TECHNICAL MEMORANDUM

I-5 Columbia River Crossing
Bridge Influence Area (BIA) Conceptual Engineering
Qualitative Concept Assessment

Date: November 8, 2004 **Project** #: 6780.02B

To: Geoff Larkin

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cc: Project Team

We have reviewed the concept plans provided by each jurisdiction. This document summarizes observations we have about the Washington State (WSDOT) and Oregon State (ODOT) concepts.

OVERVIEW AND SUMMARY

There is a clear distinction between WSDOT and ODOT concepts related to highway design practices. It appears the WSDOT concepts as developed will not sufficiently address contemporary design, operations, safety, and FHWA policy requirements without significant modification. We believe when the WSDOT concepts are developed to address these specific points, the impact areas in and around the corridor will far exceed the footprint currently conveyed on the plans. We believe the bi-state team should be aware of these potential issues and develop a strategy that will ensure the project development process can proceed as smoothly and efficiently as possible.

QUALITATIVE CONCEPT ASSESSMENT

To conduct a detailed peer review of all the concepts would be a major task. Our approach was to highlight potential design concerns quickly without the benefit of all background information. These concerns were conveyed through key words on figures while the narrative below provides a better understanding of the potential design deficiency.

Horizontal Alignment

There are several key elements to consider when establish a horizontal alignment. At a 30 percent functional design level one attempt to minimize surprises during the advance design stages that could drastically change the potential right-of-way impacts. The design features listed below are a few of the critical elements.

Broken-Back Curves

AASHTO recommends that "broken-back" arrangement of curves (with a short tangent between two curves in the same direction) should be avoided. The preponderance of successive curves in opposite directions may develop a subconscious expectation among drivers that make successive curves in the same direction unexpected.

Compound Curves

AASHTO recommends that caution should be exercised in the use of compound curves. Where topography or right-of-way restrictions make their use appropriate then the larger radius should not smaller radius by more than 50 percent. Compound curves with large differences in radius introduce the same problems that arise at tangent approaches to circular curves (Sharp curves should not be introduced at the ends of long tangents.).

Reverse Curves

According to AASHTO, successive curves in opposite directions with super-elevation require the sufficient tangent length to develop the required run-out and run-off lengths for each curve between the curves.

Off-Ramp, On-Ramp and Loop Ramp Design

The following factors are critical in the determination of the length of an off-ramp: deceleration length necessary from freeway design speed to ramp speed (especially in the presence of a sharp curve), stopping sight distance to the back of queue, and the anticipated 95^{th} percentile queue at controlled terminal intersection. For on-ramps, it is critical to know the speed differential between the ramp and the freeway to determine the required acceleration length, as well as the location of the on-ramp to meet the necessary sight distances. In addition, unconventional left-hand ramps should be avoided to maintain design consistency and driver expectation. Further, the number successive off- and/or on-ramps and the spacing between these ramps are critical due to required signing to assist the decision process of the driver. It is often recommended to combine two or more ramps allowing only one access point to the freeway system to minimize "friction" along the main-line traffic.

Lane Balance

The questions listed below need to be revisited with the traffic volumes anticipated for the specific road sections to determine the required number of lanes.

- Is it possible to serve four interchanges by one single-lane off-ramp from the freeway to the C-D road system and/or one single-lane on-ramp from the C-D road system to the freeway?

- Is it possible for two lanes to serve four lanes (e.g. continuation of two lanes plus a double-lane off-ramp)?
- Is it appropriate to have a lane trap, especially where two lanes diverge into two single lanes facilities?

Profile

A simple profile consists of a sag vertical curve, a tangent section followed by a crest vertical curve. The vertical curves need to conform to the design speeds, and the vertical grade to the classification of the roadway. The vertical grades for a freeway system is relatively flat that would require a longer distance between the structure and the gore of the ramp. In addition, the location of merge-point and diverge-points at ramps in relation with the ramp profile is also critical due to sight distance requirements.

Lane Changing

A collector-distributor (C-D) road system reduces weaving along the main-line freeway. The WSDOT concepts try to protect the main-line traffic by introducing the C-D system and still accommodating the current accesses within the BIA. However, the concepts require numerous lane changes over short distances between freeway ramps and C-D ramps to the local street systems. This results in unreasonable decision making distances and introduces very short weaving sections.

Gore Overlap

Where there is a ramp between the freeway and C-D road, it is important to provide the necessary "gore overlap." For example, the intension of a specific ramp is to provide a connection from the C-D road to the freeway; the gore overlap will prohibit motorists by using the ramp from the freeway to the C-D road (in the reverse diagonal direction).

Assessment Comments

The attached figures illustrates our design concerns related to the functional layouts of Concepts 1, 4, 6 and 7. In addition and with the limited available time, we thought it would be helpful to provide more specific feedback regarding the WSDOT concepts especially just north of the Columbia River, because the concepts do not conform to contemporary design, operations, safety, and FHWA policy requirements.

WASHINGTON STATE (WSDOT) CONCEPTS

We have generalized the topics into three general categories related to the concepts: Bridge head; Northbound C-D system; and Southbound C-D system. The following discussion summarizes issues in each category. This section is followed by more detailed observations for each concept in the bridgehead area.

Bridgehead

This area is complex given the close proximity of SR 14, service access to and from downtown Vancouver, and the beginning of the north and southbound C-D system. Each of the concepts requires modifications (some rather extensive) to conform to contemporary geometric design practice. These modifications would be needed to assure the roadway could physically be constructed and signed to meet operations and safety needs. Without changes, it would appear impossible to obtain FHWA approval. We believe the required changes will expand the impact area into a greater area, including the Columbia River. Specific changes are likely needed for:

- Providing appropriate I-5 mainline alignments and ensuring adequate numbers and arrangements of lanes
- Improving the vertical and horizontal geometric design of ramps for the SR 14 interchange
- Increasing ramp spacing between successive ramps serving SR 14 and the Northbound C-D road system
- Achieving attainable ramp profiles in the Bridge head area
- Validating constructability and identifying impacts of temporary roadways

Northbound C-D System

The proposed C-D system concept is a valid potential solution. Changes appear to be required to provide appropriate horizontal and vertical alignments between the Bridgehead and Mill Plain. Minor improvements are needed along its length to assure adequate and safe traffic operations. These changes could result in increased right of way and impacts not currently anticipated based on the current plans.

Southbound C-D System

In concept the proposed C-D system is also valid, however the current concept requires extensive revisions to conform to contemporary design practice and achieve desired operational objectives. As presently configured, the schemes are over ambitious in their plan of serving all local access via a C-D system. The conceptual layout requires extensive redesign to meet driver expectations, to provide adequate signing, and to achieve desired traffic operations. The required changes for the Southbound C-D, which are more extensive than the Northbound C-D, would likely result in more extensive impacts than are anticipated based on the current plans.

Summary

The complexity of these concepts can be attributed to the effort to maintain access to both State Routes (14 and 500) and both City arterials (4th Plain and Mill Plain). Retaining all access is a reasonable consideration, however, the appropriate design required to provide this access would be more impacting than the current concepts depict. While the FHWA supports “flexibility in design”, there are minimum design requirements that must be met to provide a safe and effective plan.

The close proximity of SR 14 to the Columbia River and the constraints of the downtown, Pearson Airpark, and Fort Vancouver create a challenging design task. The current concepts attempt to reduce these impacts while at the same time, keeping the interchange influence area off the Columbia River. Unfortunately, the concepts developed within these constraints deviate significantly from contemporary design practice. In some cases the plans may not be constructible nor will they achieve acceptable operational and safety performance.

We appreciate the efforts and challenges undertaken by previous designers. However, we are concerned that the concepts dramatically underestimate the likely impacts when applying contemporary design principles. In addition, while the completed design concepts will likely require deviations from "full standard" designs, we believe the current concepts may not be constructible in some cases and create operational and safety deficiencies in others.

The northbound and southbound C-D concepts will require modifications; particularly southbound, which has more locations needing attention than the northbound system. The "fixes" for the C-D system are relatively straight forward compared to the bridgehead concepts. Adjustments to the C-D system will likely increase the footprint of the schemes. The following discussion focuses on the bridgehead area since changes to the current concepts to attain minimum AASHTO policy objectives could significantly affect the bridge concepts.

BRIDGEHEAD CONCEPTS

Concept 1

This concept uses the existing bridges for the northbound movements. The current southbound bridge will carry three mainline lanes and the current northbound bridge will be for the northbound 3-lane C-D roadway. The future southbound traffic will have a new 5-lane bridge over LRT.

Design issues/ locations requiring review

- The southbound I-5 mainline has horizontal alignment deficiencies including compound curves leading to back-to-back (little to no tangent between) reverse curves
- The northbound C-D road and I-5 mainline should be physically separated
- The SR 14 ramp to northbound I-5 profile and connection to the northbound C-D road appears unattainable. SR 14 loop ramp to southbound I-5 horizontal alignment and lane drop in combination with profile that appears unattainable given the shortened ramp and I-5 profile that must be climbing to clear LRT

Concept 4

This concept has a new double deck structure over the existing northbound structure. The new mainline bridge will be 6 lanes northbound and 5 lanes southbound. A new bridge would be constructed west of the existing bridges to serve LRT.

Design issues/ locations requiring review

- The concept appears nearly impossible to construct (building in the location of the existing northbound bridge) while maintaining current I-5 crossing volumes. Potential use of the future LRT for temporary southbound I-5 traffic would require an extensive temporary roadway that would impact City land and close much of the SR 14 interchange
- The southbound I-5 mainline has horizontal alignment deficiencies including a "broken back curve", short curve lengths, and insufficient radii to meet design speeds
- The northbound I-5 mainline has short curve lengths and broken back alignment
- The northbound exit to SR 14 does not comply with contemporary design practice for a two-lane exit. The distance to the split to downtown is half of the 800 feet described by AASHTO. In addition, this connection has back-to-back reverse curves that will not allow appropriate super-elevation
- The northbound I-5 exit to the northbound C-D does not comply with contemporary two-lane exit design. In addition to violating AASHTO policy by dropping two mainline lanes, the plan depicts a ramp with a profile that appears unattainable

Concept 6

This concept maintains the I-5 mainline on the existing lift bridges over the Columbia River. A new 4-lane bridge would be built west of the existing bridges as part of the north and southbound C-D system for distribution of local traffic and LRT.

Design issues/ locations requiring review

- Northbound I-5 as three successive off ramps with spacing of about 750 feet and 300 feet between the Vancouver ramp and the C-D road. AASHTO states 1000 feet is the minimum spacing to meet operational and signing needs
- The SR 14 ramp to the southbound C-D road has horizontal alignment inconsistent with a State Route ramp and a profile that appears unattainable
- The profiles for ramps connecting to the northbound C-D road appear to be unattainable

Concept 7

This concept splits the I-5 mainline over three bridges by using the two existing lift spans and adding a new three lane bridge on the east side. A combination LRT and local street bridge would be constructed west of the existing bridges. I-5 northbound would have three lanes on the new bridge and a fourth lane on the existing northbound bridge. Southbound I-5 will have three lanes on the existing southbound bridge and a fourth lane on the existing northbound bridge. Two bi-directional lanes (HOV, express, or reversible lanes) would use the existing northbound bridge.

Design issues/ locations requiring review

- Northbound and southbound I-5 mainline is reduced to <u>two basic lanes</u>. Northbound this occurs just beyond the SR 14 exit; the right lane drops as an auxiliary lane to the northbound C-D as the express lane is added. Southbound this occurs as the left lane is

trapped as and express lane and the right lane is added as an auxiliary lane from the southbound C-D road

- Northbound I-5 has an 800 foot, two-sided weave between the express lane and the exit to the northbound C-D road
- The northbound exit to SR 14 does not comply with contemporary design practice and would need to lengthened to provide adequate deceleration
- The northbound exit to the C-D road does not comply with contemporary practice for length and reverse curves
- The northbound I-5 entrance ramp from SR 14 has a profile that appears unattainable
- The SR 14 ramp from the express lanes has a profile under the railroad and over the northbound mainline that appears unattainable

CLOSING

We appreciate the extensive amount of analysis completed over the years; and recognize our review was performed quickly without the benefit of all background information. We trust our technically objective comments are viewed as opportunities to reduce project risks as the project development process proceeds. We look forward to working with all design staff to clarify how our observations may not be valid. Similarly, we offer our assistance in working with design staff to mitigate potential design issues.

Please contact me at (503) 228-5230 if you have any questions regarding this project.