REVIEW DRAFT

I-5 Columbia River Crossing Partnership: Traffic and Tolling Analysis

Columbia River Crossing Tunnel Options

Working Paper 12.31

Prepared by

Parisi Associates
David Evans and Associates, Inc.

December 6, 2004

TABLE OF CONTENTS

OVERVIEW

This working paper (WP) provides an overview of tunnel options for an I-5 Columbia River crossing within the Bridge Influence Area (BIA). This WP is based on design, travel demand modeling, and traffic operational assessments conducted as a part of the Portland/Vancouver I-5 Transportation and Trade Partnership study. This WP contains five sections:

1. Tunnel Parameters: A description of "short tunnel" and "long tunnel" options, including portal locations and interchange ramps served.

2. Tunnel Design Issues, Costs, and Impacts: A discussion of tunnel design considerations, cost estimating issues for underground feasibility studies, and impacts associated with tunnel construction.

3. Collector-Distributor Roadway System Required: A discussion of the necessary collector-distributor (C-D) system that would be required with a tunnel option.

4. Traffic Performance: A description of travel patterns and traffic performance under a tunnel and C-D roadway option compared to a Baseline scenario.

5. Conclusions and Recommendations: A recap of conclusions and a presentation of recommendations.

1.0 Tunnel Parameters

In 2001, as a part of the Portland/Vancouver I-5 Transportation and Trade Partnership study, three alternative concepts were developed to provide increased freeway and arterial capacity over or under the Columbia River by constructing a new bridge or tunnel to accommodate all I-5 freeway traffic. The ~~new facility would~~ Trade Partnership's tunnel concepts included three through lanes in each direction to be consistent with several of the bridge concepts proposed in that study. All three concepts were included under "Option Package No. 14: Columbia River Crossing with New Freeway Bridge or Tunnel."*

** (Note: Twenty "Option Package's" were developed in the first phase of the I-5 Transportation and Trade Partnership Study. These options considered the I-5 corridor between I-205 in Washington and I-84 in Oregon and were summarized in a report entitled "Draft Corridor Improvement Option Packages," for the Governor's Task Force Meeting dated March 20, 2001. In a later phase of the study, eight Columbia River Crossing Concepts for specifically accommodating traffic cross the Columbia River were developed. The bridge crossing concepts were described in a report entitled "Bridge Influence Area Summary Draft" dated April 19, 2002.)*

One bridge and two tunnel concepts were developed for Option Package No. 14. The bridge concept ~~would consist of~~ proposed a new high-level, fixed-span bridge just east of the existing northbound I-5 bridge, carrying all freeway traffic and connecting to the SR 14 and Hayden Island interchanges. The existing Interstate bridges were assumed to ~~ould~~ remain in place and new approach roadways would be constructed to provide direct arterial connections between downtown Vancouver and Hayden Island. The bridge concept is illustrated in attached **Figure 1.**

The tunnel concepts proposed~~consisted of~~ a “short tunnel” option and a “long tunnel” option. The short tunnel option would extend about 9,100 feet (1.7 mile) and have its northern portal near Mill Plain Boulevard and its southern portal just north of Marine Drive. Unlike the bridge concept that would accommodate traffic to and from all nearby ramps, traffic to and from Mill Plain Boulevard, SR 14, Hayden Island Drive, and Marine Drive would be unable to access the tunnel due to the location of the portals relative to the interchange ramps. Traffic to and from Fourth Plain Boulevard and Victory Boulevard could access the tunnel, but would be required to weave across multiple freeway travel lanes. The short tunnel concept is illustrated in attached **Figure 2.**

The long tunnel option would extend about 18,500 feet (3.5 miles) and have its northern portal near 20th Street and its southern portal near Victory Drive. Due to the length of the tunnel and portal locations, traffic to and from Fourth Plain Boulevard, Mill Plain Boulevard, SR 14, Hayden Island Drive, Marine Drive, and Victory Boulevard would be unable to access the tunnel. Traffic to and from SR 500 could access the long tunnel, but would be required to weave across multiple freeway lanes. The long tunnel concept is illustrated in attached **Figure 3.**

Both proposed tunnel options would retain the existing Interstate bridges. The existing bridges would be used for most, if not all, vehicle-trips between the interchanges not accessible by the tunnel, i.e., Fourth Plain Boulevard, Mill Plain Boulevard, SR 14, Hayden Island Drive, Marine Drive, and Victory Boulevard.

For constructability purposes, the short tunnel option, which would be shallowly placed under the Columbia River, was conceived to be constructed using immersed tube technology. The long tunnel option would be placed deeper under the Columbia River, as well as the North Portland Harbor and under land areas north of the Columbia River. The long tunnel option was therefore conceptualized as using bored tunnel technology. Cross-sections of both options are attached in **Figures 4 and 5** (please note, however, that the cross-sections show two travel lanes in each direction instead of three lanes).

2.0 Tunnel Design Issues, Costs, and Impacts

Although this working paper primarily addresses how traffic would perform with the tunnel options, it is also important to understand tunnel design issues, costs and their potential impacts.

A frequently cited rule-of-thumb in engineering is that tunnels cost two to three times as much as similar length bridges. In most situations, the cost savings associated with the benefits of tunnels are not sufficient to cover the initial capital cost disadvantage. Therefore, because of the high cost, tunnel sections are often designed at lesser cross-sectional standards than bridges to reach an economic balance between the cost of construction, maintenance, and operation; while still providing a safe facility.

Designs for the tunnels in Option Package No. 14 were only developed at a very conceptual level in the I-5 Transportation and Trade Partnership study. The tunnel sections shown in Figures 4 and 5 are examples of “minimal” sections required to move two lanes of traffic in each direction. The two tunnel types provide for 12-foot wide lanes with one to two feet of shoulder, which does not meet federal Interstate standards and would require design deviations/exceptions for approval. It is assumed~~Ideally,~~ the need for added lateral space is greater in longer tunnels because of the increased likelihood of collisions or disabled vehicles. Sections that meet design standards would add to the cost of construction, maintenance, operations, and environmental impacts.

Other design considerations that impact the size of the tunnel section is the need for ventilation, guide signing, and safety considerations such as safe egress for vehicle occupants in emergencies. From an operations standpoint, underwater tunnels typically~~ would~~ prohibit trucks carrying hazardous materials, while bridges~~ would~~ continue to allow them. And, bicycles and pedestrians are typically banned from long tunnels because of air quality, access, and safety issues.

As previously stated, tunnels are expensive. Cost estimates for the minimal sections for Option Package No. 14 were estimated at $750 million for the immersed-tube short tunnel option, and $2 billion for the bored long tunnel option (these estimates were from the "Development of Alternative Scenarios – Final Report" dated December 1, 1999, as part of the Portland/Vancouver I-5 Trade Corridor project). These estimates should be considered within the context in which they were made. These were 1999 estimates that were based on historical cost data that may not be well suited for estimating underground facilities today that must meet more stringent~~based on tougher~~ safety standards. A more precise~~better~~ estimate of tunnel costs will require more extensive design, analysis of risks, and an understanding of geotechnical conditions. However, based on the available preliminary information, the costs of a tunnel are estimated at two to four times more than a bridge.

Environmental impacts of tunnels are another important factor to consider. Both the short and long tunnel options require a massive amount of surplus excavation, both for the cut-and-cover sections for the approaches and for the bored or sunken-tube sections. For the short tunnels, the surplus excavation is estimated between 1-1.5 million cubic yards of material using the minimal sections. The long tunnel is estimated to create between 2 and 3.5 million cubic yards of material for disposal. Today's stringent~~high~~ environmental standards would make it very difficult to obtain permits to deposit that much surplus excavation.

3.0 Collector-Distributor Roadway System Required

Both the short and long tunnels would operate as mainline express lanes for I-5. For the short tunnel option, access would be restricted to the tunnel for traffic entering and leaving I-5 at Mill Plain Boulevard, SR 14, Hayden Island Drive, and Marine Drive. Access to Fourth Plain Boulevard and Victory Boulevard would also be impacted since the proximity of the interchange to the portals creates a~~due to the~~ short weave. None of these interchanges could be served by traffic using the long tunnel, with these impacts extending to SR 500. Because of the large number of I-5 vehicles entering and exiting I-5 within the area of the tunnels, an extensive collector-distributor (C-D) roadway system connecting all of these interchange ramps with auxiliary lanes parallel to I-5 would be required.

The designs for a C-D system required to handle projected traffic for the tunnel options was never developed in the I-5 Transportation and Trade Partnership study. However, a C-D system that closely mirrors the needs for the tunnel concepts was developed for one of the eight Columbia River Bridge crossing concepts described in the "Bridge Influence Area Summary Draft" dated April 19, 2002. "Bridge Concept 6" included a southbound C-D facility west of I-5 and a northbound C-D facility east of I-5, except where the C-D systems were combined to the west of I-5 on a consolidated bridge structure as they crossed the Columbia River.

Similar to the tunnel concepts previously described, the I-5 mainline in Bridge Concept 6 could not be accessed directly from many of the interchanges within the BIA, including SR 500, Fourth Plain Boulevard, Mill Plain Boulevard, and Hayden Island Drive, and only limited access could be provided to SR 14, Marine Drive, and Victory Boulevard.

Bridge Concept 6's C-D system is illustrated in the attached Figures 6 and 7**.** The C-D system would include segments with up to three lanes per direction, and would require new ramps including flyovers, new and widened bridges, roadway realignments, and extensive right-of-way acquisition.

Although Bridge Option 6 included three mainline I-5 through lanes in each direction (exclusive of the C-D system) on a bridge instead of within a tunnel, the C-D system and interchange connectivity issues are similar. Therefore, the traffic operations analysis that was performed for Bridge Option 6 can be used to estimate the performance of a tunnel alternative.

4.0 Traffic Performance

Travel demand modeling was performed to evaluate the BIA options as a part of the Portland/Vancouver I-5 Transportation and Trade Partnership study. A key finding of the modeling was that in the year 2020, about 70 percent of weekday a.m. peak period traffic traveling southbound within the BIA will enter or exit I-5 within the BIA. (The BIA is defined as the segment of I-5 between and including SR 500 and Columbia Boulevard.). And, during the p.m. peak hour, about 80 percent of northbound traffic will enter and exit I-5 within the BIA (see attached **Figure 8**).

Therefore, under either the Bridge Concept 6 with a C-D system, or a tunnel option that would need to include a similar C-D system, during peak periods 70 to 80 percent of the traffic demand would be on the C-D system. Only 20 to 30 percent of the traffic would use the I-5 mainline. These figures are ~~disproportional~~ vary significantly from theo typical freeway and C-D systems, where the freeway mainline accommodates most of the vehicle-trips.

Because traffic volumes using the limited access I-5 mainline would be low, the mainline, and therefore the tunnel, would only need to consist of two lanes in each direction, not three lanes as originally envisioned. As a result, the tunnel concepts would provide only 40% (2 of 5 lanes in each direction) of the lane capacity at the crossing while the C-C system would provide 60% (3 of 5 lanes in each direction).

~~However~~In contrast, ~~due to the number of vehicle-trips that would be required to use the C-D system~~there would be~~,~~ significant congestion would result in both directions along the C-D facility due to the number of vehicle-trips that would be required to use that system. According to detailed traffic operations results, the C-D system evaluated in Bridge Concept 6 would barely decrease I-5 vehicle hours of delay in the year 2020 compared to a Baseline scenario, where no additional vehicular capacity is provided across the Columbia River (see attached **Figure 9**).

It should be noted that the C-D system studied would have up to three lanes per direction and due to its location east and west of I-5's existing mainline, would result in substantial right-of-way acquisition. Provision of a C-D system with additional capacity would result in more extensive property impacts, as well as potential environmental concerns.

The tunnel option with C-D system would be the worst perfoming option~~perform the worst~~ from a traffic operations perspective compared to other BIA improvement concepts~~s~~ evaluated as a part of the Portland/Vancouver I-5 Transportation and Trade Partnership study. River crossing concepts that performed better included providing five lanes in each direction (Bridge Concept 4) and providing four lanes in each direction plus a two-lane arterial connection between downtown Vancouver/Hayden Island/Marine Drive (Bridge Concept 7).

According to VISSIM traffic simulation modeling of 2020 conditions, average travel speeds for the tunnel with C-D system would be similar to those experienced under a Baseline scenario. This is especially true on weekdays between 7:30 a.m. and 9:00 a.m. and between 3:30 p.m. and 6:00 p.m. Travel times would also be similar (see attached **Figures 10, 11, 12, & 13**).

Due to congestion at the C-D roadway ramp junctions, vehicles accessing the C-D's ramps would experience considerable queuing and delays, in fact, substantially more than under the 2020 Baseline scenario. During the weekday a.m. peak period, on-ramps to the southbound C-D roadway would be impacted at SR 500, Mill Plain Boulevard, and the City Center entrances. During the p.m. peak period, on-ramps to the northbound C-D roadway would be impacted at Columbia Boulevard, Marine Drive, Hayden Island Drive, and Mill Plain Boulevard. In some cases, back-ups would extend past the ramp terminals, affecting traffic flow along the arterial roadways (see attached **Figures 14 and 15**).

5.0 ~~Conclusions and Recommendation~~Findings and Summary

This WP provides an overview of tunnel options for I-5 within the BIA. This WP is based on design, travel demand modeling, and traffic operational assessments conducted as a part of the Portland/Vancouver I-5 Transportation and Trade Partnership study. The following is a summary of key ~~conclusions and recommendations~~findings:

- Provision of an I-5 tunnel would preclude direct interchange ramp access to and from Fourth Plain Boulevard, Mill Plain Boulevard, SR 14, Hayden Island Drive, Marine Drive, and Victory Boulevard. Access to/from SR 500 would be difficult.

- To serve traffic to and from these ramps, as well as across the Columbia River, a comprehensive C-D roadway system with auxiliary lanes would be needed. This system would consist of two- to three-lane C-D roads and would require new ramps including flyovers, new and widened bridges, roadway alignments, and extensive right-of-way acquisition.

- Due to travel patterns, by 2020, 70 to 80 percent of the traffic using I-5 in the BIA would be required to use the C-D system and only 20 to 30 percent would use the mainline tunnel. Traffic demands would create an imbalance based on tunnel lanes providing about 40% of the total I-5 capacity to serve 20 to 30% of the demand. The remaining three bridge lanes would need to serve 70-80% of the demand with about 60% of the available capacity.

- The over-reliance on the C-D system would result in substantial congestion. In fact, compared to a Baseline scenario, a tunnel with a C-D system would function similarly in terms of vehicle hours of delay, travel speeds, and travel times, but many of the ramp terminals would experience congestion that would back-up to the arterial roadways themselves.

- The mainline tunnel's demand would only require two lanes in each direction, but would cost at least $750 million for the short tunnel option and $2 billion for the long tunnel option, excluding the costs of the extensive C-D roadway systems. If interstate design standards are required, the costs will be much higher.

- Tunnel construction would generate massive amounts of surplus excavation, estimated between 1 million to 3.5 million cubic yards of material, depending on whether a short or long tunnel is used.

- From a traffic operations perspective, lower-cost options including river crossings that provide five lanes in each direction (Bridge Option 4) and river crossings that provide four lanes in each direction, plus a two-lane arterial connection between downtown Vancouver/Hayden Island/Marine Drive (Bridge Option 7), would perform substantially better than a tunnel and C-D option.

References:

"A Policy on Geometric Design of Highways and Streets, 1994", pp. 387-391, American Association of State Highway and Transportation Officials.

V.S. Romero and J.M. Stolz, "Cost Estimating for Underground Transit: Too Dangerous to "Guestimate", pp 186-190, Track 4 – The Capital Projects Process, Cost Control.