Alaskan Way Viaduct & Seawall Replacement Program

U.S. Department of Transportation Federal Highway Administration | WSDOT | King County | City of Seattle

Draft SR 99 Bored Tunnel Alternative

Design Deviation No. 3: SR 99 Length of Grade

MP 30.40 to MP 32.83

Submitted to:
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April 2009

The Alaskan Way Viaduct & Seawall Replacement Program

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Agreement No. Y-9715

Task CE.04

The Alaskan Way Viaduct & Seawall Replacement Program is a joint effort between the Federal Highway Administration (FHWA), the Washington State Department of Transportation (WSDOT), and the City of Seattle. To conduct this project, WSDOT contracted with:

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SR 99: Alaskan Way Viaduct & Seawall Replacement Program
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April 2009

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Northwest Division
Urban Corridors Office
Seattle, Washington

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Deviation Recommended for Approval:

Date_____

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Federal Highway Administration

Deviation Approval:

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1.0 Project Overview

The Alaskan Way Viaduct and Seawall Replacement Program (AWVSRP) design team has been working since 2001 to develop alternatives for the replacement of the Alaskan Way Viaduct. The team prepared and published a Draft Environmental Impact Statement (Draft EIS) in March 2004 and a Supplemental Draft Environmental Impact Statement (Supplemental Draft EIS) in September 2006. The team also prepared and submitted a Design Approval Package (DAP) to the Washington State Department of Transportation (WSDOT) for the preferred tunnel alternative in February 2007; however, the approval of that package was deferred while the project partners (City of Seattle, WSDOT, King County, and the U.S. Federal Highway Administration (FHWA)) re-evaluated the preferred configuration of State Route (SR) 99 in Seattle's waterfront area.

On March 14, 2007, the Project Team was directed by WSDOT to advance portions of the program that would contribute to improving safety and mobility, and that have fundamental consensus among the project partners. The Governor and WSDOT then identified six "Moving Forward: Early Safety and Mobility Projects" that are currently being implemented while the preferred SR 99 configuration in the central waterfront area was re-evaluated. One of these projects is the South Holgate Street to South King Street Viaduct Replacement, which is currently under design and scheduled for construction in fall 2009.

In January 2009 a letter of agreement between WSDOT, King County, and the City of Seattle identified a four-lane, single-bore tunnel as the recommended alternative for replacing the Alaskan Way Viaduct. The Single-bore Tunnel Alternative (Tunnel Alternative) connects to the proposed South Holgate Street to South King Street Viaduct Replacement Project (South Project) at approximately S. Royal Brougham Way (M.P. 30.40) in the south with a cut-and-cover section that runs to First Avenue and S. King Street. From here a tunnel boring machine would be used to construct the tunnel, following First Avenue to approximately Stewart Street, then veering east to the area of John Street and SR 99. The alternative includes another cut-and-cover section that connects to SR 99 near Mercer Street (M.P. 32.83) in the north. Interchange ramps are provided at both the north and south sections. Additionally,

a street connection between Alaskan Way and Elliott and Western Avenues is included (see Figure 1).

The SR 99 roadway for the SR 99 Bored Tunnel Project is functionally classified as a Principal Arterial Highway by WSDOT; its geometric design classification is that of a Principal Arterial P-1 Urban, per current *WSDOT Design Manual* Figure 440-6 (see approved *SR 99 Corridor Analysis Addendum C*). The project corridor has a WSDOT freight tonnage designation of T-1 (more than 10 million tons per year), and the City of Seattle classifies the roadway as a Major Truck Street.

Design Matrix 3, lines 3-7 (*WSDOT Design Manual*, Figure 325-5) (May be Matrix 3, lines 3-11) is most applicable to the project, which requires a full design level. This document requests a deviation for reduced length of grade.

The AWVSRP is partially funded through a combination of state funds from the 2003 Nickel Funding Package and the 2005 Transportation Partnership Account Package. It has also received funding from FHWA and the City of Seattle.

2.0 Existing Conditions in Vicinity of SR 99

The existing SR 99 urban route within the project vicinity is located along the waterfront between S. King Street and Pine Street before turning northeast to the Battery Street Tunnel (BST) at First Avenue and Battery Street. It exits the BST at Denny Way and then turns north, crossing John, Thomas, Harrison, Republican, and Mercer Streets. The majority of the existing SR 99 runs along the waterfront and therefore parallels Alaskan Way directly to the west. To the east, the viaduct closely shadows downtown buildings and Western Avenue with general parking directly underneath.

The existing SR 99 through the project vicinity is generally configured as a 40-foot-wide viaduct stacked structure. The number of existing lanes ranges from three to four in each direction, with lane widths varying from 9 to 12 feet and shoulder widths ranging from 0 to 3 feet. The SR 99 roadway width narrows to 25 feet with two lanes in each direction through the BST, and then widens to three to four lanes each approximately 10 feet wide north of the BST. WSDOT currently considers the BST a high accident location. The vertical alignment of the viaduct varies from 0 percent to 4 percent slope up to the BST, and then SR 99 adjusts to approximately -2 percent north of the BST to Mercer Street before transitioning to a positive slope northward. The rolling terrain between Union and Ward Streets has a posted speed of 40 miles per hour (mph), while the southern portion of the route from S. Royal Brougham Way to Union Street is level and posted as 50 mph.

Many aspects of the existing horizontal and vertical curves do not meet today's roadway design standards for the posted speed limit. When compared to current design standards for stopping sight distance, horizontal curve radius, and vertical curve length, about two-thirds of the horizontal and vertical curves would coincide with a design speed of less than 40 mph.

The average daily traffic (ADT) peaks along the existing central waterfront mainline at 52,500 for the northbound direction and 50,500 for the southbound direction. In this area, the level-of-service (LOS) for northbound and southbound mainline traffic varies between LOS D and LOS E. Existing ADT truck traffic volumes are approximately 3 percent to 5 percent of total traffic. At the northern end of the project corridor, two existing High Accident Locations have been identified at northbound MP 31.9 to 32.1 and southbound MP 32.0 to 32.4 (see *SR 99 Corridor Analysis,* October 2004).

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Figure 1. Proposed Project Corridor (Project limits per 2004 Corridor Analysis)

3.0 Proposed Roadway Configuration

The SR 99 Bored Tunnel Alternative would replace the existing viaduct and BST with a single bored tunnel east of the existing alignment. This project is comprised of a bored tunnel containing two stacked roadway decks with cut-and-cover sections at both the north and south ends. The tunnel would be constructed with an approximately 54-foot diameter tunnel boring machine (TBM). Southbound traffic would be on the top deck, and northbound traffic would be on the bottom deck. Enclosed roadways would meet or exceed current fire, life, and safety codes. The inside of the tunnel would be lined with an approximately 2-foot-thick concrete liner. The alignment would consist of a minimum of two northbound and two southbound lanes with shoulders varying on the left from 2 to 4 feet, and on the right from 3 to 8 feet. Both the South and North Segments of the project would contain fully directional interchange movements connecting with the City's surface street grid.

3.1 South Segment

In the south, the alignment matches the S. Holgate Street to S. King Street Project structure at S. Royal Brougham Way (RBW). SR 99 includes two lanes northbound and two lanes southbound, with shoulder widths of 4 feet on the left and 8 feet on the right (see Figure 2).

Access to and from the north would be via an interchange at RBW and the Alaskan Way frontage road. The northbound on-ramp would enter a retained cut section north of RBW and merge with the two SR 99 northbound lanes from the right side. The southbound off-ramp would diverge from the left side of SR 99 (see Deviation No. 2) and enter a retained cut section as it approaches RBW from the north.

Access to and from the south would be via an interchange at Alaskan Way north of RBW. The southbound on-ramp would enter the two SR 99 southbound lanes from a retained fill section as an added third southbound lane on the right. The northbound off-ramp would exit SR 99 as right-side drop lane with two lanes remaining on the SR 99 mainline, and would approach Alaskan Way on a retained fill section.

The South Segment alignment would match the H2K Project structure. The SR 99 mainline would configure into the stacked alignment for the cut-and-cover phase before entering the single bore tunnel at approximately S. King Street and First Avenue S. The vertical alignment through the cut-and-cover phase would descend at a sustained -5 percent grade for distance of 1,300 feet.

Ramp design speeds, grades, and cross-sections are within *WSDOT Design Manual* guidelines.

3.2 Central Segment

The bored tunnel's diameter of 54 feet was determined by setting two stacked roadway widths at 36 feet, with 16.5 feet of vertical clearance each, and building out structurally from there. Any additional clearance requirements would likely have a direct impact on the tunnel bore's outside diameter. The roadway cross-section is designed with a wall-to-wall width of 36 feet in both the northbound and southbound directions. Two 12-foot lanes take up 24 feet, leaving, 12 feet for shoulders and possible barriers. Assuming a width of 9 inches for each barrier, the remaining area allows for approximately 3 feet-3 inches for left shoulders and 7 feet-3 inches for right shoulders. Southbound traffic would be on the top roadway deck, and northbound traffic would be on the lower roadway deck.

As part of the fire and life safety requirements, emergency egress locations would be located at approximately 600-foot intervals. To provide sufficient space for safe egress, the current design would require the northbound shoulder to be reduced to 3 feet minimum. The egress structures would be approximately 100 feet long.

The Central Segment's vertical alignment would continue the South Segment's -5 percent grade for an additional 1,700 feet before reaching the desired depth of approximately 130 feet below the surface. From this depth, the tunnel would transition to a positive 1 percent grade thereby allowing the tunnel to avoid key existing underground obstructions, such as the Burlington Northern-Santa Fe (BNSF) railroad tunnel and the Elliott Bay Interceptor (EBI). This 1 percent grade extends for approximately 3,000 feet before it would transition to a climbing grade of 5 percent for approximately 4,000 feet to match the North Segment's cut-and-cover section.

The horizontal and vertical design speed is 50mph, per *WSDOT Design Manual* guidelines.

3.3 North Segment

The stacked roadways of the bored tunnel section would begin to unbraid and unstack north of John Street, entering a cut-and-cover section between John and Harrison Streets, and a retained cut section north of Harrison Street. Northbound and southbound SR 99 would meet the existing vertical grade between Republican and Mercer Streets. SR 99 would follow and match the existing alignment from Mercer to Ward Streets. The existing SR 99 north of Mercer Street consists of three southbound lanes and three northbound lanes, with a fourth northbound auxiliary lane ending north of Aloha Street. The existing lane width varies from 10.5 feet to

11 feet, and there are no existing shoulders only a gore stripe adjacent to the curb and a 6-foot sidewalk. The existing posted speed is 40 mph.

Access to and from north SR 99 is via ramps at Harrison Street. A northbound on-ramp joins to the two SR 99 mainline lanes as an additional third lane from the left side at Republican Street (see Deviation No. 2). A southbound off-ramp exits from SR 99 as a left-side drop lane (see Deviation No. 2) near Republican Street, leaving two southbound mainline lanes.

Access to and from the south is via ramps at Republican Street. A southbound on-ramp merges via an acceleration lane in to the 2 SR 99 mainline lanes from the right side of SR 99 in a retained cut section. A northbound off-ramp diverges from the 2 SR 99 mainline lanes in to a deceleration lane approaching Republican Street in a cut section.

The North Segment would be connected to the Central Segment by a cut-and-cover tunnel before the alignment joins the existing SR 99 south of Mercer Street. At the cut-and-cover connection point to the Central Segment, the North Segment's grade would flatten, which is not considered part of this design deviation.

SR 99 mainline horizontal and vertical design speed is 50 mph per *WSDOT Design Manual* guidelines. Ramp design speeds range from 10-45mph.

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4.0 Deviation Description – Length of Grade

The proposed design matrix for the project indicates a "Full Design Level" for length of grade. *WSDOT Design Manual* Figure 630-1 recommends a maximum 900-foot length of grade for a 5 percent sustained upgrade.

A deviation for length of grades is proposed along the alignment between northbound Sta. 246+00 and Sta. 286+00, and southbound Sta. 186+00 and Sta. 216+00, as shown on Figures 2. Table 1 lists the design standard and proposed length of grades for the northbound and southbound directions along the mainline.

Table 1: Length of Grade

Direction	Standard (*WSDOT Design Manual* Figure 630-1, May 2008)	Proposed	
	Maximum Length (for 5 percent grade)	Length	Location
Northbound	900 feet	4,000 feet	246+00 to 286+00
Southbound	900 feet	3,000 feet	186+00 to 216+00

The deviation is necessary to adhere to the proposed alignment for the bored tunnel. This alignment was favored to achieve the preferred soil conditions, which are located at increased depths, and maintain clearance from the BNSF Railway Company tunnel and the Elliot Bay Interceptor combined sewer outfall, as well as surrounding building foundations.

5.0 Alternatives Considered

The Project Team developed and assessed alternate alignments that would best meet WSDOT design standards, minimize effects to adjacent underground structures, and allow for more structurally suitable soil conditions to reduce potential settlement caused by the TBM. The alignment alternatives for the mainline roadway are summarized in the following sections.

5.1 Alternative 1: Nonstandard Length of Grade

Alternative 1 provides an alignment that would maintain maximum clearances from existing underground structures and would avoid drilling through unsuitable loose soils closer to the surface. The preferred tunnel profile is illustrated in Figure 2. This preferred alternative includes a deviation for length of grade as described in Section 4.0. The justifications for this deviation are provided below.

The following constraints have been determined through preliminary design and discussion with the Project Team:

- Maintain a tunnel diameter clearance (54 feet) to adjacent underground structures
- Avoid possible settlement and right-of-way issues by drilling too close to the surface or near adjacent building foundations
- Maintain maximum 5 percent upgrade (actual classification maximum equals 7 percent)
- Due to the TBM drilling process, mitigate unknown inherent risks by increasing depth from surface

A deviation in the length of grade would avoid a major reconfiguration of the proposed tunnel alignment.

5.2 Alternative 2: Full Design Standards

Alternative 2 would apply a project design that used full design standards. This Full Design Standards Alternative would shorten the length of grade to 900 feet. This alternative was eliminated from further consideration because it would result in increased right-of-way impacts, settlement and clearance issues to adjacent properties, increased risk of damages, and increased cost. An alternative alignment that reduces the upgrade even further could lengthen the overall tunnel, pushing out

the portal to the north into Mercer Street under the existing SR 99 profile, resulting in additional impacts and cost (See Figure 2).

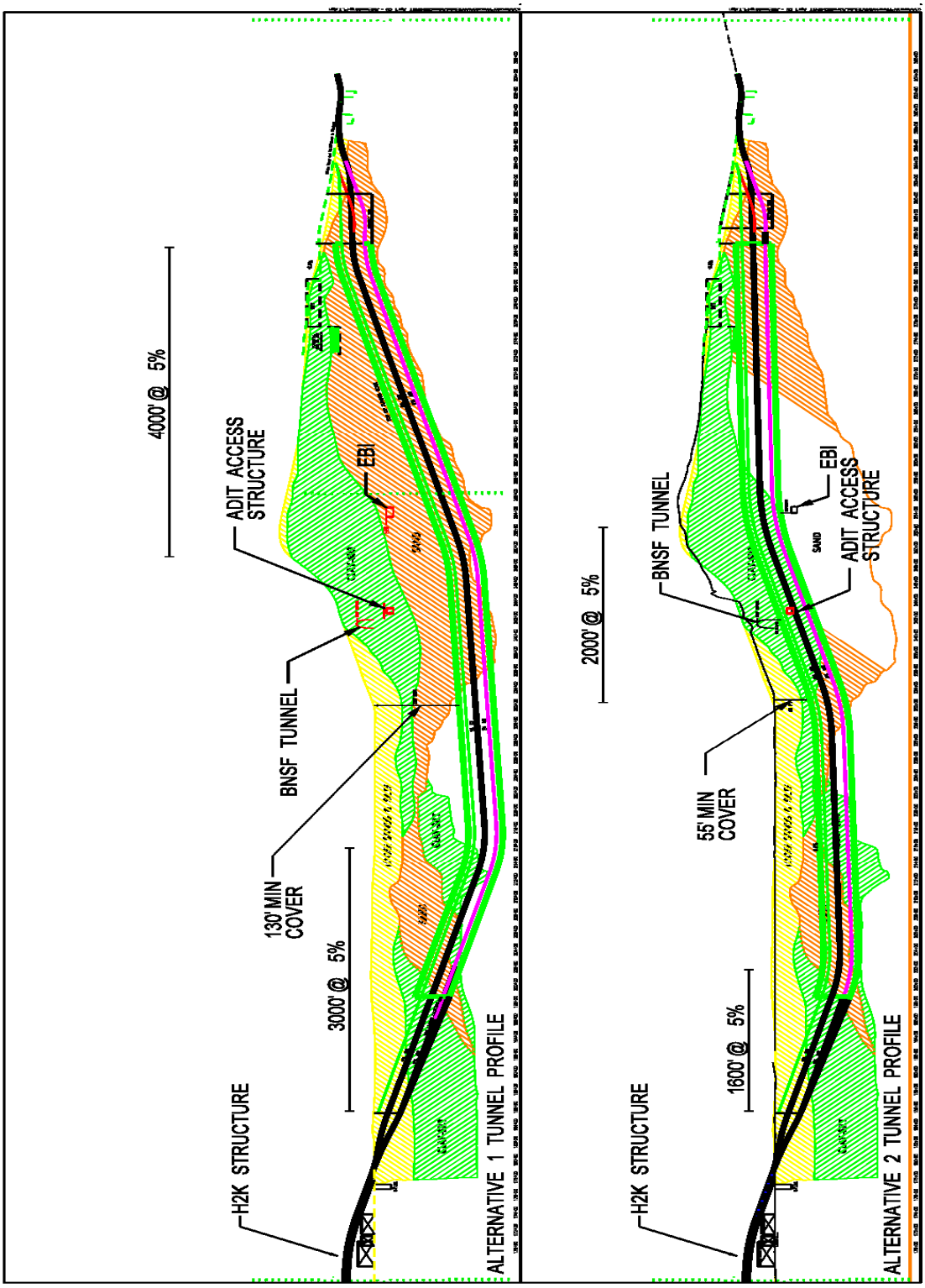

Figure 2. Alternative 1 and 2 Vertical Profiles

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6.0 Justification

Alternative 1 (Preferred Alternative) proposes nonstandard design elements for the SR 99 Bored Tunnel Project as follows:

- Northbound length of grade: 4,000 feet
- Southbound length of grade: 3,000 feet

The justifications for this recommendation are as follows:

1. Application of full standard roadway design could result in significant adverse impacts, including damages to or reinforcement for existing underground structures, lengthening of the tunnel to the north thereby impacting Mercer Street, drilling through unsuitable soils, and increasing the risk of settlement.

2. The proposed length of grades decreases settlement issues, avoids building foundations and right-of-way, shortens the tunnel, and provides adequate clearance to existing underground obstructions.

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7.0 Recommendation

Alternative 1 proposes a roadway configuration that provides sufficient roadway facilities to fully accommodate vehicular traffic. This alternative also considers the conditions inherent to the drilling process for a 54-foot-diameter tunnel balanced with appropriate roadway geometry. The proposed deviation would not adversely affect the safety or functionality of the vehicular traveled way. Impacts to high-value adjoining property would also be minimized.

This design requires that the length of grade deviate from design standards for the SR 99 Bored Tunnel Project. The Project Team recommends approval of this deviation based on the justifications discussed above.