] to bottom of girder) to meet the clearance specifications in AASHTO's *Guide Specifications for Bridges Vulnerable to Coastal Storms*, 2009, because work would only take place on the superstructure.

The reconstruction would include complete replacement of the substructure and the superstructure of the existing approach bridges; therefore, the lane and shoulder widths would be redesigned to meet current design criteria and address the physical deficiencies on the bridge. Reconstruction would also include the addition of vertical clearance above the water to an elevation of 18 feet to meet the clearance specifications in AASHTO's *Guide Specifications for Bridges Vulnerable to Coastal Storms*, 2009. This option would also require additional right-of-way on both landside approaches and the dredging of a ten-foot deep channel, with four-to-one side slopes, for the entire area between the existing approach bridges as well as 150 feet east of the westbound structure and 50 feet west of the eastbound structure.



Not to scale

LEGEND

Existing Roadway

Widening

Note: Bridge typical sections assume use of existing structures and NOT all new structures

Bridge Typical Sections

US Department of Transportation Federal Highway Administration

VDOT

Figure 8

F. Tunnel

Existing Tunnels

In the three build alternatives, the eastbound tunnel would be modified to carry two westbound lanes and both tunnels would be rehabilitated and upgraded. Rehabilitation would include replacement of wall tiles, replacement of structural slab and wearing surface, replacement/upgrade of utilities and other maintenance-related items.

The tunnel system upgrades would address the ventilation system and 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. Installation would involve removal of the existing ceiling tiles and the upper exhaust air duct to create space for the jet fans, thereby, increasing the vertical clearance. Additional detailed tunnel studies, beyond the scope of this study, would be needed to determine the exact increase in vertical clearance.

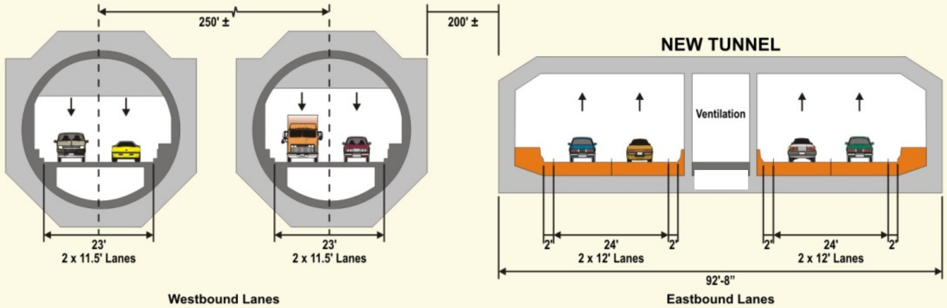
The tunnel safety systems, including fire detection and means of egress, would be upgraded to better comply with NFPA 502 standards. The National Fire Protection Association (NFPA) develops and publishes codes and standards to decrease the chances and the effects of fires or other risks. NFPA 502 provides fire protection and fire life safety requirements for limited access highways, road tunnels, bridges, elevated highways, depressed highways, and roadways that are located beneath air-right structures. However, it is not feasible to completely meet the NFPA 502 standards for cross-passageways because they cannot be installed under water between the existing tunnels. In the Build-8 Managed Alternative, the westbound managed lane(s) would not include a four-foot buffer separation between the managed lane and the general purpose lane due to the lack of width in the existing eastbound tunnel.

New Tunnels

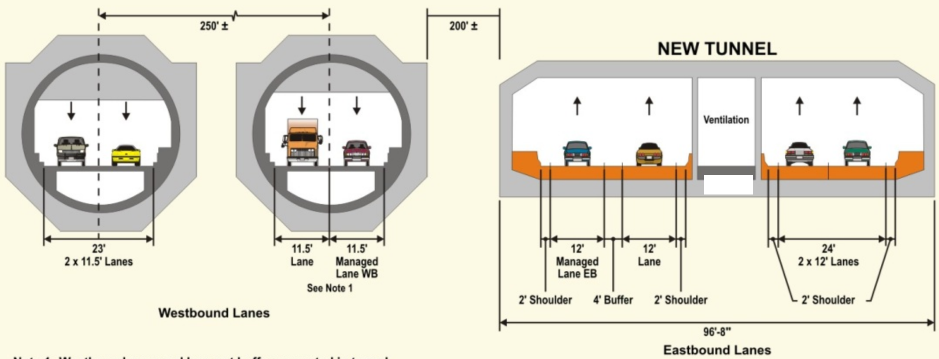
A new tunnel carrying the eastbound lanes would be constructed approximately 200 feet (outside of tunnel to outside of tunnel) west of the existing tunnel. The tunnel profile would have a minimum grade of 0.5 percent and a maximum grade of 4.0 percent. The top of the tunnel armor would be 65 feet below the mean low water (MLW) level within the existing 3,700-foot wide Hampton Roads entrance channel.

For the Build-8 Alternative and Build-8 Managed Alternative, the new tunnel would provide four travel lanes in two compartments at an estimated width of 94 and 96 feet, respectively. The two compartments would be separated by one compartment used for ventilation, maintenance and emergency egress, and utilities. In the Build-10 Alternative, the new tunnel would provide six travel lanes, including five eastbound lanes and one westbound lane for a width of approximately 148 feet. The Build-10 tunnel configuration would consist of three compartments: one with two eastbound lanes, one with three eastbound lanes, and one with one westbound lane. The three compartments would be separated by two smaller compartments used for maintenance, emergency egress, and utilities. **Figure 9** provides the build typical sections for the tunnel.

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 likely 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. The tunnel approaches would likely consist of new cast-in-place boat and cut-and-cover structures founded on piling or other suitable foundations. New ventilation buildings and flood gates would be required on each island.

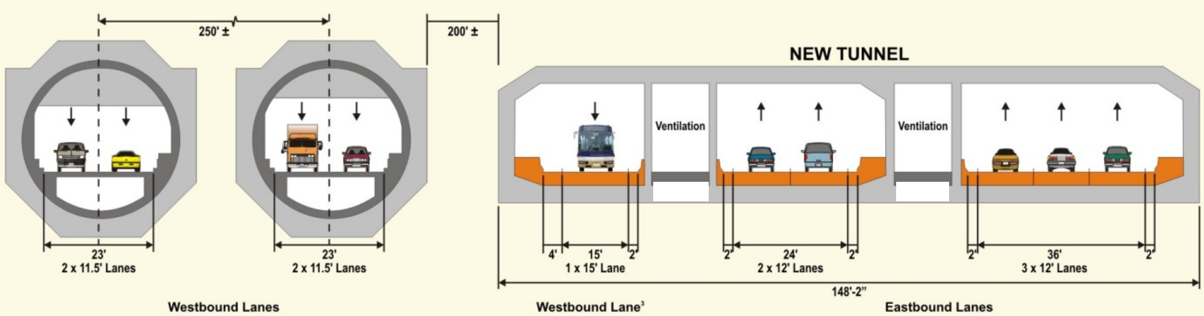


Build-8 Alternative



Note 1. Westbound managed lane not buffer separated in tunnel.

Build-8 Managed Alternative



Build-10 Alternative

Notes:

1. Top of existing tunnel structures armor are 55' below MLW.
2. Top of the new tunnel armor would be 65' below MLW.
3. Lane widths are 15' and shoulder widths are 4' and 2' providing overall pavement width of 21' which is needed to pass stalled vehicle on single lane roadway.

Not to scale

LEGEND

- Existing Roadway
- Widening

Tunnel Typical Sections

US Department of Transportation Federal Highway Administration

VDOT

Figure
9

The existing river bottom would be dredged to provide a trench for the immersed tunnel. The existing tunnels would be protected during the widening of the islands and dredging operations for the new tunnel. Once the new tube sections were placed, the trench would be backfilled with aggregate and riprap of sufficient depth to protect the new tunnel from scour, normal channel dredging operations, and impacts from passing ships.

The tunnel typical tube segments would likely be cast 300 feet to 350 feet in length. The segments could be precast with a steel bottom liner or similar protection and waterproofing method. Tunnel segments could be precast in a dry dock precasting facility. For installation, segments could be towed and floated to the project site, fitted out, with temporary ballast added to make the segments negatively buoyant. Segments could be lowered and placed onto a prepared bed in the dredged trench. Watertight seals could be established, segments could be connected together, and ballast concrete could be added to provide permanent negative buoyancy for the tunnel. The interior of the tunnel could be fitted with all required fire, life, safety items to meet NFPA 502, as well as the finished roadway surfaces and lighting.

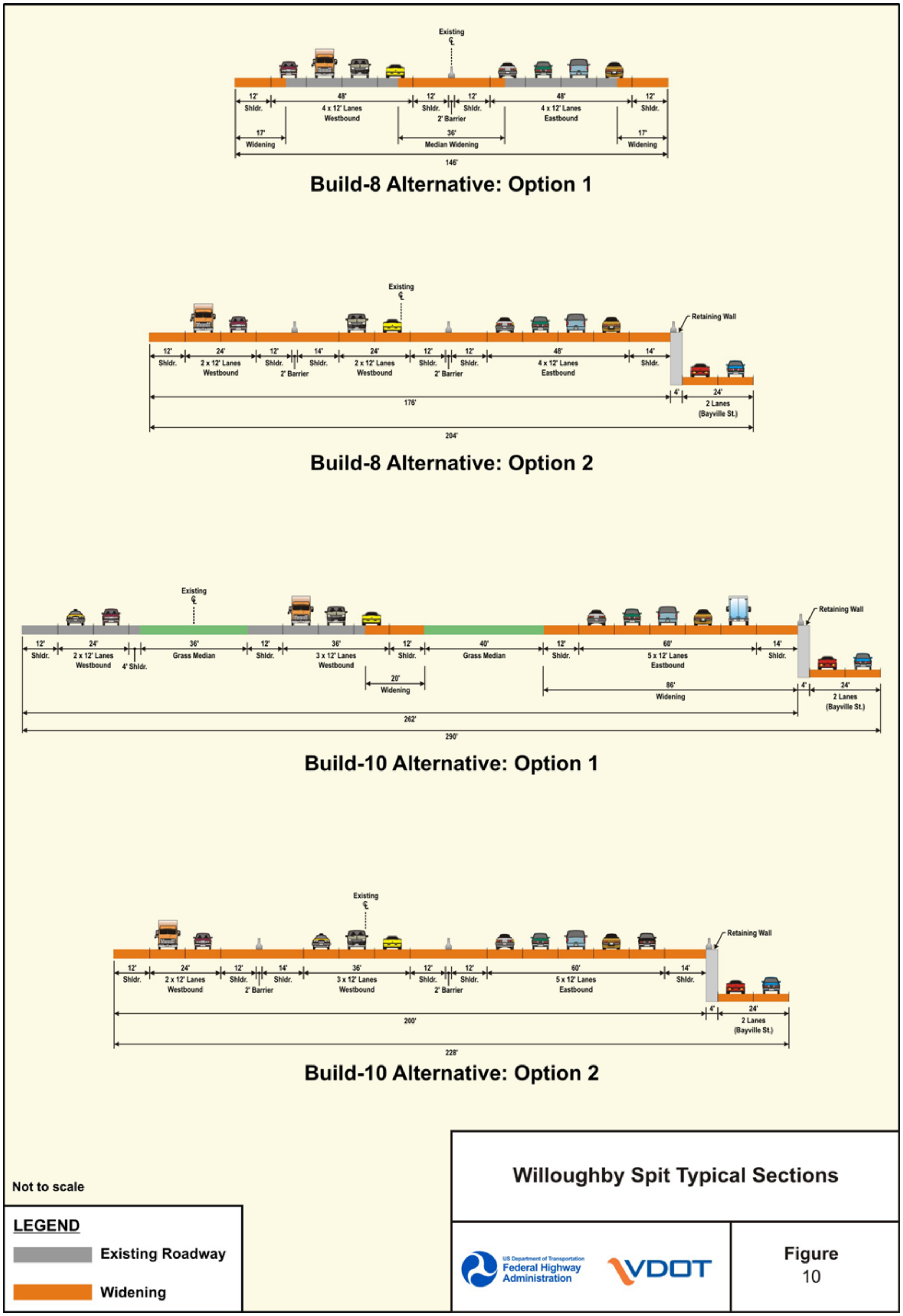
G. Willoughby Spit and Willoughby Bay Bridges

The Willoughby Spit is a peninsula located on the south side of Hampton Roads. Approximately 3,000 feet of I-64 are located at-grade between the HRBT bridges and the 5,100-foot long Willoughby Spit bridges. These bridges are 42 feet wide including lanes, shoulders, and parapets.

The Build-8 Alternative would include two mainline options through Willoughby Spit and Willoughby Bay. Option 1 would maintain the existing centerline, including widening the existing Willoughby Bay bridges to the 36 feet to the outside and increasing the shoulder widths to 14 feet to meet current design standards. The entrance ramp to eastbound I-64 from Bayville Street would be relocated closer to Willoughby Bay. Option 2 would shift the mainline toward the south, including a new 76-foot wide four-lane structure over Willoughby Bay. Eastbound traffic would utilize the new structure and westbound traffic would utilize both of the existing two-lane structures. Bayville Street would be shifted to the south and the existing Bayville Street interchange ramps would be removed. In both options, the superstructure of the Willoughby Bay Bridges would be rehabilitated. **Figures 10** and **11** provide typical sections for the Willoughby Spit and Willoughby Bay Bridges. Figures 5 and 5A in Appendices C, D, and E provide plan views of these options.

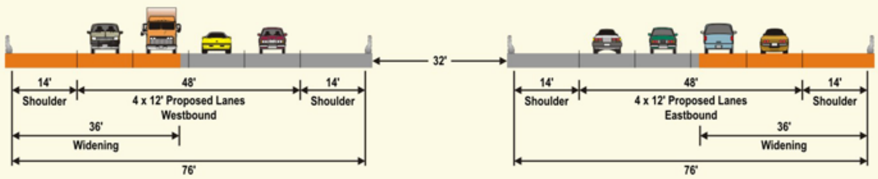
The Build-8 Managed Alternative would have the same options as the Build-8 alternative except that it would include a four-foot buffer between the eastbound mangaed lane(s) and the adjacent general purpose lanes. The westbound managed lane(s) would not be separated from the adjacent general purpose lanes due to the lack of width on the existing structure.

The Build-10 Alternative also had two mainline options through Willoughby Spit. The first option would shift the mainline toward the south, and include a new 88-foot wide five-lane structure over Willoughby Bay. The new bridge would carry the five 12-foot eastbound lanes and provide 14-foot left and right shoulders. The existing south structure would be widened by 22 feet to provide three westbound lanes. Eastbound traffic would utilize the new structure and westbound traffic would utilize both of the existing/widened structures. Bayville Street would be shifted to the south and the existing Bayville interchange ramps would be removed. The second option would be the same as the first option except that the at-grade section of mainline along Willoughby Spit would be shifted to narrow the median. Bayville Street would have to be shifted to the south and the existing Bayville interchange ramps would be removed.

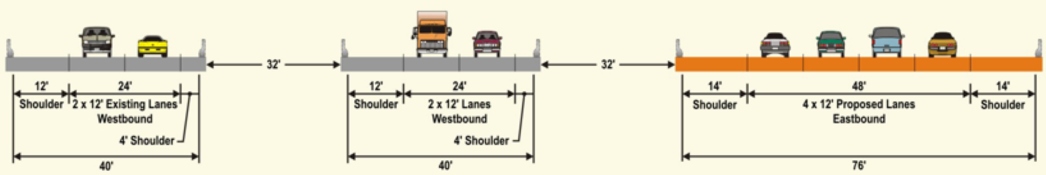


Willoughby Spit Typical Sections

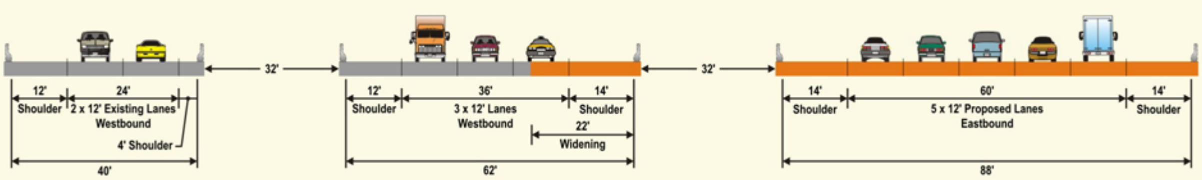
Figure 10



Build-8 Alternative: Option 1



Build-8 Alternative: Option 2



Build-10 Alternative: Options 1 and 2

Not to scale

LEGEND

Existing Roadway

Widening

Willoughby Bay Bridge Typical Sections

US Department of Transportation Federal Highway Administration

VDOT

Figure 11

10. PRELIMINARY COST ESTIMATES

Preliminary cost estimates were developed using VDOT's Transportation and Mobility Planning Division's (TMPD) 2009 Statewide Planning Level Cost Estimate where applicable. The roadway portion of the estimates was computed on a cost-per-mile basis and included a 25 percent contingency for preliminary engineering and construction, per TMPD tables. Specific costs for non-standard elements which include rehabilitation and/or reconstruction of approach bridges and tunnels and dredging costs were based on input from VDOT Structure and Bridge staff. Both the low and high unit costs were included to produce a cost range. Unit costs were inflated two percent per year from the 2009 costs listed in the TMPD table to 2012.

Nine major work items were used to develop the full cost estimate including the following:

- Mainline pavement
- Interchanges
- Landside structures
- Sound barrier walls
- Existing approach bridges
- New approach bridges
- Tunnel
- Dredging for approach bridges
- Right-of-way and utilities

The estimated cost ranges for each alternative retained for detailed study are listed below. Additional detail on the cost estimate back up is available in the *HRBT Cost Estimate Summary*:

- Build-8 Alternative: $4.8 to $6.5 billion
- Build-8 Managed Alternative: $4.8 to 6.6 billion
- Build-10 Alternative: $5.7 to $7.9 billion

APPENDIX A.

HRBT HIGH BRIDGE TECHNICAL MEMORANDUM

INTRODUCTION: The Virginia Department of Transportation (VDOT) is considering a range of alternatives for potential improvements to the Hampton Roads Bridge Tunnel (HRBT) corridor. An important component of build alternatives is the type of structure used for crossing the Hampton Roads, specifically the Hampton Roads channel. The existing 3.5-mile HRBT structure consists of the 0.6-mile western approach bridges, 1.4-mile-long tunnels under the channel, 1.2-mile eastern approach bridges, and 0.15-mile portal islands at the transitions between the bridges and the tunnels.

A new high bridge option located parallel to the existing crossing has been identified in the I-64 HRBT EIS study as a potential improvement for the crossing. This option was identified in the 2008 Hampton Roads Bridge Tunnel Expansion Feasibility Study but not advanced for further analysis. During scoping for the I-64 HRBT EIS, a new bridge or high bridge was mentioned in comments from the public. In order to create end-to-end alternatives, the high bridge could be included with capacity improvement alternatives such as the Build-8 and Build-10 alternative concepts.

The purpose of this technical paper is to describe the new high bridge option and to screen it for retention in the I-64 HRBT EIS.

HIGH BRIDGE OPTION DESCRIPTION: Two high bridge structure types have been considered: cable-stayed and suspension. Both types could provide long main spans with high clearance to accommodate the Hampton Roads shipping channel. Both bridge types would have the same typical section, which would consist of eight or ten travel lanes, 14-foot outside and median shoulders, a two-foot median traffic barrier, and outside parapets. The total deck width could be 158 feet (8-lane bridge) or 182 feet (10-lane bridge). The new bridge would carry all lanes of I-64 over Hampton Roads, allowing the existing tunnels to be decommissioned if deemed appropriate.

Cable-Stayed Bridge: A cable-stayed bridge would consist of one or more tall towers that support the bridge deck using cables directly attached to the tower and deck. A cable-stayed bridge would provide a main span of approximately 1,000 to 3,000 feet long. A noteworthy example is the Arthur Ravenel Jr. Bridge in Charleston, South Carolina; which has a main span length of 1,546 feet and a vertical clearance (water elevation to bottom of bridge deck) of 186 feet. The world's longest cable-stayed bridge, the Sutong Bridge, spans the Yangtze River in China and has a main span of 3,570 feet and a vertical clearance of 203 feet; note, however, Chinese design criteria may differ from American standards.

A cable-stayed bridge across Hampton Roads channel would have to provide an adequate width to span the main shipping channel, with a minimum vertical clearance of 250 feet over mean high water (MHW) for the full channel width. The depth of the current natural channel is greater than 35 feet for an approximate width of 4,500 feet. It is unlikely that a cable-stayed bridge could be feasible with a main span longer than 3,500 feet. The current width between the existing north and south bridge/tunnel islands is approximately 6,400 feet. A cable-stayed bridge could not be built with a main span of this length. A cable-stayed bridge would require very tall towers, likely 600 to 900 feet above the water.

The new high bridge would be offset 250 feet (minimum) from the existing tunnel (outside of structure to outside of structure). The towers of a new cable-stayed bridge would likely be built upon manmade islands. As noted, a cable-stayed bridge could not be built with a span between the existing north and south bridge/tunnel islands because the distance is too long. Instead, new bridge tower islands would have to be constructed across the existing channel between the existing tunnel portal islands and would likely be located within the natural channel.

Suspension Bridge: A suspension bridge would consist of a bridge deck suspended by two main cables spanning between two towers. The span would be anchored in the ground or in large man-made anchorage structures. Smaller cables would attach the road deck to the main cables. Suspension bridges provide longer span lengths than cable-stayed bridges, with the longest examples having main spans ranging from 4,000 to 6,500 feet in length. Noteworthy U.S. examples include the Golden Gate Bridge in San Francisco and the Verrazano-Narrows Bridge in New York City. Both of those main spans exceed 4,200 feet in length and have a vertical clearance of 220 and 228 feet, respectively. The world's longest suspension bridge is the Akashi Kaikyo Bridge in southern Japan with a main span of 6,532 feet and a vertical clearance of 216 feet; however, Japan design criteria may differ from American standards.

As with a cable-stayed bridge, a suspension bridge would have to provide an adequate length to span the main Hampton Roads shipping channel and have a minimum vertical clearance of 250 feet over MHW for the width of the channel. It would likely be feasible to construct a suspension bridge with a main span longer than the 4,500-foot wide deep channel or the 6,400-foot distance between the existing north and south bridge/tunnel islands. Very tall towers would be required, likely 600 to 900 feet above the water.

A suspension bridge would be offset 250 feet (minimum) from the existing eastbound tunnel (outside of structure to outside of structure). The towers of a new suspension bridge could be located adjacent to the existing north and south bridge/tunnel islands,

SCREENING METHODOLOGY OVERVIEW: Alternatives identified in the I-64 HRBT EIS range of alternatives are being screened for their ability to address the identified purpose and need of the study as follows.

- Capacity: the alternative should improve roadway capacity to alleviate unacceptable levels of traffic service, operating speeds, and unreliable travel times.
- Roadway deficiencies: the alternative should address roadway deficiencies that currently impede operating efficiency and contribute to unacceptable levels of traffic service.

Both high bridge structure types would be part of capacity improvement alternatives, therefore, it is assumed it would adequately improve the capacity need. Thus, screening the high bridge option for its ability to meet this need is not a determining factor for this evaluation.

The ability for an alternative to meet the roadway deficiency need is more applicable to the high bridge option. In general, structural features are evaluated to determine if they meet current interstate design standards in accordance with AASHTO's A Policy on the Geometric Design of Highways and Streets, 2004 (Green Book), VDOT Road Design Manual, and VDOT Bridge Design Manual. For bridge structures, items such as required clearance above the shipping channels are being considered. Other requirements that are specific to this crossing, such as depth of channel, width of crossing, and offset from the existing bridge tunnel are also considered in the screening. The table below provides the design criteria that are relevant to a high bridge option.

Design Parameter	Design criteria for Bridge Crossing
Clearance Over Channel	250' above MHW across main channel
Clearance Above Water for Approach Bridges	17.5' from bottom of superstructure to MHW
Width of Channel	**Minimum** (per Port of Virginia): 1,000' **Recommended:** VDOT Structure &Bridge Division requirement based on future hydraulic study
Horizontal Offset from Existing Tunnel/Bridge	200' minimum (outside of structure to outside of structure)

The Port of Virginia is one of the largest and busiest ports on the East Coast. In 2010, it handled more than 54 million tons of cargo from more than 1,800 ships making it the second busiest port on the East Coast behind only New York. The agency which manages port operations, the Virginia Port Authority (VPA), has indicated that they will require the minimum vertical clearance (air draft) from MHW to the bottom of the bridge superstructure to be 250 feet in order to accommodate large ships over the next century.[1] The suggested channel clearance height of 250 feet should be maintained for at least the width of the 1,000' wide Coast Guard Navigation Channel which is 50 or more feet deep.

In addition, the natural channel (35+ feet deep) is approximately 4,500 feet wide and the VPA has indicated a preference that this section of the channel should remain free of bridge piers/islands to avoid any impediments to shipping. In addition to the shipping channel, there are several deep water anchorages in the 50-plus foot deep sections of the channel where large ships anchor. These deep water anchorages should remain free of piers/islands and access to the deep water anchorages should be unimpeded.[2] A map showing these deepwater anchorages was provided by VPA in their July 27, 2011 letter to VDOT, and is attached to this memo.

SCREENING OF THE HIGH BRIDGE OPTION: As noted, a high bridge over Hampton Roads channel would be one of the largest and tallest bridges in the world. Highly specialized engineering expertise would be needed to successfully design the structure. Some of the engineering considerations are described below.

Shipping Channel Clearance: Both a cable-stayed and suspension bridge could be built to meet the minimum vertical clearance of 250 feet desired by VPA. Both types of bridges could also be built to span the 50-plus-feet deep part of the channel. However, the cable-stayed bridge could not be built

[1] Letter: Virginia Port Authority Scoping Comments on I-64 HRBT EIS (July 27,2011) (attached)
[2] *Ibid.*

to span the full natural channel, which is approximately 1,000 feet wider than the longest cable-stayed span in the world.

Based on mapping of the channel and deep water anchorages supplied by the VPA, the deep water anchorages are located west of the existing Hampton Roads tunnels and should not be affected by expansion of the existing north and south tunnel islands. However, new islands constructed for a suspension or cable-stayed bridge could affect access to the deep water anchorage located closest to the Hampton Roads Bridge Tunnel (approximately 1,000 feet west of the existing eastbound tunnel).

In the coming years, the Port of Virginia will accommodate the larger ships that will be able to pass through the Panama Canal after new, larger locks are constructed and opened in 2014. Currently, only the ports of New York, Baltimore, and Norfolk have the ability to receive these larger ships, which could be 1,200 or more feet long, 160 feet wide, and have a draft of 50 feet.[3] The ability of the Port to accommodate these large ships could be affected if a high bridge were to restrict the air draft of the existing shipping channel.

Bridge Tower Islands: A cable-stayed bridge would require new manmade islands because a cable-stayed bridge could not be built with a long enough span between the existing north and south tunnel portal islands. Because of this configuration, the suspension bridge would require new bridge tower islands which would be an additional obstruction in or near the shipping channel that could increase the risk of ship groundings. In contrast, a new tunnel would only require expansion of the existing islands (similar to a new suspension bridge), which would not impinge on the shipping channel.

Hampton Roads Hydrodynamics: Hampton Roads experiences a complex mixing of waters from the Atlantic Ocean, the Chesapeake Bay, and the James, Nansemond, and Elizabeth Rivers. A hydrodynamic model of the mixing of these waters was completed for the 2001 Hampton Roads Crossing FEIS and included an analysis of the effects that a new tunnel structure would have on tidal heights, tidal currents, tidal prism (volume of flood or ebb flow entering an enclosed region), salinity, and sedimentation. The study results showed that a new tunnel would generally not affect the tidal heights, tidal prism, salinity, or sedimentation. There would be slight effects to tidal currents.

The prior analysis inferred that modifications to the existing landforms and structures within and adjacent to Hampton Roads could have an effect on the hydrodynamics within Hampton Roads. Consequently, compared to a new tunnel, which would be buried in the Hampton Roads bottom and use existing islands, a new bridge structure near the existing HRBT could have a greater effect on hydrodynamics because of the new piers and/or islands within Hampton Roads. In addition, the piers of a cable-stayed bridge would be located on islands more closely spaced than the existing islands. The result would likely be different hydrodynamic effects than were modeled in the 2001 study; however, a new hydrodynamic study would be needed to evaluate the exact tidal heights,

[3] Source: Panama Canal Authority, January 19, 2009: www.pancanal.com/common/maritime/advisories/2009/a-02-2009.pdf

tidal currents, tidal prism, salinity and sedimentation effects from a new bridge. This level of detailed study would not be needed for the DEIS given the inferences from previous studies.

Driver Behavior: The high bridge deck would rise to more than 250 feet above the water and adjacent land. This height could be challenging for drivers who are fearful of bridges and heights. In addition, a high bridge would provide expansive views of the surrounding Hampton Roads area, which could be distracting to drivers crossing the bridge. Both of these distractions could create a safety concern and could lead to overall slower speeds.

A new tunnel could also cause operational issues for drivers fearful of the enclosed nature of tunnels. However, there are several tunnels in the Hampton Roads area, including the existing HRBT, so drivers in the region may be more familiar and more comfortable with using tunnels than a high bridge.

Bridge Security and Vulnerability: A high bridge would be subject to hazards and intentional threats. Hazards include hurricanes, storm surges, accidents, and fire. Intentional threats could include explosives, arson, and cutting of bridge cables. A high bridge structure could be designed to withstand hurricane force winds and storm surges and other likely natural disasters. Islands would protect the bridge towers from ship collisions. Fire could affect the integrity of the bridge; therefore, fire control and emergency response would be an important operational consideration. A high bridge would be subject to wind operational issues that would likely result in more frequent restrictions than a tunnel would have. As a comparison, on the William Preston Lane, Jr. Memorial (Bay) Bridge across the Chesapeake Bay in Maryland, wind warnings are implemented when sustained winds reach 30 mph. When sustained winds reach 40 mph, restrictions are enforced and vehicles vulnerable to high winds (such as box trailers) are prohibited from crossing the bridge.

Intentional threats could also result in damage to the bridge. Using the deter-deny-detect-defend (four Ds)[4] strategy, a high bridge could likely be designed to minimize the risk of cutting tools being used on bridge cables. These strategies could also be used to limit the access of explosive-carrying vehicles to critical bridge elements like the towers or cables. However, explosives would remain a threat to the bridge. Even an explosion that would not affect the overall integrity of the bridge could still cause significant disruption in normal bridge operations. The bridge islands could reduce or eliminate the risk of ship-based explosives targeted at the bridge towers. In the unlikely event of a major catastrophe (natural or intentional) that causes a portion of the bridge structure to fail and collapse into Hampton Roads, the existing shipping channel could be partially or fully impeded. Similar situation could happen in the tunnel.

At a meeting with VDOT on February 6, 2012, the US Coast Guard noted that high winds would result in bridge closures, making the crossing unsuitable during evacuations. I-64 is a designated hurricane evacuation route by VDOT. High winds and a storm surge would be experienced during a hurricane or tropical storm, and if they were intense enough, they would require the closure of an I-64 bridge or tunnel. However, it is likely that a high bridge would require closure sooner and more often than a tunnel because (1) high sustained winds are likely to precede a storm surge, and (2) winds intense enough to require the closure of a bridge (as determined by VDOT, but likely greater

[4] 2011 *Bridge Security Guidelines*, AASHTO.

than 40-50 mph) may occur more often than a major storm surge that could threaten to flood the tunnel (elevation of existing tunnel retaining walls above sea level).

Maintenance: A high cable-stayed or suspension bridge would create long-term maintenance, load rating, and inspection challenges. VDOT requires external experts specializing in high bridge structures to provide these services.

Hazardous Materials Transport: A bridge would allow for hazardous materials to cross Hampton Roads on I-64. Hazardous materials are restricted in tunnels, and therefore vehicles carrying hazardous materials are required to use the existing area bridges such as the James River Bridge to cross between the Peninsula and Southside. A high bridge along I-64 would save the several-mile diversion for vehicles traveling between the Peninsula and Norfolk.

Estimated Costs: Preliminary estimates of the cable-stayed and suspension bridge costs are provided in the following table. The estimates were developed using a per-square-foot cost methodology. These estimated costs include the main span as well as the approach bridges from shore to shore. In comparison, a new bridge-tunnel cost (shore-to-shore) would be approximately $3.2 billion, per 2008 Feasibility Study.

Typical Section	Cable-Stayed	Suspension
8-Lane (158' Width)	$2.0 billion	$3.4 billion
10-Lane (182' Width)	$2.3 billion	$3.8 billion

Note: These estimated costs do not include the cost associated with constructing new islands.

Environmental Considerations: A high bridge over the existing channel, on new alignment, will have potential environmental impacts that differ from those associated with a bridge tunnel option. The following presents potential environmental impacts of a high bridge option.

Physical and Visual Impact: The physical impact of a high bridge option would be similar to a bridge tunnel option. There is sufficient distance from the channel to the shores to reach the 250-foot vertical clearance. The grades would likely not require an elevated structure over land for a cable-stayed bridge, but may require an elevated structure over land for a few hundred feet on the north shore for a suspension bridge. The elevation of a new structure at the shore line could be 10± feet higher than the existing approach bridge.

The piers and islands of a high bridge would have impacts to the Hampton Roads bottom. The area of impact would be less than the disturbance required for a tunnel. However, hydrodynamic impacts resulting from pier and island placement (described above) could have impacts to the natural ecosystem of Hampton Roads, including Submerged Aquatic Vegetation (SAV) and oyster beds.

Both the suspension and cable-stayed bridge options would require very tall towers, likely 600 to 900 feet above the water. These towers would be the tallest structures in the region and would dominate the viewshed of the surrounding Hampton Roads shoreline and nearby communities. By comparison, the tallest building in Norfolk, the Dominion Tower, is 341 feet tall. The tallest building in Hampton Roads, the Westin Town Center in Virginia Beach, is 508 feet tall. The Westin Town Center is also the tallest structure in Virginia.

Air Space Obstructions: The Federal Aviation Administration (FAA) requires that all structures above specified heights in the vicinity of airports be documented and declared as obstructions. A structure is considered an obstruction if its height exceeds the level of airport imaginary surfaces defined in the Code of Federal Regulations, Sections 77.19 and 77.21, for civilian and military airports, respectively. An object that impedes on these imaginary surfaces would be an obstruction to air navigation. Although Norfolk International Airport is near the potential high bridge crossing, only Langley Air Force Base and Norfolk Naval Station (Chambers Field) have imaginary surfaces that overlap the potential crossing.

The imaginary surfaces for these two military airports consist of an inner horizontal surface, conical surface, and outer horizontal surface. The inner horizontal surface extends 7,500 feet from the runway and is 150 feet above the airfield elevation. The conical surface connects the other two surfaces and extends outward from the edge of the inner horizontal surface at a slope of 20 to 1 for a horizontal distance of 7,000 feet to reach an elevation 500 feet above the airfield. The outer horizontal surface extends 30,000 feet from the edge of the conical surface at an elevation 500 feet above the airfield.

The nearest of these potential towers would be approximately 20,000 feet (3.8 miles) from the end of the Norfolk Naval Station (Chambers Field) runway placing it within the outer horizontal surface of that facility. The potential towers would also be located inside the outer horizontal surface of Langley Air Base as they would be approximately 32,000 feet (6.1 miles) away. Any towers built as part of the potential crossing that exceed 500 feet in height would be classified as obstructions to both Norfolk Naval Station (Chambers Field) and Langley Air Base, which could require marking and lighting as defined by the FAA. The towers would not be in the direct path of planes on a straight-line approach to the end of the runways of either Langley or Chambers Field. In a meeting with VDOT on February 6, 2012, the US Navy indicated that a new high bridge could affect air operations, such as helicopter exercises and operations at Chambers Field / Norfolk Naval Air Station.

Agency and Public Comments: Several comments were received from participating agencies and the public regarding the high bridge option. These included the following:

- In a letter to VDOT on February 15, 2012, the Virginia Port Authority explained a number of key concerns for a high bridge option, including effects from insufficient vertical clearance; potential hazards to navigation caused by pier placement; hydrodynamic impacts from pier placement; impacts to deep water anchorages; and, in general, preservation of the strategic commercial and military vitality of Hampton Roads. The letter also noted that a cable-stayed bridge was not feasible and should be eliminated from consideration.
- The high bridge option was proposed for elimination to participating agencies at a meeting held April 18, 2012. As follow up to that meeting, two agencies made statements regarding the high bridge option:

- ✓ In their May 23, 2012 letter to VDOT, the US Army Corps of Engineers stated that they had no comment regarding elimination of the high bridge option.
- ✓ In an email to VDOT on May 29, 2012, the Virginia Department of Rail and Public Transportation stated that they understood the basis for eliminating the high bridge option from further analysis.

- The high bridge option was proposed for elimination from further consideration at the Citizen Information Meetings on April 18 and 19, 2012. One commenter agreed that the bridge option should be eliminated; two commenters stated that additional analysis should be completed for a high bridge option.

CONCLUSION: As a result of the analysis described in this technical paper, the high bridge option is being eliminated from further consideration in the I-64 HRBT EIS. Although a high bridge option over Hampton Roads would meet the stated transportation needs, other structure options (such as a combination of approach bridges and tunnel) would meet the transportation needs more effectively without incurring the additional problems associated with a high bridge. Thus, advantages of the high bridge under some measures, such as cost, are outweighed by the substantial disadvantages of other measures.

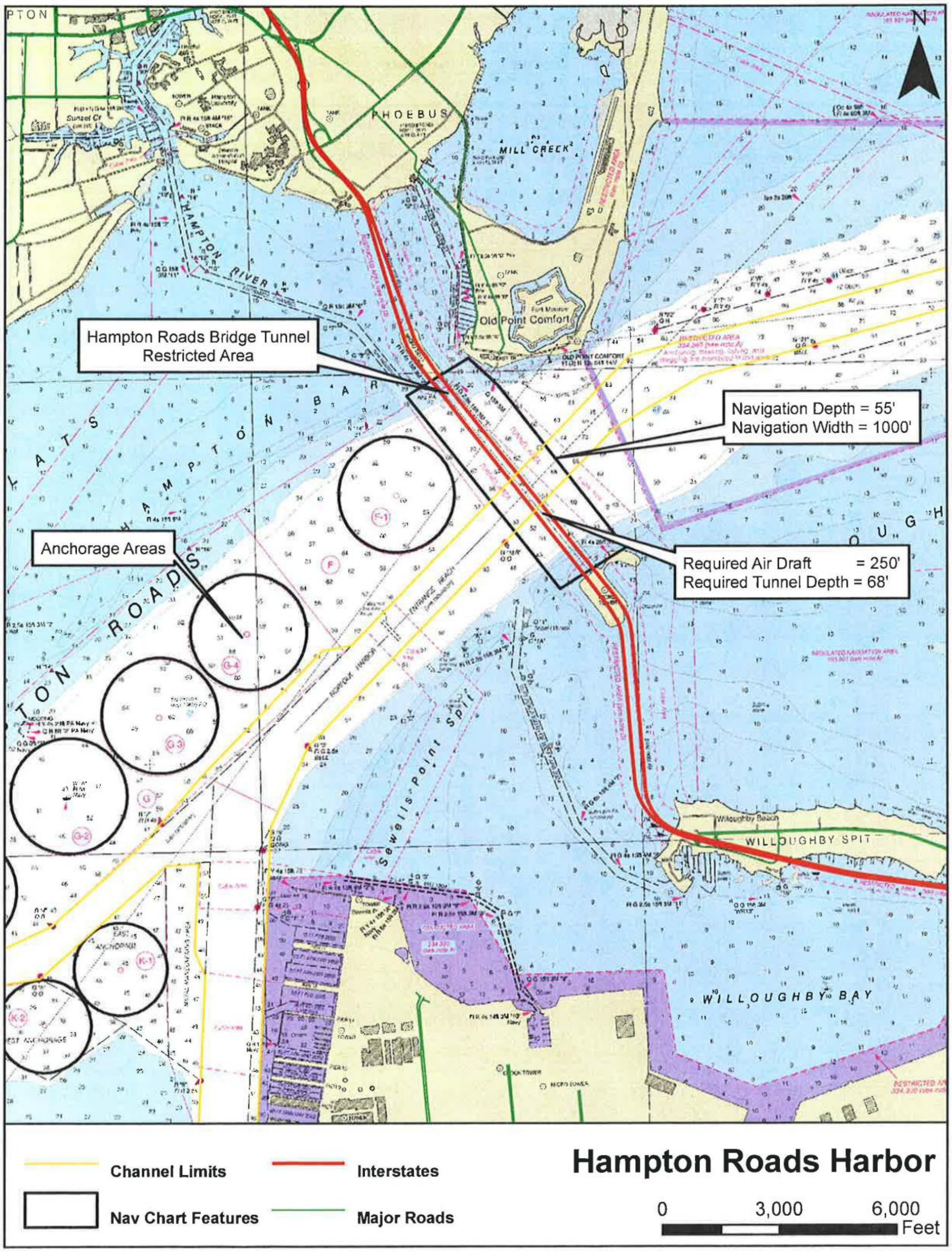
To summarize, a suspension bridge type is therefore being eliminated because the option would:

- Introduce a restriction to channel clearance over water;
- Potentially cause detrimental hydrodynamic effects to channel water flow;
- Require towers that create an obstruction to FAA controlled air space;
- Be vulnerable to hazards such as vessel collision and high winds that could cause operational concerns/vehicle restrictions, including during emergency evacuations; and
- Be vulnerable to intentional threats that could result in restriction of travel and impedance to channel.

Similarly, the cable-stayed bridge type is being eliminated from further analysis because it has all the disadvantages of a suspension bridge, and it would create a restriction to channel width because of main span limitations.

The evaluation provided in this technical paper will be summarized for inclusion in the Draft EIS.

Attachment: Deepwater anchorage map from July 27, 2011 letter from VPA


Hampton Roads Bridge Tunnel
Restricted Area
Navigation Depth = 55'
Navigation Width = 1000'
Anchorage Areas
Required Air Draft = 250'
Required Tunnel Depth = 68'
Old Point Comfort
PHOEBUS
MILL CREEK
HAMPTON RIVER
HAMPTON ROADS
WILLOUGHBY SPIT
WILLOUGHBY BAY
Channel Limits
Interstates
Nav Chart Features
Major Roads
Hampton Roads Harbor
0
3,000
6,000
Feet

APPENDIX B.

HRBT TRANSIT TECHNICAL MEMORANDUM

INTRODUCTION: The Virginia Department of Transportation (VDOT) is evaluating potential transit accommodations as part of the Interstate 64 (I-64) Hampton Roads Bridge-Tunnel (HRBT) Environmental Impact Statement (EIS) study. Transit modes under consideration include passenger rail, bus and/or ferry. This memorandum summarizes current transit operations across Hampton Roads, comments received regarding transit during the agency and public scoping for this study, and related planning documents, and sets forth the rationale for eliminating or retaining transit alternatives.

EXISTING TRANSIT OPERATIONS: Current transit accommodations across Hampton Roads are limited to bus service; there is no passenger rail or ferry service. Hampton Roads Transit (HRT) provides express bus service through the I-64 HRBT corridor via the Metro Area Express (MAX). The MAX 961 route offers services between downtown Norfolk, Hampton, and Newport News along I-64 from the Granby Street exit near Patrol Road (Exit 276) to Settlers Landing Road/Woodland Road (exit 267) and from Armistead Avenue (exit 265) to I-664 (exit 264). On weekdays, service runs from 5:00 a.m. to 10:15 p.m., with headway departures every 30 minutes during peak hours and every hour during off-peak hours. Saturday/Sunday service runs from 5:00 a.m./7:00 a.m. to 9:00 p.m. with headway departures every 30 minutes during Saturday peak hours and every hour during Saturday off-peak hours and Sundays. All HRT vehicles are equipped with bike racks and are capable of accommodating two bicycles at a time.

Amtrak also operates daily Thruway bus services connecting Norfolk and Virginia Beach to the Newport News Amtrak Station via I-64 and the HRBT. A new Amtrak station at Harbor Park in Norfolk is currently under construction, with anticipated completion in 2013. The station will be the new site of Amtrak Thruway bus service operations, which will continue providing existing services.

The nearest passenger rail is The Tide, an HRT light rail service with operations on the Southside from Fort Norfolk Station to Newtown Road Station, approximately 5 miles south of the HRBT study area. Service runs from 5:30 a.m. to at least midnight Monday through Saturday (until 12:45 am on Fridays and Saturdays), with departures every 10 to 30 minutes, and from 10:30 a.m. to 9:50 p.m. on Sundays, with departures every 15 minutes. There is no passenger rail service in Hampton.

AGENCY AND PUBLIC COMMENTS: During agency and public coordination activities for the I-64 HRBT Environmental Impact Statement (EIS), several comments were received regarding the inclusion of transit as part of the I-64 HRBT study. These comments are summarized below.

US Army Corps of Engineers (USACE) Comments: USACE commented that transit should be addressed in the study purpose and need statement. In a letter dated May 23, 2012, USACE further commented that the alternatives analysis should include a discussion of transit elements within the build alternatives. Specifically, USACE described a 7- or 9-lane alternative, with presumably one reversible lane being used as dedicated transit lanes. USACE also asked that ferry service be considered.

Department of Rail and Public Transportation (DRPT) Comments: In a letter dated July 29, 2011, DRPT recommended that public transportation be included in the consideration of alternatives for the I-64 HRBT corridor. The letter also references the *Hampton Roads Regional Transit Vision Plan*

Final Report (Final Report), which recommends that dedicated transit facilities be included in any new harbor crossing proposals. The Final Report further recommends that crossing studies consider the extent to which dedicated transit facilities are included in the crossing and how facilities can be incorporated into the overall regional transit network. DRPT restated that the EIS should consider transit in its retained alternatives during the April 18, 2012 Agency Meeting and through email on May 29, 2012.

HRT Comments: In a letter dated July 29, 2011, HRT cited Resolution 11-2008, which calls on "the Commonwealth of Virginia [to] consider adding mass transit as a component of any major transportation link, tunnel, bridge or roadway in Hampton Roads." HRT requested that a fixed guideway, transit-only lane, and/or transit connection be considered in the alternatives for the I-64 HRBT study.

Public Comments: During the public scoping period, 15 individuals submitted comments in favor of transit considerations as part of the I-64 HRBT study on the scoping comment form. Comments ranged from general support for transit operations within the corridor to specific recommendations for ferry service or rail service.

For the second Citizen Information Meeting, citizens were asked via comment form if they would increase their use of bus services if such services were improved. Only 9 respondents (15%) said they would frequently or sometimes use the bus service; 41 respondents (67%) said they would never use the bus service. On the form, 22 individuals generally commented on transit, with most of these respondents favoring light rail or rail.

OTHER STUDIES INVOLVING TRANSIT: Studies pertaining to Hampton Roads crossings, the I-64 HRBT corridor, and plans for regional transit operations and connectivity are included in several recent documents and are summarized below.

***Hampton Roads Crossing Study EIS*, December 2000/Re-evaluation Ongoing, VDOT:** In cooperation with Federal Highway Administration (FHWA), VDOT initiated the Hampton Roads (Third Crossing) Study in the 1990s to investigate methods of improving mobility across Hampton Roads. Several crossing design alternatives were considered. The Commonwealth Transportation Board (CTB) reviewed these corridors in 1997 and selected Alternative 9.

Alternative 9 would provide a new crossing parallel to the I-664 Monitor Merrimac Memorial Bridge Tunnel with two spur connections from the new bridge-tunnel to Norfolk and Portsmouth. A three-tube tunnel would cross Hampton Roads on the west side of the existing I-664 Monitor Merrimac Memorial Bridge Tunnel. One of the tubes would be designed to accommodate high occupancy vehicles (HOV), passenger rail, and/or bus service. A spur connection east to Norfolk also would include a new tube under the Elizabeth River for transit.

The Third Crossing Final EIS was completed in December 2000, and Federal Highway Administration (FHWA) issued a Record of Decision in June 2001. In cooperation with FHWA, VDOT began a re-evaluation of the EIS in 2011. The project currently is not funded.

Resolution 11-2008, December 2008, Transportation District Commission of Hampton Roads Virginia: The Commission is a 17-member body made up of appointees from seven local governments. The purpose of the Commission is to provide reliable and efficient transportation services and facilities to the Hampton Roads community. In December 2008, the Commission passed Resolution 11-2008, calling on "the Commonwealth of Virginia [to] consider adding mass transit as a component of any major transportation link, tunnel, bridge or roadway in Hampton Roads." The resolution states that higher density development, among other factors, has made investment in public transit a viable alternative mode of transportation desirable.

***A Transit Vision Plan for Hampton Roads*, March 2009, Hampton Roads Transportation Planning Organization (HRTPO)**: At the request of the DRPT, the HRTPO completed a Phase 1 study to provide a strategic approach for the development and implementation of a regional mass transit system. In the Transit Vision Plan, the HRTPO offers short-term recommendations to address current regional transit inadequacies and long-term strategies for achieving the goals of reducing traffic congestion and increasing transit use. The Transit Vision Plan also includes a *Preliminary Cost and Ridership Estimation Report* which includes estimated 2034 transit ridership across Hampton Roads.

Specific recommendations in the Transit Vision Plan included the establishment of multi-modal transit operations throughout the region. In the mid- to long-range timeframe, the Transit Vision Plan suggests that ferry service be implemented between the Peninsula and Southside in the vicinity of the I-64 HRBT and the Monitor Merrimac Memorial Bridge-Tunnel (MMMBT). The document recommends that planning studies for ferry service begin in the 2016 to 2025 range, with operations to begin in the 2026 to 2035 timeframe. Beyond 2035, the plan envisions construction of a dedicated light rail transit connection in the vicinity of the ferry crossing, although specific corridor recommendations were not provided. The plan further envisions the discontinuation of ferry service as light rail projects become operational.

***Hampton Roads Regional Transit Vision Plan Final Report*, February 2011, DRPT:** DRPT, in partnership with HRT and the Williamsburg Area Transit Authority, managed Phase 2 of the Transit Vision Plan based on the recommendations of the March 2009 study by HRTPO. The purpose of the Final Report was to provide a long-term framework for transit development in future federal, state, and municipal projects. It provides recommendations for transit projects in the short-term (by 2025), long-term (by 2035), and extended-term (after 2035).

The report recognizes that harbor crossings are an important transportation element in the Hampton Roads region and proposes new transit services connecting the Peninsula and Southside. In the short-term, a high-speed ferry service is recommended between Norfolk Naval Station North and Downtown Newport News and Downtown Hampton Waterfront.

In the extended-term, the report recommended the establishment of a dedicated light rail connection, termed "Corridor G", via a new dedicated tunnel located approximately four to five miles southwest of the I-64 HRBT crossing. The corridor would connect proposed rail transit corridors and transfer activity nodes on both sides of the crossing. The report highlighted the advantages of Corridor G over dedicated transit facilities at the Third Crossing or the I-64 HRBT, stating that a separate corridor would optimize the overall regional rail transit network, whereas the Third Crossing and the I-64 HRBT improvements would be largely dictated by the region's highway network.

Citing Resolution 11-2008, which calls for the Commonwealth of Virginia to consider multi-modal approaches in major transportation planning studies, the report also recommends that new harbor or river crossing studies include dedicated transit facilities. The report stated that "if proposals for a new harbor Third Crossing facility or modifications to the Hampton Roads Bridge-Tunnel (HRBT) move forward into more detailed planning and design phases, the Vision Plan recommends the inclusion of a dedicated transit facility in either of those proposals."

***Hampton Roads Transit: Service and Schedule Efficiency Review*, March 2011, HRT:** HRT commissioned transportation Management and Design Inc. to conduct a study to identify the possibility of achieving bus service operating savings through scheduling and service management. Four key areas were reviewed: service performance, schedule efficiency, operator work practices, and labor utilization. The study also included a review of ridership generated per hour of service. This was used to develop a set of recommendations to reduce operating costs while retaining the majority of existing riders. The study recommends eliminating five current weekday trips and one early morning Saturday trip across the HRBT on the MAX 961. It also recommends reducing Saturday service to every hour all day, eliminating an additional six trips.

Hampton Roads Transit: Transit Development Plan FY 2012 – FY 2017, December 2011, Foursquare Integrated Transportation Planning: The Transit Development Plan is a six-year plan for operational and capital improvements within the Hampton Roads region. This document serves as a management and guidance document for HRT and is a basis for the Six Year Improvement Program, Transportation Improvement Program, and Constrained Long-Range Plan. The plan outlines specific goals and objectives for HRT and performance measures to address the efficiency and effectiveness of the services provided by HRT. HRT's services are evaluated through the Vision Plan, land use and demographic profiles, historical performance of the HRT, peer review, rider surveys, stakeholder input, and focus groups.

The plan recommends proceeding with changes as recommended in the Service Efficiency Study, which includes eliminating five weekday trips and seven Saturday trips on the Max 961. The report mentions that the 5:48 a.m., 8:00 a.m., 5:45 p.m., and 6:15 p.m. weekday trips were cut on May 22, 2011.

***2034 Long-Range Transportation Plan*, January 2012: HRTPO:** As part of the Long-Range Transportation Plan (LRTP), the HRTPO staff prepares a fiscally-constrained list of recommended regional transportation priorities for Hampton Roads. The list is prepared using scores produced through a Project Prioritization Tool, recommendations from the HRTPO Transportation Technical Advisory Committee, the Governor's Transportation Funding Proposal, and stakeholders (local, state, federal, private sector, and public). The LRTP encompasses transportation studies for potential and planned interchange projects, highway projects, and multi-modal projects.

The I-64 HRBT Highway Transportation Study is identified as a priority in the 2030 LRTP and is listed as a funded highway study in the current 2034 Plan. The LRTP does not mention transit specifically in relation to this highway study, and does not include a dedicated transit crossing in this vicinity among the other listed priority projects.

Of the planning documents listed above, both Resolution 11-2008 and the *Hampton Roads Regional Transit Vision Plan Final Report* recommend, but do not mandate, that transit be considered in transportation projects such as the I-64 HRBT study. However, the *Hampton Roads Regional Transit Vision Plan Final Report* concludes that a separate rail transit corridor over dedicated transit facilities at the Third Crossing or the I-64 HRBT would optimize the overall regional rail transit network. Also, other studies recommend the reduction of bus services over the HRBT. Though there is support for transit in the Hampton Roads region, there is no specific mention of wanting or needing to increase transit opportunities over the HRBT.

CONSIDERATION OF TRANSIT ALTERNATIVES AND ABILITY TO MEET PURPOSE AND NEED: NEPA requires agencies to assess the environmental impacts of their proposed actions prior to deciding whether or not to proceed with those actions. One of the key elements of NEPA is the statement of the study's purpose and need, which helps frame and define proposed alternatives. Alternatives that do not meet the study's purpose and need are eliminated from consideration.

The study's needs are:

- Inadequate capacity of existing facilities to accommodate existing and forecasted travel demand at acceptable levels of traffic service, operating speeds, and travel times.
- Geometric deficiencies of the existing facilities that impede operating efficiency and contribute to decreased levels of traffic service.

A purpose and need statement was circulated to agencies and has been agreed upon by FHWA for use in the Draft EIS (anticipated December 2012). For a build alternative to be retained, it must address these needs. In determining the ability of a transit alternative to meet the study's purpose and need, it is critical to assess the ability of different transit modalities to increase capacity and to remedy geometric deficiencies.

Light or Heavy Rail Transit: The establishment of a light or heavy passenger rail line would entail the construction of a dedicated rail line crossing Hampton Roads either appurtenant to the existing HRBT structure or on a separate structure. There is currently no rail transit service connecting Hampton to Norfolk, nor comprehensive transit service within the larger region. For a rail transit crossing at the HRBT to be viable, a new rail transit route or system would be necessary on both the Peninsula and the Southside.

This alternative, by itself, would not address the geometric deficiencies of the existing HRBT facilities because improvements would not be made to the existing bridge-tunnel to address current design standards.

The Hampton Roads Transportation Planning Organization (HRTPO) and Virginia Department of Rail and Public Transportation (DRPT) recently completed the *Hampton Roads Regional Transit Vision Plan Final Report*. It proposes a dedicated light rail transit connection across Hampton Roads in the long term (beyond 2034), although specific corridor recommendations are not provided. Further, potential transit improvements across Hampton Roads are not funded for study, design or construction in the HRTPO's *2034 Long Range Plan*; therefore, they are not reasonably foreseeable.

The ability of a light or heavy passenger rail line to increase capacity is dependent on ridership, i.e., the comparative likelihood that automobile commuters would opt to ride a train across Hampton Roads rather than drive automobiles. The *Preliminary Cost and Ridership Estimation Report,* prepared as part of *A Transit Vision Plan for Hampton Roads (2009)*, included estimated 2034 ridership for light rail service across Hampton Roads, assuming service from Naval Station Norfolk to downtown Newport News, and from downtown Hampton to Wards Corner (near the I-64 interchange with I-564). These projections indicate that daily rail ridership in the year 2034 would be expected to be as much as 4,100 for Naval Station Norfolk to downtown Newport News, and 5,100 for downtown Hampton to Wards Corner. This represents approximately eight percent of projected year 2040 HRBT users. By contrast, approximately 28,000 vehicles would use each lane of the HRBT in 2040 under No-Build conditions.

Based on the discussion above, the Light or Heavy Rail Transit Alternative has been eliminated from further consideration because it would not address the roadway geometric deficiency or capacity needs identified by this study. The alternative would require substantial new rail transit connections on the Peninsula and Southside, and it would have limited ability to accommodate existing and future traffic volumes on the HRBT.

Bus Transit: A bus transit alternative would entail the expansion of existing bus service across Hampton Roads, potentially in conjunction with roadway build alternatives. This alternative, by itself, would not address the geometric deficiencies of the existing HRBT facilities because no improvements would be made to the I-64 roadway or existing bridge-tunnel to address current design standards.

Expansion of the existing bus transit network alone would likely not attract enough riders to substantially address the capacity need within the I-64 HRBT corridor because there is currently a lack of bus ridership across Hampton Roads. This fact is demonstrated by recent recommendations by Hampton Roads Transit (HRT) to eliminate five current weekday trips across HRBT due to low ridership (*Service and Schedule Efficiency Review, HRT, March 2011)*. All bus routes across Hampton Roads combined accommodated approximately 700 riders per day in 2011, which is the equivalent of less than one percent of the existing HRBT daily traffic volume. Any increased bus service also would continue to rely on the existing HRBT facility, and its operation would be hampered by current capacity and geometric deficiencies of existing facilities. Therefore, expanded bus transit as a stand-alone alternative has been eliminated from further consideration.

Bus transit could be included as a component of other retained build alternatives that meet the study's purpose and need, in part because additional lanes and improved capacity across Hampton Roads would be provided by these alternatives. These alternatives would also address the geometric deficiency needs of the study. Build alternatives that include managed lanes could also provide for bus transit and/or a dedicated bus lane as part of the management strategy. Thus, expanded bus transit has been carried forward for further evaluation as a component of other build alternatives.

Ferry Service: A ferry service alternative would entail the establishment of a service to carry vehicles across Hampton Roads via water transport. The alternative also would include the rehabilitation or reconstruction of elements of the existing HRBT approach bridges and the continuation of routine maintenance of the tunnels. This alternative would not address the geometric deficiencies of existing HRBT facilities because no improvements would be made to the I-64 roadway or existing bridge-tunnel to address current design standards.

Ferries would require that vehicles arrive at least 20 minutes prior to departure to load and would travel at maximum speeds less than 40 miles per hour. This speed may not be reasonable across Hampton Roads where ferries would have to traverse shipping lanes and adhere to speed restrictions. The total trip length (including loading and unloading) would be approximately 30 minutes across Hampton Roads only. The total time represents an average increase in the travel time across Hampton Roads of approximately 30 minutes as compared to the current average peak hour travel time across the bridge-tunnel of 9.5 minutes. With congestion, 2040 HRBT travel time is expected to be slower, but would still be faster than ferry travel. Ferry travel times therefore do not compete with travel times for existing and future crossings via the HRBT.

Further, projections prepared for the *Hampton Roads Regional Transit Vision Plan Final Report* indicate that the average weekday ferry ridership between downtown Hampton and the Norfolk Naval Station would range between 600 and 1,100 vehicles in the year 2034. This figure is equivalent of less than one percent of the projected 2040 No-Build HRBT traffic volume.

A similar study for a potential ferry crossing of the Chesapeake Bay to help reduce traffic congestion on the existing Chesapeake Bay was conducted by the Maryland Transportation Authority. The study findings noted that a ferry crossing would accommodate up to 335,000 vehicles per year, or less than 1,000 vehicles per day. Further, the study found that the cost of a ferry crossing would be 10 to 15 times higher for passengers per trip then using the existing tolled bridge which extends for a distance of approximately 4.3 miles.

For the reasons cited above, the Ferry Service Alternative would not address geometric deficiencies of the existing facilities or capacity needs of the HRBT, and thus has been eliminated from further study.

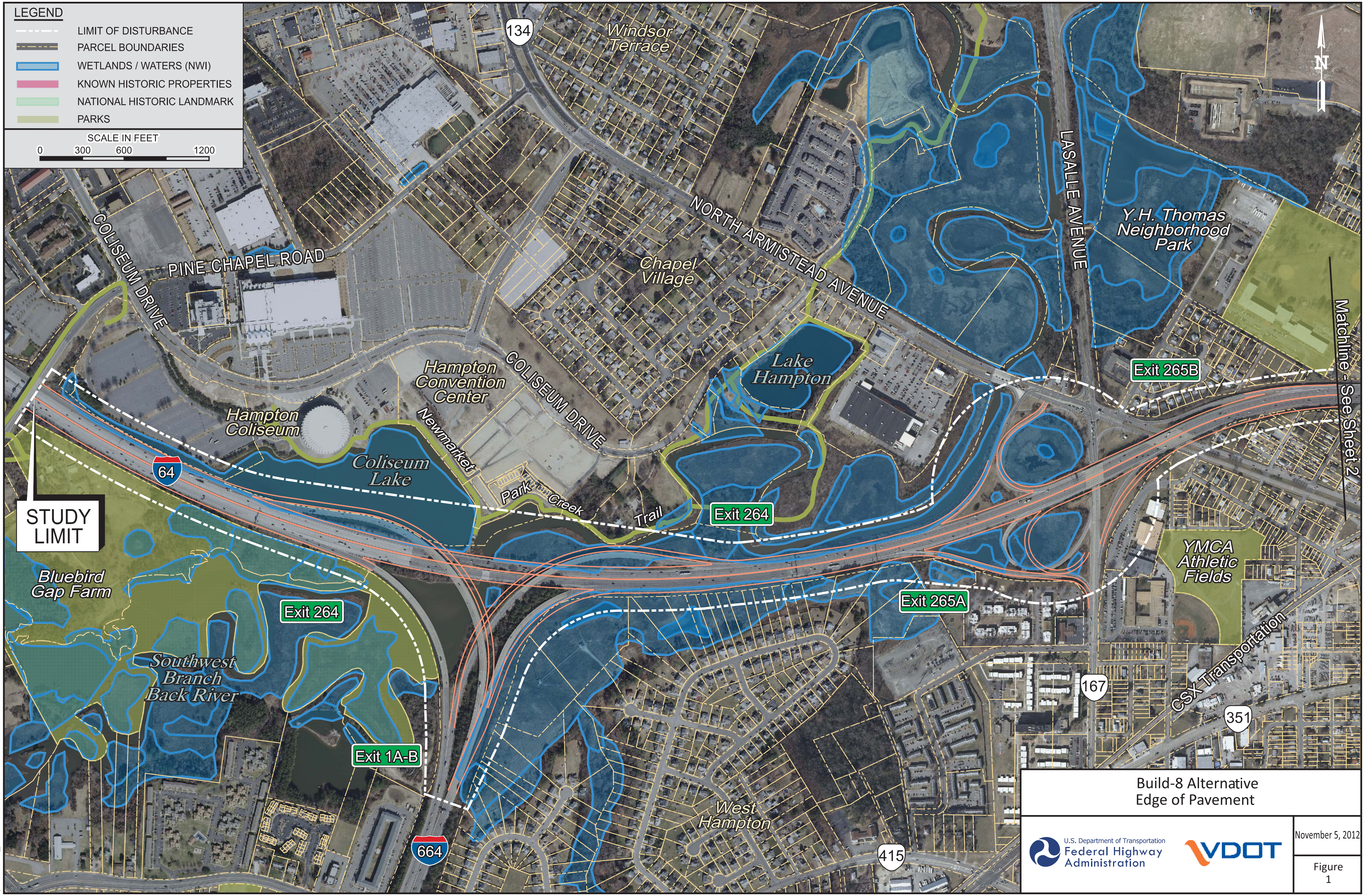
SUMMARY: Agency and public comments, as well as published reports, indicate that there is desire to consider transit opportunities in the Hampton Roads area. This document presents a review of previous studies and analyzes the viability of increased transit opportunities in the area in light of the I-64 HRBT study's purpose and need.

While previous studies recommend increasing transit opportunities in the Hampton Roads area, they do not demonstrate a consensus regarding mode, location or timeframe, nor do they analyze the viability of transit in the area. Two studies go so far as recommend the reduction of bus services over the HRBT. Further, although there is support for transit in the Hampton Roads region, no study specifically illustrates the basis of that support in terms of service needs.

The purpose and need of the proposed alternatives is to address insufficient capacity of existing facilities and geometric deficiencies of existing facilities. Light or heavy rail transit, bus transit, and ferry services were analyzed using the study's purpose and need. All transit alternatives were eliminated as stand-alone alternatives since they would not address roadway geometric deficiency or capacity needs identified by this study. Rail service will not be included in the retained build alternatives because of severe logistical problems presented by the need to establish connectivity with other area rail service. Ferry service will not be included in the retained build alternatives because it would increase travel time and cost, and would have limited ability to accommodate existing and future traffic volumes. Bus transit, however, could be included as a component of other retained build alternatives that meet the study's purpose and need.

APPENDIX C.

BUILD-8 ALTERNATIVE PLAN SHEETS



Build-8 Alternative
Edge of Pavement

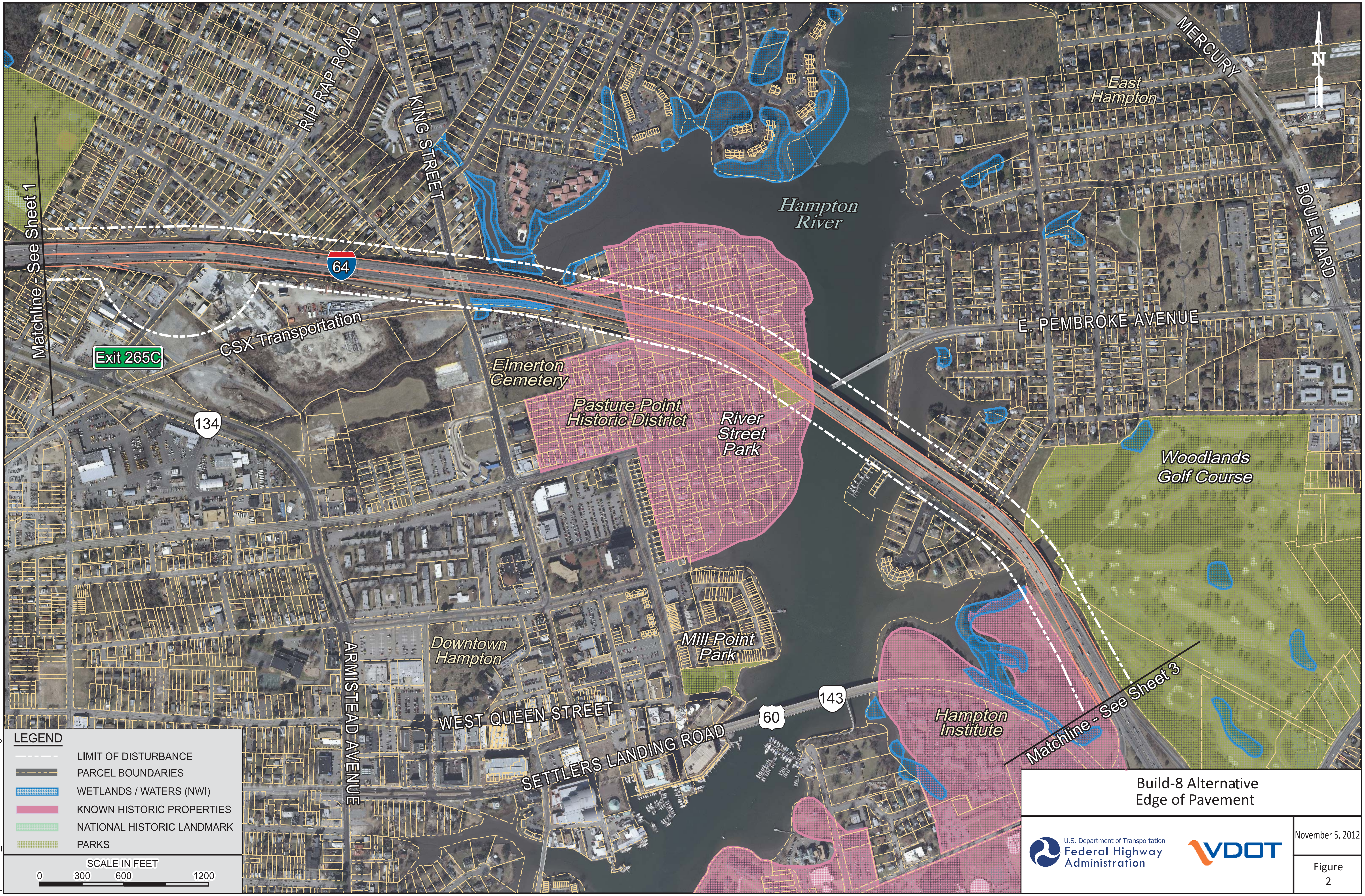
U.S. Department of Transportation
Federal Highway Administration

VDOT

November 5, 2012

Figure 1

pHD-0001_Build8EOP-11x17-600sc.dgn



Build-8 Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 2

Build-8 Alternative
Edge of Pavement

Figure 3

pHD-0004_Build8EOP-11x17-600sc.dgn

pHD-0005_Hampton-Build8EOP-11x17-600sc.dgn

Build-8 Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

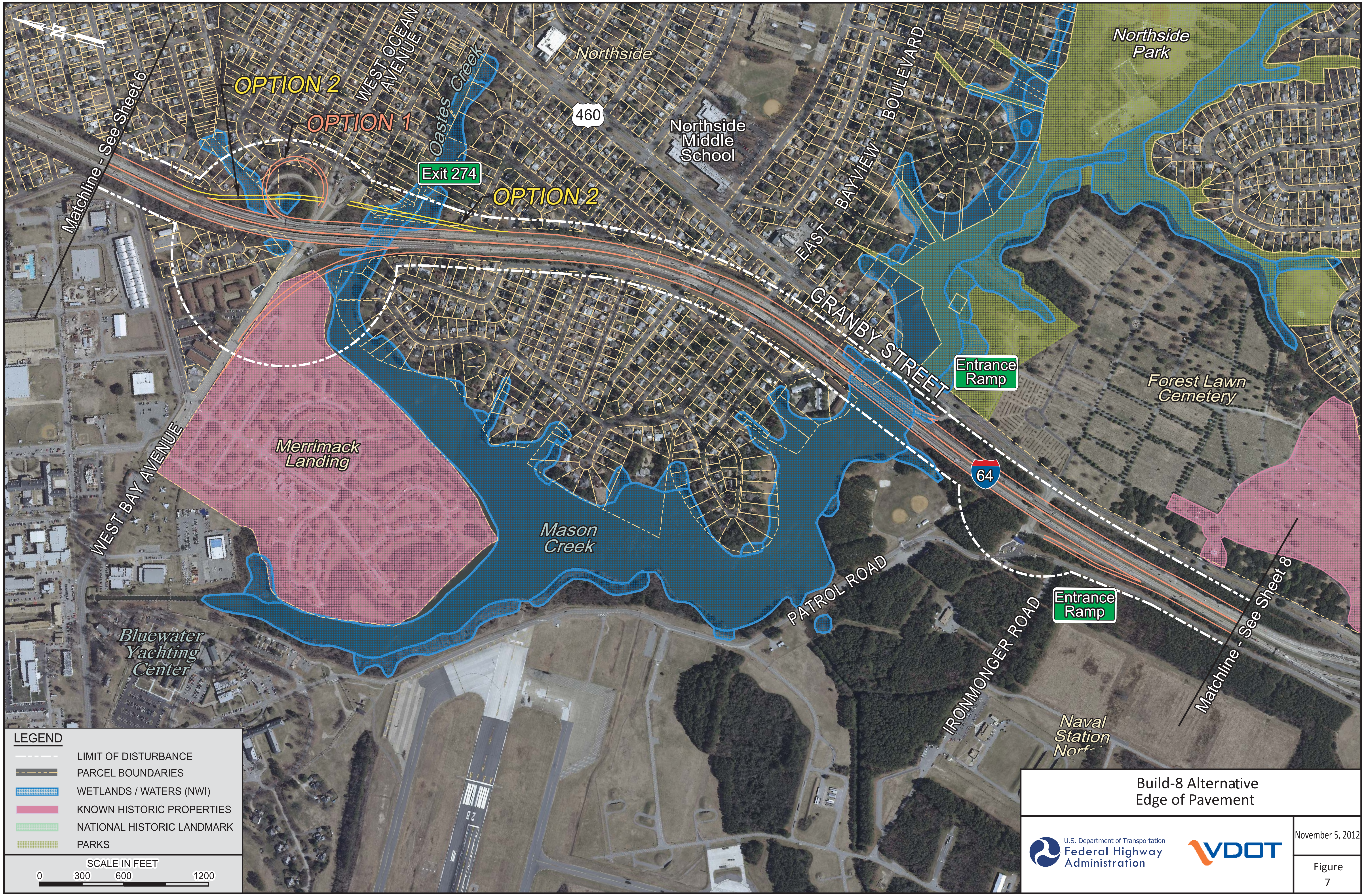
VDOT

November 5, 2012

Figure 5A

pHD-0005A_Hampton-Build8EOP-11x17-600sc.dgn

pHD-0006_Build8EOP-11x17-600sc.dgn



Build-8 Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 7

pHD-0007_Build8-11x17EOP-600sc.dgn

Build-8 Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

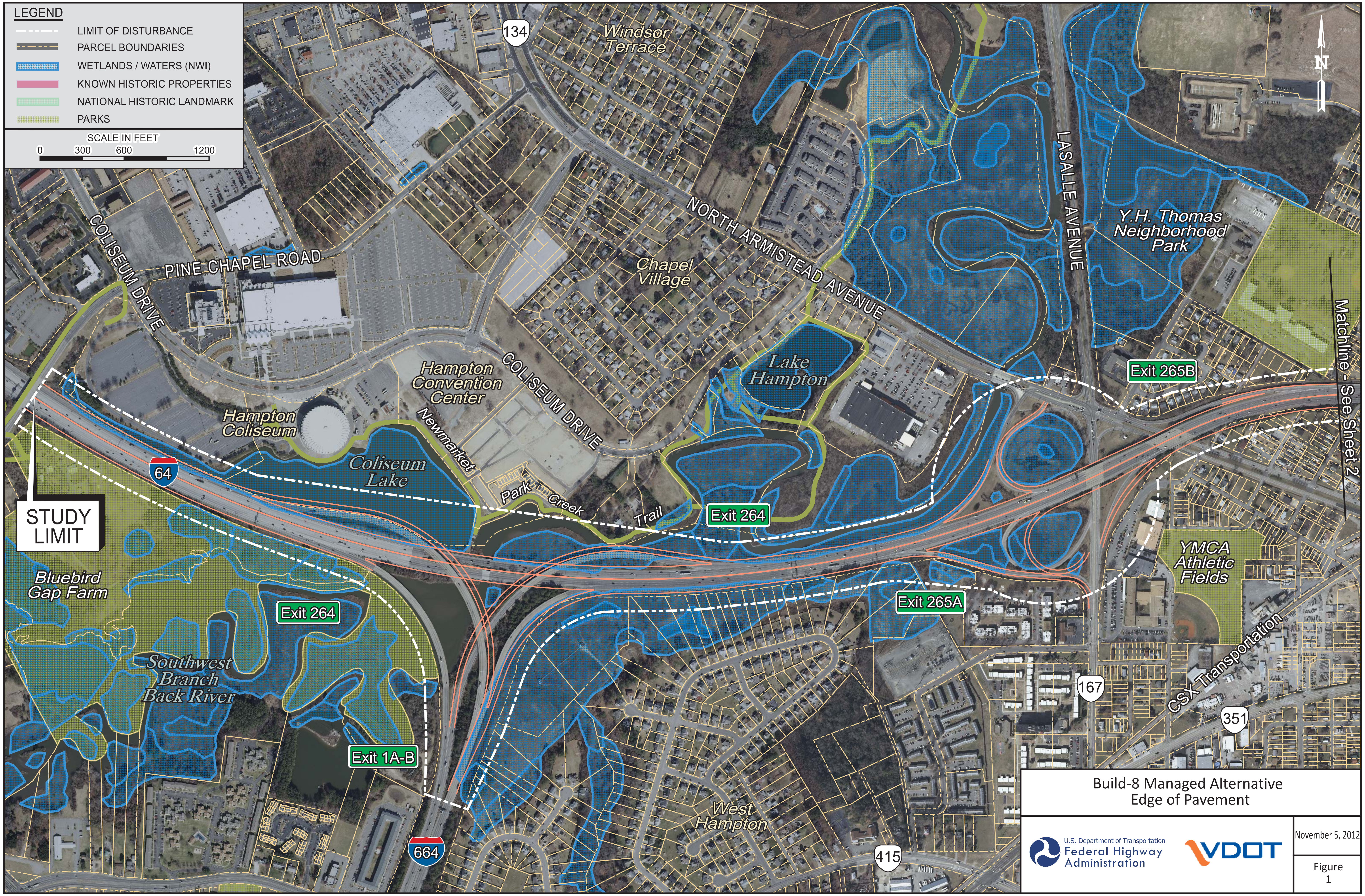
VDOT

November 5, 2012

Figure 8

APPENDIX D.

BUILD-8 MANAGED ALTERNATIVE PLAN SHEETS



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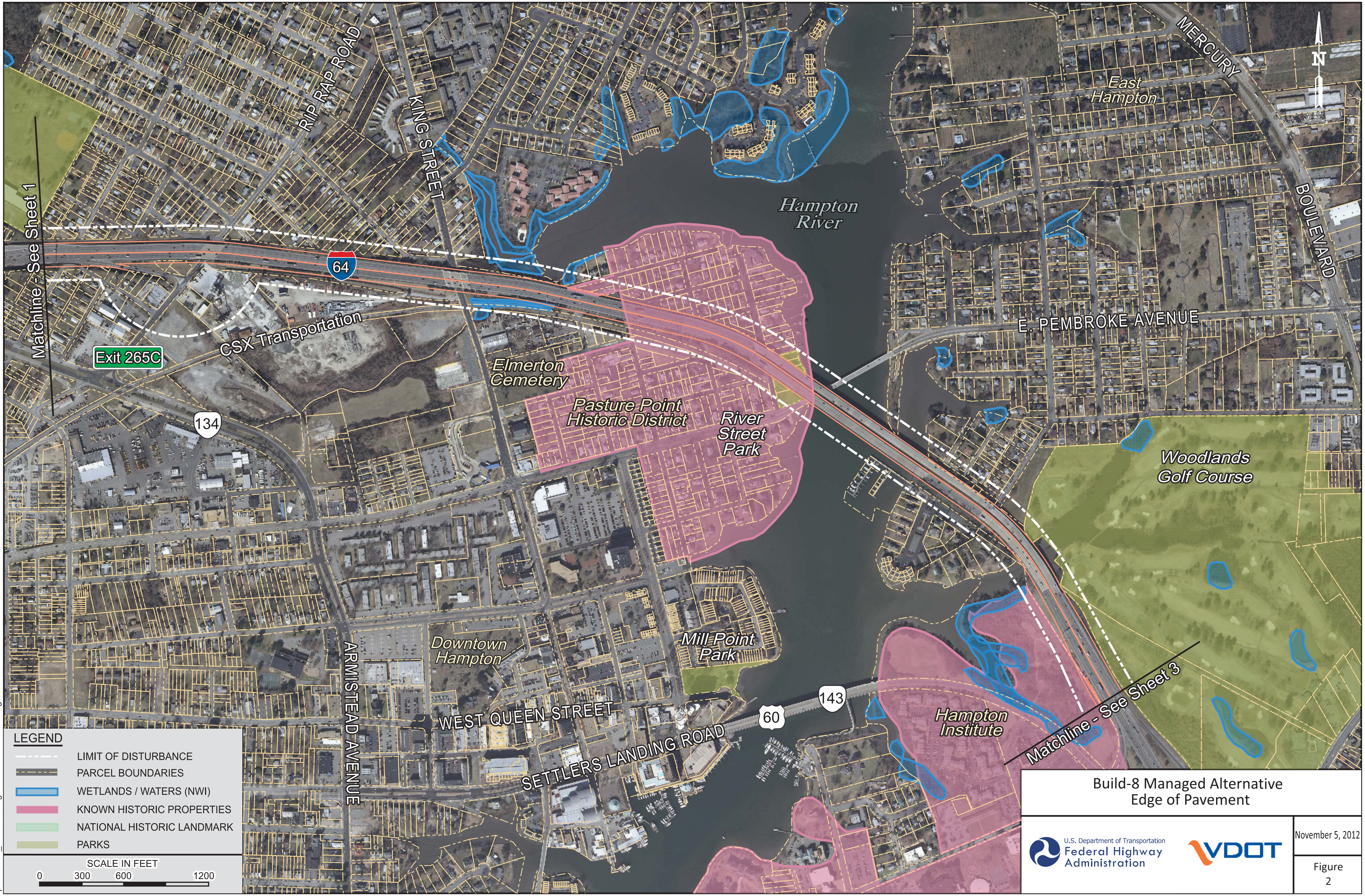

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 2

Build-8 Managed Alternative
Edge of Pavement

November 5, 2012

Figure 3

pHD-0003_Build8ManagedEOP-11x17-600sc.dgn

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

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November 5, 2012

Figure 4

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 5

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 5A

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

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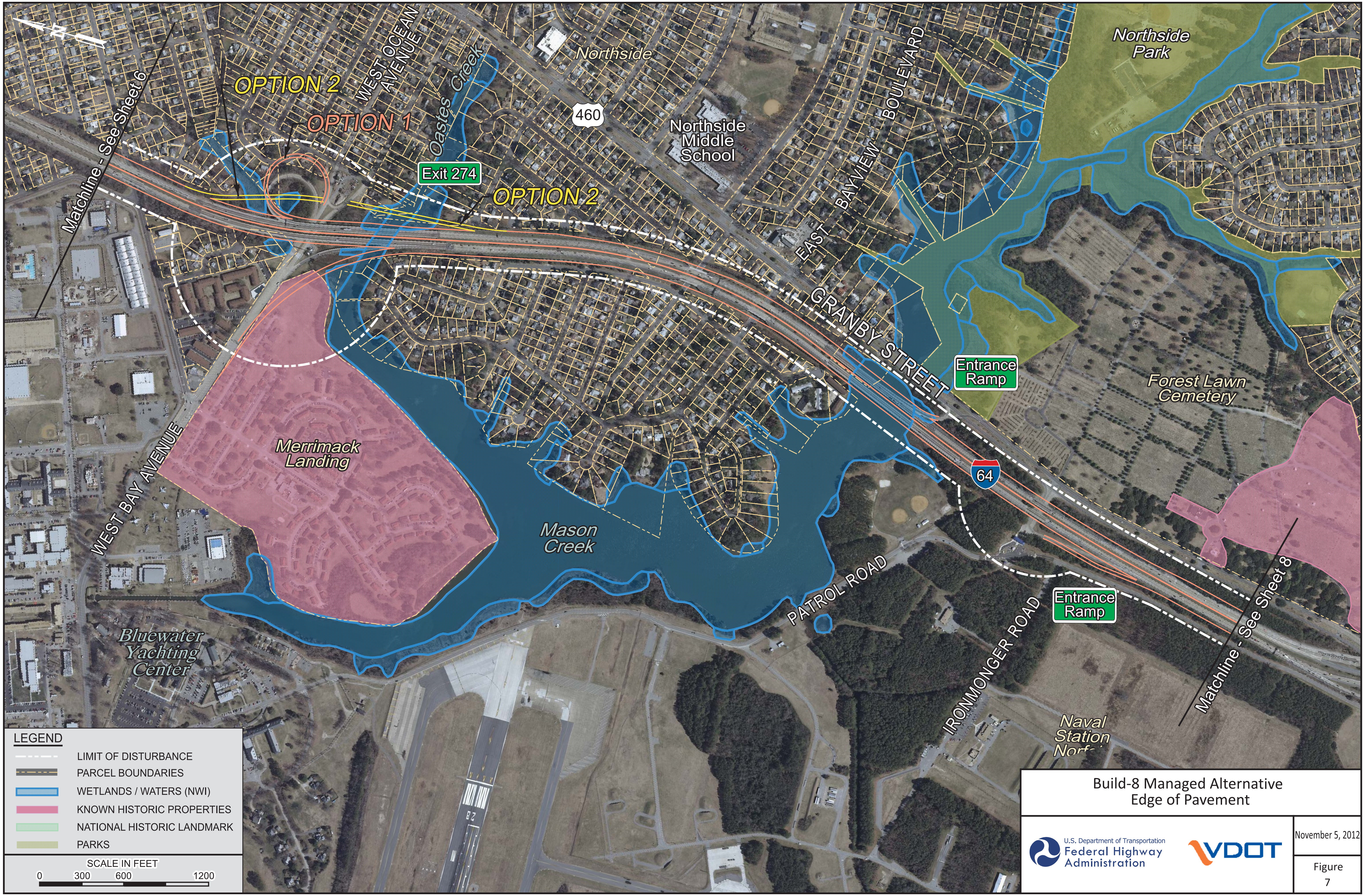
November 5, 2012

Figure 6

pHD-0006_Build8ManagedEOP-11x17-600sc.dgn



Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

VDOT

November 5, 2012

Figure 7

pHD-0007_Build8ManagedEOP-11x17-600sc.dgn

Build-8 Managed Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

VDOT

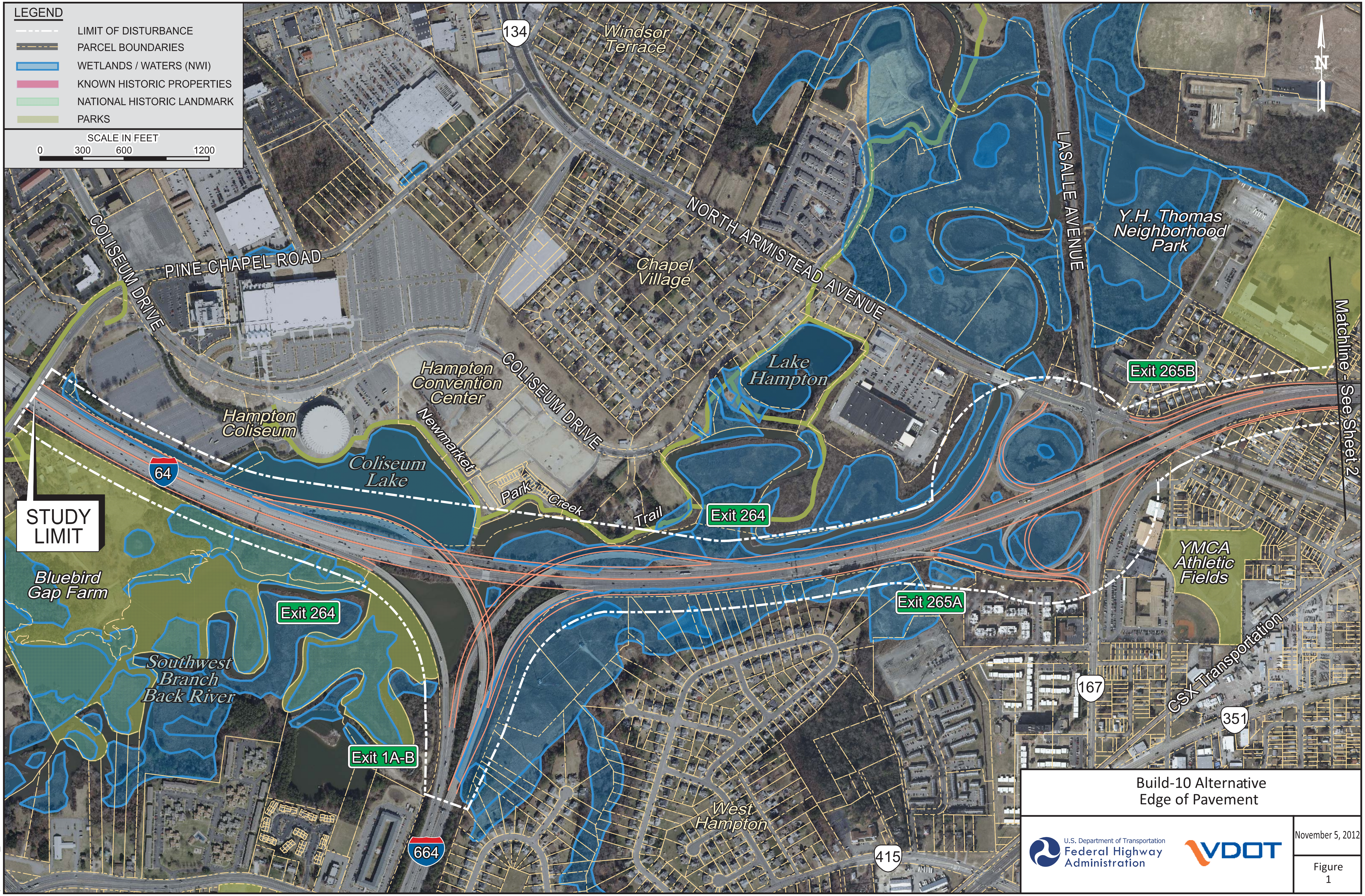
November 5, 2012

Figure 8

pHD-0008_Build8ManagedEOP-11x17-600sc.dgn

APPENDIX E.

BUILD-10 ALTERNATIVE PLAN SHEETS



Build-10 Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

VDOT

November 5, 2012

Figure 1

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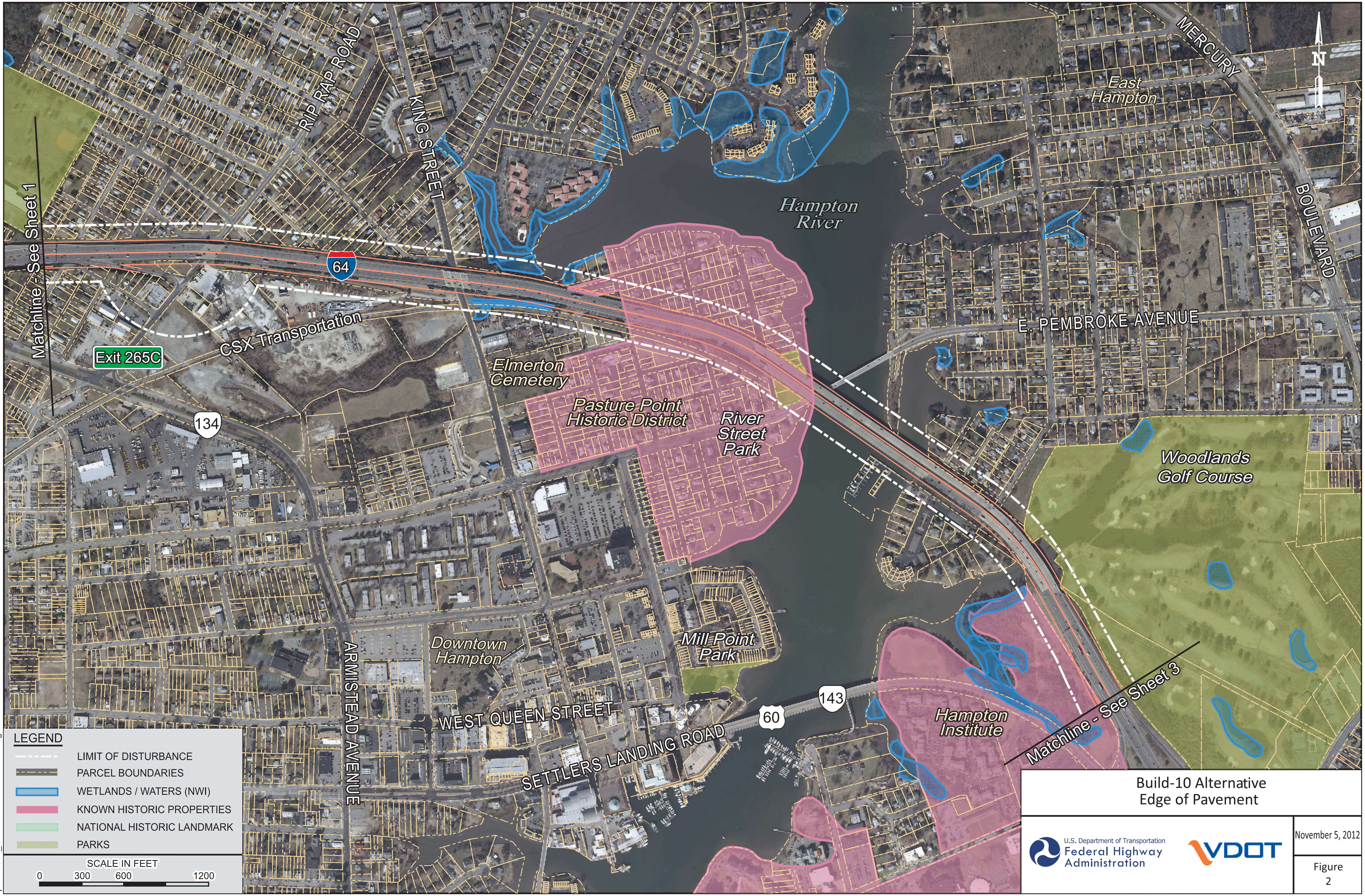


Build-10 Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration

VDOT

November 5, 2012

Figure 2

pHD-0002_Build10EOP-11x17-600sc.dgn

Build-10 Alternative
Edge of Pavement

November 5, 2012

Figure 3

Build-10 Alternative
Edge of Pavement

U.S. Department of Transportation
Federal Highway Administration
VDOT

November 5, 2012

Figure 4

pHD-0004_Build10EOP-11x17-600sc.dgn

Build-10 Alternative
Edge of Pavement

November 5, 2012

Figure 5

pHD-0005_Hampton-Build10EOP-11x17-600sc.dgn

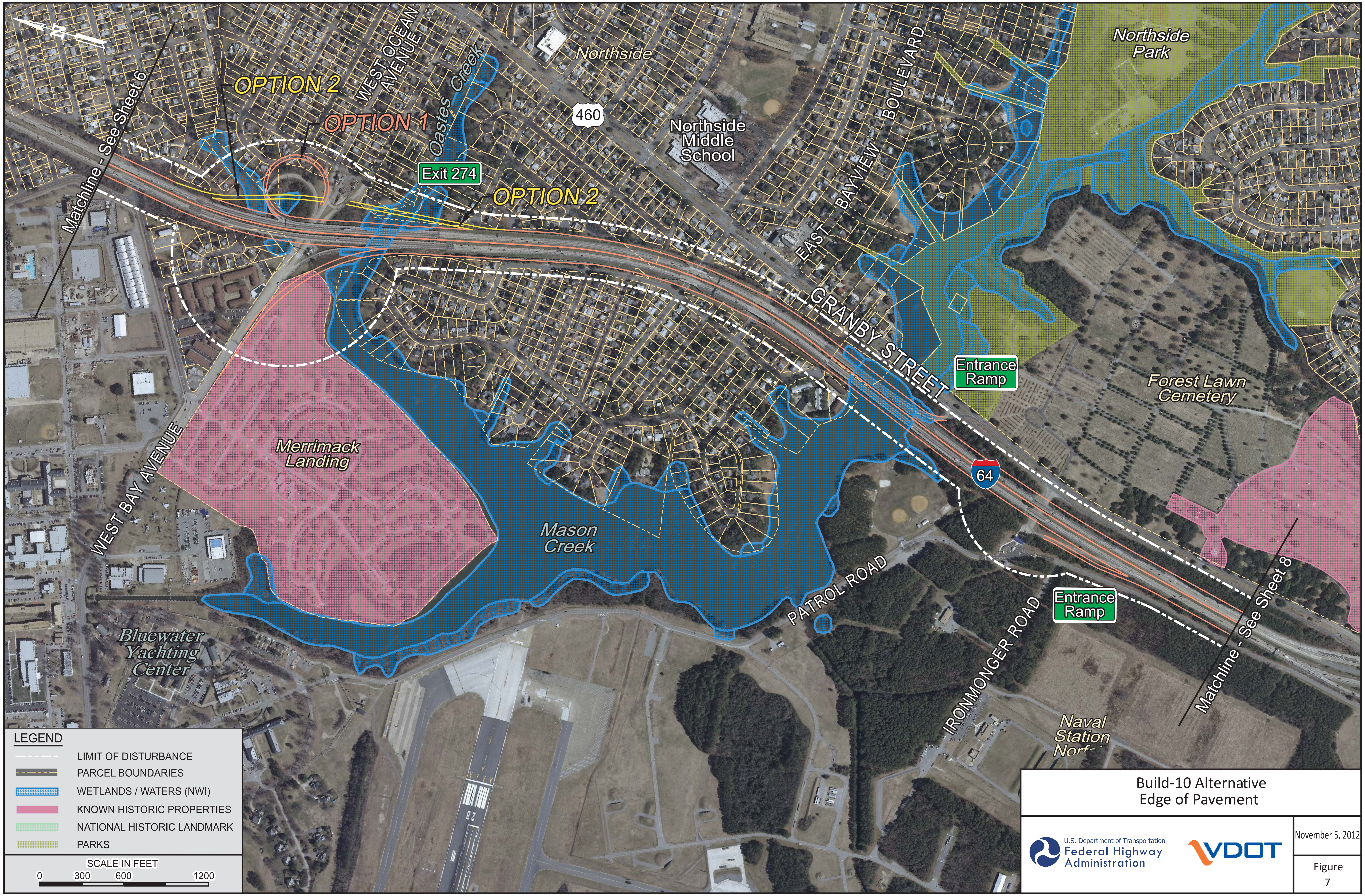
Build-10 Alternative
Edge of Pavement

November 5, 2012

Figure 5A

pHD-0005A_Hampton-Build10EOP-11x17-600sc.dgn

pHD-0006_Build10EOP-11x17-600sc.dgn



Build-10 Alternative
Edge of Pavement

U.S. Department of Transportation Federal Highway Administration

VDOT

November 5, 2012

Figure 7

pHD-0007_Build10EOP-11x17-600sc.dgn

pHD-0008_Build10EOP-11x17-600sc.dgn