NZ TRANSPORT AGENCY
WAKA KOTAHI

AWHC

Additional Waitemata Harbour Crossing

Internal Road Safety Audit –
Tunnel Option Stage 1 Feasibility

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Quality Assurance Statement	Name	Signature / Date
Prepared by:	Rob Mason (Beca)	19.10.10
Reviewed by:	Maurice Kwan (AECOM)	14.10.10

Revision Schedule

Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
A	2/09/10	Draft for Audit Team comment	Rob Mason		
B	3/09/10	Final Draft	Rob Mason		

Contents

Appendices

1. Introduction

1.1 Road Safety Audit Process

Road Safety Audit is a formalised process to:

- identify potential safety problems for road users and others affected by a road project; and
- check that measures to eliminate or reduce the problems are fully considered.

The aim of the audit is to identify any potential safety problems and bring them to the notice of the designer and the client. The auditors are independent of the design team. Any suggested solutions are intended to be indicative only, to assist the designer in focussing on the type of improvements that might be appropriate. They are not intended to be prescriptive, and other ways of resolving the issues should also be considered. The designer should consider the audit report and its recommendations and provide comment to the client on each of the issues raised. The client then makes the final decision on each of these issues. The process is explained in more detail in the Land Transport NZ Road Safety Audit Procedures for Projects Guideline, November 2004.

1.2 Scope of the Audit

This report presents the findings of an internal Stage 1 Feasibility Safety Audit for the Additional Waitemata Harbour Crossing (AWHC) project. This audit has been undertaken to assist the design team in identifying potential safety issues prior to submitting the project for review by an external Road Safety Audit Team.

The project evaluated in the audit includes a new motorway connection between the North shore and the Central Business District in Auckland, extending from north of the Esmonde Road interchange through to Wellington Street in the City. The form of this connection is a bridge structure spanning over a distance of 2.4km.

While the drawings incorporate a future rail tunnel, this alignment has been excluded from this audit.

1.3 The Audit Team

The design for this project has been undertaken jointly by Beca and AECOM, and this audit has been undertaken as an internal review for the design team. The Audit Team comprised:-

- Rob Mason, BE (Hons), Dip.Bus (FLM) Aus,
  Technical Director – Transportation, Beca Infrastructure Limited, Auckland.

- Maurice Kwan, MIPENZ, CPEng
  Principal Civil Engineer, AECOM New Zealand Ltd, Auckland.

1.4 Procedures and Reporting

In accordance with the Road Safety Audit Procedures for Projects Guideline, it should be noted that this audit is not to be regarded as a "quality check" or a design check of the project. It is focused essentially on safety issues that are considered significant in regard to the proposed design. Comments and recommendations are outlined in the following section of the report. The item headings as listed in the Contents also provide a summary of the findings. Points have been ranked as follows:

- **Serious Concern:** a major safety concern that should be addressed and requires changes to avoid serious safety problems.

- **Significant Concern:** a significant safety concern that requires consideration of changes to improve safety.

- **Minor Concern:** a safety concern of lesser significance, but which should be addressed as it may improve overall safety.

- **Comment:** a concern or an action that may be outside the scope of the road safety audit, but which may improve overall design or be of wider significance.

1.5 Disclaimer

The findings, opinions, and recommendations in this report are based on an examination of available relevant plans and a visual inspection of the site, and may not address all issues existing at the time of the audit. The report also deals with technical matters. Readers are urged to seek specific advice on particular matters and not rely solely on the report. While every effort has been made to ensure the accuracy of the report, it is made available strictly on the basis that anyone relying on it does so at their own risk without any liability to members of the audit team or their organisation.

2. General Layout

2.1 Serious Concern – Insufficient Merge Area from the Esmonde/ Onewa Southbound Connection to the existing Harbour Bridge

The southbound on-ramp connection from Esmonde Road and Onewa Road to the existing Harbour Bridge joins the SH1 southbound traffic as two additional lanes, resulting in a total of 4 southbound lanes. These 4 lanes merge to 3 general traffic lanes, before the left lane becomes an exclusive PT lane, resulting in 2 traffic lanes over the bridge.

Therefore, vehicles joining the motorway from Onewa Road will be required to merge with the left lane from Esmonde Road, before weaving across the PT lane to join the southbound general traffic lane. This lane changing and merging all needs to take place over a length of about 400m.

The traffic volume from Onewa Road and Esmonde Road to the City is likely to be high, and this short merge length is likely to result in weaving, lane change and rear end crashes.

Recommendation

Review the traffic effect of the proposed layout to understand how it will operate and identify opportunities to lengthen the distance for the merge and lane change to occur.

2.2 Serious Concern-Conflict between Shelley Beach Off-Ramp/PT lane/ Pedestrian and Cycle Lane

Traffic using this off-ramp is required to traverse the PT lane and the pedestrian cycle way in order to access the off-ramp. There is no detail as to how this off-ramp will be set out. The pedestrian and cycle way will need to terminate prior to the off-ramp to enable the PT lane to continue as is currently laid out.

Recommendation

Develop a layout for the Shelley Beach Road off-ramp that can safely accommodate the pedestrian and cycle way and PT lane.

2.3 Significant Concern – Structure in Diverge Area at Onewa Road Off-Ramp Northbound

The diverge for this off-ramp extends from the cut and cover section at the northern end of the tunnel. This is indicated as an open trench, which suggests it is leaving from the side of the tunnel. This suggests that a structural wall will be provided between the off-ramp and the northbound exit from the tunnel. This presents a road side hazard, and is particularly dangerous on the outside of the curve.

Recommendation

It is suggested that this should be incorporated into the cut and cover tunnel so that the roof structure can span the full width of the motorway without a hazard in the diverge area.

3. Highway Geometry

3.1 Serious Concern – Excessive Gradient Southbound from Tunnel

In the southbound direction, the provision of a 6.5% grade following from a long section of 1.4% grade is likely to result in truck speeds reducing to minimal values of around 25km/hr (SHGDM fig 5.12). These speeds will occur through a series of reverse curve combinations with horizontal radii of 800m and 760m.

The effect of this gradient is that there will be a significant speed differential between heavy vehicles and other lighter vehicles. Therefore it is essential that there is sufficient sight distance in the tunnel to observe slow moving trucks and adjust speed accordingly.

The left lane from the tunnel is an exclusive exit lane to SH16 and the Port. Therefore any trucks heading south will need to be travelling in lane 2. This movement is considered to be the greater movement, and this will result in more slow moving trucks being in lane 2.

This scenario is likely to result in a number of weave movements as vehicles change lanes in an attempt to avoid the slow moving trucks, and this will be exacerbated in the instance where there is a truck in each lane, and a high speed vehicle is attempting to exit at the SH16/ port off/ramp.

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

3.2 Serious Concern - Low Radius Horizontal Curve Cook Street On-Ramp to Tunnel

Cook Street descends into the tunnel at a 6.1% grade. The tunnel alignment then incorporates a 165m horizontal curve, which is very tight. This tight geometry coupled with the steep downhill grade will potentially result in loss of control crashes around this curve. A large superelevation will be required to address the horizontal radius and vertical grade combination, and this will give the perception of a banked raceway. This is not desirable in a constrained tunnel environment.

There are also likely to be limitations on the sight distance available, and stopping sight distance should be provided as a minimum. For a design speed of 80km/h and a reaction time of 1.5 sec, the required safe stopping sight distance is 103m. To achieve this, the right side shoulder would need to be about 6.6m wide. Although this is an on-ramp, the steep gradient on the approach would require the design speed for this curve to be at least 80km/h, consistent with the main alignment.

Recommendation

Amend the design to provide a larger radius curve and appropriate sight distance.

3.3 Minor Concern - Excessive Gradient Northbound from Tunnel

The gradient on the northbound exit of the tunnel has a 4.46% grade (ch 3000 to 3650). The speed of heavy vehicles is likely to reduce to around 40km/h over this distance (refer Austroads 2009 Pt 3 table 9.5) This is likely to create a capacity issue on the upgrade, although it is acknowledged that there is sufficient sight distance and heavy vehicles can remain in the left hand lane.

Recommendation

Review the geometry to identify whether the grade can be reduced.

3.4 Minor Concern - Sight Distance to Ramp Diverge

There are a number of locations where there is inadequate sight distance to the off-ramp nose. These are identified below:

1) Cook Street Off-Ramp: SH1 Temporary Diversion (ch1190,MC30) - There is a crest vertical curve with a K value of 45 through ch 920 to 1260 which may limit the visibility of the nose.

2) Tunnel Long section Main Alignment (ch 500 sbd) - There is a crest vertical curve with a K value of 67 through ch 220 and 360 which may limit the visibility to the nose.

3) Tunnel Long section Main Alignment (ch 6870 sbd) – There is a crest vertical curve with a K value of 51 through ch 6840 and 6992 and a horizontal curve with a radius of 760m (ch 6359 to 6834) which may limit the visibility to the nose.

4) Onewa Road Off-Ramp Northbound from Tunnel (MCA0) – There is crest vertical curve between ch 110 and 170 which may restrict sight distance to the nose (curve details not provided).

5) Onewa Road Southbound On ramp diverge to tunnel and Harbour Bridge – sight distance to the nose may be restricted around the horizontal curve,

Recommendation

For the locations noted above, check there is 1.4 x stopping sight distance to the nose.

3.5 Minor Concern – Separation between ramp merge and Diverge

The Onewa Road southbound on-ramp diverges to the tunnel and the Harbour Bridge. On the connection to the tunnel, the diverge is closely followed by a lane gain where the Esmonde Road traffic is entering the tunnel. This spacing is very close at approximately 150m.

Recommendation

Investigate opportunities to increase the separation between the ramps.

4. Cook Street Temporary Diversion

4.1 Significant Concern – Insufficient Sight Distance Around Curve (ch974 – 1046)

There is a horizontal curve with a radius of 200m. For a design speed of 80km/h and a reaction time of 2.0 sec, the required safe stopping sight distance is 114m. To achieve this, the left shoulder would need to be 6.62m wide, although the actual shoulder width is only 1.18m. As the length of curve is 72m which is less than the SSD, then the actual curve widening required will be less than the 6.62, although it will still be greater than that provided.

Recommendation

Realign the temporary ramp to achieve adequate sight distance.

4.2 Minor Concern – Vertical and Horizontal Geometry out of Phase (ch920 – 1260)

There is a vertical crest curve at this location with a K value of 45. This vertical curve is followed by a horizontal curve (ch 974) which will not be visible over the vertical curve.

Recommendation

Realign the temporary ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.

4.3 Minor Concern – Insufficient Sight Distance Around the Curve (ch 215 to 824)

There is a horizontal curve with a 470m radius. For a design speed of 80km/h and a reaction time of 1.5 sec, the safe stopping sight distance is 103m. To achieve this, the left side shoulder would need to be 1.11m wide, although the actual shoulder width is only 1.0m.

Recommendation

Realign the temporary ramp to achieve adequate sight distance.

5. Pedestrians / Cyclists

5.1 Serious Concern – Cyclist Access to Existing Harbour Bridge

The proposal includes a pedestrian / cycle way on the eastern lane of the existing Harbour bridge. There is no detail provided as to where access to this facility will be provided.

On the northern side of the bridge, the left hand lane sbd is used for PT up to ch3500, where it will be required to merge to the right to enable the pedestrian / cycle way to be developed. As a result, the only

possible location for access will be from Northcote point, where some form of bridge or ramp structure will be required. Pedestrian and cycle movements will need to be physically separated from the PT lane.

At the southern side of the bridge, no information is provided to indicate how the eastern pedestrian / cycle way will connect to the local road network.

Recommendation

Further consideration is required as to how access to the facility can be provided at both the northern and southern ends of the bridge and also at strategic locations along the route (i.e. via pedestrian / cycle over bridges or underpasses to gain access to the eastern side of the bridge.

6. PT Lane

6.1 Significant Concern – Conflict of Northbound PT lane through Curran Street On ramp

No detail is provided to indicate how the nbd bus lane crosses the Curran Street on-ramp before the Harbour Bridge. As a separate bus lane is provided, this will need to commence after the on-ramp once on-ramp traffic has merged, and buses will be required to merge with general northbound traffic prior to the on-ramp.

Recommendation

Develop a layout for the Curran Street northbound on-ramp so that incorporates the PT lane.

6.2 Significant Concern – Inadequate Geometry of Northbound Busway

The MCA0 connection from the Harbour Bridge to the Busway (MCA0) incorporates a horizontal curve of 120m radius (ch452 to 520). This radius is sufficient only for a design speed of 70km/h rather than the 80km/h anticipated for this bus way. In addition, the horizontal curve begins after the start of the crest vertical curve, which has a K value of 45 (ch260 to 450). This would need to be 63 to enable the road surface to be visible.

Another connection from the Harbour Bridge to the Busway (MCB0) has a crest curve with a K value of only 45. This would need to be 63 to enable the road surface to be visible. This would be required as the horizontal curve starting part way through the vertical curve would be masked (ch220 to 480).

Recommendation

Review the geometry of the ramps from the Harbour Bridge to the Busway so that the horizontal curves are not hidden be the vertical curvature, and the design speed for both horizontal and vertical curves is at least 80km/h.

7. Staging

7.1 Comment – Traffic Management during Construction

This project requires the connection of two major motorways in a very constrained area. The volume of traffic using the existing section of motorway has very high volumes and has very tidal flows. Therefore, there will be significant staging issues to be resolved. These will need to be considered in developing the design to ensure that the project is constructible, without significantly compromising the capacity of the motorway network. The key areas where staging is likely to be critical are outlined below:

- Onepoto Stream Bridges, which will require reconstruction;
- Coordination of the construction of the realigned Cook Street off-ramp and the bored tunnel, to maintain southbound traffic flow (temporary alignment proposed);
- Cut and cover beneath major arterial roads, being Fanshaw Street and Victoria Street; and
- Connection of the northbound Cook Street connection from bored tunnel to cut and cover in the vicinity of the current VPT tunnel (it is noted that the proposed option would require the VPT to be reconstructed as the Cook Street northbound on-ramp)

8. Local Road Network

8.1 Comment – Cook Street/ Union Street Realignment

The existing Connection from Cook Street to Union Street will no longer be possible for sbd traffic, as this connection is located in close proximity to the Cook Street tunnel portal. There is a risk that vehicles will

inadvertently enter the Cook Street on-ramp and there will be no opportunity for them to turn around other than the Onewa Road Interchange.

A left turn from Cook Street may still be feasible to enable vehicles to avoid entering the motorway, and the provision of a slip road would also accommodate access to the adjacent properties along this length of Cook Street.

9. Operation and Maintenance

9.1 Comment - Tunnel Access during an Incident

There is no provision for emergency access in the event of an incident in the tunnel. The nearest local road connection northbound would be from Gillies Ave, which is likely to be too far from the tunnel. Access to the southbound tunnel is likely to be easier to achieve due to the close proximity of the Onewa Road Interchange.

Consideration should be made to allow for appropriate incident response in the early concept design stage.

10. Signs

10.1 Significant Concern - Signs Indicate Non-existent Ramp

The southbound signing indicates that there is a southbound off-ramp connection from Esmonde Rd to Onewa Rd, although there is no ramp connection provided. This is an existing connection that should be provided. Otherwise there are likely to be impacts on the local road network

Recommendation

Investigate options for maintaining the existing connection between Esmonde Road and Onewa Road.

10.2 Comment – Incorrect Use of the word 'South' as a destination

It is noted that the sign plan provide is conceptual. However, the signing for the southbound SH1 connection to Fanshawe Street, Cook Street, SH16 and the Port is identified as 'SH1 South'. As these routes connect to the CBD, it is considered more appropriate to use 'SH1 City' rather than 'SH1 South' for these connections.

AUDIT TEAM STATEMENT

We certify that in carrying out this audit we have inspected the site and used the drawings and associated documents listed in Appendix A. We have endeavoured to identify features of the proposed scheme that could be modified, or included in the project scope, in order to improve safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The problems identified have been noted in this report together with recommendations that should be studied for implementation. Where recommended actions are not taken, this should be reported in writing, providing the reasons for that decision.

Signed: **Date: 14/10/2010**

Rob Mason, Beca Infrastructure Limited, Auckland

Signed: **Date: 14/10/2010**

Maurice Kwan, AECOM New Zealand Ltd, Auckland

Appendix A

Drawings and Associated Documents Reviewed

Tunnel option Lane Configuration Diagram
60157303-CSSK-001-B
60157303-CSSK-004
60157303-CSSK-005
60157303-CSSK-006
60157303-RD-020 General Arrangement
60157303-RD-021 General Arrangement
60157303-RD-022 General Arrangement
60157303-RD-023 General Arrangement
60157303-RD-024 General Arrangement
60157303-RD-030 Plan and Long Section
60157303-RD-031 Plan and Long Section
60157303-RD-032 Plan and Long Section
Busway Akoranga Station to Harbour Bridge Long Section
Cook Street off - SH1 Temp Diversion - Long and Cross Sections
Cook Street off - SH1 Temp Diversion - plan
Cook Street Northbound On-Ramp - Long Sections
Cook Street Southbound Off-Ramp - Cross Sections
Cook Street Southbound Off-Ramp - Long Sections
Esmonde Rd Long Section
Esmonde Rd Northbound Off-Ramp Long Section
Esmonde Rd Southbound On-Ramp from Link Road to Tunnel Long Section
Esmonde Rd Southbound On-Ramp Link Road Long Section
Northbound Bus Lane Harbour Bridge to Busway Long Section
Northbound Harbour Bridge to SH1 long Section
Onewa Rd Northbound Off-Ramp from Harbour Bridge Long Section
Onewa Rd Northbound Off-Ramp from Tunnel Long Section
Onewa Rd Southbound Off-Ramp Long Section
Onewa Rd Southbound On-Ramp to Harbour Bridge Long Section
Onewa Rd Southbound On-Ramp to Tunnel Long Section
Pavement Areas Northern End
Pavement Areas Southern End
Rail Cross Sections
SH1 Main Alignment - Cross Sections Ch0000-3450
SH1 Main Alignment - Cross Sections Ch6000-7000
SH1 Main Alignment Northbound - Long Sections Ch0000-4200
SH1 Main Alignment Southbound - Long Sections Ch0000-4200
Signing Strategy Esmonde to Motorway Diverge
Signing Strategy including Tolling locations and Gantries
Stafford Rd Northbound Off-ramp from Harbour Bridge Long Section
Southbound SH1 to Harbour Bridge Long Section

NZ TRANSPORT AGENCY
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Road Safety Audit Report Recommendations

DECISION TRACKING FORM

Project Title: Additional Waitemata Harbour Crossing Tunnel Option

Road Safety Audit Stage: Stage 1 Feasibility

RCA Project Manager:

Designer: Beca/AECOM

Road Safety Auditors: Rob Mason, Maurice Kwan

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
General Layout	2.		
Serious Concern **Insufficient Merge Area from the Esmonde/ Onewa Southbound Connection to the existing Harbour Bridge** *Review the traffic effect of the proposed layout to understand how it will operate and identify opportunities to lengthen the distance for the merge and lane change to occur.*	2.1	Agree further work is required to understand operation issues and the variance between am/pm peaks. This should be undertaken in Future Design.	
Serious Concern **Conflict between Shelley Beach Off ramp/ PT lane / Pedestrian and Cycle Lane** *Develop a layout for the Shelley Beach Road off ramp that can safely accommodate the pedestrian and cycle way and PT lane.*	2.2	The proposed lane usage on the AHB has been prescribed by NZTA. The pedestrian/cycle lane will terminate as soon as practicable upon land fall, and convey users to Westhaven Drive. The existing off ramp geometry will be maintained. The design team acknowledges that this has both operational and safety implications. During the next phase alternative PT lane configurations should be reconsidered.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Significant Concern **Structure in Diverge Area at Onewa Road Off ramp Nbd** *It is suggested that this should be incorporated into the cut and cover tunnel so that the roof structure can span the full width of the motorway without a hazard in the diverge area.*	2.3	Extension of the cut and cover tunnel is unlikely to eliminate the requirement for a crash cushion and TL4 concrete barriers beyond the off ramp nose. a) Increased roof span is likely to requiring additional support b) A bridge carrying AHB traffic over the ramp is located 60m beyond ramp nose. Barriers shielding the bridge abutments will extend back to the exit. However, further evaluation of the tunnel portal location should be undertaken during the next phase to address uniform daytime lighting levels throughout the exit taper and its approach.	
Highway Geometry	3.		
Serious Concern **Excessive Gradient Southbound from Tunnel** *Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.*	3.1	Agree, the gradient will produce a significant speed differential between HCV and cars. A maximum vertical gradient southbound of 5% has been adopted as instructed by NZTA. Additional lanes cannot be provided where they would overlap the bored tunnel section as the tunnel diameter would exceed current construction technology. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each producing a similar terminal speed for HCV's .	
Serious Concern **Low Radius Horizontal Curve Cook St On Ramp to Tunnel** *Amend the design to provide a larger radius curve and appropriate sight distance.*	3.2	The curve has a nominal design speed of 65kph linking the Cook St 50kph posted speed with VPT. The RH shoulder is widened to 2.5m to provide for SD using tunnel Rt of 1.5sec. Improvements to radius selected cannot be achieved without further increases to gradient as the route is constrained by the SH1 northbound carriageway passing over. A posted speed of 50kph should be maintained until tied into VPT.	
Minor Concern **Excessive Gradient Northbound from Tunnel** *Review the geometry to identify whether the grade can be reduced.*	3.3	The gradient can only be improved minimally without compromising the AHB / Onewa IC links. Significant reductions in gradient impact viability of a bored tunnel beneath the harbour.	
Minor Concern **Sight Distance to Ramp Diverge** *For the locations noted above, check there is 1.4 x stopping sight distance to the nose.*	3.4	Agreed. Item 1: Off ramp is to SH16. The temporary works alignment for the viaduct assumed a posted & design speed for diverted traffic of 70kph Item 2: K=76 in this region and	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		represents the existing mainline geometry. The design intent at this existing off ramp is to provide an additional southbound lane in part by reconstructing the median. Item 3: It has been necessary to reduce the vertical design speed to 80kph to complete a tie in by Wellington St. the ramp nose and pavement beyond remains in view as it is situated on the climbing portion of the crest curve. Item 4: The crest will be removed as it is necessary to maintain the 4% grade to achieve clearance over the CMA before joining Onewa Rd. Item 5: Agree. To be address in next phase.	
Minor Concern **Separation between ramp merge and Diverge** *Investigate opportunities to increase the separation between the ramps.*	3.5	Agreed. The designer notes that approach speed will be limited in this vicinity due to the existing tight Onewa onramp bridge geometry, however inter-visibility between connections should be check in next phase.	
Cook Street Temporary Diversion	4.		
Significant Concern **Insufficient Sight Distance Around Curve (ch974 - 1046)** *Realign the temporary ramp to achieve adequate sight distance.*	4.1	This will be address during next phase. The temporary alignment in this location is linked to the Cook St off ramp which provides for 2.5m inside shoulder.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		The temporary works alignment for the viaduct assumed a posted & design speed for diverted traffic of 70kph.	
Minor Concern **Vertical and Horizontal Geometry out of Phase (ch920 - 1260)** *Realign the temporary ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.*	4.2	A review of horizontal and vertical coordination should be undertaken in the next phase. The horizontal curve in this instance is not masked by the vertical alignment.	
Minor Concern **Insufficient Sight Distance Around the Curve (ch 215 to 824)** *Realign the temporary ramp to achieve adequate sight distance.*	4.3	Disagree. The 470m radius right hand curve was part of the then Cook St off ramp tunnel. As the curvature is to the right, the LH shoulder will not influence SD. A 2.5m wide RH shoulder has been provided to in this region to provide for SSD similar to VPT.	
Pedestrians / Cyclists	5.		
Serious Concern **Cyclist Access to Existing Harbour Bridge** *Further consideration is required as to how access to the facility can be provided at both the northern and southern ends of the bridge and also at strategic locations along the route (i.e. via pedestrian / cycle over bridges or underpasses to gain access to the eastern side of the bridge.*	5.1	Northern sector provides a continuous shared path located east of the busway facilities from Esmonde Rd to the AHB and provides connections to Stafford Rd. Southern Sector: Pedestrians and cyclists will exit the AHB via a new structure linking to Westhaven Drive.	
PT Lane	6.		
Significant Concern **Conflict of Northbound PT lane through**	6.1	To be addressed during next phase.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Curran St On ramp *Develop a layout for the Curran Street northbound on ramp so that incorporates the PT lane.*			
Significant Concern **Inadequate Geometry of Northbound Busway** *Review the geometry of the ramps from the Harbour Bridge to the Busway so that the horizontal curves are not hidden be the vertical curvature, and the design speed for both horizontal and vertical curves is at least 80km/h.*	6.2	Disagree. MCA0: Links SH1 tunnel to Onewa Rd, not a Busway. The R120m curve is the final approach to the 50kph signalised Sylvan Ave/Onewa Rd intersection and provides a suitable transition. MCB0: AHB northbound to Busway. The crest curve k=45 nominally provides for SSD to 0.2h for car travelling at 90kph. This carriageway is for exclusive use by buses only and as no intersections, lane changes or similar requirement to see pavement surface exist the designer considers the vertical geometry appropriate. SD achieved for bus driver eye heights should be addressed in the next phase.	
Staging	7.		
Comment **Traffic Management during Construction** *This project requires the connection of two major motorways in a very constrained area. The volume of traffic using the existing section of motorway has very high volumes and has very tidal flows. Therefore, there will be significant staging issues to be resolved. These will need to be considered in developing the design to ensure that the*	7.1	Agreed, Refer o the Form Assessment Report. This should be undertaken in future design.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
project is constructible, without significantly compromising the capacity of the motorway network.			
Local Road Network	8.		
Comment **Cook St/ Union St Realignment** *The existing Connection from Cook St to Union St will no longer be possible for sbd traffic, as this connection is located in close proximity to the Cook St tunnel portal.* *There is a risk that vehicles will inadvertently enter the Cook St on ramp and there will be no opportunity for them to turn around other than the Onewa Road Interchange.* *A left turn from Cook St may still be feasible to enable vehicles to avoid entering the motorway, and the provision of a slip road would also accommodate access to the adjacent properties along this length of Cook Street.*	8.1	Agreed, This should be undertaken in future design.	
Operational and Maintenance	9.		
Comment **Tunnel Access during an Incident** *There is no provision for emergency access in the event of an incident in the tunnel. The nearest local road connection northbound would be from Gillies Ave, which is likely to be too far from the tunnel. Access to the southbound tunnel is likely to be easier to achieve due to the close proximity of the Onewa Road Interchange.* *Consideration should be made to allow for*	9.1	Gillies Ave is not the closest emergency access. Edinburgh Street entrance to SH16 to SH1 link is.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
appropriate incident response in the early concept design stage.			
Signs	10.		
Signs Indicate Non-existent Ramp *Investigate options for maintaining the existing connection between Esmonde Road and Onewa Road.*	10.1	Resolved. At the time of the RSA, the geometric design had not been fully developed and the Onewa Road Southbound Off-ramp had not been completed. The signage sketch showed how the off ramp was proposed to be signed. The signage strategy will be further developed in future design. FAS drawings now show link between Esmonde Rd and Onewa Rd interchanges. Operationally there would be an opportunity during the next phase to demonstrate case to remove this link.	

Completed Decision Tracking Form sent by RCA Project Manager to:

1. Designer Date: / /

2. Audit Team Leader Date: / /

For additional rows, click in the bottom right cell of the table above and then press the **Tab** key.

To delete a row, click anywhere in the row and then choose **Delete Cells, Delete entire row** from the **Table** menu.

* RS Auditor to complete and attach to report – send electronically to RCA Project Manager

Additional Waitemata Harbour Crossing

Internal Road Safety Audit –

Tunnel Option Stage 1 Feasibility Addendum

This report has been prepared by AECOM New Zealand Ltd for the benefit of the NZ Transport Agency (NZTA). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

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Quality Assurance Statement	Name	Signature / Date
Prepared by:	Rob Mason	19.10.10
Reviewed by:	Maurice Kwan	14.10.10

Revision Schedule

Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
A	29/09/10	Draft for Audit Team comment	Rob Mason	Maurice Kwan	
B	30/09/10	Final Draft	Rob Mason	Maurice Kwan	

Contents

APPENDICES

1. Introduction

1.1 Scope of the Audit:

This report has been prepared as an addendum to the previous Road Safety Audit report for the driven tunnel option (3rd September 2010). Since undertaking the initial audit, the design team have revised the geometric alignment of the tunnel option at the southern end of the project to reduce the vertical grade from 6.5% to 5.0%. This report presents the findings of a further Stage 1 Feasibility Safety Audit for the revised alignment.

It should be noted that only those elements of the project that have been amended as a result of the reduced grade are considered in this Addendum Report. The section numbering of this addendum is consistent with that of the initial report, and the comments should be read in conjunction with that initial report.

1.2 The Audit Team:

The design for this project has been undertaken jointly by Beca and AECOM, and this audit has been undertaken as an internal review for the design team. The Audit Team comprised:-

- Rob Mason, BE (Hons), Dip.Bus (FLM) Aus,
  Technical Director – Transportation, Beca Infrastructure Limited, Auckland.

- Maurice Kwan, MIPENZ, CPEng
  Principal Civil Engineer, AECOM New Zealand Ltd, Auckland.

1.3 Procedures and Reporting:

In accordance with the Road Safety Audit Procedures for Projects Guideline, it should be noted that this audit is not to be regarded as a "quality check" or a design check of the project. It is focused essentially on safety issues that are considered significant in regard to the proposed design. Comments and recommendations are outlined in the following section of the report. The item headings as listed in the Contents also provide a summary of the findings. Points have been ranked as follows:

- **Serious Concern:** a major safety concern that should be addressed and requires changes to avoid serious safety problems.

- **Significant Concern:** a significant safety concern that requires consideration of changes to improve safety.

- **Minor Concern**: a safety concern of lesser significance, but which should be addressed as it may improve overall safety.

- **Comment**: a concern or an action that may be outside the scope of the road safety audit, but which may improve overall design or be of wider significance.

1.4 Disclaimer

The findings, opinions, and recommendations in this report are based on an examination of available relevant plans and a visual inspection of the site, and may not address all issues existing at the time of the audit. The report also deals with technical matters. Readers are urged to seek specific advice on particular matters and not rely solely on the report. While every effort has been made to ensure the accuracy of the report, it is made available strictly on the basis that anyone relying on it does so at their own risk without any liability to members of the audit team or their organisation.

2. Highway Geometry

2.1 Serious Concern – Excessive Gradient Southbound from Tunnel

The initial alignment incorporated a 6.5% uphill grade exiting the tunnel over a length of approximately 525m. This followed a gradual uphill grade of 1.4% over a length of approximately 1423m. To achieve a reduced grade from the tunnel exit, the length of 1.4% grade has been reduced to 1183m and a 5% grade provided over a longer length of 994m. Therefore, in order to achieve a reduced grade, the length has been increased.

The initial report indicated that truck speeds would reduce to approximately 25km/hr with a 6.5% grade using the SHGDM. It is understood that Austroads has been adopted as the design standard for this project, and this indicates that for the 6.5% grade from the tunnel, truck speeds will reduce to approximately 38km/h at the end of the grade.

The primary issue with regard to the steep grade and the effect on trucks is the speed differential that will result, and the fact that slower moving trucks will be required to travel in lane 2 to be able head south, as lane 1 is an exclusive exit to SH16 and the Port. As a result, there is a high likelihood that both lanes 1 and 2 could have trucks travelling at this speed. Therefore the location of the diverge area relative to truck speeds is critical in determining the risk for the project.

The length of road that a grade is applied will effect the rate that the truck speed will decrease. A comparison of the two tunnel options is provided in Figure 2.1 below, where the location of change in grade has been related to the drop in speed (based on Austroads Guide to Road design Part 3: Geometric Design, Figure 9.3). This diagram also indicates where the diverge area Is for the SH16/ Port off-ramp connection.

From this diagram, it can be seen that trucks will begin to reduce speed sooner where the 5% grade is applied, due to the need to extend it over a greater length. However, the rate that speed decreases is less than that for a 6.5% grade, where trucks would be expected to drop below 60km/h before chainage 6100. For both tunnel options, truck speeds would be expected to reduce to below 50km/h through the diverge area, with the 6.5% grade option reducing to less than 40km/h. This is considered to result in significant speed differential, and this is considered a serious concern due to the proximity of the diverge area.

While both the 5% and 6.5% options are considered a serious safety concern, the use of a 5% grade would be preferable due to the slower rate of deceleration, which results in higher speeds through the diverge area.

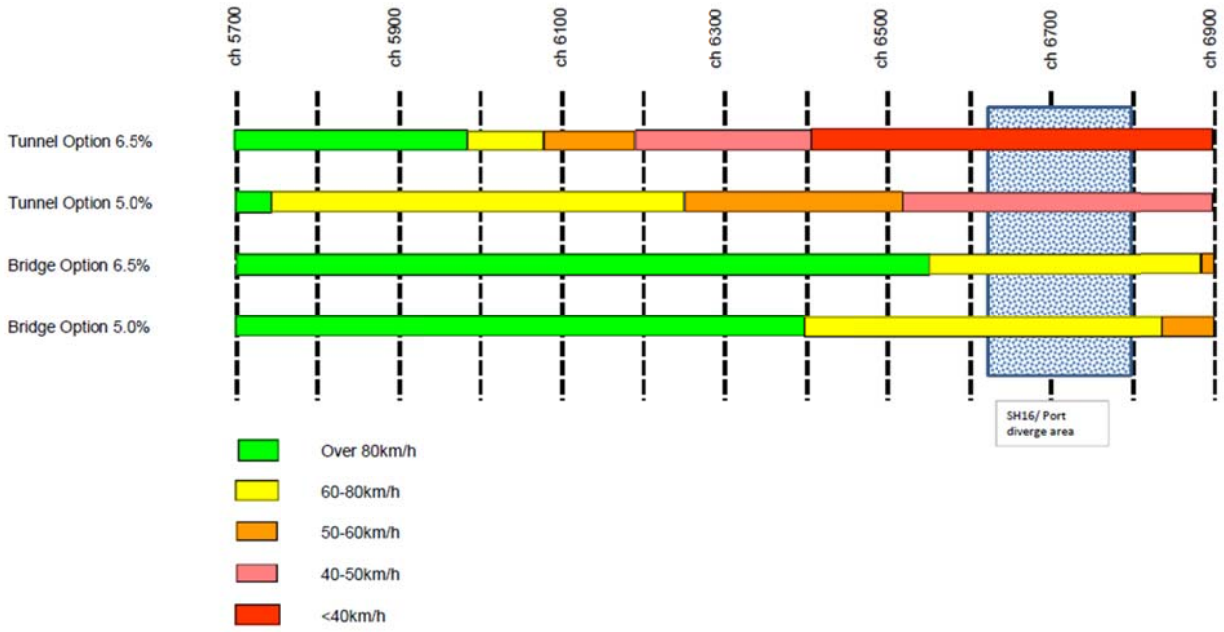

Figure 2.1: Relative rate of speed decrease

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

2.2 Significant Concern – Excessive Gradient Southbound on SH16/Port Off Ramp

The vertical grade southbound from the tunnel extends through the diverge area for the SH16/ Port off-ramp and continues along the SH16/ Port ramp as a 7.6% grade. HCV's will be travelling at approximately 35km/h at the start of this short grade and their speed is likely to reduce further.

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

AUDIT TEAM STATEMENT

We certify that in carrying out this audit we have inspected the site and used the drawings and associated documents listed in Appendix A. We have endeavoured to identify features of the proposed scheme that could be modified, or included in the project scope, in order to improve safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The problems identified have been noted in this report together with recommendations that should be studied for implementation. Where recommended actions are not taken, this should be reported in writing, providing the reasons for that decision.

Signed: **Date: 14/10/2010**

Rob Mason, Beca Infrastructure Limited, Auckland

Signed: **Date: 14/10/2010**

Maurice Kwan, AECOM New Zealand Ltd, Auckland

Appendix A

Drawings and Associated Documents Reviewed

60157303-TR-021 Rev A – General Arrangement
60157303-TR-022 Rev A – General Arrangement
60157303-TR-023 Rev A – General Arrangement
60157303-TR-024 Rev A – General Arrangement
60157303-TR-025 Rev A – General Arrangement
60157303-TR-026 Rev A – Plan and Long Section
60157303-TR-027 Rev A – Plan and Long Section
60157303-TR-028 Rev A – Plan and Long Section
mc00 - SH1 Main Alignment Sthbound - Long Sections Ch5400-Ch7150 CMJ 5 percent Rev 0
mc10 - SH1 Main Alignment Nthbound - Long Sections Ch5550-Ch7350 CMJ 5 percent Rev 0
mc90 - SH16 Main Alignment Sthbound - Long Sections CMJ 5 percent Rev 0
mcv0 - Victoria Street West - Long Section CMJ 5 percent Rev 0

NZ TRANSPORT AGENCY
WAKA KOTAHI

Road Safety Audit Report Recommendations

DECISION TRACKING FORM

Project Title: Additional Waitemata Harbour Crossing Tunnel Option

Road Safety Audit Stage: Stage 1 Feasibility - Addendum

RCA Project Manager:

Designer: Beca / AECOM

Road Safety Auditors: Rob Mason, Maurice Kwan

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Highway Geometry	3.		
Serious Concern **Excessive Gradient Southbound from Tunnel** *Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.*	3.1	Agree, the gradient will produce a significant speed differential between HCV and cars. Additional lanes cannot be provided where they would overlap the bored tunnel section as the tunnel diameter would exceed current construction technology. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		producing a similar terminal speed for HCV's .	
Significant Concern **Excessive Gradient Southbound on SH16/Port Off Ramp** *Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.*		Agree, the gradient will produce a significant speed differential between HCV and cars. Additional lanes cannot be provided where they would overlap the bored tunnel section as the tunnel diameter would exceed current construction technology. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each	

Completed Decision Tracking Form sent by RCA Project Manager to:

1. Designer Date: / /

2. Audit Team Leader Date: / /

For additional rows, click in the bottom right cell of the table above and then press the **Tab** key.

To delete a row, click anywhere in the row and then choose **Delete Cells, Delete entire row** from the **Table** menu.

* RS Auditor to complete and attach to report – send electronically to RCA Project Manager

NZ TRANSPORT AGENCY
WAKA KOTAHI

AWHC

Additional Waitemata Harbour Crossing

Internal Road Safety Audit –
Bridge Option Stage 1 Feasibility

This report has been prepared by AECOM New Zealand Ltd for the benefit of the NZ Transport Agency (NZTA). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

Quality Assurance Statement	Name	Signature / Date
Prepared by:	Rob Mason	19.10.10
Reviewed by:	Maurice Kwan (AECOM)	14.10.10

Revision Schedule

Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
A	17/09/10	Draft for Audit Team comment	Rob Mason		
B	20/09/10	Final Draft	Rob Mason		

Contents

Appendices

1. Introduction

1.1 Road Safety Audit Process

Road Safety Audit is a formalised process to:

- identify potential safety problems for road users and others affected by a road project; and
- check that measures to eliminate or reduce the problems are fully considered.

The aim of the audit is to identify any potential safety problems and bring them to the notice of the designer and the client. The auditors are independent of the design team. Any suggested solutions are intended to be indicative only, to assist the designer in focussing on the type of improvements that might be appropriate. They are not intended to be prescriptive, and other ways of resolving the issues should also be considered. The designer should consider the audit report and its recommendations and provide comment to the client on each of the issues raised. The client then makes the final decision on each of these issues. The process is explained in more detail in the Land Transport NZ Road Safety Audit Procedures for Projects Guideline, November 2004.

1.2 Scope of the Audit

This report presents the findings of an internal Stage 1 Feasibility Safety Audit for the Additional Waitemata Harbour Crossing (AWHC) project. This audit has been undertaken to assist the design team in identifying potential safety issues prior to submitting the project for review by an external Road Safety Audit Team.

The project evaluated in the audit includes a new motorway connection between the North shore and the Central Business District in Auckland, extending from north of the Esmonde Road interchange through to Wellington Street in the City. The form of this connection is a bridge structure spanning over a distance of 2.4km.

While the drawings incorporate a future rail tunnel, this alignment has been excluded from this audit.

1.3 The Audit Team

The design for this project has been undertaken jointly by Beca and AECOM, and this audit has been undertaken as an internal review for the design team. The Audit Team comprised:-

- Rob Mason, BE (Hons), Dip.Bus (FLM) Aus,
  Technical Director – Transportation, Beca Infrastructure Limited, Auckland.

- Maurice Kwan, MIPENZ, CPEng
  Principal Civil Engineer, AECOM New Zealand Ltd, Auckland.

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General Layout

1.6 Minor Concern – Insufficient Merge Area from the Esmonde/ Onewa Southbound Connection to the existing Harbour Bridge

The southbound onramp connection from Esmonde Road and Onewa Road to the existing Harbour Bridge joins the SH1 southbound traffic as two additional lanes, resulting in a total of 4 southbound lanes. These lanes then merge into 3 general traffic lanes before the left lane diverges to utilise the clip-on lane. There is only a short length for these vehicles to cross into the right lanes before the diverge, although it is acknowledge that there is a further opportunity to change lanes to the north of the bridge, and a lane change is not essential at this earlier location.

The short distance between the merge of the Onewa Road, Esmonde Road and SH1 connections from the Harbour Bridge clip-on diverge prior to the bridge diverge may result in dangerous lane change movements.

Recommendation

Review the traffic effect of the proposed layout to understand how it will operate and identify opportunities to increase the distance available for the merge and lane change.

1.7 Significant Concern – Conflict between Shelley Beach Off-Ramp and the Northbound PT lane

Traffic using this off-ramp is required to traverse the PT lane in order to access the ramp. There is no detail as to how this off-ramp will be set out to allow the safe interaction between buses and vehicles.

Recommendation

Develop a layout for the Shelley Beach Road off-ramp that can safely accommodate the PT lane.

1.8 Comment – Conflict between Rail and PT lanes at Esmonde Road

The plans indicate that the future rail line and the proposed PT are aligned at Esmonde Road (ch 700 to 900), which will result in conflict between buses and trains. The rail line is excluded from the scope of this audit as it has not yet been developed fully, however, the designer should note this issue for future design development.

1.9 Serious Concern - Low Radius Horizontal Curve Cook Street On-Ramp

Cook Street descends into the tunnel at a 6.25% grade. The tunnel alignment then incorporates a 200m horizontal curve, which is very tight. This tight geometry coupled with the steep downhill grade will potentially result in loss of control crashes around this curve. A large superelevation will be required to address the horizontal radius and vertical grade combination, and this will give the perception of a banked raceway. This is not desirable in a constrained tunnel environment.

There are also likely to be limitations on the sight distance available, and stopping sight distance should be provided as a minimum. For a design speed of 80km/h and a reaction time of 1.5 sec, the required safe stopping sight distance is 103m. To achieve this, the right side shoulder would need to be about 6.6m wide. Although this is an onramp, the steep gradient on the approach would require the design speed for this curve to be at least 80km/h, consistent with the main alignment.

Recommendation

Amend the design to provide a larger radius curve and appropriate sight distance.

1.10 Significant Concern - Insufficient Sight Distance around curve (ch 5540 to 6040)

At this location in the southbound direction, there is a curve with a radius of 502m. For a design speed of 80km/h and a reaction time of 2.5 seconds, the stopping sight distance required would be 126m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 2.2m.

Recommendation

Provide sufficient stopping sight distance around the inside of the curve (ch 5540 to 6040) in the southbound direction.

1.11 Significant Concern - Insufficient Sight Distance around curve (ch 6140 to 6400)

At this location in the southbound direction, there is a curve with a radius of 305m. For a design speed of 80km/h and a reaction time of 2.0 seconds (in the tunnel), the stopping sight distance required would be 126m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 3.9m.

Recommendation

Provide sufficient stopping sight distance around the inside of the curve (ch 6140 to 6400) in the southbound direction.

1.12 Significant Concern – Insufficient Sight Distance around curve (ch 6138 to 6400)

At this location in the northbound direction, there is a curve with a radius of 297m (MC10). For a design speed of 80km/h and a reaction time of 2.0 seconds (cut and cover tunnel), the stopping sight distance required would be 114m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 3.9m.

Recommendation

Provide sufficient stopping sight distance northbound around the inside of the curve (ch 6138-6400)

1.13 Significant Concern – Cook Street Off-Ramp Insufficient Sight Distance around curve (ch 0 to 150)

At this location in the southbound direction, there is a curve with a radius of 210m. For a design speed of 80km/h and a reaction time of 2.5 seconds, the stopping sight distance required would be 126m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 8.2m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street off-tamp curve (ch 0 to 150) in the southbound direction.

1.14 Significant Concern – Cook Street Off-Ramp Insufficient Sight Distance around curve (ch 150 to 550)

At this location in the southbound direction, there is a curve with a radius of 463m. For a design speed of 80km/h and a reaction time of 2.5 seconds, the stopping sight distance required would be 126m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 2.6m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street off-ramp curve (ch 150 to 550) in the southbound direction.

1.15 Significant Concern – Cook Street Off-Ramp Insufficient Sight Distance around curve (ch 625 to 774)

At this location in the southbound direction, there is a curve with a radius of 350m. For a design speed of 80km/h and a reaction time of 2.5 seconds, the stopping sight distance required would be 126m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 4.1m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street off-ramp curve (ch 625 to 774) in the southbound direction.

1.16 Significant Concern – Cook Street Off-Ramp Insufficient Sight Distance around curve (ch 1781 to 2010)

At this location in the southbound direction, there is a curve with a radius of 200m. For a design speed of 70km/h and a reaction time of 2.0 seconds (in the tunnel), the stopping sight distance required would be 92m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 3.8m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street off-ramp curve (ch 0 to 150) in the southbound direction.

1.17 Significant Concern – Cook Street On Ramp Insufficient Sight Distance around curve (ch 300 to 450)

At this location in the northbound direction, there is a curve with a radius of 327m. For a design speed of 80km/h and a reaction time of 2.0 seconds, the stopping sight distance required would be 114m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 3.3m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street on-ramp curve (ch 300 to 450) in the northbound direction.

1.18 Significant Concern – Fanshaw Street On-Ramp Insufficient Sight Distance around curve (ch 1300 to 1374)

At this location in the northbound direction, there is a curve with a radius of 195m. For a design speed of 70km/h (due to this being the beginning of the ramp) and a reaction time of 2.5 seconds, the stopping sight distance required would be 102m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 5.2m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Fanshaw Street On-ramp curve (ch 1300 to 1374) in the northbound direction.

1.19 Significant Concern – Compound Curves on the Fanshaw Street Southbound Off-Ramp (ch 264 to 619)

There is a pair of compound curves on the Fanshaw Street southbound off-ramp with reducing radii from 750m to 350m. This reduction in curve radii without appropriate transitions or straights can be deceptive for drivers due to the tightening of the curve, and may result in loss of control crashes.

Recommendation

Review the geometry to provide consistent curve geometry around this curve such that the compound curve is removed.

1.20 Significant Concern – Excessive Gradient Southbound from Bridge

In the southbound direction, the provision of a 6.25% grade on the approach to the SH16/ Port connection is likely to result in truck speeds reducing to around 40km/hr (Austroads 2009 Pt 3 Table 9.5). The effect of this gradient is that there will be a speed differential between heavy vehicles and other lighter vehicles.

The left lane from the tunnel is an exclusive exit lane to SH16 and the Port. Therefore any trucks heading south will need to be travelling in lane 2. This movement is considered to be the greater movement, and this will result in slower moving trucks being in lane 2.

This scenario could result in a number of weave movements as vehicles change lanes in an attempt to avoid slower moving trucks. This will be exacerbated in the instance where there is a truck in each lane, and a high speed vehicle is attempting to exit at the SH16/ port off/ramp.

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

1.21 Significant Concern – Vertical and Horizontal Geometry out of Phase on Onewa Road Southbound On-Ramp (ch140 – 320)

There is a vertical crest curve at this location with a K value of 45. This vertical curve is followed by a horizontal curve (ch 185) which will not be visible over the vertical curve.

Recommendation

Realign the ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.

1.22 Minor Concern – Excessive Gradient Southbound on upgrade of the bridge

The gradient on the southbound upgrade of the bridge is a 5.0% grade (ch 3750 to 4070). The speed of heavy vehicles is likely to reduce to around 40km/hr (Austroads 2009 Pt 3 Table 9.5). This may create a capacity issue on the upgrade, although it is acknowledged that there is sufficient sight distance and heavy vehicles can remain in the left hand lane.

Recommendation

Review the geometry to identify whether the grade can be reduced.

1.23 Minor Concern – Excessive Gradient Northbound on upgrade of the bridge

The gradient on the northbound upgrade of the bridge is a 4.5% grade (ch 5260 to 6150) extending over a length of 790m. The speed of heavy vehicles is likely to reduce to around 40km/hr (Austroads 2009 Pt 3 Table 9.5). This may create a capacity issue on the upgrade, although it is acknowledged that there is sufficient sight distance and heavy vehicles can remain in the left hand lane.

Recommendation

Review the geometry to identify whether the grade can be reduced.

1.24 Minor Concern – Sight Distance to Ramp Diverge

There are a number of locations where there is inadequate sight distance to the off-ramp nose. These are identified below:

1) Esmonde Road Southbound Off-ramp – There is a crest vertical curve with a K value of 85 through ch 220 to 380 which may limit visibility to the nose.

2) Cook Street Off-ramp: SH1 Temporary Diversion (ch1220 MC30) – There is a crest vertical curve with a K value of 45 through ch 900 to 1250 which may limit the visibility of the nose.

3) Onewa Road Southbound on-ramp (ch460 MCQ0) – There is a crest vertical curve with a K value of 13 and a 100m radius horizontal curve which may limit the visibility of the nose.

Recommendation

For the locations noted above, check there is 1.4 x stopping sight distance to the nose.

1.25 Minor Concern – Separation between ramp merge and Diverge

The Onewa Road southbound on-ramp diverges to the tunnel and the Harbour Bridge. On the connection to the tunnel, the diverge is closely followed by a lane gain where the Esmonde Road traffic is entering the tunnel. This spacing is very close at approximately 150m.

Recommendation

Investigate opportunities to increase the separation between the ramps.

1.26 Comment – Horizontal Compound Curves

There are three horizontal curves on the Cook Street southbound off-ramp (MC20) with radii of 210m, 463m, and 1503m through (ch 0 to 331). While these curves do not provide a good geometry, it is acknowledged by the auditors that they reflect the existing alignment through St Marys Bay and that this alignment is severely constrained.

2. Cook Street Temporary Diversion

2.1 Significant Concern – Insufficient Sight Distance Around Curve (ch974 – 1046)

There is a horizontal curve with a radius of 200m. For a design speed of 80km/h and a reaction time of 2.0 sec, the required safe stopping sight distance is 114m. To achieve this, the left shoulder would need to be 6.62m wide, although the actual shoulder width is only 1.0m. As the length of curve is 72m which is less than the SSD, then the actual curve widening required will be less than the 6.62, although it will still be greater than that provided.

Recommendation

Realign the temporary ramp to achieve adequate sight distance.

2.2 Significant Concern – Insufficient Sight Distance around curve (ch 215 to 824)

At this location, there is a curve with a radius of 470m. For a design speed of 80km/h and a reaction time of 2.0 seconds, the stopping sight distance required would be 114m. To achieve this sight distance across the inside of the curve, the left shoulder would need to be wider, to approx 6.6m.

Recommendation

Provide sufficient stopping sight distance around the inside of the Cook Street Off-ramp curve (ch 215 to 824).

2.3 Minor Concern – Vertical and Horizontal Geometry out of Phase (ch920 – 1260)

There is a vertical crest curve at this location with a K value of 45. This vertical curve is followed by a horizontal curve (ch 974) which will not be visible over the vertical curve.

Recommendation

Realign the temporary ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.

PT Lanes

2.4 Significant Concern – Conflict of Northbound PT lane through Curran Street On-Ramp

No detail is provided to indicate how the nbd bus lane crosses the Curran Street onramp before the Harbour Bridge. As a separate bus lane is provided, this will need to commence after the on-ramp, once on-ramp traffic has merged, and buses will be required to merge with general northbound traffic prior to the on-ramp.

Recommendation

Develop a layout for the Curran Street northbound on-ramp so that incorporates the PT lane.

2.5 Significant Concern – Northbound PT lane (MC70) Horizontal Curve Combinations provide poor Geometry (ch722 to 1005)

At this location there is a series of 4 horizontal curves and two vertical curves with K values of 20 and 45. While the horizontal curve radii are not provided, this geometry presents a poor alignment.

Recommendation

Improve the geometry to replace the numerous horizontal and vertical curves along this length.

Staging

2.6 Comment – Traffic Management during Construction

This project requires the connection of two major motorways in a very constrained area. The volume of traffic using the existing section of motorway has very high volumes and has very tidal flows. Therefore, there will be significant staging issues to be resolved. These will need to be considered in developing the design to ensure that the project is constructible, without significantly compromising the capacity of the motorway network. The key areas where staging is likely to be critical are outlined below:

- Onepoto Stream Bridges, which will require reconstruction;
- Coordination of the construction of the realigned Cook Street off-ramp to maintain southbound traffic flow (temporary alignment proposed); and
- Cut and cover beneath major arterial roads, being Fanshaw Street and Victoria Street.

Local Road Network

2.7 Comment – Cook Street/ Union Street Realignment

The existing Connection from Cook Street to Union Street will no longer be possible for sbd traffic, as this connection is located in close proximity to the Cook Street tunnel portal. There is a risk that vehicles will inadvertently enter the Cook Street on-ramp and there will be no opportunity for them to turn around other than the Onewa Road Interchange.

A left turn from Cook Street may still be feasible to enable vehicles to avoid entering the motorway, and the provision of a slip road would also accommodate access to the adjacent properties along this length of Cook Street.

Signs

2.8 Significant Concern – Signs Indicate Non-existent Ramp

The southbound signing indicates that there is a southbound off-ramp connection from Esmonde Rd to Onewa Rd, although there is no ramp connection provided. This is an existing connection that should be provided. Otherwise there are likely to be impacts on the local road network

Recommendation

Investigate options for maintaining the existing connection between Esmonde Road and Onewa Road.

2.9 Minor Concern – Incorrect Signing

The annotated sign plans were reviewed and several minor issues were identified. These are outlined below and should be considered in the development of the project Sign Plan.

Southbound:

1. Shelly Beach Destination – Shelly Beach is shown as a destination on signs at distance 1250. At distance 1900 the middle sign panel should show Shelly Beach as a destination. Once a destination is displayed it should continue until the exit point.

2. Exit Only – The left sign panel at distance 8800 should show exit only for West/East; Port/Helensville

Signs Southbound Existing Bridge

3. The sign panel located at the Shelly Beach exit – Show the distance to Fanshaw Street exit.

4. Signs at distance 3560 and 4300:
   The signs at 3560 show Shelly Beach 1.8km the sign at distance 4300 shows Shelly Beach 900m. The Cook Street signs at both distances show have the same difference in distance.
   The sign at distance 3560 has a panel for Fanshaw Street exit. A Fanshaw Street panel should be added to the signs at distance 4300. Once a destination is displayed it should continue until the exit point.
   The signs at both distances show the Bus Lane on the Left and Shelly Beach as a destination on the adjacent lane. At the exit to Shelly Beach the general traffic will need to cross the Bus Lane.

Signs Northbound

5. Distances shown on signs – The sign panels showing Esmonde Rd as a destination at distance 2450 and 1700 should have a distance of 650m between. (they are shown as 400m & 1200m)

Signs Northbound Existing Bridge

The sign panel located on the Existing Bridge – The sign shows three destinations with distances

- Stafford Rd – 1.5km
- Onewa Rd – 2.1km
- Esmonde Rd – 3.5km

Once a destination is displayed it should continue until the exit point. The sign panels located at dist 3900 and 3100 should include Esmonde Rd as a destination

2.10 Comment – Incorrect Use of the word 'South' as a destination

It is noted that the sign plan provide is conceptual. However, the signing for the southbound SH1 connection to Fanshaw Street, Cook Street, SH16 and the Port is identified as 'SH1 South'. As these routes connect to the CBD, it is considered more appropriate to use 'SH1 City' rather than 'SH1 South' for these connections.

AUDIT TEAM STATEMENT

We certify that in carrying out this audit we have inspected the site and used the drawings and associated documents listed in Appendix A. We have endeavoured to identify features of the proposed scheme that could be modified, or included in the project scope, in order to improve safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The problems identified have been noted in this report together with recommendations that should be studied for implementation. Where recommended actions are not taken, this should be reported in writing, providing the reasons for that decision.

Signed:  Date: 14/10/2010

Rob Mason, Beca Infrastructure Limited, Auckland

Signed:  Date: 14/10/2010

Maurice Kwan, AECOM New Zealand Ltd, Auckland

Appendix A

Drawings and Associated Documents Reviewed

60157303-CSSK-001-B
60157303-CSSK-012-A
60157303-RD-060 Rev B General Arrangement
60157303-RD-061 Rev B General Arrangement
60157303-RD-062 Rev B General Arrangement
60157303-RD-063 Rev B General Arrangement
60157303-RD-064 Rev B General Arrangement
60157303-RD-070 Rev B Plan and Long Section
60157303-RD-071 Rev B Plan and Long Section
60157303-RD-072 Rev B Plan and Long Section
Bridge option Lane Configuration Diagram Rev 0
Cook Street off - SH1 Temp Diversion - Long and Cross Sections Rev 0
Cook Street off - SH1 Temp Diversion - plan Rev 0
Cross Sections - Cook Street Sthbound Off Ramp Rev 0
Cross Sections Ch0000-3600 - SH1 Main Alignment Rev 0
Cross Sections Ch5460-7155 - SH1 Main Alignment Rev 0
mc00 - SH1 Main Alignment Sthbound - Long Sections Ch0000-Ch7155 Rev 0
mc00 - SH1 Main Alignment Sthbound - Long Sections Ch5400-Ch7155 Rev 0
mc10 - SH1 Main Alignment Nthbound - Long Sections Ch0000-Ch7155 Rev 0
mc10 - SH1 Main Alignment Nthbound - Long Sections Ch5400-Ch7155 Rev 0
mc20 - Cook Street Sthbound Off-Ramp - Long Sections Rev 0
mc21 - Fanshawe Street PT Sthbound Off-Ramp - Long Sections Rev 0
mc30 - Fanshawe Street Sthbound Off-Ramp - Long Sections Rev 0
mc30 - Nthbound Harbour Bridge to SH1 long Section Rev 0
mc40 - Sthbound SH1 to Habour Bridge Long Section Rev 0
mc50 - Fanshawe Street Nthbound On-Ramp - Long Sections Rev 0
mc60 - Cook Street Nthbound On-Ramp - Long Sections Rev 0
mc70 - Fanshawe Street PT Nthbound On-Ramp - Long Sections Rev 0
mc80 - Westhaven Drive - Long Section Rev 0
mca0 - Onewa Rd Nthbound Off-ramp from New Bridge Long Section Rev 0
mcb0 - Nthbound Bus Lane Harbour Bridge to Busway Long Section Rev 0
mcc0 - Stafford Rd Nthbound Off-ramp from Harbour Bridge Long Section Rev 0
mcd0 - Busway Akoranga Station to Harbour Bridge Long Section Rev 0
mce0 - Esmonde Rd Nthbound Off Ramp Long Section Rev 0
mcf0 - Esmonde Rd Long Section Rev 0
mcp0 - Onewa Rd Sthbound On-ramp to New Bridge Long Section Rev 0
mcq0 - Onewa Rd Sthbound On-ramp to Harbour Bridge Long Section Rev 0
mcr0 - Onewa Rd Sthbound Off-ramp Long Section Rev 0
mcs0 - Esmonde Rd Sthbound On-ramp Link Road Long Section Rev 0
mcu0 - Esmonde Rd Sthbound On-ramp from Link Road to New Bridge Long Section Rev 0
mcz0 - Onewa Rd Nthbound Off-ramp from Harbour Bridge Long Section Rev 0
Signing Strategy including Tolling locations and Gantries

NZ TRANSPORT AGENCY
WAKA KOTAHI

Road Safety Audit Report Recommendations

DECISION TRACKING FORM

Project Title: Additional Waitemata Harbour Crossing Bridge Option **Road Safety Audit Stage:** Stage 1 Feasibility

RCA Project Manager: **Designer:** Beca/AECOM

Road Safety Auditors: Rob Mason, Maurice Kwan

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
General Layout	2.		
Minor Concern **Insufficient Merge Area from the Esmonde/ Onewa Southbound Connection to the existing Harbour Bridge** *Review the traffic effect of the proposed layout to understand how it will operate and identify opportunities to increase the distance available for the merge and lane change.*	2.1	Agree further work is required to understand operation issues and the variance between am/pm peaks. This should be undertaken in Future Design.	
Significant Concern **Conflict between Shelley Beach Off ramp and the Northbound PT lane** *Develop a layout for the Shelley Beach Road off ramp that can safely accommodate the PT lane.*	2.2	The proposed lane usage on the AHB has been prescribed by NZTA. The pedestrian/cycle lane will terminate as soon as practicable upon land fall, and convey users to Westhaven Drive. The existing off ramp geometry will be maintained. The design team acknowledges that this has both operational and safety implications. During the next phase alternative PT lane configurations should be reconsidered	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Comment **Conflict between Rail and PT lanes at Esmonde Road** *The plans indicate that the future rail line and the proposed PT are aligned at Esmonde Road (ch 700 to 900), which will result in conflict between buses and trains. The rail line is excluded from the scope of this audit as it has not yet been developed fully, however, the designer should note this issue for future design development.*	2.3	Agreed. This should be reviewed in Future Design.	
Highway Geometry			
Serious Concern **Low Radius Horizontal Curve Cook St On Ramp** *Amend the design to provide a larger radius curve and appropriate sight distance.*	3.1	The curve has a nominal design speed of 65kph linking the Cook St 50kph posted speed with the new on ramp tunnel. The RH shoulder is widened to 2.5m to provide for SD using tunnel Rt of 1.5sec. Improvements to the radius selected further impact upon the adjacent Victoria park Market heritage site. A posted speed of 50kph should be maintained into the tunnel until beyond this curve.	
Significant Concern **Insufficient Sight Distance around curve (ch 5540 to 6040)** *Provide sufficient stopping sight distance around the inside of the curve (ch 5540 to 6040) in the southbound direction.*	3.2	The 2.5m wide LH shoulder provides 129m of SSD on the bridge This meets the requested 126m, however when grade corrected provides SSD for 80kph with 2.0sec Rt.	
Significant Concern **Insufficient Sight Distance around curve (ch 6140 to 6400)**	3.3	The 2.5m wide RH shoulder provided on the inside of curve will achieve SSD of 103 equal to 80kph with 1.5sec Rt.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Provide sufficient stopping sight distance around the inside of the curve (ch 6140 to 6400) in the southbound direction.		Widening around inside of curves within tunnels has been limited to 2.5m maximum shoulder width as per the adjacent VPT project (similar radii) under construction.	
Significant Concern **Insufficient Sight Distance around curve (ch 6138 to 6400)** *Provide sufficient stopping sight distance northbound around the inside of the curve (ch 6138-6400).*	3.4	This section of highway is part of the VPT under construction. NZTA has agreed to this cross section. The designers acknowledge that the 2.5m wide LH shoulder provided will not achieve desired SSD. 99m provided is less than 80kph at 1.5RT.	
Significant Concern **Cook St Off Ramp Insufficient Sight Distance around curve (ch 0 to 150)** *Provide sufficient stopping sight distance around the inside of the Cook St Off Ramp curve (ch 0 to 150) in the southbound direction.*	3.5	This section of highway is the existing SH1 beneath the Shelly Beach off ramp and while no further widening is proposed, SSD can be achieved as traffic will occupy only the outer 4 lanes leaving a both the existing shoulder and 5th traffic lane combined widths clearance from the barrier face.	
Significant Concern **Cook St Off Ramp Insufficient Sight Distance around curve (ch 150 to 550)** *Provide sufficient stopping sight distance around the inside of the Cook St Off Ramp curve (ch 150 to 550) in the southbound direction.*	3.6	This section of highway is the existing SH1 beyond the Shelly Beach off ramp bridge. A 2.5m LH shoulder is provided as per the existing layout. No further encroachment in to Westhaven Drive is proposed.	
Significant Concern **Cook St Off Ramp Insufficient Sight Distance around curve (ch 625 to 774)** *Provide sufficient stopping sight distance around the inside of the Cook St Off Ramp*	3.7	In this location the general traffic lane is separated from the LH edge barrier by a 1.0m flush median, a 3.5m PT lane and a 2.5m shoulder. This provides sufficient	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
curve (ch 625 to 774) in the southbound direction.		lateral offset to achieve SSD.	
Significant Concern **Cook St Off Ramp Insufficient Sight Distance around curve (ch 1781 to 2010)** *Provide sufficient stopping sight distance around the inside of the Cook St Off Ramp curve (ch 0 to 150) in the southbound direction.*	3.8	The 2.5m wide LH shoulder provided on the inside of curve (left of bus lane) will achieve SSD of 80m equal to the design speed of 65kph with 1.5sec Rt. General traffic lanes will benefit from the additional space provided by the 3.5m bus lane.	
Significant Concern **Cook St On Ramp Insufficient Sight Distance around curve (ch 300 to 450)** *Provide sufficient stopping sight distance around the inside of the Cook St On Ramp curve (ch 300 to 450) in the northbound direction.*	3.9	The 2.5m wide RH shoulder provided on the inside of curve will achieve SSD of 105m equal to 80kph with 1.5sec Rt. This is in keeping with the preceding section of carriageway exiting the tunnel.	
Significant Concern **Fanshaw St On Ramp Insufficient Sight Distance around curve (ch 1300 to 1374)** *Provide sufficient stopping sight distance around the inside of the Fanshaw St On Ramp curve (ch 1300 to 1374) in the northbound direction.*	3.10	Traffic travels in the reverse direction to the long section. Dist 1300 – 1374 is located immediately west of the Beaumont St intersection (50kph). Carriageway edge will be predominately kerb and channel. Shoulder widening is considered unnecessary in this location.	
Significant Concern **Compound Curves on the Fanshaw St Southbound Off Ramp (ch 264 to 619)** *Review the geometry to provide consistent curve geometry around this curve such that the compound curve is removed.*	3.11	Resolved. The designer cannot locate this geometric feature. The current development of this ramp does not contain compound or similar handed curves..	
Significant Concern **Excessive Gradient Southbound from Bridge**	3.12	Agree, the gradient will produce a significant speed differential between HCV and cars. A maximum vertical	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.		gradient southbound of 5% has been adopted as instructed by NZTA. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each producing a similar terminal speed for HCV's .	
Significant Concern **Vertical and Horizontal Geometry out of Phase on Onewa Road Southbound On Ramp (ch140 - 320)** *Realign the ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.*	3.13	Horizontal and vertical IP's are synchronised, however the horizontal curve is short. During the next phase a review of the coordination should be undertaken to ensure sufficient curve length is visible to the driver.	
Minor Concern **Excessive Gradient Southbound on upgrade of the bridge** *Review the geometry to identify whether the grade can be reduced.*	3.14	In the next phase a detailed analysis of maximum gradient verse longer sustained grades should be undertaken In this location the maximum elevation required for navigation is fixed. Elsewhere within the project the length of climbing grade has been demonstrated	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		to be just as critical as the maximum grade used when considering speed differential between HCV's and cars.	
Minor Concern **Excessive Gradient Northbound on upgrade of the bridge** *Review the geometry to identify whether the grade can be reduced.*	3.15	Refer to 3.14 above. Additionally in this case the alignment has been artificially steepened to provide a symmetrical looking bridge with a single central crest.	
Minor Concern **Sight Distance to Ramp Diverge** *For the locations noted above, check there is 1.4 x stopping sight distance to the nose.*	3.16	Agreed. To be addressed in next phase.	
Minor Concern **Separation between ramp merge and Diverge** *Investigate opportunities to increase the separation between the ramps.*	3.17	Agreed. The designer notes that approach speed will be limited in this vicinity due to the existing tight Onewa onramp bridge geometry, however inter-visiblity between connections should be check in next phase	
Comment **Horizontal Compound Curves** *There are three horizontal curves on the Cook St southbound off ramp (MC20) with radii of 210m, 463m, and 1503m through (ch 0 to 331). While these curves do not provide a good geometry, it is acknowledged by the auditors that they reflect the existing alignment through St Mary's Bay and that this alignment is severely constrained.*	3.18	Agreed. In future design these curves could be investigated to see if there is any improvement possible.	
Cook St Temporary Diversion			

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Significant Concern **Insufficient Sight Distance Around Curve (ch974 - 1046)** *Realign the temporary ramp to achieve adequate sight distance.*	4.1	This will be address during next phase. The temporary alignment in this location is linked to the Cook St off ramp which provides for 2.5m inside shoulder. The temporary works alignment for the viaduct assumed a posted & design speed for diverted traffic of 70kph	
Significant Concern **Insufficient Sight Distance around curve (ch 215 to 824)** *Provide sufficient stopping sight distance around the inside of the Cook St Off Ramp curve (ch 215 to 824).*	4.2	Disagree. The 470m radius right hand curve was part of the then Cook St off ramp tunnel. In the equivalent location the Cook St tunnel has a radius of 592.50m with a 2.5m RH shoulder This provides 142m of SSD around the inside of curve equal to 90kph with a 2.0 sec Rt.	
Minor Concern **Vertical and Horizontal Geometry out of Phase (ch920 - 1260)** *Realign the temporary ramp so that the vertical and horizontal geometry are in phase so that the horizontal curve will be visible.*	4.3	A review of horizontal and vertical coordination should be undertaken in the next phase. The horizontal curve in this instance is not masked by the vertical alignment.	
PT Lanes			
Significant Concern **Conflict of Northbound PT lane through Curran St On ramp** *Develop a layout for the Curran Street northbound on ramp so that incorporates the PT lane.*	5.1	To be addressed during next phase.	
Significant Concern	5.2	Agreed.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Northbound PT lane (MC70) Horizontal Curve Combinations provide poor Geometry (ch722 to 1005) *Improve the geometry to replace the numerous horizontal and vertical curves along this length.*		The alignment is intended to represent the PT lane currently under construction as part of the VPT project. The alignment will be improved at the next phase	
Staging	6.		
Comment **Traffic Management during Construction** *This project requires the connection of two major motorways in a very constrained area. The volume of traffic using the existing section of motorway has very high volumes and has very tidal flows. Therefore, there will be significant staging issues to be resolved. These will need to be considered in developing the design to ensure that the project is constructible, without significantly compromising the capacity of the motorway network.*	6.1	Agreed, Refer o the Form Assessment Report. This should be undertaken in future design.	
Local Road Network	7.		
Comment **Cook St/ Union St Realignment** *The existing Connection from Cook St to Union St will no longer be possible for sbd traffic, as this connection is located in close proximity to the Cook St tunnel portal. There is a risk that vehicles will inadvertently enter the Cook St on ramp and there will be no opportunity for them to turn around other than the Onewa Road Interchange.* *A left turn from Cook St may still be feasible to enable vehicles to avoid entering the motorway, and the provision of a slip road*	7.1	Agreed, This should be undertaken in future design.	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
would also accommodate access to the adjacent properties along this length of Cook Street.			
Signs	8.		
Significant Concern **Signs Indicate Non-existent Ramp** *Investigate options for maintaining the existing connection between Esmonde Road and Onewa Road.*	8.1	Accepted. At the time of the RSA, the geometric design had not been fully developed and the Onewa Road Southbound Off-ramp had not been completed. The signage sketch showed how the off ramp was proposed to be signed. The signage strategy will be further developed in future design FAS drawing now show link between Esmonde Rd and Onewa Rd interchanges. Operationally there would be an opportunity during the next phase to demonstrate case to remove this link.	
Minor Concern **Incorrect Signing** *The annotated sign plans were reviewed and several minor issues were identified. These are outlined below and should be considered in the development of the project Sign Plan*	8.2	Accepted. The annotated signage plans is a signage concept and were developed primarily to establish if the proposed geometric layout could be signed. The signage strategy for this project needs to be developed in greater detail with consultation with NZTA. This should be undertaken in future design	
Comment **Incorrect Use of the word 'South' as a destination** *It is noted that the sign plan provide is conceptual. However, the signing for the southbound SH1 connection to Fanshaw St, Cook St, SH16 and the Port is identified as*	8.3	Accepted. The annotated signage plans is a signage concept and were developed primarily to establish if the proposed geometric layout could be signed. The signage strategy for this project needs to be developed in greater detail with consultation with NZTA. This	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
'SH1 South'. As these routes connect to the CBD, it is considered more appropriate to use 'SH1 City' rather than 'SH1 South' for these connections		should be undertaken in future design.	

Completed Decision Tracking Form sent by RCA Project Manager to:

1. Designer Date: / /

2. Audit Team Leader Date: / /

For additional rows, click in the bottom right cell of the table above and then press the **Tab** key.

To delete a row, click anywhere in the row and then choose **Delete Cells, Delete entire row** from the **Table** menu.

* RS Auditor to complete and attach to report – send electronically to RCA Project Manager

NZ TRANSPORT AGENCY
WAKA KOTAHI

AWHC

Additional Waitemata Harbour Crossing

Internal Road Safety Audit –

Bridge Option Stage 1 Feasibility Addendum

This report has been prepared by AECOM New Zealand Ltd for the benefit of the NZ Transport Agency (NZTA). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval or to fulfil a legal requirement.

Quality Assurance Statement	Name	Signature / Date
Prepared by:	Rob Mason	19.10.10
Reviewed by:	Maurice Kwan	14.10.10

Revision Schedule

Rev. No	Date	Description	Prepared by	Reviewed by	Approved by
A	29/09/10	Draft for Audit Team comment	Rob Mason	Maurice Kwan	
B	30/09/10	Final Draft	Rob Mason	Maurice Kwan	

Contents

1. Introduction

1.1 Scope of the Audit:

This report has been prepared as an addendum to the previous Road Safety Audit report for the bridge option (3rd September 2010). Since undertaking the initial audit, the design team have revised the geometric alignment of the bridge option at the southern end of the project to reduce the vertical grade from 6.25% to 5.0%. This report presents the findings of a further Stage 1 Feasibility Safety Audit for the revised alignment.

It should be noted that only those elements of the project that have been amended as a result of the reduced grade are considered in this Addendum Report. The section numbering of this addendum is consistent with that of the initial report, and the comments should be read in conjunction with that initial report.

1.2 The Audit Team:

The design for this project has been undertaken jointly by Beca and AECOM, and this audit has been undertaken as an internal review for the design team. The Audit Team comprised:-

- Rob Mason, BE (Hons), Dip.Bus (FLM) Aus,
  Technical Director - Transportation, Beca Infrastructure Limited, Auckland.

- Maurice Kwan, MIPENZ, CPEng
  Principal Civil Engineer, AECOM New Zealand Ltd, Auckland.

1.3 Procedures and Reporting:

In accordance with the Road Safety Audit Procedures for Projects Guideline, it should be noted that this audit is not to be regarded as a "quality check" or a design check of the project. It is focused essentially on safety issues that are considered significant in regard to the proposed design. Comments and recommendations are outlined in the following section of the report. The item headings as listed in the Contents also provide a summary of the findings. Points have been ranked as follows:

- Serious Concern: a major safety concern that should be addressed and requires changes to avoid serious safety problems.

- Significant Concern: a significant safety concern that requires consideration of changes to improve safety.

- Minor Concern: a safety concern of lesser significance, but which should be addressed as it may improve overall safety.

- Comment: a concern or an action that may be outside the scope of the road safety audit, but which may improve overall design or be of wider significance.

1.4 Disclaimer

The findings, opinions, and recommendations in this report are based on an examination of available relevant plans and a visual inspection of the site, and may not address all issues existing at the time of the audit. The report also deals with technical matters. Readers are urged to seek specific advice on particular matters and not rely solely on the report. While every effort has been made to ensure the accuracy of the report, it is made available strictly on the basis that anyone relying on it does so at their own risk without any liability to members of the audit team or their organisation.

2. Highway Geometry

2.1 Serious Concern – Excessive Gradient Southbound from Tunnel

The initial alignment incorporated a 6.25% uphill grade extending from the cut and cover tunnel over a length of approximately 270m. To achieve a reduced grade southbound, the start of the upgrade was moved further north, resulting in a longer length of reduced grade (605m at 5%).

It is understood that Austroads has been adopted as the design standard for this project, and this indicates that for the 6.25% grade from the tunnel, truck speeds will reduce to approximately 45km/h at the end of the grade.

The primary issue with regard to the steep grade and the effect on trucks is the speed differential that will result, and the fact that slower moving trucks will be required to travel in lane 2 to be able head south, as lane 1 is an exclusive exit to SH16 and the Port. As a result, there is a high likelihood that both lanes 1 and 2 could have trucks travelling at reduced speed. Therefore the location of the diverge area relative to truck speeds is critical in determining the risk for the project.

The length of road that a grade is applied will effect the rate that the truck speed will decrease. A comparison of the two bridge options is provided in Figure 2.1 below, where the location of change in grade has been related to the drop in speed (based on Austroads Guide to Road design Part 3: Geometric Design, Figure 9.3). This diagram also indicates where the diverge area is for the SH16/ Port off-ramp connection.

From this diagram, it can be seen that truck speeds will remain above 60km/h through the diverge area for both scenarios, reducing to around 50km/h further south of the diverge area. While this will result in some speed differential between trucks and through traffic, potentially resulting in weave and lane change crashes, truck speeds remain relatively high compared to the driven tunnel.

There is a slight difference in truck speeds for the flatter grade of 5%, as they are able to maintain a higher speed over a longer distance.

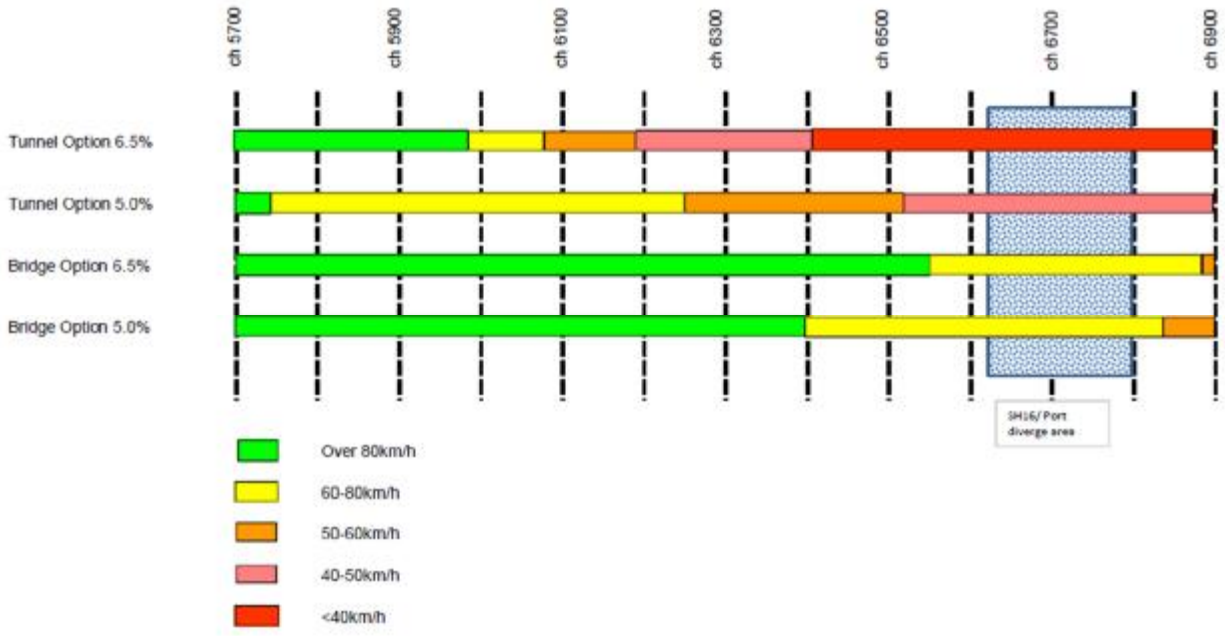

Figure 2.1: Relative rate of speed decrease

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

2.2 Significant Concern – Excessive Gradient Southbound on SH16/Port Off Ramp

The vertical grade southbound from the cut and cover tunnel extends through the diverge area for the SH16/ Port off-ramp and continues along the SH16/ Port ramp as a 7.6% grade, consistent with the tunnel option. The speed of HCV's is likely to reduce to approximately 45km/h.

Recommendation

Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off-ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.

AUDIT TEAM STATEMENT

We certify that in carrying out this audit we have inspected the site and used the drawings and associated documents listed in Appendix A. We have endeavoured to identify features of the proposed scheme that could be modified, or included in the project scope, in order to improve safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The problems identified have been noted in this report together with recommendations that should be studied for implementation. Where recommended actions are not taken, this should be reported in writing, providing the reasons for that decision.

Signed:  Date: 14/10/2010

Rob Mason, Beca Infrastructure Limited, Auckland

Signed:  Date: 14/10/2010

Maurice Kwan, AECOM New Zealand Ltd, Auckland

Appendix A

Drawings and Associated Documents Reviewed

60157303-TR-051 Rev A – General Arrangement
60157303-TR-052 Rev A – General Arrangement
60157303-TR-053 Rev A – General Arrangement
60157303-TR-054 Rev A – General Arrangement
60157303-TR-055 Rev A – General Arrangement
60157303-TR-056 Rev A – Plan and Long Section
60157303-TR-057 Rev A – Plan and Long Section
60157303-TR-058 Rev A – Plan and Long Section
mc00 - SH1 Main Alignment Sthbound - Long Sections Ch5400-Ch7150 CMJ 5 percent Rev 0
mc10 - SH1 Main Alignment Nthbound - Long Sections Ch5550-Ch7350 CMJ 5 percent Rev 0
mc90 - SH16 Main Alignment Sthbound - Long Sections CMJ 5 percent Rev 0
mcv0 - Victoria Street West - Long Section CMJ 5 percent Rev 0

NZ TRANSPORT AGENCY
WAKA KOTAHI

Road Safety Audit Report Recommendations

DECISION TRACKING FORM

Project Title: Additional Waitemata Harbour Crossing Bridge Option

Road Safety Audit Stage: Stage 1 Feasibility - Addendum

RCA Project Manager:

Designer: Beca / AECOM

Road Safety Auditors: Rob Mason, Maurice Kwan

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
Highway Geometry	3.		
Serious Concern **Excessive Gradient Southbound from Tunnel** *Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.*	3.1	Agree, the gradient will produce a significant speed differential between HCV and cars. Additional lanes cannot be provided where they would overlap the bored tunnel section as the tunnel diameter would exceed current construction technology. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each	

Recommendation *	Report Ref.	Designer Comments	RCA Project Manager Decision
		producing a similar terminal speed for HCV's .	
Significant Concern **Excessive Gradient Southbound on SH16/Port Off Ramp** *Review the geometry to identify whether the grade can be reduced, and consider whether the layout for the SH16/ Port off ramp can incorporate a third lane so that heavy vehicles can continue south from the left lane.*		Agree, the gradient will produce a significant speed differential between HCV and cars. Additional lanes cannot be provided where they would overlap the bored tunnel section as the tunnel diameter would exceed current construction technology. There is insufficient length between the SH16 exit and the Wellington St bridge pinch point to terminate a crawler lane. Opportunities to connect the SH16 link back to SH1 for HCV has previously been ruled out as not constructible Analysis of the 5% maximum gradient has demonstrates that little if any improvement will be achieved. With the tie-in to CJM fixed, the option is either a shorter length of 6.5% grade vs a longer sustained length of 5% grade, each	

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1. Designer Date: / /

2. Audit Team Leader Date: / /

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* RS Auditor to complete and attach to report – send electronically to RCA Project Manager

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Additional Waitemata Harbour Crossing

Internal Rail Safety Audit –

Tunnel Option Stage 1 Feasibility

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Quality Assurance Statement	Name	Signature / Date
Prepared by:	Alan Burford	14/10/2010

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1. Introduction

1.1 Rail Safety Audit Process

Rail Safety Audit is a formalised process to:

- identify potential safety problems for rail users and others affected by a rail project; and
- check that measures to eliminate or reduce the problems are fully considered.

The aim of the audit is to identify any potential safety problems and bring them to the notice of the designer and the client. The auditors are independent of the design team. Any suggested solutions are intended to be indicative only, to assist the designer in focussing on the type of improvements that might be appropriate. They are not intended to be prescriptive, and other ways of resolving the issues should also be considered. The designer should consider the audit report and its recommendations and provide comment to the client on each of the issues raised. The client then makes the final decision on each of these issues.

1.2 Scope of the Audit

This report presents the findings of an internal Stage 1 Feasibility Safety Audit for the Additional Waitemata Harbour Crossing (AWHC) project. This audit has been undertaken to assist the design team in identifying potential safety issues prior to submitting the project for review.

The project evaluated in the audit includes a new rail connection between the Akoranga Bus Station in the North and the proposed Gaunt Street railway station in the south. The form of this connection is a bored tunnel over a distance of 3.9km.

1.3 The Audit Team

The design for this project has been undertaken jointly by Beca and AECOM, and this audit has been undertaken as an internal review for the design team. The Audit Team comprised:-

- Alan Burford, IEng, MICE, MAPM
  Rail Segment Leader, AECOM New Zealand Limited, Auckland.

1.4 Procedures and Reporting

The audit has been undertaken in accordance with the general intent and principles presented in the Road Safety Audit Procedures for Projects Guideline, it should be noted that this audit is not to be regarded as a "quality check" or a design check of the project. It is focused essentially on safety issues that are considered significant in regard to the proposed design. Comments and recommendations are outlined in the following section of the report. The item headings as listed in the Contents also provide a summary of the findings. Points have been ranked as follows:

- Serious Concern: a major safety concern that should be addressed and requires changes to avoid serious safety problems.
- Significant Concern: a significant safety concern that requires consideration of changes to improve safety.
- Minor Concern: a safety concern of lesser significance, but which should be addressed as it may improve overall safety.
- Comment: a concern or an action that may be outside the scope of the road safety audit, but which may improve overall design or be of wider significance.

1.5 Disclaimer

The findings, opinions, and recommendations in this report are based on an examination of available relevant plans and a visual inspection of the site, and may not address all issues existing at the time of the audit. The report also deals with technical matters. Readers are urged to seek specific advice on particular matters and not rely solely on the report. While every effort has been made to ensure the accuracy of the report, it is made available strictly on the basis that anyone relying on it does so at their own risk without any liability to members of the audit team or their organisation.

2. General Layout

2.1 Comment – Rail Provision

This project provides a new rail connection between the Akoranga Bus Station in the North and the proposed Gaunt Street 'sub-surface' railway station in the south but does not provide any detail on how it is to be linked;

- to the existing Auckland Metropolitan rail network in the south, for which the primary railway terminal is centred around Britomart;
- to the proposed CBD rail link (currently under consideration), and
- to any future line, route or network extension to Auckland's North Shore.

Question's such as; 'Is this future rail connection between the North Shore and the CBD in the most optimal location for perceived future rail demand' need to be considered before proceeding with any future rail design in this corridor.

2.2 Comment – Adequate Provision for Fire and Life Safety in Tunnel Section

The design team should insure that there is adequate provision for Fire and Life Safety in the tunnel section of the route. This should include cross passages between tunnels every 240m and access walkways along the tunnels.

3. Rail Geometry

3.1 Comment – No Track or Signal Design

Rail safety is generally centred on the actual operation of the rail system. As this project is at concept phase there are no measurable safety concerns on the basis that there has been no track or signal design undertaken for this proposed connection; along with operational parameters (i.e. a developed operational train timetable). Once the operational design of the rail system is completed a detailed rail safety audit should be undertaken.

AUDIT TEAM STATEMENT

We certify that in carrying out this audit we have inspected the site and used the drawings and associated documents listed in Appendix A. We have endeavoured to identify features of the proposed scheme that could be modified, or included in the project scope, in order to improve safety, although it must be recognised that safety cannot be guaranteed since no road can be regarded as absolutely safe.

The problems identified have been noted in this report together with recommendations that should be studied for implementation. Where recommended actions are not taken, this should be reported in writing, providing the reasons for that decision.

Signed:  **Date:** 14/10/2010

Alan Burford, AECOM New Zealand Ltd, Auckland