PATTULLO BRIDGE PROJECT

DISCUSSION OF ISSUES WITH SEPARATE OR COMBINED ROAD & RAIL BRIDGES
The purpose of this memo is to summarize the technical feasibility of providing a combined road / rail bridge as an option for the replacement of the Pattullo Bridge as well as to document the findings of a high level comparison between a road only bridge option and the combined road / rail bridge option.

1.0 COMBINED ROAD / RAIL BRIDGE TECHNICAL FEASIBILITY

In the previous TransLink Pattullo Corridor Study, completed in May 2008, a specific sub study was undertaken to determine the feasibility of combining a new two track rail bridge with a new high level road bridge. This proposed combined structure would replace the existing New Westminster Rail Bridge and the existing Pattullo Bridge.

The preliminary analysis undertaken in the previous study concluded that replacing the existing Pattullo Bridge and the existing New Westminster Rail Bridge with a combined road / rail structure is technically feasible. Key design parameters and limitations stemming from the previous analysis are described below.

Based on an analysis of current and future river traffic and input from stakeholders, a minimum shipping channel of 150 metres x 43 metres has been estimated for the rail bridge or a combined road / rail bridge. Using conservative geometric design parameters for railway alignments, it is clear that a railway crossing with a 43 metre vertical clearance is not achievable in the study area. As such a moveable span will be required for the rail portion of a combined road / rail structure and that the railway alignment will dictate the location of a combined road / rail structure.

A number of rail alignments were considered to achieve a 20 metre vertical clearance under the moveable part of a combined road / rail bridge. The 20 metre vertical clearance will avoid excessive bridge openings for marine traffic in future years, therefore maintaining the bridge downtime at current levels (rail capacity anticipated to be slightly higher with two tracks). A single track tunnel with a 290 metre radius was found to be required on the New Westminster side of the river to assist in gaining the required elevation. This alignment was developed considering a number of constraints at the site in particular those resulting from the existing SkyTrain infrastructure.
Based on the limitations presented by the rail alignments, only two corridors or “zones” have been identified for the combined road rail structure. These zones, shown in Exhibit 1, have been defined based on the following assumptions:

- The combined road / rail bridge would need to be constructed in a separate alignment from either the existing rail bridge or the existing Pattullo Bridge as both rail and vehicular traffic on the existing bridges would need to be maintained during construction of the proposed road rail bridge.

- The combined road / rail bridge would need to be offset at least 50 metres from the existing Pattullo Bridge and the SkyTrain bridge to avoid impacts to the foundations of these existing structures during construction of the proposed road rail bridge.

- The north zone, Combined Structure Zone 1, is shown to be approximately 200 metres in width. This maximum width is controlled by the ability to connect into the limited road corridors available on the New Westminster side of the river and in this case, the McBride Boulevard corridor.

- The width of the north zone is also limited by the rail alignment and the ability to gain elevation to a 20.0 metre clearance at the river without affecting the rail grades / elevations approaching the CN Rail Thornton Yard.

Exhibit 1
Road / rail alignments outside of the Combined Structure Zone 1 or Zone 2 as shown on Exhibit 1 cannot achieve an elevation across the river much more than the existing rail bridge. Any such alignments are not recommended for further consideration.

Any road / rail alignment option in Combined Structure Zone 1 or Zone 2 has the ability to accommodate the new six lane road cross section for the Pattullo Bridge element. A possible split section of the road portion was considered as a plausible configuration for the combined bridge, with the lift span of the rail element being located in the centre or between the two road sections.

2.0 COMPARISON OF ROAD / RAIL AND ROAD ONLY BRIDGE OPTIONS

As indicated, a high level comparison between a road only bridge option and a combined road / rail bridge for the replacement of the Pattullo Bridge was undertaken. The comparison is based on advantages and disadvantages of each option with respect to several institutional as well as technical screening issues.

The screening results are summarized in the following tables. The first table, Table 1, identifies institutional issues, while the second table, Table 2, identifies more technical issues. The severity / criticalness of each issue has been colour coded (based solely on our judgment) from red (most critical) to yellow (minor) to neutral (green).

Additional information related to the project cost and specifically a high level comparison between completely independent road and rail bridge structures and the combined road / rail bridge is discussed below and summarized in the Table 1.

Project Cost Comparison

Two possible solutions for the road / rail option are assessed in this report:

Option 1: Build the road and rail bridges with the same spans, split the roadway deck and raise the rail lift span up the middle, between the two directions of vehicular traffic.

Option 2: Optimize the span of both bridges and build the rail bridge beside the road bridge and share only a few common piers.
For both options, the following general assumptions have been made:

- The rail bridge lift span is similar for the rail only bridge and the combined road / rail bridge.
- The mechanical / electrical components of the rail only bridge are similar as those required for the combined road / rail bridge.

To compare options at a high level, independent road and rail bridge structures have been assumed as the base case. In this base case, the road and rail bridges are completely independent and sized for optimal spans. Only the spans over the Fraser River have been considered in this high level assessment with the assumption that the shore approaches would be similar for the base case and the combined road / rail bridge options. Using past experience and engineering judgment, it is anticipated that the optimal spans for the road bridge would consist of approximately 300 metres for the main span with approximately 150 metres for the side and approach spans. The rail bridge main span (the lift span) is anticipated to be optimized at approximately 160 to 170 metres with 75 metre approach spans. Based on these assumptions for the base case and noting the vertical clearance required for the navigational channel, it is anticipated that the rail bridge represents about 1/3 of the cost of the road bridge.

For Option 1:

- The road bridge deck will be more complicated and slightly wider compared to the base case, due to the split in the roadway to allow the lift span to rise above the road deck. Assuming a two track railway bridge, a separation between the two roadway bridge decks is estimated to be approximately 12 metres. This separation of the two roadways would require additional planes of cable stays which would result in an increased deck area of approximately 10% to primarily account for the space to anchor the additional planes of cable stays. This additional deck area would increase the cost of the road bridge element by a similar amount of about 10%. The other road bridge spans are otherwise unaltered from the assumed optimal span lengths and therefore no additional costs are anticipated in this area. This increased road deck area cost would therefore increase the overall cost of the road / rail bridge option by approximately 7% as compared to the base case (noting the general assumption that the rail bridge represents approximately 1/3 the cost of the road bridge).

\[
\Delta = \frac{\text{Combined Bridge} + \text{Increase}}{\text{Base Case (Road & Rail Bridge)}} = \frac{(1 + \frac{1}{3}) + (1 \times .1)}{(1 + \frac{1}{3})} = 1.075
\]
• There will be some anticipated minor savings in the common bridge piers since the pier columns can support both the rail and the road superstructures. However, the savings are anticipated to be minor at the main pier that supports the lift span of the rail bridge since the pier structure needs to house a significant amount of the mechanical equipment for the lift bridge and will likely need to be separate from the road bridge piers due to the width differences in the road and rail superstructures. Assuming that the foundations represent 30% of the rail bridge cost and that half of the foundation costs for the rail bridge element could be reduced, an overall savings of approximately 4% could be potentially achieved with this combined road / rail bridge option (again noting the high level assumption that the rail bridge over water is approximately 1/3 of the cost of the road bridge).

\[ \Delta = \frac{\text{Combined Bridge - Reduction}}{\text{Base Case (Road & Rail Bridge)}} = (1 + \frac{1}{3}) - (\frac{1}{3} x 0.5 x 0.3) = 0.9625 \]

• Some minor savings in the common pier substructures are anticipated as both the road pier and rail pier can sit on the same footing. This may potentially result in a 2% overall savings as compared to the base case.

• By forcing longer spans onto the railway bridge (150 m vs 75 m) except for the lift span element, an approximate 30% premium to the rail bridge superstructure cost would be anticipated. Assuming that the superstructure is approximately 50% of the rail bridge cost, this premium relative to the base case is estimated at an additional 4%.

\[ \Delta = \frac{\text{Combined Bridge + Increase}}{\text{Base Case (Road & Rail Bridge)}} = (1 + \frac{1}{3}) + (\frac{1}{3} x 0.5 x 0.3) = 1.0375 \]

• In aggregate, Option 1 could represent a cost premium of nearly 5% relative to the base case based on the following potential increases and savings:
  o 7% increase – bridge deck;
  o 4% savings – piers and foundations;
  o 2% saving – pier substructures;
  o 4% increase – rail bridge superstructure.

For Option 2:

• The piers and superstructures of the road bridge and the rail bridge will be the same as for the two independent bridges (base case).

• The only link between the two bridges is a few of the foundations, which will likely result in less costs when compared to completely independent foundations. Again, by assuming that the rail bridge over water is approximately 1/3 of the cost of the road bridge over water and that 50% of
the cost of the railway foundations could be reduced, the estimated savings could be in the range of 4% overall relative to the base case. This estimate assumes that the foundations represent 30% of the rail bridge cost.

**Project Cost Comparison Summary**

For Option 1, it is anticipated that the complexities and inefficiencies would likely more than offset any savings derived from shared foundations. The non-optimal railway spans also tends to make this option more costly.

For Option 2, it is anticipated that the cost savings of sharing a few piers for the combined road / rail bridge will be minor (4%) as compared to the base case. Therefore, for comparative purposes at this level, it is anticipated that the cost of building independent road and rail bridges will be essentially the same as building a combined road / rail bridge.
Table 1 – Institutional Issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Road Bridge</th>
<th>Combined Road/Rail Bridge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Cost</strong></td>
<td>For comparison purposes, the Project Cost would include a new road bridge and separate rail bridge.</td>
<td>Likely the same as separate road and rail bridges. However, combined bridge structure could potentially be slightly lower.</td>
<td>We expect that the cost of building independent road and rail bridges will be essentially the same as building a combined road/rail bridge. We can anticipate two possible solutions for the road/rail option: 1. Build the road and rail bridges with the same spans, split the roadway deck and raise the rail lift span up the middle. 2. Optimize the span of both bridges and build the rail bridge beside the road bridge and share only a few common piers. For the split deck option, the complications and inefficiencies would likely more than offset any savings derived from shared foundations. For the side-by-side bridges, the cost savings of sharing a few piers is expected to be quite minor.</td>
</tr>
<tr>
<td><strong>Sharing / Funding</strong></td>
<td>Easier</td>
<td>Complicated</td>
<td>For a combined bridge, additional funding agreements must be negotiated between the various agencies for the initial capital costs (including engineering and management), as well as long term maintenance and operations costs which adds complications to the process. With the road portion of the bridge to be tolled, there also may be a conflict in obtaining federal funding due to the Federal Cost Recovery Policy.</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>Faster</td>
<td>Slower</td>
<td>Multi jurisdictional agreements will necessarily take more time to negotiate thus impacting schedule. Also, the location and alignment of the bridge, and clearance requirements for the rail bridge particularly will need to be established. The clearance requirement for the road bridge is expected to be straightforward to establish, but the vertical clearance for the rail bridge will be more complicated as, among other things, it will impact the cost of the rail portion of the project.</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td>Simpler</td>
<td>Complicated</td>
<td>With a combined bridge, ownership of the bridge; agreements for sharing of maintenance costs and major rehabilitation costs need to be agreed prior to advertising the project.</td>
</tr>
<tr>
<td><strong>Liability</strong></td>
<td>Simpler</td>
<td>Potentially Very Complicated</td>
<td>Agreements regarding liability/responsibility for various events, as well as who insures those events, will need to be negotiated. Complicated liability/responsibility issues include: loss of vehicle toll revenue in the event that rail bridge is damaged by a ship impact and the entire bridge is closed for repairs; cost impacts to the Port in the event that the rail lift span breaks down and does not open; impacts on the rail company in the event that the lift span breaks down in the raised position; damage caused to the bridge during a major earthquake; flood/scour damage; losses incurred by rail companies and/or the Port in the event that a vehicular accident causes the entire bridge to be closed for repairs (e.g. a vehicle crashes over the side of the bridge and falls onto the rail lift span causing it to be shut down and fixed in the lowered position for a period of time). In addition to the scenarios that will be identified, an agreement will be required on how to deal with unanticipated events.</td>
</tr>
<tr>
<td><strong>Existing Maintenance &amp; Rehabilitation</strong></td>
<td>N/A</td>
<td>Likely delay to improvements</td>
<td>In the event that a road/rail bridge is selected, as outlined above in “Schedule”, there is an inevitable delay in completing the replacement of the Pattullo Bridge. Because of this, agreements will need to be in place for establishing who is responsible for ongoing maintenance and rehabilitation costs for the existing bridge.</td>
</tr>
</tbody>
</table>
**Table 2 – Technical Issues**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Road Bridge</th>
<th>Combined Road/Rail Bridge</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Safety</td>
<td>N/A</td>
<td>Likely delay to improvements</td>
<td>Replacement of the existing road bridge has been identified by TransLink as a priority due in part to the need for improving public safety on the bridge. Since the schedule for completion of the combined option is expected to be significantly longer, the impact on public safety must be considered. The exposure of traffic in the existing condition (numerous traffic safety issues) is increased in terms of duration.</td>
</tr>
<tr>
<td>Optimum Span Length</td>
<td>Can optimize both separately</td>
<td>Likely involves compromises unless build side by side bridges and share only a few common foundations</td>
<td>Based on experience with similar structures, the most cost effective span arrangement for the road bridge will likely tend toward fewer and longer spans, while more shorter spans are likely most cost effective for the railway bridge. The main issues that lead us to this conclusion are that the lift span for the rail bridge is likely limited to something close to 150m (anything much longer and the lift span becomes infeasible). For the road bridge, there is effectively no feasible limit on the span length (cable-stayed bridges are being built with spans in excess of 1000m which is significantly more than the width of the Fraser River). When optimizing the road bridge, the cost of the substructure (piers and foundations) should be approximately the same as the cost of the superstructure. Because the ship collision loading is relatively large and the soil conditions are relatively poor, the river pier foundations are expected to be quite large regardless of the span of the bridge. Since the foundations are so large, they can support the weight of a long superstructure without any cost premium, and therefore we expect the optimum road bridge span to be more like 300m or 400m. A combined bridge will therefore likely require a compromise.</td>
</tr>
<tr>
<td>Optimum Bridge Type</td>
<td>Can optimize both separately</td>
<td>Will likely require compromises unless build side-by-side</td>
<td>In the case of the road bridge a cable-stayed structure may be optimal for a longer span (say 400m) but not for a shorter span (say 150m).</td>
</tr>
<tr>
<td>Design Code</td>
<td>Easier</td>
<td>Potentially complicated</td>
<td>CHBDC is the governing code for a road bridge while AREMA governs for rail. Specific design criteria will need to be developed for the combined bridge, and where combined road and rail loading governs, the more strict criteria may need to be applied (therefore possibly increasing the cost of the component being designed).</td>
</tr>
<tr>
<td>Ship Impact</td>
<td>Likely less risk</td>
<td>Likely more risk</td>
<td>Due to the need for more piers in the river for a combined road/rail bridge than for a road bridge alone, the risk of ship collision to the road bridge is higher in the combined option. However, if a combined structure is considered with the rail component immediately adjacent to the road component, the total number of piers in the river would be less than the number of piers needed to support both bridges separately.</td>
</tr>
<tr>
<td>River Hydraulics</td>
<td>More piers</td>
<td>Fewer piers</td>
<td>More piers in the river are potentially detrimental for river hydraulics.</td>
</tr>
<tr>
<td>Navigation Channel</td>
<td>More difficult</td>
<td>Easier</td>
<td>There may be more freedom to set the navigation channel if separate bridges are selected. However, two conflict points (associated with separate bridges) with significant separation between them could be more complicated to navigate through.</td>
</tr>
<tr>
<td>Navigation Vertical Clearance</td>
<td>Easier</td>
<td>Difficult</td>
<td>Establishing a vertical clearance at the same height as the existing bridge is easier to accomplish for the road bridge option due to flexibility of road approaches and grades. Railway grade increases are limited and create significant design/cost issues to accommodate vertical clearance requirements.</td>
</tr>
<tr>
<td>Navigation Horizontal Clearance</td>
<td>More difficult</td>
<td>Easier</td>
<td>The four bridges create alignment conflicts throughout the entire reach. While removing the New West Rail bridge somewhat rectifies the alignment it does not ultimately resolve alignment geometry to accommodate an optimum channel (currently estimated to be 169m).</td>
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3.0 FINDINGS AND RECOMMENDATION

Although the combined road / rail bridge was deemed technically feasible, the comparison of the two options being considered in this report indicates that there are a number of significant disadvantages in pursuing a combined road / rail bridge. Based on the various advantages and disadvantages listed in the two comparison tables, it is recommended that TransLink abandon the combined road / rail option for the new Pattullo Bridge and proceed with a road only crossing. This recommendation is based on the following key findings:

- **Cost:** There is only a small, or negligible, cost savings associated with the combined bridge option when compared to independent road and rail bridges;

- **Schedule:** Additional time is anticipated in commissioning the road / rail bridge as compared to the road only bridge; ongoing maintenance, operational costs, and traffic safety on the existing bridge precludes any lengthy delays for the replacement of the Pattullo Bridge.

- **Funding:** If a combined bridge option is pursued, funding agreements are potentially very complicated, including cost overrun sharing and operation and maintenance costs, and agreement may ultimately not be reached.

- **Ownership and Liability:** Ownership and liability issues are significant and extremely complex with a combined bridge, so much so that it is anticipated that these could prove to ultimately stall the project completely.