ODOT0000-0364

Technical Memorandum

To:

From:

Date: July 25, 2007

Subject: ODOT Contract No. 16902 – I-5 Trade Corridor Study Phase II
Technical Memorandum, Option Package 6

6.0. OPTION PACKAGE 6: EXPRESS BUS WITH CORRIDOR-WIDE CAPACITY INCREASE

Road Network Description

Option Package 6 involves operation of directional express bus transit service in I-5 HOV lanes between Clark County and downtown Portland. It also includes I-5 widening for a fourth travel lane in each direction between I-405 and I-205 and would require additional Columbia River Bridge crossing capacity.

Key features of this option package include the following:

- Widens I-5 from 134th Street to approximately I-405 to support operation of three general purpose lanes and one HOV lane in each direction
- Results in a directional corridor HOV system from 134th Street to approximately I-405
- Includes additional Columbia River crossing capacity compatible with 4-lane, 6-lane and 10-lane bridge crossing concepts
- Includes HOV specific facility treatments such as a directional HOV/express bus connection between I-5 and SR 14 to/from the south.

As currently proposed, Option Package 6 will only be designed and evaluated as an HOV system and not also as a reversible lane system. Option Package 7 will be modeled (but not designed) only as a reversible lane system for performance comparison to the Option Package 6 HOV system. If reversible lane system performance is deemed promising under Option 7, a reversible lane system may be evaluated for Option Package 6 and designed under Option Package 7.

River Crossing Options

Option Package 6 results in an 8-lane freeway corridor on both sides of the Columbia River. Columbia River Bridge crossing concepts under this option package are consistent with a 4-lane bridge concept shown previously under Option Package 2, or with 6-lane and 10-lane bridge concepts. This option package will be modeled and designed with 6-lane and 10-lane bridge concepts as described below.

- **4-Lane Bridge:** This option package is compatible with a new supplemental four-lane bridge as shown with Option Package 2 (See **Figures 2-3 and 2-4**). This bridge increases Columbia River crossing auto capacity to 10 lanes and results in removal of the existing I-5/Hayden Island interchange. However, a four-lane bridge concept will not be modeled or designed with this option package because performance of such a facility will be tested under Option Packages 2 and 3.

- **6-lane Bridge:** A new 6-lane bridge concept is depicted in **Figure 6-3**. As shown, this concept provides a new eastern mainline express bypass facility with no interchange access between Marine Drive and SR 14. The new bridge would peel off from the I-5 mainline in Oregon and Washington and would be configured with two general purpose lanes and one HOV lane in each direction. Access to Marine Drive, Hayden island, and SR 14 would continue to be provided from the I-5 mainline across the existing I-5 Columbia River Bridges.

  As shown, this option carries 12 roadway lanes across the Columbia River (6 each direction) serving local access and through trips. This option provides an opportunity to use one of the existing I-5 structures for LRT. Engineers will determine the number of lanes that can feasibly be retained for auto use across the existing I-5 Bridge structures while tying blending back in to the mainline on each end of the new bridge. This bridge concept will be modeled and designed with Option Packages 6 and 7.

  A detailed 6-lane Bridge concept with number of lanes and ramp connections is shown in **Figure 6-4**.

- **10-lane Bridge:** A new 10-lane bridge concept is depicted in **Figure 6-5**. This concept provides a new 10-lane Columbia River crossing with three general purpose lanes, one HOV lane, and one auxiliary lane between Hayden Island and SR 14 in each direction. This bridge would replace the existing I-5 bridge structures. Engineers will determine if grade constraints of this type of structure allow LRT to be carried on the structure versus needing an adjacent LRT only bridge. This bridge concept will initially be modeled and designed with Option Package 6 only. Based on performance results, it may be modeled and designed under Option Package 7.

  A detailed 10-lane Bridge concept with number of lanes and ramp connections is shown in **Figure 6-6**.

- **Tunnels:** Engineers will continue to review the feasibility of 4-lane and 6-lane tunnel options. Refer to March 20, 2001 option package description report for schematics.

- **Connections:** HOV connections between I-5 and I-405 (Fremont Bridge) need to be conceptually designed

Option Description

<u>ROADWAY</u>

Rose Quarter

Mark Johnson Text

I-405 to Victory

Roadway

<u>Victory Blvd. to Lombard St.</u>

The roadway portion of the 4th lane option will be very similar to Option package 1(d), utilizing the same ‘split diamond’ configuration for the Victory – Columbia interchange and with similar exit and entrance points as previously described. The main differences of the 4th lane option is the wider roadway cross section of I-5 to provide room for the HOV lanes and the proposed alignment shift of I-5 south of Columbia Blvd. The alignment shift was proposed to better use the existing freeway R/W and minimize residential impacts. The centerline alignment of I-5 would be moved easterly between Lombard St. and through the Columbia Blvd. area. This would be done using a combination of horizontal curves that would hold the westerly edge of pavement to approximately the same location as it would be with earlier options.

<u>Lombard St. to Portland Blvd.</u>

The existing northbound and southbound freeway section between Lombard St. to Portland Blvd. is failing due to the close proximity of the entrance and exit ramps. The proposed option under consideration is to remove the weaving section from the freeway by grade separating (‘braiding’) the ramps. The southbound exit for Portland Blvd. would be moved to a point under the Lombard St. structure, with the southbound entrance ramp from Lombard ‘braiding’ over the modified exit ramp. The existing Lombard St. entrance loop would be removed and replaced with a double left turn, westbound to southbound, on Lombard St. The additional left turn lanes on Lombard St. would require widening both east and west of the freeway. Access control and closures of some street approaches would be necessary on Lombard St. to preserve the operation of the ramp signals.

A similar configuration to the southbound would be used in the northbound section, with the Portland Blvd. entrance ramp 'braiding' over the northbound exit to Lombard St. The exit loop to Lombard St. would also be removed with this configuration. The ramp terminals on Lombard St. would be moved closer together to minimize impacts to adjacent properties.

The southbound and northbound 'braided' ramps would need to be two lanes wide due to their length. The northbound exit and southbound entrances from Portland Blvd. would be modified to reconnect into the widened cross section of I-5. An additional left turn lane on Portland Blvd. appears to be necessary to handle future traffic volumes. Access control and closures of some street approaches would also be necessary on Portland Blvd.

Some streets adjacent to the freeway between Lombard St. and Portland Blvd. would need to be cul-de-saced or realigned due to direct impact of the ramps or to reconnect circulation cut by the ramps.

Portland Blvd. to Going St.

This existing section has a partial, local access interchange to Alberta St. between the Portland Blvd. interchange and the Going St. interchange. The proposal for this section of freeway is to remove the partial interchange at Alberta St., create a southbound auxiliary lane between Portland Blvd. and Going St. and better define the southbound exit to Going St. The new southbound ramp would intersect directly into Going St. just west of the u-xing structure. The Alberta St. u-xing would be retained for local movements. The northbound freeway section would have an acceleration lane from the Going St. entrance loop that would merge into the additional lane created at the I-405 entrance ramp (see later description). The additional northbound lane from I-405 would drop at the new braided ramp exit to Lombard St.

Going St. to I-405

The southerly beginning and terminus of the proposed HOV lanes would at the I-405 connection with I-5. The northbound HOV lane would have a 'direct connect' from the I-405 northbound entrance ramp. This would be accomplished by exiting HOV traffic from the ramp and constructing a 'fly-over' structure over the northbound I-5 lanes and dropping the HOV lane down into the middle of the freeway. The northbound traffic on I-5 that wants to use the HOV lane could later merge with the lane created by the direct connect ramp. Locations for merging and diverging areas in and out of the HOV lane where not identified with this study. There may be additional impacts created by the widths necessary to locate these areas.

The southbound HOV lane would terminate from I-5 with a 'direct connect' ramp to the southbound exit ramp from I-5 to I-405. The HOV lane profile grade would raise up from the middle of the freeway and 'fly-over' the southbound I-5 lanes on a structure and then connect into, and merge with, the I-405 southbound ramp.

Additional width in the median of the freeway was assumed to provide minimal shoulder width offsets to the proposed fly-over structures.

The proposed layout for this section includes a southbound auxiliary lane between the Going St. entrance and the I-405 exit. The I-405 exit ramp would be a two-lane exit with a drop lane to terminate the auxiliary lane. The northbound section assumes a two-lane entrance ramp from I-405 with one auxiliary lane extending to Going St. and the additional lane extending north to Portland Blvd. This section has not been shown to provide adequate capacity for operation. Further study will be necessary to determine what lane requirements or ramp configuration is needed to accommodate the traffic.

The existing 'trumpet' interchange style was selected for the Going St. interchange. The heavy northbound to westbound movements appeared to require a free-flow style connection. The ramps were reconnected to fit the widened freeway cross-section. Access control will be necessary along Going St. up to Interstate Ave. to preserve the operation and safety of the ramp terminals.

Structures

Victory Blvd. to Lombard St.

The structures through this section, as previously stated, would be similar to the structure details in Option Package 1(d). Additional widening would be necessary along the westerly and easterly side of the Columbia Slough structure due to the widened cross section of I-5. The easterly side of the Columbia Slough structure would also be wider, including some extension of the northbound exit ramp to Columbia Blvd. onto the structure.

Retaining walls and relocated soundwalls would be necessary along the easterly side of the freeway between Lombard St. and Columbia Blvd. Additional retaining walls to retain the fill from the widened roadway would be required along the easterly side of I-5 north of the Columbia Slough. All other walls for this isolated section would be similar to those described in Option Package 1(d).

Lombard St. to Portland Blvd.

Both the Lombard St. and Portland Blvd. freeway crossings will be replaced with this option. Both streets would need to be widened over the structure to provide for double left turns at the ramp terminals. Both structures would include bike and pedestrian accommodations.

The 'braided' ramp structure southbound could be either a rigid frame or 'regular' structure. The southbound ramps will require extensive walls between the ramps and along the R/W. Tie-back or cantilever type walls appear to be necessary. There may some difficulty in constructing these walls with the close proximity of the residences. Soundwalls will be impacted, and will likely be relocated on top of the proposed walls.

The northbound 'braided' structure will be very long and will need to 'straddle' over the exit ramp. For feasibility, it was assumed that supports would need to be integrated into the proposed wall along the R/W. Profile grades will be very tight with this option.

The pedestrian structure across I-5 in this section will need to be removed due to conflicts with the braided ramps. Pedestrian movements would need to be handled over the Lombard and Portland structures.

Portland Blvd. to Going St.

The Ainsworth St., Killingsworth St. and Alberta St. u-xings will need to be replaced with this option. Retaining walls will be continuous on both the east and west sides of the freeway. Soundwalls will be impacted, and will likely be relocated on top of the proposed walls.

Going St. to I-405

The Going St. and Skidmore St. u-xing structures will need to be replaced with this option. Retaining walls will be continuous on both the east and west sides of the freeway between Going St. and I-405. These retaining walls would need to extend westerly along the north and south side of Going St. Soundwalls will be impacted, and will likely be relocated on top of the proposed walls.

The existing pedestrian structure between Going St. and I-405 would be impacted and would need to be relocated to provide pedestrian accommodation east and west.

The direct connect HOV ramps will require extended walls in the median to effect the grade change to clear the freeway lanes. The fly-over structures will likely require 'straddle' bents for support over the freeway. Some widening of the southbound I-405 ramp structure appears necessary to merge the HOV traffic.

- Typical Sections (Connie)
- Deviations from Standards

Deviations from Standards

Victory Blvd. to Lombard St.

(See Option Package 1(b) for detail)

Access management and Highway Plan policies give recommended distances for separation of freeway interchanges. The close proximity of the existing interchanges may require deviations for policies. Federal Highway policies for modification of access to the freeway will need to be followed, and will require formal approval of these proposals.

Lombard St. to Portland Blvd.

No roadway design deviations were identified.

As above, access management, Highway Plan and Federal policies will come into play.

Portland Blvd. to Going St.

No roadway design deviations were identified.

Access management and Federal Policies were one of the main reasons for the proposal to remove the Alberta St. ramps. There would still be review and approval required on a Federal level for this section. As before, deviations may be necessary for access and Highway Plan policies.

Going St. to I-405

The direct connect HOV ramps may require minimal acceptable vertical and horizontal geometry. The NCHRP report 'HOV Systems Manual' was used for much of the planning elements of the HOV layout. Some of the recommendations from this manual differ from standard freeway designs due to the exclusiveness of the HOV lanes. Some of the recommended values will need to be approved for use on Oregon state highways.

As above, access management, Highway Plan and Federal policies will come into play.

- ROW Impacts

R/W Impacts

Victory Blvd. to Lombard St.

In an attempt to maximize the existing R/W and minimize the impacts, the I-5 centerline was shifted to the east north of Lombard St. The shift avoided multiple impacts to the west side of the freeway, but three residences would be impacted on the east side. These appear to be direct impacts to the buildings with three relocations, but further data would be necessary to know precisely. All other impacts in this isolated section would be similar to those described in Option Package 1(d).

Lombard St. to Portland Blvd.

The proposed braided ramps will impact the adjacent city streets, with some residential property impacts and a small number of building takes. There would be approximately (X) number of residences impacted (Connie – I need to talk to Abner to get the exact number on these). Traffic circulation and driveway approaches to adjacent properties are not clear and may cause additional impacts not identified in the study.

Portland Blvd. to Going St.

The main impact through this isolated section will be the realignment of the adjacent city streets caused by the widened freeway section. Some property impacts appear necessary. No built impacts or relocations have been identified.

Going St. to I-405

As discussed in the 'Roadway' portion for this section, the northbound weaving section proposed between I-405 and Going St. may not provide adequate capacity and operations. Some alternative to the current design will likely require R/W and would impact the homes adjacent to the freeway. Some modification of the freeway alignment may be possible to minimize this potential, but there was not sufficient time to determine this in this study.

The proposed layout has several property and residence impacts on the easterly side of the freeway. The approximate number of residential impacts is (X) – (Connie –I need to have Canh give you the number for this, and he won't be back till Tuesday of next week… I hope you can work with this for now.)

The modified portion of Going St. between the freeway and Interstate Ave. will have residential and commercial impacts on both sides of the street. The approximate number is (X)… (need to talk to Canh.) The city street approaches along this stretch of Going will need to be closed and made into right-in, right-out connections. The closures may require additional property in this area.

There may be indirect impact issues with the proposed southbound HOV fly-over ramp. The ramp will be elevated and be very close to Kaiser Hospital. No direct impacts are anticipated.

- Costs (Jack)
- Figure 1 – Option Schematic (Connie)

Victory to Marine Dr.

Hardy Li Text

STRUCTURE - 6-LANE BRIDGE

Roadway

The mainline of the 6-lane bridge section is designed with three lanes in each direction (1 HOV and 2 General Purpose) between Marine Drive and Mill Plain in both directions. This provides a total of 6-lanes for the new river crossing, 8-lanes elsewhere. Operation of the existing I-5 bridge structures is maintained. At the Vancouver site, the developed downtown and the Fort Vancouver Historical Reserve constrain the corridor. As a result, the northbound Mill Plain access ramp (from I-5 and SR14) must be cantilevered over the freeway between SR14 and Mill Plain if these connections are to be accommodated on the widened freeway with minimal impacts to the adjacent properties.

By maintaining the existing I-5 bridge structures, connections to Hayden Island remain in their current locations. For this reason, there are no impacts to the existing circulation system in this area.

The northbound connection to SR14 as well as the southbound connection to I-5 from SR14 also remain in their current locations. However, to alleviate weaving between Mill Plain and SR14, the southbound off-ramp to SR14 and the Mill Plain on-ramp are braided. For safety reasons, the Mill Plain on-ramp merges with the mainline south of the new 6-lane bridge touchdown point (approx. 7th Street). Northbound, a structure separate from the existing SR14 to I-5 structure is used for a direct SR14 to Mill Plain/Fourth Plain connection. This connection merges with the relocated I-5 off-ramp to Mill Plain/Fourth Plain which is the result of braiding this ramp with the SR14 northbound on-ramp.

Additionally, although not shown, a southbound slip ramp connecting to 6th St. could be provided if warranted.

Direct HOV connections are provided (northbound and southbound) between the new 6-lane structure and SR14 to eliminate the need for HOVs to change lanes south of the southern touchdown point (approx. 1500' south of Marine Drive) to access the GP SR14 connection, which requires use of the existing bridge structures. Accommodating these connections requires a split in the new 6-lane structure at SR14, as they are left-hand merge/diverges.

At Marine Drive, the southbound on-ramp and off-ramp to Interstate Avenue are braided. Due to the future light rail line planned for the area, the location of the Interstate Avenue diverge remained in its existing location, requiring the southbound Marine Drive on-ramp to be on structure through the wetland area to the west of Expo Road and merging with the mainline near Victory Boulevard. Northbound connections from the mainline to Marine Drive remain predominantly the same.

Structural Design

Main River Crossing

The 6 Lane Bridge alternative over the Columbia River is conceptualized as a concrete segmental type with a bascule moveable span over the navigation channel. The Span layout could be comprised of (south bank to north bank) 260'-540'-270'-540'-540'-280'(Bascule Draw Span)-320'. Currently the existing dual bridges provide a horizontal clearance of 263 feet between the lift spans piers over the main navigation channel. The lift span provides a 39-foot vertical clearance above the Columbia River Datum (also refereed to as zero gage or low water) when closed, and a maximum of 178 feet when fully raised. An increase vertical clearance of 58 feet is provided at the alternate barge channel beneath the bridge's fixed 531-foot truss span. South of the 531-foot span, a vertical clearance of 72 feet is provided between prier 6 and 7 and piers 7 and 8; these spans are outside of the maintained channel limits. The assumed profile of the 6-lane bridge has the bridge deck elevation over the navigation channel at 145 feet in the closed position. This is compared to the existing twin I-5 bridges which has a deck elevation of 45'feet(+-) in the closed position. The 6 lane bridge will function with the exiting I-5 Bridges in operation. The new bridge is conceptualized to have a bascule moveable span, that when open provided unlimited vertical clearance. The deck elevation of 145 feet was assumed based on the vertical restriction associated with Person Airpark. The airpark airspace restriction is approximately at 175 feet; with the deck at 145 feet this should allow lights, signs and trucks to pass without infringing into the airspace.

Major Considerations

- *Superstructure Type* - The superstructure section could be a multi-cell trapezoidal concrete box girder built by the balanced cantilever method. The cross section varies in depth from maximum depths over the interior piers to 10' at midspan. A suggested depth to span ration would be 1/20 at the pier, and 1/50 at midspan (but no less than 10 feet). The parabolic soffit resulting from the variable structure depth coupled with the sloping webs of the box girder provides a dramatic aesthetic appearance, similar to the Glenn Jackson (I-205) Columbia River Crossing.

- *Column Type* - The river pier columns could consist of two 6' by 20' shafts spaced longitudinally 24' on center. The purpose of these twin wall shafts is to provide longitudinal stability during balanced cantilever erection, and then to provide longitudinal flexibility for the large time dependent displacements experienced by this type of bridge in the final service condition. The piers for the moveable span would with be solid 20' X 120' rectangles, housing the bascule lift span drive motors, and if a vertical lift span is utilized, the bridge would most likely be two bridges with 4 towers to lift the large deck section.

- *Foundations* - The two end transition piers are on land at the riverbanks, and the remaining interior piers are all in the river. For the river piers, a footing size of approximately 36' by 36' (non-moveable piers) is required. Deep foundation elements may be either driven piles or drilled shafts.

Larger diameter drilled shafts may be preferable to limit the construction impacts of noise and vibration normally associated with driven piles.

- *Construction Procedures* - The river piers may be constructed by conventional methods using cofferdams. This features braced sheet piling walls, driven piles, underwater tremie concrete pours, and extensive pumping of the water inside the cofferdam to allow construction of the remainder of the pier footing and columns in the dry. This foundation type features footings that are founded below the river bottom. Because contractors assume a high risk with this type of foundation construction, costs are generally high for the cofferdams.

  The river piers may also be constructed as water level foundations. This foundation makes use of a precast concrete lost footing form. The form has a bottom and four sides approximately 15' high. The bottom has holes for piling or in this case, large diameter drilled shafts. The drilled shafts are installed with permanent casings from the water level down below the bottom of the river. The precast footing form is lifted and placed over the top of the shaft casings and supported by hangers from the casings. Underwater tremie concrete is placed in the bottom of the form to allow pumping out the water to construct the remainder of the footing in the dry. However, in this configuration, the bottom of footing is at a much higher elevation, requiring a smaller tremie pour due to the reduced hydrostatic head. This type of foundation is generally less costly, because the contractor risk is lowered.

  Superstructure construction could be by the balanced cantilever method. The concrete superstructure may be either cast-in-place or precast, however for the 500' span range (anticipated for this crossing), cast-in-place has been more widely used and is the recommended construction type. Segments are cast in pairs using form travelers, and typically two segments are cast per one week cycle. Segment lengths may vary between 10' and 15', with the shorter lengths occurring near the piers where the sections are heavier.

- *Construction Duration* - Substructure construction could be expected to take about 3 months per main river pier. Construction of the land-based piers could overlap with the construction of the river piers. Therefore substructure construction would be dependant on the actual type of bridge selected and the spans over Columbia River. Superstructure construction is dependent on the number of form travelers utilized (overhead erection equipment). With an average segment length of 12', one would calculate the numbers of segment pairs comprise each cantilever (½ span). Assuming a one-week cycle per segment pair, superstructure construction could be approximated with only one pair of travelers. Total construction time with mobilization and demobilization could be readily calculated once a conceptual span arrangement is determined. This schedule could be accelerated with the use of additional travelers.

STRUCTURE - 10-LANE BRIDGE

Roadway

The mainline of the 10-lane bridge section is designed with four lanes in each direction (1 HOV and 3 General Purpose) plus an auxiliary lane between Hayden Island and SR14 in both directions. This provides a total of 10-lanes for the river crossing, 8-lanes elsewhere. On the Vancouver site, the developed downtown and the Fort Vancouver Historical Reserve constrain the corridor. As a result, the freeway must be double decked between SR14 and Mill Plain if all the ramp connections are to be accommodated on the widened freeway with minimal impacts to the adjacent properties. Construction of the 10-lane bridge assumes full replacement of the existing bridges. As a result, connections to Hayden Island and SR14 need to be reestablished.

On Hayden Is., the ramps will not be able to connect at the current locations. As a result, the existing circulation system for the Hayden Island area will need to be extensively modified.

The northbound connection to SR14 would diverge from the bridge onto an independent structure. This ramp would then split with one ramp going to downtown Vancouver via a loop and the other connecting to SR14 eastbound. The ramp to SR14 begins at such a high elevation that it cannot connect to SR14 before conflicting with the existing Columbia Way interchange. Therefore, it is assumed a braided ramp would be constructed at Columbia Way to accommodate both ramps.

In the southbound direction, the SR14 ramp would diverge north of Mill Plain, braiding with the Mill Plain on-ramp (discussed below). This ramp would connect to SR14 at approximately the same location as the existing ramp but would be lowered to approximately the elevation of I-5 currently. Additionally, a slip ramp connecting to 6th St. could be provided if warranted.

From SR14, the northbound connector would braid with the Mill Plain/Fourth Plain off-ramp, providing a split to optionally exit to Mill Plain/Fourth Plain instead of entering the freeway. The southbound connector would cross under the I-5 mainline then rise to connect to the mainline at approximately the location of the ship navigation channel. This ramp is two lanes to incorporate an HOV bypass of the ramp meter.

Note, due to the high elevation of the bridge, a connection from downtown Vancouver to I-5 is not possible. Vehicles needing to go southbound would access I-5 at Mill Plain Blvd.

Structural Design

Main River Crossing

The 10 Lane Bridge alternatives over the Columbia River is conceptualized as a concrete segmental type without a lift or a bascule moveable span over the navigation channel. The Span layout could be comprised of (south bank to north bank) 260’-540’-270’-540’-540’-280’minimum (280 horizontal clearance is documented to be deficient, therefore Coast Guard and river users to be consulted for preferred horizontal clearance)-320’. Currently the existing dual bridges provide a horizontal clearance of 263 feet between the lift spans piers over the main navigation channel. The lift span provides a 39-foot vertical clearance above the Columbia River Datum (also refereed to as zero gage or low water) when closed, and a maximum of 178 feet when fully raised. An increase vertical clearance of 58 feet is provided at the alternate barge channel beneath the bridge’s fixed 531-foot truss span. South of the 531-foot span, a vertical clearance of 72 feet is provided between prier 6 and 7 and piers 7 and 8; these spans are outside of the maintained channel limits. The assumed profile of the 10-lane fixed span bridge has the bridge soffit (underside of Bridge) elevation over the current main navigation channel at 178 feet. This is compared to the existing twin I-5 bridges which has a deck elevation of 45’feet(+-) in the closed position and when the moveable span is open the maximum vertical clearance is 178 feet. The 10 lane bridge will function without the exiting I-5 Bridges in operation (existing I-5 Bridges Demolished). The resulting deck elevation of 200 feet over the current river navigation channel assumes a 300-foot span for main river navigation channel and a structure depth of 20 feet at the piers and 10 feet at midspan. A deviation to Person Airpark airspace will be required for this alternative. Alternative profiles could be examined which would shift the navigation channel to the south, but this could adversely affect the ramp connections to Hayden Island. With any alternative an in-depth analysis of current and future river navigation needs and uses should occur, reductions in the 178 foot clearance could be possible facilitating an improve profile and touchdown to Hayden Island and Vancouver.

Major Considerations

- *Superstructure Type* - The superstructure section could be a multi-cell trapezoidal concrete box girder built by the balanced cantilever method. The cross section varies in depth from maximum depths over the interior piers to 10’ at midspan. A suggested depth to span ration would be 1/20 at the pier, and 1/50 at midspan (but no less than 10 feet). The parabolic soffit resulting from the variable structure depth coupled with the sloping webs of the box girder provides a dramatic aesthetic appearance, similar to the Glenn Jackson (I-205) Columbia River Crossing.

- *Column Type* - The river pier columns could consist of two 6’ by 20’ shafts spaced longitudinally 24’ on center. The purpose of these twin wall shafts is to provide longitudinal stability during balanced cantilever erection, and then to provide longitudinal flexibility for the large time dependent displacements experienced by this type of bridge in the final service condition.

- *Foundations* - The two end transition piers are on land at the riverbanks, and the remaining interior piers are all in the river. For the river piers, a footing size of approximately 36’ by 36’ is required. Deep foundation elements may be either driven piles or drilled shafts. Larger diameter drilled shafts may be preferable to limit the construction impacts of noise and vibration normally associated with driven piles.

- *Construction Procedures* - The river piers may be constructed by conventional methods using cofferdams. This features braced sheet piling walls, driven piles, underwater tremie concrete pours, and extensive pumping of the water inside the cofferdam to allow construction of the remainder of the pier footing and columns in the dry. This foundation type features footings that are founded below the river bottom. Because contractors assume a high risk with this type of foundation construction, costs are generally high for the cofferdams.

  The river piers may also be constructed as water level foundations. This foundation makes use of a precast concrete lost footing form. The form has a bottom and four sides approximately 15' high. The bottom has holes for piling or in this case, large diameter drilled shafts. The drilled shafts are installed with permanent casings from the water level down below the bottom of the river. The precast footing form is lifted and placed over the top of the shaft casings and supported by hangers from the casings. Underwater tremie concrete is placed in the bottom of the form to allow pumping out the water to construct the remainder of the footing in the dry. However, in this configuration, the bottom of footing is at a much higher elevation, requiring a smaller tremie pour due to the reduced hydrostatic head. This type of foundation is generally less costly, because the contractor risk is lowered.

  Superstructure construction could be by the balanced cantilever method. The concrete superstructure may be either cast-in-place or precast, however for the 500' span range, cast-in-place has been more widely used and is the recommended construction type. Segments are cast in pairs using form travelers, and typically two segments are cast per one-week cycle. Segment lengths may vary between 10' and 15', with the shorter lengths occurring near the piers where the sections are heavier.

- *Construction Duration* - Substructure construction could be expected to take about 3 months per main river pier. Construction of the land-based piers could overlap with the construction of the river piers. Therefore substructure construction would be dependant on the actual type of bridge selected and the spans over Columbia River. Superstructure construction is dependent on the number of form travelers utilized (overhead erection equipment). With an average segment length of 12', one would calculate the numbers of segment pairs comprise each cantilever (½ span). Assuming a one-week cycle per segment pair, superstructure construction could be approximated with only one pair of travelers. Total construction time with mobilization and demobilization could be readily calculated once a conceptual span arrangement is determined. This schedule could be accelerated with the use of additional travelers.

    South Approaches

    North Approaches

STRUCTURE - TWIN TUBE TUNNEL

Roadway

The tunnel section is designed to provide a total of 4-lanes of capacity (1 HOV and 1 general purpose) to supplement the existing 6-lane freeway section between Marine Drive and Mill Plain Blvd. The south tunnel portal would be located approximately 800' south of the Marine Drive interchange. The north portal will be located approximately 500' north of the SR14 interchange. The tunnel profile assumes the use of cut and cover box and immersed tube tunneling techniques. In the vicinity of the portals, the existing freeway will be flared to accommodate the tunnel approaches in the center of the freeway. The tunnel approaches extend 1000' south and 1600' north of the tunnel portals. Flaring of the freeway in the Marine Dr. vicinity will require reconstruction of the Marine Dr. northbound off-ramp and southbound on-ramp. The Marine Dr. overpass will also require reconstruction. Flaring the freeway in the SR14 vicinity will require reconstruction of the southbound I-5 to SR14 off-ramp and SR14 to northbound I-5 on-ramp. The Evergreen Blvd. overpass will also require reconstruction.

The HOV lane and the center most general purpose lane in each direction would be directed into the tunnel, bypassing the Marine Drive, Hayden Island, and SR14 interchanges. Access to these interchanges will remain on the existing surface system.

Structural Design

The Columbia River tunnel Crossing could be immediately to the west or east of the existing I-5 Bridges. At this location, the river is approximately one-half mile wide. There are a number of tunnel types distinguished by the method of tunneling. Three broad range categories include, cut-and-cover, Immersed tube, and bored tunnels. A profile for an immersed tube tunnel has been prepared, but alternatively a bored tunnel section could also be developed. Both types would utilize sections of cut-and-cover tunnels as transition tunnel segments across land for immersed tubes, or as portals for bored sections. For example for an Immersed Tube, at grade segments of the alignment could transition to a cut-and-cover for land crossing, and then transitioning to immersed tube for water crossings. U-shaped retained cut section would extend along the alignment from the area, which the highway starts a downward grade and reaching a depth below ground providing enough clearance for the highway traffic and cut-in-cover structure to be completely below ground. At this point the tunnel would be cut-in-cover.

Cut-in-cover construction would continue until water crossing sections are needed, at which time the tunnel would switch to an immersed tube section, transitioning back to cut-and-cover when reaching land again. Alternatively a bored tunnel would start with a U-shape retained cut, transiting to cut-and-cover, then to a bored section. The difference coming from once a bored section is started the tunnel boring equipment will continue from the south side of Portland harbor until reaching evergreen blvd in Vancouver. For this study either alternative is a viable tunnel alterative, but an immersed tube was selected for profiling due to its ability to daylight sooner, making the overall length shorter.

- *Construction Techniques*- For the landside tunnels (on Hayden Island, south of Portland Harbor, and in Vancouver) could include cut-in-cover methods and bored or mined methods. The subqueous portion of the tunnel (below water) could be accomplished by two different methods: bored using Earth Pressure Balance Tunnel Boring Machines (EPB TBM), or, by dredging a trench in the river bottom and placing a prefabricated tunnel sections in the trench and backfilling over the tunnel. This method is referred to as Immersed Tube. Immersed Tube tunnels generally require less depth below the river bottom than bored tunnel sections do. Since they are shallower, the Immersed Tube can transition back to an at grade alignment quicker that bored tunnels.
- *Typical Section*-
  - *Immersed Tube*- Immersed Tube tunnels are tunnel sections, which are, prefabricated in convenient lengths (usually 300 to 400 feet), floated the site, and then placed into a predredged trench, jointed, connected and protected by backfilling the excavation. The sections may be prefabricated with steel or concrete in temporary construction basins serving as dry docks. In the United States, immersed tubes have been used successfully for subaqueous transit and highway tunnels since the 1930's. As an alternative to dredging a trench with side slopes, the trench could be excavated and the tubes placed in a cofferdam in the River. However, the cofferdam could pose a serious obstacle to river traffic.
  - *Bored Tube*- Twin Bores (drilled tunnels) have been successfully constructed with diameters from the teens, up to 50 feet. The cross-section that would be necessary for this alternative configuration would be comprised of twin 35-foot diameter bores. This would provide the necessary clearance to facilitate two lanes of traffic, shoulders, and emergency/maintenance walkway in each tunnel bore. The tunnel sections are constructed by first constructing a entrance portal tunnel or drop shaft, then a Tunnel Boring machine is inserted to drill the section under

land obstructions and water. Since the minimum cover above a bored tunnel is approximately one tunnel diameter (a general "rule of thumb" for soft ground tunneling), the depth of the tunnel below the existing river bottom would increase as compared to an immersed tube tunnel. This in turn, would increase the overall tunnel length since it will take longer to transition to an at-grade south of Portland Harbor and north into Vancouver. Generally the larger the diameter the higher the capital cost start up, which in turns necessitates a longer tunnel to keep this tunneling method cost effective.

- *Property Sensitivity*- The conceptual tunnels, could pass beneath business, highway overpasses and or private property. Similar situation are in existence in San Francisco, Los Angeles, Chicago, New York, Boston, Baltimore, and Atlanta just to name a few. The issue one must be concerned about is the potential ground settlement that may occur within a calculated settlement tough around the tunneling operations. Many factors will affect whether a property is at risk of settling, some factors include, tunnel techniques, depth of tunnel below ground, soil, foundation and design of the affected property improvement. Detailed investigation should occur to assess the risk and potential remedies to offset tunneling effects.
- *Benefits and Impacts*-
  - Immersed tubes tunnels:
    - Shorter in length that a bored tunnel
    - Large in water open excavation required
    - Possible future limitation river dredging
    - Large landside disruption in cut-in-cover section approaching water crossings
    - Would required open cut sections across Hayden Island, through Vancouver, and South of Portland Harbor.
  - Bored tunnels:
    - Would avoid all in-water construction in the Columbia River
    - Could result in significant construction impacts to tunnel portal areas in North Portland and Vancouver. Large tunnel staging area requirements, muck (tunnel waste) removal, and cut-and-cover transition areas.
    - Would probably not transition to at-grade section until north of Mill Plain Blvd and south of Marine Drive.

Mill Plain to SR500

Between Mill Plain Blvd. and SR500 in Vancouver, the proposed design includes widening of the mainline to provide a total section of four through lanes (1 HOV and 3 General Purpose). Additional lanes were added as auxiliary lanes between interchanges where the space between ramps was inadequate to provide for a merge and a diverge from the highway. Widening of the highway will require replacement of the existing overpasses for 29th St., 33rd St., and SR500, and widening of the Mill Plain and McLaughlin overcrossings.

Interchanges were modified based upon the schematic design developed at a workshop held with DOT and consultant team members on June 29, 2001. The design concept included braiding most of the ramps to and from the existing interchanges. Ramps to be braided include:

Northbound

- Fourth Plain on-ramp with SR500 off-ramp: The new diverge point for the SR500 off-ramp would begin on the north side of the Fourth Plain overpass. The Fourth Plain on-ramp would pass over the SR500 off-ramp, merging with the highway near the 29th Street overpass. The Fourth Plain on-ramp would also have an split to allow traffic to decide between accessing I-5 Northbound or SR500 Eastbound. Braiding of these ramps will require reconstruction of the 29th St. and 33rd St. overpasses.

Southbound

- SR500 on-ramp with Fourth Plain off-ramp: The diverge point for the Fourth Plain off-ramp would be moved to the area between the 39th St. off-ramp and the SR500 overpass. The new ramp would align to the west side of the SR500 on-ramp, cross under the 39th St. on-ramp, and parallel the highway to connect to the existing interchange area. The design currently includes a connection between SR500 and Fourth Plain Blvd via a short weaving area. This weave takes place within the same zone that includes the SR500 to mainline weave and may negate the advantages of braiding the ramps. As a result, further study of the ramp configuration is recommended during the subsequent alternatives analysis to determine the need for this connection and, if warranted, whether the correct design approach is to braid the ramps at this location.
- Fourth Plain on-ramp with Mill Plain off-ramp: The diverge point for the Mill Plain off-ramp would be moved to approximately the same location as the existing Fourth Plain off-ramp diverge. The Mill Plain ramp would rise and crossover both the Fourth Plain on-ramp, which is left mostly unchanged from the existing configuration, and Fourth Plain Blvd. Much of this ramp will be on structure because of the need to clear Fourth Plain.
- Mill Plain on-ramp with SR14 off-ramp: To mitigate an existing short weave distance between the Mill Plain on-ramp and the SR14 off-ramp, the SR14 off-ramp diverge point would be move to the north edge of the Mill Plain underpass, braid over the Mill Plain on-ramp and make a connection to SR14 via the ramp included in the design for each of the river crossing options. The Mill Plain on-ramp would offer the option, via a mid-ramp split, to go to either I-5 southbound or SR14 eastbound.

This design segment also includes a connector between SR500 westbound and the 39th St. northbound on-ramp providing a direct connection between SR500 and northbound I-5.

During the I-5 HOV study, performed by Parsons Brinckerhoff, the observation was made that in Vancouver I-5 functions as both a regional and local connector. To improve performance of I-5, these two traffic types could be separated via a barrier creating, what is in affect, a bypass system through Vancouver for the regional traffic. This option would require additional widening of the freeway to accommodate all the lanes, but would eliminate the need to extensively braid the interchanges. Separation of the freeway would occur north of SR500 and south of SR14, although the river crossing options that include a bypass bridge could connect into the regional route. Lane configurations would likely include 3 lanes on the bypass (1 HOV and 2 General Purpose) and 2 lanes on the "local" system plus any necessary auxiliary lanes between interchanges. It is recommended that this option be revisited in future studies along with the braided ramp option shown.

SR500 to I-205

OPTION DESCRIPTION

This option creates 4 lanes (1 HOV and 3 General Purpose) each direction on I-5 between SR-500 and just prior to the merge with I-205 at 134th Street. Through the traffic analysis auxiliary lanes are warranted between the 39th and Highway 99/Main Street interchange and also between the 78th and 99th street interchanges. This effectively makes the option 5 lanes in each direction at these locations. The team was charged with minimizing impacts to the existing structures that are currently in construction or which were recently constructed. In order to accomplish this, some design exceptions to the typical section will be necessary. This option also includes widening for Express Bus and HOV bypass lanes at the Highway 99/Main Street and 99th Street south bound on-ramps.

Typical Sections
See attached.

DESIGN EXCEPTIONS

The newly constructed Highway 99/Main Street, 78th Street and 99th Street interchanges, and the CCRR bridge are the locations where the typical section does not meet the WSDOT standards. The design varies from the standard in order to keep from impacting those structures. The distance from the center travel lane to the center barrier will be 2 feet where 12 foot minimum is required by WSDOT standards. Additionally in these same locations the outside shoulder widths will be 6-7 feet. WSDOT standards call for 10 foot minimum shoulders. At the section from the Highway 99/Main Street interchange to the CCRR bridge, the non-standard section length is approximately 1000' on the southbound side and approximately 2800' on the northbound side. At the 78th Street interchange the non-standard section runs for approximately 3100' and approximately 3000' at the 99th Street interchange.

ROW IMPACTS

Minimal impacts are expected between the 78th Street and 99th Street interchanges. The frontage roads will be pushed out approximately 12' from their current location, which may potentially require additional right-of-way and/or temporary construction easements.

This option's improvements have the potential of creating a need for additional treatment areas the locations of, which has not yet been determined. The required total area is estimated to be approximately 2.4 acres. For details, see the Water Quality Estimate Memorandum, August 30, 2001.

COSTS

$_______ for I-5 improvements to 4 lanes
$_______ for HOV bypass lane widening
$2,091,750 for park and ride facility construction

Total $_______

FIGURE 1 – OPTION SCHEMATIC

See attached.

Typical Sections

Deviations from Standards

ROADWAY

Rose Quarter

I-405 to Victory

Victory to Marine Dr.

STRUCTURE - 6-LANE BRIDGE

Roadway

The improvements shown were designed using the standards of the appropriate DOT jurisdiction.

Structural Design

Mike Traffalis Text

STRUCTURE - 10-LANE BRIDGE

Roadway

The improvements shown were designed using the standards of the appropriate DOT jurisdiction. Two deviations from standard were noted. On the northbound off-ramp from I-5 to SR14/Downtown Vancouver, the downtown Vancouver leg of the ramp has a profile grade of 7%. On the SR14 to southbound I-5 ramp, a profile grade of 6% is required to cross under the I-5 mainline and connect to the mainline at a reasonable distance from Hayden Island. A maximum of 5% is considered standard. There is limited opportunity to modify the I-5 to Vancouver ramp to accommodate a lesser slope. The 6% slope on the SR14 to I-5 ramp could be reduced if either the ramps is extended south or I-5 is kept at a higher elevation in the proximity of the crossing.

Structural Design

Mike Traffalis Text

- Pearson Airspace

STRUCTURE - TWIN TUBE TUNNEL

Roadway

The improvements shown were designed using the standards of the appropriate DOT jurisdiction.

Structural Design

Mike Traffalis Text

Mill Plain to SR500

The improvements shown were designed to the standards presented in the WSDOT Highway Design Manual and no deviations from standard were noted.

SR500 to I-205

ROW Impacts

ROADWAY

Rose Quarter

I-405 to Victory

Victory to Marine Dr.

Marine Dr. to Mill Plain

6-Lane

10-Lane

Construction of the 10-lane bridge will require limited additional right of way for the main structure. However, reconstruction of the many ramps will require the acquisition of additional right of way. Key impacts include a service station on Hayden Island, the parking lot for the Western Region headquarters of FHWA,

4-Lane Tunnel

Assuming the use of cut and cover tunnel construction techniques, right of way impacts are expected on Hayden Island to perform excavation. Impacted properties on Hayden Island include Waddles Restaurant, Safeway Marketplace, Doubletree Hotel. South of the Oregon Slough, a boat sales dealership would be impacted. North of the Columbia River, one developed parcel (building use unknown) is expected to be impacted by the tunnel construction. Most of the other work will take place within the existing public right of way.

A total parcel take of xxx acres and xxx structures was identified.

Mill Plain to SR500

Most of the right of way acquisition required within this section I-5 results from the construction of the braided ramps. Northbound, the majority of the property take will be north of Fourth Plain and will include the half block bounded by I-5 on the west and K St. on the east. In the southbound direction, the new off-ramp location to Fourth Plain will impact a number of residential properties.

A total parcel take of xxx acres and xxx houses was identified.

SR500 to I-205

Costs

Figure 1 – Option Schematic