NZ TRANSPORT AGENCY
WAKA KOTAHI

Ngauranga to Aotea Quay

Scoping Report

November 2011

Beca

Fletcher

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Executive Summary

The Ngauranga to Aotea Quay Project has been identified as one of eight sections within the Wellington Northern Corridor (State Highway 1 from Levin to the Wellington Airport) which is a Road of National Significance (RoNS) in terms of the 2009 Government Policy Statement on Land Transport Funding.

The Project includes the four kilometre section of State Highway 1 between Ngauranga Gorge and the Aotea Quay on and off-ramps which forms part of the Wellington Urban Motorway. This is the most congested part of the motorway network, particularly during morning and evening peak periods.

The New Zealand Transport Agency (NZTA) awarded Fletcher Construction Company Ltd (Fletcher) the ECI Contract No 446PN: Ngauranga to Aotea Quay: Wellington Active Traffic Management, to carry out the investigation, design and construction of the Project. The ECI Team comprises of Fletcher, Beca Infrastructure Ltd (Beca), Parsons Brinkerhoff (PB), TERNZ and Tyco.

The project objectives were reviewed during the course of the scoping stage. The current high level objectives for the project which were agreed are:

- Improve journey efficiency through journey time reliability, reducing congestion and driver stress;
- Making best use of the asset by delivering a value for money and flexible solution;
- Improve compliance through influencing driver behaviour;
- Maintain or improve safety for all users;
- Adverse effects on the environment are no more than minor;
- The solution can be delivered effectively; and
- The solution fits with NZTA's economic strategy.

The section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks, resulting in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road network. Based on the scoping stage assessments, engagement with the Traffic Operations Centre, key stakeholders, and the public survey, the problems with SH1 from Ngauranga to Aotea Quay can generally be described as congestion and travel time reliability.

To accommodate the forecast traffic flow, relieve congestion and improve travel time reliability, four lanes are required on SH1 from Ngauranga to Aotea Quay in each direction.

The option development and assessment process confirmed that it is feasible to provide four lanes in each direction on SH1 from Ngauranga to Aotea Quay. Through development and assessment of a corridor management framework and workshop with NZTA it was confirmed that the operational strategy for this stretch of SH1 is to be a fully-managed motorway.

The scoping stage assessments have found that providing four lanes in each direction with full management meets the project objectives. Providing four lanes in each direction was found to be physically possible to construct and will provide overall safety benefits through a reduced hazard risk profile. The cost range for providing four lanes with full management is between $69.6M and $105M if a clip-on structure and between $91.7M and $134.7M if a separate structure is used at the Thorndon Overbridge. Providing four lanes full time has an acceptable BCR (greater than 1) if a clip-on structure is used at Thorndon Overbridge.

During scheme assessment, a preferred option for implementing four lanes with full management will be confirmed. This will include further design and assessment of options to choose between full time or part time management, full shoulders or minimal shoulders, a clip-on structure to the Thorndon Overbridge or a new standalone structure, and other project features.

The Scoping Study has concluded that it is feasible to provide four lanes in each direction as a fully managed motorway. The intention is to develop the preferred option and then consider potential phasing. Opportunities will be sought to implement full management in stages. It will also create an opportunity to prove the concept of full management on three lanes before investing in four lanes. The development of a phasing plan will be undertaken in the scheme assessment and will include the consideration of:

- Getting better use out of the existing ATMS system (including improving education and enforcement) before investing in four lanes;
- Timing of four laning between Ngauranga and Aotea Quay relative to the implementation of other RoNS schemes in Wellington such as Terrace Tunnel duplication;
- Whether the implementation of the "specific solutions" such as improvements to the northbound Hutt Road On-Ramp / SH2 merge will significantly delay the need to four lane between Ngauranga and Aotea Quay;
- The timing of potential improvements to the Interislander terminal and the impact it will have on choosing between a clip on or separate structure for Thorndon Overbridge;
- Whether to implement four laning in one direction first (i.e. northbound four lanes and southbound three lanes for an interim period);
- Improvement in journey time reliability to be obtained;
- Cashflow for the Wellington RoNS; and
- Economic efficiency.

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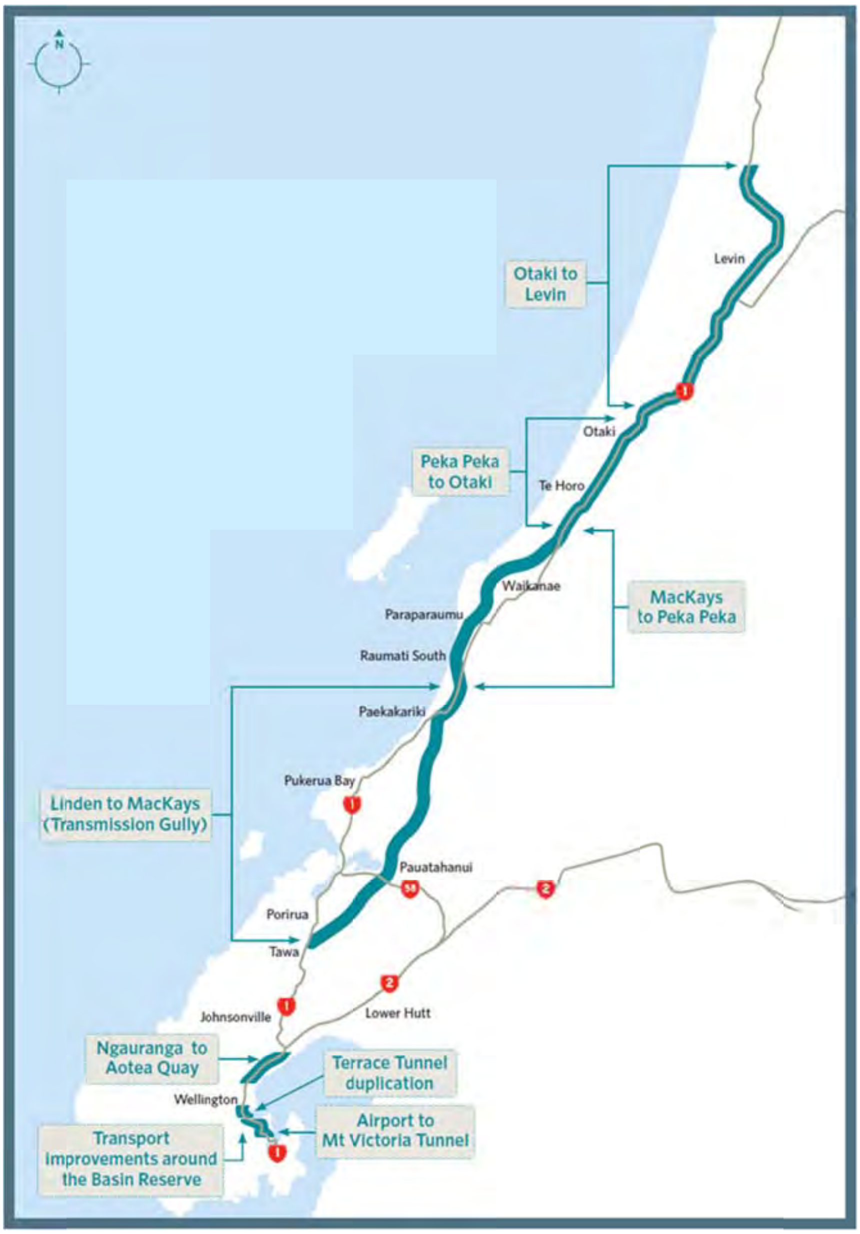
1. Introduction

The Ngauranga to Aotea Quay Project (the "Project") has been identified as one of eight sections within the Wellington Northern Corridor (State Highway 1 from Levin to the Wellington Airport) which is a Road of National Significance (RoNS) in terms of the 2009 Government Policy Statement (GPS) on Land Transport Funding. The upgrading of the Wellington Northern Corridor and the other six RoNS across the country are to be substantially progressed in the next 10 years. The GPS identifies the RoNS as New Zealand's most essential routes that carry high traffic volumes and require solutions to reduce congestion, improve safety and support economic growth. The location of the Ngauranga to Aotea Quay project within the Wellington Northern Corridor RoNS is shown in **Figure 1.1** below.

Figure 1.1: Wellington Northern Corridor RoNS



The Project includes the four kilometre section of State Highway 1 between Ngauranga Gorge and the Aotea Quay on and off-ramps which forms part of the Wellington Urban Motorway. This is the most congested part of the Wellington motorway network, particularly during morning and evening peak periods.

The New Zealand Transport Agency (NZTA) awarded Fletcher Construction Company Ltd (Fletcher) the ECI Contract No 446PN: Ngauranga to Aotea Quay: Wellington Active Traffic Management, to carry out the investigation, design and construction of the Project. The ECI Team comprises of Fletcher, Beca Infrastructure Ltd (Beca), Parsons Brinkerhoff (PB), TERNZ and Tyco.

The ECI Contract will be delivered in three Separable Portions:

- Separable Portion 1 (SP1): Scoping and Scheme Assessment Reporting;
- Separable Portion 2 (SP2): Specimen design; and
- Separable Portion 3 (SP3): Detailed design and construction works.

This Scoping Report is a key deliverable of SP1. The purpose of this report is to:

- Define the problem that the Project is solving;
- Provide a policy and strategic context under which the project will be evaluated;
- Describe the method used to evaluate options;
- Describe the options considered;
- Describe a process for evaluating and staging the implementation of technology based projects outside of this project;
- Summarise the public and stakeholder consultation carried out to date;
- Describe the assessment process and outcomes;
- Provide an analysis of the results of the option assessment in terms of the project context and evaluation criteria; and
- Define the project macroscope and recommend an option(s) to carry forward to Scheme Assessment.

1.1. RoNS & Project Specific Objectives

1.1.1. RoNS Objectives

The Wellington RoNS objectives are:

- to enhance inter regional and national economic growth and productivity;
- to improve access to Wellington's CBD, key industrial and employment centres, port, airport and hospital;
- to provide relief from severe congestion on the state highway and local road networks;
- to improve the journey time reliability of travel on the section of SH1 between Levin and the Wellington airport; and
- to improve the safety of travel on State highways.

1.1.2. Project Specific Objectives

The Ngauranga to Aotea Quay Project specific objectives set at the start of the project (in the RFP) are summarised in **Table 1.1**:

Table 1.1 – RFP Project Objectives

Goal	Objective
Improve Journey Efficiency	■ Contribute to improved journey time reliability ■ Improve driver ambience ■ Integrate with the existing road network
Ease Congestion	■ Smooth traffic flows ■ Increase capacity when needed
Flexibility	■ Operate as required (24/7) ■ Operate independently in each direction ■ Be capable of automatic operation ■ Controllable from any Traffic Operations Centre
Compliance	■ Compliance through intuitive systems ■ Legally enforceable (at time of opening and future-proof hardware) ■ No NZTA liability
Maximise Asset	■ Make best use of existing asset ■ Minimal additional infrastructure ■ Value for Money ■ Consider maintenance and renewal requirements
Knowledge Transfer	■ Develop ATM capabilities in NZ ■ Repeatable (Pilot Scheme) ■ Demonstrate & prove new operating regimes ■ Prove new technologies ■ Extend capabilities of operators
Integration	■ Use latest technology ■ Integrate with existing ATMS ■ Use existing NZTA operating systems ■ Fit with adjacent State Highway and local road network ■ Sustainability of operations (operator ownership)
Improve Safety	■ Improve safety for road users ■ Improve safety for network maintenance ■ Improve safety for Emergency Services
Early Delivery	■ Consider staged delivery to achieve early project delivery
Customers First	■ Minimise construction disruption ■ Innovation ■ Traveller Information ■ Positive Marketing

The Project objectives were reviewed during the course of the scoping stage and were updated during the options assessment process. The current objectives for the Project are:

- Improve journey efficiency through journey time reliability, reducing congestion and driver stress;
- Making best use of the asset by delivering a value for money and flexible solution;
- Improve compliance through influencing driver behaviour;
- Maintain or improve safety for all users;
- Adverse effects on the environment are no more than minor;
- The solution can be delivered effectively; and
- The solution fits with NZTA's economic strategy.

The Project is governed by a Project Steering Group (PSG). The purpose of the PSG is to set project specific objectives and ensure operational requirements of the project are achieved. The PSG also has a technical focus and monitors development of the project against the specific objectives. The PSG consists of senior representatives from NZTA Operations, Safety, Transport Planning, and Network Performance Teams supported by Specialist Advisors as required.

1.2. NZTA Early Work

NZTA and their Specialist Advisor Mouchel carried out early research, investigation and consultation work prior to awarding the ECI Contract. This early research identified that providing an additional running lane in both directions during peak periods and implementing Active Traffic Management Systems (ATMS) will reduce congestion. Utilising the existing shoulder where possible was considered to offer a best value solution and maximise the existing asset. The Early Work concluded that similar projects have been undertaken in the UK, Europe and USA with positive and tangible benefits to the road user, stakeholders and asset owner.

1.3. NZTA Macroscope

On 16 December 2010, NZTA's Value Added Committee (VAC) met to discuss the macroscope definition of the Project. The VAC noted that the Project will be delivered in terms of how SH1 is operated rather than its physical characteristics. The VAC defined the Project macroscope as:

"A preferred concept of operations (operational strategy)" which is:

- *Physically possible;*
- *Has an acceptable BCR; and*
- *No overall safety disbenefits.*

A copy of the VAC paper is included in **Appendix A**.

1.4. Legislative Context

A number of policies and procedures currently exist against which transportation projects are to be evaluated within New Zealand. Many of these procedures are legislated and are required to be carried out to satisfy funding requirements and the government's obligations. A brief summary of each, relevant to its interaction with the Ngauranga to Aotea Quay project is contained below:

1.4.1. Land Transport Management Act

The Land Transport Management Act (LTMA) provides the legal framework for managing and funding land transport activities. The purpose of the LTMA is to contribute to the aim of achieving an affordable, integrated, safe, responsive and sustainable land transport system. The LTMA:

- provides an integrated approach to land transport funding and management;
- improves social and environmental responsibility in land transport funding, planning, and management;
- provides the NZTA with a broad land transport focus;
- improves long-term planning and investment in land transport; and
- ensures that land transport funding is allocated in an efficient and effective manner; and
- improves the flexibility of land transport funding by providing for alternative funding mechanisms.

1.4.2. New Zealand Transport Strategy

The New Zealand Transport Strategy (NZTS) sets out the government's vision for transport to 2040 and the strategic approach to be taken. The vision is that: 'People and freight in New Zealand have access to an affordable, integrated, safe, responsive, and sustainable transport system.'

The vision is supported by five transport objectives:

- ensuring environmental sustainability;
- assisting economic development;
- assisting safety and personal security;
- improving access and mobility;
- protecting and promoting public health; and
- maintaining and improving international links.

1.4.3. Government Policy Statement

The Government Policy Statement on Land Transport Funding (GPS) sets out the government's priorities for expenditure from the National Land Transport Fund over the next 10 years. Under the LTMA:

- NZTA must give effect to the GPS in developing the National Land Transport Programme and take account of the GPS when approving funding for activities;
- Regional Land Transport Strategies must take account of the GPS; and
- Regional Land Transport Programmes must be consistent with the GPS.

In the GPS the government has listed seven initial Roads of National Significance (RoNS) as a statement of national road development priorities, of which the Wellington Northern Corridor (SH1 from Levin to Wellington) is one.

1.4.4. Regional Land Transport Strategy

The Ngauranga Interchange section of SH1 and SH2 is identified in the Hutt Corridor Plan, the Ngauranga to Airport and Western Corridor Plans within the Wellington Regional Land Transport Strategy as a significant and influential area of congestion. The RLTS and the Plans contained within it identify the long term vision for each of these key corridors.

The Ngauranga to Airport Corridor Plan (2008) includes the Nguaranga to Aotea Quay Project. The Corridor Plan identifies the Project as being undertaken in parallel with the implementation of bus lanes on Hutt Road.

The ECI project team is investigating improvements to SH1 and the implementation of bus lanes is a separate project which will be led by Wellington City Council.

1.4.5. Resource Management Act

The purpose of the Resource Management Act (RMA) is to promote the sustainable management of natural and physical resources. Sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, that enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety, while:

- sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;
- safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
- avoiding, remedying or mitigating any adverse effects of activities on the environment.

The RMA sets out the functions, powers and duties of local government, and the resource consent and designation process. When building or maintaining state highways, the RMA requires the NZTA to avoid, remedy or mitigate adverse environmental effects caused by the highway infrastructure.

1.5. Scoping Report Structure

The content of the Scoping Report is summarised as follows:

- Section 1 provides an introduction to the Project;
- Section 2 discusses the process followed in the scoping stage;
- Section 3 describes the existing conditions of the study area;
- Section 4 summarises preliminary stakeholder consultation undertaken;
- Section 5 provides a description of the problem that the project is seeking to address;
- Section 6 describes the option development and evaluation process;
- Section 7 summarises key design considerations;
- Section 8 summarises the option cost estimates;
- Section 9 describes the risk assessment process;
- Section 10 discusses the detailed evaluation and multi criteria assessment of options;
- Section 11 describes the development of a corridor management framework and the concept of operations for operating SH1 as four lanes with full management;
- Section 12 discusses potential phasing and next steps; and
- Section 13 contains the Scoping Report summary and recommendations.

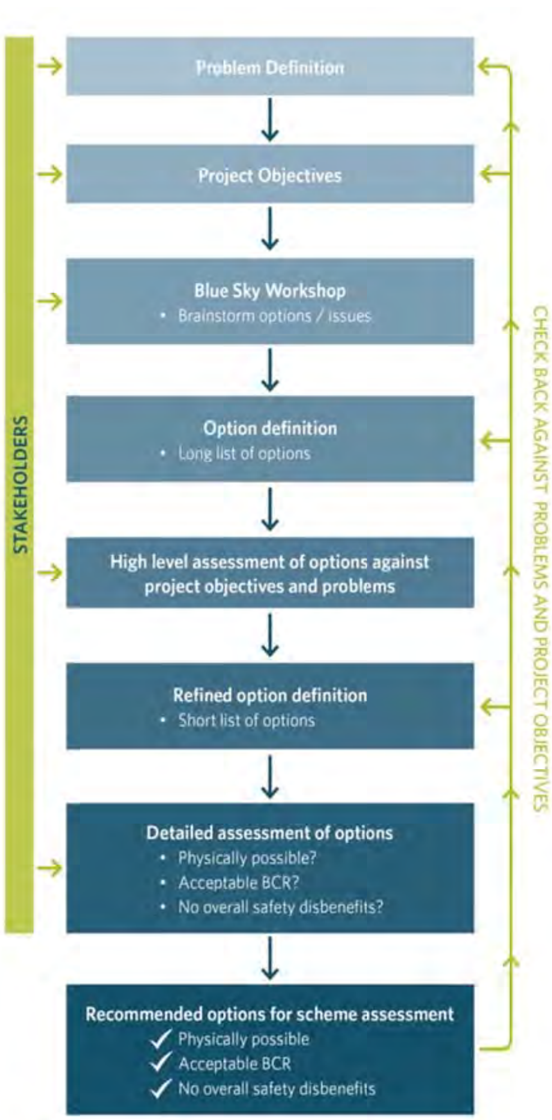
The Ngauranga to Aotea Quay Project will develop an operational strategy which is:

- ***Physically possible;***
- ***Has an acceptable BCR; and***
- ***No overall safety disbenefits.***

2. Scoping Stage Process

The scoping stage is the first stage in the typical investigation and reporting phase of NZTA project development. In broad terms, the purpose of the scoping stage is to identify and undertake a high level assessment of options which meet the project objectives, and recommend feasible options to take forward to more detailed assessment in the scheme assessment stage. The process used in the scoping stage is summarised in **Figure 2.1**.

Figure 2.1: Scoping Stage Process



The first step in the scoping stage was an analysis of existing traffic conditions in the study area and an analysis of projected future conditions without the project in place. Supporting this analysis was a public survey of the public's view on how the stretch of motorway from Ngauranga to Aotea Quay operates and consultation with stakeholders. Together this work formed a problem definition for the Project.

The second step in the scoping stage was an options development process. This was generally carried out through a series of workshops between the ECI team and NZTA, including a "Blue Sky Workshop" which is described in **Section 6**. This process defined a number of options for the Project and also a number of options to improve "specific points" in the general vicinity of the project area which would improve the flow of traffic on SH1.

Options were put through an evaluation process which included traffic modelling, a multi-criteria assessment, and assessment against project objectives. Following the multicriteria assessment workshop a corridor mangagement framework was developed to confirm a strategy for the Ngauranga to Aotea Quay section of SH1 to be a "fully managed system." This is discussed further in **Section 11**.

Following the assessment of options and confirmation of a preferred operational framework, an envelope of considerations for implementing four lanes with full management was developed. The result of the scoping stage is the recommendation of a preferred operational framework for SH1 to be further developed in the Scheme Assessment stage.

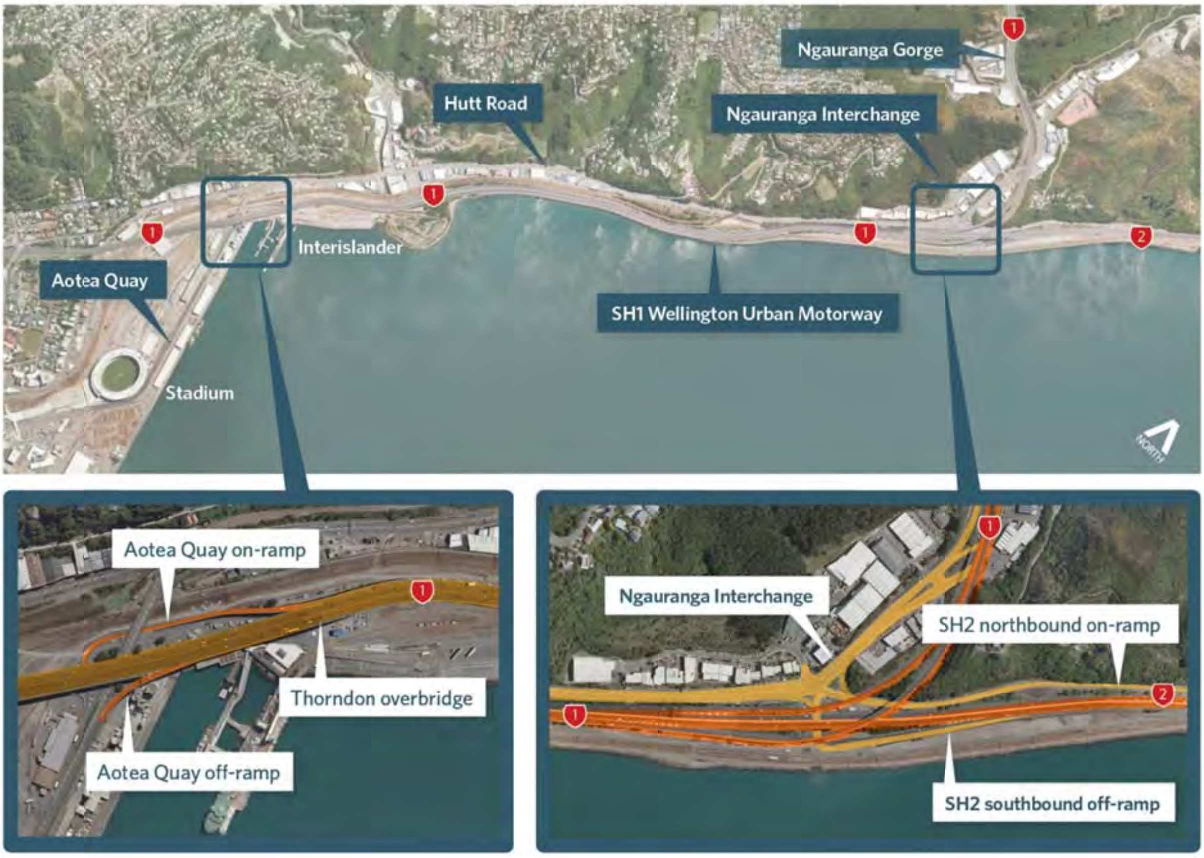
The purpose of the scoping stage is to identify and undertake a high level assessment of options which meet the project objectives, and recommend feasible options to take forward to more detailed assessment in the Scheme Assessment stage.

3. Site Description

3.1. Study Area – The Existing Network

The Project Study Area is described below and illustrated in **Figure 3.1** and in **Appendix B**.

Figure 3.1 Project Study Area Map



3.1.1. State Highway 1 Southbound

At the northern most point of the study area is the Ngauranga Gorge interchange where SH1 and SH2 meet. On the approach to the merge point both SH1 and SH2 have two lanes in each direction and these four lanes (two lanes on SH1 and two lanes on SH2) are then merged into three lanes over approximately a 250m length.

Heading south along SH1 from Ngauranga there are three traffic lanes plus a 2.5m shoulder until the nub of reclaimed land adjacent to the Interislander Ferry Terminal, where the road transitions onto the Thorndon Overbridge. At this point the shoulder narrows then expands again on the viaduct, where an unused merge stub exists. This however quickly narrows again and a narrow shoulder (0.5m) is provided up to the Aotea Quay off-ramp.

3.1.2. State Highway 1 Northbound

The southernmost point of the study area is the Aotea Quay on ramp, where a merge currently occurs on a slight right hand bend on Thorndon Overbridge. The Aotea Quay on ramp rises up to the Viaduct over the railway branch line to the Interislander Ferry Terminal.

Heading north from the start of the Aotea Quay on-ramp merge a shoulder starts which widens to 3.5m at the end of the merge and then tapers away over the next 100m and becomes narrow. Approximately 300m north of this point a 3.5m wide shoulder forms again and runs continuously to the SH1 and SH2 diverge at Ngauranga. Along this section of the corridor SH1 consists of three lanes with Hutt Road providing a further two lanes of capacity.

Over the length of the study area SH1 undulates vertically and horizontally. From Thorndon Overbridge it descends, before it rises again over the Main North Island Truck line to descend prior to splitting at Ngauranga where SH1 rises up the Gorge and SH2 continues along the harbour.

3.1.3. Connections to the Local Area Network

Whilst the study is focused on the section of SH1 described above there are many interactions with the local area network which impact upon the study area.

The Hutt Road runs parallel to SH1 for the length of the study corridor, providing two lanes of traffic in each direction (northbound and southbound), with connections to Aotea Quay in the south and Ngauranga Interchange in the north.

The Hutt Road / Centennial Highway intersection has four entry roads, Hutt Road, Jarden Mile, Centennial Highway and the SH2 off ramp. There are no pedestrian facilities provided at the intersection though a number of cycle lanes pass through the site. Left turn slips are provided on all entrances to the intersection with the exception of Jarden Mile. The intersection exit on Centennial Highway links onto SH1 approximately 500m west of the intersection. Similarly the Hutt Road exit provides an entrance onto SH2 travelling north approximately 500m north of the intersection.

South of the study area there are a number of ramps on and off SH1 which may impact upon the project. The Murphy Street off ramp is the next opportunity to exit SH1 after the Aotea Quay southbound off ramp and provides links with the Thorndon area and the CBD.

3.1.4. ATMS Operation

The project area is managed using overhead mounted mandatory variable speed control signs between Ngauranga Interchange and the Terrace Tunnel. All ramps have side mounted speed control signs and there are a limited number of motorway variable message signs.

The ATMS 2 project extended the ability to manage traffic on State highway 1 through speed management from Ngauranga to the Terrace Tunnel. The ATMS hardware is managed through the DYNAC system which allows the Traffic Operations Centre (TOC) operators to manage congestion, incident and weather related events by reducing the speed limit, informing motorists of the incidents ahead and provides the ability to close a lane or lanes due to a either crash, incident or for maintenance.

The Project area includes SH1 from the Ngauranga merge to the Aotea Quay on and off ramps. The Project area is managed using overhead mounted mandatory variable speed control signs and a limited number of variable message signs.

4. Preliminary Stakeholder Consultation

4.1. Pre-Scoping Stage Consultation

Prior to the contract being awarded, NZTA undertook a good level of consultation with key stakeholders to help inform project inception. Most significantly, a series of four workshops were held with key stakeholders between February and June 2010. Key stakeholders included:

- Greater Wellington Regional Council (GWRC);
- Wellington City Council (WCC);
- Kiwirail;
- Interislander; and
- CentrePort.

Preliminary consultation with stakeholders included the development of a high-level Draft Memorandum of Understanding with Greater Wellington Regional Council, Wellington City Council, KiwiRail and CentrePort. There were no fatal flaws raised in early engagement from operational and footprint stakeholders specific to this project. Issues and opportunities were raised by stakeholders that will be considered throughout this Project in ongoing consultation with stakeholders as scheme investigations progress.

In addition, meetings were held with the following stakeholders because of their close proximity with the project area:

- Golden Bay Cement – cement silos located on Aotea Quay; and
- Mobil – oil pipeline runs through the southern section of the site.

These early stakeholder meetings established a good working relationship between NZTA and stakeholders for this project and also informed the Stakeholder Management and Communications Strategy described below.

4.2. Purpose of Scoping Stage Consultation

During the scoping stage, the purpose of consultation was to work with relevant stakeholders to identify important issues, constraints and opportunities to help inform the identification and consideration of options.

4.3. Stakeholder Management and Communications Strategy

Consultation and stakeholder activities are set out in detail in a separate *Stakeholder Management and Communications Strategy*. This Strategy is focussed on undertaking a sufficient and meaningful level of consultation to support the Project and meet statutory consultation requirements. The desired outcomes of this Strategy are:

- Driver behaviour is influenced positively - improving driver behaviour to help ease congestion, smooth traffic flows and provide greater journey time reliability;
- There is good awareness and understanding of the benefits of the Project and the need for the improvements; and
- All stakeholders and the public feel well informed and listened to throughout the duration of the Project.

The preliminary stakeholder consultation undertaken during the scoping stage established key relationships and set a good platform for ongoing stakeholder engagement as the project progresses to scheme assessment.

The road user will be an important focus of this Project in terms of the influence driver behaviour will have on the success of the solution. A separate *Driver Awareness Plan* will be developed to improve driver behavior at the Scheme Assessment stage.

Stakeholder activities and communications are recorded in the Stakeholder Register Database as an excel spreadsheet to document consultation over time.

4.4. Stakeholder Groups

Stakeholders were engaged with broadly in terms of 'operational' and 'footprint' groups as summarised in **Table 4.1**. The engagement was important to get an early indication of how potential options may integrate with the surrounding environment and land uses and also to gauge the main issues for the management of traffic, such as enforcement and the safe provision of emergency services.

Table 4.1: Project Stakeholder Groups

Stakeholder Group	Key Stakeholders for Scoping Options
Operational Operational stakeholders include those with interests in the management of traffic.	■ NZ Police ■ NZTA - Traffic Operations Centre (TOC) ■ Wellington City Council ■ Greater Wellington Regional Council ■ Wellington Free Ambulance ■ NZ Fire Service ■ Road Users
Footprint Footprint stakeholders include those with properties and business activities adjoining the project area, and including groups with an identified interest in the environmental effects of the project. Footprint stakeholders may also have an interest in the management of traffic in terms of the impact of that on their interests and operations.	■ KiwiRail, including InterIslander ■ CentrePort ■ Golden Bay Cement ■ Holcim Cement ■ Mobil ■ Trelissick Park Group

Preliminary consultation with stakeholders included the development of a high-level Draft Memorandum of Understanding with Greater Wellington Regional Council, Wellington City Council, KiwiRail and CentrePort. There were no fatal flaws raised in early engagement from operational and footprint stakeholders specific to this project. Issues and opportunities were raised by stakeholders that will be considered throughout this Project in ongoing consultation with stakeholders as scheme investigations progress.

4.4.1. Operational Stakeholders

Consultation with operational stakeholders focussed on enhancing the understanding of issues around traffic management. At a broader level, stakeholders with an important role in Wellington's transport network strategy were engaged with to ensure a strategic fit for this project with other initiatives such as the Ngauranga to Airport Strategy Study (2008). Discussions with Greater Wellington Regional Council and Wellington City Council in particular provided a good understanding of the network issues and initiatives, including developing proposals by Wellington City Council for improving access to the Port.

At a more detailed level, operational stakeholders such as the NZ Police, Emergency Services and the TOC were engaged with to better understand how these stakeholders manage traffic and driver behaviour within the study area. A good level of information was obtained relating to the management of traffic along the Ngauranga to Aotea Quay study area to inform the scoping of options.

The main interests of operational stakeholders in relation to this project are summarised in **Table 4.2**. These interests will be taken into account as scheme investigations develop in on-going engagement with stakeholders.

Table 4.2: Operational Stakeholder Interests

Stakeholder	Main Interest
NZ Police	The safe and efficient operation of the highway, particularly in terms of emergency response times, incident control and enforceability
NZTA - Traffic Operations Centre	The safe and efficient operation of the highway, particularly in terms of managing and operating the traffic operations systems, maintenance and accessibility of the system, positively influencing driver behaviour.
Wellington City Council	The safe and efficient operation of the highway, particularly integration with local roads and land uses and the effective flow of traffic through Wellington City. The strategic fit of the option in relation to road network strategies, including the Ngauranga to Airport Strategy Study.
Greater Wellington Regional Council	The safe and efficient operation of the highway, particularly in terms of regional land use and transport integration and strategic fit.
Emergency Services: Wellington Free Ambulance St John's Ambulance NZ Fire Service	The safe and efficient operation of the highway, particularly in terms of emergency response times, incident control and positively influencing driver behaviour.

4.4.2. Footprint Stakeholders

Consultation with footprint stakeholders focussed on understanding the issues around integrating options with surrounding land uses and activities. The engagement indicated that the range of options developed can likely be accommodated within the existing highway footprint and as a consequence any adverse effect on stakeholders as a result of this project is expected to be no more than minor. The main interests of footprint stakeholders in relation to this project are summarised in **Table 4.3**. These interests will be taken into account as scheme investigations develop in on-going engagement with stakeholders.

Table 4.3: Footprint Stakeholder Main Interests

Stakeholder	Main Interest
Kiwirail/ Interislander/ OnTrack	Kiwirail (who own the Interislander Line) lease land from the Government for the operation of its rail shunting yard. It also owns land at the existing Ferry Terminal buildings and also leases land from CentrePort for ferry operations. Kiwirail has been investigating options to reconfigure the port and improve access. Kiwirail, Interislander and OnTrack have a common interest in maintaining access to their sites and maintaining their 24 hour, 7 day operations.
CentrePort	CentrePort owns the existing wharf and some land under the ferry terminal buildings as well as the area of reclaimed land to the north east of Thorndon Overbridge. It also owns land adjacent to the Aotea off-ramp which is currently leased to Golden Bay Cement who on-lease to Holcim Cement. CentrePort is interested to ensure that the NtAQ project does not hinder the safe and efficient access to and from the wharf, terminal buildings and operations.
Golden Bay Cement & Holcim Cement	Golden Bay Cement owns the existing cement silos located in close proximity to the Aotea off-ramp. Holcim Cement lease the cement silos from Golden Bay Cement.

	Both are interested to ensure that the NtAQ project does not hinder the safe and efficient access to and from the silos and surrounding site.
Mobil	Mobil own the existing oil pipeline that runs from Aotea Quay wharf along the top of the existing sea wall and across from the ferry terminal carpark. Mobil is interested to ensure that the NtAQ project does not hinder the safe and efficient access to the pipeline and does not present a risk in terms of damaging the pipeline.
Trelissick Park Group	This Group has a specific interest in protecting and enhancing the Kaiwharawhara Stream which runs through Trelissick Park in the Ngaio Gorge and enters the harbour at Kaiwharawhara Point.

4.5. Engagement with iwi

In terms of iwi, groups whose *rohe* (tribal area) are generally within the project area are Te Atiawa and Taranaki Whanui ki Whanganui a Tara (Port Nicholson Block Settlement Trust). Ngati Tama, as previous occupants of the Kaiwharawhare Marae may also have an interest in the project. Nga Uranga (the landing place) is within the project area and is noted in the District Plan as a significant site.

This project is largely 'operational' in nature with no anticipated adverse effects on sites of significance to iwi. In particular, no foreshore issues are anticipated with the project at this point in time. The area is a highly modified landscape and the scheme options assessed can likely be accommodated within the existing highway footprint. Iwi will be engaged with as the detail of how scheme options may impact upon cultural values becomes better defined and tangible to iwi during scheme assessment.

The purpose of consultation during the Scoping Stage was to work with relevant stakeholders to identify important issues, constraints and opportunities to help inform the identification and consideration of options. Consultation was undertaken with footprint and operational stakeholders.

5. Problem Definition

The problem definition for the study area is made up of several elements including road capacity, geometry and traffic operations which are discussed below.

5.1. Traffic Volumes and Travel Times

Traffic volumes and travel times for the base (2009) and 2016 and 2026 Do Minimum scenarios (without the project in place) were obtained from the Wellington CBD SATURN traffic model (WTM) and are discussed below.

5.1.1. NZTA Traffic Counts

Table 5.1 summarises available NZTA traffic counts within the project area published in the *State Highway Traffic Data Booklet 2006 – 2010*.

Table 5.1 – NZTA SH1 and SH2 Traffic Counts

Location	AADT					Per cent Heavy Vehicles
	2006	2007	2008	2009	2010	
SH1 at Ngauranga (Northbound)	21,369	22,192	21,788	22,264	22,329	3.1
SH1 at Ngauranga (Southbound)	21,767	22,327	21,987	22,386	22,509	2.8
SH1 Between Ngauranga and Aotea Quay (Northbound)	43,072	44,018	42,767	43,473	43,720	3.3
SH1 Between Ngauranga and Aotea Quay (Southbound)	43,342	44,116	43,108	43,657	44,092	3.0
Aotea Quay Off Ramp	16,339	15,533	10,014[1]	10,094	10,111	2.8
SH2 at Ngauranga (Northbound)	21,703	21,826	20,979	21,209	21,391	3.4
SH2 at Ngauranga (Southbound)	21,575	21,789	21,121	21,271	21,583	3.3
Hutt Road Northbound On-Ramp to SH2	-	-	-	12,436	12,782	3.4
Hutt Road Southbound Off-Ramp from SH2	-	-	-	12,198	12,055	3.3

[1] Reduction in AADT on Aotea Quay in 2008 is due to the opening of the Inner City Bypass.

5.1.2. Modelled Traffic Volumes

The Base and Do-Minimum traffic volumes for SH1 and ramps are summarised in **Table 5.2**.

Table 5.2 - Modelled Traffic Volumes (Vehicles)

Location	Base (2009)			2016 Do Minimum			2026 Do Minimum		
	AM	PM	AADT	AM	PM	AADT	AM	PM	AADT
SH1 Northbound between Ngauranga and Hutt Road On Ramp	930 (1,060)	3,140 (3,350)	19,470 (20,260)	940 (1,140)	3,080 (3,460)	19,590 (20,970)	940 (1,200)	3,140 (3,810)	20,810 (23,440)
SH1 Southbound between Hutt Road Off Ramp and Ngauranga	2,930 (3,390)	1,680 (1,680)	22,750 (23,670)	2,860 (3,640)	1,770 (1,770)	23,010 (24,660)	2,830 (4,450)	1,920 (1,990)	24,900 (28,610)
SH2 Northbound between Ngauranga and Hutt Road On Ramp	1,790 (2,040)	1,780 (1,900)	22,210 (23,170)	1,890 (2,250)	1,860 (2,090)	23,270 (24,850)	2,050 (2,570)	2,000 (2,480)	26,470 (29,350)
SH2 Southbound between Hutt Road Off Ramp and Ngauranga	2,880 (4,300)	1,880 (1,880)	24,480 (27,320)	2,840 (4,380)	2,070 (2,070)	25,770 (28,850)	2,700 (4,890)	2,150 (2,560)	31,810 (37,010)
SH2 Hutt Road Off Ramp	1,150 (1,750)	1,190 (1,620)	16,450 (18,510)	1,130 (1,810)	1,180 (1,730)	16,170 (20,170)	1,130 (2,300)	1,180 (2,280)	15,950 (24,890)
SH2 Hutt Road On Ramp	1,520 (2,300)	820 (860)	15,720 (17,430)	1,490 (2,560)	780 (790)	17,410 (19,790)	1,500 (3,790)	1300 (1,330)	20,230 (29,270)
SH1 Northbound between Ngauranga and Aotea Quay)	2,710 (3,100)	4,920 (5,250)	41,670 (43,450)	2,820 (3.370)	4,940 (5,430)	42,840 (45,440)	2,990 (3,740)	5,170 (6,150)	47,250 (51,810)
SH1 Southbound between Ngauranga and Aotea Quay)	5,370 (7,690)	3,560 (3,560)	46,340 (50,980)	5,310 (8,020)	3,840 (3,840)	47,980 (53,330)	5,590 (9,240)	4,090 (4,480)	56,930 (64,873)
Aotea Quay Off Ramp	1,020 (1,510)	790 (790)	9,250 (10,210)	1,040 (1,610)	660 (660)	9,990 (11,150)	970 (1,780)	310 (340)	7,960 (9,740)
Aotea Quay On Ramp	530 (663)	1,310 (1,310)	8,390 (8,740)	520 (680)	1,260 (1,380)	8,490 (9,170)	520 (720)	1,100 (1,310)	8,680 (9,890)
Key: xx = Actual Flow (xx) = Demand Flow									

The WTM predicts an increase in traffic between 2009, 2016 and 2026. In 2026 traffic volumes on the Aotea Quay ramps are predicted to decrease compared to 2016. This is due to the inclusion of the Terrace Tunnel duplication in the 2026 model, which attracts traffic away from Aotea Quay.

5.1.3. Travel Times

Bluetooth Travel Time Data

Three Bluetooth transverses were installed for the Project to collect data on travel times. The devices are located on:

- SH1 Ngauranga Gorge Motorway VMS;
- SH2 Petone Weighbridge VMS; and
- SH1 Hobson Street VMS.

Table 5.3 summarises the average off peak and peak hour journey times and differences.

Table 5.3 – Bluetooth Journey Time Information[2]

Routes	Distance (km)	Peak Period	Inter-Peak Travel Time (mins)	Average Peak Travel Time (mins)[3]	Per cent Difference Off Peak to Average Peak[4]	Per cent Trip Reliability[5]
SH1 Ngauranga Gorge to SH1 Hobson Street	5.7	AM	03:39	09:44	167%	46%
SH2 Petone Weighbridge to SH1 Hobson Street	5.8	AM	03:32	06:24	81%	44%
SH1 Hobson Street to SH1 Ngauranga Gorge	5.7	PM	03:35	05:43	59%	56%
SH1 Hobson Street to SH2 Petone Weighbridge	5.8	PM	03:32	06:16	78%	73%
SH1 Ngauranga Gorge to SH2 Petone Weighbridge	3.7	PM	02:50	05:16	85%	116%
SH2 Petone Weighbridge to SH1 Ngauranga Gorge	3.7	PM	03:29	04:19	24%	42%

Table 5.3 shows that during the AM peak traffic from SH1 travelling southbound towards the city centre is delayed for approximately twice as long as traffic travelling from SH2 by the SH1/SH2 merge.

During the PM peak the Aotea Quay and SH2 Hutt Road on-ramp merges delay the northbound traffic to SH1 and SH2 by 59% and 78% respectively. The trip reliability for traffic travelling to SH1 and SH2 is 56% and 73% respectively. As calculated this means that the minimum and maximum recorded travel times for those routes are 56% and 73% of the average peak travel time over the two week period. From this we can conclude that the trip from the city centre to SH2 in the PM peak is more delayed and unreliable than to SH1.

The data in **Table 5.3** shows that the route from SH1 Ngauranga Gorge to SH2 Petone Weighbridge via the Hutt Road on-ramp incurs a greater delay (85%) and lower trip reliability (116%) than the route via the mainline from SH1 Hobson Street to SH2 Petone Weighbridge which is 78% and 73% respectively. From this it can be concluded that the SH2 Hutt Road on ramp merge has a significant effect on ramp and mainline traffic flows.

Travel Time Surveys

Travel time surveys were undertaken for the validation of the Wellington Traffic Model (WTM) on the following three routes:

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[2] Bluetooth travel time data is from post implementation of the "Early Works" (changes to the SH1 / SH2 merge/diverge areas. Preliminary analysis showed that the Early Works has resulted in travel time savings. A separate technical note will be produced documenting the travel time impacts of the Early Works.

[3] Journey times are based on average peak hourly flow over a two week period post the implementation of the early works.

[4] Difference between free flow (off peak) and average peak hour travel time.

[5] Percentage trip reliability is based on the difference between the minimum and maximum peak hour travel time over the two week period divided by the average peak hour travel time over the two week period.

- Newlands On-Ramp to Oriental Parade (via State Highway 1);
- Johnsonville Off-Ramp to Willis Street (via State Highway 1); and
- Ngauranga Gorge to Wellington Railway Station (via Thorndon Quay and Hutt Road).

The results of the travel time surveys are shown in **Figures 5.1 to 5.6** below.

Figure 5.1 Average Observed Travel Times; Newlands On-Ramp to Oriental Parade

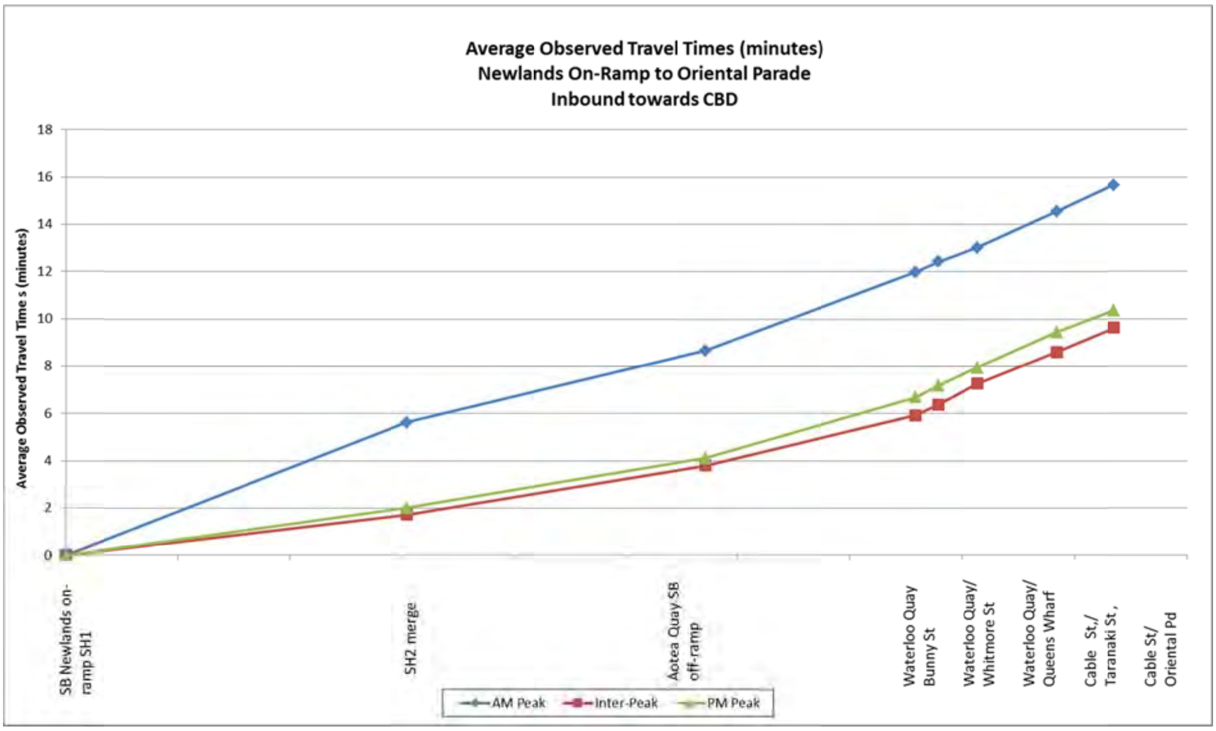


Figure 5.2 Average Observed Travel Times; Oriental Parade to Newlands Off-Ramp

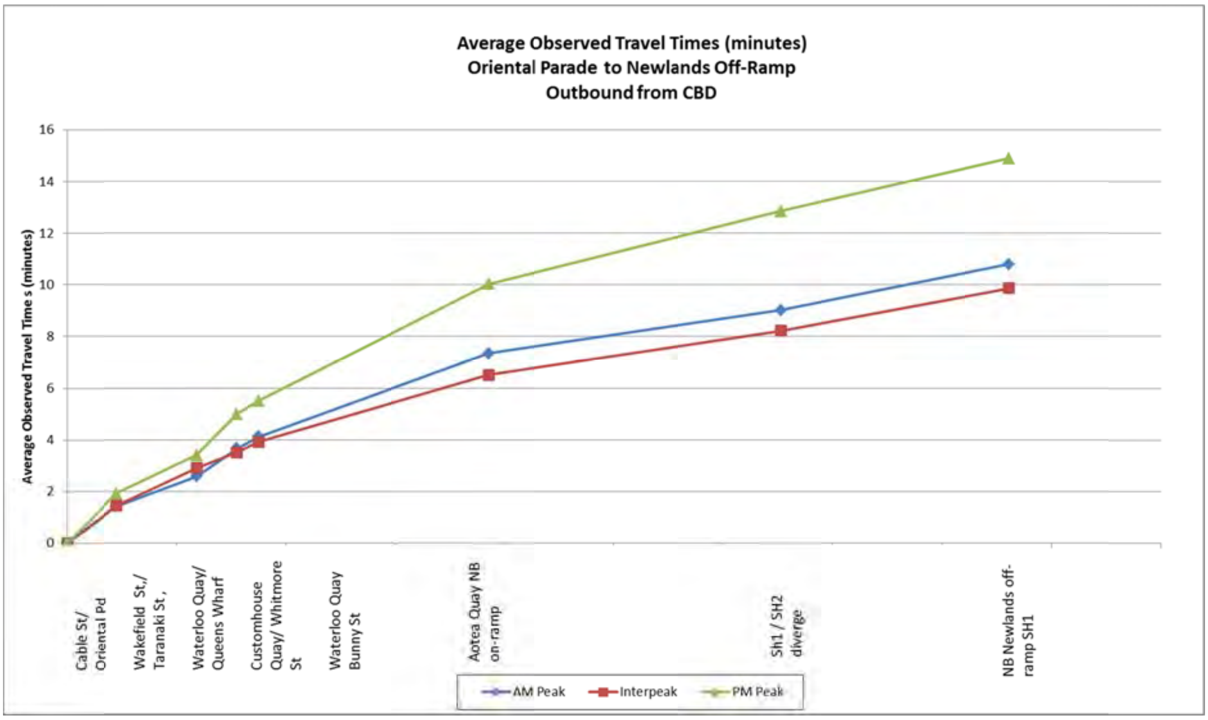


Figure 5.3 Average Observed Travel Times; Johnsonville Off-Ramp to Willis Street

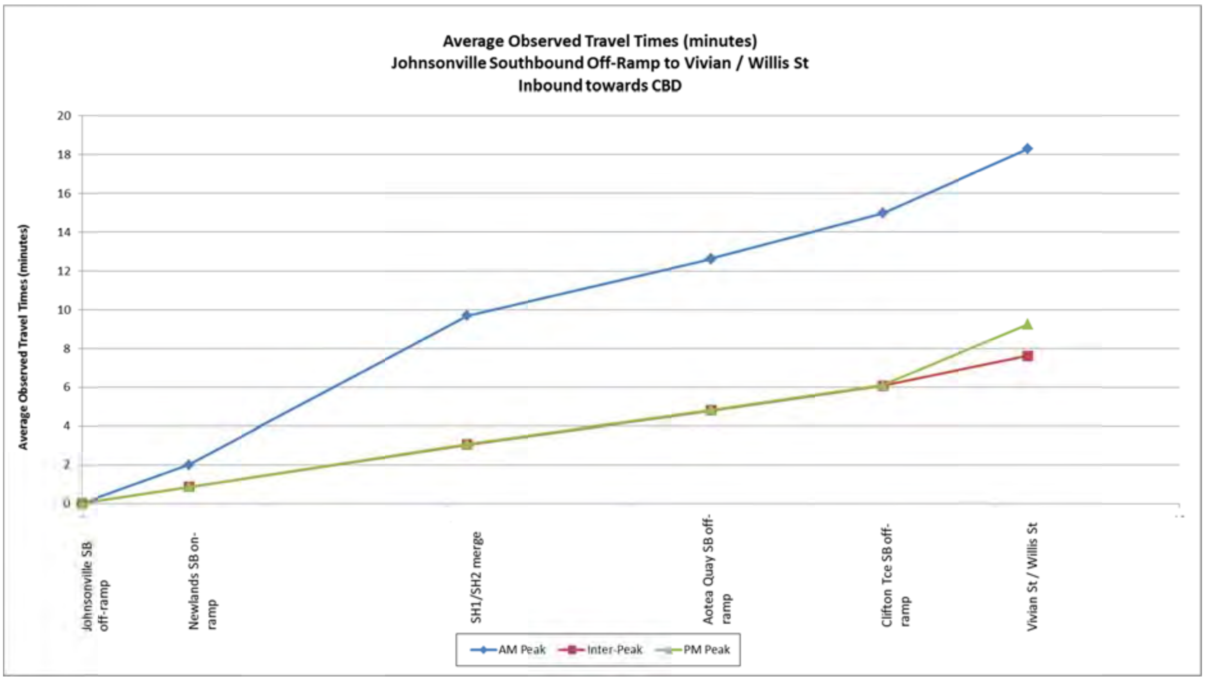


Figure 5.4: Average Observed Travel Times; Willis Street to Johnsonville On-Ramp

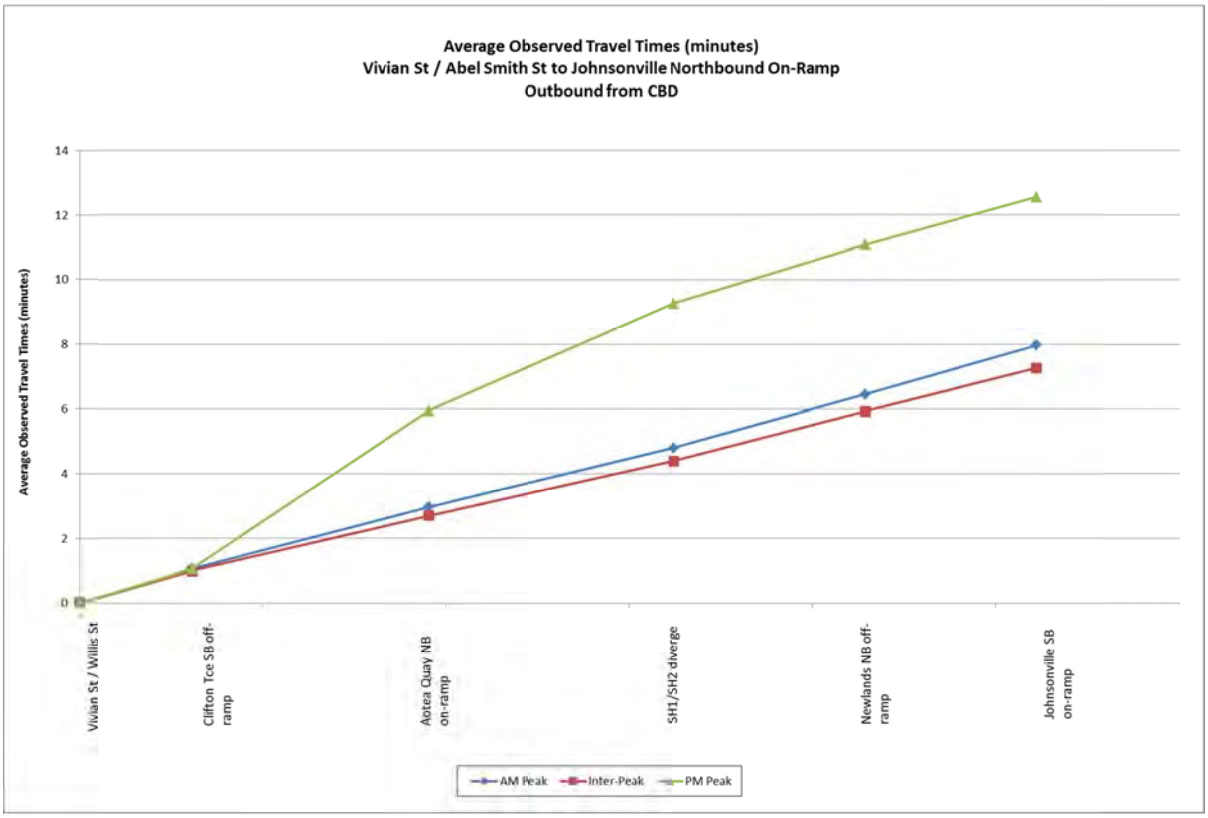


Figure 5.5: Average Observed Travel Times; Ngauranga Gorge Off-Ramp to Wellington Railway Station

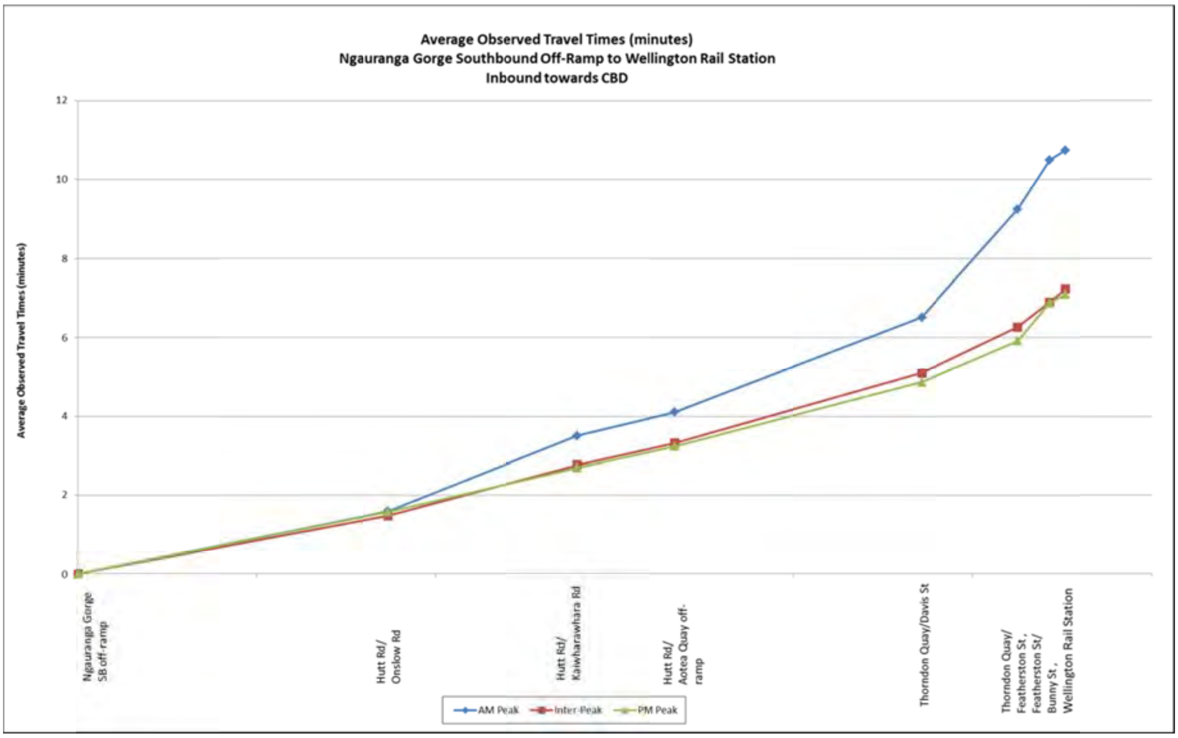
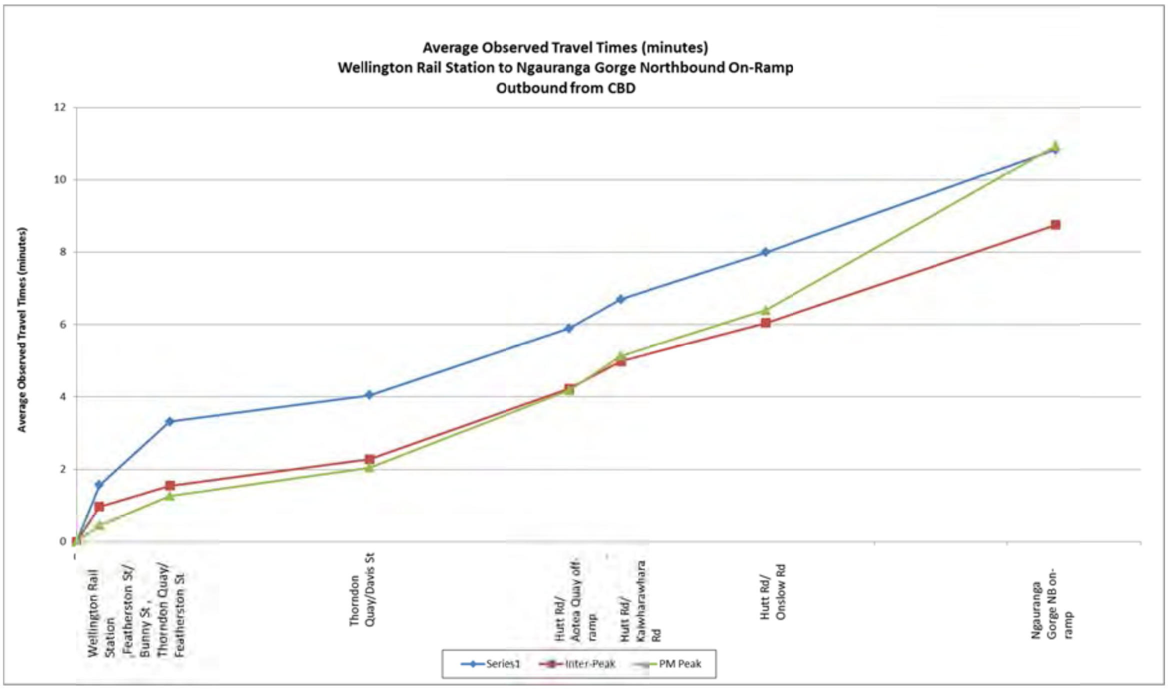


Figure 5.6: Average Observed Travel Times; Wellington Railway Station to Ngauranga Gorge On-Ramp



The travel time data indicates that:

- In the peak commuter direction, during the AM and PM peak hours, the average travel time increases significantly along SH1 in the study area. This is observed to be due to the high levels of traffic congestion experienced within the study area in the weekday peak periods;

- AM and PM peak travel times are higher than the inter-peak travel times along these routes which again highlights that the state highway in the study area creates a 'pinch point' due to limited available capacity and which results in slower journey times;
- The vehicles travelling along these routes also experience higher travel times immediately upstream of the study area due to the heavy congestion and 'blocking' back;
- Vehicles travelling downstream from the study area in the AM peak hour (inbound to CBD) and outbound direction (away from the CBD) in the PM peak hour, experience similar travel times to those travelling outside the peak periods along this route; and
- On SH1 in the Project area, the average travel speed in the southbound direction in the AM peak was recorded as 55kph. The average travel speed in the northbound direction in the PM peak was recorded as 48kph. The survey results indicate that vehicles are travelling significantly slower than the free flow speed of 100kph.

5.1.4. Operational Characteristics

The study section of SH1 between Ngauranga Gorge and Aotea Quay and its approaches experiences very high levels of tidal congestion in both the AM and PM peaks in the southbound and northbound direction respectively. This congestion results in:

- excessive queuing;
- low traffic speeds;
- differential speeds between lanes resulting from queuing back from off-ramps; and
- stop/start condition resulting from queue rippling up stream.

Based on current and projected future traffic flows, the SH1 Ngauranga to Aotea Quay corridor requires four lanes in each direction to accommodate traffic demand, relieve congestion and provide more reliable travel times.

A detailed assessment of the traffic modelling outputs highlighted that in the southbound direction during the AM peak there is currently demand that exceeds three lanes at the Ngauranga merge. Traffic modelling with 4 lanes southbound (detailed in **Appendix C**) indicates there is approximately 550 vehicles queued upstream of the merge.

In addition, the Aotea Quay off ramp queues back onto the motorway as a result of the poor off ramp geometry and the impact of the rail crossing on Waterloo Quay. Observation through the CCTV cameras and data recorded from vehicle detecting radar shows that drivers regularly miss the end of the Aotea Quay off ramp queue. If they cannot find a gap to pull into prior to the off ramp, these drivers stop in lane two near the off ramp and force a lane change to exit. This results in significant speed differentials between the three lanes, with lane one travelling around 30 – 50km/h, lane two stopped and lane three travelling between 80 – 100km/h. Four lanes would allow better management of this section of SH1 and is required by current conditions.

During the PM peak one of the key root causes of congestion is the Hutt Road SH2 on-ramp merge, which dominates the merge and causes the mainline to breakdown through forced and unnecessary lane changes. This results in traffic queuing back along SH1 towards the Aotea Quay on ramp. As discussed later in the report this merge problem can be managed better through Access Management level control (.i.e Using ramp signals). Currently the high PM peak Aotea Quay on ramp flow dominates the merge and causes the mainline traffic breakdown similar to SH2 Hutt Road on ramp. Traffic modelling indicates that with future traffic volumes this high traffic flow will remain, even with the duplication of the Terrace Tunnel. The uphill gradient of the ramp does not suit the installation of ramp signals without the construction of a truck priority lane, which will be very difficult. Four laning is required under current conditions and will allow the Aotea Quay on ramp to be a lane gain. This would better accommodate the high proportion of truck movements.

5.1.5. Reported Crash History

To understand the existing number and pattern of crashes in the study area a search was conducted using NZTA's Crash Analysis System (CAS) to obtain the most recent crash data available, which was the five year period from 2005 – 2009. The reported crash history is summarised in **Table 5.4**. The data shows that there was one recorded fatality and 19 serious injury crashes during this period. **Table 5.5** compares the crash rate for each direction on State Highway 1 between Ngauranga merge/diverge to the Aotea ramps with the typical crash rate for a motorway and four-lane divided rural road sourced from the NZTA Economic Evaluation manual. This section has a lower crash rate than would be typically expected by between 24% northbound and 42% southbound.

Table 5.4 - Annual Crash Statistics

Severity	Year					Total
	2005	2006	2007	2008	2009	
Fatal	0	0	0	1	0	1
Serious	1	3	6	5	4	19
Minor	17	20	28	28	21	114
Non-Injury	48	70	67	45	54	284
Total	66	93	101	79	79	418

Reviewing the total crash history by year there appears to be a peak in 2007 with a slight reduction in 2008 and then remaining constant. Similarly if the non-injury accidents are discounted, which are likely to have some under-reporting issues due to the possibility of vehicles being able to continue on with their journey, then there is a peak in incidents in 2007 and 2008 with a slight reduction in 2009.

Table 5.5 - Crashes per 100 Million Vehicle Kilometres Travelled (VKT) Per Year

Type	Northbound	Southbound
Study Area Injury Crashes	3.3	2.5
Typical Injury crash rate – Motorway	4.3	4.3
Typical Injury crash rate – Four-Lane Divided Rural Road	5.2	5.2

5.1.6. Hazards

In order to evaluate the safety performance of the proposed scenarios it is necessary to have an understanding of the risk profile that currently exists. This will provide an understanding of the significant hazards that would require mitigation by the proposed operational regimes in order to attain the Safety Objectives.

The Safety Objective for this project as stated in the *Project Safety Strategy and Plan, October 2010* and defined below has been agreed in principal with the Value Added Committee (VAC).

"The scheme will aim to deliver either the same safety standard or an improvement in safety"

The purpose of setting a safety baseline is to allow measurement of changes in predicted project safety performance. The safety baseline defines the level of safety against which the project objective will be measured.

The process to set a safety baseline was for the ECI team to review and validate the Project Safety Baseline and Base Case Risk Profile developed by Mouchel as presented in the report *Project Safety Baseline and Risk Profile for the 'Before' Case*, dated 11 November 2010.

The ECI team reviewed the two factors that helped define what the Safety Baseline was and these were:

- The availability of data, and
- The characteristics of the scheme

In order to define the risk profile for the base case (i.e. the current risk profile for the area covered by the safety baseline) a hazard log was developed based on a list of hazards that has been developed for the scheme by Mouchel. The scheme hazards are an adaption of those developed and applied to motorway schemes in the UK. The high level hazard log is contained in **Appendix D**.

Using the locally collected data, hazard scores were derived for each hazard and reported in *Project Safety Baseline and Risk Profile for the 'Before' Case*, dated 11 November 2010. The ECI team reviewed these as part of the *Project Safety Baseline Validation Report*. The resulting risk profile has been compared to the crash data from the area of influence and a good correlation has been observed.

From this analysis it has been identified that the hazards associated with the greatest safety risk are:

- Hazardous states from driving too fast;
- Change in vehicle speed;
- Events associated with drivers losing control of vehicle;
- Unsafe lane changing;
- Tailgating;
- Events associated with slip roads; and
- Vehicles drifting off carriageway or out of lane.

These top seven hazards represent approximately 80% of the risk.

5.1.7. Geometry

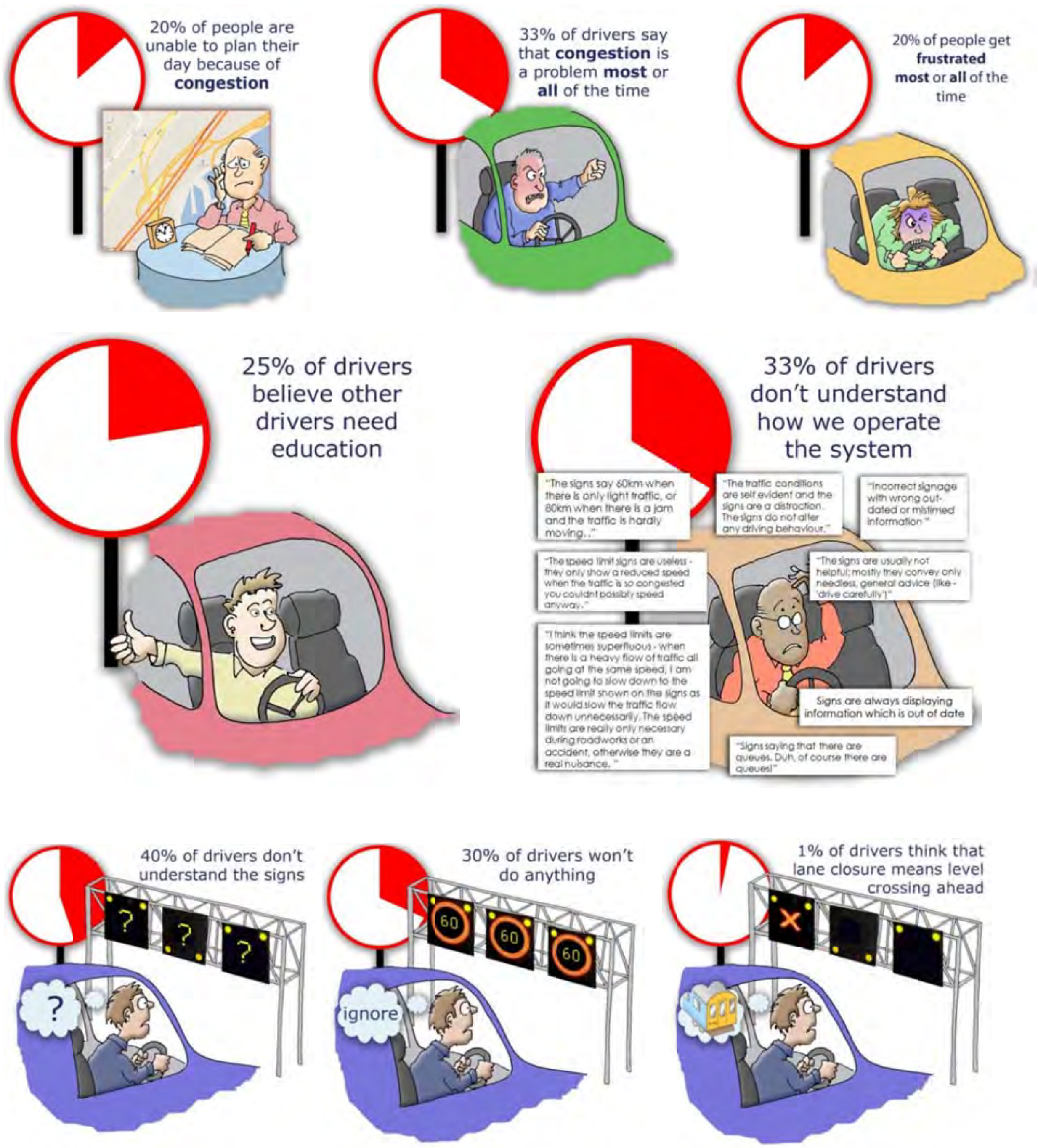
There are a number of geometric deficiencies within the study area including:

- There is no signage or lane marking provided to indicate how road users should behave in the merge area where SH1 and SH2 southbound come together. This existing layout at Ngauranga does not comply with the Traffic Control Devices (TCD) Manual Part 10 Motorways and Expressways standards due to the following deficiencies:
  - The rate of taper in the gore area is greater than desirable (3.0% compared to 2.0%); and
  - The rate of taper in the merge area is less than the desirable rate (1.1% compared to 2.0%).
- At the south end of the study area the Aotea Quay off ramp also has a number of deficiencies which mean it does not comply with the current SHGDM standards:
  - The diverge length is approximately 60m, 90m less than specified in the design standard (150m); and
  - The exit curve radius is approximately 120m and starts directly from the end of the diverge gore area. This is much shorter than current standards and would normally commence on a straight section of highway.
- The existing Aotea Quay on-ramp does not comply with SHGDM standards due to the following deficiencies:
  - The Approach angle on the on ramp is too steep; and
  - The on-ramp forms an auxiliary lane for 110m and then merges over 130m on a right hand curve. The merge should be constant over 265m.
- Over the length of the study area SH1 undulates vertically. It descends from the Thorndon Overbridge, before it rises again over the Main North Island Truck line to descend again prior to splitting at Ngauranga where SH1 rises up the Gorge and SH2 continues along the harbour. This undulation and relatively tight radius bends impairs forward visibility especially in the left hand lane.

5.2. Public Survey

The NZTA (through Colmar Brunton) undertook an online public survey over March and April 2011 to better understand driver behaviour and how the stretch of highway is perceived and used by the public. The survey was advertised through a newspaper campaign and also through the Stuff website (www.stuff.co.nz). The public survey was well received, with 1,133 respondents providing comments to better understand what changes to traffic management the public would like to improve their journey in and out of Wellington City. The key findings are summarised in **Figure 5.7**.

Figure 5.7: Results of Public Survey



The public survey highlighted the respondents' view of problems within the study area which include:

- Congestion;
- Lack of understanding of the ATMS signs;
- Lack of enforcement of the ATMS signs; and
- Driver education.

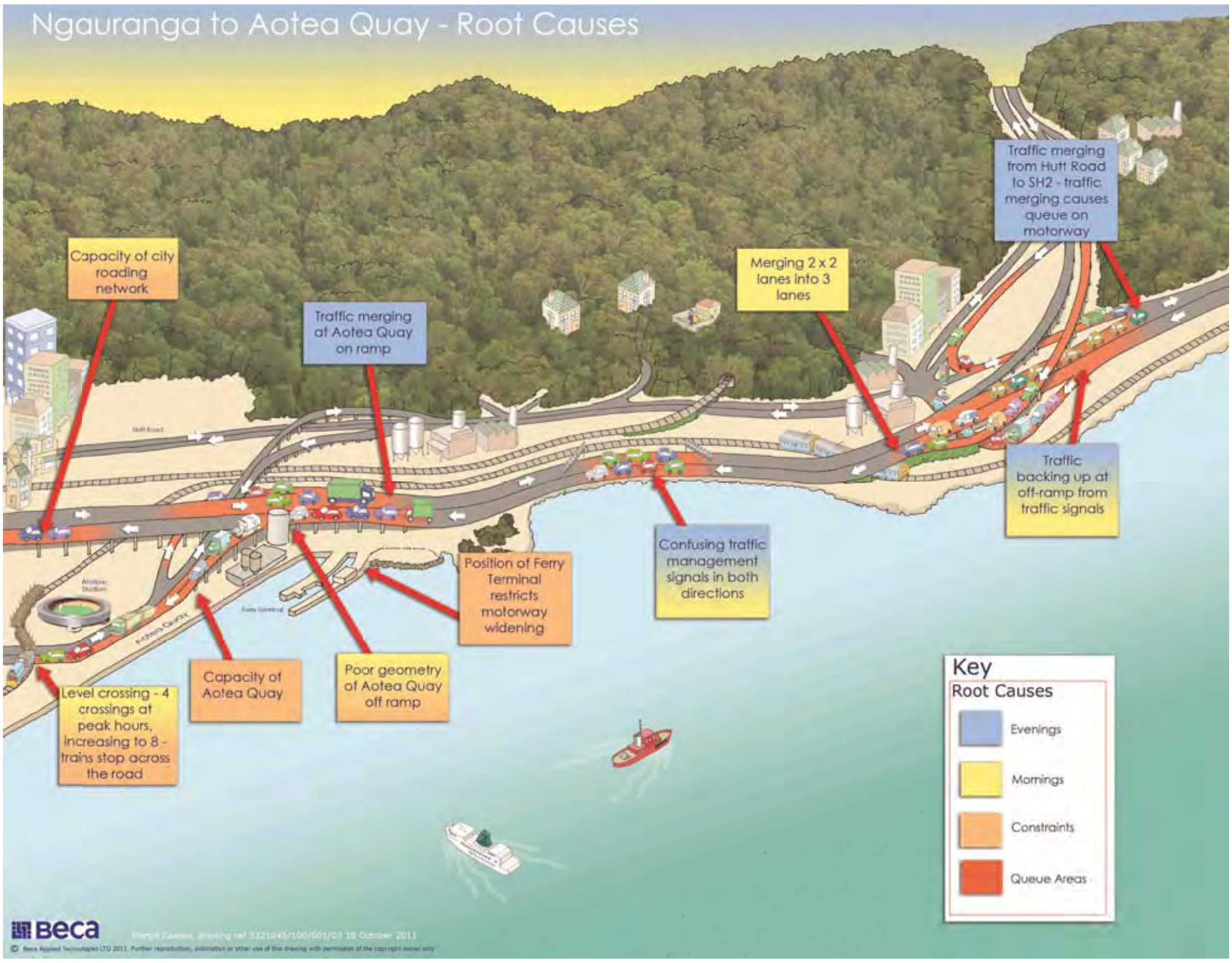
The results from this survey will help to inform a Driver Awareness Plan for this project, aimed at improving driver behaviour. The Driver Awareness Plan will look for new and effective ways to promote the 'management of traffic' concept to road users, stakeholders and the public. It is envisaged that the Plan will be developed and implemented in partnership with a range of key stakeholders involved with the safe and efficient operation of the highway, including the Automobile Association.

5.3. "Root Causes"

The project team reviewed the peak hour traffic operation from the Traffic Operations Centre (TOC) and interviewed TOC staff to understand the current operational and capacity problems. Crash related issues were also identified from the work undertaken in a Wellington State Highway Crash Reduction Study. An understanding of the future capacity issues was developed from future traffic model predictions based on the Wellington City SATURN traffic model outlined in **Section 5.1.** Initial investigation was also undertaken of the traffic data collected by DYNAC.

From the initial investigation the "root causes" of traffic congestion, safety related issues and poor trip reliability were identified that affect traffic using SH1 between Ngauranga and Aotea Quay. The root causes are illustrated in **Figure 5.8**. The assessment of the root causes is included in **Appendix E**.

Figure 5.8: Illustrated Root Causes



5.4. Summary

Based upon the above assessments, engagement with the TOC and key stakeholders, and the public survey, the problems with SH1 from Ngauranga to Aotea Quay can generally be described as congestion and travel time reliability. The section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks, resulting in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road network.

The problems with SH1 from Ngauranga to Aotea Quay can generally be described as congestion and travel time reliability due to the:

- **SH1 / SH2 merge / diverge;**
- **SH2 Hutt Road on-ramp merge;**
- **Merge from Aotea Quay on ramp;**
- **Geometry of Aotea Quay off ramp; and**
- **Traffic backing up from Hutt Road off ramp.**

6. Option Development

6.1. Introduction

This chapter describes the process for developing and evaluating options. The process is illustrated in **Figure 6.1**.

Figure 6.1: Option Development and Evaluation Process

The key steps in the development and evaluation of options were:

- Initial brainstorming to develop ideas at a "Blue Sky Workshop";
- Rationalising these ideas into distinct options for evaluation;
- Evaluating the options to produce an option shortlist for costing and a full evaluation at a Multi-Criteria Assessment Workshop;
- Operational framework development; and
- Identify scenarios to carry forward to Scheme Assessment stage.

6.2. Workshops

6.2.1. Blue Sky Workshop

A "Blue Sky Workshop" was held on 25 November 2010 attended by the ECI Contractor, NZTA, Mouchel, and Wellington City Council. The purpose of the workshop was to gather a range of ideas from different areas of expertise and viewpoints. As discussed earlier, engagement with stakeholders occurred prior to option development to avoid creating a perception of *"fait accompli"*.

The workshop was also used to provide confirmation of the scope and objectives of the study and to identify the known issues and constraints at an early stage.

A long list of ideas was initially developed through a brainstorming exercise in the Blue Sky Workshop and these are recorded in **Appendix F**.

Following the Blue Sky Workshop the 55 ideas were rationalised to 25 options for assessment at the Option Definition Workshop.

The long list of 55 ideas was reduced to 25 options by applying the following approach:

- Combining ideas where possible into a single option;
- Eliminating ideas of similarity; and
- Eliminating ideas which were not considered to be practical.

The process for rationalising the 55 options is available in **Appendix F**.

The 25 options with an explanation of each are available in **Appendix G**.

6.2.2. Option Definition Workshop

Having identified 25 options a framework was developed by the ECI Team to assess which options should be taken forward to the Multi-Criteria Assessment (MCA) Workshop. Weighted objectives were developed based on NZTA's project objectives. The objectives were given a rating based on the NZTA objectives as shown in the table in **Appendix H.** Options were awarded a 'Y' if they met a stated objective and an 'N' if they did not. Options awarded a Y were then weighted according to the priority level stated by NZTA, with a value of 1, 2 or 3 for those viewed as low, medium and high priorities respectively.

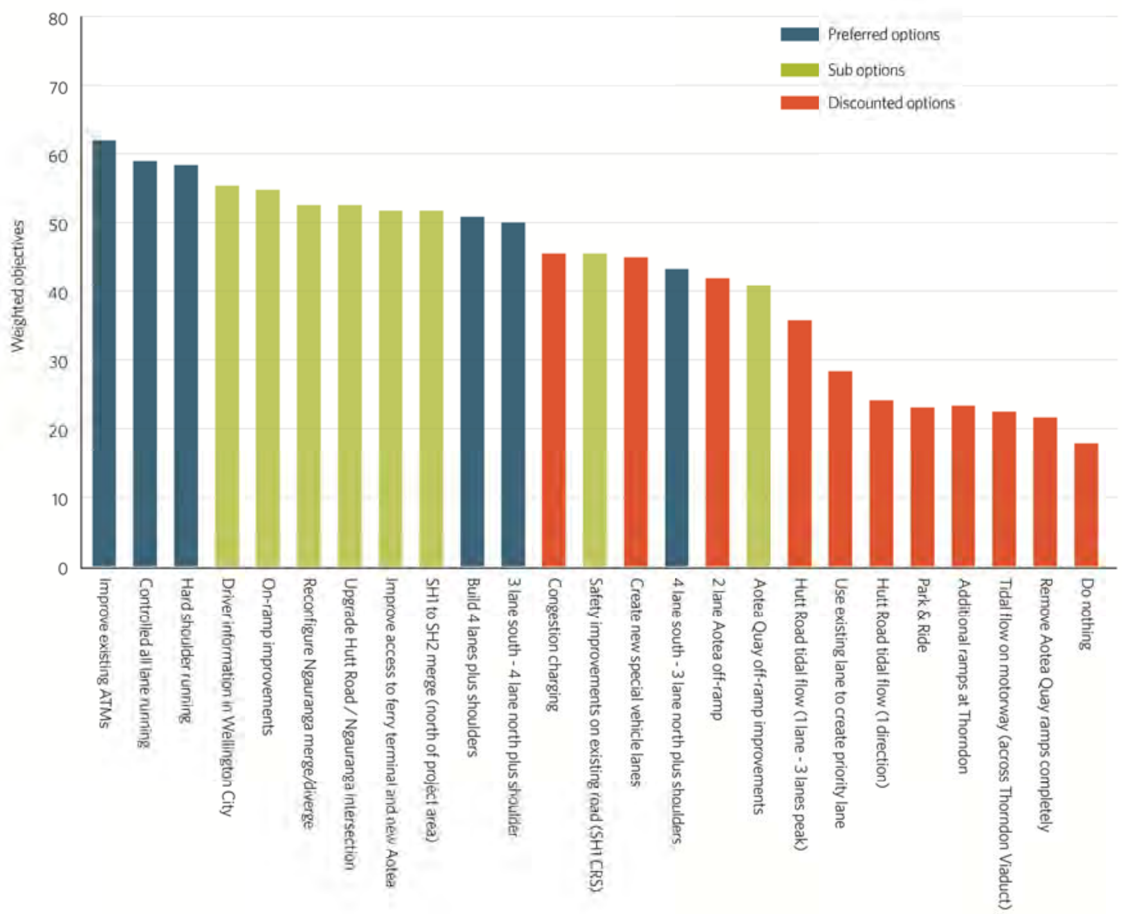
All 25 options were scored against the weighted objectives, creating a Master Rating. This was used to trial the rating system and to identify any initial concerns with the system. The Master Rating was issued to the Project Team, with graphs showing both weighted and unweighted (sensitivity test) scores prior to the Option Definition Workshop. These graphs clearly showed that while no appreciable difference in final ranking of the options was gained by weighting the scores, the weighting did produce greater numerically larger differences between options. This original weighting is included in **Appendix H**.

In addition, a sensitivity test was undertaken on increasing the weightings of the objectives 'improve journey efficiency' and 'ease congestion' from 17% to 30% of the total weighting, the result being no change in the overall profile of option scores. The weighting of these objectives was 'doubled' to test the significance of these two important project objectives on influencing the overall outcome. Similarly, sensitivity testing of changing the 'no' score from 0 to -1 was also carried out with an expectant result of making the already poorly scoring options 'slightly worse', with little change in overall graph profile (the top 11 options remaining unchanged and Congestion Charging moving from 12th to 15th place).

Having produced a framework for the assessment of options and created a Master Rating, the Option Definition Workshop was held to reach a consensus on the scoring of each option. The Option Definition Workshop was held on the 27th January 2011, attended by the ECI Contractor, NZTA and their external specialist Mouchel, New Zealand Police and Wellington City Council. The aim of this workshop was to once again review the options identified previously, map these against objectives and agree an overall rating for each option. Working in groups to mark each objective against the rating framework allowed for a broad spectrum of ideas to be represented in a standardised format. The averages of the scores allowed each option to be ranked.

Each workshop group reviewed the Master Rating and produced a group score for each option against the objectives. These ratings were combined with the Master Rating to provide an average rating for each option. The scores for achievements against objectives for each option are shown in the graph in **Figure 6.2.**

Figure 6.2: Option Definition Workshop Evaluation Results



Following the option scoring, the options were divided into three categories:

- "Preferred Options" which would be taken forward;
- "Suboptions" which would be considered as part of the Preferred option development; and
- "Discounted Options" which would not be considered further.

The following options were discounted from further consideration:

- Congestion charging: this option was discounted as NZTA does not have the ability to implement it under current transport legislation;
- Create new Special Vehicle Lanes was discounted as it was predicted to result in excessive and potentially unsafe lane changing and it did not score as well as the other four laning options;
- Hutt Road Tidal Flow was discounted as it was anticipated to be expensive, difficult to implement, and it did not score as well as other four laning options;
- The last seven options ("use existing lane to create priority lane" to "do nothing") had the lowest scores against the Project objectives. Do nothing was not considered to be an acceptable option and was discounted accordingly. In addition to having low scores, the tidal flow options were likely to have high costs. Park and Ride is a travel demand management measure which is not readily able to implemented by NZTA in the Project area; and
- The two-lane Aotea Quay off ramp was discounted due to property impacts (would impact on cement silos) and the need to design the new structure to current seismic standards. Both of these factors would lead to a high cost for this option.

The following sub options will be further considered during detailed investigation:

- "Reconfigure Ngauranga Merge/Diverge" which would be pursued separately (and has since been constructed);
- "Safety Improvements on Existing Road (SH1 CRS)": at the time of the workshop this study was being progressed separately by NZTA. If, through the separate study, improvements were identified for this corridor then these improvements would be coordinated as part of the final solution;
- "Upgrade Hutt Road / Ngauranga Intersection";
- Improving access to the Ferry Terminal
  - Driver information in Wellington City;
  - Improvements to the Aotea Quay on and off ramp; and
  - Hutt Road northbound on ramp to SH2

The options which scored highest at the workshop can generally be grouped into two categories:

- Options involving ATMS on SH1; and
- Other options which are not located on SH1 but will contribute to improving traffic flow on SH1.

All of the top scoring options for SH1 included ATMS.

The preferred options and remaining suboptions were combined into five options for the MCA workshop. This is discussed further below.

6.3. Options for MCA

Following the Option Definition Workshop, the preferred options were packaged into five options for further development, costing, and evaluation at the MCA Workshop. The MCA Workshop is discussed in **Section 10.5**. The five options are:

- Option 1: Improve Existing ATMS;
- Option 2: Hard Shoulder Running;
- Option 3: Controlled All Lane Running;
- Option 4: Four Lanes with Full Shoulders; and
- Option 5: Four Lanes with Full Shoulders and Enhanced ATMS.

The five options are described below. Drawings of the options are included in **Appendix I**.

6.3.1. Option 1: Improve Existing ATMS

Option 1 retains three lanes in each direction but improves the operation of the existing ATMS. Compliance with the mandatory variable speed limit signage and lane control signals will be improved through engineering, education and an improved level of enforcement using speed cameras. Lane discipline and queue warning will be improved with additional Variable Message signage on each gantry above Lane 1 plus a queue protection system. Overall this option will have a small increase in technology and operational resource to improve the management of this section of motorway.

This option will retain the existing carriageway cross section (with 3.5m lanes) so no widening is required.

Option 1 also includes:

- Driver information in Wellington City. This will be confirmed following further investigation in the Scheme Assessment stage; and
- Improvements to the Hutt Road SH2 northbound on ramp.

Drawings of Option 1 are contained in **Appendix I**.

6.3.2. Option 2: Hard Shoulder Running

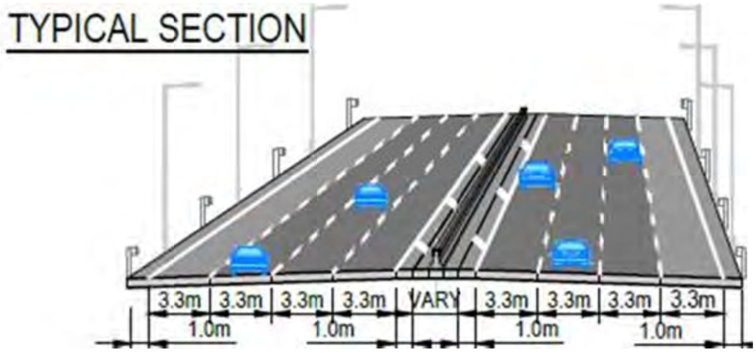
Option 2 is Hard Shoulder Running which enables the part time use of the shoulder as a fourth traffic lane. Improvements to the ATMS system are provided under this option and one additional gantry is required.

Widening of the carriageway is required to enable four traffic lanes in each direction. This includes widening of the Thorndon Overbridge (discussed further below) and also widening of the carriageway from the Thorndon Overbridge to the Ngauranga Merge. For the section between the Thorndon Overbridge and the Ngauranga Merge, there are two options to achieve the widening which are discussed below. Drawings of both options are included in **Appendix I**.

Option 2A: Keep Existing Median Barrier

With the median barrier retained, four 3.3m wide lanes with a 1.0m shoulder next to the outside lane will be provided. The proposed cross section for Option 2A is shown in **Figure 6.3**.

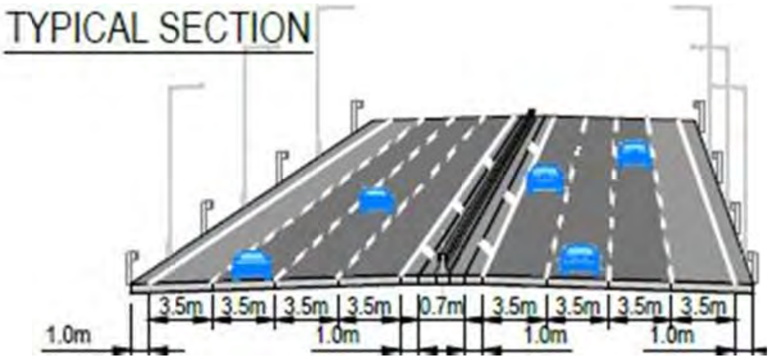
Figure 6.3: Option 2A Typical Cross Section



Option 2B: Replace Median Barrier

There is an option to replace the existing barrier with a TL4 concrete barrier. By replacing the barrier, four 3.5m lanes with a 1.0m shoulder are proposed as shown in **Figure 6.4**. Replacing the barrier allows widening to be accommodated by reducing the width of the median and minimising widening towards the harbour.

Figure 6.4: Option 2B Typical Cross Section



Also included in Option 2 (A and B) are:

- Improvements to the Aotea Quay on and off ramps;
- Driver information in Wellington City. This will be confirmed following further investigation in the Scheme Assessment stage; and
- Improvements to the Hutt Road SH2 northbound on ramp.

6.3.3. Option 3: Controlled All Lane Running

Option 3 is Controlled All Lane Running. Under this option a fourth lane is provided full time and is managed by the ATMS system. Improvements to the ATMS system are provided under this option. Similar to Option 2, to accommodate widening between the Thorndon Overbridge and the Ngauranga Merge, the median can either be retained or replaced. This results in two suboptions for Option 3**:**

- Option 3A is Controlled All Lane Running with the existing median; and
- Option 3B is Controlled All Lane Running with the median replaced.

The proposed cross section for Options 3A and 3B are the same as Options 2A and 2B, respectively. Both options are shown on the drawings in **Appendix I.**

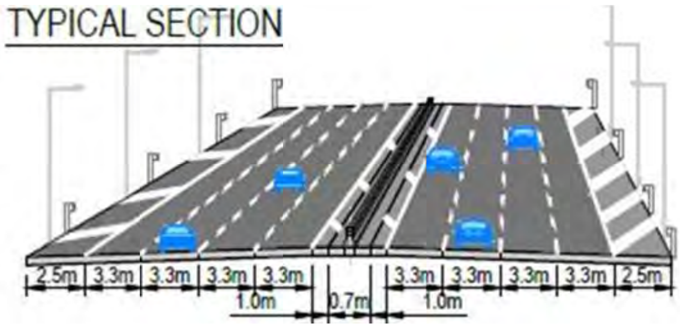
Also included in Option 3 (A and B) are:

- Improvements to the Aotea Quay on and off ramps;
- Driver information in Wellington City. This will be confirmed following further investigation in the Scheme Assessment stage; and
- Improvements to the Hutt Road SH2 northbound on ramp.

6.3.4. Option 4: Four Lanes plus Full Shoulders

Option 4 provides four lanes full time with full shoulders. The existing ATMS system will be retained for this option without any additional enhancements. Under this option the carriageway will be widened to accommodate four 3.3m lanes and a 2.5m outside shoulder in each direction. Provision of 3.3m lanes versus 3.5m lanes reduces the amount of widening towards the harbour. The median from the Ngauranga Merge to Thorndon Overbridge will be replaced under this option which also reduces the amount of widening towards the harbour. The proposed cross section for Option 4 is shown in **Figure 6.5**.

Figure 6.5: Option 4 Typical Cross Section



Also included in Option 4 are:

- Improvements to the Aotea Quay on and off ramps;
- Driver information in Wellington City. This will be confirmed following further investigation in the Scheme Assessment stage; and
- Improvements to the Hutt Road SH2 northbound on ramp.

Drawings of Option 4 are contained in **Appendix I**.

6.3.5. Option 5: Four Lanes plus Shoulders and ATMS Enhancements

Option 5 provides four lanes full time with full shoulders and has the same proposed cross section as Option 4. The ATMS system will be enhanced under this option .

Also included in Option 5 are:

- Improvements to the Aotea Quay on and off ramps;
- Driver information in Wellington City. This will be confirmed following further investigation in the Scheme Assessment stage; and
- Improvements to the Hutt Road SH2 northbound on ramp.

Drawings of Option 5 are contained in **Appendix I**.

6.3.6. Thorndon Overbridge

To accommodate the widening of the corridor for Options 2 through 5, Thorndon Overbridge will need to be widened. There are two options for achieving this:

- Construct a clip-on structure; or
- Construct a separate stand-along structure.

These options are discussed further in the Preliminary Design Philosophy Statement (**Appendix J**). The drawings for Options 2 through 5 include a clip-on structure (Option 1 does not involve widening and so does not need a clip-on structure). However a concept for a separate stand-alone structure was developed and these drawings are also included in **Appendix I**.

The option development and evaluation process started with a list of 55 ideas. Through a series of workshops the 55 ideas were narrowed down to five options to take forward to detailed assessment.

7. Design Considerations

7.1. Preliminary Design Philosophy Statement

The design approach adopted is to make the best use of the existing asset. The design will start from the premise that the existing carriageway alignment, the motorway centre line, pavement crossfalls and pavement construction should be retained to the maximum extent possible whilst achieving acceptable operational and safety standards.

a. Cross section

The typical cross section through the main carriageway for the different options is discussed in **Section 6**.

NZTA confirmed that the existing median barrier was nearing the end of its design life and it may be possible to provide wider lane widths within the existing carriageway "barrier to barrier" space if the median barrier is replaced.

Final shoulder widths will depend on the chosen work package, however the general approach will be to provide wider lanes at the expense of shoulder width if a trade-off is required.

b. Thorndon Overbridge

The original structure was not designed using the "capacity design" concept of modern structural design codes and consequently had serious seismic vulnerabilities. The structure was seismically retrofitted in the mid 1990's and post retrofit performance is expected to be adequate under seismic events of up to a 500 year Annual Probability of Exceedance (APE). This was considered an appropriate level of retrofit that was economically and technically feasible at the time, given the geotechnical conditions at the site, the risk of liquefaction and lateral spreading and the preference not to undertake the extensive and costly ground improvement measures required to mitigate these effects.

Two concept options have been considered for increasing the southbound carriageway width on Thorndon Overbridge from the northern abutment to Aotea Quay off ramp:

- The first option is the construction of a light weight "clip-on" deck widening; and
- The second option is provision of a separate elevated off-ramp structure.

For widening using a "clip-on" option, the key features are:

- Existing 500 year APE will not be adversely affected (proposed 10% additional seismic load on substructure is within existing capacity of piers and foundations);
- 3.3m traffic lanes to be used (but may require 3.25m lane widths) and narrow (0.5m) shoulders; and
- TL4 "high" protection level, using "nested" steel Thriebeam side protection barriers to be used as per the existing structure.

For a separate off-ramp structure, if required:

- 1000 year APE to be adopted;
- 2 x 3.5m traffic lanes with 0.6m inner and outer shoulders;
- TL5 side protection barriers will be adopted; and
- Vertical clearance will be broadly in line with existing Thorndon Overbridge

Both the aforementioned options assume that the current Aotea Quay off-ramp bridge structure will be retained as existing and will not be modified, strengthened or replaced on the basis that there will be no change to the current risk profile for this structure, noting that this structure is vulnerable to liquefaction and lateral spreading with an APE of about 200 years.

The option selection for providing the additional traffic lane over Thorndon Overbridge will be carried out in the scheme assessment stage following further investigation of options and risk assessment.

c. Stormwater Treatment

The following assumptions have been made regarding stormwater treatment:

- The stormwater runoff is to be treated if the impervious area changes (i.e. increase in the pavement area) and
- The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected.

If treatment is required:

- The stormwater treatment would most likely involve proprietary devices rather than swales and wetlands because of spatial constraints;
- The treatment is to be carried out to Best Practicable Option (BPO). Runoff from the motorway is to be collected and passed through stormwater treatment devices, prior to discharging to the receiving environment. Particular sensitive environments are the harbour, Kaiwharawhara stream and the Korimako stream; and
- The treatment devices will address the removal of gross debris, suspended sediment, heavy metals, and hydrocarbons, and will be in accordance with NZTA's Stormwater Treatment Standard for State Highway Infrastructure.

The discharge of stormwater to land and/or water is a permitted activity under the Greater Wellington Regional Plans subject to meeting a number of standard conditions (such as the discharge should not give rise to conspicuous oil or grease films, change in colour or objectionable odour and should not have any adverse effects on aquatic life). Options that increase the impervious area of existing highway (through the addition of an extra lane for example) will likely increase the volume of stormwater running through the system. For such options, an assessment to confirm that the stormwater treatment applied will result in a stormwater discharge that can comply with the permitted activity conditions will need to be undertaken at scheme assessment stage. Ultimately, compliance with stormwater discharge standards is dependent on the level of treatment applied and management of stormwater volumes generated by the highway and therefore a design solution is available.

Further information on design considerations can be found in the Preliminary Design Philosophy Statement (PDPS) which included in **Appendix J**.

7.2. Preliminary Geotechnical Appraisal Report

A Preliminary Geotechnical Appraisal Report (PGAR) was prepared which presents a summary of the available ground investigation data and geotechnical reports throughout the NtAQ corridor. The PGAR is included in **Appendix K**.

The information gathered has then been used to identify the key geotechnical constraints affecting the scheme and develop the scope for a pre-tender ground investigation. A site walkover was undertaken by the Project's lead geotechnical Engineer on the 8th June 2011.

The design intent for the NtAQ project is to ensure that the additional elements exhibit an acceptable level of performance during a major seismic event, but do not require improving the overall performance of the existing motorway corridor.

Published geology by Begg and Mazengarb indicates the site is underlain by Reclamation Fill overlying Alluvium. The NZSEE Site Subsoil Classification of Wellington City (2011) shows the depth to basement rock (in situ greywacke) could be in the order of 200 to 350m below ground in the Thorndon study area. Elsewhere rock-head is evidenced by the Western Hills, immediately to the west of the project corridor.

A high level desk study has been undertaken to determine the potential for contaminated material to be present within the project footprint. It is recommended that a contamination assessment be undertaken and this would provide information to determine resource consent requirements (if any) and reuse/disposal options for any spoil generated by the construction phase.

The Wellington Fault line crosses below the existing Thorndon Overbridge immediately south of the proposed scheme. Fault rupture is anticipated to cause considerable damage to Thorndon Overbridge. Outwith this section of the scheme, the fault is sufficiently offset such that it does not present a fault rupture hazard although near fault effects will apply.

The following investigations are recommended as an indicative scope, to be confirmed when the preferred option for the Thorndon Overbridge area has been identified.

- Thorndon Overbidge: a series of CPT's at each pier and a borehole at every second pier.
- Kaiwharawhara: Benkleman Beam (BB) testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m centres, and boreholes at 200m centres throughout the extent of the proposed retaining wall – Ch2200 to 3000. A borehole to 10m depth is recommended at the location of the two widened gantries.
- Southern Rail Overbridge: no additional geotechnical investigations are proposed.
- Ngauranga: as for Kaiwharawhara, BB testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m intervals and boreholes (to between 10m and 20m depth) at 200m intervals are recommended along the length of the proposed retaining wall – Ch1700 to 1800.

The design approach adopted is to make the best use of the existing asset.

Two key design issues to be considered are whether to construct a clip-on or separate structure to accommodate widening at the Thorndon Overbridge and whether to replace the central median.

8. Cost Estimates

Cost Estimates have been developed for each of the option layouts described in Section 6.3 of this report. The Expected estimate and the 95th percentile estimate for each of the Options is shown in **Table 8.1** below:

The Option Estimates are based on providing a clip-on widening to Thorndon Overbridge but also include a provision for the construction of a standalone bridge structure. As detailed in Section 6.3 a determination on whether or not a standalone bridge structure is required will be made during the Scheme Assessment phase of the Project. The costs associated with the standalone bridge structure have therefore been reported separately, in **Table 8.1**, for clarity.

Table 8.1 – Option Estimate Values

Option and Description	Expected Estimate with Clip-On Bridge Structure ($M)	Expected With Standalone Bridge Structure ($M)	95th Percentile Estimate with Clip-On Structure ($M)	95th With Standalone Bridge Structure ($M)
Option 1 – Improve Existing ATMS	20.6	-	22.0	-
Option 2A – Hard Shoulder Running (keep existing median barrier)	69.6[6]	91.7	85.4	115.8
Option 2B - Hard Shoulder Running (replace median barrier)	76.7	98.8	91.9	121.8
Option 3A – Controlled All Lane Running (keep existing median barrier)	69.6	91.7	85.6	116.4
Option 3B - Controlled All Lane Running (replace median barrier)	79.3	101.4	95.4	125.5
Option 4 - Four Lanes plus Full Shoulders (existing ATMS and replace median barrier)	80.5	102.6	97.4	127.8
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements (replace median barrier)	88.6	110.7	105.0	134.7

Each of the options includes an allowance for the following items in the cost estimates:

- The construction of a new merge layout from Hutt Road onto SH2 (approximately $1.5M + Preliminary and General Items and risk);
- The construction of a new emergency vehicle access on-ramp immediately south of the Nguaranga intersection, on the western side of SH1 (approximately $2.1M + Preliminary and General Items and risk); and

[6] The base estimates for Options 2A and 3A are $60.7M and $58.9M, respectively. These options have different risk profiles and when applied to the base estimates, the expected estimate for both options comes to $69.6M. The cost estimate summaries are contained in **Appendix L**.

- A provision for additional driver information signs within Wellington City (approximately $2.1M + Preliminary and General Items and risk).

The standalone bridge structure includes the following:

- Bridge Deck (approx. 7000m2) $16.5M total
- Piles (approx. 570m) $4.9M total
- New TL5 concrete barrier (approx. 1,500m) $2.5M total
- Plus funding risk, less savings on other items such as pavement area and markings.

Option estimates are contained in **Appendix L.**

The Option Estimates are based on providing a clip-on widening to Thorndon Overbridge but also include a provision for the construction of a standalone bridge structure. A determination on whether or not a standalone bridge structure is required will be made during the Scheme Assessment phase of the Project.

9. Risk Assessment

A formal risk workshop for the project was held on 12 August 2011 and was attended by representatives from NZTA, Fletcher Construction (and their sub-consultants) and Beca. The risk workshop was facilitated under the guidelines of NZTA Risk Management Manual AC/Man/1 and the output of the workshop was the updating of the single project risk register to reflect the increased understanding of the project threats and opportunities. As a total of five options for the project are being explored the risk process identified the specific risks that applied to each option and detailed these in a single risk register. The risk register is included in **Appendix M**.

The risk workshop identified that there was a specific risk associated with the assumption that the existing Thorndon Overbridge could be widened with the use of a 'clip-on' type structure. The risk is that a new separate structure may be required and that even if it is technically feasible to widen the structure, it may not be desirable to widen a structure with a seismic capacity of 500 years APE given that this is significantly below the current design standard for a new structure. The importance of this structure in providing access to Wellington from the north will also need to be considered. The workshop recommended that a separate specific contingency allowance is made for this specific threat and that further investigation of the severity of the threat and development of mitigation plans is required.

A follow up meeting attended by a smaller group of NZTA, Fletcher and Beca representatives was held to close out issues raised at the risk workshop and to gain consensus on the method of pricing the risks so that contingency and 95th percentile funding allowances could be determined. Fletcher construction then priced each of the risks identified on the risk register for each of the options. These were then analysed by Beca to confirm the contingency and 95th percentile risk funding allowances for each of the five option estimates for the project. As the project is in the Investigation and Reporting phase on-going risk reviews and mitigation of project risks is recommended.

The key risks that have been identified and assessed at the risk workshop are:

- Alignment of stakeholder objectives;
- Road users not understanding or complying with the ATMS system for the selected option;
- NZTA's ITS standards are in draft form and could change;
- Port access requirements and future development of the Port could prevent or interfere with the Project;
- Additional ground improvement may be required to protect the Thorndon Overbridge;
- Capacity of shoulder pavement to cope with traffic volumes; and
- Drainage scope and treatment due to unknown conditions of existing or unmarked services.

In addition, the Thorndon Overbridge seismic risk will be slightly increased by any widening solutions which could lead to reputational risk following a major seismic event.

A formal risk workshop for the project was held and was attended by representatives from NZTA, Fletcher Construction (and their sub-consultants) and Beca. The risk workshop was facilitated under the guidelines of the NZTA Risk Management Manual and the output of the workshop was the updating of the single project risk register to reflect the increased understanding of the project threats and opportunities.

10. Options Assessment

10.1. Transport Network Assessment

The Wellington CBD SATURN traffic model (WTM) was used to model the network effects of the concept of operation scenarios. A test was also run with minor improvements to the existing three lane motorway but not providing a fourth running lane. The background and assumptions that went into the modelling process are included in **Appendix N**.

10.1.1. Option Tests

The WTM 2016 and 2026 models were run for four options. Traffic volume outputs are contained in **Appendix C**.

A variable demand approach was used to generate an option matrix from the Do Minimum. The modelling (and economic analysis discussed in **Section 10.2**) was undertaken on a 'global' network basis. As such, there was model noise having an impact on the analysis when comparing the Do Minimum and Options since variable demand was introduced. Because of this 'noise', it was assumed that no benefits were realised between Option 1 and the Do Min. The Option 1 results were adopted as a 'new' Do Minimum to calculate the BCRs and MCA scores for Options 2 to 5 inclusive. The rationale behind this was that Option 1 was assumed to deliver very minor travel and de-congestion benefits (and hence close to a Do Min situation).

It is noted that four options were tested rather than five. This is because SATURN does not have the ability to model many of the ITS management solutions proposed for the options that feature enhanced ATMS. SATURN is only able to capture the benefits of increased capacity. Accordingly, the model outputs for Option 5 would be similar to those produced for Option 4.

10.1.2. Results

A range of different outputs from the model have been extracted to form the basis of a quantitative comparison of the scenarios. **Table 10.1** summarises Vehicle Kilometres Travelled (VKT) for the various scenarios.

Table 10.1 – Model Network VKT by Option Compared to Do-Min (DM)

Option	2009 (Base)		2016		2026	
	VKT	% v DM	VKT	% v DM	VKT	% v DM
Do Minimum	610267	-	654240	-	760020	-
Option 1 [7]– Improve Existing ATMS	-	-	654240	0.0%	760020	0.0%
Option 2 – Hard Shoulder Running	-	-	654477	0.0%	760289	0.0%
Option 3 – Controlled All Lane Running	-	-	655298	0.2%	761462	0.2%
Option 4 - Four Lanes plus Full Shoulders	-	-	655136	0.1%	761013	0.1%
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements	-	-	655136	0.1%	761013	0.1%

The Do Minimum results demonstrate a 7% increase in overall network VKT from 2009 to 2016 and a 25% increase in VKT from 2009 to 2026. The modelling results indicate that there is very little change in VKT

[7] The Do Min results were adopted as the Option 1 results as discussed earlier.

between the options compared to the Do Minimum. The modelling results indicate that Options 3, 4, and 5 result in a small increase in overall network VKT as a result of some vehicles transferring onto a slightly longer route to save travel time.

Vehicle Hours Travelled (VHT) for the various options are summarised in **Table 10.2**.

Table 10.2 – Model Network VHT by Option

Option	2009 (Base)		2016		2026	
	VHT	% v DM	VHT	% v DM	VHT	% v DM
Do Minimum	26067	-	31380	-	46241	-
Option 1[8] – Improve Existing ATMS	-	-	31380	0.0%	46241	0.0%
Option 2 – Hard Shoulder Running	-	-	31135	-0.8%	45906	-0.7%
Option 3 – Controlled All Lane Running	-	-	31237	-0.5%	45745	-1.1%
Option 4 - Four Lanes plus Full Shoulders	-	-	31234	-0.5%	45676	-1.2%
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements	-	-	31234	-0.5%	45676	-1.2%

The modelling results indicate that overall network VHT decreases for Options 2, 3, 4 and 5 reflecting the capacity improvements associated with the extra lane (particularly in peak hours). Further interrogation of the results, however, reveals that the majority of the benefit is achieved through the extra capacity provided southbound in the AM peak. This reflects the fact that SH1 is running at capacity on the approach to the interchange.

The predicted year 2026 travel time savings on SH1 through the Project area for each option based on the WTM modelling is summarised in **Table 10.3**.

Table 10.3: WTM Predicted Travel Time Saving[9] on SH1 (2026)

Option	Travel Time Saving in AM Peak Southbound: mm:ss (% reduction compared to Do-Min)	Travel Time Saving in PM Peak Nouthbound: mm:ss (% reduction compared to Do-Min)
Option 2 – Hard Shoulder Running	00:40 (-2%)	00:40 (-5%)
Option 3 – Controlled All Lane Running	01:45 (-6%)	00:40 (-5%)

[8] The Do Min results were adopted as the Option 1 results as discussed earlier.

[9] As noted earlier the Do-Min results were adopted as the Option 1 results. The travel time savings for Options 2 through 5 are compared to Option 1.

Option 4 - Four Lanes plus Full Shoulders	01:55 (-7%)	00:40 (-5%)
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements	01:55 (-7%)	00:40 (-5%)

As summarised in **Table 10.3**, Option 2 is predicted to result in 40 seconds of travel time savings on SH1 through the Project area in both the AM and PM peaks, resulting in a two to five per cent reduction compared to the Do Min. Options 3, 4, and 5 are predicted to result in nearly two minutes of travel time savings in the AM peak and 40 seconds in the PM peak, resulting in a five to seven per cent reduction compared to the Do-Min.

As discussed In **Section 5**, early indications are that the implementation of the "Early Works" resulted in travel time savings which are not included in the modelling results summarised above.

It is expected that based on experience from overseas applications of these types of ITS solutions, the increased capacity and ITS management solutions will lead to a tangible improvement in journey time reliability, as well as the reduction in travel times noted above, but the extent of improvement is yet to be established. The improvement to journey time reliability through implementing the options has not been assessed in the Scoping Stage, because the SATURN software is only able to capture the benefit of increased capacity. It is recommended that during the Scheme Assessment stage micro-simulation modelling combined with analysis of Bluetooth travel time data should be utilised to capture the benefits of the ITS-based improvements and to consider potential staging of the preferred option.

10.2. Economic Analysis

An economic analysis was completed for the options. The analysis was undertaken in accordance with the Economic Evaluation Manual (EEM), with travel costs based on the SATURN model output. Special consideration was required for specific elements, as discussed below.

10.2.1. Economic Analysis Considerations

a. Required Model Outputs

The economic analysis uses outputs from the WTM model. **Table 10.4** outlines the required model outputs and their purpose.

Table 10.4 – Required Model Outputs for Baseline, Do Minimum and Option Tests

Required Outputs	Model Years & Time Periods	Purpose
Assigned Traffic Networks	2009[10], 2016, 2026 AM, IP, PM	To provide road journey times and travel distance
Traffic Demand Matrices		To provide road travel demand trips split by vehicle type
Assignment Statistics[11]		Provides information on convergence

b. Consideration of Induced Traffic

The EEM provides some guidance on when induced traffic procedures should be considered. Firstly in its description of future traffic flows (A2.8):

[10] 2009 only required for Baseline Scenario

[11] The assignment statistics are for sanity checks only – they provide no explicit input to the economic appraisal but do provide confidence in model convergence

"Activities that reduce the cost of travel by reducing travel time or removing constraints can induce new trips or redistribute trips. In the cases where induced or redistributed trips are expected to significantly affect the evaluation, then a variable matrix approach should be adopted (see appendix A11)."

In Appendix 11, the EEM states:

"Variable matrix methods differ from conventional fixed trip matrix techniques in that demand in the option matrix is generally higher than that in the do-minimum matrix for a given forecast year. Variable trip matrix methods are to be used for all complex improvements, unless it can be demonstrated that:

- *the congestion level expected throughout the analysis period in the do-minimum or option will not be substantial, and*
- *the peak period passenger transport mode share is less than 15 per cent, or*
- *preliminary evaluation shows that the fixed trip matrix benefits are unlikely to differ by more than 10 per cent from those from a variable trip matrix approach; or*
- *the NZTA approves the use of a fixed trip matrix approach for other reasons.*
- *A substantial congestion level is such that the congestion (relative to a non– congested/free flow situation) would add at least 10 per cent to the typical peak period trips (of typical trip length) travel times. A 10 per cent travel time change equates to typical elasticities from a five per cent traffic volume change. The evidence from various evaluations indicates that such a traffic volume change between the do-minimum and option has a substantial effect (at least 25 per cent) on the benefits."*

Substantial congestion is expected in the Do Minimum scenario (hence the need for the project), and hence criteria (a) above is not met for using fixed matrices.

The complexities of the process mean that it is not practical to undertake a 'preliminary' estimate of the likely scale of effect, without first setting up the procedures.

It is not clear what level of induced traffic could be expected, however given the proposed options do not significantly increase the capacity of the roadway, significant changes in demand patterns would not be expected. More complex procedures are required to be used to assess induced traffic benefits, and the output is much more difficult to audit or verify.

Therefore, as induced traffic effects make it more difficult to audit and understand where benefits are coming from, a fixed trip matrix approach has been used as this provides better comparison between the options.

c. Components of Economic Analysis

The components assessed include:

- Travel Times – Travel time benefits are likely to be the largest benefit component of the model output. Urban Arterial road category composite values of base travel time have been used in the economic evaluation for the light and heavy vehicles;
- Congestion Costs – Traffic congestion values have been developed in the same way as the base travel time values. All intersection delay has been included as 'bottleneck' delay and congested time on links has been assessed as per section A4 of the EEM;
- Reliability – The detailed calculations in the EEM for calculating trip reliability are not readily implemented in the SATURN software so an alternative method was utilised. In many projects the EEM-derived procedures generate a low proportion of the overall benefits. The EEM procedures are based around estimates of changes in travel time due to day-to-day variations in traffic demands. So rather than applying the resulting EEM functions (which is not practical in SATURN), reliability was taken as 5% of travel time benefits;
- Vehicle Operating Costs (VOC) – These have been calculated in accordance with the EEM (section A5), for Base Running costs, which are a function of speed and distance. Additional running costs related to congested conditions have also been assessed in accordance with the EEM; and
- Carbon Dioxide Emission Savings – As per the EEM A9.7, CO_2 savings have been calculated as 4% of the vehicle operating costs.

d. Hazards

Each scenario was assessed on how it impacts the hazards in terms of ERIC (Is it **E**liminated, **R**educed, how is the option **I**nform drivers of the hazard or how the option **C**ontrols the hazard) and the summary of this assessment is outlined below. Further to this assessment the *Project Safety Report* will be prepared as part of scheme assessment. This report will outline how the key hazards above will be eliminated, reduced, informed or controlled through driver information and operational controls. This process and report will be reviewed by the Safety Control Review Group. The purpose of the group is to guide the approach to operational safety management, so the expected outcomes are met. This proved successful when applied by the UK Highway Agency as part of their Managed Motorway projects

A safety hazard analysis was undertaken which informed the crash benefit analysis. The hazard analysis involved using the Safety Baseline to calculate a percentage change to safety hazards for each option. The Safety Baseline was developed by Mouchel and subsequently validated by the ECI team. The hazard analysis was then verified by Mouchel.

For the five options the Baseline hazard logs were reviewed and the change in risk profile that would be expected for each hazard was estimated based on experience from other assessments. The risk profile for each hazard was mostly reduced but there were a few hazards where the risk increased. **Table 10.5** summarises the overall impact on the hazard index score for each option. Further information on this assessment is included in **Appendix O**.

Table 10.5: Estimated Percentage Change in Overall Option Risk Profile

Scenario	Percentage Change to Hazard Index Score
Option 1 – Improve Existing ATMS	-10.0%
Option 2 – Hard Shoulder Running	-18.4%
Option 3 – Controlled All Lane Running	-26.7%
Option 4 - Four Lanes plus Full Shoulders	-8.0%
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements	-23.4%

The hazard analysis indicated that all of the scenarios would result in safety benefits.

e. Annualisation

The annual benefits were estimated by aggregating the weekday peak and interpeak models. Generally, the AM and PM peaks were used to represent weekday peaks, with the interpeak results used to represent all other periods. The expansion factors to apply to the interpeak models to represent weekday off peak and weekend periods were derived from traffic count profiles in the area. The non-linear relationship between flow and delays was also considered in these expansion factors based on testing the models at a range of flow levels, and determining a global relationship between delay and flow rates.

10.2.2. Option Benefit Cost Ratios

Benefit Cost Ratios (BCR) for the options were calculated. A 30-year evaluation period was used in accordance with the EEM. Two BCRs were calculated for each option based on having a clip on or standalone bridge structure at Thorndon Overbridge as described in **Section 6**. The results of the economic analysis are summarised in **Table 10.6**. The EEM worksheets are included in **Appendix P.**

Table 10.6 - Option BCR's

Option	NPV Benefits ($M)	NPV Costs ($M)		BCR	
		With Clip On Structure	With Standalone Bridge Structure	With Clip On Structure	With Standalone Bridge Structure
Option 1 – Improve Existing ATMS	7.8	17.2	-	0.5	-
Option 2A – Hard Shoulder Running (keep existing median barrier)	47.5	55.3	72.2	0.9	0.7
Option 2B - Hard Shoulder Running (replace median barrier)	47.5	60.7	77.6	0.8	0.6
Option 3A – Controlled All Lane Running (keep existing median barrier)	70.6	55.5	72.8	1.3	1.0[12]
Option 3B - Controlled All Lane Running (replace median barrier)	70.6	62.9	80.2	1.1	0.9
Option 4 - Four Lanes plus Full Shoulders (existing ATMS and replace median barrier)	79.5	62.7	80.0	1.3	1.0[13]
Option 5 - Four Lanes plus Shoulders and ATMS Enhancements (replace median barrier)	83.5	69.8	87.1	1.2	1.0[14]

The BCR for Options 1 and 2 is below 1.0 which indicates that these options are not economic. The costs and benefits of Option 2 will be assessed further in the scheme assessment phase and when considered with the education, enforcement, and technology requirements will determine whether it becomes a viable option. Option 3 achieves a BCR greater than 1.0 with both keeping the median barrier and replacing it, but only if a clip on structure is constructed. Options 4 and 5 achieve a BCR greater than 1.0 if a clip on structure is constructed. None of the options achieve a BCR greater than 1.0 if a separate structure is constructed.

10.3. Transport Policy Assessment

The concept of operations scenarios aim to fulfil as many of the Government Policy Statement objectives as possible. The policy context has been considered at all stages of the preliminary scoping stage with particular reference to the New Zealand Transport Strategy, Government Policy Statement and Land Transport Management Act.

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[12] By rounding to the nearest tenth decimal as per the EEM a 1.0 is achieved however as shown the NPV costs ($72.8M are greater than the NPV benefits ($70.6M).

[13] By rounding to the nearest tenth decimal as per the EEM a 1.0 is achieved however as shown the NPV costs ($80.0M are greater than the NPV benefits ($79.5M).

[14] By rounding to the nearest tenth decimal as per the EEM a 1.0 is achieved however as shown the NPV costs ($87.1M are greater than the NPV benefits ($83.5M).

The scenarios were assessed against each of these acts and found to be consistent with each of them. The full assessment is contained in **Appendix Q**.

An assessment of the project was also undertaken against the funding profile in NZTA's *Planning, Programming and Funding Manual* (PPFM). Based on this assessment the funding profile is:

- **High** Strategic Fit;
- **Medium** Effectiveness; and
- **Low** Efficiency

The full assessment against the PPFM criteria is contained in **Appendix Q.**

10.4. Preliminary Social and Environmental Screen

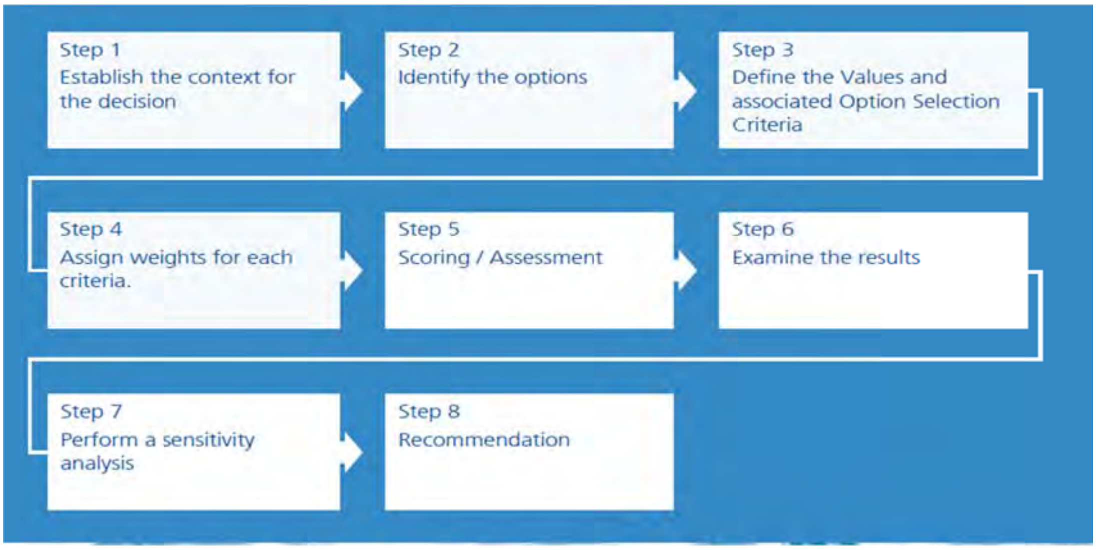
A preliminary social and environmental screen was undertaken and is included in **Appendix R.** The social and environmental issues were assessed as having low to medium effects, with a number of issues not applicable to the Project. There were no issues identified with high effects. The assessment indicated that there would be no significant differences in social or environmental effects between the options.

10.5. Multi-Criteria Assessment

10.5.1. Process

Multi-Criteria Analysis (MCA) provides a systematic approach to assessing the merits of alternative options. The generic steps of the MCA process are provided in **Figure 10.1** below.

Figure 10.1 MCA Process



The project objectives were reviewed prior to the MCA workshop. The outcome was that the project team considered that some of the original project objectives biased the assessment towards ATMS options. The objectives were updated to mitigate this bias and the objectives agreed were:

- Improve journey efficiency through journey time reliability, reducing congestion and driver stress;
- Making best use of the asset by delivering a value for money and flexible solution;
- Improve compliance through influencing driver behaviour;
- Maintain or improve safety for all users;
- Adverse effects on the environment are no more than minor;
- The solution can be delivered effectively; and

- The solution fits with NZTA's economic strategy.

The context for this project and the options that have been scoped are well-defined in the earlier sections of this report. In terms of defining the values and selection criteria in Step 3, the project objectives were used as assessment criteria, incorporating key decision-making measures and including measures unique to this project such as operational; driver behaviour; and compliance issues. This process of assigning weights, scoring and examining the results through sensitivity analysis is summarised below and the full MCA Summary Report is provided in **Appendix S**.

10.5.2. Multi-Criteria Assessment

The Multi-Criteria Assessment (MCA) Workshop was held on 13 June 2011, attended by a range of project experts and NZTA staff as listed in **Appendix S**. The purpose of the Workshop was:

- To identify any differentiators between the options to help inform the selection of a preferred option(s) to take forward for further investigation (Scheme Assessment stage);
- To check for information gaps or further investigation required to inform the SOR; and
- To ensure due process in terms of considering the full range of transport, economic and environmental factors to inform the SOR.

The MCA framework was tailored specifically to suit the project objectives – whereby project objectives were used as assessment criteria, incorporating measures unique to this project such as operational; driver behaviour; and compliance issues. In determining the scores, options were compared to the baseline 'do nothing' option. The scores indicate the degree to which the option will contribute to achieving the specific criteria measure. The framework and ratings are included in **Appendix S**[15].

All MCA measures were pre-scored prior to the Workshop by experts to allow the focus of the Workshop to be on understanding the rationale behind the scores and debating that as a group. At the Workshop, each lead expert introduced their respective measure and summarised the scoring of each option and the rationale behind the scores. Opportunity for any discussion/ agreement/ challenge of the scoring followed. The aim was to end the workshop with an agreed set of MCA option ratings. The non-weighted and weighted scores from the MCA are summarised in **Table 10.7**.

[15] It is noted that following the MCA workshop minor changes to the cross sections were made which are not expected to impact on option scores. The updated cross sections are reflected in the MCA report. The minor changes include providing consistent lanes widths (3.3m or 3.5m lanes) and providing for a 1.0m shoulder for HSR. Updates to the cost estimates and benefits were also made after the MCA workshop which are not expected to impact on the option scores.

Table 10.7 MCA Scores

	3 Lanes + Minor Works	Hard Shoulder Running (HSR)	Controlled All Lane Running (CALR)	4 Lanes + Hard Shoulder	4 Lanes + Shoulder + ATM
Non-weighted scores	2.9	1.9	5.5	2.6	6.0
Weighted scenarios					
1 Journey efficiency (bias 70%)	0.6	1.6	2.0	1.8	2.1
2 Best use (bias 70%)	0	0.5	1.0	1.5	0.8
3 Compliance (bias 70%)	1.5	0.5	1.6	1.5	2.0
4 Safety (bias 70%)	0.8	0.8	1.3	0.5	1.5
5 Environment (bias 70%)	0.2	-0.3	-0.3	-0.6	-0.5
6 Delivery (bias 70%)	0.2	-1.0	-0.9	-0.1	-0.8
7 Economic (bias 70%)	0.2	0.7	1.4	1.2	1.6
8 Social factors only	1	-1.5	1	1	2.0
9 Social factors removed	0.5	1.4	1.6	1.1	1.6
10 Economic fit removed	0.6	0.3	0.7	0.2	0.8
11 Equal weighting of objectives (14%)	0.5	0.4	0.8	0.4	0.9
12 Workshop weightings	0.4	0.9	1.4	1.1	1.5
Average Weighted Score	0.5	0.4	0.8	0.4	0.9

The social and environmental assessments undertaken for the Workshop built on the initial screening of social and environmental issues summarised on the project PSF/13 form attached in **Appendix R**. Overall the findings of the MCA expert assessments was consistent with that initial screening, being that there were no fatal flaws or areas of high risk for social and environmental effects identified at this stage for the various options under consideration. In terms of environmental and social effects, the close proximity of the Wellington Harbour and Kaiwharawhara Stream to the Project site was identified as needing to be carefully managed during any construction works, both being sensitive receiving environments of social and cultural significance.

Key findings of the MCA Workshop were:

- All options are feasible to be constructed;
- All options have social and environmental effects that can be sufficiently managed to ensure that any adverse effects were no more than minor;
- All options have positive transport benefits in relation to the 'do nothing' option; and
- There was sufficient differentiation to show those options that more positively contribute to the project objectives than others. Principally, Option 3 (CALR) and Option 5 (4 lanes + shoulder + ATM) had a more positive overall contribution than Options 1, 2 and 4. Options 3 and 5 scored well against the measures of journey time reliability, compliance and safety.

The MCA workshop participants found it complicated to evaluate the physical and operational aspects of the options at the same time. The workshop was able to confirm that the options were physically feasible however more work was necessary to develop and evaluate the operational aspects of the options. Following the MCA workshop an operational framework was developed and this is discussed in **Section 11**.

A multi-criteria assessment process was undertaken which concluded that:

- **All options are feasible to be constructed;**
- **All options have social and environmental effects that can be sufficiently managed to ensure that any adverse effects were no more than minor;**
- **All options have positive transport benefits in relation to the 'do nothing' option; and**
- **There was sufficient differentiation to show those options that more positively contribute to the project objectives than others. Principally, Option 3 (CALR) and Option 5 (4 lanes + shoulder + ATM) had a more positive overall contribution than Options 1, 2 and 4. Options 3 and 5 scored well against the measures of journey time reliability, compliance and safety.**

The workshop was able to find that the options were physically feasible however more work was necessary to develop and evaluate the operational aspects of the options.

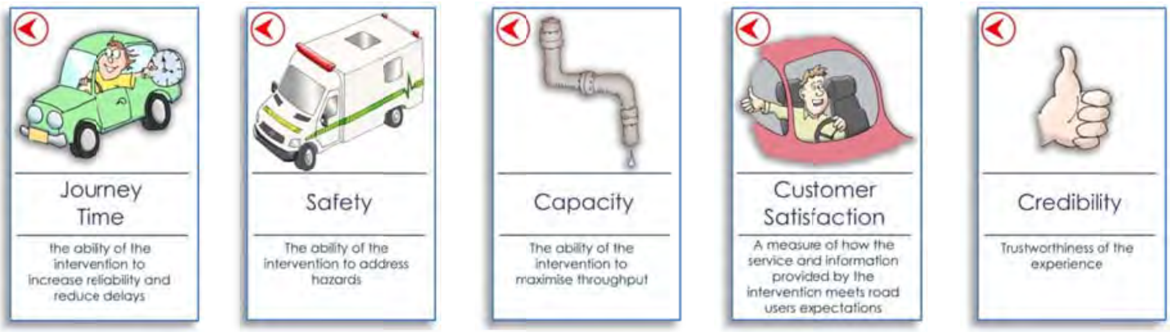
11. Corridor Management Framework

The Options Development Workshop confirmed that the top-scoring options for improvements to SH1 involved varying forms of ATMS. A critical part of further developing options in the scoping stage was to develop a corridor management framework for the operation of SH1 from Ngauranga to Aotea Quay. This involved workshops with NZTA including members of the PSG and Regional Management Team. The intent of the corridor management framework is to define a strategy which NZTA will use to manage this section of motorway. The development of the corridor management framework is discussed below.

11.1. Development Process

A framework was developed outlining the different levels of operational management for a green field state highway and the level of benefits and potential impact on the performance indicators shown in **Figure 11.1.**

Figure 11.1: Root Cause Performance Indicators



These performance indicators were developed from the Root Cause, Associate Objective and Operational Requirements outline in **Appendix E** and discussed in **Section 5.**

The levels of operational management were identified as:

- Do Nothing;
- Monitoring;
- Information;
- Control; and
- Transport Network Integration.

The level of public education, enforcement and operation required was identified for each level of operation. In addition the type of technology that would be included with each intervention was identified. The international case studies and literature that supports these levels of management and their potential benefits is outlined in the report *Ngauranga to Aotea Quay Operational Management Level Assessment Literature Review*, 17 August 2011 contained in **Appendix T**.

11.1.1. Basic Level: Monitoring, and Information

Figure 11.2 outlines the basic level of operational management for Do Nothing, Monitoring, and Information.

Figure 11.2 – Basic Level of Operational Management

	Do nothing	Monitoring	Information
	The intended purpose is for all road users to have fully uncontrolled access without any operational management, information or control.	The intended purpose is to monitor the movement and performance of the traffic flow and direct emergency services to incidents on the network	The intended purpose is to provide information to drivers on the performance of the road network
Public Education	✗	✗	✓
Enforcement	✗	✗	✗
Operability	✗	✓	✓
Technology	Pavement and line marking Static directional signage in accordance with MOTSAM	Vehicle Detection loops and Radar - Traffic flow, Vehicle Type, Vehicle Speed and Occupancy Pan, Tilt and Zoom CCTV Cameras Incident or Queuing Detection - Fixed Cameras	Strategic Variable Message Signs Traveller Information Signs - State Highway or on Local Road Network
Intervention	None	Data Collection	Network Information

a. Monitoring

The intelligence function behind monitoring is the foundation of the managed motorway, informing the control and information functions as well as outcome monitoring. The intelligence behind monitoring is:

i. Vehicle Detection Equipment

Vehicle detection equipment provides volume, speed, occupancy (density) and classification on a lane by lane basis. The information is the basis of monitoring and control for motorways.

ii CCTV

CCTV provides operators with a view of the motorway, enabling more detailed assessment of conditions than provided by vehicle detection equipment. This allows the operator to manage unusual conditions such as incidents and planned events. This is a useful tool in congestion management, such as assessing queuing and queue lengths and conditions on arterial roads on the approaches to motorway on-ramps. These are also useful tools to allow the operator to assess the performance of modifying ramp metering system changes.

iii. Emergency Phones

This device enables motorists to advise the TOC of an incident or broken down vehicles. This is of most use to drivers without access to mobile phones and provides direct access to the appropriate response agency. They also allow the TOC to accurately identify the location of the caller.

iv. Environmental Monitoring

This equipment monitors environmental conditions such as temperature, wind speed and rain fall rate. Where appropriate it can also directly activate warning signs.

v. Travel time tracking equipment

This equipment tracks vehicle movements for travel time calculations. It is also useful for determining origin-destination patterns.

b. Information

The information function assists road users to be warned about a hazard up ahead and make informed decisions about their travel, through route choice and time of travel.

An overall traveller information strategy for potential motorway users should consider three time periods for provision of information:

- Pre-trip (e.g. before leaving home or work);
- En-route but before entering the motorway; and
- En-route, after entering the motorway.

Ways to provide traveller information are:

i. Web Site or Radio

Web sites and radio allow motorists to receive information on road conditions and incidents prior to leaving home. This allows them to plan an alternative route, defer their trip and retime their trip if they would be affected by an incident. It is assumed that this is outside the scope of the options being assessed.

ii. Motorway Variable Massage Signs

Variable message signs (VMS) allow information to be conveyed to motorists once on the motorway. This information can warn them of hazards or disruptions, why speed limits have changed under a speed management system and detail actions to be taken (e.g. merge right left lane closed due to incident) as part of a lane management system.

These signs can be used to provide travel time information when not required for incident management.

iii. Traveller Information Signs

These are variable message signs located on arterial roads on the approach to motorway on-ramps. These signs provide travel times and other motorway condition information and enable motorists to make route choice decisions before entering the motorway.

11.1.2. Control

The interventions under this level of operational management are outlined in **Figure 11.3**. These interventions can complement each other to form an appropriate level of motorway management to meet operational requirements. It is expected that between speed management and fully managed the operability would move from reactive to proactive. The more automated the fully managed system becomes the more the operator would be able to move away from dealing with the day to day and respond more to the unusual.

Figure 11.3 – Control Level of Operational Management

There are five levels of intervention under the control level of operations management including:

- Speed management;
- Queue protection
- Lane control;
- Access management; and
- Full managed.

a. Speed Management

Speed management can assist in managing safety in adverse conditions, such as heavy rain, high winds, incidents and roadworks. Speed management can also assist in maximising capacity and traffic flow during heavy demand periods. Speed management can also be provided as part of an integrated speed and lane management system.

Public education and enforcement are necessary to gain the benefits of introducing speed management. It is expected that to gain the necessary level of compliance that digital enforcement of the mandatory variable speed limit and a high level of public education would be required. As part of the public education additional Variable Message Signs should be installed to inform drivers why the speed limit has changed to encourage compliance.

Currently operators are required to watch, respond and actively implement operational management plans to set variable speed limits to manage congestion effects resulting from incidents and peak traffic flow conditions. It is assumed that the system would be updated via an automated system which can be fine turned to react to traffic conditions and implement a speed limit change before severe flow breakdown would occur. Any human interaction-based system drastically reduces the accuracy of this timing and impact on benefits.

b. Queue Detection

Vehicle detection devices using either an image processing system or an algorithm applied to traffic data will detect traffic flows. The queue detection algorithm will process the information and either set a VMS warning of a queue ahead or set speed limits (to protect the queue), which will be displayed to drivers. These systems are usually self- explanatory and require enforcement and driver education to gain a good level of compliance.

Operators would only be required to watch, as these systems are usually automated in terms of detecting queues and setting a response. An operator would be required to be trained to analyse the performance of the automated system and calibrate as required.

c. Lane Management

Lane Management of urban motorways refers to the allocation and management of available road space to achieve desired performance outcomes during an incident or maintenance. The most common application for urban motorways is expected to be Integrated Speed and Lane Management. Other applications include dynamic use of the shoulder between on and off-ramps, exit queue storage and priority applications for specified road user classes.

Enforcement and public education is necessary to ensure the appropriate level of safety and compliance.

Operators would be required to watch, respond and actively implement incident management plans by set lane control signs during incidents. For maintenance activities the operator would be required to liaise with the STMS when implementing temporary traffic management.

d. Access Management

Motorway Ramp Signals manage access to the motorway, to prevent capacity being exceeded (causing flow breakdown) and breaking up on-ramp vehicle platoons that temporarily overload the merge area. Motorway Ramp Signals are most effective when implemented as a corridor wide dynamic system, providing full control of the motorway and allowing effective management of the queues at the ramps.

This level of management would require public education prior to construction and opening. These systems usually have a high level of compliance when operated efficiently and drivers view that the ramp signals are providing an overall improvement in the reliability of their journey and require only directed enforcement when a large number of non-compliances is detected.

Operators would only be required to watch as the access management system will be automated. Operators will only respond and adaptively control the system if queues on the local network exceed maximums. Staff will be required to monitor the operations and analyse traffic data to optimise the system settings.

e. Fully Managed

A fully managed or managed motorway system uses the control interventions speed, queue, lane and access management to optimise the motorway performance, and manage safety, reliability and capacity.

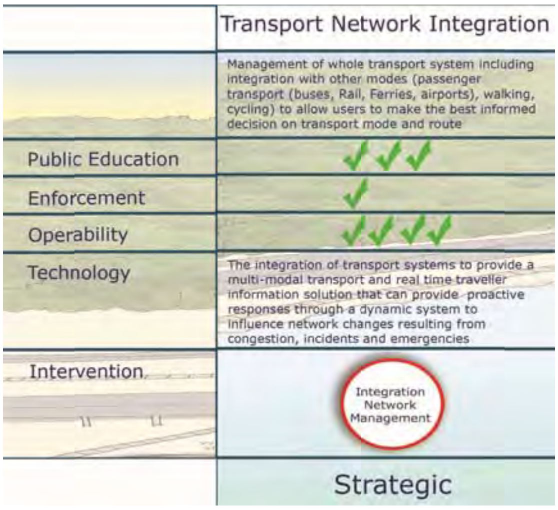
Normally a managed motorway system would have a combination of speed, lane and access management interventions to best achieve the optimum performance outcomes.

The systems will be complex and require a high level of training for the operator and analysts. The system should run automatically with operators required to watch, respond and actively deal with the unusual events and incidents. A 24 hour traffic operations centre would be required to provide the optimum performance outcome.

11.1.3. Transport Network Integration

This operational level of management as shown in **Figure 11.4** proposes to integrate the systems of all modes to allow users to make best informed decisions on transport mode and route. This level of operational management will provide the greatest level of flexibility and increase trip reliability.

Figure 11.4 – Transport Network Integration Level of Operational Management



A continuous level of public education/advertising is required to inform drivers of the information provided by the system to make informed travel decisions.

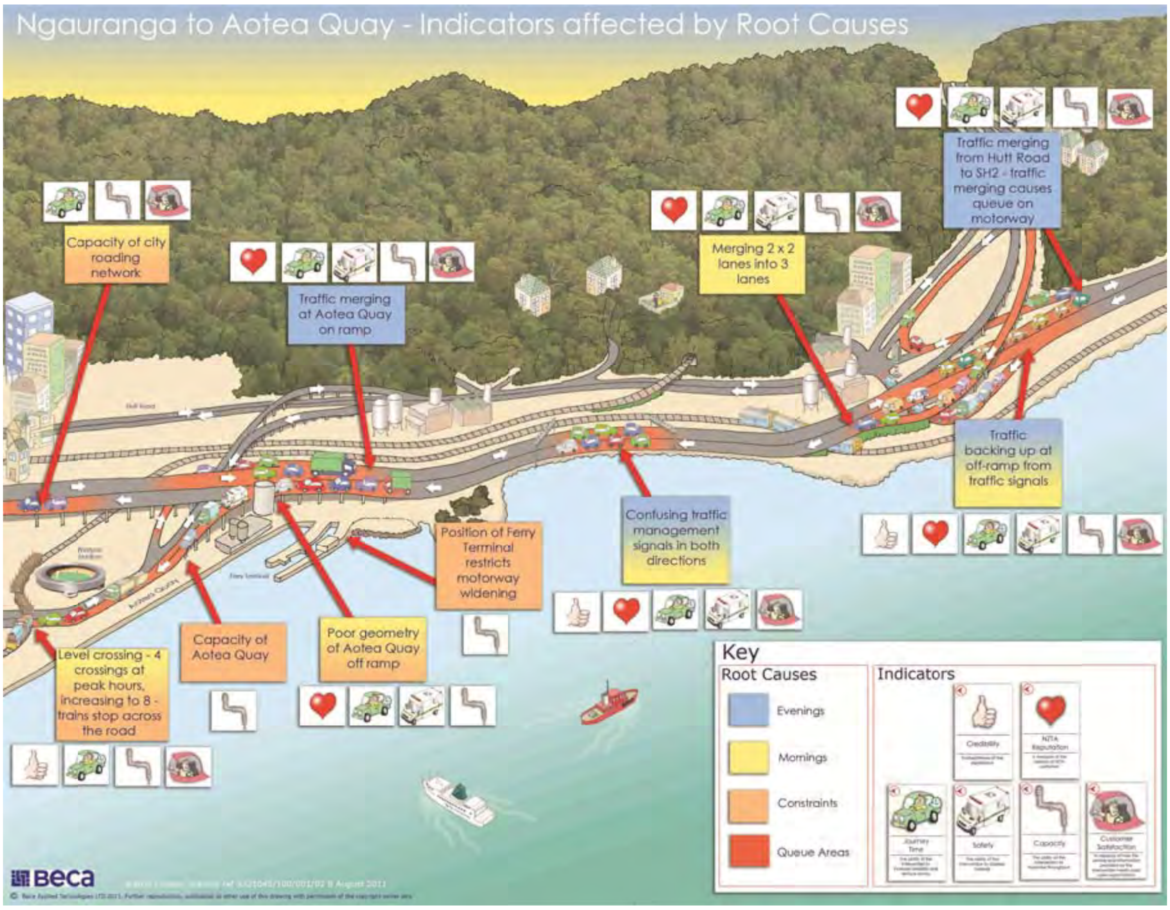
It is believed that with a mature integrated transport system the level of enforcement required to maintain compliance would decrease significantly.

The systems will be complex and require a high level of training for operators and analysts. Operators would be required to watch and respond and actively manage the state highway and local arterial road network. TOC staff would be required to actively provide traveller information, multi-modal services, data broker services and systems, media broadcasts, etc. A 24 hour multi-agency operations centre would be required to provide the optimum performance outcomes. A Memorandum of Understanding with passenger transport agencies and authorities would be required.

11.2. Indicators Affected By Root Causes

An assessment was made on indicators (**Figure 11.1**) which would be affected by the root causes. This was informed by a literature review which is contained in **Appendix T.** The indicators affected by the root causes are illustrated in **Figure 11.5**.

Figure 11.5: Illustrated Root Causes



11.3. NZTA Workshop

A workshop was held with key staff from NZTA to introduce the concept of operational level of management and confirm with NZTA where the performance indicators should be positioned on the performance scale for the existing system and desired system.

11.3.1. Framework Table

Levels of performance were developed based on the research undertaken to determine the level of benefits that could potentially be achieved. These levels were:

- Unsatisfactory;
- Poor;
- Acceptable;
- Performing; and
- Optimised.

Research data outlined in **Appendix T** supporting each intervention was aggregated into the performance indicators, so their impact could be measured against the performance levels as shown in **Appendix U.**

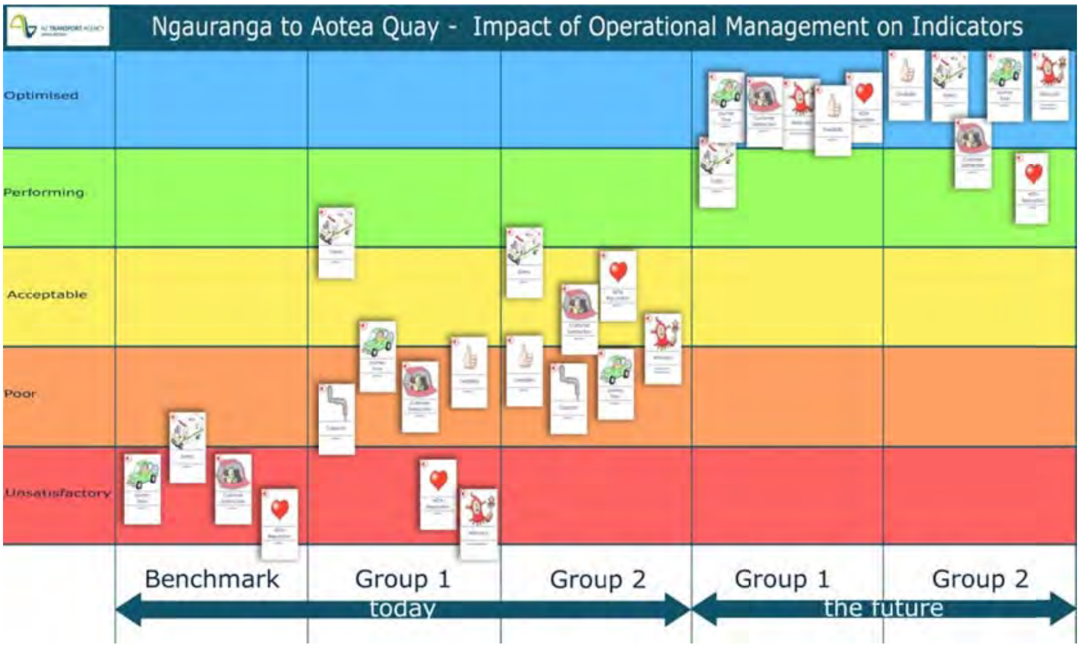
11.3.2. Workshop Outcomes

Workshop attendees formed two groups and confirmed where each group believed the six performance indicators should be positioned against the performance levels. Each of the two groups was given a wildcard to use if they believed an additional performance indicator was required. Group 1 identified that Safety was performing well but that driver behaviour was poor through the corridor. Group 2 identified that Operational Management should be a performance indicator. Therefore the confirmed performance indicators were:

- Journey Time Reliability
- Safety
- Capacity
- Customer Satisfaction
- Credibility (NZTA Reputation)
- Driver Behaviour
- Operational Management

The workshop groups then confirmed where each of the performance levels should be located on a scale between unsatisfactory and optimised both for today and in the future. This is shown on **Figure 11.6**.

Figure 11.6: Group Evaluation of Performance Indicators



Based on the workshop exercises, the level of performance desired by both groups required the level of operational management to be Fully Managed. Following the exercises the workshop attendees discussed the levels of management and agreed that Fully Managed was the preferred level of management. The workshop attendees felt that Transport Network Integration was going too far and it was confirmed that it was outside this project scope and should not be considered further.

Full management was confirmed as the operational strategy for SH1 from Ngauranga to Aotea Quay.

12. Summary and Next Steps

12.1. Summary of Findings

12.1.1. Full Management

The section of SH1 between Ngauranga Gorge and Aotea Quay experiences high levels of congestion during both the AM and PM peaks, resulting in high levels of queuing and low traffic speeds along this section of SH1 and on the surrounding state highway and local road network. Based on the scoping stage assessments, engagement with the Traffic Operations Centre, key stakeholders, and the public survey, the problems with SH1 from Ngauranga to Aotea Quay can generally be described as congestion and travel time reliability.

To accommodate the forecast traffic flow, relieve congestion and improve travel time reliability, four lanes are required on SH1 from Ngauranga to Aotea Quay in each direction.

The option development and assessment process confirmed that it is feasible to provide four lanes in each direction on SH1 from Ngauranga to Aotea Quay. Through development and assessment of a corridor management framework and workshop with NZTA it was confirmed that the strategy for this stretch of SH1 is a fully-managed motorway.

The key principles behind the implementation of a fully managed system with four lanes in each direction are:

- Understanding network existing and future demands;
- Understanding network capacity and constraints;
- Providing the ability to maximise capacity and manage demand;
- Improving access to travel information;
- Improving the management of congestion and secondary incidents;
- Providing sufficient queue storage where on-ramp demand is restrained;
- Understanding the requirements and impact of broken down vehicles;
- Affording priority to special users;
- Understanding the safety, community, economic and operational priority for trip types, mode and access; and
- Developing and testing operational strategies.

The active traffic management of urban motorways requires a commitment to on-going operational efforts to manage and optimise the performance of the motorway. These operational efforts are central to sustaining and building upon the benefits achieved through the application of managed motorway tools.

12.1.2. Envelope of Considerations

When further developing the fully management system it should be assessed in terms of:

- Physical layout, including future capacity requirements, consent constraints, land availability, constructability and safety hazards;
- Enforcement and how this should be part of the operational strategy to enforce and develop a compliance culture for the Variable Mandatory Speed Limits;
- Operability including the level of complexity of the operational regimes required by each option;
- Education required for motorists to understand the operation of the system; and
- The amount of technology required to facilitate enforcement, operability and education.

These considerations are discussed further below.

12.1.3. Physical Considerations

There are two key parameters which define the physical envelope:

- Whether the four lanes are operated full time or part time; and
- Whether to provide minimal shoulders or full shoulders.

12.1.4. Operability

As discussed earlier, the processes for a fully-managed system will be complex and require a high level of trained operators and analysts. The system should run automatically with operators required to watch, respond and actively deal with unusual events and incidents. Analysts will require a higher level of training to analyse traffic flows, provide operational reports and optimise the ITS systems. A 24 hour traffic operations centre would be required to provide the optimum performance outcome.

12.1.5. Education and Enforcement

The implementation of a fully managed system will need to be supported by public education. As discussed earlier, the public survey indicated that:

- 40% of drivers do not understand the current signs;
- 25% of drivers believe other drivers need education; and
- 33% of drivers do not understand how NZTA operates the system.

As part of the Scheme Assessment stage, a public education strategy will be developed to help motorists understand the *how*, *why* and *what to do* in response to the operational regimes applied.

The Police stated that it is currently difficult to enforce the Variable Mandatory Speed Limits because if they pull a driver over for non-compliance the cost of the congestion caused by rubbernecking significantly outweighs the cost of the fine. The Police have stated that they will not enforce the Variable Mandatory Speed Limit using standard enforcement processes. The results of the Public Survey as outlined in Section 4.5 showed that 30% of respondents do not comply with the Mandatory Variable Speed Limits. The team has met with the Police and NZTA Lawyers to discuss in principal the use of digital cameras to enforce the Variable Mandatory Speed Limit. As part of the scheme assessment stage a concept design for enforcement will be prepared for discussion with the Police to confirm that it is enforceable and meets the current legislative framework, or if modifications are required. An MoU will be required for enforcement of the fully managed system.

12.1.6. Technology

Additional technology is required to implement full management. The existing speed management system has been reviewed and for each scenario the level of technology will be increased as appropriate to meet the operational requirements based on international best practice and to meet the educational and enforcement deficiencies of the existing system.

Additional gantries, variable message signs and speed control signs will be required. Section 6 of the Preliminary Design Philosophy Statement (**Appendix J**) discusses active traffic management system design standards and specifications. Further consideration and design of technology required to implement the fully-managed system will be undertaken in the scheme assessment stage.

12.1.7. Suboptions

A number of suboptions were developed to improve traffic flow through the study area as discussed in **Section 6**. These suboptions are to address three “root causes” which are not expected to be addressed by providing four lanes with full management on SH1. The three root causes are:

- Traffic merging from Hutt Road to SH2 at Ngauranga causes queuing on SH2 to regularly extend down SH1 to Aotea Quay and at times to the Terrace Tunnel;
- The rail level crossing on Waterloo Quay currently has four trains cross during the AM peak hour and this is expected to increase to eight trains. Frequently train drivers making the crossing stop

short and leave a carriage blocking Waterloo Quay. This has been observed to occur for up to ten minutes; and

- Lack of traveller information on the approach to the city northbound ramps and within the city to inform motorists of delays on the motorway. This traveller information could allow motorists to re-time their trip or take an alternative route.

These suboptions are discussed below.

SH2 Hutt Road Northbound On-Ramp

It has been observed that the SH2 Hutt Road northbound on-ramp at Ngauranga traffic dominates the SH1 / SH2 merge. In addition the on-ramp traffic peak finishes prior to the motorway traffic peak resulting in a large queue on the motorway with no queue on the ramp. This encourages traffic to avoid SH1 and use Hutt Road to access SH2 via the Hutt Road on-ramp to bypass the bottle neck created by the merge.

To address the merge capacity issue two options have been identified for further investigation as part of the Scheme Assessment phase. These options are:

a. Access Management

Access management using traffic signals that manage motorway traffic flows by metering the flow of traffic entering a motorway. The use of ramp signals is an effective means of managing and optimising the motorway flow to minimise the likelihood of traffic congestion and to provide stable and reliable travel. Being able to create stable traffic flows and improving merge conditions contributes to improved safety.

b. Split Two Lane On-ramp

This option would provide a two lane ramp where the first lane merges and the second lane is separated by a flush median which allows the second lane to merge approximately 200m downstream. The idea is that this on-ramp configuration splits the ramp load. However when the ramp is congested there is no operational control to manage the merge traffic.

Waterloo Rail Crossing

As part of the Scheme Assessment phase it is recommended that options are developed for improving the operability of the rail crossing to minimise its impact.

Traveller Information

As part of the Scheme Assessment phase it is recommended that a scheme for the introduction of Variable Message Signs be developed with Wellington City to provide traveller information within the city and at the on-ramp approaches. These signs could provide travel times and other motorway conditions information enabling motorists to make route choice decisions before entering the motorway.

12.1.8. Macroscope

On 16 December 2010, NZTA's Value Added Committee (VAC) met to discuss the macroscope definition of the Project. The VAC noted that the Project will be delivered in terms of how SH1 is operated rather than its physical characteristics. The Project macroscope was defined as:

"A preferred concept of operations (operational strategy)" which is:

- *Physically possible;*
- *Has an acceptable BCR; and*
- *No overall safety disbenefits.*

The scoping stage assessments have found that providing four lanes in each direction with full management meets the project objectives. Providing four lanes in each direction was found to be physically possible to construct and will provide overall safety benefits through a reduced hazard risk profile. Providing four lanes full time has an acceptable BCR (greater than 1) if a clip-on structure is used at Thorndon Overbridge. Running four lanes part time does not currently have an acceptable BCR. The costs and benefits of this scenario will be assessed further in the Scheme Assessment phase and when considered with the education, enforcement, and technology requirements will determine whether it becomes a viable option.

The preference is to construct a clip on structure at Thorndon Overbridge and not to replace the median. However it may be necessary to construct a separate structure for the fourth lane. While not replacing the central median is acceptable for the Project, NZTA network operations prefer to have the median replaced for maintenance reasons.

The Scoping Study has concluded that it is feasible to provide four lanes in each direction as a fully managed motorway.

12.2. Recommendations

It is recommended that a preferred scenario for implementing four lanes plus management, as well as potential phasing of options, is investigated further in the Scheme Assessment stage. The costs and benefits of running four lanes part time with full management will be assessed further in the scheme assessment phase and when considered with the education, enforcement, and technology requirements will determine whether it becomes a viable option.

It is also recommended that opportunities be sought to implement full management in stages. A staged approach will create the opportunity to realise early benefits. It will also create an opportunity to prove the concept of full management on three lanes before investing in four lanes.

12.3. Phasing and Next Steps

The assessments undertaken during the Scoping Stage indicate that the preferred strategy to operate SH1 between Ngauranga and Aotea Quay is a fully managed system. Analysis of current and forecast traffic volumes indicates that SH1 will need to be four lanes in each direction to accommodate projected traffic volumes and provide better travel time reliability. Further analysis will be undertaken at Scheme Assessment stage to demonstrate the improvements in reliability that will be achieved by the options. A number of options were developed that will satisfy the strategy of having four lanes in each direction with full management.

Following NZTA sign off of macroscope for four lanes in each direction with full management, the project will progress to the scheme assessment stage. During scheme assessment, a preferred option for implementing four lanes with full management will be confirmed. This will include further design and assessment of options for full time or part time management, full shoulders or minimal shoulders, a clip-on structure to the Thorndon Overbridge or a new standalone structure, and other project features. Further consultation will be undertaken with stakeholders during the scheme assessment phase.

The intention is to develop the preferred option and then consider potential phasing. Opportunities will be sought to implement full management in stages. A staged approach will create the opportunity to realise early benefits. It will also create an opportunity to prove the concept of full management on three lanes before investing in four lanes. The development of a phasing plan will be undertaken in the scheme assessment and will include the consideration of:

- Getting better use out of the existing ATMS system (including improving education and enforcement) before investing in four lanes;
- Timing of four laning between Ngauranga and Aotea Quay relative to the implementation of other RoNS schemes in Wellington such as Terrace Tunnel duplication;
- Whether the implementation of the “specific solutions” such as improvements to the northbound Hutt Road On-Ramp / SH2 merge will significantly delay the need to four lane between Ngauranga and Aotea Quay;
- The timing of potential improvements to the Interislander terminal and the impact it will have on choosing between a clip on or separate structure for Thorndon Overbridge;
- Whether to implement four laning in one direction first (i.e. northbound four lanes and southbound three lanes for an interim period);
- Improvement in journey time reliability to be obtained;
- Cashflow for the Wellington RoNS; and

- Economic efficiency.

Following the completion of the Scheme Assessment the Project will move into the specimen design phase of a preferred option.

Providing four lanes in each direction with full management is:

- ***Physically possible;***
- ***Has an acceptable BCR; and***
- ***Has no overall safety disbenefits.***

During Scheme Assessment, a preferred option for implementing four lanes with full management will be confirmed.

Appendix A

NZTA VAC Paper

NZ TRANSPORT AGENCY
WAKA KOTAHI

VAC Paper

To	Value Added Committee
Date of Meeting	16th December 2010
From	Hannah Hyde
Date Prepared	3rd December 2010
Endorsed By	Wellington State Highway DMT
Subject	Ngauranga to Aotea Quay: Wellington Active Traffic Management (NtAQ) Macroscope Definition Approval

Purpose

The purpose of this paper is to:

- Gain VAC approval for the proposed definition of macroscope for this project

Recommendations

It is recommended that the VAC:

- Agrees macroscope definition for NtAQ

Specialist subject matters covered

Traffic operations

Gateway approvals

Discussion

Ngauranga to Aotea Quay: Wellington Active Traffic Management project (NtAQ) will be developed in terms of how we operate the road rather than its physical characteristics.

For a 'normal' project the means of achieving the additional capacity between points a and b may be to build an extra lane or a new road and hence the macroscope is defined in terms of these physical characteristics. The means of achieving the additional capacity between Ngauranga and Aotea Quay is likely to be achieved through how we operate the road. This management of the road corridor will be influenced by, and an influencer on, the physical characteristics, but the operation of it will achieve the objectives. As such, it is necessary to define what macroscope means in these terms. It is therefore proposed that, for this project, macroscope is defined as:

"a preferred concept of operations (operational strategy)"[1]

It is further proposed that the macroscope be submitted for approval when we know that it:

- **will be physically possible,**
- **has an acceptable BCR and**

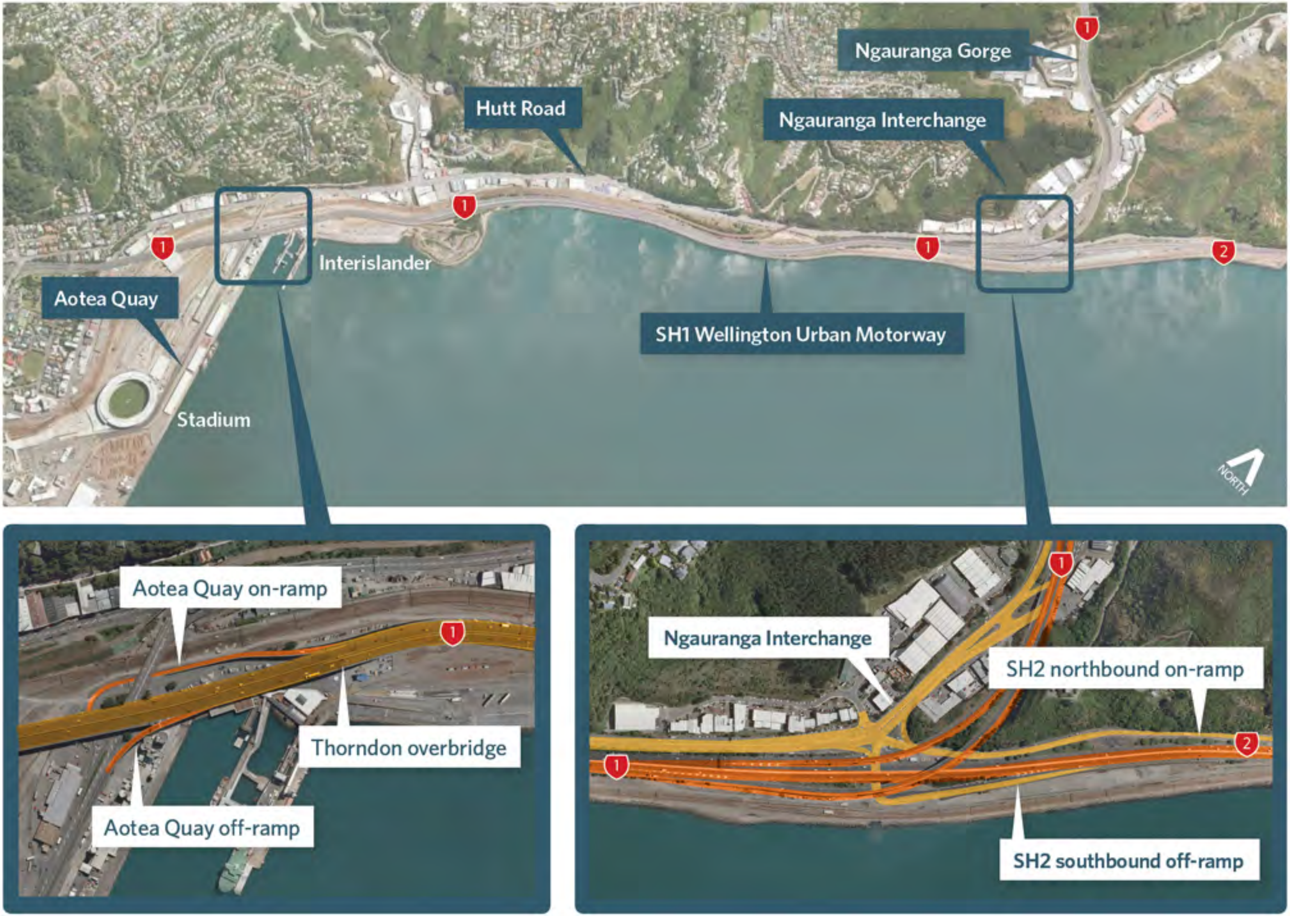
[1] See VAC paper regarding Operational Regimes submitted for consideration at the same meeting

	○ **no overall safety disbenefits**[2]
Consultation	**Project Overview & Scope & Standards** A project overview with recommended scope and standards to be adopted on the project was presented to VAC on the 13th May 2010. VAC meeting minutes confirms standards to be adopted and also notes macroscope will be presented to VAC for approval during SP1. **Macroscope Definition** Hannah Hyde met with Roly Frost (acting VAC chair) on 22 October 2010 and discussed and agreed in principal the definition of macroscope for NtAQ. Wellington State Highway DMT agreed this macroscope definition on 2nd December 2010.
Attachments	○ WSHDMT minutes 2nd December 2010
Supporting Documents	○ None
Key considerations	Macroscope definition, in terms of the physical configuration of a project, is not suitable for a project that addresses how the road is to be operated. As such, a more appropriate definition is required for this operational project.

[2] See VAC paper regarding Safety Management System and safety objective submitted for consideration at the same meeting

Appendix B

Project Study Area


Ngauranga Gorge
Hutt Road
Ngauranga Interchange
Interislander
Aotea Quay
SH1 Wellington Urban Motorway
Stadium
NORTH
Aotea Quay on-ramp
Thorndon overbridge
Aotea Quay off-ramp
Ngauranga Interchange
SH2 northbound on-ramp
SH2 southbound off-ramp

Appendix C

Modelled Traffic Volumes

Location: State Highway 1 between Ngauranga & Aotea Quay	Actual Flow (total vehicles) AM	Actual Flow (total vehicles) PM	Actual Flow (total vehicles) AADT	Demand Flow (total vehicles) AM	Demand Flow (total vehicles) PM	Demand Flow (total vehicles) AADT
Inbound to CBD						
2009 - Base Year	5,372	3,563	46,343	7,689	3,563	50,977
2016 Do Minimum	5,306	3,840	47,975	7,984	3,840	53,331
2016 Option 1 - Improve Existing ATMS	5,305	3,840	48,141	8,059	3,840	53,647
2016 Option 2 - Hard Shoulder Running	5,306	3,837	48,137	8,171	3,837	53,867
2016 Option 3 - Controlled All Lane Running	5,842	3,873	49,497	8,246	3,873	54,305
2016 Option 4 (and Option 5) - Four Lanes plus Shoulders	5,854	3,876	49,539	8,265	3,876	54,361
2026 Do Minimum	5,207	4,086	52,043	9,238	4,480	64,873
2026 Option 1 - Improve Existing ATMS	5,217	4,129	56,603	9,449	4,527	65,862
2026 Option 2 - Hard Shoulder Running	5,216	4,120	56,583	9,535	4,520	66,020
2026 Option 3 - Controlled All Lane Running	5,679	4,159	58,062	9,624	4,559	66,753
2026 Option 4 (and Option 5) - Four Lanes plus Shoulders	5,692	4,171	58,130	9,645	4,573	66,840
Outbound from CBD						
2009 - Base Year	2,713	4,922	41,669	3,105	5,248	43,450
2016 Do Minimum	2,821	4,938	42,810	3,374	5,434	45,441
2016 Option 1 - Improve Existing ATMS	2,826	5,034	43,144	3,389	5,553	45,858
2016 Option 2 - Hard Shoulder Running	2,835	5,085	43,267	3,399	5,628	46,028
2016 Option 3 - Controlled All Lane Running	2,707	5,096	43,464	3,424	5,637	46,197
2016 Option 4 (and Option 5) - Four Lanes plus Shoulders	2,865	5,104	43,505	3,426	5,646	46,253
2026 Do Minimum	2,989	5,172	47,251	3,741	6,151	51,808
2026 Option 1 - Improve Existing ATMS	2,997	5,191	47,916	3,764	6,285	52,760
2026 Option 2 - Hard Shoulder Running	3,013	5,351	48,267	3,784	6,429	53,090
2026 Option 3 - Controlled All Lane Running	3,022	5,341	49,279	3,795	6,449	54,207
2026 Option 4 (and Option 5) - Four Lanes plus Shoulders	3,027	5,371	49,448	3,802	6,472	54,350

Appendix D

High Level Hazard Log

Assessment of NZ Hazard Logs proformance against Blue Sky Options

		Abnormal/hazardous loads	Escorted Convoys	Opening or closing shoulder	Opening or closing shoulder	MM Operational	MM Operational	Emergency Stopping Bays	Emergency Stopping Bays	MM Comprehension/Confusion	Maintenance	Maintenance	System glitches	System glitches	Debris	Fatigue	Losing control on shoulders	Auth. Persons on carriageway	Auth. persons on carriageway	Driving too fast	Driving too fast	Slow vehicle in running lane	Environmental conditions	Environmental conditions	Motorcyclists in traffic	Motorcyclists on shoulder	Pedestrians in running lane	Pedestrians on ramps / shoulders	On-ramps & Off-ramps	Terrorism and vandalism	Infrastructure Collapse	Behaviour at lane closures	Unsafe Lane changing	Excessive Lane merging	Speed camera flash unit	Health of occupant	Rubber-necking	Stationary traffic at exit point	Tailgating	Vehicle rejoins running lane	Merging and Diverging	Illegal manoeveures (reversing)	Driving in wrong direction	Vehicles obstructing lanes	Vehicles obstructing lanes	Change in vehicle speed	Vehicle drifts off carriageway	Stop on closed shoulder	Intersections	Private Property Access	Cyclist in traffic	Hazards Addressed by Option
		NZ01E	NZ01S	NZ02E	NZ02S	NZ03E	NZ03S	NZ04E	NZ04S	NZ05E	NZ06E	NZ06S	NZ07E	NZ07S	NZ08S	NZ09E	NZ10E	NZ11E	NZ11S	NZ12E	NZ12S	NZ13S	NZ14E	NZ14S	NZ15E	NZ15S	NZ16E	NZ16S	NZ17E	NZ18E	NZ19E	NZ20E	NZ21E	NZ21S	NZ22S	NZ23E	NZ24S	NZ25S	NZ26S	NZ27E	NZ28E	NZ29E	NZ29S	NZ30E	NZ30S	NZ31E	NZ32E	NZ33S	NZ34E	NZ35E	NZ36E	
1	Do Nothing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Improve Existing ATMS	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	(1)	0	0	1	1	(1)	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	15
3	Reconfigure Nguaranga Merge/Diverge	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	5
4	SH1 to SH2 Merge (North of Project Area)	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8
5	SH1-CRS safety improvements on existing road	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	7
6	Ramp Signaling & On-Ramp Improvements	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	9
7	Driver information in Wellington City	1	1	1	1	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10
8	Hard Shoulder Running	1	1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	1	1	1	1	(1)	0	(1)	1	1	1	1	1	1	1	1	1	1	0	0	(1)	0	(1)	1	1	(1)	0	0	0	1	(1)	1	0	0	0	0	1	0	(1)	0	0	0	7
9	CALR	0	0	0	0	(1)	(1)	(1)	(1)	0	1	1	1	1	(1)	0	1	1	1	(1)	(1)	1	1	1	1	1	1	0	0	(1)	0	(1)	1	1	(1)	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	8
10	Build 4 Lanes with Shoulders	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	(1)	0	0	1	1	0	0	0	1	1	0	(1)	0	0	0	0	0	1	0	0	0	0	1	(1)	1	0	0	0	0	1	0	1	0	0	0	11
11	4 Lane South - 3 Lane North	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	(1)	0	0	1	1	0	0	0	1	1	0	(1)	0	0	0	0	0	1	0	0	0	0	1	(1)	1	0	0	0	0	1	0	1	0	0	0	11
12	3 Lane South - 4 Lane North	1	1	0	0	0	0	0	0	0	1	1	0	0	1	0	(1)	0	0	1	1	0	0	0	1	1	0	(1)	0	0	0	0	0	1	0	0	0	0	1	(1)	1	0	0	0	0	1	0	1	0	0	0	11
13	Hutt Road Tidal Flow (1-W)	(1)	(1)	0	0	0	0	0	0	0	0	0	(1)	(1)	(1)	0	0	(1)	(1)	0	0	0	(1)	(1)	0	0	0	0	0	0	0	(1)	0	0	0	0	0	0	(1)	0	(1)	0	0	0	0	0	0	0	(1)	(1)	(1)	(15)
14	Hutt Road Tidal Flow (2-W, 3-I)	0	0	0	0	0	0	0	0	0	0	0	(1)	(1)	(1)	0	0	(1)	(1)	0	0	0	(1)	(1)	0	0	0	0	0	0	0	(1)	0	(1)	0	0	0	0	1	0	(1)	0	0	0	0	0	0	0	(1)	(1)	(1)	(12)
15	Existing Main Carriageway Tidal Flow	0	0	0	0	(1)	(1)	0	0	0	(1)	(1)	(1)	(1)	(1)	0	0	(1)	(1)	(1)	(1)	1	0	0	0	1	1	0	0	0	0	0	0	(1)	0	0	(1)	0	(1)	0	1	0	0	0	0	1	0	0	0	0	0	(9)
16	2 Lane Aotea Off-ramp	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	6
17	Improve Access to Ferry Terminal	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	(1)	0	0	1	0	0	0	0	0	4
18	Aotea Quay Off-Ramp Improvements	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	(1)	0	0	0	1	0	0	0	0	0	5
19	Remove Aotea Quay Ramps Completely	(1)	(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	(1)	0	0	0	0	0	0	0	(1)	0	0	0	0	0	(2)
20	Use existing Lane to Create Priority Lane	1	1	0	0	0	(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)	(1)	(1)	0	0	0	0	(1)	0	0	0	0	0	0	0	0	0	0	0	0	(3)
21	Create new Special Vehicle Lanes	1	0	0	0	0	(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	(1)	(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)
22	Park & Ride	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Additional Ramps at Thorndon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(1)	0	0	0	(1)	(1)	0	0	0	1	0	0	0	(1)	(1)	0	0	(1)	0	0	0	0	0	(5)
24	Congestion Charging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	Upgrade Hutt Road/Ngauranga Intersection	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	8
		11	10	1	0	(3)	(5)	(2)	(2)	4	7	7	0	0	(1)	0	(3)	0	0	7	7	6	1	1	5	6	4	(3)	7	(3)	0	(5)	2	2	(3)	0	2	4	3	(4)	10	(2)	(2)	0	0	10	1	3	(1)	(2)	(2)	

Appendix E

Analysis of Root Causes

Issues and Root Cause Identification

Key Issue	Item	Issues	Root Cause	Associated Objectives	Operational Requirements	Themes	Constraints	Impacts	Comments	How can the Operational requirement be realised
Yes	1	Queuing can occur at the SH1/SH2 merge during the AM peak	SH 2 Hutt Road On-ramp merge dominance	Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions.	Control Traffic Speeds	Existing VMS sign is not appropriately located to inform road users at an appropriate distance from the back of the queue		Extensive queuing occurs on SH1 and SH2 upstream of the Ngauranga interchange. Existing Mandatory speed limit signage on SH1 and overhead VMS on SH2 north of Ngauranga interchange.	Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Reduce congestion	Increase capacity	Provide Additional Capacity	Determine level of capacity required to meet future operational needs			Provide additional capacity
				Customer First	Inform road users of queues	Inform Roads Users				Provide Information to users in advance of queue
Yes	2	Queuing can occur on Aotea Quay and create queues on motorway	Poor geometry of the Aotea Quay Off-ramp, and trains crossing Aotea Quay and lack of strategic optimisation of the Aotea Quay traffic signals	Safety	Inform road users of queues	Inform Roads Users				Provide information to users in advance of queue
				Reduce congestion	Control trains or grade separate crossing Aotea Quay to optimise off-ramp capacity	Optimise Local Road Network			Confirm operational requirements for Ontrack trains	Agreed Operational protocol with WCC and Ontrack to optimise local road network
Yes	3	Aotea Quay off-ramp is likely to become saturated at peak times in the future	Lack of capacity of the Aotea Quay off-ramp to accommodated current and future traffic demand flows	Reduce congestion	Additional capacity is required in the future	Provide Additional Capacity	Determine level of capacity required to meet future operational needs and requirements of the Wellington City local road network and Port operation			Provide additional capacity.
Yes	4	Geometrics and sight distance at Aotea Quay off-ramp requires vehicles to slow drastically	Poor geometry of the Aotea Quay Off-ramp	Safety	Reconstruct off-ramp	Reconstruct				Reconstruct off ramp to meet current standards
Yes	5	Queuing can occur at the Aotea Quay off-ramp during the AM peak (Results in late lane changes)	Poor geometry of the Aotea Quay Off-ramp, and trains crossing Aotea Quay and lack of strategic optimisation of the Wellington City Traffic Signal associated with Aotea Quay	Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions.	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Roads Users				Provide Information to users in advance of queue
Yes	6	Queuing can occur at the Murphy Street off-ramp during the AM peak (Results in late lane changes)	Lack of strategic optimisation of the Wellington Road Network	Reduce congestion	Optimise arterial traffic signals to improve off-ramp capacity	Optimise Local Road Network	Determine level of capacity required to meet future operational needs and requirements of the Wellington City local road network	Weaving and congestion occurs		Agreed Operational protocol with WCC to optimise local road network
				Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions.	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Roads Users				Provide information to users in advance of queue
Yes	7	Aotea Quay on-ramp suffers from merge dominance during the PM peak	Aotea Quay On-ramp merge dominance	Reduce congestion	Control access at on-ramp	Control Access		Weaving and congestion occurs		Control On-ramp traffic flows during peak flows condition to address flow breakdown
				Reduce congestion	Increase capacity	Provide Additional Capacity	Determine level of capacity required to meet future operational needs			Provide additional capacity
				Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions.	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Roads Users				Provide information to users in advance of queue

Issues and Root Cause Identification

Key Issue	Item	Issues	Root Cause	Associated Objectives	Operational Requirements	Themes	Constraints	Impacts	Comments	How can the Operational requirement be realised
Yes	8	SH2 Hutt Road on-ramp Northbound suffers from merge dominance during the PM peak	SH 2 Hutt Road On-ramp merge dominance	Reduce congestion	Control the access of traffic from the on-ramp joining the main carriageway	Control Access	The layout of SH1/SH2 south diverge is not optimal if queue extends back	Weaving and congestion occurs		Control On-ramp traffic flows during peak flows condition to address flow breakdown
				Reduce Congestion	Increase capacity	Provide Additional Capacity	Determine level of capacity required to meet future operational needs			Provide additional capacity
				Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions.	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Roads Users				Provide information to users in advance of queue
	9	Queuing and poor lane behaviour (weave) can occur at the SH1 Hutt Road on-ramp Northbound during the PM peak	SH 2 Hutt Road On-ramp merge dominance	Reduce congestion	Control access at on-ramp	Control Access		Weaving and congestion occurs		Control On-ramp traffic flows during peak flows condition to address flow breakdown and poor lane behaviour
				Safety	Control traffic speeds approaching the queues to reduce impact/likelihood of collisions. Restrict ability to merge early	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Roads Users				Provide information to users in advance of queue
Yes	10	During peak periods flows breakdown occurs in the existing three lanes	Southbound - Poor geometry of the Aotea Quay Off-ramp, and trains crossing Aotea Quay and lack of strategic optimisation of the Wellington City Traffic Signal associated with Aotea Quay and Murphy Street Northbound - SH 2 Hutt Road On-ramp merge dominance	Reduce congestion	Control traffic speeds to reduce flow breakdown	Control Traffic Speeds		Unnecessary lane changing and congestion occurs		Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Reduce congestion	Additional capacity is required	Provide Additional Capacity	Determine level of capacity required to meet future operational needs			Provide additional capacity
				Safety	Control traffic speeds	Control Traffic Speeds		Weaving and congestion occurs		Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
Yes	11	Differential lane speeds	Southbound - Poor geometry of the Aotea Quay Off-ramp, and trains crossing Aotea Quay and lack of strategic optimisation of the Wellington City Traffic Signal associated with Aotea Quay and Murphy Street Northbound - SH 2 Hutt Road On-ramp merge dominance	Safety	Control traffic speeds	Control Traffic Speeds		Unnecessary lane changing and congestion occurs		Display and enforce mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Customer First	Inform road users of queues	Inform Road Users				Provide Information to users on problem ahead
Yes	12	Incidents occur within running lanes	Associated with all Root Causes	Safety	Control traffic speeds approaching incidents to reduce impact / likelihood of collisions	Control Traffic Speeds				Display mandatory speed limits to road users, which can be varied according to the prevailing conditions
				Safety	Control lane availability to protect incidents	Control Lane Use				Convey lane use to road users. Consider ERAs and use of shoulders
				Customer First	Inform road users of incidents	Inform Roads Users	Existing VMS sign is not appropriately located to inform road users at an appropriate distance from the incident			Provide information to users in advance of incident. Determine and implement diversion plans in the event of an incident. Provide information to captured vehicles
				Journey Efficiency	Control lane availability to provide an appropriate level of capacity	Control Lane Use				Provide sufficient lanes to meet operation traffic flows

Issues and Root Cause Identification

Key Issue	Item	Issues	Root Cause	Associated Objectives	Operational Requirements	Themes	Constraints	Impacts	Comments	How can the Operational requirement be realised
Yes	13	Poor Geometry (lack of sight distance, causing slowing, incidents)	Associated with all Root Causes	Safety	Appropriate geometric alignment is required	Geometric Alignment to Meet Standard				Geometric design improvements or control speed
	14	Hutt Road / Ngauranga Intersection and Interfaces	Hutt Road off-ramp capacity deficiency	Reduce congestion	Additional capacity is required	Provide Additional Capacity	Determine level of capacity required to meet future operational needs			Provide additional capacity
				Reduce congestion	Optimise traffic signals to improve off-ramp capacity	Optimise Local Road Network	Determine level of capacity required to meet future operational needs and requirements of the Wellington City local road network		Manage the intersection off-ramp approach queue	Agreed Operational protocol with WCC to optimise local road network
Yes	15	Traffic projections indicates that current corridor capacity is insufficient		Reduce congestion	Additional capacity is required in the future	Provide Additional Capacity				Provide additional capacity in terms of one extra lane during peak traffic flow direction

Appendix F

Blue Sky Workshop Ideas

Appendix F Blue Sky Workshop Ideas

Long list of 55 options initially tabled at the Blue Sky Workshop

1. Ngauranga Station, Story Park and Ride, Free Trains, Comparative JTR on highway Sagas. (+ possible Hutt Road Bus Way)
2. Pay people not to travel in Peak (Netherlands), or congestion charge
3. Provide a new Thorndon Quay off ramp and on ramp (with ramp signalling)
4. Build new lanes in both directions (Possible toll / Bull lane / HOT lanes?)
5. Tidal by 3000 uph am / 2000 uph pm (Demand)
6. Screen the harbour view to reduce distraction
7. Provide 2 Lane off ramp to Aotea Quay, stack traffic on Aotea Quay
8. Make Hutt Road one way in the am/pm
9. Make Aotea Quay Ramp for Thorndon local traffic only
10. Ramp signalling
11. HCV Lane
12. Use existing shoulders as 4^{th} lane
13. Realign the Aotea Quay off ramp
14. Re-allocate lane space at the merge
15. Single lane from SH1 off ramp down to merge
16. Reconfigure the SH1 and SH2 merges
17. Better driver information in the city
18. Radical use of lanes during incidents
19. Review peak period responses (breakdowns)
20. Provide incentives for Kiwirail not to use crossing during peaks
21. Change access to ferry
22. Build more lanes on SH1
23. Build the interchange north of Aotea Quay that never was
24. Tidal flow
25. Use Thorndon Quay as on/off ramp
26. Dual off ramp at Aotea Quay
27. Build Petone to Grenada project
28. Tunnel
29. Piling
30. Two lane on ramp at Aotea Quay
31. Hard Shoulder Running (HSR) – with ATMS
32. Controlled All Lane Running (CALR)
33. Permanent 4 lanes south, 3 lanes north
34. Rail – use Burma Road
35. Dedicated lanes / physical separation – control weaving
36. Improve SH2 on/off ramps at Ngauranga
37. Road user rail or vice versa for length
38. New off ramps in Aotea and Thorndon Quay and possibly more
39. Move ferry terminal
40. One way circulation using Aotea, Thorndon and Hutt Road

41. Narrow median barriers
42. Remove barriers and lower speed limit
43. Travel time information on local roads /at people's desktop
44. Ramp metering – Aotea Quay on ramp, SH2 northbound at Ngauranga on ramp
45. Floating highway across harbour
46. Demolish Thorndon Overbridge and provide grade separated rail
47. Pay people to use public transport
48. Tolls and/or city cordons and charges
49. SH2 reduced to one lane before merge with SH1
50. Tidal flow with a moveable barrier
51. Upgrade the speed limit
52. HOV lanes
53. Provide a two lane off ramp at Aotea Quay with metering on Hutt Road to Aotea
54. Full length tunnel connection to the port
55. Encourage:
    - Greater use of Hutt Road
    - Advertising
    - Move Aotea on ramp 3km north
    - Free flow of traffic at either end (removing traffic lights)

Table i - 55 Ideas to 25 Options for Option Definition Workshop

Blue Sky Idea	Comments	Resulting Option for Definition Workshop
1. Ngauranga Station, Park and Ride, Free Trains, Comparative JTR on highway Sagas. (+ possible Hutt Road Bus Way)	Take forward to Option Definition Workshop	Option 22: Park and Ride
2. Pay people not to travel in Peak (Netherlands), or congestion charge	Take forward to Option Definition Workshop	Option 24: Congestion Charging
3. Provide a new Thorndon Quay off ramp and on ramp (with ramp signalling)	Take forward to Option Definition Workshop	Option 23: Additional Ramps at Thorndon Quay
4. Build new lanes in both directions (Possible toll / Bull lane / HOT lanes?)	Take forward to Option Definition Workshop. Forms part of two options.	Option 10: Build Four Lanes Option 21: Create New Special Vehicle Lanes
5. Tidal by 3000 uph am / 2000 uph pm (Demand)	Take forward to Option Definition Workshop. Consider both on SH1 and Hutt Road.	Option 13: Tidal Flow on Motorway Option 14: Hutt Road Tidal Flow in One Direction Option 15: Hutt Road Tidal Flow (1 Lane Non –Peak and 3 Lanes Peak Direction)
6. Screen the harbour view to reduce distraction	Not considered practical.	Not taken forward to Option Definition Workshop
7. Provide 2 Lane off ramp to Aotea Quay, stack traffic on Aotea Quay	Take forward to Option Definition Workshop	Option 16: Two Lane Aotea Quay Off Ramp
8. Make Hutt Road one way in the am/pm	Take forward to Option Definition Workshop	Option 14: Hutt Road Tidal Flow in One Direction
9. Make Aotea Quay Ramp for Thorndon local traffic only	Not considered practical.	Not taken forward to Option Definition Workshop
10. Ramp signalling	Included in other options	Included in other options
11. HCV Lane	Take forward to Option Definition Workshop. Forms	Option 20: Use Existing Lanes to Create Priority Lanes

Blue Sky Idea	Comments	Resulting Option for Definition Workshop
	part of two options.	Option 21: Create New Special Vehicle Lanes
12. Use existing shoulders as 4th lane	Taken forward as Hard Shoulder Running (HSR)	Option 8: Hard Shoulder Running
13. Realign the Aotea Quay off ramp	Take forward to Option Definition Workshop	Option 18: Aotea Quay Off Ramp Improvements
14. Re-allocate lane space at the merge	Take forward to Option Definition Workshop	Option 3: Reconfigure Ngauranga Merge/Diverge
15. Single lane from SH1 off ramp down to merge	Combine with Idea 14	Option 3: Reconfigure Ngauranga Merge/Diverge
16. Reconfigure the SH1 and SH2 merges	Combine with Idea 14	Option 3: Reconfigure Ngauranga Merge/Diverge
17. Better driver information in the city	Take forward to Option Definition Workshop	Option 7: Driver Information in Wellington City
18. Radical use of lanes during incidents	Included in other options such as HSR, CALR, and improving existing system	Option 2: Improve Existing ATMS Option 8: Hard Shoulder Running Option 9: Controlled All Lane Running
19. Review peak period responses (breakdowns)	Considered to be part of improving existing ATMS system.	Option 2: Improve Existing ATMS
20. Provide incentives for Kiwirail not to use crossing during peaks	Not considered feasible as outside the immediate control of NZTA.	Not taken forward to Option Definition Workshop
21. Change access to ferry	Take forward to Option Definition Workshop	Option 17: Improve Access to Ferry Terminal
22. Build more lanes on SH1	Combined with other options which involved additional lanes	Combined with other options which involved additional lanes
23. Build the interchange north of Aotea Quay that never was	Not considered feasible	Not taken forward to Option Definition Workshop

Blue Sky Idea	Comments	Resulting Option for Definition Workshop
24. Tidal flow	Similar to idea 5.	Option 13: Tidal Flow on Motorway Option 14: Hutt Road Tidal Flow in One Direction Option 15: Hutt Road Tidal Flow (1 Lane Non –Peak and 3 Lanes Peak Direction)
25. Use Thorndon Quay as on/off ramp	Take forward to Option Definition Workshop	Option 23: Additional Ramps at Thorndon Quay
26. Dual off ramp at Aotea Quay	2 lane off ramp	Option 16: Two Lane Aotea Quay Off Ramp
27. Build Petone to Grenada project	Outside project area	Not taken forward to Option Definition Workshop
28. Tunnel	Not considered practical	Not taken forward to Option Definition Workshop
29. Piling	Design consideration for other options.	Not taken forward to Option Definition Workshop
30. Two lane on ramp at Aotea Quay	Considered part of on ramp improvements	Option 6: On Ramp Improvements
31. Hard Shoulder Running (HSR) – with ATMS	Take forward to Option Definition Workshop	Option 8: Hard Shoulder Running
32. Controlled All Lane Running (CALR)	Take forward to Option Definition Workshop	Option 9: Controlled All Lane Running
33. Permanent 4 lanes south, 3 lanes north	Taken forward as two options: 4 lanes southbound 3 lanes northbound and vice versa	Option 11: 4 Lanes South 3 Lanes North Option 12: 3 Lanes South 4 Lanes North
34. Rail – use Burma Road	Rail improvements considered outside project	Not taken forward to Option Definition Workshop
35. Dedicated lanes / physical separation – control weaving	Considered part of improvements to merging	Option 3: Reconfigure Ngauranga Merge/Diverge
36. Improve SH2 on/off ramps at Ngauranga	Considered part of Ngauranga Intersection	Option 25: Upgrade Hutt Road / Ngauranga Intersection

Blue Sky Idea	Comments	Resulting Option for Definition Workshop
37. Road user rail or vice versa for length	PT improvements considered to be part of park and ride option	Option 22: Park and Ride
38. New off ramps in Aotea and Thorndon Quay and possibly more	Considered part of additional Thorndon ramps	Option 23: Additional Ramps at Thorndon Quay
39. Move ferry terminal	Not considered practical. Improved access considered as part of Option 17	Not taken forward to Option Definition Workshop
40. One way circulation using Aotea, Thorndon and Hutt Road	Not considered feasible	Not taken forward to Option Definition Workshop
41. Narrow median barriers	Design consideration for other options.	Not taken forward to Option Definition Workshop
42. Remove barriers and lower speed limit	Design consideration for other options.	Not taken forward to Option Definition Workshop
43. Travel time information on local roads /at people's desktop	Same as idea 17.	Option 7: Driver Information in Wellington City
44. Ramp metering – Aotea Quay on ramp, SH2 northbound at Ngauranga on ramp	Included as part of these other options.	Option 4: SH2 Hutt Road On Ramp merge Northbound Option 6: On-Ramp Improvements
45. Floating highway across harbour	Not considered feasible	Not taken forward to Option Definition Workshop
46. Demolish Thorndon Overbridge and provide grade separated rail	Not considered feasible	Not taken forward to Option Definition Workshop
47. Pay people to use public transport	Not considered feasible	Not taken forward to Option Definition Workshop
48. Tolls and/or city cordons and charges	Considered same as congestion charging	Option 24: Congestion Charging
49. SH2 reduced to one lane before merge with SH1	Considered part of other options	Option 3: Reconfigure Ngauranga Merge/Diverge Option 25: Upgrade Hutt Road / Ngauranga Intersection
50. Tidal flow with a moveable	Tidal flow same as idea 5.	Option 13: Tidal Flow on

Blue Sky Idea	Comments	Resulting Option for Definition Workshop
barrier	Moveable barrier is a design consideration	Motorway
51. Upgrade the speed limit	Speed management considered part of improving existing ATMS	Option 2: Improve Existing ATMS
52. HOV lanes	Same as special vehicle lanes	Option 20: Use Existing Lanes to Create Priority Lanes Option 21: Create New Special Vehicle Lanes
53. Provide a two lane off ramp at Aotea Quay with metering on Hutt Road to Aotea	Take forward to Option Definition Workshop	Option 16: Two Lane Aotea Quay Off Ramp
54. Full length tunnel connection to the port	Not considered feasible	Not taken forward to Option Definition Workshop
55. Encourage: ▪ Greater use of Hutt Road ▪ Advertising ▪ Move Aotea on ramp 3km north ▪ Free flow of traffic at either end (removing traffic lights)	Ideas taken forward to Option Definition Workshop as several options.	Option 14: Hutt Road Tidal Flow in One Direction Option 15: Hutt Road Tidal Flow (1 Lane Non –Peak and 3 Lanes Peak Direction) Option 16: Two Lane Aotea Quay Off Ramp Option 7: Driver Information in Wellington City Option 19: Remove the Aotea Quay Ramps Completely. Option 23: Additional Ramps at Thorndon Quay Option 25: Upgrade Hutt Road / Ngauranga Intersection

Appendix G

25 Options from Option Development Workshop

Appendix G - List of 25 Concepts Derived from Option Development Workshop

Options	Name	Description
Option 1	Do Nothing	No addition works
Option 2	Improve Existing ATMS	This option in concept would include Active Traffic Management interventions to address the issue identified. These interventions could be: ■ Automatic Queue Detection and Signals – This is provided through a Motorway Incident Detection and Automatic Signalling (MIDAS) system. The MIDAS system would set signals automatically to display advisory speed limits together with supplementary text messages such as "QUEUE AHEAD"; ■ Variable Mandatory Speed Limits – This system is designed to minimise the risk of flow breakdown and reduce accident by setting mandatory speed limits automatically using traffic data from the DYNAC loops and radars; ■ Lane Specific Speed Limits – This option would see the use of gantry signage to enable different speed limits to be set across different lanes of the motorway with the aim of improving vehicle throughput and safety; ■ Advance Driver Information - Additional Variable Message Signs (VMS) on each gantry to provide information to driver to explain or reinforcing the lower mandatory speed limit, additional gantries to provide a greater level of inter-visibility between gantries. The aim would be to provide a greater level of lane control, speed enforcement and traveller information; and ■ Enforcement - This option may include electronic speed enforcement to increase the compliance of the lower variable mandatory speed limits.
Option 3	Reconfigure Ngauranga Merge/Diverge	This option in concept would look to extend and remark the merge to provide a greater level of priority. The diverge would be extended using an auxiliary lane to allow traffic destined for SH1 to bypass the queue extending back from the Hutt Road On-ramp merge during the PM peak.
Option 4	SH2 Hutt Road On Ramp merge Northbound	This option would either extending the Hutt Road northbound on ramp merge using an auxiliary lane or installing ramp signals to improve the merge capacity, safety and trip reliability.
Option 5	Safety Improvements on Existing Road	Implementation of Crash Reduction Study recommendation within the project area.
Option 6	On-Ramp Improvements	This option is focused on Aotea Quay on ramp. This option would either extending on ramp merge using an auxiliary lane or installing ramp signals to improve the merge capacity, safety and trip reliability. If ramp signal were installed additional ramps signals maybe investigated at Tinakori Road and May Street on ramps to better manage the on ramp operations during peak operations.
Option 7	Driver Information in Wellington City	In concept this option would provide VMS on Wellington Road Network at strategic location so information on State Highway network incidents and performance can be displayed to road users in order for them to be better informed before accessing

		the State Highway network. This would allow motorist to make alternative route chooses or re-time their trips to avoid congestion points.
Option 8	Hard Shoulder Running	This option would permit motorist to use the hard shoulder of the motorway as a running lane at times of high congestion by message signs and lane control unit installed above the carriageway. A speed limit would be introduced across all lanes of the motorway direction and displayed by lane control units above each lane including the hard shoulder. At times when the hard shoulder is not in operation the overhead lane control unit would display a red "X" and mandatory variable speed limits would be in force across the other lanes. This option would require the shoulder to be widened to 3.5m in both directions from the Ngauranga merge/diverge to the Aotea Quay ramps. In addition the following technology would be required: ■ CCTV; ■ Automatic Stopped Vehicle Detection; ■ Automatic Queue Detection and Signalling; ■ Variable Message Signs; ■ Lane Control Units; and Digital Speed Enforcement Cameras. This option may also include emergency refuge areas placed at regular interval, to provide a safe place to stop away from the traffic while the hard shoulder is open to traffic.
Option 9	Controlled All Lane Running	The concept of this option is to make use of the full width of the motorway, thus no shoulder would be provided with this option. This option would widen the carriageway to provide four lanes in both directions from the Ngauranga merge/diverge to the Aotea Quay ramps. Lanes would be electronically controlled with Lane Control Signs to display mandatory variable speed limits and lane control information showing if the lane is open or closed. Addition VMS sign would be provide to increase information to the road users. This option may also include emergency refuge areas placed at regular interval, to provide a safe place to stop away from the traffic while the hard shoulder is open to traffic.
Option 10	Build Four Lanes	Build four lane in each direction from the Ngauranga merge/diverge to the Aotea Quay ramps with a 2.5 metre minimum shoulder. Existing ATMS would be retained
Option 11	4 Lanes South and 3 Lanes North	Build four lane in a southbound direction from the Ngauranga merge/diverge to the Aotea Quay ramps with a 2.5 metre minimum shoulder. Existing ATMS would be retained
Option 12	3 Lanes South and 4 Lanes North	Build four lane in a northbound direction from the Ngauranga merge/diverge to the Aotea Quay ramps with a 2.5 metre minimum shoulder. Existing ATMS would be retained
Option 13	Tidal Flow on Motorway	Provide a moveable barrier from Hobson Street across the Thorndon Viaduct to SH2 north of the Ngauranga Ramps. This option would require widening of the Thorndon Viaduct or lane narrowing. The motorway would need to be widened at both ends to allow the construction of the house for the barrier machine with in the central median.
Option 14	Hutt Road Tidal Flow in One Direction	Hutt Road would be tidal one way in the peak flow direction. This would require the system to close Hutt Road and Private Accesses while the direction is changed to accommodate peak

		traffic flows. This option could eliminate the need for traffic signals at Kaiwharawhara Road and Onslow Road. No concept has been provided.
Option 15	Hutt Road Tidal Flow (1 Lane Non –Peak and 3 Lanes Peak Direction)	Hutt Road would be tidal with one lane non-peak and three lanes in the peak flow direction. This would require the installation of overhead gantries and lane control units to control the opening and closing of tidal lanes. Traffic signals at Kaiwharawhara Road and Onslow Road would require modification to accommodate the tidal flow operation. All central medians and islands would need to be removed. No concept has been provided.
Option 16	2 Lane Aotea Quay Off Ramp	Reconstruct Aotea Quay off ramp to provide a two lane off ramp to accommodate current and future traffic demand.
Option 17	Improve Access to Ferry Terminal	Reconstruct the Aotea Quay off ramp to provide direct access to the Ferry Terminal from SH1 and additional capacity to Aotea Quay to accommodate current and future traffic demand.
Option 18	Aotea Quay Off Ramp Improvements	Reconstruct the Aotea Quay off ramp to address the geometric deficiencies. This would involve widening the Thorndon Viaduct to improve the diverge to current standards and widening the off–ramp to improve the curve radius.
Option 19	Remove the Aotea Quay Ramps Completely	Close the Aotea Quay Ramps with traffic diverted to use Hutt Road, off–ramps to the south and the Terrace Tunnel. No concept has been provided.
Option 20	Use Existing Lane to Create Priority Lane	Remark the left hand lane as a priority lane for Buses, High Occupancy Vehicles (2+), Taxis, Tracks and Motorcycles. No concept has been provided.
Option 21	Create New Special Vehicle Lane	Any new lane would be marked as a Special Vehicle Lane for Buses, High Occupancy Vehicles (2+), Taxis, Tracks and Motorcycles. No concept has been provided.
Option 22	Park and Ride	Create a Park and Ride site on the Rail land at Ngauranga with access off and on to SH2 Ngauranga off ramp. Additional shuttle trains would run from Ngauranga Station. No concept has been provided.
Option 23	Additional Ramps at Thorndon Quay	Additional ramps would be constructed to provide access and egress between SH1 and Thorndon Quay. This would require demolition of existing builds and removal of car parking. No concept has been provided.
Option 24	Congestion Charging	A charge would be imposed on vehicles entering the Wellington CBD. This would require technology to record road users and change the appropriate charge. No concept has been provided.
Option 25	Upgrade Hutt Road/Ngauranga Intersection	Upgrade the configuration/capacity of the SH2 Hutt Road Off-ramp approach and Centennial Highway exit capacity at the Ngauranga/Hutt Road intersection to provide for the current and projected traffic demands between SH2 and SH1.

Appendix H

Assessment of 25 Options against Project Objectives

Project Goal	Objective	Priority	Do Nothing	Improve Existing ATMS	Reconfigure Nguaranga Merge/Diverge	SH1 to SH2 Merge (North of Project Area)	Safety Improvements on Existing Road (SH1 CRS)	On-Ramp Improvements	Driver information in Wellington City	Hard Shoulder Running	Controlled All Lane Running	Build 4 Lanes plus Shoulders	4 Lane South - 3 Lane North plus Shoulders	3 Lane South - 4 Lane North plus Shoulder	Tidal Flow on motorway (Across Thordon Viaduct)	Hutt Road Tidal Flow (1-Direction)	Hutt Road Tidal Flow (1 Lane - 3 Lanes Peak Direction)	2 Lane Aotea Off-ramp	Improve Access to Ferry Terminal and New Aotea Quay Off Ramp	Aotea Quay Off-Ramp Improvements	Remove Aotea Quay Ramps Completely	Use existing Lane to Create Priority Lane	Create new Special Vehicle Lanes	Park & Ride	Additional Ramps at Thorndon	Congestion Charging	Upgrade Hutt Road/Ngauranga Intersection
			Opt.01	Opt.02	Opt. 03	Opt.04	Opt.05	Opt.06	Opt.07	Opt.08	Opt.09	Opt.10	Opt.11	Opt.12	Opt.13	Opt.14	Opt.15	Opt.16	Opt.17	Opt.18	Opt.19	Opt.20	Opt.21	Opt.22	Opt.23	Opt.24	Opt.25
Improve Journey Efficiency	Improve Journey time reliability	M	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	N	N	Y	Y
	Improved driver ambience	L	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	Y	Y	Y
	Integrate with existing road network	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y
Ease Congestion	Smooth traffic flows	H	N	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	Y	N	N	Y	Y
	Increase capacity where needed	H	N	N	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	Y	N	N	N	Y
Flexibility	Operate as required (24/7)	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
	Operate independently in both directions	H	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y
	Be capable of automated operation	L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
	Controllable from any Traffic Ops. Centre	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y
Compliance	Compliance through intuitive systems	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	N	Y
	Legally enforceable	H	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
	No NZTA liability	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Maximise Asset	Make best use of existing asset	H	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	N	Y	N	N	Y	N	N	Y	Y
	Minimal additional infrastructure	M	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y
	Value for money	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N	Y	Y
	Considers maint.& renewal requirements	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y
Knowledge Transfer	Develop ATM capabilities in New Zealand	L	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	Y	N
	Repeatability (Pilot Scheme)	H	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
	Demonstrate & prove new operating regimes	M	N	Y	Y	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N	N	Y	Y	N	N	N	N
	Prove new Technologies	L	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Extend capabilities of operators	M	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Integration	Use latest technology	H	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
	Integrate with existing ATMS	H	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Use existing NZTA operating system	H	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Fits with adjacent SH & local road network	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N	N	Y	Y
	Sustainability of ops. (operator ownership)	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y
Improve Safety	Improve safety for road users	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y
	Improve safety for network maintenance	H	N	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	N	N	Y	N	N	N	N
	Improve safety for Emergency Services	H	N	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	Y	N	Y	N	N
Early Delivery	Consider staged delivery	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Customers First	Minimise construction disruption	M	Y	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N	N	N	N	Y	N	Y	Y	Y	Y	N	Y	N
	Innovation	M	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	N	N	N	N	Y	N	Y	N
	Traveler Information	H	N	Y	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
	Positive Marketing	H	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	Y	Y	N	N	Y
Support Economic Growth	Improve access to Wellington's CBD, Indust. & employment centres, port, airport & hospital.	H	N	y	y	y	y	y	y	y	Y	Y	Y	N	Y	N	N	Y	Y	N	N	N	Y	N	N	Y	y
Score	Unweighted		11	32	26	24	22	32	32	33	33	23	21	24	21	14	18	22	24	21	11	15	22	10	12	22	24
	Weighted by NZTA Priority		17	61	53	51	46	55	55	60	60	50	44	50	39	23	30	47	51	42	22	27	46	20	25	44	51

		Do Nothing	Improve Existing ATMS	Reconfigure Ngauranga Merge/Diverge	SH1 to SH2 Merge (North of Project Area)	Safety Improvements on Existing Road (SH1 CRS)	On-Ramp Improvements	Driver information in Wellington City	Hard Shoulder Running	Controlled All Lane Running	Build 4 Lanes plus Shoulders	4 Lane South - 3 Lane North plus Shoulders	3 Lane South - 4 Lane North plus Shoulder	Tidal Flow on motorway (Across Thordon Viaduct)	Hutt Road Tidal Flow (1-Direction)	Hutt Road Tidal Flow (1 Lane - 3 Lanes Peak Direction)	2 Lane Aotea Off-ramp	Improve Access to Ferry Terminal and New Aotea Quay Off Ramp	Aotea Quay Off-Ramp Improvements	Remove Aotea Quay Ramps Completely	Use existing Lane to Create Priority Lane	Create new Special Vehicle Lanes	Park & Ride	Additional Ramps at Thorndon	Congestion Charging	Upgrade Hutt Road/Ngauranga Intersection
Score	Unweighted	11	32	26	24	22	32	32	33	33	23	21	24	21	14	18	22	24	21	11	15	22	10	12	22	24
	Weighted by NZTA Priority	17	61	53	51	46	55	55	60	60	50	44	50	39	23	30	47	51	42	22	27	46	20	25	44	51
	Outcome (unweighted)	DROP	RET.	RET.	RET.	RET.	RET.	RET.	RET.	RET.	RET.	DROP	RET.	DROP	DROP	DROP	RET.	RET.	DROP	DROP	DROP	RET.	DROP	DROP	RET.	RET.
	Outcome (weighted)	DROP	RET.	RET.	RET.	RET.	RET.	RET.	RET.	RET.	RET.	DROP	RET.	DROP	DROP	DROP	RET.	RET.	DROP	DROP	DROP	RET.	DROP	DROP	DROP	RET.
Weighted score cut off	22																									
Unweighted score cut off	45																									

Appendix I

Option Drawings

Appendix J

Preliminary Design Philosophy Statement

Draft Report

Ngauranga to Aotea Quay Wellington ATM Preliminary Design Philosophy Statement

Prepared for NZ Transport Agency (NZTA) (Client)

By Beca Infrastructure Ltd (Beca)

18 May 2011

Revision History

Revision Nº	Prepared By	Description	Date
A	Peter Bradshaw	First Draft for discussion with NZTA experts	5 May 2011
B	Richard Atherton	Update – Second Draft	16 May 2011
C	Richard Atherton	Update – Third Draft	18 May 2011

Document Acceptance

Action	Name	Signed	Date
Prepared by	Peter Bradshaw		
Reviewed by	Geoff Brown		
Approved by	Geoff Brown		
on behalf of	Beca Infrastructure Ltd		
Approved by	Stephen Wright		
on behalf of	Fletcher Construction Company Ltd		

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Executive Summary

Purpose

The purpose of this report is threefold:

1. to outline the current status of the design approach and process;
2. to obtain acceptance from NZTA RMT and VAC on the standards and guidelines used for evaluation purposes during the design process; and
3. to obtain approval for any departures from Standards identified thus far.

Recommendations

It is recommended that the Wellington RMT and VAC:

- Endorse the overall design approach thus far;
- Approve departures from Standards identified in Table 1-1;
- Agree NZTA trigger for new stormwater infrastructure and treatment requirements:
  - The stormwater runoff is to be treated if the impervious area changes (i.e. we increase the pavement area);
  - The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected;
  - This will need further agreement from GWRC.
- Endorse spot speed enforcement; and
- Agree to modelling scenarios.

Table 1-1 Design Approach and Departures Summary

	Design Element	Standard	Design Approach	Departures
1.	**Road and Pavement Design**			
1.1	Design and Posted Speed			
	design speed	110 kph	110 kph	
	posted speed	100 kph		80 kph (during peak hours)
1.2	Motorway lane widths	3.5m		3.25 to 3.3m
1.3	Shoulder widths	2.5m		0.5m – 1.0m
1.4	Driver Reaction time		2.5secs	
1.5	Median barrier	TL3 – TL4		
2	**Intelligent Transport System**	Draft National Standard		Refer to Table 1-2
3	**Bridge Structures**			
3.1	Thorndon Overbridge “clip-on” option			
	Earthquake APE	1-in-2500		1-in-500 (existing)
	External barriers	TL5		TL4
	Median barriers	TL4		TL4
3.2	Thorndon Overbridge Separate Structure (new)			
	Earthquake APE	1-in-2500		1-in-1000

	Design Element	Standard	Design Approach	Departures
	External barriers	TL5	TL5	
3.3	Aotea Quay off-ramp bridge structure			
	Earthquake APE	1-in-2500		1-in-200 (existing)
3.4	Southern Rail Overbridge			
	Earthquake APE	1-in-2500		1-in-200 (existing)

Discussion

Overall Design Approach

We recognise the requirement to make best use of the existing asset. Our design approach will therefore assess the constraints of the existing environment against the need to meet the operational goals of the project (capacity, safety, reliability, travel time). The ability of a design to meet these goals will be informed by evaluating it against accepted design standards.

We will suggest solutions that test the bounds of the existing NZTA design standards. We will evaluate these solutions by comparing the impacts or benefits against the project operational goals, alternative solutions and existing and accepted standards. The comparison against accepted standards will allow us to evaluate the likely costs, benefits and operational impacts associated with departures from these standards.

We have been advised by NZTA that the design should start from the premise that the existing carriageway alignment, the motorway centre line, the existing pavement crossfalls and pavement construction should be retained to the maximum extent possible whilst maintaining acceptable operational and safe standards. The aim of the project is to maximise the use of the existing asset.

Key Considerations

The key considerations are summarised below:

Existing Environment

a. State Highway 1 and 2

The existing motorway is a curvilinear alignment approached by two sections of state highway with very different environments. State Highway 1 (SH1), further to the North, consists of a very constrained environment, mostly without shoulders, with high cuts, a steep gradient and a posted speed limit of 80 kph.

State Highway 2 (SH2) to the Northeast consists of a more open environment with shoulders and a 100 kph posted speed limit.

b. Study Corridor

SH1, further to the Southwest between Ngauranga Gorge and Aotea Quay is constrained by:

- the railway lines on the west side;
- the coastal marine area on the east;
- the port area adjacent to the Aotea off-ramp;
- the Southern Rail Overbridge; and
- Thorndon Overbridge, which is a long elevated structure with minimal shoulder widths.

There are sections of the existing motorway within the study corridor that do not comply with the current State Highway Geometric Design Manual (SHGDM) standards. Changes to the existing motorway will need to be designed to provide a “readable” environment which transitions appropriately from the adjacent sections of highway (SH1 & SH2).

There are four connections to local roads, in the form of on and off ramps. The interface with the local roads will be designed in coordination with the NZTA and Wellington City Council (WCC).

c. Thorndon Overbridge

The original structure was not designed using the “capacity design” concept of modern codes and consequently had serious seismic vulnerabilities.

The structure was seismically retrofitted in the mid 1990’s and post retrofit performance is expected to be adequate under seismic events of up to a 500 year Annual Probability of Exceedance (APE).

This was considered an appropriate level of retrofit that was economically and technically feasible at the time, given the geotechnical conditions at the site, the risk of liquefaction and lateral spreading and the preference not to undertake the extensive and costly ground improvement measures required to mitigate these effects.

Road and Pavement Design

a. Geometric Design Standards Adopted for Evaluation Purposes

The existing situation and proposed designs will be evaluated against a series of NZTA accepted design criteria. Most of these criteria will be based on the Austroads Guide for Road Design (AGRD) because it is consistent with other designs being carried out within New Zealand and will provide a “readable” and familiar environment for motorists.

b. Operating Speed and Design Speed

- We propose that all of the horizontal and vertical alignment elements of our designs are evaluated against the requirements of a design speed of 110 kph. This will then enable proposed design solutions to be compared to an “ideal” situation and the existing situation to determine benefits or disbenefits of the proposed solutions.
- It is not intended to modify the existing Aotea Quay off-ramp structure; however any new connections to that off-ramp will be evaluated against the requirements of the AGRD.
- The operating speed for Hard Shoulder Running is 80 kph while the hard shoulder is in operation during peak periods.

c. Cross Section

- The typical cross section through the main carriageway is yet to be determined, however, we propose to generally use 3.3m lane widths but may require 3.25m lane widths (previously agreed for investigation by VAC) on the overbridge structures.
- NZTA confirmed that the existing median barrier was nearing the end of its design life and it may be possible to provide wider lane widths within the existing carriageway “barrier to barrier” space if the median barrier is replaced.
- Final shoulder widths will depend on the chosen work package, however the general approach will be to provide wider lanes at the expense of shoulder width if a trade-off is required.

d. Sight Distance

This is a high speed urban section of motorway with alert drivers and few intersections; however the alignment is generally curvilinear with few sections of straight road. We have therefore adopted a driver reaction time of 2.5 seconds for sight distance calculations.

e. Location, Design and Requirement for Emergency Refuge Areas (ERAs)

The location, design and requirement of the ERAs will depend on the chosen work package, the rate and type of incident occurrence and the design lane and shoulder widths.

f. Pavement Design

The pavement design and / or evaluation will be based on the following supplied data and assumptions:

- 30 year design life;
- 95% project reliability;
- A motorway and state highway design speed of 110 kph;
- Subgrade CBR data obtained from ground investigations; and
- Final calculations of predicted traffic flows and percentage of heavy vehicles will be determined once the work package configurations and regional freight strategies and models have been confirmed.

Active Traffic Management Design

The Active Traffic Management design is based on the Draft National ITS Standards and Specifications that will require the departures identified in Table 1-2 in order to make them specific to the Wellington region:

Table 1-2 Summary of the Departures from the Draft National ITS Standards/Specifications

Draft National ITS Standards/Specifications		Departures
ITS-01 General	01 General Requirements	§ Section 2.2 Preliminary Documentation, agreement will need to be sought with NZTA Wellington to confirm the wording within this section is applicable to the region and their methods of management. § Section 3 ITS Numbering System, the system detailed within this section relates to the numbering system that is currently employed within the Auckland region, the method of ITS numbering in Wellington will need to be established and referenced within this section. § Section 5 Glossary of Terms, local terms will need to be included.
	02 Environmental Requirements	§ Environmental Requirements applicable to the Wellington region.
	04 Civil and Motorway Site Works	§ The reference to Auckland will need to removed and replaced with a generic statement of the "NZTA Motorway Network".
	05 Support Structures and Foundations	§ No departures.
ITS-02 Communication Infrastructure	01 Duct Supply and Installation	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	02 Jointing Chambers and Pull Pits	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	03 Optical Fibre Supply and Installation	§ A detailed review of this document will need to be undertaken against the current methodology of Wellington's fibre installation to ensure the process and procedures detailed within will be applicable to Wellington. § Change Control procedures will need to be assessed for their suitability in the Wellington region
	04 Roadside Cabinets	§ Section 1.3 Roadside Cabinet Numbering, as per ITS-01-01 General Requirements the Wellington numbering will need to be followed § Section 3.4 Optical Fibre Interface supply of Network Switch. Confirmation of the type of Network Switch currently used within the Wellington region § Section 3.5 ITS Network Change Control, a review in conjunction with ITS-02-03 will need to be undertaken for its suitability to Wellington § Attachments, Auckland reference to be removed and either a generic statements or Wellington references inserted.

Draft National ITS Standards/Specifications		Departures
ITS-04 Lane Control System	01 Lane Control System (LCS) Civil and Structural Works	§ Dual pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § Single pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § LCS support structure will need to be identified detailing units connection to post mounted installation
ITS-06 Variable Message Signs	02 Variable Message Sign Supply and Installation	§ ITS-01-02 Environmental Requirements is referenced which as explained previously will need to updated to identify Wellington conditions.
ITS-07 Closed Circuit Television	01 Closed Circuit Television Civil and Structural Works	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
	Closed Circuit Television Supply and Installation	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
ITS-09 Motorway Emergency Telephones	01 Motorway Emergency Telephone	§ Currently this specification details standard installation of MET but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for MET.
ITS-10 Testing, Commissioning and Handover	01 Testing, Commissioning and Handover	§ This document is intended to be a guideline and a detailed Handover & Commissioning Plan will be developed for the preferred work package using this specification as reference

Stormwater Management

a. Approach

Our approach will be to evaluate the design solutions against the requirements of the applicable NZTA standards and the geometric design in order to determine if and what stormwater management changes are required.

We initially propose to develop geometric sub-options that would fit within the existing impervious area (for work packages 1, 2 and 3), thereby reducing or negating the requirement for new stormwater management infrastructure.

b. Treatment

- We have made the following assumptions regarding stormwater treatment:
  - The storm water runoff is to be treated if the impervious area changes (i.e. we increase the pavement area) and
  - The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected.
- If required, the stormwater treatment would most likely involve proprietary devices rather than swales and wetlands because of spatial constraints.
- If required, treatment is to be carried out to Best Practicable Option (BPO). Runoff from the motorway is to be collected and passed through stormwater treatment devices, prior to discharging to the receiving environment. Particular sensitive environments are the harbour, Kaiwharawhara stream and the Korimako stream.
- The treatment devices will address the removal of gross debris, suspended sediment, heavy metals, and hydrocarbons, and will be in accordance with NZTA's Stormwater Treatment Standard for State Highway Infrastructure.

Structures

a. Thorndon Overbridge

- Two concept options have been considered for increasing the southbound carriageway width on Thorndon Overbridge from the northern abutment to Aotea Quay off ramp:
  1) The first option is the construction of a "clip-on" widening deck; and
  2) The second option is provision of a separate elevated off-ramp structure.
- For widening option using a "clip-on" option:
  - Existing 500 year APE will not be adversely affected (proposed 10% additional seismic load on substructure is within existing capacity of piers and foundations);
  - Our approach will use 3.3m traffic lanes and narrow (0.5m) shoulders; and
  - TL4 "high" protection level, using "nested" steel Thriebeam side protection barriers as per the existing structure.
- For a separate off-ramp structure:
  - 1000 year APE;
  - 2 x 3.5m traffic lanes with 0.6m inner and outer shoulders;
  - TL5 side protection barriers; and
  - Vertical clearance broadly in line with existing Thorndon Overbridge
- Both the aforementioned options assume that the current Aotea Quay off-ramp bridge structure will be retained as existing in all proposed widening options and will not be modified,

strengthened or replaced on the basis that there will be no change to the current risk profile for this structure.

- The following design standards are proposed for the existing Aotea Quay off-ramp structure:
  - Existing structure will not be modified, strengthened or replaced;
  - Existing 200 year APE will not be adversely affected; and
  - Existing carriageway layout will not be changed.
- The northbound carriageway will also require widening between the Aotea Quay on-ramp and the northern abutment to suit the additional traffic lane but this will depend on the actual shoulder widths which we are currently assessing. Any widening would be less than for the southbound structure.
- It is our understanding that the new replacement protection barriers on the outer edge of Thorndon Overbridge have been designed to provide a TL4 "high" protection level, using "nested" steel Thriebeam barriers. We propose to use the same level of protection on the outer edge.

b. Southern Rail Overbridge

- We have assumed that as part of this scheme, the existing spine beam on the Southern Rail Overbridge will be strengthened to the full HN loading in accordance with the latest NZTA standards to suit the additional carriageway width required for this project.
- Any widening to the existing Southern Rail Overbridge structure to suit carriageway widening will replicate the current structural form and will be designed to comply with the current HN loading requirements.
- We have assumed that the bridge will not be retrofitted for earthquake capacity as part of the current scheme nor will its seismic performance be adversely affected by the works. It is our understanding that an earthquake retrofitting scheme may be considered for the whole structure at a future time as part of a separate scheme.
- The following design standards are proposed for the Southern Rail Overbridge:
  - Existing 200 year APE will not be adversely affected;
  - Bridge will not be seismically retrofitted;
  - Spine beam will be strengthened to full HN loading; and
  - New widening section will be designed to full HN loading requirements and will replicate the existing structural form.

c. Sign and VMS Gantries

Where required, the existing gantries will be modified to take additional signs and extended to match the new road geometry.

Geotechnical Design

For general design of cut and fill slopes, the following loadings and factors of safety (FOS) will be adopted:

Load Case	Loading	FOS
Long Term Static Case (embankments and cuts)	Traffic surcharge as per NZTA	≥ 1.5
Short Term - End of Construction Case (embankments)	Initial undrained strength parameters and construction traffic surcharge, strength gain from staged construction	≥ 1.3

Enforcement

The variable speed limit nature of the project lends itself to spot speed enforcement rather that point to point (average speed) enforcement and our design will therefore be based on spot speed enforcement.

Transport Models

a. Levels of Service

We propose that the main carriageway section of the project achieve a Level of Service “C” in the design year 2038.

b. Future Year Scenarios

The difference between Table 1-3 and Table 1-4 below is the inclusion of Ngauranga to Aotea Quay in Table 1-4.

Table 1-3 Future Year Do Minimum Traffic Scheme Assumptions (RoNS and Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin[1]	x	x
Peka Peka to Otaki	**P**	**P**
MacKays to Peka Peka	**P**	**P**
Linden to MacKays (Transmission Gully)	x	**P**
Ngauranga to Aotea Quay	x	x
Terrace Tunnel duplication	x	**P**
Basin Reserve	**P**	**P**
Airport to Mt Victoria Tunnel	**P** in part	**P**
Other	**2016**	**2026**
Petone to Grenada link road	x	**P**

[1] Not in WTSM modelled area

Table 1-4 Future Year Reference Case Traffic Scheme Assumptions (RoNS & Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin	x	x
Peka Peka to Otaki	P	P
MacKays to Peka Peka	P	P
Linden to MacKays (Transmission Gully)	x	P
Ngauranga to Aotea Quay	P	P
Terrace Tunnel duplication	x	P
Basin Reserve	P	P
Airport to Mt Victoria Tunnel	P in part	P
Other	2016	2026
Petone to Grenada link road	x	P

Table 1-5 Future Year Option Tests Assumptions[2]

Option	2016	2026
1 – Minor Works	P	P
2 – Hard Shoulder Running	P	P
3 – Control All Lane Running	P	P
4 – Four Lanes plus Shoulders	P	P

[2] Based on Future Year Reference Case Traffic Scheme Assumptions

Introduction

1.2 Purpose

The Ngauranga to Aotea Quay Wellington ATM Project (NtAQ) Standards Review Report (SRR) has been developed to outline the current status of the design process and the standards and guidelines used in that process. A new Standards Review Report will be issued at Macroscope confirmation stage and again during the development of the design associated with Scheme Assessment.

1.3 Scope

The standards, guidelines and key criteria that are intended for use in the design of the Ngauranga to Aotea Quay Wellington ATM project are presented in this document for review and comment by the NZ Transport Agency (NZTA) Wellington Regional Management Team (RMT) and Value Assurance Committee (VAC). This report is not intended to support final approval or endorsement of a preferred option.

The SRR sits within a much wider context of several contributing high level requirements and expectations:

- The Project Objectives. These drive the project at the highest level;
- National and Regional Strategy and Policy. These require certain high level strategic outcomes from transport projects;
- Local agreements with the surrounding stakeholders (as defined by the draft Memorandum of Understanding between KiwiRail, Interislander, Greater Wellington Regional Council (GWRC), CentrePort, Wellington City Council and NZTA; and
- A drive for customer service by the NZTA.

1.4 Project Overview

1.4.1 Project Background

Seven roads of national significance (RoNS) have been identified by NZTA, as New Zealand's most essential routes that carry high traffic volumes, and require solutions to reduce congestion, improve safety and support economic growth.

The Ngauranga to Aotea Quay: Wellington Active Traffic Management (NtAQ) project has been identified as one of nine sections of the Wellington Northern Corridor RoNS requiring improvement.

1.4.2 Project Description

The NtAQ involves the four kilometre section of State Highway 1 between Ngauranga Gorge and the Aotea Quay on and off-ramps which forms part of the Wellington Urban Motorway. This is the most congested part of the motorway network, particularly during morning and evening peak periods, during incidents and other discrete events that bring people into Wellington City. The project area is shown in **Figure 1-1**.

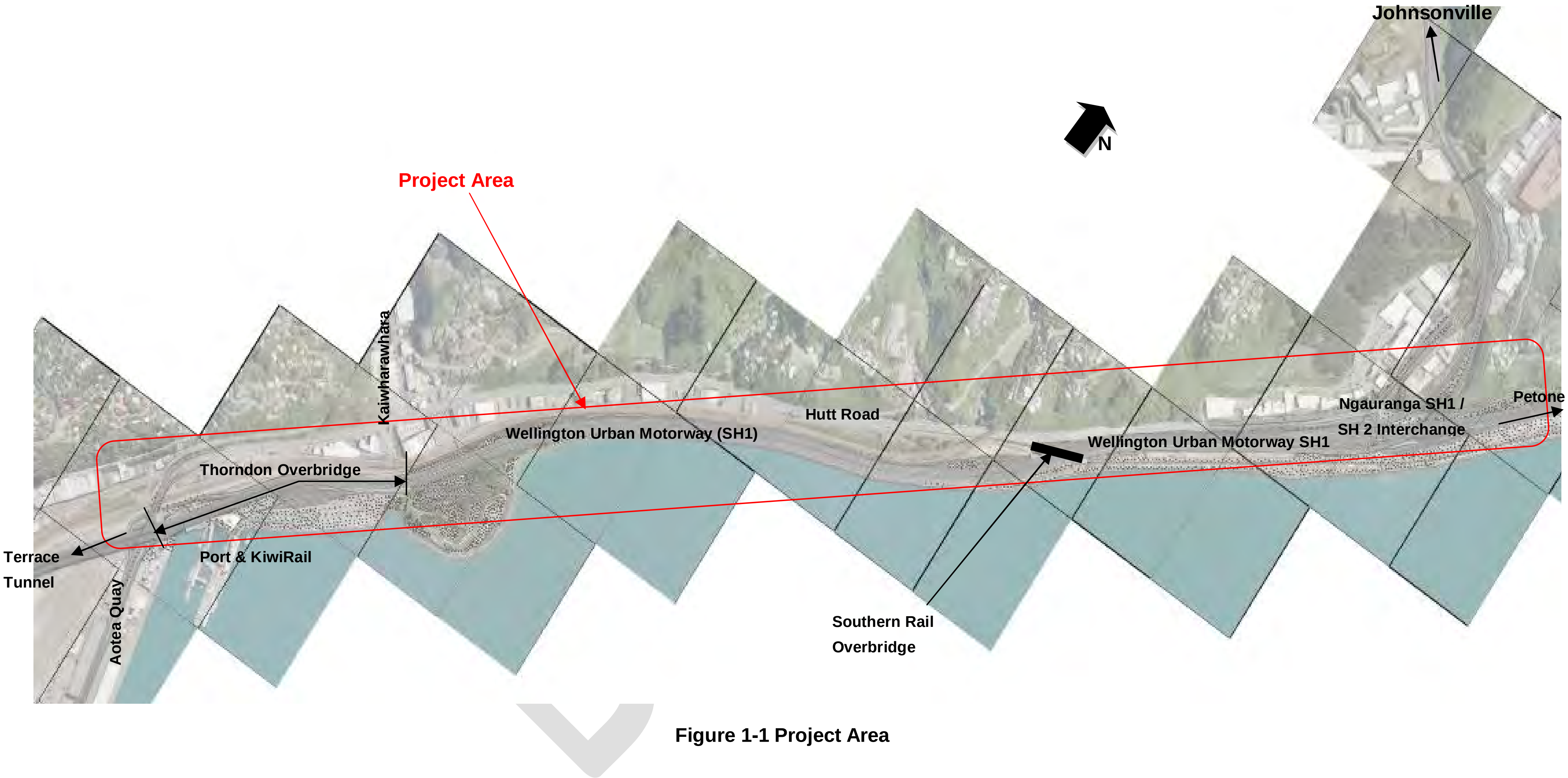

Figure 1-1 Project Area

1.4.3 Project Aim

The aim of this project is to investigate, design, and construct improvements that reduce congestion and improve journey time reliability on this section of State Highway by:

- Maximising use of the existing asset;
- Achieving desired capacity, travel time and safety requirements; and
- Providing civil and ATM solutions based on long term value for money objectives.

1.4.4 Early Work and Consultation

NZTA and their Specialist Advisor, Mouchel, carried out some early research, investigation and consultation work prior to awarding the Early Contractor Involvement (ECI) Contract.

This early research identified that providing an additional running lane in both directions during these periods and implementing Active Traffic Management (ATM) would reduce congestion. Utilising the existing shoulder where possible was considered to offer a best value solution and to maximise the benefits of the existing asset. Similar projects have been undertaken in the UK, Europe and USA with positive and tangible benefits to the road user, stakeholders and asset owner.

The following Mouchel reports document most of the early investigation work undertaken:

- DOC000 ATM Options Report.
- DOC001 Operational Regimes.
- DOC002 Operations and Maintenance Requirements (Mouchel).
- DOC003 Project Safety Strategy and Plan.
- DOC004 Project Safety Baseline and Risk Profile for the 'Before' Case (Mouchel).
- DOC005 Stakeholder Gap Analysis.
- DOC006 Legislation and Standards Requirements.
- DOC007 Technology Requirements Report.
- DOC008 Operations and Maintenance Report.
- DOC009 Compliance and Enforcement Requirements.

In addition to the Mouchel reports, NZTA have also collected a range of background information, historical documents and technical papers relevant to the project that have been posted on the Project SharePoint site called TeamView.

NZTA has undertaken initial consultation with the following key stakeholders during the early project scope development:

- KiwiRail (including Ontrack)
- Interislander
- Greater Wellington Regional Council (GWRC)
- CentrePort Wellington
- Wellington City Council (WCC)

The purpose of NZTA's initial consultation was to outline the project objectives, identify and discuss the Port Constraints, and discuss the options should an additional running lane be provided from Thorndon Overbridge north abutment to Aotea Quay, which would affect the above stakeholders.

1.4.5 Existing ATM in Wellington

NZTA has implemented and operated a moderate level of ATM over the last ten years on certain sections of the State Highway within the Wellington Region. These include:

SH2 between Johnsonville and Ngauranga Gorge

In February 2001, Transit New Zealand (now NZTA) started operating ATMS within a 4km section of the Ngauranga Gorge between Johnsonville in Wellington and SH1 and SH2 interchange. The aim of the Ngauranga ATM was designed to create a safer motorway environment by:

- reducing the number, severity and impact of incidents on this demanding section of highway; and
- improve overall traffic flow that will subsequently reduce driver frustration and delays.

This has been achieved through the communication of up-to-the-minute information (ATM) to road users, emergency services and traffic controllers and implementation of faster, more appropriate traffic and emergency management responses.

Petone to Terrace Tunnel ATM

Between 2008 and 2010, NZTA implemented ATM phase 1 and phase 2 on the section of SH1 between Petone and Terrace Tunnel. This has enabled the Traffic Operations Centre (TOC) to pro-actively manage the traffic speed, improve customer information and better manage the incidents on the network.

Objectives

The NtAQ project specific objectives are:

- to ease congestion, by:
  - smoothing traffic flows and increase capacity;
- to increase network flexibility, by:
  - allowing operation of the system continuously and independently in each direction;
- to have a high level of compliance, by:
  - operating an intuitive and legally enforceable system;
- to maximise existing assets, by:
  - using existing infrastructure more efficiently and effectively and considering maintenance and renewal requirements;
- to develop knowledge of ATM systems, by:
  - developing ATMS capabilities and expertise in New Zealand and utilising new technologies
- to integrate the ATMS, by:
  - considering how it fits with the existing State highway network and the NZTA's existing systems;
- to improve safety, by:
  - considering the needs of road users, network maintenance contractors and emergency services;
- to be delivered early, by:
  - considered staging of project delivery; and
- to prioritise the NZTA's customers, by:
  - minimising disruption to road users;

- delivering high quality information to road users; and
- using innovation.

2 Options under Consideration

There are five options, which for the purposes of this project will subsequently be referred to as work packages, currently under consideration. Four of these were endorsed by the NZTA RMT on 25 February 2011 and a fifth one has subsequently been added comprising a package of the four lanes plus shoulders with the implementation of the minor works package.

The components that make up each of the work packages are summarised in **Table 2-1** on the next page.

Table 2-1 - Work Packages

Work Package Components and Add-Ons		Five Work Packages				
		Minor Works	Hard Shoulder Running	Control All Lane Running	4 Lanes plus Shoulders	4 Lanes plus Shoulders plus ATM
What the basic work package Includes:		Reconfigure Ngauranga Merge/Diverge	Reconfigure Ngauranga Merge/Diverge	Reconfigure Ngauranga Merge/Diverge	Reconfigure Ngauranga Merge/Diverge	Reconfigure Ngauranga Merge/Diverge
		Aotea Quay Off Ramp Improvement	Aotea Quay Off Ramp Improvement	Aotea Quay Off Ramp Improvement	Aotea Quay Off Ramp Improvement	Aotea Quay Off Ramp Improvement
		Variable Mandatory Speed Limits (VMSL)	Variable Mandatory Speed Limits (VMSL)	Variable Mandatory Speed Limits (VMSL)		Variable Mandatory Speed Limits (VMSL)
		Motorway Incident Detection and Automatic Signaling (MIDAS)	Motorway Incident Detection and Automatic Signaling (MIDAS)	Motorway Incident Detection and Automatic Signaling (MIDAS)		Motorway Incident Detection and Automatic Signaling (MIDAS)
		Digital Enforcement System (DECS)	Digital Enforcement System (DECS)	Digital Enforcement System (DECS)		Digital Enforcement System (DECS)
		Advance Driver Information Systems (ADIS)	Advance Driver Information Systems (ADIS)	Advance Driver Information Systems (ADIS)		Advance Driver Information Systems (ADIS)
			CCTV	CCTV		
			Semi-Automatic Control Systems (SCS)			
				Vehicle Detection System		
					Four lanes	Four lanes
					Hard Shoulder (2.5m minimum width)	Hard Shoulder (2.5m minimum width)
What Add-Ons could be included:		SH2 Hutt Road On Ramp Northbound Improvement	SH2 Hutt Road On Ramp Northbound Improvement	SH2 Hutt Road On Ramp Northbound Improvement	SH2 Hutt Road On Ramp Northbound Improvement	SH2 Hutt Road On Ramp Northbound Improvement
		Aotea Quay On Ramp Improvement	Aotea Quay On Ramp Improvement	Aotea Quay On Ramp Improvement	Aotea Quay On Ramp Improvement	Aotea Quay On Ramp Improvement
		SH1 Ngauranga On Ramp Improvement	SH1 Ngauranga On Ramp Improvement	SH1 Ngauranga On Ramp Improvement	SH1 Ngauranga On Ramp Improvement	SH1 Ngauranga On Ramp Improvement
		Ngauranga Intersection Improvement	Ngauranga Intersection Improvement	Ngauranga Intersection Improvement	Ngauranga Intersection Improvement	Ngauranga Intersection Improvement
		Driver Information in Wellington City	Driver Information in Wellington City	Driver Information in Wellington City	Driver Information in Wellington City	Driver Information in Wellington City
					Advance Driver Information Systems(ADIS)	

3 Selection Method

In considering the context of the project, the regional and national strategies and the on-going operation of the motorway the following criteria have been determined to select a preferred work package. These criteria will be assessed using a multi-criteria analysis framework and will be tested using various weightings and sensitivities.

Table 3-1 - Selection Criteria

Project Outcomes	Criteria	Measure
Improve journey efficiency through journey time reliability, reducing congestion and driver stress	Improve journey time reliability	Less variability and better accuracy of vehicle journey times
	Reduce congestion	Traffic flow profiles to show smooth traffic flows and vehicle speeds (less shockwaves). Journey Time savings
	Reduce driver stress	Positive customer survey results
Making best use of the asset by delivering a value for money and flexible solution	Flexible operation	Can accommodate expected traffic flows. Able to operate 24/7 if required and independently in each direction. Can be operated from Wellington and Auckland
	Delivering value for money	Deliver a solution that addresses the root causes for the lowest cost and greatest benefit
	Design for operation, maintenance and renewal requirements	Optimal operation and maintenance and renewal regime
	Compatible where possible with existing infrastructure and systems	Deliver a solution that minimises modifications
Improve compliance through influencing driver behaviour	Improve driver behaviour	Provide a legally enforceable scheme
	Improve driver behaviour	Engineer an intuitive system
Maintain or improve safety for all users	Maintain or improve safety for road users	Reduction in crashes
	Improve emergency services	Develop and deliver an operation regime for incident management
	Safety in design	Implement and monitor a safety management system
Adverse effects on the environment are no more than minor	Built environment	The project provides for the integration of infrastructure in the urban environment. The design does not significantly detract from the urban form and the adverse effects on urban form, culturally significant sites and heritage features are no more than minor
	Natural environment	The project integrates well with the natural environment and any adverse environmental effects on natural resources and systems are no more than minor

Project Outcomes	Criteria	Measure
	Hazards	The project minimises risks of hazards recognising the physical and geotechnical conditions of the area such as ground condition, fault lines, flooding risk and including any contaminated sites
	Social well-being and health	The project does not adversely affect people's well-being and health (air emissions, noise impacts, social factors)
	Sustainability	The project takes account of whole-of-life sustainability criteria
The solution can be delivered effectively	Resource consent / planning approval process	The project is straightforward to consent
	Land acquisition	No significant land acquisition issues
	Staging	The project can be staged as required
The solution is economic	Strategic fit	Aligns with NZTA's strategic investment direction
	Effectiveness	Provides for an effective long-term, integrated and enduring solution that is part of an accepted strategy
	Economic efficiency	Benefit Cost Ratio
	Local business impacts	Consideration of economic impact on local businesses
	Wider economic impacts	Consideration of wider economic impacts (regional and national level)

4 Road Design

4.1 General

4.1.1 Approach to Design

We recognise the requirement to make best use of the existing asset. Our design approach will therefore assess the constraints of the existing environment against the need to meet the operational goals of the project (capacity, safety, reliability, travel time). The ability of a design to meet these goals is usually informed by evaluating it against accepted design standards.

We will suggest solutions that test the bounds of the existing NZTA design standards. We will evaluate these solutions by comparing the impacts or benefits against the project operational goals, alternative solutions and existing and accepted standards. The comparison against accepted standards will allow us to evaluate the likely costs, benefits and operational impacts associated with departures from these standards.

An outline of the process we will follow is shown below:

i. Understand the existing geometric alignment (horizontal and vertical);

ii. Develop sub-options that would fit between the existing lanes and barriers (for work packages with hard shoulder running and controlled all lane running);

iii. Test against accepted standards, sight distance, lane width, capacity etc;

iv. Identify deficiencies;

v. Modify design to mitigate deficiencies (including looking at options outside the existing barriers and realignment);

vi. Re-test; and

vii. Agree design for the work packages with four lanes plus shoulders it is expected that it will be necessary to extend outside the existing barriers to accommodate the width required.

4.1.2 Existing Environment

The existing motorway is a curvilinear alignment approached by two sections of state highway with very different environments. State Highway 1 (SH1), further to the North, consists of a very constrained environment, mostly without shoulders, with high cuts, a steep gradient and a posted speed limit of 80 kph. State Highway 2 (SH2) to the Northeast consists of a more open environment with shoulders and a 100 kph posted speed limit. SH1, further to the Southwest is again a very constrained environment with an approach over a long elevated structure with minimal shoulder width.

Figure 1-1 Project Area provides an aerial photograph of the existing motorway and connections to adjacent sections of state highway and local roads.

Changes to the existing motorway will need to be designed to provide a “readable” environment which transitions appropriately from the adjacent sections of highway (SH1 & SH2).

There are four connections to local roads, in the form of on and off ramps. The interface with the local roads will be designed in coordination with the NZTA and Wellington City Council (WCC).

4.2 Geometric Design Standards Adopted for Evaluation Purposes

The existing situation and proposed designs will be evaluated against a series of NZTA accepted design criteria. Most of these criteria will be based on the Austroads Guide for Road Design (AGRD). This has been chosen because it is consistent with other designs being carried out within New Zealand and will provide a "readable" and familiar environment for most motorists. Overseas design standards have and will continue to be considered for this project, however, it is important to provide a design that is in keeping with the overall context for existing, new and rehabilitated sections of highway in New Zealand[3].

The new AGRD uses the term 'Driver Domains'. These define the desirable range of values for parameters, given the prevailing topography and conditions. The RoNS guidelines have tabulated some of the specific requirements but these will need to be reviewed in the light of the AGRD and the specific context of the section of motorway and the additional control and guidance provided by the Automated Traffic Management (ATM).

The standards generally adopted for the evaluation of designs for the NtAQ project have been taken from the following documents:

Table 4-1 Geometric Design Standards

Design Element	Standards
Alignment	NZTA - Roads of National Significance Design Standards and Guidelines Austroads, Guide to Road design 2009 – Parts 1, 2 & 3 NZTA DRAFT State Highway Geometric Design Manual (SHGDM)
At Grade Intersections (Ngauranga Gorge / Hutt Road / SH2)	NZTA DRAFT State Highway Geometric Design Manual (SHGDM) NZTA Manual of Traffic Signs and Markings (MOTSAM) Part 2 LTSA RTS 14 – Blind and Vision Impaired Pedestrians LTSA RTS 18 – On Road Tracking Austroads - Guide to Traffic Management – Part 6 Austroads - Guide to Road design Parts 4, 4A & 4B WCC Design Requirements NZS 4404 Land Development & Subdivision infrastructure (local roads)
Grade Separated Intersections on and off ramps	NZTA DRAFT State Highway Geometric Design Manual (SHGDM) Austroads - Guide to Traffic Management – Part 6 Austroads - Guide to Road design Parts 4 & 4C NZTA Traffic Control Devices Manual – Part 10 (MOTSAM Part 3)
Road & Cross Section	NZTA DRAFT State Highway Geometric Design Manual (SHGDM) Austroads - Guide to Road design Parts 3, 6 & 6B NZS 4404 2010 Land Development & Subdivision infrastructure (local roads)

[3] Section 1.4 of Part 3: Geometric Design, of the AGRD notes that a specific objective related to geometric design is "maintenance of a degree of uniformity, particularly across administrative boundaries to provide a consistent and operationally effective driving experience relative to the functional class of the road"

Design Element	Standards
Safety Barriers	NZTA M23 Road Safety Barrier Systems AS/NZS 3845: 1999 Road Safety Barriers Austroads – Guide to Road Design – Part 6
Signs & Line Markings	NZTA Manual of Traffic Signs and Markings (MOTSAM Parts 1, 2 & 3)
Drainage	Refer section 7, Stormwater Management
Bridges	Refer section 8, Structures
Pedestrian & Cyclist (Ngauranga Gorge / Hutt Road / SH2)	Austroads Guide to Road Design - Part 6A

4.3 Operating Speed and Design Speed

As noted previously, the parameters outlined below will first be used for evaluation of work packages, followed by agreement of exceptions then design as required.

4.3.1 Main Carriageway

The existing operating speed of the motorway is in excess of 100 kph. This is because of the unconstrained nature of the environment, the number of lanes and the lack of intersections. The high operating speed of the motorway means that the design speed should ideally be no less than 110kph. The existing motorway already has sections that do not comply with all elements of this design speed (for example sub-standard stopping sight distance).

We propose that all of the horizontal and vertical alignment elements of our designs are evaluated against the requirements of a design speed of 110kph. This will then enable proposed design solutions to be compared to an "ideal" situation and the existing situation to determine benefits or disbenefits of the proposed solutions.

4.3.2 On ramps and off ramps

The ramp design speed will be determined in accordance with the requirements of Section 6.4.1 of Austroads – Guide to Road Design – Part 4c. It is not intended to modify the existing Aotea Quay off-ramp; however any new connections to that off-ramp will be evaluated against the requirements of the AGRD.

4.4 Cross Section

4.4.1 Main Carriageway

The typical cross section through the main carriageway is yet to be determined, however, an absolute minimum lane width of 3.25m has previously been approved for investigation by VAC, for this project, on 13 May 2010. This lane width was based on a Hard Shoulder running scheme, incorporating the existing median barrier and it may be possible to provide wider lane widths within the existing carriageway "barrier to barrier" space if the median barrier is replaced.

As noted in section 10, the AGRD uses a "Design Domain" approach to specify Design Criteria. The AGRD discusses the concept of Normal Design Domain (NDD) and Extended Design Domain (EDD). EDD values are outside of the NDD, but have been found to provide a suitable solution in a constrained environment, through research and / or operating experience.

Design of lane widths (and shoulders) for this section of motorway will be evaluated against the lane widths included in the:

- AGRD Part 3: Geometric Design, Appendix A Extended Design Domain (EDD) For Geometric Road Design **Table A 1**.

Table A1, from the AGRD, provides guidance for the EDD through lane width for urban freeways. It should be noted that the lane width EDD is a departure from NDD and should not be used in conjunction with EDD for other parameters, e.g. reduced sight distance or driver reaction time, or vertical or horizontal design standards. Each of these departures result in a reduction in standard and the combination these reductions may make it more difficult for the driver to “read” the road.

Table A1, from the AGRD, includes guidance for sections of managed motorways similar to that proposed for this project.

Table A1, from the AGRD, has been reproduced below for consideration:

Table A 1: EDD Widths for Urban Freeways

Element	Width (m)	Typical Use
Traffic Lane (1)	3.3	Minimum traffic lane width with 100km/h posted speed limit (4)
	3.1	Minimum traffic lane width with 80km/h posted speed limit
Left shoulder (2),(3)	2.5	Minimum shoulder with adjacent to a safety barrier on non managed freeways. Minimum shoulder width on non managed freeways of 3 or more traffic lanes.
	1.0	Shoulder width for a managed freeway with posted speed limit ≤ 100 km/h, emergency stopping bays required.
Median shoulder (2),(3)	2.5	Minimum shoulder width adjacent to a safety barrier on non managed freeways. Minimum shoulder width on non managed freeways of 3 or more traffic lanes.
	1.0	Shoulder widths on non managed freeways for 2 traffic lanes. Shoulder widths on non managed freeways where there are 3 or more traffic lanes and a posted speed limit ≤ 80 km/h. Shoulder widths on managed freeways where there are 3 or more traffic lanes.

1. Traffic lane widths include lane lines but are exclusive of edge lines.
2. Shoulder widths are subject to sight distance requirements. Shoulders may be locally narrowed where there are overpass bridge piers or similar large constraint.
3. Shoulders to be sealed for the full width. Where the wearing course is placed on the traffic lane, but not the shoulders (e.g. open graded asphalt), this should extend for the full width of shoulders on the high side of superelevation. The wearing course should extend for a minimum of 0.3 m beyond the edge line to minimise the risk associated with the edge drop-off.
4. Lanes adjacent shoulders may be reduced to 3.2 m in constrained situations, provided shoulders are a minimum of 1 m.

Note: Managed freeways include variable speed limits, lane control signs, incident management, vehicle detectors and monitoring (real time manual or automatic).

Table A1 indicates that lane widths of 3.3m on managed motorways are acceptable values when combined with median and left shoulder widths of 1.0m and emergency stopping bays are provided. This will be used as our criteria to evaluate our design proposals against (for instance the reduction of median shoulder width). We propose to use 3.3m lane widths rather than the 3.25m lane widths previously agreed by VAC.

4.4.2 Shoulders

Shoulder widths will be based on Table A1 above (EDD widths).

Final shoulder widths will depend on the chosen work package, however the general approach will be to provide wider lanes at the expense of shoulder width if a trade-off is required.

4.4.3 Clear Zones

The preferred method of treatment for all hazards on state highways has typically been to provide a trafficable 9m wide clear zone no steeper than 1:6 (v:h). This will not be possible in the constrained motorway environment such as the NtAQ section of the motorway. Therefore edge barriers will be provided if newly constructed hazards require protection, as per the existing situation.

4.5 Sight Distance

This is a high speed urban section of motorway with alert drivers and few intersections; however the alignment is generally curvilinear with few sections of straight road. We have therefore adopted a driver reaction time of 2.5 seconds for sight distance calculations.

4.5.1 Main Carriageway

All traffic lanes on the main carriageway for the proposed work packages will be evaluated against the following two stopping sight distance (SSD) criteria:

- 1 x SSD from a driver eye height of 1.10m to an object height of 0.2m.

TThe evaluation of the design’s ability to meet the SSD criteria will assist in the selection and use of EDD standards.

4.5.2 Off-ramps

Where possible and if modifications are required to the off-ramp diverge, all alterations to off ramps (Aotea Quay and if necessary the SH2 off-ramp to the Hutt Road / Ngauranga Gorge intersection) and their approach lanes will be designed to comply with the following criteria:

- 310m from an eye height of 1.10m to the start of the diverge taper (object height 0.0m);
- 310m from eye height of 1.10m to the pavement adjacent to the ramp nose(object height 0.0m); and
- 310m from an eye height of 1.10m to the pavement (zero) through the diverge to 60m past the nose.

The following criteria will apply if modifications are required at the off-ramp terminal at Ngauranga or if the signalised intersection is modified to provide more capacity:

- Approach sight distance (ASD) and safe intersection sight distance (SISD) will be provided at the ramp terminal intersection. (ASD eye height = 1.10m to 0.0m object height, SISD eye height = 1.10, object = 1.25m); and

4.5.3 On-ramps

All modifications to the Hutt Road / SH2 on ramp will be designed to comply with the following criteria:

- Approach to: 6 seconds of travel time at respective operating speeds on each carriageway prior to the nose (1.10m eye height to 0.1m object height)
- Mutual visibility between carriageway: 4 seconds of travel time at respective operating speeds for each carriageway prior to point where merging lanes are separated by 2m (1.10m eye height to 1.10m eye height)
- Terminal visibility: 6 seconds of travel time at operating speed to any point on merge taper (1.10m eye height to 0.0m object height)
- Approach sight distance (ASD) and safe intersection sight distance (SISD) will be provided at ramp terminal intersections. (ASD eye height = 1.10m to 0.0m object height, SISD eye height = 1.10, object = 1.25m)
- Minimum gap sight distance (MGSD) will be provided at unsignalised ramp terminal intersections. (MGSD eye height = 1.10m, object height = 0.65m)

4.5.4 Local Road Intersections

This will apply if work packages are chosen that include changes to the signalised intersection at Ngauranga and the creation of a full movement intersection at the Aotea Quay off ramp terminal (changes to this terminal will be driven by external organisations).

- Approach sight distance (ASD) safe intersection sight distance (SISD) will be provided at local road intersections (ASD eye height = 1.10m, object = 0.0m, SISD eye height = 1.10m, object height = 1.25m); and
- Minimum gap sight distance (MGSD) will be provided at local road unsignalised intersections (MGSD eye height = 1.10m, object height = 0.65m).

4.6 Vertical Clearances

New or modified sign gantries will be designed for a minimum vertical clearance of 6m. Vertical clearance to gantries and signs over local roads will be designed in accordance with the WCC council requirements.

4.7 Design Vehicles

The design vehicle used for all movements will be a 19m quad axle semi-trailer. All turning movements will be assessed using the general minimum turning radius rather than the absolute minimum turning radius. This allows for greater capacity through ramp terminals and intersections.

All multi-lane turn movements shall be designed so that the primary design vehicle can use any lane with a 90th percentile car turning in the adjacent lane.

4.8 Emergency Refuge Areas

4.8.1 Location, Design and Need

The location and design of the Emergency Refuge Areas (ERA) will depend on the chosen work package, the rate and type of incident occurrence and the design lane and shoulder widths. It is anticipated that the design vehicle will be a 95th percentile car and tow truck combination with low speed deceleration requirements. ERAs will also be designed to allow intermittent (off-peak) access to ATM gantries (this may be via a pathway behind a guardrail).

4.9 Local Roads

4.9.1 General

All local roads changes will be designed, in consultation with WCC to meet their design guidelines. The extent of work undertaken on local roads will depend on the final work package chosen. There may be locations were existing roads and access will require realignment. In all such situations design solutions will be developed and discussed with NZTA and then with WCC and / or the affected property owners.

4.9.2 On and Off-ramps

On ramp modifications will be designed to allow for future ramp signalling if not constructed as part of this project.

4.10 Other Transport Modes

4.10.1 Cycleway and on-road cycles

There is an existing southbound cycleway adjacent SH2 (on the eastern seaboard side) separated from the highway by a wire rope barrier. In the northbound direction cyclists can use the existing sealed shoulder to ride in and there are marked cycle paths in the shoulder. Cyclists commonly use the left hand shoulder of the Hutt Road / SH2 on ramp to access SH2 northbound. Design of any changes to the on-ramp will consider the existing cycle facilities and connectivity will be maintained.

Cyclists will continue to be banned from using the motorway and there is no intention to extend the separate southbound facility further south of Ngauranga as part of this project.

5 Pavement Design

5.1 General

Pavement design will generally fall into four categories;

- Existing motorway and state highway pavements to be retained as they are
- New motorway pavements (if required);
- Existing motorway and state highway pavement rehabilitation and widening (if required); and
- Local road pavements (if required).

5.2 Design Standards and References

Any new motorway pavements, rehabilitation and widening will be designed to match the existing pavement (Open Graded Porous Asphalt (OGPA) surfacing over a granular pavement or concrete bridge structure base).

New pavements on the non-motorway section of the project e.g. if changes are made to the Hutt Road / SH2 on ramp) will be designed to match the existing adjacent pavements, full pavement rebuilds will be avoided wherever possible.

If changes are required to local roads, the pavements will be designed in accordance with the requirements of the WCC.

New pavements will be designed in accordance with Austroads (2004) Pavement Design Guide and the TNZ supplement (2007). We are aware that there is a 2009 Austroads Guide with a 2010/2011 supplement due out in the next 12 months which will be used during the detailed design phase. A design life of 30 years will be adopted as required by the NZ Transport Agency (NZTA).

The design life of existing pavements will also be assessed using this criterion to determine if a whole-of-life rehabilitation solution should be implemented as part of this project.

5.2.1 Assumptions

The pavement design and / or evaluation will be based on the following supplied data and assumptions:

- 30 year design life;
- 95% project reliability;
- A motorway and state highway design speed of 110 kph ;
- Subgrade CBR data obtained from ground investigations; and
- Final calculations of predicted traffic flows and percentage of heavy vehicles will be determined once the work package configurations and regional freight strategies and models have been confirmed.

5.2.2 Traffic Loadings

Traffic volumes and heavy vehicle percentages will be extracted from the traffic model and data obtained from heavy vehicle operators in the region. A growth rate based on historic data will be assumed between traffic flows of 2012 and 2016. Transport model results will be used between 2016 and 2026. From 2026 onwards an arithmetic growth rate based on historical trends and traffic modelling will be used.

6 Active Traffic Management Design

6.1 General

Table 6-1 lists the existing NZTA Intelligent Transport Systems (ITS) Standards and Specifications that will be used to facilitate any design and implementation associated with the NtAQ project. Under each Standard and Specification will be a brief description detailing the relevance of the specification and if necessary any departures that will be needed to the document in order to make them specific to the Wellington region.

For any item of ITS or operational methodology that falls outside the scope of these standards and specifications that are deemed necessary for NtAQ, an amended or new standard/specification will be created.

Table 6-1 Draft National ITS Standards/Specification and Departures

Draft National ITS Standards/Specifications		Departures
ITS-01 General	**01 General Requirements** Outlines the minimum requirements for documentation, reliability and availability that will need to be supplied within an ITS/Active Traffic Management System (ATMS) project.	§ Section 2.2 Preliminary Documentation, agreement will need to be sought with NZTA Wellington to confirm the wording within this section is applicable to the region and their methods of management. § Section 3 ITS Numbering System, the system detailed within this section relates to the numbering system that is currently employed within the Auckland region, the method of ITS numbering in Wellington will need to be established and referenced within this section. § Section 5 Glossary of Terms, local terms will need to be included.
	02 Environmental Requirements Outlines the operating conditions that all ITS assets will be expected to work within including the following: § Vibration; § Wind buffeting; § Spray drenching; § Dust and grit intrusion; and § Oil, bitumen and vehicular emissions.	§ Environmental Requirements applicable to the Wellington region.
	03 General Electrical Requirements Outlines the work required in the provision of a complete working electrical system	§ No departures.
	04 Civil and Motorway Site Works Outline the requirements for the detailed design and construction of general civil and motorway site works associated with ITS sites.	§ The reference to Auckland will need to removed and replaced with a generic statement of the "NZTA Motorway Network".
	05 Support Structures and Foundations Outlines the minimum requirements for detailed design and construction of structures and their associated foundations for NZTA ITS equipment installation	§ No departures.

Draft National ITS Standards/Specifications		Departures
ITS-02 Communication Infrastructure	**01 Duct Supply and Installation** Outlines the requirements for the design and construction of the ITS Communication Infrastructure mainline, local power, fibre optic, control cables and loop feeder cable ducts.	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	02 Jointing Chambers and Pull Pits Sets out the requirements for the design and construction of the ITS Communications Infrastructure cable pull pits, jointing chambers, local power, fibre optic, control cable, loop feeder cable pits and toby boxes.	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	03 Optical Fibre Supply and Installation Sets out the requirements for the supply and installation of the ITS Communications backbone and local fibre cable.	§ A detailed review of this document will need to be undertaken against the current methodology of Wellington's fibre installation to ensure the process and procedures detailed within will be applicable to Wellington. § Change Control procedures will need to be assessed for their suitability in the Wellington region
	04 Roadside Cabinets Sets out the requirements for the installation of Roadside Control Cabinets and Network Node Cabinets.	§ Section 1.3 Roadside Cabinet Numbering, as per ITS-01-01 General Requirements the Wellington numbering will need to be followed § Section 3.4 Optical Fibre Interface supply of Network Switch. Confirmation of the type of Network Switch currently used within the Wellington region § Section 3.5 ITS Network Change Control, a review in conjunction with ITS-02-03 will need to be undertaken for its suitability to Wellington § Attachments, Auckland reference to be removed and either a generic statements or Wellington references inserted.
ITS-03 Vehicle Detection Systems	**01 Inductive Loop and Feeder Cables** Sets out the requirements for the supply and installation of inductive loops	§ No departures.
	02 Traffic Counting System Sets out the minimum requirements for the installation of Traffic Counting Sites	§ No departures.

Draft National ITS Standards/Specifications		Departures
ITS-04 Lane Control System	**01 Lane Control System (LCS) Civil and Structural Works** Sets out the minimum requirements for the supply and construction of the civil and structural works for the lane control system field installations.	§ Dual pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § Single pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § LCS support structure will need to be identified detailing units connection to post mounted installation
	02 Lane Control Signal Supply and Installation Sets out the minimum requirements for the supply, testing, installation and commissioning of the lane control system.	§ No departures.
ITS-05 Ramp Meter System	**01 Ramp Meter System Layout** Is used to identify the design requirements for the equipment layouts at a Ramp Meter Site in order for a detailed design to be undertaken.	§ No departures.
	02 Ramp Meter Supply and Installation Sets out the requirements for the supply, testing, installation and commissioning of a Ramp Meter System.	§ No departures.
	03 Ramp Meter System Standard Drawings Details all the standards drawing associated with Ramp Meter Systems.	§ No departures.
ITS-06 Variable Message Signs	**01 Variable Message Sign Civil and Structural Works** Sets out the minimum requirements for the supply and construction of the Variable Message Sign Field Installation civil and structural works.	§ No departures.
	02 Variable Message Sign Supply and Installation Sets out the requirements for the supply, testing, installation and commissioning of Motorway Variable Message Sign, within section 1.7.	§ ITS-01-02 Environmental Requirements is referenced which as explained previously will need to updated to identify Wellington conditions.

Draft National ITS Standards/Specifications		Departures
ITS-07 Closed Circuit Television	**01 Closed Circuit Television Civil and Structural Works** Sets out the requirements for the supply and construction of the Closed Circuit Television (CCTV) Field Installation civil and structural works.	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
	02 Closed Circuit Television Supply and Installation Sets out the requirements for the supply, testing, installation and commissioning of a CCTV camera. This specification contains two types of camera, these being: § Motorway Surveillance PTZ CCTV; and § IP enabled Web Camera.	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
ITS-08 Incident Detection Systems	**01 Automatic Video Incident Detection** Outlines the minimum requirements a contractor will need to meet in the supply, testing, installation and commissioning of an Automatic Video Incident Detection System.	§ No departures.
	02 Over Height Vehicle Detection Outlines the minimum requirements a contractor will need to meet in the supply, testing, installation and commissioning of an Over Height Vehicle Detection System	§ No departures.
ITS-09 Motorway Emergency Telephones	**01 Motorway Emergency Telephone** Outline the minimum requirements a contractor will need to meet in the supply, testing, installation and commissioning of an Emergency Roadside Telephone (MET).	§ Currently this specification details standard installation of MET but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for MET.
ITS-10 Testing, Commissioning and Handover	**01 Testing, Commissioning and Handover** The purpose of ITS-10-01 is to define the process that is to be followed in the delivery and handover of ITS Systems and Components into Operation and Maintenance (O&M).	§ This document is intended to be a guideline and a detailed Handover & Commissioning Plan will be developed for the preferred work package using this specification as reference

7 Stormwater Management

7.1 General

Our approach will be to evaluate the design solutions against the requirements of the applicable NZTA standards and the geometric design in order to determine if and what stormwater management changes are required. This section outlines the design criteria to which this evaluation will be carried out.

Similar to the geometric design an outline of the process we will follow is shown below:

i. Understand the existing geometric alignment and impervious width;

ii. Develop geometric sub-options that would fit between the existing lanes and barriers (for work packages 1, 2 and 3), thereby reducing or negating the requirement for new stormwater management infrastructure;

iii. Test geometric design against accepted standards;

iv. Identify deficiencies;

v. Modify design to mitigate deficiencies (including looking at options outside the existing barriers and realignment) and identify any requirements for new stormwater management;

vi. Agree design standards to be applied.

NZTA's approach to stormwater management sets the context and framework for stormwater management on this Project. This approach, noted in NZTA's Stormwater Treatment Standard for Road Infrastructure, is:

"To provide best practice for both stormwater quantity and quality control that, in the absence of local requirements or where local requirements are limited, NZTA will undertake to demonstrate environmental responsibility"

For NtAQ, the stormwater management can be divided into five general areas:

- Stormwater quantity;
- Stormwater quality
- Pavement surface drainage;
- Subsurface drainage; and
- Wider catchment stormwater management.

The NtAQ project will interact will the following stormwater and related features along the route:

- Kaiwharawhara stream;
- Wellington Harbour;
- Korimako stream;
- Local WCC / GWRC drainage networks; and
- Other yet unknown drainage for KiwiRail and the Interislander Ferry Terminal.

7.2 Design Standards and References

The evaluation will be against the NZTA requirements for highway serviceability and the RoNS standards, but will also be consistent with expected conditions of Consent for stormwater discharge to the harbour environment and associated work in watercourses. The design will be prepared according to the following standards and guidelines as appropriate:

- Roads of National Significance Design Standards and Guidelines;
- Stormwater Treatment Standard for State Highway Infrastructure, 2010, NZTA;
- The Environmental Policy Manual, 2005, NZTA;
- Austroads Part 5: Drainage Design, 2008;
- WCC CoP for Land Subdivision: Sewer and Stormwater Design and Construction;
- Ministry for the Environment, Tools for Estimating the Effects of Climate Changes on Flood Flow, 2010;
- TNZ F3 Pipe Culvert Construction;
- TNZ Highway Surface Drainage: A Design Guide for Highways with a Positive Collection, 1977;
- GWRC Regional Fresh Water Plan;
- WCC District Plan;
- NZS4404:2010 Land Development and Subdivision Engineering; and
- Verification Method E1/VM1, New Zealand Building Code.

7.3 Design Constraints

The following are identified as stormwater design constraints:

- Not increasing flooding to land upstream or downstream;
- Existing flood levels, routes, storage areas and floodplains;
- Existing underground utilities;
- Existing Structures (e.g. Thorndon Overbridge) and culverts etc;
- Lack of drainage as-built records; and
- Any new culvert's capacity 100yr with 2m mead or to 0.5m of carriageway and 10yr to 5 off .7 of culvert or WCC Standard may take precedent if the culvert passes under a local road.

7.4 Design Assumptions

The key assumptions for the design are:-

- Existing drainage is unlikely to have sufficient capacity for current design standards. Effects of this will be considered on a case by case basis;
- The capacity of WCC downstream network is unlikely to be of sufficient capacity to match NZTA standards however, this requires further investigation to confirm potential implications;
- Kerb and Channel is to be used due to spatial restrictions. This will have a bearing on the type of drainage (i.e. sumps) and treatment used i.e. no room for swales and ponds;
- Attenuation could be required where discharging to WCC or other networks (i.e. not needed where direct to harbour). However this will be considered on a case by case basis in agreement with WCC/GWRC. Significant attenuation is expected to be difficult to practically achieve.
- Stormwater runoff maybe required to be treated prior to discharge if the impervious areas change. This is most likely to involve proprietary devices rather than swales and wetlands because of spatial constraints.

7.5 Principal Elements

7.5.1 Hydrologic Design Criteria

Design Rainfall Intensity

We note that the WCC Code of Practice is slightly more conservative than NIWA's (e.g. HIRDS V3.0) even with climate change factored in. Therefore, all stormwater works for this project will be designed using rainfall data in accordance with Section D of WCC CoP.

Runoff Coefficient

Runoff from carriageway catchment will be determined by Rational Method. According to Table 1 of The New Zealand Building Code Handbook, the following run-off coefficient will be used:

- Impervious area (e.g. paved surfaces) C=0.85; and
- Pervious area (e.g. grass, vegetation etc.) C=0.30.

Future development may need to be considered in accordance with the District Plan where existing cross culverts are being assessed.

7.5.2 General Design Requirements

The general design requirements for the project with respect to the management of stormwater runoff are:-

- The drainage design shall comply with Resource Consent conditions;
- Drainage pipes shall be designed with a minimum life expectancy of 100 years;
- If practical, no access structures shall be located in the sealed carriageway;
- Where practical, all new longitudinal pipelines shall be designed such that they are outside the carriageway; and
- The drainage design will allow for runoff from beyond the motorway designation to the extent dictated by the natural topography (e.g. KiwiRail reserve area).

7.5.3 Pavement Surface Design

Aquaplaning

If alignment and pavement areas are changed, specific design is likely to be required at altered merge and diverge areas. Aquaplaning will be checked so that the maximum surface water depth at any point on any running lane, including merge, diverge and gore areas, during a storm of 50mm/hr is not greater than 4mm above the top of the surfacing texture (assuming that the existing OGPA or new pavement provided is fully clogged). In situations where the standard cannot be achieved, such as super-elevation development, specific departure will be required from NZTA.

At super elevated areas of the alignment, the drainage design will include for the collection of stormwater adjacent to the centreline. No stormwater from the uphill side of the carriageway will be allowed to flow across the pavement of the opposing lanes of traffic or, in the case of on/off ramps, across the pavement of traffic on adjacent carriageways.

Sufficient inlet capacity will be provided on the main SH1 carriageway so that surface drainage flow does not encroach into the carriageway during a ten minute, 10% AEP (1 in 10 year return period) storm. The maximum depth of water shall not exceed 100mm deep in the channel and its velocity will not exceed 2m/s.

The design capacity of the pipe system shall be sufficient for the 10% AEP peak flows where there is a secondary overland flow path. In the locations where there is no secondary overland path, the pipe capacity shall be designed to convey the 1% AEP peak flow. Existing overland flow paths will be maintained along the road network.

In a ten minute, 1% AEP rainfall event one lane of carriageway may be covered with water that is no more than 100mm deep and its velocity will not exceed 2m/s. On a ramp in the same event, there shall be at least 2m of carriageway free of water.

Stormwater Runoff Collection Systems

If alignment and pavement areas are changed, a positive collection system is likely to be required at each side of the pavement for the collection and conveyance of surface stormwater to treatment devices prior to discharge.

If required, new cesspit leads will have a minimum diameter of 300mm diameter and all culverts will be 375mm diameter minimum. Cesspit leads will connect directly into the manhole chamber within a greater pipe network.

Where kerb and channel or slot drain is used, grated inlets to piped stormwater systems will have either a bypass that enables the inlet to remain effective should the grate become clogged with debris, or an overland flow path provided. All grates will be designed to carry a HN-H-072 vehicle wheel load.

Where practical, all cesspit inlets to the piped stormwater system will have a secondary flow path that prevents any ponded stormwater encroaching on the running lanes in the event of a blockage of the inlet.

High capacity cesspits may be required at low points on the main carriageway alignment and at low points on the access ramps instead of standard double sumps. There will be sized assuming a 50% blockage of the next cesspit upstream. The capacity of a pipe network upstream of the low point must also be taken into consideration.

All existing manholes that are currently positioned within lanes on pipeline crossings will be adjusted to suit final levels if required. New heavy duty bolt down (i.e. Gatic type lids) will be used if existing lids are not to a similar standard.

Stormwater Conveyance Systems

For new infrastructure, if required, the minimum pipe network diameter will be 300mm.

All outlet structures will be specifically designed so that adequate energy dissipation is considered and that the effect of the discharge does not cause scour / erosion within the immediate receiving environment.

Pipework will be designed to achieve a self-cleaning velocity of at least 0.75 m/s.

A manhole access chamber within the pipe network will be placed at a maximum of every 90m and as appropriate to suit required cesspit locations.

Stormwater Treatment

We have made the following assumptions regarding Stormwater treatment:

- The storm water runoff is to be treated if the impervious area changes (i.e. we increase the pavement area) and
- The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected.

If required, the stormwater treatment would most likely involve proprietary devices rather than swales and wetlands because of spatial constraints.

If required, treatment is to be carried out to Best Practicable Option (BPO). Runoff from the motorway is to be collected and passed through stormwater treatment devices, prior to discharging to the receiving environment. Particular sensitive environments are the harbour, Kaiwharawhara stream and the Korimako stream.

The treatment devices will address the removal of gross debris, suspended sediment, heavy metals, and hydrocarbons, will be in accordance with NZTA's Stormwater Treatment Standard for State Highway Infrastructure.

Stormwater Attenuation

Stormwater attenuation may be required in areas where discharges occur to WCC networks. This is to avoid overloading the receiving network and to mitigate the effects of these existing networks being designed to a lesser standard than NZTA's requirements. Given the location of the motorway attenuation is expected to be very difficult to achieve.

Maintenance Considerations

Access to all new drainage system (including access for vehicles such as vacuum trucks etc), will be considered during the design for safe and appropriate access for inspection and maintenance traffic control.

Minimising traffic management requirements will also be considered in the design.

7.5.4 Wider Catchment Stormwater Management Design

Floodplains and Flood Storage

The effect on existing flood plains and flood storage areas may need to be tested in the WCC / hydraulic models. Any effects will be minimised or mitigated to the approval of WCC / GWRC, particularly appropriate at Kaiwharawhara and Ngaio, heading streams and the existing 1200 diameter culvert near Hutt Road.

Cross Culverts

Any new culvert will have a 1% AEP capacity with a 2m head or up to 0.5m of the carriageway and in a 10% AEP storm, heading to soffit of culvert. The WCC standard may take precedence if the culvert passes under a local road.

8 Structures

8.1 Design Standards and References

8.1.1 Bridge Design Standards

The Transit New Zealand Bridge Manual (TNZBM) Second edition 2003 and the material design standards specified therein define the general design criteria to be adopted for the structures. This includes the June and September 2004 amendments and the Provisional Amendment dated December 2004.

The Roads of National Significance (RoNS) Design Standards and Guidelines include a number of bridge related requirements. These include:

- Use of Texas HT edge barriers on bridges; and
- Full width 3m shoulders to be taken over full bridge length.

Where the Transit Bridge Manual does not address the specific requirements the appropriate Australian or UK bridge design standards are referenced.

8.1.2 Materials and Finishes

The choice of materials and finishes for bridges and retaining walls will be developed in conjunction with the urban design team.

8.1.3 Lighting

Provision is to be made in the design of vehicle and pedestrian/cyclist bridges for the support and integration of lighting requirements.

8.1.4 Sign gantries

Provision is to be made in the design of all vehicle and pedestrian bridges for required signage.

8.1.5 Retaining walls

The form and location of retaining walls will be determined in close collaboration with the wider design team.

8.1.6 Provision for services

Provision is to be made on structures to accommodate existing and where appropriate future services. Requirements are to be determined in consultation with NZTA, Utility companies and WCC.

8.2 Thorndon Overbridge

8.2.1 General

Thorndon Overbridge comprises twin three lane (2x3 lanes) elevated concrete bridges located on the reclaimed foreshore of Wellington Harbour. Constructed between 1967 and 1972, the overbridge forms part of an important link from Wellington City to the north. It is 1.3 km long and carries State Highway 1 over the main trunk railway, an extensive area of rail yards, the Inter Islander Ferry Terminal and three important access roads into Wellington City; Hutt Road, Aotea Quay and Thorndon Quay. The reclaimed land was placed between 1882 to 1970. The reclamations typically consist of 4m to 16m of gravel rockfill or pumped hydraulic fill and overly a 1 to 2m layer of sandy gravel Holocene beach and marine sediments.

The superstructure consists of simply supported precast concrete 'I' girders with spans of up to 41m on large cellular box pier cap umbrellas via half joints. Substantial seismic linkage bolts tie the girders onto the umbrellas. The substructure consists of multi column framed piers on driven piles and single column piers on either driven or bored piles. The existing southbound and northbound carriageways are typically 11.5m wide and carry 3x3.5m traffic lanes plus 0.5m shoulders. The bridge layout is shown in **Figures 8-1 to 8-3**.

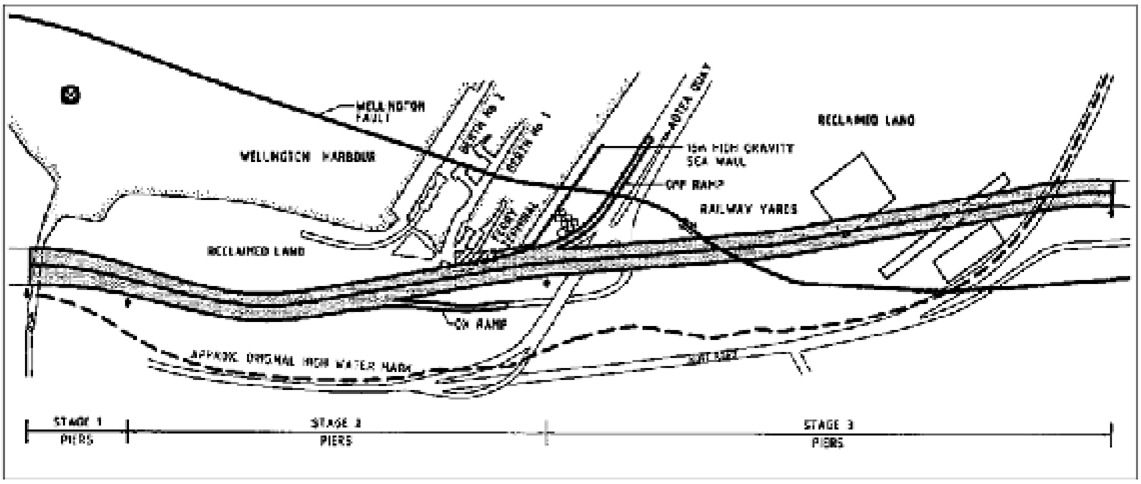

Figure 8-1 - Thorndon Overbridge Plan

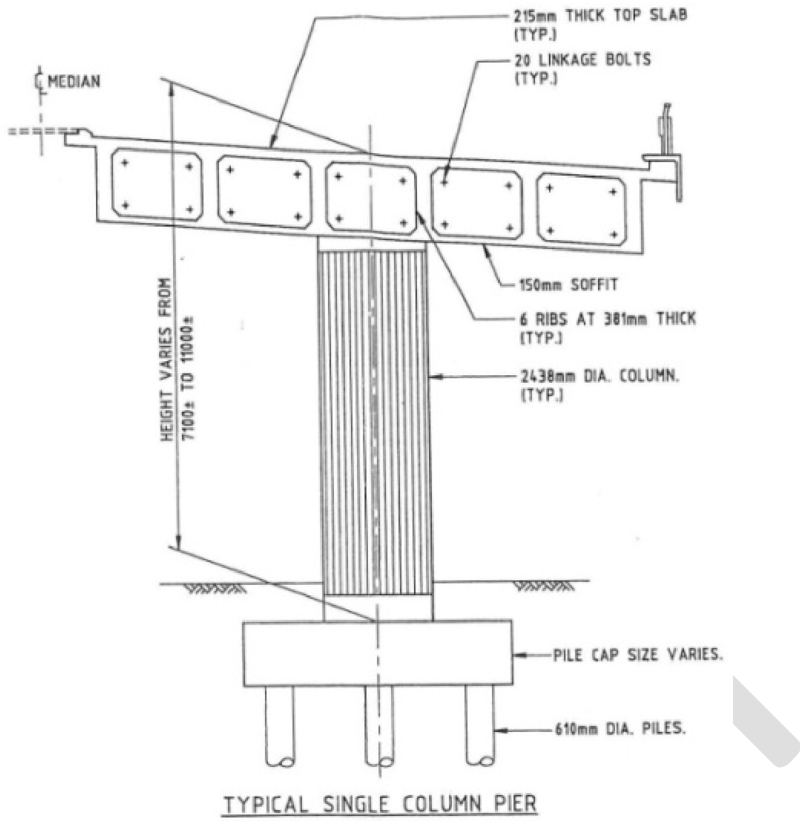

Figure 8-2 – Typical Single Column Pier

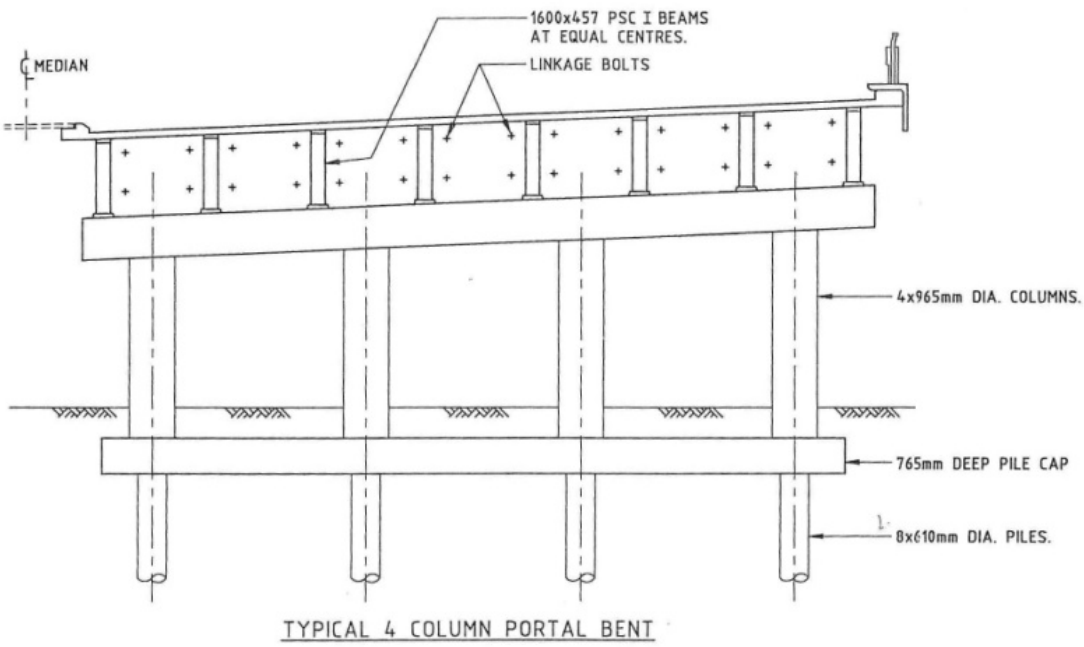

Figure 8-3 – Typical Four Column Portal Bent

8.2.2 Seismic Performance

The bridge is located in an area of high seismicity and crosses over the Wellington Fault, the dominant active fault in the area. A site specific hazard study carried out as part of the retrofitting project in the mid 1990's, showed that permanent ground displacement of approximately 5 m horizontal and 1m vertical can be expected from a Wellington Fault event.

The original structure was not designed using the "capacity design" concept of modern codes and consequently had serious seismic vulnerabilities. The structure was seismically retrofitted in the mid 1990's. The retrofit involved linkage beams across pilecaps to improve resistance to lateral spreading, pilecap strengthening, column jacketing, portal pier infill walls, linkage bolt modifications and steel catch frames on piers crossheads adjacent to the Wellington Fault to support the deck unseated by a fault rupture. Post retrofit performance is expected to be adequate under seismic events of up to a 500 year Annual Probability of Exceedance (APE). This was considered an appropriate level of retrofit that was economically and technically feasible at the time, given the geotechnical conditions at the site, the risk of liquefaction and lateral spreading and the preference not to undertake ground improvement measures. In comparison, the latest NZTA standard, classifies State Highway 1 as an Importance Level 3 route, which would require a 2500 year earthquake APE for design of a new bridge on this route for a 100 year design life.

The seismic strengthening undertaken in the 1990's was carried out to achieve a 500 year APE rather than a higher standard because of the extensive ground improvement works that would have been required to mitigate the risk of liquefaction and lateral spreading. Therefore, the decision was taken to retrofit the bridge to a level that could be achieved without extensive ground improvement works.

The philosophy adopted for this project to widen the existing Thorndon Overbridge is to accept the previous 500 year APE design standard and to not seek to increase the seismic performance above this level due to the significant costs that would be involved in ground improvements to mitigate the risk of liquefaction and lateral spreading. At the same time it is proposed that the proposed widening should not reduce the seismic performance of the bridge below the 500 year APE.

8.2.3 Edge Barriers

The existing side protection barriers have recently been replaced along the bridge. It is understood that the new replacement barriers have been designed to provide a TL4 "high" protection level, using "nested" steel Thriebeam barriers. TL5 barriers can not be installed to the existing deck due to the high loads that would be imposed on the existing deck slabs.

8.2.4 Southbound Carriageway Widening

As part of the scheme to reduce congestion and improve journey time reliability of State Highway 1 between Ngauranga Gorge and the Aotea Quay off-ramp, the southbound carriageway width over Thorndon Overbridge needs to be increased from northern abutment to Aotea Quay off-ramp.

The northbound carriageway will also require widening between the Aotea Quay on-ramp and the northern abutment, but the additional width can be accommodated within the existing structure width because of the wider existing shoulder on the northbound carriageway

Two concept options have been considered for increasing the southbound carriageway width from the northern abutment to Aotea Quay off ramp. The first option is construction of a "clip-on" widening deck and the second option is provision of a separate elevated off-ramp structure. Both options assume that the existing Aotea Quay off ramp will be retained as existing.

a. Clip-on Option

Figure 8-4 shows an indicative concept sketch for the “clip-on” widening option. In this option, the deck extension ties into the existing deck along the whole length of the widened section. Considering that the “gap” at the median between the northbound and southbound decks is only 1.37m (approx.) wide, it is proposed to widen the bridge 1.0m on the median side and 1.6m on the outer edge. A minimum “gap” of 0.37m is maintained between the two decks to avoid pounding during an earthquake event. This widening arrangement is suitable for accommodating four traffic lanes of up to 3.25m wide each plus 0.6m wide inner and outer shoulders.

Composite structural steel girders and concrete slab deck are proposed. The extension will be supported off the existing piers using an extension to the umbrella or framed pier heads. This arrangement has been proposed to minimise additional weight and corresponding seismic effects on the existing substructure. A preliminary assessment shows that deck widening to this extent, will not adversely affect the seismic performance of the existing structure and the adopted 500 year APE for the recent seismic retrofit works will not be compromised since the existing piers and foundations have sufficient seismic capacity for this increase in load. However, adoption of a higher seismic design standard would require further strengthening of the pier and foundations, as well as extensive ground improvement measures to mitigate liquefaction and lateral spreading which would result in a very high cost.

It may also be possible to widen the deck 2.6m on the outer edge to achieve the full 3.5m lane widths for all four lanes; however this will be subject to a detailed analysis of the substructure, foundations and geotechnical aspects. A preliminary analysis shows that widening to this extent would increase the vertical and earthquake loads by approximately 15% and 10% respectively.

It is further assumed that for a “clip-on” widening option; the current TL4 performance level side protection barriers will be retained.

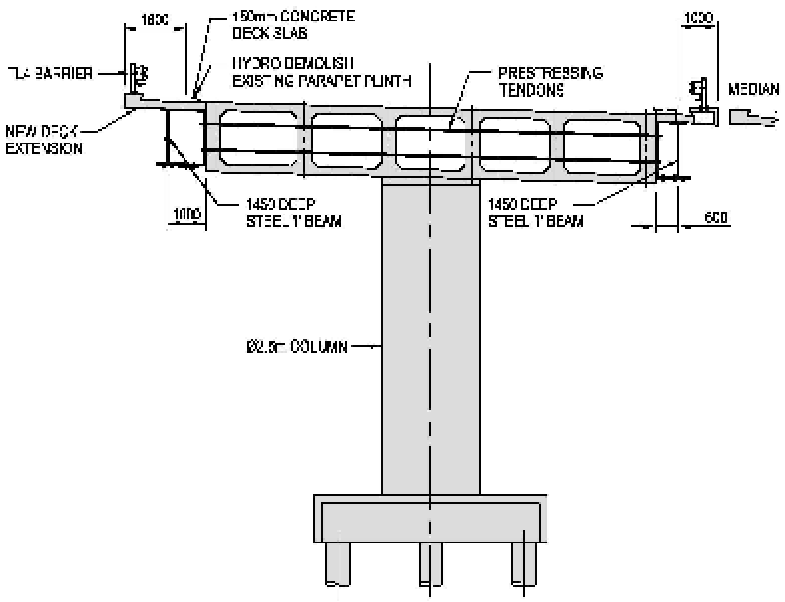

Figure 8-4 – Indicative Sketch of “Clip on” Option

b. Separate off-ramp option

Figure 8-5 shows an indicative concept sketch for a typical pier section for the separate elevated off-ramp structure option. The carriageway configuration in the option comprises two 3.5m wide traffic lanes plus 0.6m wide inner and outer shoulders. This corresponds to a 9.2m wide overall deck width including plinths for side barriers. Span lengths are anticipated to be in the range of 30 - 60m based on the location of constraints through the site. A tie-in to the Thorndon Overbridge is required near the existing Aotea Quay off-ramp structure. This requires a partial deck widening to the existing overbridge supported off an extension to the pierhead at Pier 19.

This option has not been investigated as part of the current study, however a Concept Design Constraints Review undertaken for NZTA by Holmes Consulting Group in 2010, recommended that a minimum earthquake 1000 year APE should be adopted for this option. Considering that the separate elevated off-ramp structure is not part of the main State Highway 1, an Importance Level of 2 could be adopted, corresponding to a 1000 year APE. Liquefaction and lateral spreading across the site is assessed to occur under a 200 year return period earthquake. Therefore design for a 1000 year APE, will require the new piles to be designed for liquefaction and lateral spreading or significant amounts of ground improvements to be undertaken to ensure satisfactory performance of the structure during a significant earthquake event. Design for a 1000 year APE is proposed due to the significantly higher cost of designing for a 2500 year APE due to the loads on the structure from liquefaction effects.

It is assumed that a TL5 performance level side protection barrier will be adopted for a new separate off-ramp structure option. This is due to the higher risk factors associated with the alignment of a new off-ramp structure through the rail yard, as well as the ease of accommodating a higher test level barrier for a brand new structure.

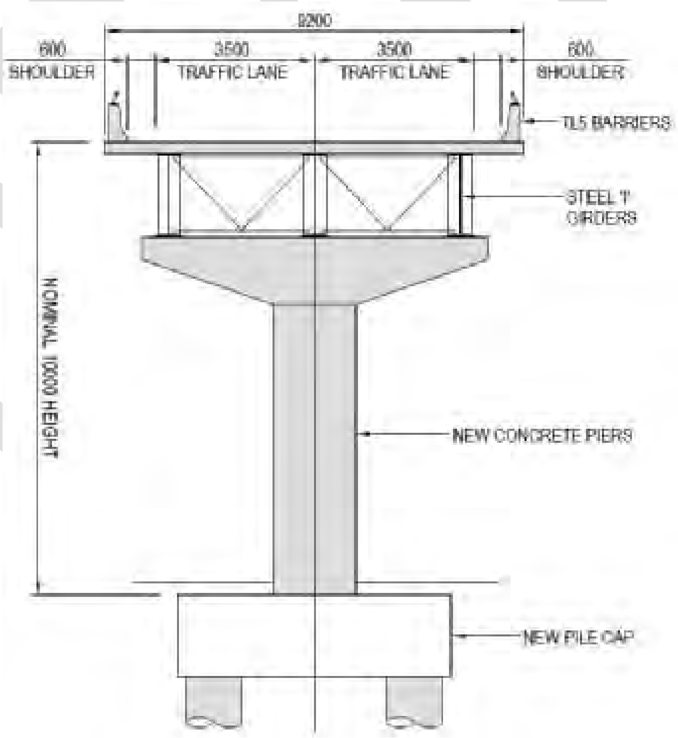

Figure 8-5 - Indicative Sketch of a Standalone Bridge Structure

In both options, all new structural elements will be designed to achieve a 100 year design life. It is assumed that the vertical clearance under the deck will be retained broadly in line with the existing Thorndon Overbridge. Typical vertical clearances are minimum 6.0m over railway lines and roads.

8.2.5 Preferred widening option

A preferred option will be selected at SAR stage after completing a full assessment and cost estimate for each option.

8.2.6 Recommended design standards

For the options described above, the following design standards are proposed for Thorndon Overbridge:

For widening option using a “clip-on” option:

- Existing 500 year APE will not be adversely affected (10% additional seismic load on substructure is within existing capacity of piers and foundations);
- Our approach will use four 3.3m traffic lanes and narrow (0.5m) shoulders; and
- TL4 “high” protection level “nested” steel Thriebeam side protection barriers as per the existing structure.

For a separate off-ramp structure:

- 1000 year APE;
- 2 x 3.5m traffic lane with 0.6m inner and outer shoulders;
- TL5 side protection barriers; and
- Vertical clearance broadly in line with existing Thorndon Overbridge.

8.2.7 Aotea Quay Off-Ramp

The existing Aotea Quay off-ramp is a 9 span structure with a 5.79m wide carriageway, which is sufficient to provide a 3.5m wide single lane carriageway plus substandard shoulder widths. **Figure 8-6** shows a typical cross section of the ramp at the pier location.

The existing Aotea Quay off-ramp is located in one of the most vulnerable areas of Thorndon overbridge. It is founded on soils which include a pocket of highly liquefiable sand and it also crosses the Wellington Fault. There is mass concrete seawall up to 14.5m high, which runs beneath the Aotea Quay Wharf past the Ferry Terminal building and alongside Piers 18 and 19 of the existing Thorndon Overbridge.

The off-ramp structure has not been retrofitted as part of the Thorndon Overbridge retrofitting project undertaken in mid-1990’s due to the high cost of ground improvements required. The liquefaction of the off-ramp is predicted to occur at a 200 year APE, leading to lateral spreading of ground in this area and subsequent collapse of the seawall and off ramp structure.

It is assumed that the current Aotea Quay off-ramp bridge will be retained as existing in all proposed widening options and will not be modified, strengthened or replaced on the basis that there will be no change to the current risk profile for this structure.

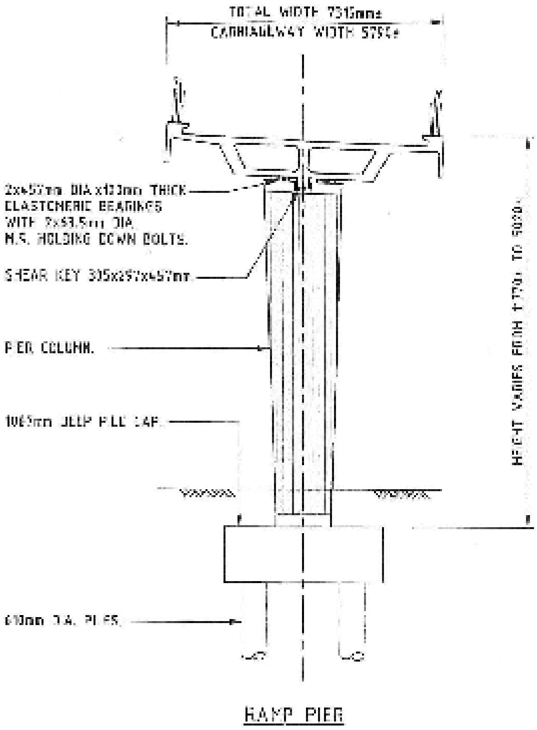

Figure 8-6 Existing Aotea Quay Off-ramp

For the option described above, the following design standards are proposed for the existing Aotea Quay off-ramp:

- Existing structure will not be modified, strengthened or replaced;
- Existing 200 year APE will not be adversely affected; and
- Existing carriageway layout will not be changed.

8.2.8 Southern Rail Overbridge

The southern rail overbridge is located approximately 1km south of the Ngauranga Interchange on State Highway 1 and currently carries three traffic lanes in each direction plus a median and shoulders across the twin Hutt Valley/ Wairarapa railway lines. The structure is a highly skewed twin reinforced concrete box constructed in the 1960's. The overall length of the structure is 139m. This includes an approximately 75m long central twin cell section, extended at each alternate end by 27m and 35m long single boxes to accommodate the skew of the highway above. The northern cell span is 9.64m wide while the southern cell span varies from 5.7m to 10.9m. The structure is founded on driven steel tube piles filled with reinforced concrete. The bridge layout is shown in **Figure 8-7 and 8-8**.

Figure 8-7 - Southern Rail Overbridge

Figure 8-8 - Southern Rail Overbridge Cells

The structure is located in a highly seismic region, within 200m of the Wellington Fault. Liquefaction associated with lateral spreading is likely to be initiated for seismic shaking with an APE of between 100 and 350 years. While liquefaction alone may not be critical for the structure, assuming the piles are sufficiently long, lateral spreading toward the sea could create unbalanced earth pressure resulting in structural damage or failure. In addition, the capacity of the shear key joints at the top and bottom of the abutment wall were found to be insufficient for a seismic event with and APE of greater than about 250 years. A number of structural deficiencies have been identified in the seismic performance of the structure which requires retrofitting.

The live load carrying capacity of the bridge has been assessed previously and found to be just adequate for the Class 1 assessment loading under the current carriageway layout. This was governed by the shear capacity of the spine beam.

It is assumed that as part of this scheme, the existing spine beam will be strengthened to the full HN loading in accordance with the latest NZTA standards to suit the additional carriageway width required for this project. Furthermore, any widening to the existing structure to suit carriageway widening will replicate the current structural form and will be designed to comply with the current live load requirements.

It is however assumed that the bridge will not be retrofitted for earthquake capacity as part of the current scheme nor will its seismic performance be adversely affected by the works. It is understood that an earthquake retrofitting scheme may be considered for the whole structure at a future time as part of a separate scheme.

For the option described above, the following design standards are proposed for the Southern Rail Overbridge:

- Existing 200 year APE will not be adversely affected;
- Bridge will not be seismically retrofitted;
- Spine beam will be strengthened to full HN loading; and
- New widening section will be designed to full HN loading requirements and will replicate the existing structural form so that seismic strengthening can be carried out in the future.

8.2.9 Sign and VMS Gantries

There are currently six existing sign and VMS gantries between Ngauranga interchange and Aotea Quay off-ramp structure, which may be affected by the works. Where required, the existing gantries will be modified to take additional signs and extended to match the new road geometry. If it is found that modification of the existing gantries is not a viable option, they will be fully replaced with new gantries. All new and modified gantries will be designed to comply with the current NZTA standards.

9 Geotechnical Design

9.1 General

The NtAQ project corridor extends alongside Wellington Harbour to the south-east and steeply sloping hills to the north-west. Published geology supplemented with historic exploratory holes indicates the site is underlain by Reclamation Fill and Marine Sediments overlying alternating bedded sandstone/argillite bedrock. The Wellington fault runs parallel and in close proximity to its project corridor. Groundwater is anticipated to lie at shallow depth, with tidal fluctuations owing to the close proximity of Wellington Harbour.

The scheme will be predominately at grade, and comprise upgrading and/or widening of the existing motorway corridor. As such, fairly limited earthworks are anticipated. Two considerable structures lie within the corridor, namely the Thorndon Overbridge and Southern Rail Overbridge. Comparatively minor gantry structures are proposed for the various options.

The footprint of the earthworks may require limiting due to designation or neighbouring property constraints. Retaining walls will be constructed where necessary to suit property constraints.

The location and extent of the geotechnical works will be developed as the shortlisted options are selected and preliminary design is undertaken.

9.2 Design Standards & References

If any geotechnical design is required it will carried out to the relevant NZTA design standards where applicable. Designs will also comply with the relevant sections of the New Zealand Building Code. Geological descriptions and materials assessments will be to New Zealand Geotechnical Society Guidelines.

Significant p*ortions of the geotechnical scope are not covered by specific New Zealand Standards. Where this is* the case a relevant international standard or guideline will be referenced. Anticipated standards that will be used are:

- Transit New Zealand Bridge Manual (TNZBM) June 2003, 2nd Edition & June 2004, September 04, December 04 & July 05 Amendments;
- NZ Building Code, Verification Method B1/VM4, Foundations, December 2008;
- NZS 1170.5: 2004, "Structural Design Actions, Part 5, Earthquake Actions, New Zealand";
- New Zealand Geotechnical Society "Geotechnical Earthquake Engineering Practice – Module 1: Guidelines for the identification, assessment and mitigation of liquefaction hazards", July 2010;
- NZS 4402: 1986, "Methods of Soil Testing for Civil Engineering Purposes" & Supplement 1: 1998;
- AS 2159: 2009, "Piling – Design and Installation";
- AS 4678: 2002, "Earth Retaining Structures" & Amendment 1 & 2;
- BS/EN 1537: 2000, "Execution of Special Geotechnical Work – Ground Anchorages" (partly replaces BS 8081);
- BS 8002: 1994, "Code of Practice for Earth Retaining Structures" & Amendments 12062, 13386 & 8851;
- BS 8006: 1995, "Code of Practice for Strengthened /Reinforced Soils and Other Fills" (partially replaced by BS EN 14475:2006);
- BS 8081, "Code of Practice for Ground Anchorages" & Amendment 7268 (partially replaced by BS 1537);

- FHWA - Mechanically Stabilised Earth Walls and Reinforced Earth Slopes, Design and Construction Guidelines, March 2001, Publication No. FHWA-NHI-00-043;
- FHWA - Geotechnical Engineering Circular No. 3, Design Guidance: Geotechnical Earthquake Engineering for Highways, Vol. I & II, May 1997, Publication No. FHWA-SA-97-076 & 077;

9.3 Design Constraints & Assumptions

9.3.1 Design Constraints

The geotechnical design constraints that have been identified for the design of the earthworks, retaining walls and foundations are outlined below. Additional constraints may become apparent through the design and construction process

- High seismicity (liquefaction, fault rupture, lateral spreading);
- Reclaimed fill; and
- Shallow groundwater (tidal).

9.4 Principal Elements

9.4.1 Earthworks: Static Slope Stability

Engineered fill embankments, cut slopes and existing slopes affected by the motorway corridor will be designed as follows:

Methods of Analysis

Where applicable, stability analysis will be undertaken using the computer program Slope/W at critical cross sections along the alignment. The lowest factor of safety will generally be located by searching through a range of circular and translational failure surfaces.

Analysis Cases

The following cases will be analysed:

- Long Term Static Case;
- Short Term End of Construction Case (for fill embankments); and
- Staged Construction Case (for fill embankments).

Factors of Safety

For general design of cut and fill slopes, the following loadings and factors of safety (FOS) will be adopted:

Load Case	Loading	FOS
Long Term Static Case (embankments and cuts)	Traffic surcharge as per NZTA	≥ 1.5
Short Term - End of Construction Case (embankments)	Initial undrained strength parameters and construction traffic surcharge, strength gain from staged construction	≥ 1.3

9.4.2 Earthworks: Consolidation Settlements

Localised motorway widening may include differential settlements with the existing pavement. The magnitude and timing of these settlements will be assessed, when these locations have been identified. The performance requirements will be discussed and agreed with NZTA.

9.4.3 Earthworks: Seismic Design

Seismic Design Parameters

Seismic design parameters will be derived based on NZTBM and NZS1170.5.

Liquefaction Assessment

A liquefaction assessment will be undertaken generally based on the New Zealand Geotechnical Society Geotechnical Earthquake Engineering Practice (July 2010).

9.4.4 Retaining Walls

All retaining walls will be designed in accordance with the Transit New Zealand Bridge Manual. The extent and location of the retaining walls are yet to be defined.

9.4.5 Bridge Structures and Foundations

This section should be read in conjunction with Section 8. The piles are to be designed in accordance with Transit New Zealand Bridge Manual and AS2159.

10 Street Lighting

If new lighting is required it will be designed in accordance to the current road lighting Standard AS/NZS 1158 (all parts) and WCC by-laws.

The motorway and ramp sections for this project will be designed to AS/NZS 1158 Lighting Category V3, which is the usual designation for New Zealand expressways. Where the motorway intersects with local roads, these intersections shall be designed to V2 or V1 category depending on the rating of the arterial road requested by the WCC.

The current NZTA specification M19: Specification for Steel Tubular Lighting Columns deals mostly with the structural aspects of lighting columns. This specification is expected to be withdrawn and replaced with Specification M26 Road Lighting Columns during the first half of 2010*, (TBC).*

The following (refer to Table 6.1) published design standards are used to form the basis of the road lighting performance design specification.

Table 10-1 Lighting Design Standards

Design element	Standard	Description
Main carriageway	AS/NZS 1158.1.1:2005	Lighting for roads and public spaces – Vehicular Traffic (Category V) Performance and design requirements
	AS/NZS 1158.1.3:1997	Road Lighting – Vehicular Traffic (Category V) Guide to design, installation, operation and maintenance
Tie in roads, minor connector roads	AS/NZS 1158.3.2:2005	Lighting for roads and public Spaces – Pedestrian areas (Category P) Performance and design requirements
Pedestrian crossing	AS/NZS 1158.4:2009	Lighting for Public Spaces – Lighting of Pedestrian Crossings
Bridge underpass at Ngauranga	AS/NZS 1158.5	2007 Lighting for Roads and Public Spaces – Tunnels and Underpasses
Electrical	AS/NZS 3000	Electrical Installations – Wiring Rules
HV overhead lines	NZECP 34:2001	Electrical Safe Distances from Overhead HV Lines
Traffic signals	AS/NZS 2276	Cables for signal installations
Spill Light	AS4827 : 1997	Control of Obtrusive Effects of Outdoor Lighting

11 Enforcement

The variable speed limit nature of the project lends itself to spot speed enforcement rather that point to point (average speed) enforcement and our design will therefore be based on spot speed enforcement.

12 Transport Models

12.1 Levels of Service

As required by the NZTA Planning policy manual - for integrated planning & development of state highways (version 1, Aug 2007) we proposed that the main carriageway section of the project achieve a Level of Service “C” in the design year 2038.

Specific design and capacity requirements will be determined for each of the on and off ramps as well as any changes to the local road intersections. The primary objective associated with design for these aspects will be the mitigation of adverse effects on the local network, compared to an agreed (between NZTA, GWRC and WCC) do-minimum rather than a target Level of Service. The reason for this is to allow capacity constraints to be implemented on the local road network to improve the performance of the motorway and highways and limit “rat-running”.

12.2 Modelling Method Overview

No single transport model can cover the range of spatial and temporal scales and processes involved. For this stage in the project, a two-tiered hierarchical modelling approach will be adopted to determine the likely impacts of the proposed work packages on the traffic performance of the highway between Ngauranga and Aotea Quay, and to ultimately inform the transport economic appraisal.

12.2.1 Upper Tier Model

The Wellington Transport Strategy Model (WTSM) sits at the top of the model hierarchy. WTSM is a spatially aggregate, multi-modal transport and demand model covering the Greater Wellington region and, hence, operates and represents highway and public transport travel demand and patterns at a strategic (macro) level. WTSM provides travel demand matrices which will be used to inform the lower-tier SATURN traffic models – only highway demand is applicable to SATURN.

Note: WTSM has modelled the NtAQ capacity improvements simply as 4 lanes in each direction for the AM and PM peaks.

12.2.2 Lower Tier Model

SATURN traffic models are ‘conventional’ assignment models. NtAQ will use Opus’ Wellington CBD SATURN traffic models as the basis for testing the proposed work packages. It is the outputs from this model that will be used to inform the transport economic appraisal.

This model is more spatially disaggregate than WTSM – the model contains not only the strategic, arterial routes approaching Wellington CBD but more local ‘feeder’ routes. The model takes as input the strategic demand from WTSM and for the purposes of base year development only, further refinement of this demand is undertaken to ‘infill’ more regional and localised trips. Opus has undertaken this process and the work is detailed in their **draft** calibration and validation report.

Note: whilst a total of five work packages have been identified, it is acknowledged that for the purposes of the SATURN modelling, two of these will appear identical and therefore only four work packages will be developed in the modelling.

Table 12-1 on the following page provides general Wellington City SATURN model information:

Table 12-1 General SATURN model information

Item	Description
Years	2009, 2016, 2026
Time periods	AM peak hour (8am – 9am) Inter peak hour (11.30am – 12.30pm) PM peak hour (4.45pm – 5.45pm)
Vehicle types[4]	Cars, LCVs, HCVs
Geographical coverage	Johnsonville to Island Bay (north to south) and Seatoun to Karori (east to west)
Assignment technique	Wardrop Equilibrium
Does the base year model converge?	Yes and meets EEM criteria.

12.2.3 Travel Demand Matrices

For the purposes of testing each of the proposed work packages, a fixed matrix approach will be adopted as opposed to a Variable Demand Matrix (VDM) approach. Given the strategic nature of WTSM and the differences between each work package are only likely to generate modest effects on travel costs, using a fixed matrix approach is deemed appropriate. The matrices for each of the options will be the same as those derived from the WTSM Do Something test, i.e. four lanes assumed in each direction for the AM and PM peak hours, but converted to the SATURN zone system level and time periods. A summary of the matrix approach is given below in **Table 12-2**.

Table 12-2 Matrix approach

Year	Scenario	Fixed Matrix	VDM
2009	Base	Yes	No
2016, 2026	Do Minimum	Yes	No
	Do Something	No	Yes
	Work package testing	Yes[5]	No

[4] Cars and LCVs are combined to give Light Vehicles

[5] Using the Do Something matrices

12.3 Future Year Scenarios

The difference between **Table 12-3** and **Table 12-4** below is the inclusion of Ngauranga to Aotea Quay in **Table 12-4**.

Table 12-3 Future Year Do Minimum Traffic Scheme Assumptions (RoNS and Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin[6]	x	x
Peka Peka to Otaki	P	P
MacKays to Peka Peka	P	P
Linden to MacKays (Transmission Gully)	x	P
Ngauranga to Aotea Quay	x	x
Terrace Tunnel duplication	x	P
Basin Reserve	P	P
Airport to Mt Victoria Tunnel	P in part	P
Other	**2016**	**2026**
Petone to Grenada link road	x	P

Table 12-4 – Future Year Reference Case Traffic Scheme Assumptions (RoNS & Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin	x	x
Peka Peka to Otaki	P	P
MacKays to Peka Peka	P	P
Linden to MacKays (Transmission Gully)	x	P
Ngauranga to Aotea Quay	P	P
Terrace Tunnel duplication	x	P
Basin Reserve	P	P
Airport to Mt Victoria Tunnel	P in part	P
Other	2016	2026
Petone to Grenada link road	x	P

Table 12-5 – Future Year Option Tests Assumptions[7]

Option	2016	2026
1 – Minor Works	P	P
2 – Hard Shoulder Running	P	P
3 – Control All Lane Running	P	P
4 – Four Lanes plus Shoulders	P	P

[6] Not in WTSM modelled area
[7] Based on Future Year Reference Case Traffic Scheme Assumptions

12.4 Land Use Scenario

It has been agreed with NZTA at a meeting held on 19th of April 2011 that the High Growth land-use scenario will be used for testing the proposed NtAQ work packages. Furthermore, it has been assumed that there is a 20% increase in fuel price and PT fares from a 2006 base. This 20% has been assumed for both 2016 and 2026. It should be noted that such elements are currently under review and are not expected to be current beyond May 2011.

12.5 Model Constraints

The model constraints are outlined below:

- One of the key aims of the Wellington Modelling Panel is to bring together consultants within the Wellington region to develop and document standard modelling practices and methodologies to help achieve robustness and consistency in the transport modelling work. This is an on-going process and model assumptions and inputs and scenarios may change. An agreed baseline and future year model scenarios for economic analysis is essential;
- Only a very high level review of Opus' Wellington CBD base year traffic model in the area of interest has been undertaken. This review was based on Opus' draft calibration and validation report; no model networks have been scrutinised because the model is yet to receive official 'sign-off' from the peer reviewer. We understand that the model has received verbal 'sign-off';
- Outputs from 'off-the-shelf' WTSM runs that will be used to inform the SATURN road traffic models were carried out approximately six months ago. The evolving nature of the RoNS schemes since this time; in particular Linden to Mackays (Transmission Gully) was highlighted by David Young in a previous correspondence on the 20th of April. Confirmation from NZTA that the current WTSM runs are appropriate is essential (as NZTA are most well informed regarding all of the planned RoNS projects). A comparison against the 2011/12 State Highway Plan will inform this process;
- WTSM has assumed a 20% increase in fuel and public transport fares from a 2006 base. This 20% is assumed for both 2016 and 2026. This element, amongst others, is currently under review;
- There is a requirement to update the HCV travel demand matrices at both the WTSM and SATURN levels. The WTSM HCV matrices are underestimating trips to and from Wellington Port and, as such, the representation in the SATURN base model also under-represents HCVs. Matrix estimation procedures (SATURN level) during base year model development have not improved the volume and distribution of HCV trips as discussed in Opus' draft calibration and validation report. NZTA and Opus, and other Wellington Modelling Panel participants, are aware there is a requirement to update the HCV matrix in WTSM – this will no doubt form part the WTSM update commission but will not be available in time for NtAQ preliminary economic appraisal. The approach to revise the HCV matrix for NtAQ will be fairly simplistic (i.e. using the existing HCV travel pattern but elevated to match figures supplied by CentrePort and KiwiRail). Any revision, however, at this stage can be seen as an improvement to the current matrix;
- A total of five work packages have been identified. It is acknowledged that for the purposes of the SATURN modelling, two of these will appear identical and therefore only four work packages will be developed in the modelling (i.e. Work Package 1 – Minor Works, Work Package 2 – Hard Shoulder Running, Work Package 3 – Control All Lane Running, Work Package 4 – Four Lanes plus Shoulders); and
- We have less confidence in the SATURN model's performance in forecasting mode, primarily because it has not been used in 'live' project applications. It would therefore be prudent to check the model results including demand growth and levels of trip making, journey times, level of service at key locations, congestion and re-routing effects etc.

13 Discussion

13.1 Overall Design Approach

We recognise the requirement to make best use of the existing asset. Our design approach will therefore assess the constraints of the existing environment against the need to meet the operational goals of the project (capacity, safety, reliability, travel time). The ability of a design to meet these goals will be informed by evaluating it against accepted design standards.

We will suggest solutions that test the bounds of the existing NZTA design standards. We will evaluate these solutions by comparing the impacts or benefits against the project operational goals, alternative solutions and existing and accepted standards. The comparison against accepted standards will allow us to evaluate the likely costs, benefits and operational impacts associated with departures from these standards.

We have been advised by NZTA that the design should start from the premise the existing carriageway alignment, the motorway centre line, the existing pavement crossfalls and pavement construction should be retained to the maximum extent possible whilst maintaining acceptable operational and safe standards. The aim of the project is to maximise the use of the existing asset.

14 Internal Consultation

The ECI Team consulted with the following members of the RMT and VAC committee and their advisors:

- Mike Pilgrim / James Hughes for geometric and safety;
- Barry Wright for bridge structures;
- Tony Brennand for transport models; and
- Henry Pretorius for ITS standards.

15 Recommendations

It is recommended that the Wellington RMT and VAC:

- Endorse the overall design approach;
- Approve departures from Standards identified in Table 1;
- Agree NZTA trigger for new stormwater infrastructure and treatment requirements:
  - The stormwater runoff is to be treated if the impervious area changes (i.e. we increase the pavement area);
  - The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected;
  - This will need further agreement from GWRC.
- Endorse spot speed enforcement; and
- Agree to modelling scenarios.

Table 15-1 Summary of Design Approach and Departures

	Design Element	Standard	Design Approach	Departures
1.	**Road and Pavement Design**			
1.1	Design and Posted Speed			
	design speed	110kph	110kph	
	posted speed	100kph		80kph (during peak hours)
1.2	Motorway lane widths	3.5m		3.25 to 3.3m
1.3	Shoulder widths	2.5m		0.5m – 1.0m
1.4	Driver reaction time		2.5secs	
1.5	Median barrier	TL3 – TL4		
2	**Intelligent Transport System**	Draft National Standard		Refer to Table 1-2
3	**Bridge Structures**			
3.1	Thorndon Overbridge “clip-on” option			
	Earthquake APE	1-in-2500		1-in-500 (existing)
	External barriers	TL5		TL4
	Median barriers	TL4		TL4
3.2	Thorndon Overbridge Separate Structure (new)			
	Earthquake APE	1-in-2500		1-in-1000
	External barriers	TL5	TL5	
3.3	Aotea Quay off-ramp bridge structure			
	Earthquake APE	1-in-2500		1-in-200 (existing)
3.4	Southern Rail Overbridge			
	Earthquake APE	1-in-2500		1-in-200 (existing)

16 Key Considerations

The key considerations are summarised below:

16.1 Existing Environment

16.1.1 State Highway 1 and 2

The existing motorway is a curvilinear alignment approached by two sections of state highway with very different environments. State Highway 1 (SH1), further to the North, consists of a very constrained environment, mostly without shoulders, with high cuts, a steep gradient and a posted speed limit of 80 kph.

State Highway 2 (SH2) to the Northeast consists of a more open environment with shoulders and a 100 kph posted speed limit.

16.1.2 Study Corridor

SH1, further to the Southwest between Ngauranga Gorge and Aotea Quay is constrained by:

- the railway lines on the west side;
- the coastal marine area on the east;
- the port area adjacent to the Aotea off-ramp;
- the Southern Rail Overbridge; and
- Thorndon Overbridge, which is a long elevated structure with minimal shoulder widths.

There are sections of the existing motorway within the study corridor that do not comply with the current State Highway Geometric Design Manual (SHGDM) standards. Changes to the existing motorway will need to be designed to provide a "readable" environment which transitions appropriately from the adjacent sections of highway (SH1 & SH2).

There are four connections to local roads, in the form of on and off ramps. The interface with the local roads will be designed in coordination with the NZTA and Wellington City Council (WCC).

a. Thorndon Overbridge

The original structure was not designed using the "capacity design" concept of modern codes and consequently had serious seismic vulnerabilities.

The structure was seismically retrofitted in the mid 1990's and post retrofit performance is expected to be adequate under seismic events of up to a 500 year Annual Probability of Exceedance (APE).

This was considered an appropriate level of retrofit that was economically and technically feasible at the time, given the geotechnical conditions at the site, the risk of liquefaction and lateral spreading and the preference not to undertake the extensive and costly ground improvement measures required to mitigate these effects.

16.2 Road and Pavement Design

16.2.1 Geometric Design Standards Adopted for Evaluation Purposes

The existing situation and proposed designs will be evaluated against a series of NZTA accepted design criteria. Most of these criteria will be based on the Austroads Guide for Road Design (AGRD) because it is consistent with other designs being carried out within New Zealand and will provide a "readable" and familiar environment for motorists.

16.2.2 Operating Speed and Design Speed

- We propose that all of the horizontal and vertical alignment elements of our designs are evaluated against the requirements of a design speed of 110kph. This will then enable proposed design solutions to be compared to an “ideal” situation and the existing situation to determine benefits or disbenefits of the proposed solutions.
- It is not intended to modify the existing Aotea Quay off-ramp structure; however any new connections to that off-ramp will be evaluated against the requirements of the AGRD.
- The operating speed for Hard Shoulder Running is 80kph while the hard shoulder is in operation during peak periods.

16.2.3 Cross Section

- The typical cross section through the main carriageway is yet to be determined, however, we propose to generally use 3.3m lane widths but may require 3.25m lane widths (previously agreed for investigation by VAC) on the overbridge structures.
- NZTA confirmed that the existing median barrier was nearing the end of its design life and it may be possible to provide wider lane widths within the existing carriageway “barrier to barrier” space if the median barrier is replaced.
- Final shoulder widths will depend on the chosen work package, however the general approach will be to provide wider lanes at the expense of shoulder width if a trade-off is required.

16.2.4 Sight Distance

This is a high speed urban section of motorway with alert drivers and few intersections; however the alignment is generally curvilinear with few sections of straight road. We have therefore adopted a driver reaction time of 2.5 seconds for sight distance calculations.

16.2.5 Location, Design and Requirement for Emergency Refuge Areas (ERAs)

The location, design and requirement of the ERAs will depend on the chosen work package, the rate and type of incident occurrence and the design lane and shoulder widths.

16.2.6 Pavement Design

The pavement design and / or evaluation will be based on the following supplied data and assumptions:

- 30 year design life;
- 95% project reliability;
- A motorway and state highway design speed of 110km/h;
- Subgrade CBR data obtained from ground investigations; and
- Final calculations of predicted traffic flows and percentage of heavy vehicles will be determined once the work package configurations and regional freight strategies and models have been confirmed.

16.3 Active Traffic Management Design

The Active Traffic Management design is based on the Draft National ITS Standards and Specifications that will require the departures identified in table 1-2 in order to make them specific to the Wellington region:

Table 16-1 Summary of the Departures from the Draft National ITS Standards/Specifications

Draft National ITS Standards/Specifications		Departures
ITS-01 General	01 General Requirements	§ Section 2.2 Preliminary Documentation, agreement will need to be sought with NZTA Wellington to confirm the wording within this section is applicable to the region and their methods of management. § Section 3 ITS Numbering System, the system detailed within this section relates to the numbering system that is currently employed within the Auckland region, the method of ITS numbering in Wellington will need to be established and referenced within this section. § Section 5 Glossary of Terms, local terms will need to be included.
	02 Environmental Requirements	§ Environmental Requirements applicable to the Wellington region.
	04 Civil and Motorway Site Works	§ The reference to Auckland will need to removed and replaced with a generic statement of the "NZTA Motorway Network".
	05 Support Structures and Foundations	§ No departures.
ITS-02 Communication Infrastructure	01 Duct Supply and Installation	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	02 Jointing Chambers and Pull Pits	§ Standard design drawings will need to updated to remove the Auckland reference and replaced with a generic statement of the "NZTA Motorway Network".
	03 Optical Fibre Supply and Installation	§ A detailed review of this document will need to be undertaken against the current methodology of Wellington's fibre installation to ensure the process and procedures detailed within will be applicable to Wellington. § Change Control procedures will need to be assessed for their suitability in the Wellington region
	04 Roadside Cabinets	§ Section 1.3 Roadside Cabinet Numbering, as per ITS-01-01 General Requirements the Wellington numbering will need to be followed § Section 3.4 Optical Fibre Interface supply of Network Switch. Confirmation of the type of Network Switch currently used within the Wellington region § Section 3.5 ITS Network Change Control, a review in conjunction with ITS-02-03 will

Draft National ITS Standards/Specifications		Departures
		need to be undertaken for its suitability to Wellington § Attachments, Auckland reference to be removed and either a generic statements or Wellington references inserted.
ITS-04 Lane Control System	01 Lane Control System (LCS) Civil and Structural Works	§ Dual pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § Single pole structure in relation to current Wellington installations will need to be identified and foundation design drawings will need to be created § LCS support structure will need to be identified detailing units connection to post mounted installation
ITS-06 Variable Message Signs	02 Variable Message Sign Supply and Installation	§ ITS-01-02 Environmental Requirements is referenced which as explained previously will need to updated to identify Wellington conditions.
ITS-07 Closed Circuit Television	01 Closed Circuit Television Civil and Structural Works	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
	Closed Circuit Television Supply and Installation	§ Currently this specification details standard installation of CCTV but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for CCTV.
ITS-09 Motorway Emergency Telephones	01 Motorway Emergency Telephone	§ Currently this specification details standard installation of MET but once a preferred work package has been developed there may be a requirement to develop a particular installation and operational methodology for MET.
ITS-10 Testing, Commissioning and Handover	01 Testing, Commissioning and Handover	§ This document is intended to be a guideline and a detailed Handover & Commissioning Plan will be developed for the preferred work package using this specification as reference

16.4 Stormwater Management

16.4.1 Approach

Our approach will be to evaluate the design solutions against the requirements of the applicable NZTA standards and the geometric design in order to determine if and what stormwater management changes are required.

We initially propose to develop geometric sub-options that would fit within the existing impervious area (for work packages 1, 2 and 3), thereby reducing or negating the requirement for new stormwater management infrastructure.

16.4.2 Treatment

- We have made the following assumptions regarding Stormwater treatment:
  - The storm water runoff is to be treated if the impervious area changes (i.e. we increase the pavement area) and
  - The stormwater runoff is to be treated if the median drainage (i.e. existing slot drain, sumps and manholes) is affected.
- If required, the stormwater treatment would most likely involve proprietary devices rather than swales and wetlands because of spatial constraints.
- If required, treatment is to be carried out to Best Practicable Option (BPO). Runoff from the motorway is to be collected and passed through stormwater treatment devices, prior to discharging to the receiving environment. Particular sensitive environments are the harbour, Kaiwharawhara stream and the Korimako stream.
- The treatment devices will address the removal of gross debris, suspended sediment, heavy metals, and hydrocarbons, and will be in accordance with NZTA's Stormwater Treatment Standard for State Highway Infrastructure.

16.5 Structures

16.5.1 Thorndon Overbridge

- Two concept options have been considered for increasing the southbound carriageway width on Thorndon Overbridge from the northern abutment to Aotea Quay off ramp:
  1) The first option is the construction of a "clip-on" widening deck; and
  2) The second option is provision of a separate elevated off-ramp structure.
- For widening option using a "clip-on" option:
  - Existing 500 years APE will not be adversely affected (proposed 10% additional seismic load on substructure is within existing capacity of piers and foundations);
  - Our approach will use 3.3m traffic lanes and narrow (0.5m) shoulders; and
  - TL4 "high" protection level, using "nested" steel Thriebeam side protection barriers as per the existing structure.
- For a separate off-ramp structure:
  - 1000 years APE;
  - 2 x 3.5m traffic lane, 0.6m inner and outer shoulders;
  - TL5 side protection barriers; and
  - Vertical clearance broadly in line with existing Thorndon Overbridge
- Both the aforementioned options assume that the current Aotea Quay off-ramp bridge structure will be retained as existing in all proposed widening options and will not be modified, strengthened or replaced on the basis that there will be no change to the current risk profile for this structure.

- The following design standards are proposed for the existing Aotea Quay off-ramp structure:
  - Existing structure will not be modified, strengthened or replaced;
  - Existing 200 years APE will not be adversely affected; and
  - Existing carriageway layout will not be changed.
- The northbound carriageway will also require widening between the Aotea Quay on-ramp and the northern abutment to suit the additional traffic lane but this will depend on the actual shoulder widths which we are currently assessing. Any widening would be less than for the southbound structure.
- It is our understanding that the new replacement protection barriers on the outer edge of Thorndon Overbridge have been designed to provide a TL4 “high” protection level, using “nested” steel Thriebeam barriers. We propose to use the same level of protection on the outer edge.

16.5.2 Southern Rail Overbridge

- We have assumed that as part of this scheme, the existing spine beam on the Southern Rail Overbridge will be strengthened to the full HN loading in accordance with the latest NZTA standards to suit the additional carriageway width required for this project.
- Any widening to the existing Southern Rail Overbridge structure to suit carriageway widening will replicate the current structural form and will be designed to comply with the current live load requirements i.e. HN loading.
- We have assumed that the bridge will not be retrofitted for earthquake capacity as part of the current scheme nor will its seismic performance be adversely affected by the works. It is our understanding that an earthquake retrofitting scheme may be considered for the whole structure at a future time as part of a separate scheme.
- The following design standards are proposed for the Southern Rail Overbridge:
  - Existing 200 years APE will not be adversely affected;
  - Bridge will not be seismically retrofitted;
  - Spine beam will be strengthened to full HN loading; and
  - New widening section will be designed to full HN loading requirements and will replicate the existing structural form.

16.5.3 Sign and VMS Gantries

Where required, the existing gantries will be modified to take additional signs and extended to match the new road geometry.

16.6 Geotechnical Design

For general design of cut and fill slopes, the following loadings and factors of safety (FOS) will be adopted:

Load Case	Loading	FOS
Long Term Static Case (embankments and cuts)	Traffic surcharge as per NZTA	≥ 1.5
Short Term - End of Construction Case (embankments)	Initial undrained strength parameters and construction traffic surcharge, strength gain from staged construction	≥ 1.3

16.7 Enforcement

The variable speed limit nature of the project lends itself to spot speed enforcement rather that point to point (average speed) enforcement and our design will therefore be based on spot speed enforcement.

16.8 Transport Models

16.8.1 Levels of Service

We propose that the main carriageway section of the project achieve a Level of Service “C” in the design year 2038.

16.8.2 Future Year Scenarios

The difference between Table 1-2 and table 1-3 below is the inclusion of Ngauranga to Aotea Quay in Table 1-3.

Table 16-2 Future Year Do Minimum Traffic Scheme Assumptions (RoNS and Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin[8]	x	x
Peka Peka to Otaki	P	P
MacKays to Peka Peka	P	P
Linden to MacKays (Transmission Gully)	x	P
Ngauranga to Aotea Quay	x	x
Terrace Tunnel duplication	x	P
Basin Reserve	P	P
Airport to Mt Victoria Tunnel	P in part	P
Other	**2016**	**2026**
Petone to Grenada link road	x	P

Table 16-3 Future Year Reference Case Traffic Scheme Assumptions (RoNS & Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin	x	x
Peka Peka to Otaki	P	P
MacKays to Peka Peka	P	P
Linden to MacKays (Transmission Gully)	x	P
Ngauranga to Aotea Quay	P	P
Terrace Tunnel duplication	x	P
Basin Reserve	P	P
Airport to Mt Victoria Tunnel	P in part	P
Other	2016	2026
Petone to Grenada link road	x	P

[8] Not in WTSM modelled area

Table 16-4 Future Year Option Tests Assumptions[9]

Option	2016	2026
1 – Minor Works	P	P
2 – Hard Shoulder Running	P	P
3 – Control All Lane Running	P	P
4 – Four Lanes plus Shoulders	P	P

9 Based on Future Year Reference Case Traffic Scheme Assumptions

Appendix K

Preliminary Geotechnical Appraisal Report

Report

Ngauranga to Aotea Quay Wellington ATM Preliminary Geotechnical Appraisal Report
Contract:446PN

Prepared for NZ Transport Agency (NZTA)

By Beca Infrastructure Ltd (Beca)

20 June 2011

Revision History

Revision Nº	Prepared By	Description	Date
A	Jerry Spinks	First Draft to form part of Scoping Report	14 September 2011

Document Acceptance

Action	Name	Signed	Date
Prepared by	Jerry Spinks		
Reviewed by	Gavin Alexander		
Approved by	Geoff Brown		
on behalf of	Beca Infrastructure Ltd		
Approved by	Stephen Wright		
On behalf of	Fletcher Construction Company Ltd		

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1 Executive Summary

This Preliminary Geotechnical Appraisal Report (PGAR) presents a summary of the available ground investigation data and geotechnical reports throughout the NtAQ corridor. The information gathered has then been used to identify the key geotechnical constraints affecting the scheme and develop the scope for a pre-tender ground investigation. A site walkover was undertaken by the project's lead geotechnical Engineer on the 8th June 2011.

The design intent for the NtAQ project is to ensure that the additional elements exhibit an acceptable level of performance during a major seismic event, but do not require to improve the overall performance of the existing motorway corridor.

Option 1 comprises the 'do nothing', whereby the existing motorway asset is simply maintained.

Option 2 comprises widening the existing motorway to incorporate an additional lane north and southbound, with a hard shoulder beyond. In addition, it incorporates improvements to the existing Active Traffic Management System (ATMS). At present, the additional southbound lane at the Thorndon Overbridge will be accommodated with a clip-on structure or alternatively, an entirely separate structure extending alongside the Interislander Terminal.

Published geology by Begg and Mazengarb indicates the site is underlain by Reclamation Fill overlying Alluvium. The NZSEE Site Subsoil Classification of Wellington City (2011) shows the depth to basement rock (in situ greywacke) could be in the order of 200 to 350m below ground in the Thorndon study area. Elsewhere rock-head is evidenced by the Western Hills, immediately to the west of the project corridor.

A high level desk study has been undertaken to determine the potential for contaminated material to be present within the project footprint. It is recommended that a contamination assessment be undertaken and this would provide information to determine resource consent requirements (if any) and reuse/disposal options for any spoil generated by the construction phase.

The Wellington Fault line crosses below the existing Thorndon Overbridge immediately south of the proposed scheme. Fault rupture is anticipated to cause considerable damage to the Thorndon Overbridge. Outwith this section of the scheme, the fault is sufficiently offset such that it does not present a fault rupture hazard.

The following investigations are recommended as an indicative scope, to be confirmed when the preferred option for the Thorndon Overbridge area has been identified.

1. Thorndon Overbidge, a series of CPT's at each pier and a borehole at every second pier.

2. Kaiwharawhara, Benkleman Beam (BB) testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m centres, and boreholes at 200m centres throughout the extent of the proposed retaining wall – Ch2200 to 3000. A borehole to 10m depth is recommended at the location of the two widened gantries.

3. Southern Rail Overbridge, no additional geotechnical investigations are proposed.

4. Ngauranga, as for Kaiwharawhara, BB testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m intervals and boreholes (to between 10m and 20m depth) at 200m intervals are recommended along the length of the proposed retaining wall – Ch1700 to 1800.

2 Introduction

Beca Infrastructure Ltd (Beca) has been engaged by Fletcher Construction Ltd to undertake, on behalf of the New Zealand Transport Agency (NZTA) the options assessment and for the proposed Ngauranga to Aotea Quay project (NtAQ).

This Preliminary Geotechnical Appraisal Report (PGAR) presents a summary of the available ground investigation data and geotechnical reports throughout the NtAQ corridor, supplemented with the observations made during a site walkover undertaken by the project's lead geotechnical engineer. The information gathered has then been used to identify the key geotechnical constraints affecting the scheme and develop the scope for a pre-tender ground investigation.

For clarity the project corridor has been separated into four sections, namely: Thorndon Overbridge, Kaiwharawhara, Southern Rail Overbridge and Ngauranga.

The NtAQ project corridor extends approximately 2.65km along State Highway 1 (SH1), from Ngauranga Gorge to Aotea Quay and includes the associated on/off ramps. Figure 1 below identifies the extent of the NtAQ project.

For the scheme extent, refer to the Scoping Report, Introduction Figure 1.1

3 Summary of Options

The Scoping Report presents two options that are to be carried forward for this report:

Option 1 comprises the 'do nothing', whereby the existing motorway asset is simply maintained.

Option 2 comprises widening the existing motorway to incorporate an additional lane north and southbound, with a hard shoulder beyond. In addition, it incorporates improvements to the existing Active Traffic Management System (ATMS). At present, the additional southbound lane at the Thorndon Overbridge will be accommodated with a clip-on structure or alternatively, an entirely separate structure extending alongside the Interislander Terminal.

Other options have previously been proposed but currently are not being considered.

4 Site Characteristics

4.1 Topography and Geomorphology

The project corridor is typically level and elevated on embankment above the surrounding ground, with localised comparatively steep slopes associated with the formation of railway lines (NIMT and Hutt Valley) and roads (SH1 and SH2). The escarpment of the Western Hills runs adjacent to the corridor and comprises steep slopes, typically up to 40 degrees. An approximately 4m to 8m high rock rip-rap slope, lying at 20 to 30 degrees, forms the eastern boundary of the project corridor.

To the west of the project corridor, numerous watercourses have formed deep gullies within the Western Hills. To the east of the project corridor lies Wellington Harbour, where bathymetric maps indicate a gently sloping sea floor extending out to the central harbour, where the average depth is approximately 20m.

4.2 Geological Setting

The basement rock in the Wellington region is greywacke and argillite of the Torlesse Group comprising, at depth, highly indurated strong rock (UCS up to 200MPa), un-weathered and massive (un-jointed). However near the surface the rock is weathered to varying degrees and in many areas the rock is closely jointed and sheared as a result of episodes of major tectonic action in the 200M years since it was originally deposited.

Published geology by Begg and Mazengarb [(1)] indicates the site is underlain by Reclamation Fill overlying Alluvium. In the vicinity of Aotea Quay the Reclamation Fill comprises hydraulic fill (sand and mud) pumped from the harbour floor between 1924 and 1932. The hydraulic fill has typically poor engineering properties and is capped by well compacted sandy clay and gravel. Quarried rock fill was used in reclamations along the west side of the harbour in the 1960's for the Hutt Motorway.

Published geology suggests the Alluvium has been deposited predominantly by the Hutt River, with comparatively minor deposition from local watercourses such as the Ngauranga and Kaiwharawhara Streams. The near surface Alluvium comprises alternating silts and aquifer gravels.

The NZSEE Site Subsoil Classification of Wellington City (2011) [(2)] shows the depth to basement rock (in situ greywacke) could be in the order of 200 to 350m below ground in the Thorndon study area. Elsewhere rock-head is evidenced by the Western Hills, immediately to the west of the project corridor.

4.3 Hydrogeology

It is anticipated that the regional groundwater table lies within the Reclamation Fill or underlying Alluvium. Tidal fluctuations are anticipated due to the close proximity of Wellington Harbour.

4.4 Local Faulting

Published geology by Begg and Mazengrab [(1)] indicates the Wellington Fault crosses the site at Aotea Quay and then runs north by north east through Wellington Harbour, offset to the east of the project corridor by 100m to 400m. Numerous mapped faults extend across the project corridor in a typically east north-east orientation. The alignment of each fault is presented within Drawings 3321045-G-101 to 105, refer to Appendix A1.

4.5 Wellington City Council District Plans

An initialexamination of the district plans was undertaken, as published within the WCC website (www.wellington.govt.nz). These indicate that the section of motorway extending from Thorndon to Kaiwharawhara lies within the hazard (fault line) area and ground shaking area, as delineated within WCC district plan map 15. WCC district plan Section 13.5.3 details the following:

"Limitations have been imposed on developments in fault zones to reduce development intensity and promote safety.

The fault rupture hazard area is a narrower zone within the wider Hazard (Fault Line) Area. As the fault is expected to rupture within this narrower zone, it is desirable to avoid locating new structures and buildings in this zone.

The Hazard (Fault Line) Area extends beyond the fault rupture hazard zone because of inherent uncertainties associated with fault rupture. Engineering measures should also be applied to buildings in this wider hazard area to reduce the effects of a fault rupture.

The provision of site-specific geotechnical and engineering design reports carried out by experts will assist the Council to assess the adverse effects arising from the fault rupture hazard for the development site and how those effects can be minimized."

The district plan defines construction of a building or structure within this zone as a discretionary activity, whereby under Section 13.3.5.2, WCC adopts the following assessment criteria:

"The extent to which a geotechnical report and an engineering design report shows that the risk of building failure following a fault rupture can be reduced to minimise the effects of fault rupture on the safety of occupiers and neighbours."

5 Available Site Specific Information

5.1 Previous Ground Investigations

In 2009 Beca was commissioned by the NZTA to undertake a seismic assessment of the Southern Rail Overbridge in order to determine its performance, during a major seismic event, compared with the adjoining motorway corridors to the north and south. Wellington Urban Motorway Thorndon to Petone – Summary of Existing Geotechnical Data and Interpretation[3] was issued in March 2010, collating geotechnical data along SH1 from Thorndon to Petone. This report has been used as a primary source of collated information on the ground conditions along the NtAQ corridor.

The Beca Geotechnical Reports Database was searched for geotechnical reports and borehole logs, relevant geological maps, commentaries and selected technical literature. The Beca report library and archives were also searched for projects within the study area.

5.2 Site Walkover

A site walkover was undertaken by the project's lead geotechnical Engineer on the 8th June 2011. Operational restrictions of the live motorway were such that access to the hard shoulder was not possible. A visual inspection either side of the motorway was also undertaken.

5.2.1 Northbound

Crib walling extends beyond the Southern Rail Overbridge and Ngauranga Overbridge, project chainage Ch2000 to 1700 and Ch 1350 to 1200. The wall ranges in height typically from 4m to 8m. The wall is generally in sound condition, with localised spalling observed within the precast concrete facing elements.

Vegetated soil slopes, at a batter ranging from 2H:1V to 3H:1V, extend from Ch 2200 to 2000 and Ch 1700 to 1350.

5.2.2 Southbound

Crib walling extends south of the Ngauranga Overbridge from Ch 1100 to 1400, with wall heights ranging from 8 to 12m north of the Southern Rail Overbridge. The wall is in a similar condition to that which was observed Northbound.

Vegetated soil slopes, at a batter ranging from 2H:1V to 3H:1V, extend from Ch 1400 to 2200, where the motorway ties into the rip rap slope formed adjacent to Wellington Harbour, terminating at Ch3250.

The Kaiwharawhara stream outlets at Ch3550, to the north of the Interislander Ferry Terminal. The condition of the outlet structure is not known; careful consideration will be required in order to assess how it will be tied into the proposed widening works.

6 Route Security

The NZTA accept that the SH1 motorway corridor will be subject to considerable damage during a major seismic event. Fault rupture may cause considerable damage to the Thorndon Overbridge. Widespread liquefaction and lateral spreading is anticipated throughout the majority of the motorway corridor, resulting in considerable disturbance and settlement of the motorway pavement. As such, the design intent for the NtAQ project is to ensure that the additional elements exhibit an acceptable level of performance during a major seismic event, but do not require to improve the overall performance of the existing motorway corridor.

7 Preliminary Geotechnical Appraisal

7.1 Thorndon Overbridge

7.1.1 Site Description

The Wellington suburb of Thorndon is built on uplifted terrace surfaces in the West, and a broad area of flat lying, reclaimed land in the East. The Wellington Urban Motorway crosses the reclamation from Thorndon to Kaiwharawhara on an elevated structure known as the Thorndon Overbridge.

The Thorndon Overbridge is a twin three lane (2 x 3 lanes), pre-stressed 'I' girder deck with spans of up to 41 m on cellular box pier heads. The overbridge is founded on concrete filled, driven, hollow steel piles. The structure was seismically retrofitted in the mid 1990's. The retrofit involved linkage beams across pilecaps (to improve resistance to lateral spreading), overlay of pilecaps and sleeving of columns (to increase capacity and ductility), additional piles and catch frames on pier cross heads adjacent to the fault (to support deck unseated by fault rupture).

7.1.2 Soil Profile

The soil profile has been established from historical reclamation records and summarised in the Wellington Urban Motorway Thorndon to Petone report(3).

Within the older reclamation areas the soil profile typically comprises loose to medium dense sandy/gravelly end tipped fill. In more recent areas of reclamation the soil profile is typically hydraulically placed silty/sandy fill, overlying a thin layer of very loose/soft Holocene sand/silt marine deposits, overlying a very thick sequence of Pleistocene alluvial silts/sands/gravels, overlying (at considerable depth) Greywacke bedrock.

Groundwater is anticipated to lie at shallow depth and influenced by the tide of the Wellington Harbour.

An indicative cross section is presented within Appendix 2.

7.1.3 Evaluation

Two concept options have been considered for increasing the southbound carriageway width from the northern abutment to Aotea Quay off ramp. The first option is construction of a "clip-on" widening deck and the second option is provision of a separate elevated off-ramp structure. Both options assume that the existing Aotea Quay off ramp will be retained.

The Ground Investigations scoped below assume that Option 2 incorporates a separate elevated off-ramp structure, the alignment of which is detailed within Dwg 3321045-G-103 to 104, Appendix A. A Concept Design Constraints Review undertaken for NZTA by Holmes Consulting Group in 2010, recommended that a minimum earthquake 1000 year Annual Probability of Exceedence (APE) should be adopted for this option, adopting an Importance Level of 2, recognising that the structure will be independent of State Highway 1. Widespread liquefaction and lateral spreading is anticipated under a 200 year return period seismic event. Extensive ground improvement works will therefore be required in order to ensure that the structure exhibits adequate performance.

7.1.4 Recommended Investigations

Ground investigations required only for the new bridge structure. Boreholes to between 10m and 20m depth located at every second pier location, and CPT's at every pier location. Three cone penetration tests (CPT's) undertaken at all pier where a machine borehole is not drilled (one at the pier location and one offset between 10 to 30m either side of the pier). Refer to Appendix A – Geotechnical Investigation Plans for further details.

7.2 Kaiwharawhara

7.2.1 Site Description

The Kaiwharawhara area is a 100 to 300m wide reclamation, extending beyond the historic shoreline at the foot of the Western Hills. SH1 runs generally along the south eastern edge of the reclamation with rail, industrial/commercial/retail land use and SH2 (Hutt Road) to the north west. The Hutt Road lies along the old shoreline at the foot of the escarpment. The mouth of the Kaiwharawhara stream lies immediately north of the Ferry Terminal.

7.2.2 Soil Profile

The soil profile has been established from historical reclamation records and summarised in the Wellington Urban Motorway Thorndon to Petone report[3].

Within the reclamation the soil profile typically comprises loose to medium dense sandy/gravely end tipped fill overlying a thin layer of very loose/soft Holocene sand/silt marine deposits, overlaying a very thick sequence of Pleistocene alluvial silts/sands/gravels overlying (at considerable depth) Greywacke bedrock. The depth of rock is undefined in the above references but is expected to be shallower than in the Thorndon area.

Groundwater is anticipated to be tidal and controlled by the close proximity of Wellington Harbour.

An indicative cross section is presented within Appendix 2.

7.2.3 Evaluation

Proposed works comprise upgrading the existing gantries to include variable message signage and additional technology such as speed enforcement cameras and CCTV. Removal of the existing, approximately 4m wide, central median and barrier is proposed, together with construction of a new barrier.

Reconstruction of the existing hard shoulder and addition of north and southbound lanes will be undertaken, predominantly at grade where the works lie within the existing motorway corridor. Beyond the motorway corridor, from CH2200 to CH3000, retention works are required to support the widening. The preferred solution is a pre-cast panel L-shaped wall, sub-excavated and founded onto the existing embankment shoulder.

Whilst widespread liquefaction and lateral spreading, during a major seismic event, is anticipated throughout the motorway corridor, this constraint has not been targeted for ground investigation, as discussed in Section 6 Route Security above.

7.2.4 Recommended Investigations

Benkleman Beam testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders.

Test pits at 100m intervals and boreholes (to between 10m and 20m depth) at 200m intervals are recommended along the length of the proposed retaining wall (Southbound Ch2200 to 3000).

A borehole to 10m depth is recommended at the location of the two widened gantries, southbound Ch 2850 and 3450.

7.3 Southern Rail Overbridge

7.3.1 Site Description

The Southern Rail Overbridge is a heavily skewed double box reinforced concrete road over Rail Bridge. The structure is positioned immediately adjacent to the SH2 Hutt Road and some 50m from the shoreline of Wellington Harbour. SH1 embankment approaches extend north and south of the overbridge, ranging in height from 4 to 8m; the north approach is supported by crib walls while vegetated slopes support each side of the south approach. Beyond the motorway corridor the site is typically level.

7.3.2 Soil Profile

Recent exploratory holes (2no.), undertaken by Beca in 2007 and collated within the Wellington Urban Motorway Thorndon to Petone report(3), indicate the structure is underlain by 6m to 17m of Reclamation Fill, overlying 3 to 4m of medium dense to very dense Marine Sands, overlying very dense basal Gravels, overlying greywacke bedrock at around 10m below natural ground level.

Groundwater is anticipated to be tidal and controlled by the close proximity of Wellington Harbour.

An indicative cross section is presented within Appendix 2.

7.3.3 Evaluation

Widespread liquefaction and lateral spreading is anticipated during a 100 to 350 year return period seismic event. A number of structural deficiencies have been identified in the seismic performance of the structure, such that it is considered that its structural performance corresponds to a 220 year return period seismic event. The NZTA do not require improvement of the structural performance, but any modifications to the structure shall be designed such that the structural performance is not reduced.

Widening of the structure is not required to accommodate the NtAQ project. Minor strengthening works are proposed in order to carry the additional traffic, such as upgrading the spine beam to full HN loading.

7.3.4 Recommended Investigations

No additional geotechnical investigations are proposed.

7.4 Ngauranga

7.4.1 Site Description

The existing SH1 motorway corridor runs adjacent to SH2 Hutt Road at the foot of the Western Hills. The Hutt Valley railway line runs immediately adjacent to SH1 and the Wellington Harbour foreshore beyond.

The Ngauranga Interchange is situated at the intersection of the steeply incised Ngauranga Gorge and the foreshore of the Wellington Harbour. The SH2 Hutt Road extends below the SH1 Ngauranga underbridge. The site is typically level with steep to sub-vertical slopes associated with the reclamation fill embankments, railway lines and road infrastructure.

7.4.2 Soil Profile

The Wellington Urban Motorway Thorndon to Petone report[3] did not identify information on the Ngauranga interchange, however, information was obtained from excerpts taken from technical papers which describe the ground conditions beneath the Ngauranga wall (which retains fill for the off-ramp), and beneath the foundations of the bridge structures.

The material beneath the wall is described as sandy gravels with some shells and silt, overlying basement greywacke rock at up to around 16 m below ground. The bores on which this profile is based indicate SPT ‘N’ values near the surface (reportedly due to railway track ballast and compaction by train vibrations) of around N=50, with loose materials of N=9 at 5m depth, becoming medium dense with N=25 at around 9 m depth.

The materials beneath the bridge foundations are described as predominantly sandy and silty gravel overlying fractured greywacke rock with some crushed zones. The depth to rock increases southward from the northern end beside Hutt Road (0.5 m below ground) to the former Ngauranga Stream bed (24 m below ground).

Groundwater is anticipated to be tidal and controlled by the close proximity of Wellington Harbour.

With the lack of location specific ground investigation data, an indicative cross section has not been prepared for this section of the scheme.

7.4.3 Evaluation

The proposed works comprise reconstruction of the existing hard shoulder and addition of north and southbound lanes, predominantly at grade where the works lie within the existing motorway corridor. Beyond the motorway corridor, from CH1700 to CH1800, retention works are required to support the widening. The preferred solution offers a pre-cast panel L-shaped wall, sub-excavated and founded onto the existing embankment shoulder.

Removal of the existing, approximately 4m wide, central median and barrier is proposed, together with construction of a new barrier.

Whilst widespread liquefaction and lateral spreading, during a major seismic event, is anticipated throughout the motorway corridor, this constraint has not been targeted for ground investigation, as discussed in Section 6 Route Security above.

7.4.4 Recommended Investigations

Benkleman Beam testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders.

Test pits at 100m intervals and boreholes (to between 10m and 20m depth) at 200m intervals are recommended along the length of the proposed retaining wall (Southbound Ch1700 to 1800).

7.5 Wellington Fault Line

The Wellington Fault line crosses below the existing Thorndon Overbridge immediately south of the proposed scheme (beyond chainage 4200), as identified within Appendix A. Fault rupture is anticipated to cause considerable damage to the Thorndon Overbridge. The alignment of the Wellington Fault in this region is well defined and as such we do not recommend fault alignment investigations. Outwith this section of the scheme, the fault is sufficiently offset such that it does not present a fault rupture hazard.

7.6 Site Contamination

A high level desk study has been undertaken to determine the potential for contaminated material to be present within the project footprint. The study comprised a review of available borehole logs from the immediate area (as detailed in "Previous Ground Investigations" Page 6), a review of Greater Wellington Regional Council's (GWRC) Selected Land Use Register (SLUR), and a review of available photographs within Wellington City Council's online photographic archives (as available on 22 June 2011).

7.6.1 Historical Development

The site is located on reclaimed land formed in the late 1960s. The section of land between Kaiwharawhara and Ngaruanga was reclaimed specifically to allow the construction of existing State Highway 1 (SH1) and main trunk line railway corridors. The reclaimed land is predominantly formed of hydraulic fill sourced from Wellington Harbour and overlain by a capping of general fill comprising construction debris and quarry spoil.

The soil descriptions on borehole logs from previous geotechnical investigations confirm that the site is underlain by fill.

7.6.2 GWRC Selected Land Use Register

The SLUR provided by GWRC lists activities which are found on the Ministry for the Environment (MfE) Hazardous Activities and Industries List (HAIL). This list provides a compilation of activities and industries that have potential to cause land contamination as a result of the storage or use of hazardous substances. The SLUR identified the following areas which have the potential to be contaminated sites; further detail is shown in Appendix A3:

- The Kiwi Rail and Centre Port land located between Thorndon and Wellington Harbour
- Commercial properties at the base of the Ngaio Gorge, Kaiwaharara.
- Kiwi Rail land between Sh1 and Wellington Harbour, Ngauranga

Whilst these locations cover an extensive area, they are all offset in plan and for the most part lie below the proposed works, and are therefore unlikely to contribute directly to soil contamination within the proposed project footprint. However, the possibility exists for contaminant migration from these sites via groundwater or direct leaching. Pile excavation for the Thorndon Overbidge ramp may directly encounter contaminants.

7.6.3 Evaluation

The high level desk study has shown that the potential for contamination exists within the project footprint as a result of underlying fill and HAIL activities on some neighbouring sites. However, no actual contaminant data is known to exist for soils in either of these locations.

Where soils are to be disturbed as part of the project, soils should be assessed to determine whether the site, or part thereof, is considered a “contaminated site”.

A contaminated site is defined in the Greater Wellington Regional Council - Discharges to Land Plan as:

“A site at which a hazardous substance occurs at concentrations above background levels and where assessment indicates it poses or is likely to pose an immediate or long term hazard to human health or the environment”

7.6.4 Recommended Investigations

It is recommended that a contamination assessment be undertaken and this would provide information to determine resource consent requirements (if any) and reuse/disposal options for any spoil generated by the construction phase.

A representative set of soil and water samples will be taken from each trial pit and laboratory tested for the appropriate suite of determinands.

8 Summary of Proposed Investigations

In summary the following investigations are recommended as an indicative scope, to be confirmed when the preferred option for the Thorndon Overbridge area has been identified.

- Thorndon Overbidge, a series of CPT's at each pier and 10m to 20m depth boreholes at every second pier
- Kaiwharawhara, Benkleman Beam testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m centres, and 10 to 20m deep boreholes at 200m centres throughout the extent of the proposed retaining wall – Ch 2200 to 3000. A borehole to 10m depth is recommended at the location of the two widened gantries.
- Southern Rail Overbridge, no additional geotechnical investigations are proposed.
- Ngauranga, as for Kaiwharawhara, Benkleman Beam testing (at 20m centres) is recommended throughout the entire length of the north and southbound hard shoulders. Test pits at 100m intervals and boreholes (to between 10m and 20m depth) at 200m intervals are recommended along the length of the proposed retaining wall – Ch1700 to 1800.
- A representative set of soil and water samples will be taken from each trial pit and laboratory tested for the appropriate suite of contamination determinands.

9 References

[1] Begg, J.G., Mazengarb, C., 1996: Geology of the Wellington area, scale 1:50 000. Institute of Geological and Nuclear Sciences geological map 22. 1 sheet + 128 p. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited.

[2] NZSEE, NZS 1170.5:2004 Site Subsoil Classification of Wellington City (April 2011), S.Semmens et al.

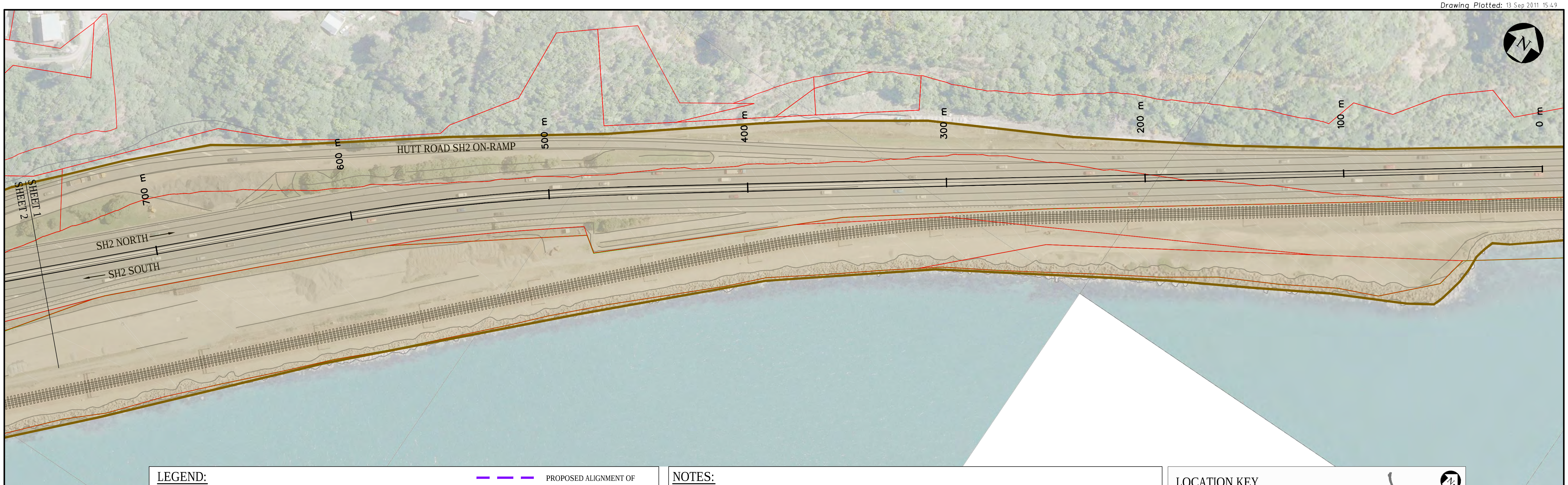
[3] Wellington Urban Motorway Thorndon to Petone – Summary of Existing Geotechnical Data and Interpretation, 19 March 2010, Beca Infrastructure Ltd

10 Appendices

A1 - Summary Geological Plans – 3321045-G-001 to 004

A2 - Indicative Cross Sections, Thorndon Overbridge, Kaiwaharawhara and Southern Rail Overbridge.

A3 – Greater Wellington City Council, Selected Land Use Register



SHEET 1

LEGEND:

- RECLAIMED FILL
- FAULT (ACTIVE)
- FAULT (NOT ACTIVE)
- HAZARD (FAULT LINE) AREA
- ALLUVIUM
- EXISTING BOREHOLE
- EXISTING TEST PIT
- EXISTING CPT
- PROPOSED ALIGNMENT OF SEPARATE ELEVATED OFF RAMP STRUCTURE
- PROPOSED BOREHOLE
- PROPOSED TEST PIT
- PROPOSED CPT
- PROPOSED PIER LOCATION

NOTES:

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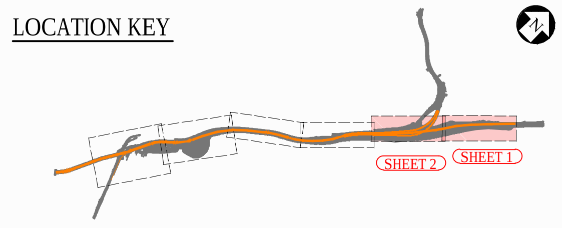
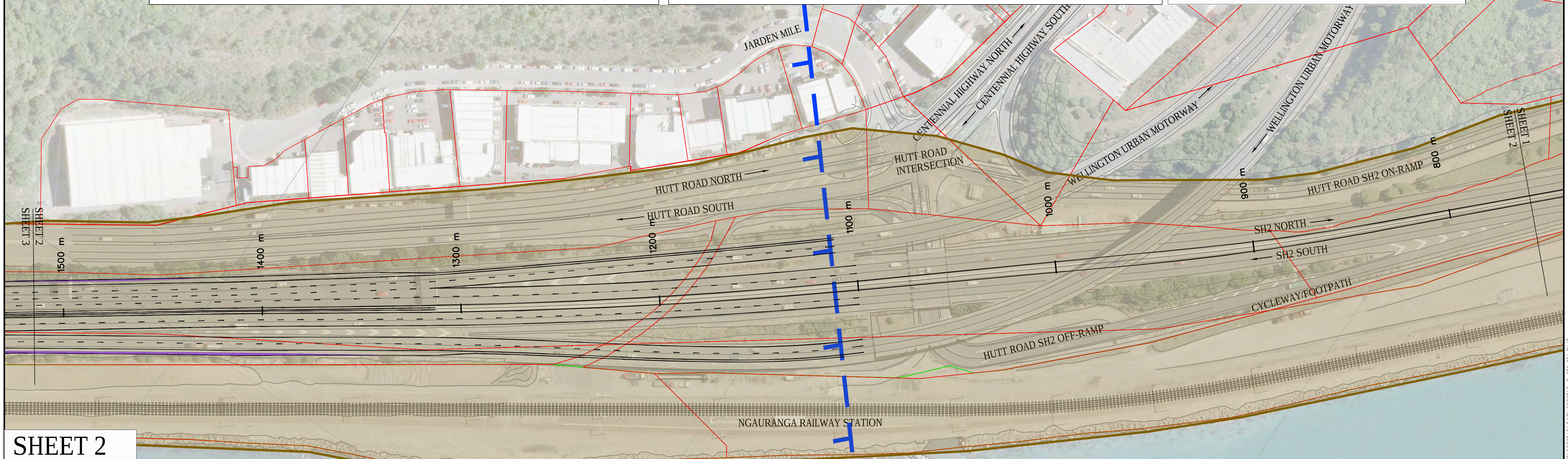
3. RECOMMENDED HAZARD ZONE (FAULT LINE AREA) INFERRED FROM WCC RECORDS (WELLINGTON CITY COUNCIL, WELLINGTON FAULT MAP INDEX, MAPS 1 & 2). BOUNDARIES ARE INDICATIVE ONLY.
4. EXPLORATORY HOLE LOCATIONS TAKEN FROM THE BECA GEOTECHNICAL DATABASE. HOLE LOCATIONS ARE INDICATIVE ONLY.

LOCATION KEY





SHEET 2

No.	Revision	By	Chk	Appd	Date
*	UNDER REVISION				

Original Scale (A1) 1:1,000	Design	MDH	22.06.11	Approved For Issue*
	Drawn	JA	22.06.11	
Reduced Scale (A3) 1:2,000	Dsg Verifier	JS	23.06.11	
	Dwg Check	JAH	23.06.11	Date

* Refer to Revision 1 for Original Signature

Fletcher | Beca

Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: N⫯AQ CONTRACT NO. 446PN

Title: GEOTECHNICAL INVESTIGATION PLAN SHEET 1 & 2

Discipline: GEOTECH

Drawing No. 3321045-G-101 Rev. A

UNDER REVISION

DO NOT SCALE

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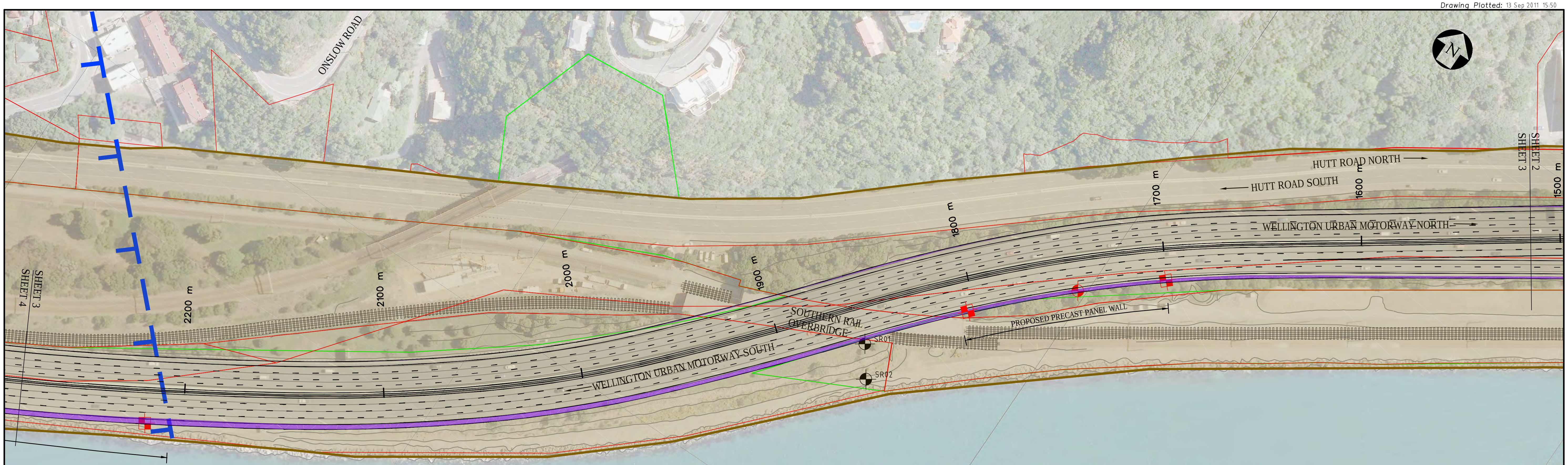

SHEET 3

LEGEND:

	RECLAIMED FILL		ALLUVIUM		PROPOSED ALIGNMENT OF SEPARATE ELEVATED OFF RAMP STRUCTURE
	FAULT (ACTIVE)		EXISTING BOREHOLE		PROPOSED BOREHOLE
	FAULT (NOT ACTIVE)		EXISTING TEST PIT		PROPOSED TEST PIT
	HAZARD (FAULT LINE) AREA		EXISTING CPT		PROPOSED CPT
					PROPOSED PIER LOCATION

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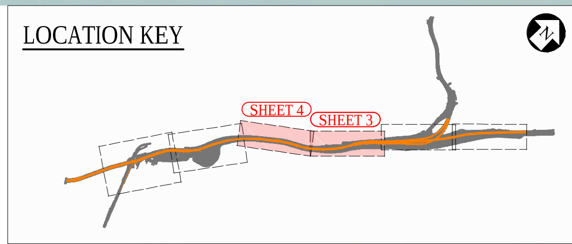
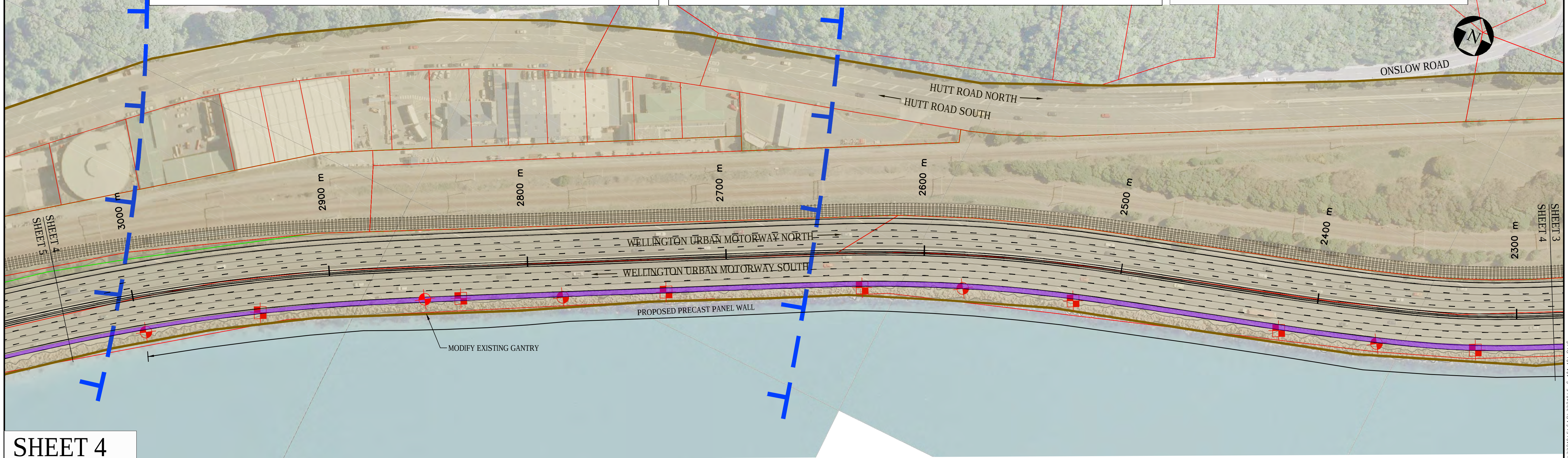
4. EXPLORATORY HOLE LOCATIONS TAKEN FROM THE BECA GEOTECHNICAL DATABASE. HOLE LOCATIONS ARE INDICATIVE ONLY.

LOCATION KEY





SHEET 4

No.	Revision	By	Chk	Appd	Date
+	UNDER REVISION				

Original Scale (A1) 1:1,000	Design	MDH	22.06.11	Approved For Issue*
	Drawn	JA	22.06.11	
Reduced Scale (A3) 1:2,000	Dsg Verifier	JS	23.06.11	
	Dwg Check	JAH	23.06.11	Date
	* Refer to Revision 1 for Original Signature			

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: NtAQ CONTRACT NO. 446PN

UNDER REVISION

Title: GEOTECHNICAL INVESTIGATION PLAN SHEET 3 & 4

Discipline: GEOTECH

Drawing No. 3321045-G-102 Rev. A

DO NOT SCALE

IF IN DOUBT ASK.

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LEGEND:

- RECLAIMED FILL
- ALLUVIUM
- FAULT (ACTIVE)
- FAULT (NOT ACTIVE)
- HAZARD (FAULT LINE) AREA
- EXISTING BOREHOLE
- EXISTING TEST PIT
- EXISTING CPT
- PROPOSED ALIGNMENT OF SEPARATE ELEVATED OFF RAMP STRUCTURE
- PROPOSED BOREHOLE
- PROPOSED TEST PIT
- PROPOSED CPT
- PROPOSED PIER LOCATION

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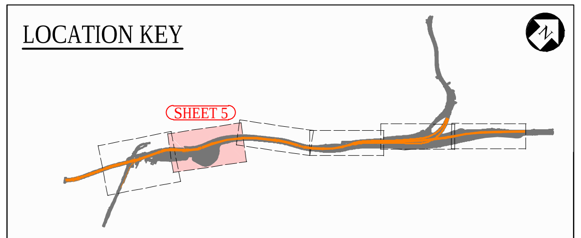
4. EXPLORATORY HOLE LOCATIONS TAKEN FROM THE BECA GEOTECHNICAL DATABASE. HOLE LOCATIONS ARE INDICATIVE ONLY.

LOCATION KEY



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+	UNDER REVISION				

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	Drawn	JA	22.06.11	
Reduced Scale (A3) 1:2,000	Dsg Verifier	JS	23.06.11	
	Dwg Check	JAH	23.06.11	Date

* Refer to Revision 1 for Original Signature

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: N+AQ CONTRACT NO. 446PN

Title: GEOTECHNICAL INVESTIGATION PLAN SHEET 5

UNDER REVISION

Discipline: GEOTECH

Drawing No: 3321045-G-103 Rev. A

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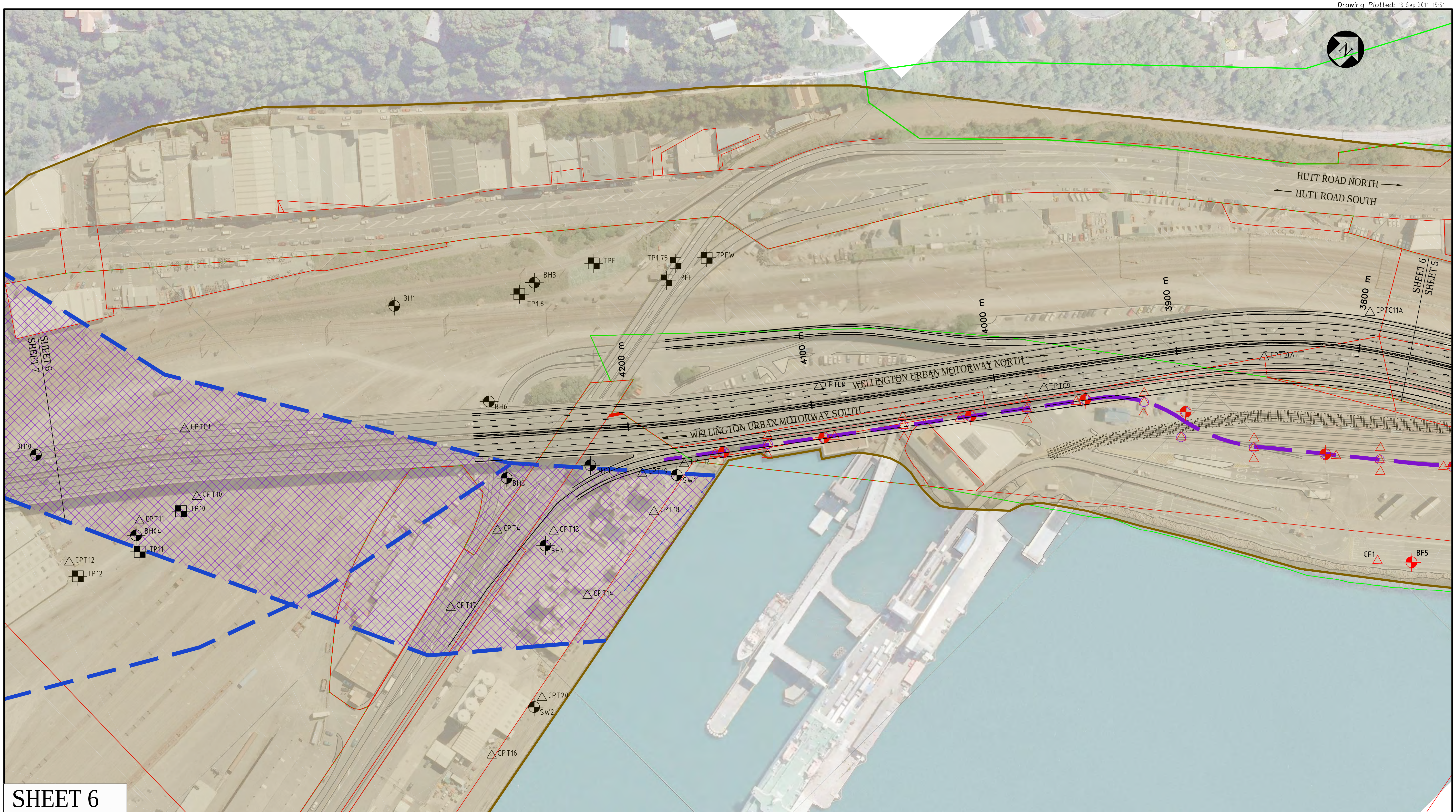

SHEET 6

LEGEND:

	RECLAIMED FILL		ALLUVIUM		PROPOSED ALIGNMENT OF SEPARATE ELEVATED OFF RAMP STRUCTURE
	FAULT (ACTIVE)		EXISTING BOREHOLE		PROPOSED BOREHOLE
	FAULT (NOT ACTIVE)		EXISTING TEST PIT		PROPOSED TEST PIT
	HAZARD (FAULT LINE) AREA		EXISTING CPT		PROPOSED CPT
					PROPOSED PIER LOCATION

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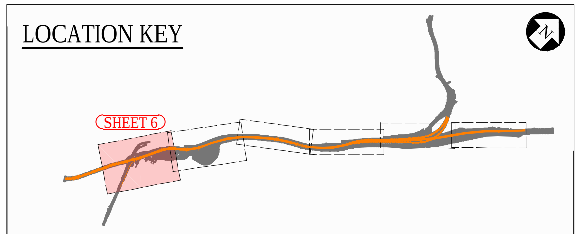
LOCATION KEY



No.	Revision	By	Chk	Appd	Date
*	UNDER REVISION				

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	Drawn	JA	22.06.11
Reduced Scale (A3) 1:2,000	Dsg Verifier	JS	23.06.11
	Dwg Check	JAH	23.06.11

Approved For Issue*

Date

* Refer to Revision 1 for Original Signature

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Client: NZ TRANSPORT AGENCY WAKA KOTAHI

Project: NtAQ CONTRACT NO. 446PN

Title: GEOTECHNICAL INVESTIGATION PLAN SHEET 6

UNDER REVISION

Discipline: GEOTECH

Drawing No. 3321045-G-104

Rev. A

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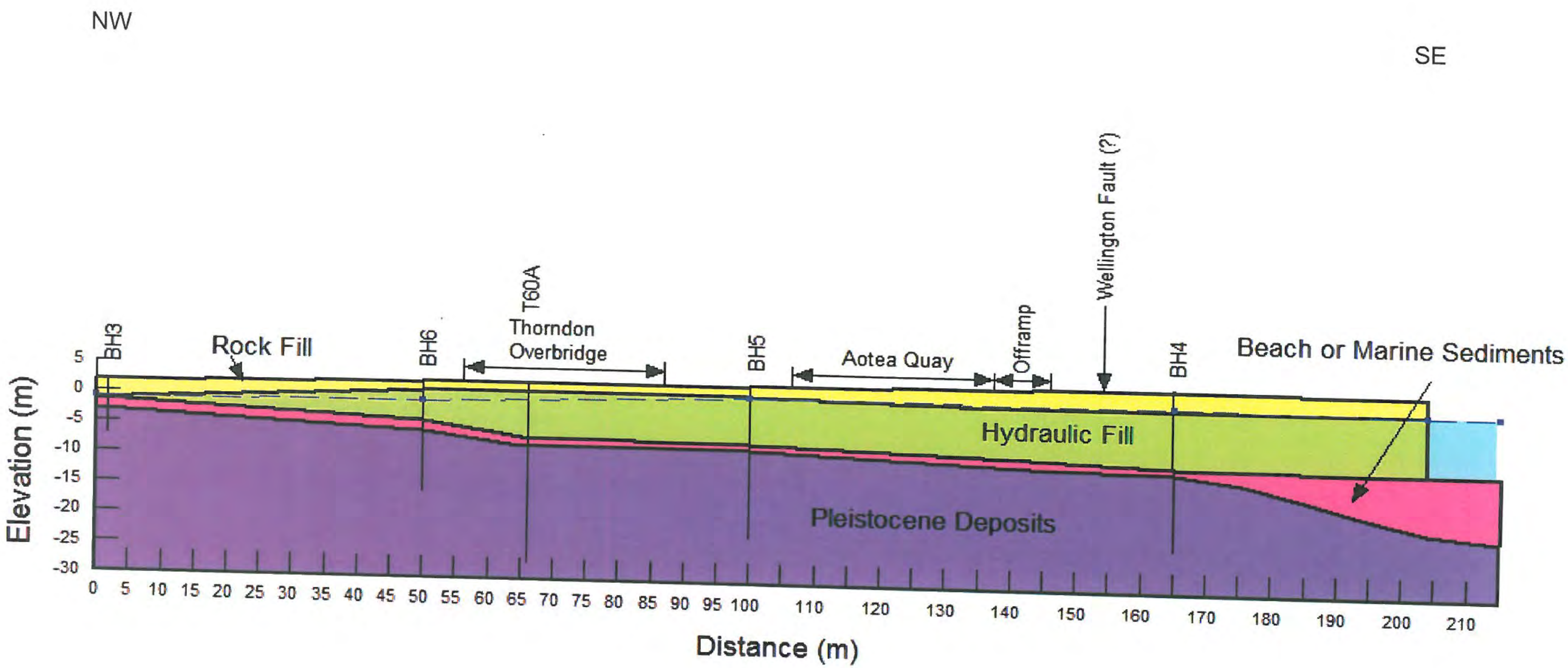
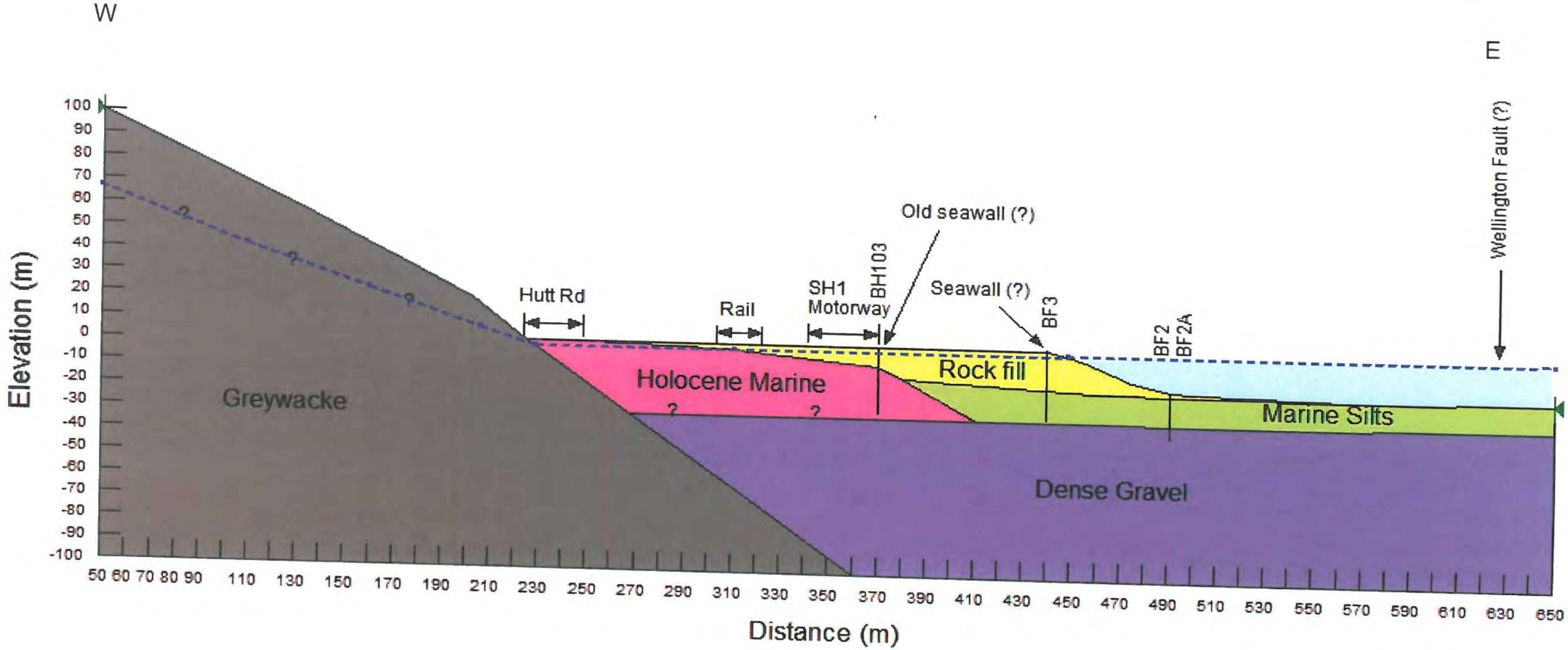


Beca

Thorndon Overbridge

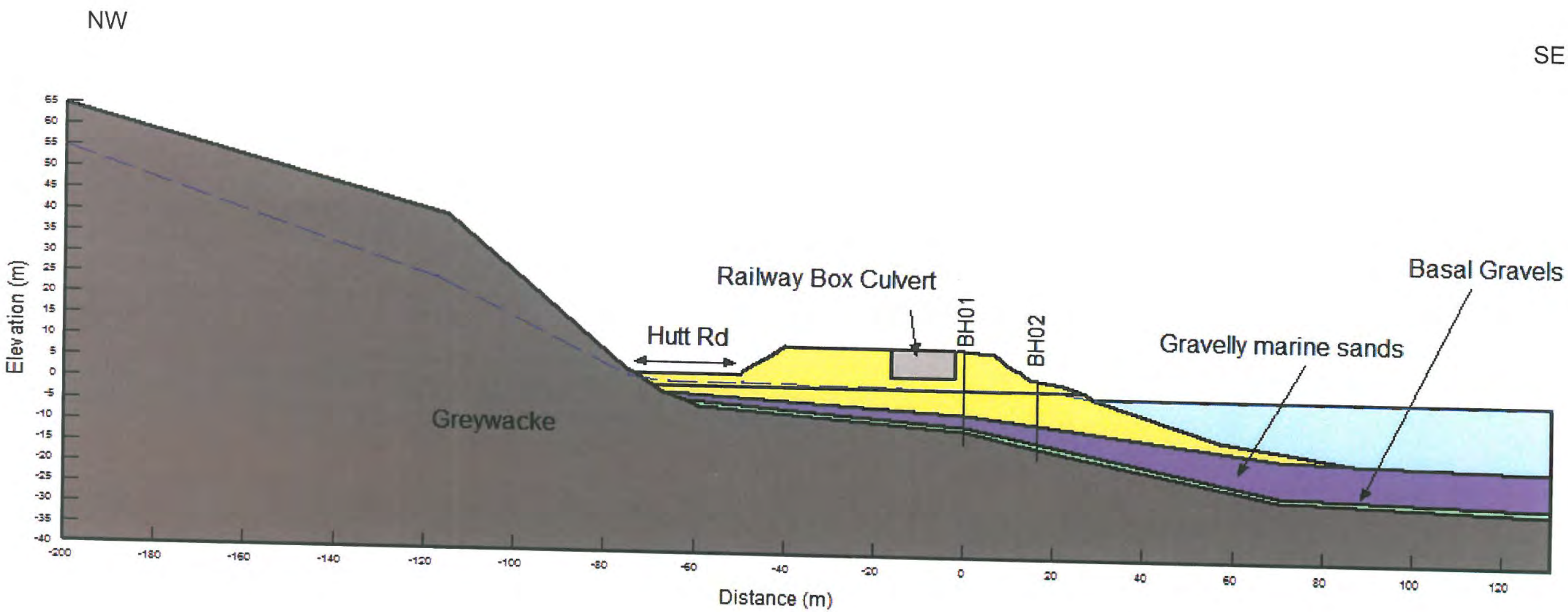
Indicative Cross Section



Beca

Kaiwharawhara

Indicative Cross Section



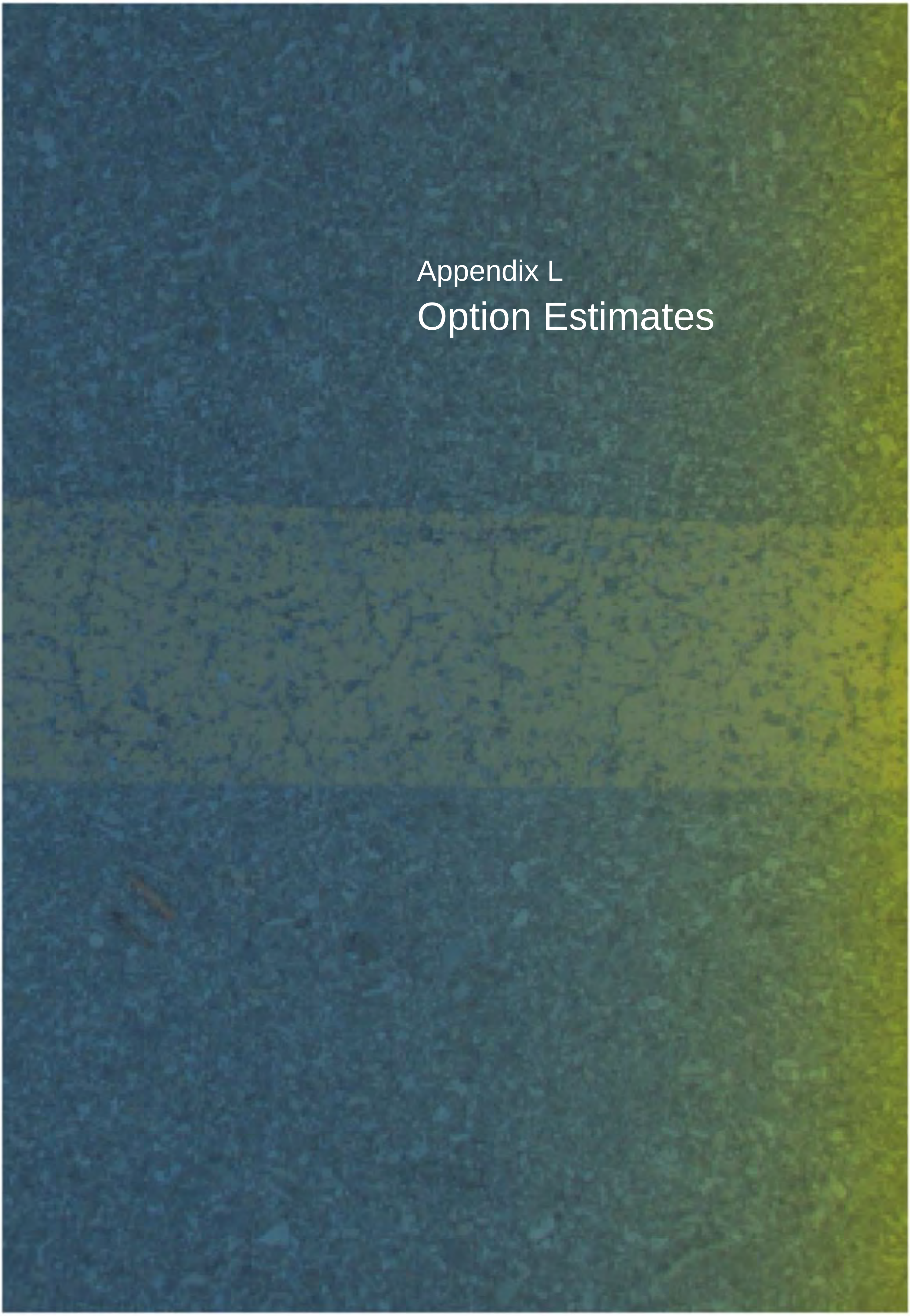
Southern Rail Overbridge

Indicative Cross Section

Greater Wellington Regional Council

0 0.2 0.4 Kilometers

greater WELLINGTON REGIONAL COUNCIL



Appendix L
Option Estimates

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 1

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$375,352				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$375,352**		**$375,352**		
	Construction					
	MSQA					
	- Consultancy Fees	$642,400				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$642,400**	**10%**	**$708,000**		
	Physical Works					
1	Environmental Compliance	$55,000	10%	$60,616		
2	Earthworks	$4,634	10%	$5,107		
3	Ground Improvements	$0	10%	$0		
4	Drainage	$0	10%	$0		
5	Pavement and Surfacing	$0	10%	$0		
6	Bridges	$0	10%	$0		
7	Retaining Walls	$24,305	10%	$26,787		
8	Traffic Services	$4,767,497	10%	$5,254,339		
9	Service Relocations	$0	10%	$0		
10	Landscaping	$0	10%	$0		
11	Traffic Management and Temporary Works	$723,085	10%	$796,924		
12	Preliminary and General	$803,000	10%	$885,000		
13	Extraordinary Construction Costs	$4,117,531	10%	$4,538,000		
14	Risk	$401,500	10%	$442,500		
15	Sub Option Works	$4,117,530	10%	$4,537,999		
	Sub Total Base Physical Works	**$15,014,082**		**$16,547,272**		
D	**Total Construction**	**$15,656,482**		**$17,255,272**		
E	**Project Base Estimate** (A+B+C+D)	**$19,031,834**		**$20,630,624**		
F	**Contingency** (Assessed/Analysed)			**$1,598,790**		
G	**Project Expected Estimate** (E+F)			**$20,630,624**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) (A+B+C+D)				**7%**	**$1,381,590**
I	**95th percentile Project Estimate** (G+H)					**$22,012,214**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
Estimate prepared by	**Signed**
Estimate internal peer review by	**Signed**
Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 2A

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,335,733				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,335,733**		**$1,335,733**		
	Construction					
	MSQA					
	- Consultancy Fees	$2,904,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$2,904,000**	**16%**	**$3,366,473**		
	Physical Works					
1	Environmental Compliance	$220,000	16%	$255,036		
2	Earthworks	$127,998	16%	$148,382		
3	Ground Improvements	$0	16%	$0		
4	Drainage	$4,263,598	16%	$4,942,592		
5	Pavement and Surfacing	$6,648,916	16%	$7,707,780		
6	Bridges	$7,986,011	16%	$9,257,812		
7	Retaining Walls	$687,188	16%	$796,626		
8	Traffic Services	$12,020,753	16%	$13,935,102		
9	Service Relocations	$0	16%	$0		
10	Landscaping	$10,751	16%	$12,463		
11	Traffic Management and Temporary Works	$4,154,062	16%	$4,815,612		
12	Preliminary and General	$7,260,000	16%	$8,416,181		
13	Extraordinary Construction Costs	$4,117,531	16%	$4,773,263		
14	Risk	$1,815,000	16%	$2,104,045		
15	Sub Option Works	$4,117,530	16%	$4,773,262		
	Sub Total Base Physical Works	**$53,429,339**		**$61,938,155**		
D	**Total Construction**	**$56,333,339**		**$65,304,628**		
E	**Project Base Estimate** **(A+B+C+D)**	**$60,669,072**		**$69,640,361**		
F	**Contingency** (Assessed/Analysed)			**$8,971,289**		
G	**Project Expected Estimate** **(E+F)**			**$69,640,361**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) **(A+B+C+D)**				**23%**	**$15,718,373**
I	**95th percentile Project Estimate** **(G+H)**					**$85,358,735**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
Estimate prepared by	**Signed**
Estimate internal peer review by	**Signed**
Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 2B

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,507,848				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,507,848**		**$1,507,848**		
	Construction					
	MSQA					
	- Consultancy Fees	$3,784,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$3,784,000**	**13%**	**$4,262,859**		
	Physical Works					
1	Environmental Compliance	$220,000	13%	$247,841		
2	Earthworks	$127,448	13%	$143,576		
3	Ground Improvements	$0	13%	$0		
4	Drainage	$5,312,235	13%	$5,984,489		
5	Pavement and Surfacing	$7,276,486	13%	$8,197,312		
6	Bridges	$7,986,011	13%	$8,996,627		
7	Retaining Walls	$687,188	13%	$774,151		
8	Traffic Services	$13,557,356	13%	$15,273,016		
9	Service Relocations	$0	13%	$0		
10	Landscaping	$10,751	13%	$12,112		
11	Traffic Management and Temporary Works	$5,076,390	13%	$5,718,798		
12	Preliminary and General	$9,460,000	13%	$10,657,147		
13	Extraordinary Construction Costs	$4,117,531	13%	$4,638,597		
14	Risk	$2,365,000	13%	$2,664,287		
15	Sub Option Works	$4,117,530	13%	$4,638,596		
	Sub Total Base Physical Works	**$60,313,927**		**$67,946,549**		
D	**Total Construction**	**$64,097,927**		**$72,209,408**		
E	**Project Base Estimate** (A+B+C+D)	**$68,605,775**		**$76,717,256**		
F	**Contingency** (Assessed/Analysed)			**$8,111,481**		
G	**Project Expected Estimate** (E+F)			**$76,717,256**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) (A+B+C+D)				**20%**	**$15,174,791**
I	**95th percentile Project Estimate** (G+H)					**$91,892,048**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
Estimate prepared by	**Signed**
Estimate internal peer review by	**Signed**
Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 3A

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,285,819				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,285,819**		**$1,285,819**		
	Construction					
	MSQA					
	- Consultancy Fees	$3,168,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$3,168,000**	**20%**	**$3,790,976**		
	Physical Works					
1	Environmental Compliance	$220,000	20%	$263,262		
2	Earthworks	$130,198	20%	$155,801		
3	Ground Improvements	$0	20%	$0		
4	Drainage	$4,263,598	20%	$5,102,019		
5	Pavement and Surfacing	$6,648,916	**20%**	$7,956,400		
6	Bridges	$7,986,011	20%	$9,556,431		
7	Retaining Walls	$355,747	20%	$425,703		
8	Traffic Services	$9,528,417	20%	$11,402,145		
9	Service Relocations	$0	20%	$0		
10	Landscaping	$10,751	20%	$12,865		
11	Traffic Management and Temporary Works	$4,154,062	20%	$4,970,943		
12	Preliminary and General	$7,920,000	20%	$9,477,439		
13	Extraordinary Construction Costs	$4,117,531	20%	$4,927,228		
14	Risk	$1,980,000	20%	$2,369,360		
15	Sub Option Works	$4,117,530	20%	$4,927,227		
	Sub Total Base Physical Works	**$51,432,760**		**$61,546,824**		
D	**Total Construction**	**$54,600,760**		**$65,337,799**		
E	**Project Base Estimate** (A+B+C+D)	**$58,886,579**		**$69,623,618**		
F	**Contingency** (Assessed/Analysed)			**$10,737,039**		
G	**Project Expected Estimate** (E+F)			**$69,623,618**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) (A+B+C+D)				**23%**	**$16,001,935**
I	**95th percentile Project Estimate** (G+H)					**$85,625,554**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
Estimate prepared by	**Signed**
Estimate internal peer review by	**Signed**
Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 3B

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,475,052				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,475,052**		**$1,475,052**		
	Construction					
	MSQA					
	- Consultancy Fees	$3,960,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$3,960,000**	**19%**	**$4,705,039**		
	Physical Works					
1	Environmental Compliance	$220,000	19%	$261,391		
2	Earthworks	$701,595	19%	$833,593		
3	Ground Improvements	$0	19%	$0		
4	Drainage	$5,312,235	19%	$6,311,686		
5	Pavement and Surfacing	$7,339,792	19%	$8,720,709		
6	Bridges	$7,986,011	19%	$9,488,509		
7	Retaining Walls	$1,511,157	19%	$1,795,468		
8	Traffic Services	$10,234,085	19%	$12,159,537		
9	Service Relocations	$0	19%	$0		
10	Landscaping	$10,751	19%	$12,774		
11	Traffic Management and Temporary Works	$5,076,390	19%	$6,031,468		
12	Preliminary and General	$9,900,000	19%	$11,762,598		
13	Extraordinary Construction Costs	$4,117,531	19%	$4,892,208		
14	Risk	$2,475,000	19%	$2,940,649		
15	Sub Option Works	$4,117,530	19%	$4,892,207		
	Sub Total Base Physical Works	**$59,002,076**		**$70,102,797**		
D	**Total Construction**	**$62,962,076**		**$74,807,836**		
E	**Project Base Estimate** (A+B+C+D)	**$67,437,128**		**$79,282,888**		
F	**Contingency** (Assessed/Analysed)			**$11,845,760**		
G	**Project Expected Estimate** (E+F)			**$79,282,888**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) (A+B+C+D)				**20%**	**$16,139,654**
I	**95th percentile Project Estimate** (G+H)					**$95,422,542**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
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Estimate internal peer review by	**Signed**
Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 4

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,515,016				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,515,016**		**$1,515,016**		
	Construction					
	MSQA					
	- Consultancy Fees	$4,312,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$4,312,000**	**17%**	**$5,049,039**		
	Physical Works					
1	Environmental Compliance	$1,100,000	17%	$1,288,020		
2	Earthworks	$889,940	17%	$1,042,055		
3	Ground Improvements	$0	17%	$0		
4	Drainage	$6,167,679	17%	$7,221,903		
5	Pavement and Surfacing	$7,518,272	17%	$8,803,350		
6	Bridges	$7,986,011	17%	$9,351,038		
7	Retaining Walls	$4,557,776	17%	$5,336,824		
8	Traffic Services	$5,594,496	17%	$6,550,748		
9	Service Relocations	$0	17%	$0		
10	Landscaping	$0	17%	$0		
11	Traffic Management and Temporary Works	$5,076,390	17%	$5,944,084		
12	Preliminary and General	$10,780,000	17%	$12,622,596		
13	Extraordinary Construction Costs	$4,117,531	17%	$4,821,329		
14	Risk	$2,695,000	17%	$3,155,649		
15	Sub Option Works	$4,117,530	17%	$4,821,328		
	Sub Total Base Physical Works	**$60,600,624**		**$70,958,926**		
D	**Total Construction**	**$64,912,624**		**$76,007,964**		
E	**Project Base Estimate** (A+B+C+D)	**$69,427,639**		**$80,522,980**		
F	**Contingency** (Assessed/Analysed)			**$11,095,341**		
G	**Project Expected Estimate** (E+F)			**$80,522,980**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) (A+B+C+D)				**21%**	**$16,919,536**
I	**95th percentile Project Estimate** (G+H)					**$97,442,516**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
Estimate prepared by	**Signed**
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Estimate external peer review by	**Signed**
Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Project Estimate - Form B

Project Name: Ngauranga to Aotea Quay - Option 5

OE
Options Estimate

Item	Description	Base Estimate	+ Contingency %	+ Contingency $	Funding Risk %	Funding Risk $
A	**Nett Project Property Cost**					
	Investigation and Reporting					
	- Consultancy Fees	$3,000,000				
	- Transit Managed Costs					
B	**Total Investigation and Reporting**	**$3,000,000**		**$3,000,000**		
	Design and Project Documentation					
	- Consultancy Fees	$1,654,068				
	- Transit Managed Costs					
C	**Total Design and Project Documentation**	**$1,654,068**		**$1,654,068**		
	Construction					
	MSQA					
	- Consultancy Fees	$4,840,000				
	- Transit Managed Costs					
	- Consent Monitoring Fees					
	Sub Total Base MSQA	**$4,840,000**	**18%**	**$5,722,802**		
	Physical Works					
1	Environmental Compliance	$1,100,000	18%	$1,300,637		
2	Earthworks	$902,824	18%	$1,067,496		
3	Ground Improvements	$0	18%	$0		
4	Drainage	$6,167,679	18%	$7,292,645		
5	Pavement and Surfacing	$7,518,272	18%	$8,889,582		
6	Bridges	$7,986,011	18%	$9,442,636		
7	Retaining Walls	$4,557,776	18%	$5,389,101		
8	Traffic Services	$9,493,700	18%	$11,225,323		
9	Service Relocations	$0	18%	$0		
10	Landscaping	$0	18%	$0		
11	Traffic Management and Temporary Works	$5,076,390	18%	$6,002,308		
12	Preliminary and General	$12,100,000	18%	$14,307,004		
13	Extraordinary Construction Costs	$4,117,531	18%	$4,868,556		
14	Risk	$3,025,000	18%	$3,576,751		
15	Sub Option Works	$4,117,530	18%	$4,868,555		
	Sub Total Base Physical Works	**$66,162,712**		**$78,230,594**		
D	**Total Construction**	**$71,002,712**		**$83,953,396**		
E	**Project Base Estimate** **(A+B+C+D)**	**$75,656,780**		**$88,607,463**		
F	**Contingency** (Assessed/Analysed)			**$12,950,684**		
G	**Project Expected Estimate** **(E+F)**			**$88,607,463**		
	Project Property Cost Expected Estimate					
	Investigation and Reporting Expected Estimate					
	Design and Project Documentation Expected Estimate					
	Construction Expected Estimate					
H	**Funding Risk** (Assessed/Analysed) **(A+B+C+D)**				**19%**	**$16,415,732**
I	**95th percentile Project Estimate** **(G+H)**					**$105,023,195**
	Project Property Cost 95th percentile Estimate					
	Investigation and Reporting 95th percentile Estimate					
	Design and Project Documentation 95th percentile Estimate					
	Construction 95th percentile Estimate					

Date of Estimate	**Cost Index (Qtr/Year)**
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Estimate accepted by Transit	**Signed**

Note: (1) These estimates are exclusive of escalation and GST.

Appendix M

Risk Register

						Qualitative Risk Analysis			Risk Evaluation							
Item	Name	The risk: what can happen and how can it happen	Applies to Option	Threat or Opportunity	Existing Controls	How likely is the event?	Consequence Rating	What are the consequences of the event?	Likelihood Rating	Consequence Rating	Risk Score	Risk Priority	Risk Manager	Risk Status	Threat Rank	Opportunity Rank
1	**General**															
1.1	Capacity of Network	Insufficient Capacity of the existing Network and Local Roads to meet output of capacity improvements to project	All	Threat	Extend traffic model beyond project area	Likely	Medium	Image / Reputation	5	40	200	Very High Threat		Live	16	
1.2	Waterloo Quay Rail Crossing	Use of Rail Crossing by KIwiRail hampers the effectiveness of the network operations	All	Threat	None	Likely	Medium	Image / Reputation	5	40	200	Very High Threat		Live	16	
1.3	Early Works	Political drive for early works, Opportunity for staging of the works for early wins. The benefit is potentially a more fundable project		Opportunity	DMT / VAC / NZTA Board approvals	Expected	Medium	Image / Reputation	4	-40	-160	Very High Opportunity		Live		1
1.4	Approval Process	NZTA approval process delays project	All	Threat	PSG / RMT / VAC / NZTA Board approvals processes	Unlikely	Medium	Time	3	40	120	High Threat		Live	36	
1.5	Accuracy of the Scheme Assessment Estimate	Scheme Assessment estimate accuracy developed by Fletcher/Beca. The risk is BCR changes from SP1 to SP2	All	Threat	Scheme Assessment Brief	Unusual	Medium	Cost and Time	2	40	80	High Threat		Live	47	
1.6	Accuracy of the Scheme Assessment Benefits	Scheme Assessment benefits change resulting in lower BCR between SP1 and SP2	All	Threat	Scheme Assessment Estimate	Unusual	Medium	Time	2	40	80	High Threat		Live	47	
1.7	Project Scope Changes outside of current options 1-5 and affects additional length of SH	Change to Project Scope or NZTA requirements (additional or reduced scope)	All	Threat	Scope of ECI project	Unusual	Medium	Time	2	40	80	High Threat		Live	47	
1.8	NZTA Standards	Non acceptance by NZTA of design innovation (change in existing NZTA standards)	All	Threat	Pier Reviewers / VAC	Unlikely	Major	Cost and Time	3	70	210	Very High Threat		Live	8	
1.9	NZTA Standards	ITS standards are currently in draft form. The risk is the draft changes or does not adequately cover scope.	All	Threat	Pier Reviewers / VAC	Quite Common	Major	Cost and Time	4	70	280	Very High Threat		Live	3	
1.1	Functionality	Theoritical functionality is not achieved. The risk is Project objective is not achieved.	All	Threat	Extend traffic model beyond project area	Unlikely	Major	Image / Reputation	3	70	210	Very High Threat		Emerging	8	
1.11	Functionality	Opportunity to achieve benefits prior to implementation of final stages	2 to 5	Opportunity		Very Unlikely	Substantial	Image / Reputation	1	-100	-100	High Opportunity		Emerging		3
2	**Legislative**															
2.1	Land Designation	Additional Designation required during design and/or for construction (including temporary site working areas)	All	Threat	Existing designation	Likely	Medium	Time	5	40	200	Very High Threat		Live	16	
2.2	Land Designation	Unable to confirm Motorway designation boundary.	All	Threat	Existing designation	Likely	Medium	Time	5	40	200	Very High Threat		Live	16	
2.3	Sound Legislation	Unable to enforce - can be challenged	2,3 and 5	Threat	None	Likely	Medium	Image / Reputation	5	40	200	Very High Threat		Live	16	
2.4	Adequate Legislation	Design of operational regime for which there is no adequate legislation	2,3 and 5	Threat	None	Unlikely	Medium	Image / Reputation	3	40	120	High Threat		Live	36	
2.5	Consenting Process	Failing to achieve consents	All	Threat	None	Unlikely	Medium	Cost and Time	3	40	120	High Threat		Live	36	
2.6	Legally Enforceable	Design of operational regime which is legally unenforceable (included in Item 2.3)			None									Closed		
3	**Property**															
3.1	Property Requirements	Issues acquiring property such as air rights.	All	Threat	None	Unlikely	Major	Time	3	70	210	Very High Threat		Live	8	
3.2	Timing of property purchase	Unable to acquire land for widening of the designation for possible design proposals in time.	4,5	Threat	None	Unusual	Major	Time	2	70	140	High Threat		Live	33	
3.3	Port Access	Access requirements and future development of port prevent or interfere with proposal. KiwiRail objections results in revisions to Port Access plans. The risk is additional time and cost to resolve access issues.	All	Threat	GWRC port access study	Quite Common	Major	Time	4	70	280	Very High Threat		Live	3	
4	**Physical Constraints**															
4.1	Geotechnical	Unforeseen ground conditions. (Refer to Item 11.7)			None									Closed		
4.2	Structural capacity of structures	Ability of existing structure to accommodate any additional load. (Refer Section 11).			None									Closed		
4.3	Port / Rail Operations	Operations and physical of port constraints impact on proposal	All	Threat	Consultation with Stakeholders	Unlikely	Major	Cost	3	70	210	Very High Threat		Live	8	
4.4	Constructability	Working within requirements of existing stakeholders. Risk is design or construction methodology to be modified to meet stakeholder requirements	All	Threat	None	Likely	Medium	Cost	5	40	200	Very High Threat		Live	16	
4.5	Civil Constraints	Civil constraints of ATMS installation causes poor functionality. (Refer to Section 11).			None									Closed		
4.6	Existing Shoulder Pavement Construction	Settlement of existing shoulders if utilised for running traffic. (Refer to Section 11).			None									Closed		
4.7	Location of Existing Services	Failure to identify existing services. (Refer to Section 11).			None									Closed		
5	**ATMS Requirements**															
5.1	ATMS Knowledge	Not having enough knowledge of existing ATMS system	2,3 and 5	Threat	None	Unlikely	Major	Cost	3	70	210	Very High Threat		Live	8	
5.2	Existing Gantries	Capacity of existing gantries to accommodate additional signage	2,3 and 5	Threat	None	Unusual	Major	Cost	2	70	140	High Threat		Live	33	
5.3	ATMS Components	Availability/Specifications/Standards of components	2,3 and 5	Threat	None	Unlikely	Major	Cost	3	70	210	Very High Threat		Live	8	
5.4	Compatibility Issues	Incompatibility with systems, priorities and programme. Risk is integration and functionality (especially Signage).	2,3 and 5	Threat	None	Unlikely	Major	Cost	3	70	210	Very High Threat		Live	8	
5.5	Capacity of Existing TOC Facility	Insufficient capacity of existing NZTA system to operate and control proposed systems	2,3 and 5	Threat	None	Unusual	Major	Cost	2	70	140	High Threat		Live	33	
6	**Safety & Security**															

						Qualitative Risk Analysis			Risk Evaluation							
Item	**Name**	**The risk: what can happen and how can it happen**	**Applies to Option**	**Threat or Opportunity**	**Existing Controls**	**How likely is the event?**	**Consequence Rating**	**What are the consequences of the event?**	**Likelihood Rating**	**Consequence Rating**	**Risk Score**	**Risk Priority**	**Risk Manager**	**Risk Status**	**Threat Rank**	**Opportunity Rank**
6.1	Enforcement Resources	Additional resources (NZTA or Police) will be required to enforce	2,3 and 5	Threat	Consultation with Police	Unlikely	Medium	Cost	3	40	120	High Threat		Live	36	
6.2	Geometrics	Chosen package does not achieve required safety functionality by pushing geometrics boundaries. (Closed, Contained in 1.10)			None									Closed		
6.3	Signage	Chosen package does not achieve required safety functionality. (Closed, Contained in 1.10)			None									Closed		
7	**Stakeholder**															
7.1	Hutt Road Bus Lanes	Hutt Road Bus lane impacts success of project by increasing use of SH1. Base estimates assumes no allowance (WCC to construct bus lane after project completion).	All	Threat	Consultation with wcc	Unlikely	Medium	Image / Reputation	3	40	120	High Threat		Live	36	
7.2	Stakeholder Objectives	Alignment of stakeholder objectives	All	Threat	Initial stakeholder consultation	Likely	Major	Cost	5	70	350	Extreme Threat		Live	1	
7.3	NZTA Personnel	Lose of key NZTA staff and knowledge	All	Threat	None	Likely	Medium	Time	5	40	200	Very High Threat		Live	16	
7.4	Wellington City Council (WCC)	Increase in traffic on local network may result in objection by WCC	All	Threat	None	Quite Common	Medium	Image / Reputation	4	40	160	Very High Threat		Live	26	
7.5	NZTA Network Operations	Additional maintenance requirements	All	Threat	None	Unusual	Medium	Cost	2	40	80	High Threat		Live	47	
7.6	Project Staff	Changes in project Staff delays project.	All	Threat	None	Unusual	Minor	Time	2	10	20	Low Threat		Live	52	
7.7	NZTA Network Operations	Additional maintenance requirements	All	Opportunity	None	Unlikely	Minor	Cost	2	-10	-20	Low Opportunity		Live		4
8	**Design**															
8.3	Traffic Model Accuracy	Traffic model is poorly mainteained leading to inaccurate and inconsistent. (Closed, Included in Item 1.10)			None									Closed		
8.4	Gantry Specification	Opportunity to reduce access and barrier protection to new gantries	All	Opportunity	None	Likely	Medium	Cost	3	-40	-120	High Opportunity		Live		2
					#N/A											
9	**Construction**				0											
9.1	Construction Safety	Design of proposal which creates unsafe construction methodologies	All	Threat	Use of ECI	Unlikely	Major	Health & Safety	3	70	210	Very High Threat		Live	8	
9.2	Construction Access	Access & working areas for construction not working	All	Threat	None	Likely	Medium	Cost	5	40	200	Very High Threat		Live	16	
9.3	Construction Methodology	Design of proposal which makes construction methodology more expensive and/or takes longer	All	Threat	Use of ECI	Likely	Medium	Cost	5	40	200	Very High Threat		Live	16	
10	**Operation**															
10.1	Compliance	Road users do not understand or comply	2,3 and 5	Threat	None	Likely	Major	Health & Safety	5	70	350	Extreme Threat		Live	1	
10.2	Technical capacity at TOC	Abiity of TOC to cope with additional technology	2,3 and 5	Threat	None	Likely	Medium	Image / Reputation	5	40	200	Very High Threat		Live	16	
10.3	System Failure	Failure of system at any time	All	Threat	None	Quite Common	Medium	Image / Reputation	4	40	160	Very High Threat		Live	26	
10.4	Operational Regime Failure	Go-live of operational regime failure	2,3 and 5	Threat	None	Unlikely	Medium	Health & Safety	3	40	120	High Threat		Live	36	
10.5	Interface Between Ngauranga Gorge and N2AQ ATMS	Driver confusion over different ATMS configurations in Ngauranga gorge ATMS and new N2AQ system	2,3 and 5	Threat	none	Unlikely	Medium	Image / Reputation	3	40	120	High Threat		Live	36	
10.6	Accident At Ends of Scheme	Inability to manage an incident at either end of the scheme	All	Threat	None	Unlikely	Medium	Image / Reputation	3	40	120	High Threat		Live	36	
11	**Specific risks from Options Developed**															
11.1	Viaduct Resurfacing	Re-asphalt viaduct after widening (whole southbound section).	2 to 5	Threat	None	Unlikely	Medium	Cost	3	40	120	High Threat		Live	36	
11.2	Existing Viaduct On-ramp Southbound	On-ramp south to be demolished due to grade difference and gap. Risk is that Base Estimate allowance is inadequate as work is more complex than envisaged	2 to 5	Threat	None	Quite Common	Medium	Cost	4	40	160	Very High Threat		Live	26	
11.3	Median Resurfacing	Additional pavement in median due to over excavation (drainage removal and large boulders from reclaim material)	2 to 5	Threat	None	Quite Common	Medium	Cost	4	40	160	Very High Threat		Live	26	
11.4	Median Barrier Removal	Concrete in Median Barrier. (Include in base estimate). Risk is that Base Estimate allowance is inadequate	2 to 5	Threat	None	Quite Common	Medium	Cost	4	40	160	Very High Threat		Live	26	
11.5	Fibre Optic Capacity	Fibre optic upgrade to TOC. Closed.			None									Closed		
11.6	Existing Loops	Existing loop electronics unknown and may require upgrade.	All	Threat	None	Likely	Minor	Cost	5	10	50	Moderate Threat		Live	51	
11.7	Separate Bridge Structure for Thorndon Off Ramp	The risk is the clip on widening of the Thorndon Bridge is not viable. The remedy is that a separate bridge structure is required (including ground improvement, etc). Separate Contingency item	2 to 5		Additional Investigation required											
11.7A	Separate Bridge Structure for Thorndon Off Ramp	Additional ground improvement is required to protect existing structure	2 to 5	Threat	Extent of ground improvement to be determined	Quite Common	Major	Cost	4	70	280	Very High Threat		Live	3	
11.8	Shoulder Pavement Capacity	Rebuild exisitng shoulder pavement material to cope with traffic volumes. The risk is rutting of pavements.	2 to 5	Threat	Re-build sub-base and re-surface. Potential for rehab at end of defects liability (if rutted)	Quite Common	Major	Cost	4	70	280	Very High Threat		Live	3	
11.9	Existing Aotea Quay On ramp	Upgrade existing (old) Aotea on-ramp or remove ramp structure (demolish)	2 to 5	Threat	Determine scope of potential work required	Quite Common	Medium	Cost	4	40	160	Very High Threat		Live	26	
11.1	Alignment resurfacing	Resurface whole alignment (Rather than patching) to be Included in Base Estimate. Risk is that a greater amount (or a higher quality) of re-surfacing is required	2 to 5	Threat	None	Quite Common	Medium	Cost	4	40	160	Very High Threat		Live	26	
11.11	Drainage	Additional cost of drainage due to unknown conditions of existing or unmarked services. The risk is Drainage Scope and Treatment differs to the allowance is made in the base estimate.	2 to 5	Threat	CCTV - Further Investigation	Quite Common	Major	Cost	4	70	280	Very High Threat		Live	3	

Item	Name	The risk: what can happen and how can it happen	Applies to Option	Threat or Opportunity	Existing Controls	Qualitative Risk Analysis			Risk Evaluation		Risk Score	Risk Priority	Risk Manager	Risk Status	Threat Rank	Opportunity Rank
						How likely is the event?	Consequence Rating	What are the consequences of the event?	Likelihood Rating	Consequence Rating						
11.12	Structural Deep Lift Pavement	NZTA requires existing pavement to be replaced with a structural asphalt (excluded).												Closed		
11.13	Services Relocation	Services relocation costs are more than base estimate allowance	2 to 5	Threat	Obtain budgets from Utilities Companies	Unlikely	Medium	Cost	3	40	120	High Threat		Live	36	
11.14	Detailed Design	Design Creep from SP2 to SP3	All	Threat	Allow sufficient timely peer reviews	Unlikely	Medium	Cost	3	40	120	High Threat		Live	36	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	
									0	0	0	#N/A			53	

Appendix N

Transport Model Background

Appendix N Traffic Model Background Information

Process

In order to assess the impact of the various options on the transport network a macro-level transport modelling exercise has been undertaken. This is considered appropriate for this stage of the project as it is able to assess the implications of wider road projects that will have an impact on the study corridor. This is particularly important in the context of the Wellington Region where a number of RoNS projects are in development. However, no single transport model can cover the range of spatial and temporal scales and processes involved and, as such, at this stage in the project, a two-tiered hierarchical modelling approach has been adopted to determine the likely impacts of the proposed work on the road section between Ngauranga and Aotea Quay and to ultimately inform the transport economic appraisal.

Upper Tier Model

The Wellington Transport Strategy Model (WTSM) sits at the top of the model hierarchy. WTSM is a spatially aggregate, multi-modal transport and demand model covering the Greater Wellington region and, hence operates and represents highway and public transport travel demand and patterns at a strategic level. WTSM 'outputs' travel demand matrices which will be used to inform the lower-tier SATURN traffic models – only highway demand is applicable to SATURN. As a strategic model, WTSM is only able to model NTAQ capacity improvements as 4 lanes in each direction. This has been done for the AM and PM periods only.

Lower Tier Model

SATURN traffic models are 'conventional' assignment models. NtAQ has used NZTA's Wellington CBD SATURN traffic model (WTM), as developed by Opus as the basis for testing the proposed work. It is the outputs from this model that will be used to inform the transport economic appraisal.

This model is more spatially disaggregate than WTSM – the model contains not only the strategic, arterial routes approaching Wellington CBD but more local 'feeder' routes. The model takes as input the strategic demand from WTSM and for the purposes of base year development only, further refinement of this demand is undertaken to 'infill' more regional and localised trips. **Table i** below presents some general information regarding the WTM SATURN model.

Table i – General SATURN model information

Item	Description
Years	2009, 2016, 2026
Time periods	AM peak hour (8am – 9am) Inter peak hour (11.30am – 12.30pm) PM peak hour (4.45pm – 5.45pm)
Vehicle types[1]	Cars, LCVs, HCVs
Geographical coverage	Johnsonville to Island Bay (north to south) and Seatoun to Karori (east to west)
Assignment technique	Wardrop Equilibrium
Does the base year model converge?	Yes and meets EEM criteria.

Travel Demand Matrices

For the purposes of testing each of the proposed options, a fixed matrix approach has been adopted as opposed to a Variable Demand Matrix (VDM) approach. Given the strategic nature of WTSM and the differences between each option only likely to generate modest effects on travel costs, using a fixed matrix approach is deemed appropriate. The matrices for each of the options will be the same as those derived from the WTSM Do Something test, ie 4 lanes assumed in each direction for the AM and PM peak hours, but converted to the SATURN zone system level and time periods. A summary of the matrix approach is given below in **Table ii**.

It was agreed with NZTA that the **High Growth** land-use scenario would be used for testing the proposed NtAQ options. Furthermore, it has been assumed that there is a 20% increase in fuel price and PT fares from a 2006 base; this 20% has been assumed for both 2016 and 2026.

Table ii – Matrix approach

Year	Scenario	Fixed Matrix	VDM
2009	Base	Yes	No
2016, 2026	Do Minimum	Yes	No
	Do Something	No	Yes
	Options testing	Yes[2]	No

[1] Cars and LCVs are combined to give Light Vehicles
[2] Using the Do Something matrices

Base Year validation

The model used was NZTA's WTM, as developed by Opus and peer reviewed by SKM. This was considered fit for purpose for NtAQ, therefore a detailed validation exercise wasn't undertaken. However the model was developed for the purposes of assessing changes to the CBD road network (rather than specifically for assessing changes to the NtAQ corridor), therefore a number of checks were undertaken:

- Model geographical coverage – the model was observed to cover the NtAQ study area including the roads necessary to inform route choice (as far north as Johnsonville and Newlands and including Burma Road);
- Traffic flows – AM peak (8am-9am) and PM peak (4.45pm-5.45pm) total traffic flows show a good correlation between modelled and observed in key areas (including SH1 at Murphy St, Aotea Quay off-ramp, SH1 at Ngauranga and Hutt Road south of Jarden Mile), with only a slight overall tendency for the model to over-estimate. However, there is a 23% underestimation in modelled total pcu traffic volumes on SH2 at Ngauranga in the PM peak hour in the northbound direction towards Petone;
- Travel patterns – checks have been made regarding trip length distribution which revealed a large drop in 5km to 6km long trips shifting to the 6km – 11km distance band. These are related to movements between SH1 and SH2 at the northern periphery of the model which is considered to be a reasonable effect of the matrix estimation process. Analysis of the change in patterns has shown logical differences with the largest changes occurring at the very periphery of the model to the north in the SH1 and SH2 sectors;
- Traffic routing – select link analyses for the AM and PM peak hours for traffic routing though SH1 and Hutt Road, both south of Ngauranga, illustrate sensible routing. As the routing analysis has received 'sign-off' from the peer reviewer it is reasonable to be confident that the correlation between the modelled and observed traffic flows are robust;
- Screenline validation – a screenline has been set south of the SH1 / SH2 merge at Ngauranga which captures total traffic flow into and out of the CBD. The AM and IP show the total amount of modelled traffic to be less than the observed and the PM showing the reverse of this, however the levels are considered reasonable;
- Connections to the Interislander port – review of the model demonstrated simplifications in the way the port of Wellington was represented with all port traffic (including that for the Interisland line ferries) using Aotea Quay. This was remedied for the purposes of NtAQ; and
- HCVs – there is a requirement for the WTSM model base year HCV matrix to be updated in the future since the underlying travel patterns and volumes are somewhat historic. There was not enough observed data to inform matrix estimation procedures at the SATURN level to make any sort of improvement to the HCV matrix in the NtAQ study area. However, a simplistic approach was adopted to improve the magnitude of HCV traffic volumes along Aotea Quay using data from Interislander, Bluebridge and Centreport's cargo tracking database, Centric.

In order that the model was adequate for the purposes of the scoping study analysis, a range of improvements were made. These principally revolved around the way the model represented the SH1/SH2 interchange and access to the port. These changes have resulted in a much improved model with potential benefits to NZTA for a wide variety of projects.

Future Years

Two future years have been modelled for each of the scenarios. In addition to the NtAQ improvements a range of other schemes have been included. These are documented in **Table iii** below.

Table iii – Future Year Reference Case Traffic Scheme Assumptions (RoNS & Other)

RoNS Traffic Scheme	2016	2026
Otaki to north of Levin	x	X
Peka Peka to Otaki	✓	✓
MacKays to Peka Peka	✓	✓
Linden to MacKays (Transmission Gully)	x	✓
Ngauranga to Aotea Quay	✓	✓
Terrace Tunnel duplication	x	✓
Basin Reserve	✓	✓
Airport to Mt Victoria Tunnel	✓ in part	✓
Other	**2016**	**2026**
Petone to Grenada link road	x	✓

Assumptions on speed and flow throughput (capacity)

Tables I – iii outline the free flow speeds (km/hr) and capacities (pcus/hr) for key highway sections between Ngauranga and Aotea Quay. The key points to note are:

- Each option assumes the same free-flow speed on the key highway sections; there are no free-flow speed differences between the base year, forecast year do minimums and the options; and
- The only differences between the options are capacity on the highway section between Ngauranga and Aotea Quay and hours of operation (part time – peak periods – for '3 lanes plus shoulder' and full time for '4 lanes with minimal shoulder' and '4 lanes with full shoulder.'). Refer to last paragraph of Section 9.1 in the Scoping Report, ie "It is only able to capture the benefits of increased capacity."

Table i Capacity and Speed Assumptions for '3 Lanes plus shoulder' option

Location	AM Peak Hour		PM Peak Hour	
Inbound to CBD	Capacity (pcus / hr)	Free flow speed (km / hr)	Capacity (pcus / hr)	Free flow speed (km / hr)
SH2 approaching SH1/SH2 merge at Ngauranga	3,800	100	3,800	100
SH1 on-ramp	3,800	100	3,800	100
SH1 between Ngauranga and Aotea Quay	5,400 then into 7,200	100	5,400	100
SH1 Aotea Quay off-ramp	1,100	70	1,100	70
SH1 immediately downstream of Aotea Quay off-ramp	4,500	100	4,500	100
Outbound from CBD	Capacity (pcus / hr)	Free flow speed (km / hr)	Capacity (pcus / hr)	Free flow speed (km / hr)
SH1 immediately upstream of Aotea Quay on-ramp	4,500	100	4,500	100
SH1 Aotea Quay on-ramp	1,800	80	1,800	80
SH1 between Aotea Quay and Ngauranga	5,400	100	7,200	100
SH1 at Ngauranga	3,800	100	3,800	100
SH2 (Hutt Road) at Ngauranga	3,600	100	3,600	100

Table ii Capacity and Speed Assumptions for '4 Lanes with minimal shoulder' option

Location	Capacity (pcus / hr)	Free flow speed (km / hr)
Inbound to CBD		
SH2 approaching SH1/SH2 merge at Ngauranga	3,800	100
SH1 on-ramp	3,800	100
SH1 between Ngauranga and Aotea Quay	7,200	100
SH1 Aotea Quay off-ramp	1,100	70
SH1 immediately downstream of Aotea Quay off-ramp	4,500	100
Outbound from CBD	Capacity (pcus hr)	Free flow speed (km / hr)
SH1 immediately upstream of Aotea Quay on-ramp	4,500	100
SH1 Aotea Quay on-ramp	1,800	80
SH1 between Aotea Quay and Ngauranga	7,200	100
SH1 at Ngauranga	3,800	100
SH2 (Hutt Road) at Ngauranga	3,600	100

Table iii Capacity and Speed Assumptions for '4 Lanes with full shoulder' option

Location	Capacity (pcus / hr)	Free flow speed (km / hr)
Inbound to CBD		
SH2 approaching SH1/SH2 merge at Ngauranga	3,800	100
SH1 on-ramp	3,800	100
SH1 between Ngauranga and Aotea Quay	7,600	100
SH1 Aotea Quay off-ramp	1,100	70
SH1 immediately downstream of Aotea Quay off-ramp	4,500	100
Outbound from CBD	Capacity (pcus hr)	Free flow speed (km / hr)
SH1 immediately upstream of Aotea Quay on-ramp	4,500	100
SH1 Aotea Quay on-ramp	1,800	80
SH1 between Aotea Quay and Ngauranga	7,600	100
SH1 at Ngauranga	3,800	100
SH2 (Hutt Road) at Ngauranga	3,600	100

SATURN Model Limitations

The main modelling limitation of SATURN in the context of NtAQ is that the software cannot effectively model the likely detailed effects of Active Traffic Management System (ATMS). This includes the modelling of Variable Message Signs (VMS) which can help improve vehicle merging, weaving and lane changing. It must be borne in mind, however, SATURN is **not** designed to be used as a **detailed** operational assessment tool; this is the purpose of micro-simulation software such as VISSIM.

SATURN is, however, designed to be used as a more aggregate operational tool which can capture the likely region-wide travel time savings, de-congestion and vehicle operating costs benefits from transport interventions such as that proposed between Ngauranga and Aotea Quay. It is these benefits, and in this case, generated from highway infrastructure changes, which contribute most to network performance and economic efficiency and therefore are key to identifying a preferred option. It is then the role of more detailed micro-simulation modelling to help refine the preferred option which can add benefit to the overall operational and economic performance. It is vitally important, therefore, to use an appropriate modelling tool and this is very much dependent on each stage of the evaluation process. This is put into context in **Table iv** below.

Table iv – Modelling Hierarchy Main Purpose and Outcomes

Modelling Hierarchy	Main Purposes	Outcomes
Upper Tier (Strategic WTSM model covering Greater Wellington region).	To act as a key source of transport supply and demand data and provide strategic road traffic for SATURN model.	Robust base representation of **strategic** road traffic volumes, patterns and journey times from which to forecast.
Mid-Tier (SATURN-based project model covering Wellington City).	**Option Assessment Stage:** Undertakes route choice for micro-simulation model and produces highway-based travel demand and costs for operational, economic, and safety appraisals.	Robust base representation of **strategic and more detailed** traffic volumes, patterns and journey times from which to forecast.
Lower Tier (Micro-simulation model, detailed local level for operational assessments).	**Refinement (preferred option) Stage:** Undertake detailed operational assessments of highway infrastructure and intersection performance, driver behaviour and vehicle interactions.	Robust **detailed** appraisal tool to test proposed mitigation measures and devise solutions more easily to make best use of the existing transport network infrastructure at the most detailed level.

Increasing level of spatial and temporal detail

Traditionally three-tiered modelling hierarchy systems are adopted when appraising transport interventions since no single transport model can cover the range of spatial and temporal scales and processes involved. It is clear from table 2.5, SATURN project models sit in the mid-tier of the modelling hierarchy and therefore illustrate their limitations in modelling very detailed operational mitigation measures such as ATMS.

Considering this limitation, SATURN was deemed a robust modelling tool for appraising the NtAQ traffic options and identifying differentiators which were likely to highlight a preferred option. The reasons behind this were as follows:

- Journey time savings, de-congestion and vehicle operating costs benefits form a large component of the overall benefits of each option, and it was these benefits, captured by the SATURN modelling, which were the main drivers in determining a preferred option;
- Journey time savings, de-congestion and vehicle operating cost benefits brought about by the main, physical highway infrastructure improvements (ie additional lane in options '3 lane plus shoulder,' '4 lanes with minimal shoulder' and '4 lanes with full shoulder') that had a greater influence on network performance and transport economic efficiency than the likely smaller beneficial effects of Active Traffic Management System (ATMS) that would be captured in micro-simulation;
- The magnitudes of the ATMS benefits were not likely to outweigh the larger benefits brought about by the main, physical highway infrastructure changes envisaged for the above options. It is these larger benefits, captured in the SATURN modelling, that have therefore been recommended to inform the option assessment and decision making process in determining a preferred option for NtAQ;
- Micro-simulation is a detailed design tool which will better highlight individual intersection performance along State Highway 1 and Hutt Road. This may show potential refinements that could be made and fed back into the SATURN intersection modelling to improve overall journey times. It is likely these refinements would have small beneficial impacts on the overall end-to-end journey times, but were not likely to greatly improve the journey times the SATURN modelling produced; and

A review exercise has been undertaken of the SATURN model to ensure a satisfactory level of robustness in our area of interest was demonstrated and, in turn, provided confidence in the model prior to commencing options testing, informing the MCA workshop and the option assessment processes. This review exercise was highly recommended since we were using an 'off-the-shelf' model which has not necessarily been developed for this specific project.

Appendix O

Hazard Analysis

Hazard Scoring

Introduction

The main purpose of a harard log is to provide an auditable record of the management of harards. This is through the recording of hazard risk assessments which include the calculation of a risk score for each hazard. This score is used to determine which hazards require the most attention. The higher the score, the more effort should be expended in managing that hazard.

Hazards are categorised as either an 'Event' or a 'State'.

Events and States

An Event is a hazard which occurs momentarily, e.g. a vehcile carries out a high risk lane change. Usually it is not meaningful to talk of how long such a hazard exists for.

A State hazard is one which is present for a period of time e.g. vehcile stpped on hard shoulder - the longer it is present, the greater the risk of an incident occurring. Such hazards will have a measurable duration and can persist for long periods.

It is important to distingish betwwen these two types of hazards as the risk scores are evaluated slightly differently depending on the choice. Care should be taken in comparing the risk assocaited with Events and Stares.e not directly comparable.

Parameters used in Hazard Risk Scores

Event hazard risk scores are eveluated by adding together a score for each of the following three factors:

1. The rate ate which the hazard is expected to occur
2. The probability that the hazard causes an incident
3. The severity of the incident

State hazard risk scores are evaluated by adding together a score for each of the following three factors:

1. The likelihood that the hazardous state is present
2. The rate at which incidents occure if the hazardous state is present
3. The severity of the incident, which is the same as for event hazards

Therefore, Risk scores for both Event and State hazards consist of three parameters as shown in Figure A1. The individual scores for the three parameters are then added together to give an overall Risk Score for that hazard or sub-hazard. The Risk Score is then converted into an Actual Score (10 to the power of the Risk Score) for each sub-hazard and added together to form a Composite Score for the overall hazard. The Composite Score is then converted to a Index Score for the hazard by multipling the Composite Score by Log to the power of 10.

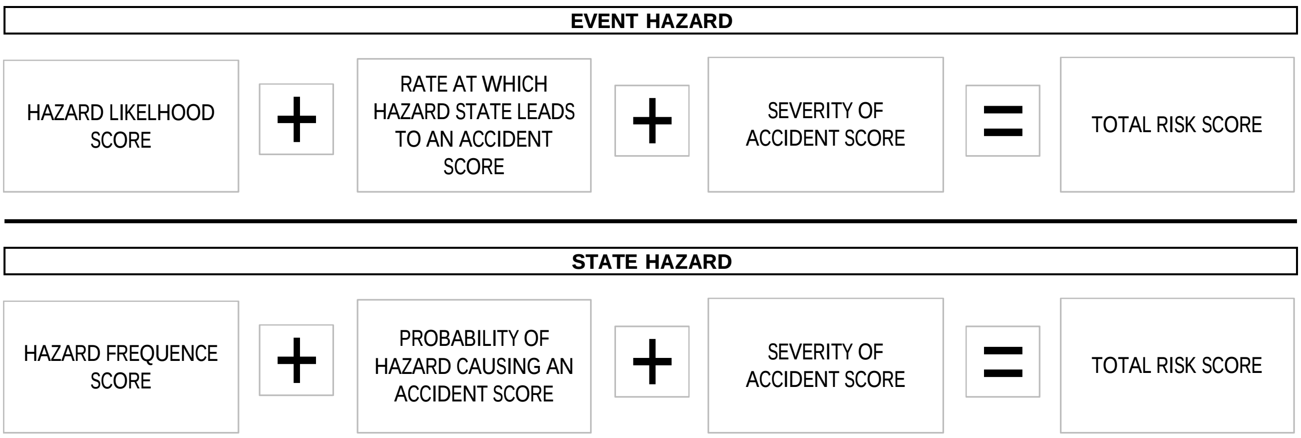

Figure A1: Hazard Scoring Parameters

Option Assessment

For each option the baseline hazard logs have been reassessment and either the frequency or probability has been reduced or increased to reflect the posibile percentage reduction or increase

The supporting reason for changing the hazard log score and the percentage change has been presented in the Scoping Option summary page.

NtAQ Option Safety Assessment

Associated Hazards		Probability Class.	Probability Index	Severity Class.	Severity Index	Frequency Class	Frequency Index	Score Index	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score
NZ01E	Events associated with abnormal/hazardous loads	Remote	2.00	Average	2.00	Frequent	5.50	9.50	31622876.6	7.50	1.2%
NZ01S	Hazardous states around abnormal/hazardous loads	Remote	1.00	Average	1.00	Occasional	3.00	5.00	100000.0	5.00	0.0%
NZ02E	Events associated with the opening or closing of the shoulder		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ02S	Hazardous states around the opening or closing of the shoulder		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ03E	Events associated with MM Operational		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ03S	Hazardous states around MM operational		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ04E	Events associated with ERAs		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ04S	Hazardous states around ERAs		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ05E	MM Comprehension / Confusion		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ06E	Events associated with maintenance	Remote	1.00	Severe	2.00	Occasional	2.50	5.50	316230.8	5.50	0.0%
NZ06S	Hazardous states around maintenance	Remote	7.00	Severe	10.00	Occasional	15.50	32.50	31000000.0	7.49	1.2%
NZ07E	Events associated with system glitches (including operator error)	Occasional	6.00	Severe	6.00	Remote	12.00	24.00	511097.1	5.71	0.0%
NZ07S	Hazardous states around system glitches (including operator error)	Occasional	10.00	Average	7.00	Remote	5.00	22.00	166824.1	5.22	0.0%
NZ08S	Debris	Occastional	2.00	Average	1.50	Probable	4.50	14.00	101000000.0	8.00	4.0%
NZ09E	Fatigue - Drowsy, tired, fell asleep	Occasional	2.00	Severe	2.00	Occasional	3.50	7.50	31622776.6	7.50	1.2%
NZ10E	Events associated with driver losing control of vehice	Probable	4.00	Average	1.00	Frequent	8.00	13.00	316259388.8	8.50	12.4%
NZ11E	Events associated with Authorised Persons on the carriageway	Remote	9.00	Severe	14.00	Occasional	29.00	52.00	17001000.0	7.23	0.7%
NZ11S	Hazardous states around Authorised persons on the carriageway	Remote	2.00	Average	3.00	Occasional	4.50	9.50	131622.8	5.12	0.0%
NZ12E	Events associated with driving too fast	Certain	4.00	Average	1.00	Remote	2.00	7.00	10000000.0	7.00	0.4%
NZ12S	Hazardous states around driving too fast	Occasional	4.00	Above Average	2.50	Frequent	10.00	16.50	416227766.0	8.62	16.3%
NZ13S	Excessively slow moving vehicle in running lane	Remote	1.00	Average	1.00	Occasional	3.00	5.00	100000.0	5.00	0.0%
NZ14E	Events associated with environmental conditions	Remote	1.00	Above Average	1.50	Probable	3.50	6.00	1000000.0	6.00	0.0%
NZ14S	Hazardous states around environmental conditions	Remote	3.00		3.00		7.00	13.00	6324555.3	6.80	0.2%
NZ15E	Events associated with motorcyclists	Remote	1.00	Severe	3.50	Frequent	9.00	13.50	100316227.8	8.00	3.9%
NZ15S	Hazardous states around motorcyclists	Improbable	0.00	Severe	2.00	Probable	4.00	6.00	1000001.0	6.00	0.0%
NZ16E	Events associated with pedestrians	Occasional	4.00	Severe	4.00	Probable	6.50	14.50	41622776.6	7.62	1.6%
NZ16S	Hazardous states around pedestrians	Occasional	2.00	Severe	2.00	Occasional	3.00	7.00	10000002.0	7.00	0.4%
NZ17E	Events associated with slip roads	Probable	12.00	Average	0.50	Occasional	24.00	42.50	143162277.7	8.16	5.6%
NZ18E	Events associated with terrorism and vandalism	Probable	5.00	Severe	4.00	Improbable	4.00	13.00	329390.0	5.52	0.0%
NZ19E	Infrastructure Collapse	Probable	6.00	Above Average	3.00	Improbable	1.00	10.00	200000.0	5.30	0.0%
NZ20E	Bad driver behaviour at lane closures	Remote	2.00	Average	2.00	Frequent	9.50	13.50	13162277.7	7.12	0.5%
NZ21E	Unsafe Lane changing	Remote	1.00	Above Average	1.50	Very Frequent	6.00	8.50	316227766.0	8.50	12.4%
NZ21S	Excessive Lane merging	Remote	1.00	Below Average	0.50	Probable	4.00	5.50	316227.8	5.50	0.0%
NZ22S	Speed camera flash unit becomes misaligned, affecting drivers on opposite carriageway	Improbable	0.00	Minor	0.00	Incredible	0.00	0.00	1.0	0.00	0.0%
NZ23E	Health deterioration of vehicle occupant	Probable	3.00	Above Average	1.50	Occasional	3.00	6.50	31622776.6	7.50	1.2%
NZ24S	Incidents or congestion caused in other lanes or carriageway due to rubber-necking	Occasional	2.00	Average	1.00	Probable	3.50	6.50	3162277.7	6.50	0.1%
NZ25S	Stationary traffic backed up onto motorway at exit point	Remote	1.00	Below Average	0.50	Frequent	5.00	6.50	3162277.7	6.50	0.1%
NZ26S	Tailgating	Occasional	2.00	Below Average	0.50	Very Frequent	6.00	8.50	316227766.0	8.50	12.4%
NZ27E	Vehicle rejoins running lane	Remote	1.00	Average	1.00	Occasional	5.50	7.50	31622776.6	7.50	1.2%
NZ28E	Merging and Diverging	Remote	2.00	Below Average	1.00	Very Frequent	11.50	14.50	41622776.6	7.62	1.6%
NZ29E	Events asociated with Illegal manoeveures	Occasional	3.00	Severe	4.00	Occasional	6.00	13.00	11000000.0	7.04	0.4%
NZ29S	Hazardous states around vehicle driving in wrong direction	Probable	3.00	Severe	2.00	Remote	1.50	6.50	3162277.7	6.50	0.1%
NZ30E	Events associated with vehicles obstructing carriageway	Occasional	4.00	Above Average	2.50	Probable	7.50	14.00	34785054.3	7.54	1.4%
NZ30S	Hazardous states around vehicles obstrucing carriageway	Remote	1.00	Above Average	1.50	Probable	3.50	6.00	1000000.0	6.00	0.0%
NZ31E	Change in vehicle speed	Occasional	3.00	Below Average	1.50	Very Frequent	11.50	16.00	347850542.6	8.54	13.6%
NZ32E	Vehicle drifts off carriageway or out of lane	Certain	5.00	Below Average	1.00	Probable	9.50	15.50	131622776.6	8.12	5.1%
NZ33S	Vehicle stops on the shoulder (not open to traffic)	Remote	1.00	Severe	2.00	Probable	4.00	7.00	10000000.0	7.00	0.4%
											100.0%
								Comp Actual Score	2556562387.8		
								Comp Index Score		9.408	

Option 1 Minor Works

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	69405307.89	7.84	2.7%	Queue detection and increased CCTV coverage would give the TOC operators great visibility of the project area will allowing them to better managed debris on the road and inform drivers of its location. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage to inform driver of situation and control would reduce proability of this hazard by 30%	31.3%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	251220265.93	8.40	9.8%	Enforcement of posted speed limit on the existing gantries should reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs with environmental information should reduce loss of control vehicles by 20%	20.6%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	7943282.35	6.90	0.3%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ12S	330621466.62	8.52	12.9%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	100316227.77	8.00	3.9%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	143162277.66	8.16	5.6%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	316227766.02	8.50	12.4%		
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	3162277.66	6.50	0.1%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	281838293.13	8.45	11.0%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 10% by having some inflence of sudden stopping	10.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	41622776.60	7.62	1.6%		
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	310022122.44	8.49	12.1%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 10%	10.9%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			90.0%		
	2300753057.8				
	Comp Index Score	9.362	0%		
	Percentage	Reductions	-10.0%		

Option 2 HSR

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	110362277.66	8.04	4.3%		
NZ02S	4110960.96	6.61	0.2%		
NZ03E	48047331.92	7.68	1.9%		
NZ03S	2100317.23	6.32	0.1%		
NZ04E	9624251.44	6.98	0.4%		
NZ04S	1000000.00	6.00	0.0%		
NZ05E	110031623.78	8.04	4.3%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	55130595.70	7.74	2.2%	Debris detection is enhanced through the installed of Trafficon cameras and increased CCTV PTZ and Fixed camera coverage would give the TOC operators great visibility of the project area allowing them to better managed debris on the road and inform drivers of its location. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 45%	45.4%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	199557854.27	8.30	7.8%	Enforcement of posted speed limit on the existing gantries plus 4 additional will reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on existing plus 4 additional ganties with environmental information will reduce loss of control vehicles by 35%	36.9%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	6309573.44	6.80	0.2%	Enforcement of posted speed limit on the existing gantries plus 4 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 4 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ12S	262621965.94	8.42	10.3%	Enforcement of posted speed limit on the existing gantries plus 4 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 4 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additional gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	199526231.50	8.30	7.8%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, increased capacity, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 35%. HSR will operate as CALR with no shoulders during the peak periods when most rear end crashes occur	36.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capacity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchange is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	42972994.72	7.63	1.7%	Frequency would increase slightly due to the use of the shoulders in the peak periods	-23.5%
NZ30S	1000000.00	6.00	0.0%		
NZ31E	246259325.24	8.39	9.6%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 25 - 30%	29.2%
NZ32E	143824622.03	8.16	5.6%	Lanes narrowed from 3.5m to 3.3m and during the peak period there will be a 0.5m narrow left hand shoulder should result in the frequency increasing by around 10%	-9.3%
NZ33S	10000000.00	7.00	0.4%		
			81.6%		
	2087039683.1				
	Comp Index Score	9.320	1%		
			-18.4%		

Option 3 CALR

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	9624251.44	6.98	0.4%		
NZ04S	1000000.00	6.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	77874036.28	7.89	3.0%	Queue detection, increased CCTV coverage would give the TOC operators great visibility of the project area. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 25%	22.9%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	199557854.27	8.30	7.8%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries will reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on existing plus 3 additional ganties with environmental information will reduce loss of control vehicles by 35%	36.9%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	6309573.44	6.80	0.2%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 3 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ12S	262621965.94	8.42	10.3%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 3 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	54668359.22	7.74	2.1%	This excepted to increase the frequency by 30% as there is no shoulder present so there are likely to be more pedestrians in the carriageway	-31.3%
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	199526231.50	8.30	7.8%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, increased capacity, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 35%.	36.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	66258012.11	7.82	2.6%	Frequency would increase due to no shoulder	-90.5%
NZ30S	1000000.00	6.00	0.0%		
NZ31E	246259325.24	8.39	9.6%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 25 - 30%	29.2%
NZ32E	157515317.78	8.20	6.2%	Lanes narrowed from 3.5m to 3.3m and a 1.0m narrow left hand shoulder should result in the frequency increasing by around 20%	-19.7%
NZ33S	0.00	0.00	0.0%	No shoulder exist	
			73.3%		
	1875151907.9				
	Comp Index Score	9.273	1%		
			-26.7%		

Option 4 - 4 Lanes + Shoulders

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	101000000.00	8.00	4.0%		
NZ09E	31622776.60	7.50	1.2%		
NZ10E	316259388.79	8.50	12.4%		
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	10000000.00	7.00	0.4%		
NZ12S	416227766.02	8.62	16.3%		
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	329390.04	5.52	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	316227766.02	8.50	12.4%		
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	3162277.66	6.50	0.1%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	281838293.13	8.45	11.0%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 10%	10.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	347850542.62	8.54	13.6%		0.0%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			92.0%		
	2351639584.2				
	Comp Index Score	9.371	0%		
			-8.0%		

Option 5 - 4 Lanes + Shoulders + ATM

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	69405307.89	7.84	2.7%	Queue detection, increased CCTV coverage would give the TOC operators great visibility of the project area. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 30%	31.3%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	251220265.93	8.40	9.8%	Enforcement of posted speed limit on the existing gantries should reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs with environmental information should reduce loss of control vehicles by 20%	20.6%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	7943282.35	6.90	0.3%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ12S	330621466.62	8.52	12.9%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	177827941.00	8.25	7.0%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, increased capacity, fully time shoulder, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 40% - 45%	43.8%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	310022122.44	8.49	12.1%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 10%	10.9%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			76.6%		
	1959007974.3				
	Comp Index Score	9.292	1%		
			-23.4%		

NtAQ Option Safety Assessment

	Associated Hazards	Probability Class.	Probability Index	Severity Class.	Severity Index	Frequency Class	Frequency Index	Score Index	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score
NZ01E	Events associated with abnormal/hazardous loads	Remote	2.00	Average	2.00	Frequent	5.50	9.50	31622876.6	7.50	1.2%
NZ01S	Hazardous states around abnormal/hazardous loads	Remote	1.00	Average	1.00	Occasional	3.00	5.00	100000.0	5.00	0.0%
NZ02E	Events associated with the opening or closing of the shoulder		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ02S	Hazardous states around the opening or closing of the shoulder		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ03E	Events associated with MM Operational		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ03S	Hazardous states around MM operational		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ04E	Events associated with ERAs		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ04S	Hazardous states around ERAs		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ05E	MM Comprehension / Confusion		0.00		0.00		0.00	0.00	0.0	0.00	0.0%
NZ06E	Events associated with maintenance	Remote	1.00	Severe	2.00	Occasional	2.50	5.50	316230.8	5.50	0.0%
NZ06S	Hazardous states around maintenance	Remote	7.00	Severe	10.00	Occasional	15.50	32.50	31000000.0	7.49	1.2%
NZ07E	Events associated with system glitches (including operator error)	Occasional	6.00	Severe	6.00	Remote	12.00	24.00	511097.1	5.71	0.0%
NZ07S	Hazardous states around system glitches (including operator error)	Occasional	10.00	Average	7.00	Remote	5.00	22.00	166824.1	5.22	0.0%
NZ08S	Debris	Occastional	2.00	Average	1.50	Probable	4.50	14.00	101000000.0	8.00	4.0%
NZ09E	Fatigue - Drowsy, tired, fell asleep	Occasional	2.00	Severe	2.00	Occasional	3.50	7.50	31622776.6	7.50	1.2%
NZ10E	Events associated with driver losing control of vehice	Probable	4.00	Average	1.00	Frequent	8.00	13.00	316259388.8	8.50	12.4%
NZ11E	Events associated with Authorised Persons on the carriageway	Remote	9.00	Severe	14.00	Occasional	29.00	52.00	17001000.0	7.23	0.7%
NZ11S	Hazardous states around Authorised persons on the carriageway	Remote	2.00	Average	3.00	Occasional	4.50	9.50	131622.8	5.12	0.0%
NZ12E	Events associated with driving too fast	Certain	4.00	Average	1.00	Remote	2.00	7.00	10000000.0	7.00	0.4%
NZ12S	Hazardous states around driving too fast	Occasional	4.00	Above Average	2.50	Frequent	10.00	16.50	416227766.0	8.62	16.3%
NZ13S	Excessively slow moving vehicle in running lane	Remote	1.00	Average	1.00	Occasional	3.00	5.00	100000.0	5.00	0.0%
NZ14E	Events associated with environmental conditions	Remote	1.00	Above Average	1.50	Probable	3.50	6.00	1000000.0	6.00	0.0%
NZ14S	Hazardous states around environmental conditions	Remote	3.00		3.00		7.00	13.00	6324555.3	6.80	0.2%
NZ15E	Events associated with motorcyclists	Remote	1.00	Severe	3.50	Frequent	9.00	13.50	100316227.8	8.00	3.9%
NZ15S	Hazardous states around motorcyclists	Improbable	0.00	Severe	2.00	Probable	4.00	6.00	1000001.0	6.00	0.0%
NZ16E	Events associated with pedestrians	Occasional	4.00	Severe	4.00	Probable	6.50	14.50	41622776.6	7.62	1.6%
NZ16S	Hazardous states around pedestrians	Occasional	2.00	Severe	2.00	Occasional	3.00	7.00	10000002.0	7.00	0.4%
NZ17E	Events associated with slip roads	Probable	12.00	Average	0.50	Occasional	24.00	42.50	143162277.7	8.16	5.6%
NZ18E	Events associated with terrorism and vandalism	Probable	5.00	Severe	4.00	Improbable	4.00	13.00	329390.0	5.52	0.0%
NZ19E	Infrastructure Collapse	Probable	6.00	Above Average	3.00	Improbable	1.00	10.00	200000.0	5.30	0.0%
NZ20E	Bad driver behaviour at lane closures	Remote	2.00	Average	2.00	Frequent	9.50	13.50	13162277.7	7.12	0.5%
NZ21E	Unsafe Lane changing	Remote	1.00	Above Average	1.50	Very Frequent	6.00	8.50	316227766.0	8.50	12.4%
NZ21S	Excessive Lane merging	Remote	1.00	Below Average	0.50	Probable	4.00	5.50	316227.8	5.50	0.0%
NZ22S	Speed camera flash unit becomes misaligned, affecting drivers on opposite carriageway	Improbable	0.00	Minor	0.00	Incredible	0.00	0.00	1.0	0.00	0.0%
NZ23E	Health deterioration of vehicle occupant	Probable	3.00	Above Average	1.50	Occasional	3.00	6.50	31622776.6	7.50	1.2%
NZ24S	Incidents or congestion caused in other lanes or carriageway due to rubber-necking	Occasional	2.00	Average	1.00	Probable	3.50	6.50	3162277.7	6.50	0.1%
NZ25S	Stationary traffic backed up onto motorway at exit point	Remote	1.00	Below Average	0.50	Frequent	5.00	6.50	3162277.7	6.50	0.1%
NZ26S	Tailgating	Occasional	2.00	Below Average	0.50	Very Frequent	6.00	8.50	316227766.0	8.50	12.4%
NZ27E	Vehicle rejoins running lane	Remote	1.00	Average	1.00	Occasional	5.50	7.50	31622776.6	7.50	1.2%
NZ28E	Merging and Diverging	Remote	2.00	Below Average	1.00	Very Frequent	11.50	14.50	41622776.6	7.62	1.6%
NZ29E	Events asociated with Illegal manoeveures	Occasional	3.00	Severe	4.00	Occasional	6.00	13.00	11000000.0	7.04	0.4%
NZ29S	Hazardous states around vehicle driving in wrong direction	Probable	3.00	Severe	2.00	Remote	1.50	6.50	3162277.7	6.50	0.1%
NZ30E	Events associated with vehicles obstructing carriageway	Occasional	4.00	Above Average	2.50	Probable	7.50	14.00	34785054.3	7.54	1.4%
NZ30S	Hazardous states around vehicles obstrucing carriageway	Remote	1.00	Above Average	1.50	Probable	3.50	6.00	1000000.0	6.00	0.0%
NZ31E	Change in vehicle speed	Occasional	3.00	Below Average	1.50	Very Frequent	11.50	16.00	347850542.6	8.54	13.6%
NZ32E	Vehicle drifts off carriageway or out of lane	Certain	5.00	Below Average	1.00	Probable	9.50	15.50	131622776.6	8.12	5.1%
NZ33S	Vehicle stops on the shoulder (not open to traffic)	Remote	1.00	Severe	2.00	Probable	4.00	7.00	10000000.0	7.00	0.4%
											100.0%
								Comp Actual Score	2556562387.8		
									Comp Index Score	9.408	

Option 1 Minor Works

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	69405307.89	7.84	2.7%	Queue detection and increased CCTV coverage would give the TOC operators great visibility of the project area will allowing them to better managed debris on the road and inform drivers of its location. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage to inform driver of situation and control would reduce proability of this hazard by 30%	31.3%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	251220265.93	8.40	9.8%	Enforcement of posted speed limit on the existing gantries should reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs with environmental information should reduce loss of control vehicles by 20%	20.6%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	7943282.35	6.90	0.3%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ12S	330621466.62	8.52	12.9%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	100316227.77	8.00	3.9%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	143162277.66	8.16	5.6%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	316227766.02	8.50	12.4%		
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	3162277.66	6.50	0.1%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	281838293.13	8.45	11.0%	Better operational regime around the setting of variable speed limits as approaching bottlenecks, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 10% by having some inflence of sudden stopping	10.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	41622776.60	7.62	1.6%		
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	310022122.44	8.49	12.1%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 10%	10.9%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			90.0%		
	2300753057.8				
	Comp Index Score	9.362	0%		
	Percentage	Reductions	-10.0%		

Option 2 HSR

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	110362277.66	8.04	4.3%		
NZ02S	4110960.96	6.61	0.2%		
NZ03E	48047331.92	7.68	1.9%		
NZ03S	2100317.23	6.32	0.1%		
NZ04E	9624251.44	6.98	0.4%		
NZ04S	1000000.00	6.00	0.0%		
NZ05E	110031623.78	8.04	4.3%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	55130595.70	7.74	2.2%	Debris detection is enhanced through the installed of Trafficon cameras and increased CCTV PTZ and Fixed camera coverage would give the TOC operators great visibility of the project area allowing them to better managed debris on the road and inform drivers of its location. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 45%	45.4%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	199557854.27	8.30	7.8%	Enforcement of posted speed limit on the existing gantries plus 4 additional will reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on existing plus 4 additional ganties with environmental information will reduce loss of control vehicles by 35%	36.9%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	6309573.44	6.80	0.2%	Enforcement of posted speed limit on the existing gantries plus 4 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 4 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ12S	262621965.94	8.42	10.3%	Enforcement of posted speed limit on the existing gantries plus 4 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 4 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additional gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	199526231.50	8.30	7.8%	Better operational regime around the setting of variable speed limits as approaching bottlenecks, increased capacity, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 35%. HSR will operate as CALR with no shoulders during the peak periods when most rear end crashes occur	36.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capacity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchange is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	42972994.72	7.63	1.7%	Frequency would increase slightly due to the use of the shoulders in the peak periods	-23.5%
NZ30S	1000000.00	6.00	0.0%		
NZ31E	246259325.24	8.39	9.6%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 25 - 30%	29.2%
NZ32E	143824622.03	8.16	5.6%	Lanes narrowed from 3.5m to 3.3m and during the peak period there will be a 0.5m narrow left hand shoulder should result in the frequency increasing by around 10%	-9.3%
NZ33S	10000000.00	7.00	0.4%		
			81.6%		
	2087039683.1				
	Comp Index Score	9.320	1%		
			-18.4%		

Option 3 CALR

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	9624251.44	6.98	0.4%		
NZ04S	1000000.00	6.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	77874036.28	7.89	3.0%	Queue detection, increased CCTV coverage would give the TOC operators great visibility of the project area. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 25%	22.9%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	199557854.27	8.30	7.8%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries will reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on existing plus 3 additional ganties with environmental information will reduce loss of control vehicles by 35%	36.9%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	6309573.44	6.80	0.2%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 3 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ12S	262621965.94	8.42	10.3%	Enforcement of posted speed limit on the existing gantries plus 3 additional gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs on the existing plus 3 additional gantires will improve compliance of drivers to travel at the posted speed limit. Reduction 35% as the additioanl gantries are prior to the loss of control type crash cluster around Ngauranga Interchange	36.9%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	54668359.22	7.74	2.1%	This excepted to increase the frequency by 30% as there is no shoulder present so there are likely to be more pedestrians in the carriageway	-31.3%
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	199526231.50	8.30	7.8%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, increased capacity, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 35%.	36.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	66258012.11	7.82	2.6%	Frequency would increase due to no shoulder	-90.5%
NZ30S	1000000.00	6.00	0.0%		
NZ31E	246259325.24	8.39	9.6%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 25 - 30%	29.2%
NZ32E	157515317.78	8.20	6.2%	Lanes narrowed from 3.5m to 3.3m and a 1.0m narrow left hand shoulder should result in the frequency increasing by around 20%	-19.7%
NZ33S	0.00	0.00	0.0%	No shoulder exist	
			73.3%		
	1875151907.9				
	Comp Index Score	9.273	1%		
			-26.7%		

Option 4 - 4 Lanes + Shoulders

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	101000000.00	8.00	4.0%		
NZ09E	31622776.60	7.50	1.2%		
NZ10E	316259388.79	8.50	12.4%		
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	10000000.00	7.00	0.4%		
NZ12S	416227766.02	8.62	16.3%		
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	329390.04	5.52	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	316227766.02	8.50	12.4%		
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	3162277.66	6.50	0.1%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	281838293.13	8.45	11.0%	Better operational regime around the setting of variable speed limits as approaching bottlenecks, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 10%	10.9%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	347850542.62	8.54	13.6%		0.0%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			92.0%		
	2351639584.2				
	Comp Index Score	9.371	0%		
			-8.0%		

Option 5 - 4 Lanes + Shoulders + ATM

	Comp Actual Score (log 10)	Comp Index Score	% Comp Index Score		
NZ01E	31622876.60	7.50	1.2%		
NZ01S	100000.00	5.00	0.0%		
NZ02E	0.00	0.00	0.0%		
NZ02S	0.00	0.00	0.0%		
NZ03E	0.00	0.00	0.0%		
NZ03S	0.00	0.00	0.0%		
NZ04E	0.00	0.00	0.0%		
NZ04S	0.00	0.00	0.0%		
NZ05E	0.00	0.00	0.0%		
NZ06E	316230.77	5.50	0.0%		
NZ06S	31000000.00	7.49	1.2%		
NZ07E	511097.10	5.71	0.0%		
NZ07S	166824.06	5.22	0.0%		
NZ08S	69405307.89	7.84	2.7%	Queue detection, increased CCTV coverage would give the TOC operators great visibility of the project area. Improved compliance of variable mandatory speed limits , lane controls and installation advance driver information signage would reduce proability of this hazard by 30%	31.3%
NZ09E	31622776.60	7.50	1.2%		
NZ10E	251220265.93	8.40	9.8%	Enforcement of posted speed limit on the existing gantries should reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs with environmental information should reduce loss of control vehicles by 20%	20.6%
NZ11E	17001000.00	7.23	0.7%		
NZ11S	131622.78	5.12	0.0%		
NZ12E	7943282.35	6.90	0.3%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ12S	330621466.62	8.52	12.9%	Enforcement of posted speed limit on the existing gantries would reduce this event by reducing excessive speed drivers during off peak periods and environmental conditions. In addition the Advance Driver Information signs will improve compliance of drivers to travel at the posted speed limit. Reduction 20%	20.6%
NZ13S	100000.00	5.00	0.0%		
NZ14E	1000000.00	6.00	0.0%		
NZ14S	6324555.32	6.80	0.2%		
NZ15E	10316227.77	7.01	0.4%		
NZ15S	1000001.00	6.00	0.0%		
NZ16E	41622776.60	7.62	1.6%		
NZ16S	10000002.00	7.00	0.4%		
NZ17E	74785054.26	7.87	2.9%		
NZ18E	1034785.05	6.01	0.0%		
NZ19E	200000.00	5.30	0.0%		
NZ20E	13162277.66	7.12	0.5%		
NZ21E	251188643.15	8.40	9.8%	Increased capacity, geometric layout, speed enforcement and advance driver information should make an improvement to the frequency. Lane drop at Aotea Quay may trip some drivers creating additional unsafe lane changes . Overall the expected reducing is 20%.	20.6%
NZ21S	316227.77	5.50	0.0%		
NZ22S	1.00	0.00	0.0%		
NZ23E	31622776.60	7.50	1.2%		
NZ24S	1000000.00	6.00	0.0%		
NZ25S	3162277.66	6.50	0.1%		
NZ26S	177827941.00	8.25	7.0%	Better operational regime around the setting of varable speed limits as approaching bottlenecks, increased capacity, fully time shoulder, Enforcement of the variable mandatory speed limits plus improved advanced driver information (VMS on every gantry) is expected to reduce this hazard by 40% - 45%	43.8%
NZ27E	31622776.60	7.50	1.2%		
NZ28E	29466669.23	7.47	1.2%	Increase capcity and eliminating the 2+2 into 3 merge and the 3 into 2 + 2 diverge at Nganuranga interchnage is expected to reduce this hazard by 30%	29.2%
NZ29E	11000000.00	7.04	0.4%		
NZ29S	3162277.66	6.50	0.1%		
NZ30E	34785054.26	7.54	1.4%		
NZ30S	1000000.00	6.00	0.0%		
NZ31E	310022122.44	8.49	12.1%	Greater compliance of variable mandatory speed limits from speed enforcement cameras, improved operational regimes and education should reduce the frequency of this hazard by 10%	10.9%
NZ32E	131622776.60	8.12	5.1%		
NZ33S	10000000.00	7.00	0.4%		
			76.6%		
	1959007974.3				
	Comp Index Score	9.292	1%		
			-23.4%		

Appendix P

EEM Worksheets

Worksheet 1: Evaluation Summary

Evaluation Summary		Worksheet 1
1	**Evaluator(s)**	Graham Bell (Beca)
	Reviewer(s)	Jerry Khoo (Beca)
2	**Project/Package**	
	Organisation Name	NZTA / Fletcher Construction Ltd
	Project/Package name	Ngauranga to Aotea Quay ATMS
	Your reference	3321045
	Project Description	The Ngauranga to Aotea Quay Wellington ATM project includes the problem definition, investigation, design and construction of the Project.
	Describe problem	High levels of congestion during both the morning and evening peak periods results in high levels of queuing and low traffic speeds along the study area (SH1) and on the surrounding state highway and local road network.
3	**Location**	
	Brief description of location	State Highway 1, extending from the Ngauranga Gorge to the Aotea on and off-ramps.
4	**Alternatives and Options**	
	Describe the Do Minimum	The Do Minimum can be described as "business as usual", with no alterations to the existing environment.
	Alternatives considered	The project considered the use of active traffic management and better use of the existing carriageway to improve on current efficiencies.
	Options assessed	The following five options were assessed which included '**with**' bridge and '**without**' bridge structure estimates. Option 1 - Improve existing ATMS; Option 2A - Hard Shoulder Running (keep existing median barrier); Option 2B - Hard Shoulder Running (replace median barrier); Option 3A - Controlled All Lane Running (keep existing median barrier); Option 3B - Controlled All Lane Running (replace median barrier); Option 4 - Four Lanes plus Shoulders (existing ATMS and replace median barrier); and Option 5 - Four Lanes plus Shoulders and ATMS Enhancements (replace median barrier).
5	**Timing**	
	Earliest construction start date (mm/yy)	1-Jul-13
	Expected construction start date (mm/yy)	1-Jul-13
	Expected ruration of construction start date (months)	24
6	**Economic Efficiency**	
	Date economic evaluation completed (mm/yy)	Nov-11
	Time Zero	Jul-10
	Base date for costs and benefits	Jul-11
	PV cost of do minimum, $m NPV	$1.99
	PV net cost of preferred option, $m NPV	
	PV net benefits of preferred option, $m NPV	
7	**BCR**	
8	**FYRR**	
9	**Non-monetised impacts**	
10	**National strategic factors**	

No preferred option

Worksheet 3: Benefit Cost Analysis

Benefit Cost Analysis

Project:	**Ngauranga to Aotea Quay ATM**
Component:	**Project Expected Estimate Without Bridge Structure**

Discount Rate 8%
Analysis Period 30 years

Project Options	DM	Option 1	Option 2A	Option 2B	Option 3A	Option 3B	Option 4	Option 5	Option 1	Option 2A	Option 2B	Option 3A	Option 3B	Option 4	Option 5
Compared Against	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**
Code	DMDM	Opt1DM	Opt2ADM	Opt2BDM	Opt3ADM	Opt3BDM	Opt4DM	Opt5DM							
BENEFITS (NPV, $m):															
Travel Time Benefits									2.4	28.8	28.8	52.7	52.7	62.5	62.5
Congestion Benefits									-0.1	13.7	13.7	16.5	16.5	19.6	19.6
Trip Reliability									0.1	1.4	1.4	2.6	2.6	3.1	3.1
Vehicle Operating Costs Benefits									2.6	-1.2	-1.2	-7.9	-7.9	-7.5	-7.5
Accident Costs									2.6	4.8	4.8	6.9	6.9	2.1	6.1
Carbon Dioxide									0.1	0.0	0.0	-0.3	-0.3	-0.3	-0.3
Reduced Driver Frustration															
Monetised External impacts															
PV Total Net Benefits									**7.8**	**47.5**	**47.5**	**70.6**	**70.6**	**79.5**	**83.5**
COSTS (NPV, $m):	**PV of Costs ($m)**								**PV of Net Costs ($m)**						
Investigation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-	-
Design	0.000	3.010	3.866	4.019	3.821	3.990	4.026	4.150	3.0	3.9	4.0	3.8	4.0	4.0	4.1
Property	0.000	0.000	0.000	0.000	0.446	0.446	0.446	0.446	-	-	-	0.4	0.4	0.4	0.4
Construction	0.000	13.190	49.921	55.199	49.946	57.185	58.103	64.177	13.2	49.9	55.2	49.9	57.2	58.1	64.2
Maintenance	1.986	2.987	3.483	3.483	3.259	3.259	2.115	3.016	1.0	1.5	1.5	1.3	1.3	0.1	1.0
									-	-	-	-	-	-	-
									-	-	-	-	-	-	-
									-	-	-	-	-	-	-
									-	-	-	-	-	-	-
									-	-	-	-	-	-	-
PV of Total Net Costs ($m)	1.986	19.187	57.270	62.701	57.473	64.881	64.690	71.789	17.2	55.3	60.7	55.5	62.9	62.7	69.8
								National BCR	**0.5**	**0.9**	**0.8**	**1.3**	**1.1**	**1.3**	**1.2**

DM = Do Minimum
Option 1 = Improve Existing ATMS
Option 2A = Hard Shoulder Running (keep existing median barrier)
Option 2B = Hard Shoulder Running (replace median barrier)
Option 3A = Controlled All Lane Running (keep existing median barrier)
Option 3B = Controlled All Lane Running (replace median barrier)
Option 4 = Four Lanes plus Shoulders (existing ATMS and replace median barrier)
Option 5 = Four Lanes plus Shoulders and ATMS Enhancements (replace median barrier)

Worksheet 3: Benefit Cost Analysis

Benefit Cost Analysis

Project:	**Ngauranga to Aotea Quay ATM**
Component:	**Project Expected Estimate With Bridge Structure**

Discount Rate 8%
Analysis Period 30 years

Project Options	DM	Option 1	Option 2A	Option 2B	Option 3A	Option 3B	Option 4	Option 5	Option 1	Option 2A	Option 2B	Option 3A	Option 3B	Option 4	Option 5
Compared Against	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**	**DM**
Code	DMDM	Opt1DM	Opt2ADM	Opt2BDM	Opt3ADM	Opt3BDM	Opt4DM	Opt5DM							
BENEFITS (NPV, $m):															
Travel Time Benefits									-	28.8	28.8	52.7	52.7	62.5	62.5
Congestion Benefits									-	13.7	13.7	16.5	16.5	19.6	19.6
Trip Reliability									-	1.4	1.4	2.6	2.6	3.1	3.1
Vehicle Operating Costs Benefits									-	-1.2	-1.2	-7.9	-7.9	-7.5	-7.5
Accident Costs									-	4.8	4.8	6.9	6.9	2.1	6.1
Carbon Dioxide									-	0.0	0.0	-0.3	-0.3	-0.3	-0.3
Reduced Driver Frustration															
Monetised External impacts															
PV Total Net Benefits									**-**	**47.5**	**47.5**	**70.6**	**70.6**	**79.5**	**83.5**
COSTS (NPV, $m):	**PV of Costs ($m)**								**PV of Net Costs ($m)**						
Investigation	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	-	-	-	-	-	-	-
Design	0.000	-	3.866	4.019	3.821	3.990	4.026	4.150	-	3.9	4.0	3.8	4.0	4.0	4.1
Property	0.000	-	0.000	0.000	0.892	0.892	0.892	0.892	-	-	-	0.9	0.9	0.9	0.9
Construction	0.000	-	66.815	72.093	66.840	74.079	74.997	81.071	-	66.8	72.1	66.8	74.1	75.0	81.1
Maintenance	1.986	-	3.483	3.483	3.259	3.259	2.115	3.016	-	1.5	1.5	1.3	1.3	0.1	1.0
PV of Total Net Costs ($m)	1.986	-	74.164	79.595	74.813	82.221	82.030	89.128	-	72.2	77.6	72.8	80.2	80.0	87.1
								National BCR	**-**	**0.7**	**0.6**	**1.0**	**0.9**	**1.0**	**1.0**

DM = Do Minimum
Option 1 = Improve Existing ATMS
Option 2A = Hard Shoulder Running (keep existing median barrier)
Option 2B = Hard Shoulder Running (replace median barrier)
Option 3A = Controlled All Lane Running (keep existing median barrier)
Option 3B = Controlled All Lane Running (replace median barrier)
Option 4 = Four Lanes plus Shoulders (existing ATMS and replace median barrier)
Option 5 = Four Lanes plus Shoulders and ATMS Enhancements (replace median barrier)

Appendix Q

Transport Policy Assessment

1 Transport Policy Assessment

The options developed aim to fulfil as many of the Government Policy Statement objectives as possible. The policy context has been considered at all stages of the preliminary scoping stage with particular reference to the New Zealand Transport Strategy, Government Policy Statement and Land Transport Management Act.

1.1 LTMA

The Land Transport Management Act (LTMA) provides the legal framework for managing and funding land transport activities. The purpose of the LTMA is to contribute to the aim of achieving an affordable, integrated, safe, responsive and sustainable land transport system. Transport projects must be assessed against the LTMA and most importantly its five objectives:

- Ensuring environmental sustainability;
- Assisting economic development;
- Assisting safety and personal security;
- Improving access and mobility; and
- Protecting and promoting public health.

All of the options were developed with the requirements of the LTMA in mind. All of the options offer significant transport improvements. There is unlikely to be any significant differences between choices of congestion easing in their ability to achieve the objectives of the LTMA. Accordingly the LTMA assessment below is for the project rather than discrete options.

1.1.1 Economic Development

The proposed improvements from Ngauranga Gorge to Aotea Quay are likely to contribute to the stimulation of economic growth by the reduction of travel times and improved journey reliability along SH1 and SH2 (within and adjacent the project area) including those for freight.

1.1.2 Assist Safety and Personal Security

Ngauranga Gorge to Aotea Quay has a significant crash history. There have been a number of serious injury crashes resulting from congestion and road geometry in the study area. This project aims to reduce the congestion and mitigate this type of crash risk. Improving driver information and guidance and reducing queuing will also reduce the likelihood of rear-end crashes. This project will therefore greatly assist safety and personal security.

1.1.3 Improve Access and Mobility

The proposed improvements will primarily result in improvements to regional mobility. However the project will also contribute to improved local access and mobility by connecting local roads at Aotea Quay and Ngauranga Interchange and possibly improving access to the port area.

1.1.4 Protect and Promote Public Health

The project will have a positive impact on public health by reducing air pollution levels through the provision of congestion reduction improvements which will reduce stopping and queuing. Further assessment is required in this regard during the scoping and scheme assessment phases.

1.1.5 Ensure Environmental Sustainability

No significant impacts to environmental sustainability are expected as a result of this project. Specialist preliminary environmental assessments will be completed during the scoping report phase and more detailed assessment during the scheme assessment phase.

1.2 NZTS

The NZTS sets out a number of key components where increased emphasis need be applied, the components directly addressed by the options developed are:

1.2.1 Making best use of existing networks and infrastructure

The options developed focus strongly on the use of existing network and infrastructure with most variants involving only minor infrastructure improvements, with improved technologies and optimisation of current signals important components to the recommend option.

1.2.2 Investing in critical infrastructure and the transport sector workforce

The preferred option focuses on making the most use of the existing network, but does have the potential to enhance some of the existing infrastructure which may require investment, such as the existing median barrier and drainage.

Considering options for charging that will generate revenue for investment in transport infrastructure and services;

The options for charging and revenue generation have been examined and discounted.

Using new technologies and fuels; and

New technologies are instrumental to the options examined and will specifically consider technological solutions including MIDAS, VMSL, ADIS, and DECS solutions.

1.3 GPS

Under the LTMA the NZTA must give effect to the Government Policy Statement on Land Transport Funding (GPS) in developing the National Land Transport Programme and take account of the GPS when approving funding for activities. The LTMA requires the GPS to contribute to the aim of achieving an affordable, integrated, safe, responsive and sustainable land transport system, and also to the five transport objectives of the LTMA.

The GPS contains a number of short to medium term impacts to contribute to economic growth and productivity including:

- Improvements in the provision of infrastructure and services that enhance transport efficiency and lower the cost of transportation through:
  - improvements in journey time reliability
  - easing of severe congestion
  - more efficient freight supply chains
  - better use of existing transport capacity
- better access to markets, employment and areas that contribute to economic growth;
- a secure and resilient transport network;
- reductions in deaths and serious injuries as a result of road crashes;
- more transport choices, particularly for those with limited access to a car where appropriate;
- reductions in adverse environmental effects from land transport; and
- Contributions to positive health outcomes.

The following is an assessment of the project against the targets of the GPS. Similar to the LTMA assessment, there is unlikely to be any significant differences between choices of congestion improvement option in their ability to achieve the targets of the GPS. Accordingly the GPS assessment below is for the project rather than discrete grade separation options.

Improvements in the provision of infrastructure and services that enhance transport efficiency and lower the cost of transportation

The proposed improvements will enhance transport efficiency and lower the cost of transportation by reducing travel times, improving journey time reliability and easing congestion.

Better access to markets, employment and areas that contribute to economic growth

Economic growth will be supported by reducing congestion on SH1 and SH2 and lowering the cost of transport. The proposed improvements are expected to result in a significant improvement in accessibility at a regional level through the reduction in travel times and also possibly at a National Level through improved access to the Port Area and Wellington CBD. Further investigation will be carried out during the scheme assessment phase.

A secure and resilient transport network

The improvement of some of the project variants would have a positive impact towards the provision of a more secure and resilient transport network by providing an alternative access to the Port Area.

Reductions in deaths and serious injuries as a result of road crashes

Serious injury crashes recorded in the period 2005-2009 have been a result congestion and poor geometry on this section of Motorway. The reduced congestion will assist in the reduction of deaths and serious injuries on this section of Motorway.

More transport choices, particularly for those with limited access to a car where appropriate

The proposed improvements while significantly improving the level of service for private vehicles is not expected to increase or decrease transport choices.

Reductions in adverse environmental effects from land transport

No significant impacts to environmental sustainability are expected as a result of this project. Specialist environmental assessments will be completed during the scheme assessment phase.

Contributions to positive health outcomes

Similar to the results of the LTMA assessment, this project will have a positive impact on public health by reducing air pollution levels. The project will have a positive impact on public health by reducing air pollution levels through the provision of congestion reduction improvements which will reduce stopping and queuing. Further assessment is required in this regard during the scoping and scheme assessment phases.

The project has the potential to realise these short and medium term aims to a varying degree. The improvement in journey time reliability, easing of severe congestion, better use of existing transport infrastructure and the reductions in deaths and serious injuries have been assessed during this preliminary scoping stage, however it is envisaged that through the final scoping report and the eventual recommendation other benefits will also be realised.

1.4 RLTS

The project fits with the Regional Land Transport Strategy and relevant corridor plans.

1.5 RMA

Preliminary assessment indicates that the project is consistent with the purpose of the Act, with several project goals sitting particularly well with the concept of sustainable management; including maximising the existing asset and ensuring the adverse effects on the environment are no more than minor. Both of these gaols were assessment criteria for the MCA workshop. A full Environmental Impact Assessment will be carried out during scheme assessment.

1.6 PPFM

The Planning Programming and Funding Manual (PPFM) require the creation of an assessment profile for any project seeking funding from the NZTA. The assessment profile is made up of three factors:

- **Strategic fit** of the problem, issue or opportunity that is being addressed;
- **Effectiveness** of the proposed solution; and the
- **Economic efficiency** of the proposed solution.

The following is an assessment of the project against the three factors. Similar to the LTMA and GPS assessments, individual options are not expected to differ in their strategic fit or effectiveness. There will be some minor variance in economic efficiency, however this has not been analysed as yet.

1.7 Strategic Fit

According to the PPFM, strategic fit focuses on the problem, issue or opportunity being addressed. A strategic fit assessment considers how an identified problem, issue or opportunity aligns with NZTA's strategic investment direction. Strategic fit ensures that the activities the NZTA approves for funding address issues that are significant from a national perspective.

Based on section G5.6 of the PPFM, by default, the strategic fit rating for road improvements is low. A medium strategic fit rating may be given if there is potential for significant improvements in safety or there is potential for significant improvements on key routes (as defined in the PPFM) in one or more of the following:

- Journey time reliability;
- Congestion in main urban areas;
- Capacity constraints; and/or
- Network security and resilience.

The PPFM states that a road improvement project must only be given a high strategic fit rating if:

- it is on a RoNS, including local roads and/or services identified as critical to the operation of a RoNS; or
- there is potential for a major contribution to national economic growth and productivity on:
  - Freight routes or Tourism routes; or
  - Urban arterials critical for maximising access to significant markets, areas of employment or economic growth.

The proposed project is expected to make a significant contribution to regional economic growth, safety and is on a RoNS.

Based on the assessment criteria in the PPFM, the proposed project has a strategic fit rating of **High**.

1.8 Effectiveness

The effectiveness assessment considers the contribution that the proposed solution makes to achieving the potential identified in the strategic fit assessment and to the purpose of the LTMA and the relevant NZTA objectives. Higher ratings are provided for those proposals that provide long term, integrated and enduring solutions. At this stage only an initial rating of the project effectiveness can be provided. A more detailed assessment will be provided with the Scoping Report.

The PPFM states that an activity or a combination of activities must only be given a medium rating for effectiveness if it meets each of the following:

- meets all the low effectiveness criteria
- is part of an accepted strategy, activity management plan or macroscope
- is significantly effective in achieving the potential identified in the strategic fit assessment
- provides a long-term solution with enduring benefits appropriate to the scale of the solution
- provides a solution that considers land use strategies and implementation plans, where appropriate to the activity.

The assessment of the project against the criteria for a medium effectiveness rating is summarised in **Table 1**.

Table 1 - Medium Effectiveness Rating Assessment Summary

Criteria	Assessment
Meets all the low effectiveness criteria. This includes: a. Strategic fit potential b. Contribution to LTMA and NZTA objectives c. Consideration of alternative and impacts d. Affordability e. Part of accepted strategy f. Enduring benefits	a. The project has strategic fit potential because it improves safety, congestion, and travel time reliability. b. The project strongly contributes to the objectives of the LTMA and NZTS. c. Alternatives have been considered and assessed as discussed in this report. d. Affordability criteria have been met, including the development of cost estimates to NZTA standards and the inclusion of the project in the NLTP. e. The project is part of an accepted strategy, being the Wellington Regional Land Transport Strategy and also the Hutt Corridor Plan, Ngauranga to Airport Corridor Plan and Otaki to Ngauranga Corridor Plan. f. The project provides enduring benefits by providing a solution which improves road safety through the provision of congestion relief.
Is part of an accepted strategy, activity management plan or macroscope	The project is part of the Wellington Regional Land Transport Strategy and the Hutt Corridor Plan, Ngauranga to Airport Corridor Plan and Otaki to Ngauranga Corridor Plan.
Is significantly effective in achieving the potential identified in the strategic fit assessment	The project is significantly effective in achieving the potential identified in the strategic fit assessment because it will make a strong contribution to road safety, congestion and travel time reliability.

Criteria	Assessment
Provides a long-term solution with enduring benefits appropriate to the scale of the solution	The project provides enduring benefits by providing a solution which improves road safety and congestion.
Provides a solution that considers land use strategies and implementation plans, where appropriate to the activity.	The project provides a solution that is consistent with recognised strategies and implementation plans including the Wellington Regional Land Transport Strategy and the Wellington Regional Strategy.

Based on the assessment above, the improvements qualify for at least a **medium** effectiveness rating.

The PPFM states that a high rating for effectiveness must only be given if the activity or combination of activities delivers on each of the following:

- meets all the low and medium rating criteria
- improves integration within and between transport modes, where appropriate to the activity
- provides a solution that integrates land transport, land use and other infrastructure, where appropriate to the activity
- supports networks from a national perspective, where appropriate to the activity

The assessment criteria for a high effectiveness rating is summarised in **Table 2** This is provided for information only as it is too early to assess the project against this criteria.

Table 2 High Effectiveness Rating Assessment Summary

Criteria	Assessment
Meets all the low and medium rating criteria	The project meets all low and medium rating criteria
Improves integration within and between transport modes, where appropriate to the activity	The project does not assist in the integration of transport modes
Provides a solution that integrates land transport, land use and other infrastructure, where appropriate to the activity	The project does not provide a solution that integrates *new* land transport and *new* land use and other infrastructure, however, the project is wholly located within existing motorway or highway designation and will provide a more efficient flow of people and goods between transport and land use Wellington City and it's surrounds).
Supports networks from a national perspective, where appropriate to the activity	This project will support regional networks and because it is part of a RoNS has been deemed to support national growth and economic activity.
Is an optimised transport solution	This will be confirmed during the Scheme Assessment Reporting stage, however, the MCA confirms that the recommended option is feasible, economic and will achieve the project objectives

1.9 Economic Efficiency

The economic efficiency assessment considers how well the proposed solution maximises what is produced from the resources used. The benefit cost ratio (BCR) provides a basis to rate the economic efficiency of projects as follows:

- BCR ≥ 4 is High
- BCR ≥ 2 and < 4 is Medium
- BCR ≥ 1 and < 2 is Low.

The recommended option has a BCR of between 1 and 2 and therefore a **Low** Economic Efficiency rating.

Appendix R

PSF-13 Form

Ngauranga to Aotea Quay - Social and Environmental Management Form (PSF 13)

Option Description:					
Social and Environmental Screen			**Social and Environmental Assessment**		
Issue	**Effects**	**Degree of Effect**	**Requirements**	**Addressing effects and meeting requirements**	
Social and environmental issues	***Describe the potential social and environmental effects of the option, including where the option may improve social and environmental outcomes***	***H / M / L / NA***	***List all legal requirements and relevant Transit social and environmental objectives***	***List actions to be taken to meet specific social and environmental requirements and objectives and address all effects identified. Include an estimated cost.***	
				Specific Actions	***Estimated Cost ($)***
Noise *eg construction noise, traffic noise, maintenance noise, presence of sensitive receivers (homes, schools, hospitals)*	Road improvements are unlikely to increase traffic volumes, however, operation noise of roads can generate adverse noise effects, particularly from heavy vehicles. Construction noise can temporarily generate adverse noise effects, particularly annoyance and sleep interference to local residents. Poor choice of road surfacing can generate adverse noise effects. This stretch of SH1 lies between the NIMT (North Island Main Trunk Line) and Wellington Harbour Operational Port Area, including the Interislander Ferry Terminal, limiting the number of sensitive receivers in the area. As part of the MCA Workshop in June 2011, Marshall Day Acoustics undertook a preliminary noise assessment and determined no significant issues over and above the existing situation.	L			
Air Quality *eg dust, air pollution, greenhouse gas emissions, odour*	Volumes of earthworks, route selection and gradient can alter emissions of CO, CO2, NOX and methane, potentially resulting in adverse greenhouse effects or alternatively improvements in air quality. The potential option to widen the road involves earthworks that may have a temporary impact on air quality through dust generation.	L			
Water resources *eg sedimentation, contaminants in road run-off, climate change impacts (sea level rise and changing rainfall patterns), impacts on sensitive water bodies, changing hydrological cycles and water flow patterns.*	Construction and operation can generate contaminated site/road runoff that may have an adverse effect on waterways. Works can modify drainage paths resulting in a change to flood patterns. Any option for widening the road will have a more significant impact, because it will involve larger earthworks volumes. This stretch of SH1 is adjacent to Wellington Harbour and the Kaiwharawhara Stream, which could be adversely affected by containments in run off. The existing stormwater system includes non-point discharges to the Wellington Harbour, a permitted activity under the GWRC Plans subject to meeting activity standards.	M			
Erosion and sediment control *eg soil slips, landslides, water erosion (raindrop, sheet, rill gully,*	Construction works may expose surfaces to water and wind erosion. Sedimentation from earthworks may enter nearby	M			

Option Description:					
Social and Environmental Screen			**Social and Environmental Assessment**		
Issue	**Effects**	**Degree of Effect**	**Requirements**	**Addressing effects and meeting requirements**	
Social and environmental issues	***Describe the potential social and environmental effects of the option, including where the option may improve social and environmental outcomes***	***H / M / L / NA***	***List all legal requirements and relevant Transit social and environmental objectives***	***List actions to be taken to meet specific social and environmental requirements and objectives and address all effects identified. Include an estimated cost.***	
				Specific Actions	***Estimated Cost ($)***
tunnel, channel) and wind erosion (dust)	watercourses. During highway use phase, no new or exacerbation of existing environmental effects are anticipated.				
Social responsibility *eg social, severance, social interaction, connectivity*	The proposed upgrades are intended to ease congestion and smooth traffic flows as well as improve safety, route security and provide greater journey time reliability. During construction, there may be some disruption to travel (northbound and southbound) on this stretch of SH1. The existing SH1 lies within the State Highway designation. At this stage it is expected that all options can be accommodated within the existing designation (subject to the designation boundary being confirmed)	L			
Culture and Heritage *eg waahi tapu and Statements of identified Maori interests, archaeological sites, historic buildings, places, trees and special features*	Works can adversely affect heritage features, historic buildings and sites, areas of significance to Tangata Whenua. Nga Uranga (the landing place) is within the project area and is noted in the District Plan as a significant site. Ngati Tama has historic connections with the area. The area is a highly modified landscape. Works will largely be within the existing road corridor. At this stage it is expected that all options can be accommodated within the existing designation (subject to the designation boundary being confirmed)	L			
Ecological resources *eg significant vegetation, fauna passage, habitat protection, special trees, reinstatement of vegetation, slope stabilisation, use of low-growth vegetation to reduce maintenance costs*	Works can have an adverse effect on ecology, including loss of vegetation and habitat and adverse effects on flora and fauna. The existing stretch of SH1 is adjacent to the NIMT, which runs through Open Space zoned land in several areas. This land is characterised for its vegetation, minimal structures, largely undeveloped areas and open expanses of land. At this stage it is expected that all options can be accommodated within the existing designation (subject to the designation boundary being confirmed)	L			
Spill response and contamination *eg spills from vehicle accidents, on-site storage of fuels, excavations of contaminated soils/clean fill*	Potential contamination spills onto SH1 or adjoining land during and post construction.	L			

Option Description:					
Social and Environmental Screen			**Social and Environmental Assessment**		
Issue	**Effects**	**Degree of Effect**	**Requirements**	**Addressing effects and meeting requirements**	
Social and environmental issues	***Describe the potential social and environmental effects of the option, including where the option may improve social and environmental outcomes***	***H / M / L / NA***	***List all legal requirements and relevant Transit social and environmental objectives***	***List actions to be taken to meet specific social and environmental requirements and objectives and address all effects identified. Include an estimated cost.***	
				Specific Actions	*Estimated Cost ($)*
Resource efficiency *eg in situ pavement recycling, energy efficiency, initiatives to reduce waste to landfill, use of local materials.*	No significant issues.	L			
Climate change: *adaptation and mitigation eg sea level rise, green house gas emissions, increase incidence of flooding and coastal storms*	No significant issues. The issue of wave break along that section of the highway adjoining the Wellington Harbour is a design consideration – the potential for waves to break up and over the seawall onto the highway as a safety issue. This risk may be exacerbated with sea level rise.	L			
Visual quality *eg landscaping, retaining walls, noise walls, views from roads neighbouring properties*	There is an opportunity to make improvements to the visual quality of the road barriers and street furniture. Works have the potential to cause adverse visual effects.	L			
Vibration *eg construction and maintenance vibration, pavement surface, heavy traffic vibration, presence of sensitive receivers including historic buildings and features.*	Construction activities and heavy vehicle use can generate temporary adverse vibration effects. This can impact on residents living in close proximity. Presence of sensitive receivers (such as schools and houses) is limited due to location between NIMT and the Wellington Harbour.	L			
Landuse and transport integration *eg integration of land use and development with transport networks, reverse sensitivity, access management.*	Lack of integration between land use and transport planning can result in insubstantially planned settlements and transport systems. Close proximity of the Interislander and rail yards in terms of bridging and road construction has the potential to affect their access. The integration with existing rail, port and road network activities is an important consideration. No residential access points will be impacted by the proposed options.	M			
Urban design *eg context sensitive design, including aesthetics of structures (refer PSG/12 for guidance).)*	The project area is located within an urban environment, in an existing stretch of SH1. An opportunity to create better connections between urban areas, including smoothing traffic flows and improving safety.	L			
Public Health *eg stress to individuals and community, personal security, cycling and walking opportunities*	This is the most congested part of Wellington's motorway network and the project objective is to ease congestion and smooth traffic flows as well as improve safety, route security and provide greater journey time reliability. This should result in less stress and higher personal security for road users.	L			
Cycling infrastructure *eg on highway cycle lanes,*	No cycling infrastructure proposed.	NA			

Option Description:					
Social and Environmental Screen			**Social and Environmental Assessment**		
Issue	**Effects**	**Degree of Effect**	**Requirements**	**Addressing effects and meeting requirements**	
Social and environmental issues	***Describe the potential social and environmental effects of the option, including where the option may improve social and environmental outcomes***	***H / M / L / NA***	***List all legal requirements and relevant Transit social and environmental objectives***	***List actions to be taken to meet specific social and environmental requirements and objectives and address all effects identified. Include an estimated cost.***	
				Specific Actions	*Estimated Cost ($)*
segregated cycle path adjacent to SH, links into local cycling network					
Cycle crossing facilities *eg shared cycle/pedestrian crossing at traffic signals, widened traffic island to accommodate cyclists where cycle route crosses SH, dropped crossings*	No crossing facilities proposed.	NA			
Walking infrastructure *eg new or widened footway, connections to local road footways*	No walking infrastructure proposed.	NA			
Pedestrian crossing facilities *eg signalised crossings, traffic islands, dropped crossings, pedestrian desire lines*	No pedestrian crossing facilities will be provided for.	NA			
Bus related Infrastructure *eg bus laybys, hardstandings, build-outs into carriageway at bas stop*	N/A	NA			
Priority lanes *eg potential to include bus, freight, HOV or HOT lane either through the reallocation of existing roadspace or new construction to make certain modes more efficient and widen travel choice*	There may be an opportunity for the use of priority lanes. This can result in more efficient travel and smoother travel flow, as transportation mode choice becomes wider.	L			
Traffic management *eg potential for ITS, variable message signing, variable speed management, ramp signalling*	Potential for increased use of traffic management, including ramp signalling and variable speed management. This will have temporary effects to road users (i.e. during construction) and permanent effects for road users (i.e. for operation).	M			

Appendix S

MCA Summary Report

NZ TRANSPORT AGENCY
WAKA KOTAHI

Roads of national significance

1 Ngauranga to Aotea Quay

Multi-Criteria Assessment Workshop 13 June 2011

Summary Report





New Zealand Government

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Prepared by	Reviewed by
Nathan Baker, Beca	Geoff Brown, Beca

1 Introduction

This report summarises the key findings from the Multi-Criteria Assessment (MCA) Workshop held on 13 June 2011, and provides a sensitivity analysis of the weighting of criteria and scoring of measures. MCA is a recognised, systematic approach to assessing the merits of alternative options. The MCA framework for this project has been tailored specifically to suit the project objectives – whereby project objectives are used as assessment criteria, incorporating measures unique to this project such as operational; driver behaviour; and compliance issues.

It is important to note that MCA is simply one tool used for this project to assess options. The findings of this Workshop will require further scrutiny and investigation and the top scores from this Workshop do not necessarily identify the best solution. All MCA measures were pre-scored prior to the Workshop by experts to allow the focus of the Workshop to be on understanding the rationale behind the scores and debating that as a group. Ratings of options was against a baseline of 'do nothing'. Each lead expert introduced their respective measure and summarised the scoring of each option and the rationale behind the scores. Opportunity for any discussion/ agreement/ challenge of the scoring followed. The aim was to end the workshop with an agreed set of MCA option ratings.

The summary provided in this report will be presented as a section of the Scoping Options Report (SOR), which will comprehensively describe the process for option assessment for the scoping phase of this project.

Purpose of the Workshop

- To identify any differentiators between the options to help inform the selection of a preferred option(s) to take forward for further investigation (Scheme Assessment Report);
- To check for information gaps or further investigation required to inform the SOR.
- To ensure due process in terms of considering the full range of transport, economic and environmental factors to inform the SOR.

Summary of Key Findings

The Workshop presented the following key findings:

1. Option Presentation: It was evident that the presentation of options will require more focus on the 'level of operational management' rather than their 'physical make-up' in the SOR report and supporting assessment.
2. Common to MCA criteria, the measures used for assessment are to a degree both interdependent and linked. For example improved journey time efficiency and reduced congestion will likely reduce driver stress. Similarly, making the best use of the existing asset will have flow on implications for associated environmental effects and delivery. Economic measures will likely reflect the combination of most other measures, for example economic efficiency which relates to Benefit-Cost-Ratio. However each measure is considered to be important for the assessment of this project and relates back to the core project objectives. The sensitivity analysis provided in this report provides for a range of scenario tests that seek to reduce and take account of 'double-counting'.
3. The assumptions made in relation to the options have an influence over the ratings applied. These assumptions need to be identified and recorded, along with the status of information used.
4. A key area of scoring challenge was around the social factors of driver stress and intuitive systems. More investigation, drawing on international experience where possible and linking that back to the New Zealand context, is required around these factors. In particular, these factors have shown a differentiator for Hard Shoulder Running (HSR). which has been rated as slightly more stressful and less intuitive than the baseline 'do nothing' option. Challenge was raised over whether this accurately reflects international experience and whether this differentiator would reduce over time as drivers became familiar with HSR. The rationale behind the ratings for social factors are summarised in this document.

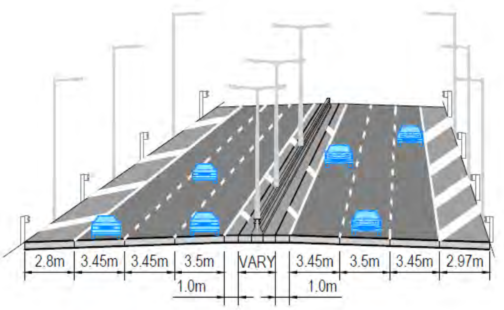
In terms of the assessment of options, key findings include:

5. There was sufficient differentiation between the options to show those options that more positively contribute to the project objectives than others. Principally, Option 3 (CALR) and Option 5 (4 lanes + shoulder + ATM) had a more positive overall contribution than Options 1, 2 and 4. Options 3 and 5 scored well against the measures of journey time reliability, compliance and safety.
6. Overall, all options had a positive contribution in relation to the 'do nothing' option.

Workshop Attendees:

- Hannah Hyde, NZTA
- Dave Robertson, NZTA
- Mike Pilgrim, NZTA
- Des O'Sullivan, NZTA
- David Arrowsmith, NZTA
- Mark Owen, NZTA
- Peter Martineau, Forty 1 South
- Stephen Wright, Fletcher
- Tim Grammer, Fletcher
- David Hoffman, Fletcher
- Stephen Hewett, Beca
- Peter Bradshaw, Beca
- Nathan Baker, Beca
- Richard Atherton, Beca
- Alan Kerr, Beca
- Geoff Brown, Beca
- Jeremy Spinks, Beca
- Simon Bannock, Beca
- Tim Arianpour, Beca
- Iain Smith, Beca
- Graham Bell, Beca
- Sam Sherlaw, Beca
- Rachael Quinn, Mouchel
- Michael Berger, Winsborough Limited

2 Options



Three operational lanes plus hard shoulder

1 Three Lanes plus Minor Works

Retains the existing three lanes with improved Active Traffic Management.

Motorway Capacity

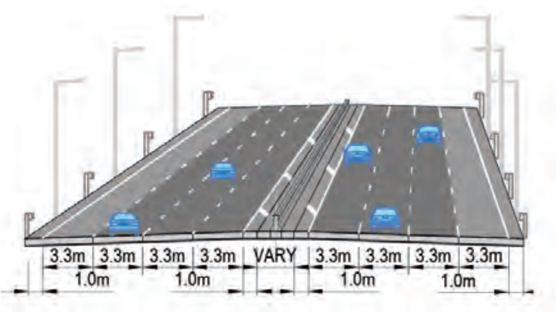
- Retain the existing 3.5m wide lanes with improvement to the Ngauranga merge and diverge and Hutt Road SH2 on-ramp.
- Includes improvements to Hutt Road SH2 on-ramp.
- Does not provide sufficient lane capacity during peak periods.

Motorway Enforcement

- Compliance with the mandatory variable speed limit signage and lane control signals will be improved through engineering, education and an improved level of enforcement using speed cameras.

Level of Motorway Management

- Lane discipline and queue warning will be improved with additional Variable Message signage on each gantry above Lane 1 plus a queue protection system.
- Overall this option will have a small increase in technology and operational resource to improve the management of this section of motorway.
- Includes advanced message signs in Wellington City.



Three operational lanes plus hard shoulder when required

2 Hard Shoulder Running (HSR)

Provides a part-time fourth lane through the use of the shoulder with improved Active Traffic Management.

Motorway Capacity

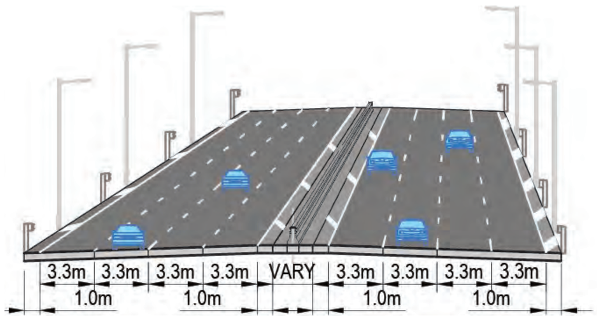
- This option will use the existing shoulder to provide an additional lane of capacity during peak periods (when required).
- Includes improvements to Hutt Road SH2 on-ramp.
- Provides sufficient lane capacity during peak periods.

Motorway Enforcement

- Compliance with the mandatory variable speed limit signage and lane control signals will be improved through engineering, education and enforcement.

Level of Motorway Management

- Lane discipline and queue warning will be improved with additional Variable Message signage on each gantry above Lane 1 plus a queue protection system.
- Overall this option will require additional technology and operational resource to manage the opening and closing of the shoulder lane to provide additional capacity as required.
- Includes advanced message signs in Wellington City.



Four operational lanes plus minimal hard shoulder

3 Controlled All Lane Running (CALR)

Provides a full-time fourth lane with narrow shoulders and improved Active Traffic Management.

Motorway Capacity

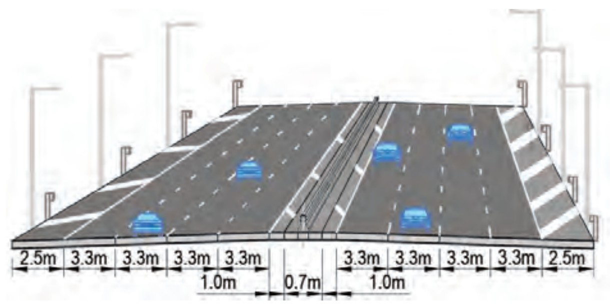
- This option will construct 1.0m wide hard shoulder lane and use the existing hard shoulder to provide an additional lane of capacity.
- Includes improvements to Hutt Road SH2 on-ramp.
- Provides sufficient lane capacity during peak periods.

Motorway Enforcement

- Compliance with the mandatory variable speed limit signage and lane control signals will be improved through engineering, education and enforcement.

Level of Motorway Management

- Lane discipline and queue warning will be improved with additional variable message signage on each gantry above Lane 1 plus a queue protection system.
- Overall this option will require increased technology and operational resource to manage this option due to the narrow shoulders.
- Includes advanced message signs in Wellington City.



Four operational lanes plus standard shoulder

4 Four Lanes Plus Shoulder

Provides a full-time fourth lane with standard shoulders. No improvements to Active Traffic Management.

Motorway Capacity

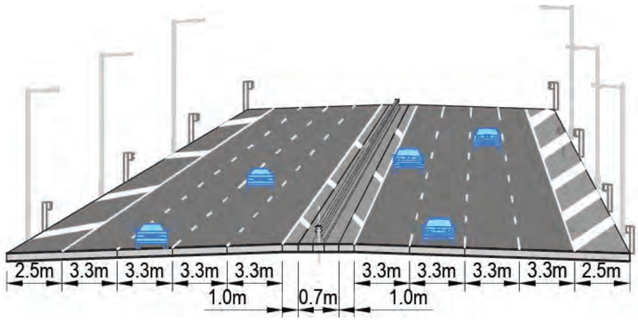
- This option provides an additional lane of capacity through four lanes and standard shoulders.
- Includes improvements to Hutt Road SH2 on-ramp.
- Provides sufficient lane capacity during peak periods.

Motorway Enforcement

- Compliance of the mandatory variable speed limit signage and lane control signals will only be improved through education.

Level of Motorway Management

- Lane discipline and queue warning will not be improved.
- Overall this option will have no increased technology and operational resource to manage this option.
- Includes advanced message signs in Wellington City.



Four operational lanes plus standard shoulder lane

5 Four Lanes plus Shoulder and improved Active Traffic Management

Provides a full-time fourth lane with standard shoulders and improved Active Traffic Management

Motorway Capacity

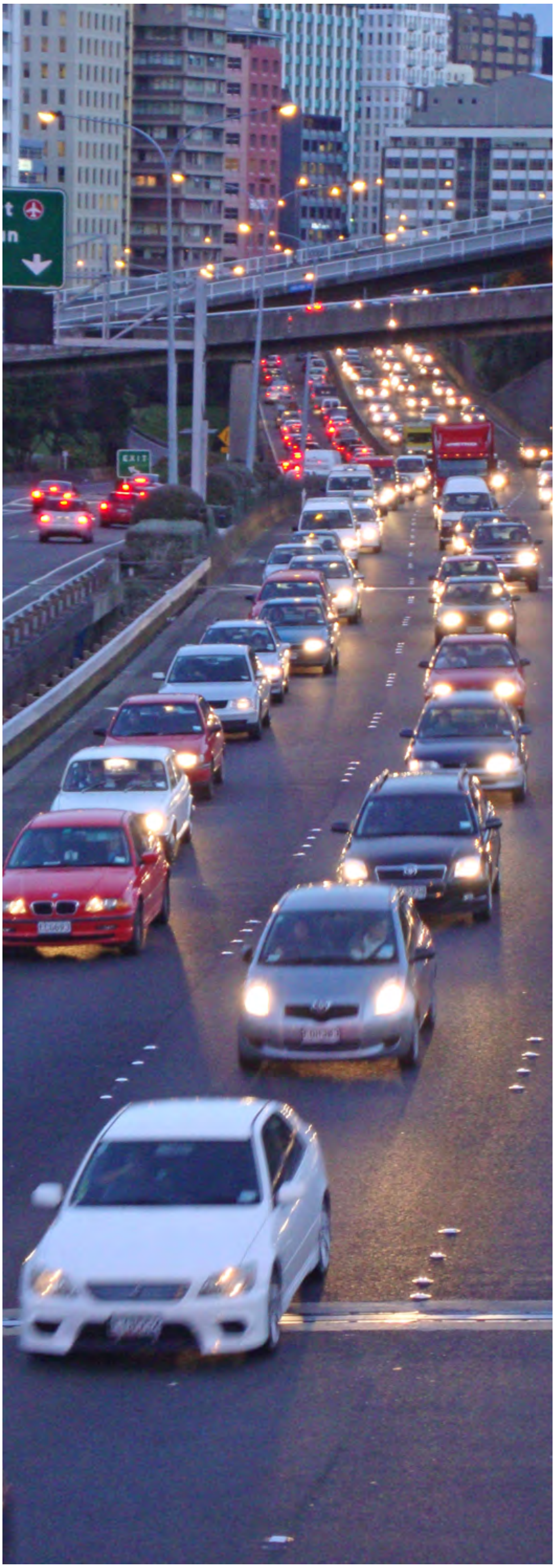
- This option provides an additional lane of capacity through four lanes andstandard shoulders.
- Includes improvements to Hutt Road SH2 on-ramp.
- Provides sufficient lane capacity during peak periods.

Enforcement

- Compliance of the mandatory variable speed limit signage and lane control signals will be improved through engineering, education and enforcement.

Level of Management

- Lane discipline and queue warning will be improved with additional variable message signage on each gantry above Lane 1 plus a queue protection system.
- Overall this option will have increased technology and operational resource to improve the management of this section of motorway.
- Includes advanced message signs in Wellington City.



3 MCA Criteria and Ratings

The following criteria and ratings were used at the Workshop, to identify key differentiators between the options.

Objectives/ Outcomes	Criteria	
Improve journey efficiency through journey time reliability, reducing congestion and driver stress	• Improve Journey Time Reliability • Reduce Congestion	• Reduce Driver Stress
Making best use of the asset by delivering a value for money and flexible solution	• Flexible Operation • Design for Operation, Maintenance and Renewal Requirements	• Compatible where possible with existing infrastructure and systems • Best use of existing assets
Improve compliance through influencing driver behaviour	• Improve Driver Behaviour	
Maintain or improve safety for all users	• Maintain or Improve safety for Road Users • Improve Emergency Services access	• Safety in Design
Adverse effects on the environment are no more than minor	• Built environment • Natural environment • Hazards • Sustainability	• Social well-being and health – air quality • Social well-being and health – noise impacts
The solution can be delivered effectively	• Resource consent / planning approval process	• Land acquisition • Staging/Constructability
The solution fits with NZTA's economic strategy	• Strategic Fit • Effectiveness • Economic efficiency	• Local business impacts • Wider economic impacts

In determining the scores, options will be compared to the baseline 'do nothing' option. The scores indicate the degree to which the option will contribute to achieving the specific criteria measure.

The ratings used for the MCA Workshop is:

3	Significant positive contribution
2	Moderate positive contribution
1	Minor positive contribution
0	No / insignificant contribution
-1	Minor negative contribution
-2	Moderate negative contribution
-3	Significant negative contribution

4 MCA Workshop Findings

The following table summarises the rating scores of each option against the MCA measures, including a summary rationale behind the scoring.

Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Improve journey efficiency through journey time reliability, reducing congestion and driver stress	Improve journey time reliability	Less variability and better accuracy of vehicle journey times	1	3	3	3	3	Option 1 Journey time reliability is predicted to improve only slightly as a result of very minor journey time savings and improvements to the ATM systems. The latter, which is not captured in the traffic modelling, is likely to improve journey time reliability in real life through better management of traffic flow (queue management, lane discipline etc) and reducing accidents.	Options 2,3,4,5: There are significant journey time savings in options 2 to 5 inclusive. The greater reductions in congestion levels along with the improved journey times will help improve journey time reliability along the Ngauranga to Aotea section of State Highway 1 (SH1). It is anticipated the variability in journey time between Ngauranga and Aotea Quay is likely to be improved substantially as a result of the reduced congestion and improved management of traffic flow in options 2 to 5 inclusive. It is worth noting that there are likely to be a number of aspects driving improved journey time reliability. Firstly, there is a proven link between congestion and reliability. In general, reduced congestion results in improved reliability, largely through reductions in Day to Day Variability (DTDV). Secondly, the improved ATMS will result in improved reliability - traffic speeds will be regulated more effectively resulting in more consistent journey times; VMS systems will allow drivers to make more choices in terms of routes and time of travel; the incident detection systems will reduce the impact of incidents. Although the model does not capture the reliability benefits associated with the improved ATMS, it is fair to state that this benefit will be present in options 2, 3 and 5. Option 4 will feature reliability benefits associated with reduced congestion.				Please refer to ATM Standard's Review Report for information regarding modelling methodology and key modelling assumptions. No journey time reliability benefits have been quantified at this point in the project.
	Reduce congestion	Traffic flow profiles to show smooth traffic flows and vehicle speeds (less shockwaves). Journey Time savings	0	3	3	3	3	Option 1 Given the tidal nature of traffic flow in the project area, it is the AM inbound and PM outbound on State Highway 1 (SH1) which will benefit most from improvement works and hence journey times have been extracted for these time periods. Only very minor journey time savings (an average of 4 seconds) are predicted in the 2016 AM peak hour with the improvements to the SH1 / SH2 merge in the inbound direction towards the CBD and this is a reflection of the predicted 1km/hr improvement in average speed between Ngauranga and Aotea Quay. The improvements made to the SH1 / SH2 diverge in the northbound direction predict minor 2016 PM peak hour journey time savings; the model estimates an average journey time saving of 10 seconds and this is a reflection of the predicted 6km/hr average speed improvement . As the traffic model is SATURN-based, we cannot robustly model the affects of improved ATM. However, there is, in reality, the potential for journey time savings to be realised from improving ATMS, ie improved ATMS will help to 'smooth' traffic flows, reduce concertina effects etc by providing improved information to drivers via VMS; these potential benefits have not been captured in the modelling. There is negligible journey time savings on Hutt Road as expected. Options 2, 3, 4, 5: There are significant journey time savings in the 2016 AM peak hour inbound on SH1, with the model predicting an approximate 1 minute time saving - this being a reflection of the estimated 35 km/hr improvement in average speed. In the 2016 PM peak hour outbound on SH1, the journey time savings are more modest, with the model predicting journey time savings of around 18 to 20 seconds - this being a reflection of the estimated 13 km/hr improvement in average speed. There are negligible journey time savings on Hutt Road as expected.					Please refer to ATM Standard's Review Report for information regarding modelling methodology and key modelling assumptions.
	Reduce driver stress	Provide for a stress free driver experience (ultimately positive customer survey results)	1	-1	1	1	2	The driver stress scores mirror the intuitive system scores as driver stress is directly linked. A more intuitive system results in less driver stress and vise versa. Note that the HSR score -1 (as compared with -2 for the intuitive system score) is because the increased capacity might offset driver stress caused by a potentially confusing system.					
Objective totals			2	5	7	7	8						
Objective average score			0.7	1.7	2.3	2.3	2.7						

Project Outcomes	Criteria Heading	Measure	OPTIONS					RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)					ASSUMPTIONS
			1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 -Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	
Making best use of the asset by delivering a value for money and flexible solution	Flexible operational	Can accommodate expected traffic flows. Able to operate 24/7 if required and independently in each direction. Can be operated from Wellington and Auckland	0	2	2	2	3	Not expected to be able to accommodate expect variability of traffic flows and is similar to the existing. In addition, the three lanes will provide no additional flexibility to managed traffic during maintenance works. Impact = 0 Will have some improved ability for lane management and therefore provide flexible for managing incidents, breakdowns and maintenance, but not much better than the existing. Impact = 0 Total Score = 0	In terms of traffic flows this option has the ability to accommodate the variability of traffic flows in the shoulders of the peak periods, during the inter-peaks, weekends and on special events. In addition, the four lanes will provide additional flexibility to manage traffic during maintenance works. Impact = 1 In terms of flexibility of operations this option will allow increased operational flexibility through the opening and closing of the shoulder lane to meet capacity requirements. However, there is a risk of debris or a stopped vehicle delaying opening of the shoulder lane when required will reduce this flexibility marginally. It should be noted that this option operates as CALR (Option 3) for the 4 hour peak periods operation. In addition, this option will have the ability for improved lane management and is therefore flexible for managing incidents and breakdowns due to the increased Advance Traffic Management systems and the increased flexibility provided by have four lanes. Impact = 1 Total Score = 2	In terms of traffic flows this option has the ability to accommodate the variability of traffic flows in the shoulders of the peak periods, during the inter-peaks, weekends and on special events. In addition, the four lanes will provide additional flexibility to managed traffic during maintenance works. Impact =1 In terms of flexibility of operations this option is very similar to Option 2 and will have a Impact =1 Total Impact = 2	In terms of traffic flows this option has the ability to accommodate the variability of traffic flows in the shoulders of the peak periods, during the inter-peaks, weekends and on special events. In addition, the four lanes will provide additional flexibility to managed traffic during maintenance works. Impact =1 In terms of flexibility of operations this option will be able to accommodate breakdown anywhere alone the length of the project, which is better than Option 2 and 3, but will have the ability to improve lane management and therefore provide flexibility for managing incidents and breakdowns mainly due to the provision of four lanes. Impact =1 Total Impact =2	In terms of traffic flows this option has the ability to accommodate the variability of traffic flows in the shoulders of the peak periods, during the inter-peaks, weekends and on special events. In addition, the four lanes will provide additional flexibility to manage traffic during maintenance works. Impact =1 In terms of flexibility of operations this option will be able to accommodate breakdowns using the shoulder anywhere alone the length of the project and have the ability to improve lane management and therefore provide flexibility for managing incidents and breakdowns due mainly to the increased flexibility provide by have four lanes available but also the increased Advanced Driver Information signage. Impact =2 Total Impact = 3. The flexibility of this option is greater that Option 2, 3 and 4.	This criteria has been scored against: - the ability to accommodated the flexibility of traffic flows outside the peak periods; and - the ability to manage incidents and breakdowns All option will be able to be operated from Wellington and Auckland providing 24/7 operation.
	Deliver a value for money solution that makes the best use of the existing asset	Deliver a value for money solution that makes the best use of the existing asset	0	2	2	0	0	Wording of the measures was altered during the course of the MCA workshop to remove the words "value for money" and the focus was then put onto the phrase "Make the best use of the existing asset". With this in mind the following scoring was determined:					
								The existing asset is incorporated into the design of this option, but is modified to include additional enforcement etc. However, because there is no "step change" in the management of the motorway it is unlikely that the changes will create a big enough change in public perception for the user to change their behaviour. The lack of physical alteration is not enough to make the end user appreciate the difference and behave accordingly.	This option again incorporates the existing ITS and physical infrastructure in the final design but provides the step change in use that will assist the change in public perception. This solution will also provide additional capacity within the existing physical infrastructure.	Rationale as per option 2	This option includes the modification of the physical infrastructure but limited changes to the ITS infrastructure. The use of the ITS infrastructure will not be enhanced and therefore the "best use" of it will not be achieved. The additional physical infrastructure to provide additional capacity also results in no additional "best use" of the existing lane space	Rationale as per Option 4. While the ITS infrastructure is incorporated and enhanced to provide a best use, the additional work required for the managed motorway aspects will not be worthwhile as the additional capacity will be provided by additional physical infrastructure.	3.3m lanes for all options No ITS improvements for Option 4, just use of the existing with some widening of gantries etc New digital enforcement included for Options 1,2,3 and 5

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Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Making best use of the asset by delivering a value for money and flexible solution	Design for operation, maintenance and renewal requirements	Optimal operation and maintenance and renewal regime	0	0	1	0	1	This option has a slight increase in ITS technology through the addition of CCTV and Advance Driver Information variable message signs on all gantries. This will improve the operational ability of this option. Impact = 1 The increased ITS assets will require additional maintenance and renewals. Impact = -1 Total Impact = 0 (no real change for the existing situation)	This option has a significant increase in ITS technology through the addition of 4 new gantries, CCTV and additional Advance Driver Information variable message signs on all gantries, plus additional Lane Control Units for the shoulder lane. This option will also include 32 fixed CCTV cameras to ensure that the shoulder lane is not opened when debris or vehicles are stopped in this lane. This option will provide a very high level of operational ability. Impact =2 The increased ITS assets will require significant additional maintenance and renewals. The 32 fixed cameras will need to be maintained from the shoulder. Impact = -2 Total Impact = 0 (The increases maintenance and renewal requirement will cancel out the operational advantages of this option.)	This option has a significant increase in ITS technology through the addition of 3 new gantries, CCTV and additional Advance Driver Information variable message signs on all gantries, plus additional Lane Control Units for the fourth lane. This option will provide a very high level of operational ability. Impact =2 The increased ITS assets will require additional maintenance and renewals but not the level of Option 2. Most gantries will be maintained from the Emergency Breakdown Area. Impact = -1 Total Impact = 1	This option provide no real operational or maintenance improvements over the existing. Total Impact = 0	This option increases ITS technology through the addition of CCTV and Advance Driver Information variable message signs on all gantries plus additional Lane Control Units for the fourth lane. This will improve the operational ability of this option, but not as great as Option 2 and 3. Impact = 1 The increased ITS assets will require additional maintenance and renewals. The shoulder will provide access to maintenance bays similar to Option 1. Impact = -1 Total Impact = 1	This criteria has been scored against the increased operational ability provide by the additional ITS technology provided by each option and the impact on maintenance and renewal of that increased technology.
	Compatible where possible with existing systems	Deliver a solution that minimises modifications	-1	-3	-2	0	-1	Capable with the existing system: Dynac can operate the system and new asset (loops, CCTV, VMS) with minimal modification Queue Detection system requires modifications to Dynac Enforcement system will require modifications to Dynac This option requires minimal additional work to ensure compatibility with the existing systems. Total Impact = -1	Compatible with the existing system: Dynac can operate new asset (loops, CCTV, fixed CCTV, VMS, new gantries, LCU) with minimal modification Additional algorithm will be required to operate the Shoulder Running lane. Queue Detection system requires modification to Dynac Enforcement system will require modifications to Dynac This option requires significant work to ensure compatibility with the existing systems. Total Impact = -3	Compatible with the existing system: Dynac will require some modification to operate this option. Dynac can operate new asset (loops, CCTV, fixed CCTV, VMS, New Gantries, LCU) with minimal modification Queue Detection system requires modification to Dynac Enforcement system will require modifications to Dynac This option requires moderate work to ensure compatibility with the existing systems. Total Impact = -2	Compatibility with the existing system: No new additions to system Total Impact = 0	Compatible with the existing system: Dynac can operate the system and new asset (loops, CCTV, VMS,LCU) with minimal modification Queue Detection system requires modification to Dynac Enforcement system will require modifications to Dynac This option requires minimal additional work to ensure compatibility with the existing systems. Total Impact = -1	This criteria has been score against the amount of work required ensure compatible with the existing systems.
		Objective totals	-1	1	3	2	3						
		Objective average score	-0.3	0.3	0.8	0.5	0.8						

Project Outcomes	Criteria Heading	Measure	1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 -Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
			OPTIONS					RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)					
Improve compliance through influencing driver behaviour	Improve driver behaviour - A	Allow a legally enforceable scheme/ improve enforcement	3	3	3	0	3	Discussions with Police and NZTA lawyers has identified that a legally enforceable system can be implemented.					
	Improve driver behaviour - B	Engineer an intuitive system	0	-2	1	1	1	Provides extra information / support for drivers so is slightly better than doing nothing.	Some previous literature suggests hard shoulder running can result in some added driver confusion/ stress (Chase, Avineri 2008). "LIMITATIONS: emergency access; breakdown safety; altering the role of the hard shoulder; reactions of ATM technology to incidents; AMI/S reliability; 'cheap' investment;driver compliance; driver confusion and habitual behavior;overhead signage confusion; other causes of confusion; increased driver stress levels; HSR relationship with demand management". Also, I think the importance of an intuitive road environment (what the driver sees out their windscreen) cannot be overstated. While active signs are useful and effective, if they contradict the environment or are associated with an otherwise confusing environment, drivers cannot be expected to behave appropriately. Check out the work around self explaining roads to support this. A comparison with transit lanes might be useful. Despite them being in place in Auckland for some time with clear signage about when they can and cannot be used, they are largely mis-used. People don't understand that they can use them sometimes and then at other times they get used when they shouldn't. Admittedly active overhead signs for HSR would be more effective and more intuitive, but the point about a confusing environment stands.	The main point is that extra technology will help with driver understanding of the road situation. It is important to draw a distinction between things that are likely to affect different types of driver behavior. For routine stuff like lane keeping, headway, speed management etc this largely happens at a subconscious level and so the environment is most important. Things like navigation and warnings, we process this at a more conscious (alert) level and so well placed active signs can be effective. The extra lane but reduced shoulder cancel each other (in my view).	The main point is that the extra lane will improve capacity (at least short-term) and lead to smoother driving and better overall behavior. The extra lanes are also likely to be associated with more intuitive connections without the need for lane changes.	The best overall score because of improved information/support and extra capacity with no loss of shoulder.	Scores relate specifically to how intuitive the system is compared to "do nothing" and do not reflect the overall preference for each option.
		Objective totals	3	1	4	1	4						
		Objective average score	1.5	0.5	2.0	0.5	2.0						

Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 -Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Maintain or improve safety for all users	Maintain or improve safety for road users	Reduction in crashes.	1	2	2	1	2	Hazard Log assessment shows a 10% reduction	Hazard Log assessment shows a 19% reduction	Hazard Log assessment shows a 22% reduction.	Hazard Log assessment shows a 8% reduction	Hazard Log assessment shows a 23% reduction	There maybe some minor changes in the percentage crash reductions associated with Options 2, 3 and 4 but it will not change the scoring between these options. These option should have a similar score.
	Improve emergency services access	Develop and deliver an operation regime for incident management and access.	1	2	3	1	3	Option has shoulders for vehicle breakdown 24/7. This Option provided an improved Operational regime for queue and incident detection and lane management through driver information sign and Variable mandatory speed limits. Drivers can be better informed of emergency service activities Total Impact = 1	Option has shoulders for approximately 20 hours per day and one northbound and three southbound fully time Emergency Breakdown areas. Operation regimes for queue and incident detection and management through driver information sign and Variable mandatory speed limits. Drivers can be better informed on emergency service activities and better managed during and incident Four additional gantries will provide an improved level of incident management. However, the 0.5m shoulders in the peak period will reduce the accessibility for emergency vehicles travelling between lane 1 and 2 as there will not be sufficient space for vehicles in lanes 1 and 2 to part. Total Impact = 2 The impact on emergency vehicles has result in a one point reduction for this option.	Option has no shoulders except one northbound and three southbound fully time Emergency Breakdown areas. Operation regimes for queue and incident detection and lane management through driver information sign and Variable mandatory speed limits. Drivers can be better informed on emergency service activities and better managed during and incident Four additional gantries will provide an improved level of incident management. The 1.0m shoulders will allow emergency vehicles to travel between lane 1 and 2 with space for vehicles to part. This Option is 1 point better than Option 2 due to the ability for emergency vehicle travel between lane 1 and 2 in congested situation. Total Impact = 3	Option has shoulders for vehicle breakdown 24/7. The 2.5m shoulders will allow with space for vehicles to part emergency vehicles to travel between lane 1 and 2 . The fourth lane will give this option with an 1 point advantage over the existing. Total Impact = 1	Option has shoulders for vehicle breakdowns 24/7 Operation regimes for queue and incident detection and lane management through driver information sign and Variable mandatory speed limits. The 2.5m shoulders will allow for space for vehicles to part emergency vehicles to travel between lane 1 and 2 . The fourth lane will give this option with an 1 point advantage over the existing. This option will not have the technology advantages of Option 3, but the addition of the shoulder will give this option a similar Impact. Total Impact = 3	Fire engine truck driver has stated that with the 3.3m wide lanes that a 1.0m shoulder will allow fire truck to pass between lane 1 and 2, which is their preferred route of travel to an incident in congested situations.

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Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 -Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Maintain or improve safety for all users	Safety in design	Implement and monitor a safety management system. Safe to construct, operate and maintain.	1	-2	-1	-1	0	No construction related to the viaduct or the link between the viaduct and Ngauranga Interchange. No impact at opening No extra education about how this option will operated There will be an improve operational environment through queue detection, lane management and speed enforcement. Impact =1 Maintenance access similar to existing. Total Impact = 1	No construction related to the link. Impact = 0 Major education relating to the opening. Impact =-1 There will be increased hazards around the operation of this option especially during the early phase of this option. Impact =-1 Improve operational environment through queue detection, lane management and speed enforcement Impact =1 The greatest maintenance requirement of all the options especially related to the 32 fixed cameras and for additional gantries. Fixed cameras will need to be maintained from the shoulder lane. Impact =-1 Total Impact = -2	Medium construction related to the link between the viaduct and Ngauranga Interchange related to the 1m widening on the outside and replacement of edge barrier and street lighting. This will require narrow lanes with no shoulder and a reduced speed limit. This is the most difficult option to constructed. Impact =-2 Minimal education relating to the opening. Impact = 0 Improve operational environment through queue detection, lane management and speed enforcement. Impact = 1 There is no increase risk associated with the maintenance activities as these will be undertaken mostly from the Emergency Breakdown Areas. Impact = 0 Total Impact = -1	Major construction related to the link between Viaduct and Ngauranga interchange related to the 1m widening on the seaward side and replacement of edge barrier, street lighting and reconstruction of the median barrier. This can be constructed behind long term barriers. This Option will be easier and safer to construct than Option 3. Impact =-1 Minimal education relating to the opening Impact = 0 No increase in maintenance. Impact = 0 Total Impact = -1	Major construction between Viaduct and Ngauranga interchange related to the 1m widening on the seaward side and replacement of edge barrier, street lighting and reconstruction of the median barrier similar to Option 4. This can be constructed behind long term barriers. This Option will be easier and safer to construct than Option 3. Impact =-1 Minimal education relating to the opening. Impact = 0 Improve operational environment through queue detection, lane management and speed enforcement. Impact = 1 Minor increase in maintenance. Impact = 0 Maintenance access similar to existing. Impact = 0 Total Impact = 0	This criteria have been scored on the safety of the option during Construction, at Opening, during Operation and to undertake Maintenance. As all option except Option 1 require widening of the viaduct. This impact has not been scored.
		Objective totals	3	2	4	1	5						
		Objective average score	1.0	0.7	1.3	0.3	1.7						

			OPTIONS					RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)					
Project Outcomes	Criteria Heading	Measure	1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Adverse effects on the environment are no more than minor	Built environment	The project provides for the integration of infrastructure in the urban environment. The design does not significantly detract from the urban form and the adverse effects on urban form, culturally significant sites and heritage features are no more than minor.	0	-1	-1	-1	-1	The built environment assessment takes into account the built form of the immediate environment (being a heavily modified highway environment, with an elevated highway structure in places and rail lines and yards in close proximity, and also takes into account the adjoining context of Hutt Road businesses and buildings, the ferry and port facilities and the wider context of residential properties overlooking the site and the Wellington harbour setting. Overall, there is a minor adverse effect of additional works and structures associated with Options 2-5 over and above the existing built environment. No adverse effects are expected from any option on identified heritage or cultural sites for protection.					
	Natural environment	The project integrates well with the natural environment and any adverse environmental effects on natural resources and systems are no more than minor (including Kaiwharawhara Stream/Coastal Marine Area)	0	-1	-1	-2	-2	Overall, any adverse environmental effect generated by any option is expected to be minor and able to be adequately mitigated. However, compared to the do nothing baseline, works associated with options 2 and 3 have the potential to generate a minor adverse effect and options 4 and 5 will potentially have a greater environmental impact due to the construction of a fourth lane and associated stormwater and works in close proximity to the Coastal Marine Area.					
	Hazards	The project minimises risks of hazards, recognising the physical and geotechnical conditions of the area such as ground condition, faultlines, flooding risk and including any contaminated sites	0	-1	-1	-1	-1	Refer to NZ1-4536225 for a summary of the individual hazard scores presented at the MCA workshop 13 June 2011. Key attributes of each hazard are as summarised below: a) Fault Rupture- Could cause partial or complete collapse of Thorndon Overbridge Structure. b) Liquefaction and Lateral Spreading - Thorndon Overbridge and Southern Rail Overbridge structures were designed to performance levels significantly below current code requirements. - Could cause partial or complete collapse of Thorndon Overbridge and Southern Rail Overbridge. - Anticipate widespread damage to existing motorway pavements and embankments. Project design does not require to improve the overall performance of the motorway corridor. c) Tsunami/Flooding/Hurricane - Anticipate varying degrees of damage to the motorway corridor however, entirely out of our control as designers/constructors. d) Site Contamination - All options - New sign gantries may expose/excavate contaminated soils within the existing motorway embankment – low risk. - Options 3/4/5 - Retaining wall construction, as above – low risk. - New Structure for AQ off-ramp – ground improvement within reclamation fill may expose/excavate contaminated soils – moderate to high risk. e) Ground Settlement- Low risk – predominantly granular soils, immediate settlement, requiring reconstruction/relaying the existing pavement.					

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Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 -Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
Adverse effects on the environment are no more than minor	Social well-being and health - air quality	Adverse effects over and above the existing environment are no more than minor	**0**	**1**	**1**	**1**	**1**	People who live or spend a lot of time near major roads may be affected by increased levels of contaminants emitted by motor vehicles and which are known to cause adverse health effects. Children, elderly people and individuals with other health issues tend to be more sensitive than healthy adults to the effects of these air pollutants. The extent of any adverse health effects depends on the volume of traffic on the road, the degree of congestion, and the proximity of the road to houses and other sensitive receptors and a number of lesser factors (e.g. age and composition of the vehicle fleet). For the purposes of air quality assessments, sensitive receptors include places that sensitive individuals are likely to be present for extended periods, including schools, pre-schools, residential healthcare facilities and residential dwellings. Commercial premises are not generally regarded as sensitive receptors, since the majority of users of such premises tend to be healthy adults. In general, exhaust emission rates per vehicle are highest in congested traffic, where vehicles are constantly stopping, starting and accelerating. For most pollutants, vehicle exhaust emissions decrease as average vehicle speed increases. Concentrations of vehicle exhaust pollutants decrease rapidly with increasing distance from roads, due to natural dilution and to dispersion in the air – long term average concentrations of pollutants at distances greater than 100m from the kerbside are typically less than 10% of those within 20m of the kerb, and are negligible beyond about 200-250m from the kerb. There is one sensitive receptor within 100m of the existing alignment of SH1 between the intersection with State Highway 2 (SH2) at Ngauranga and Aotea Quay - Early Years Kidicorp at 172 Hutt Road. There are a limited number of residential dwellings within 100-200m of the alignment in the vicinity of Onslow Road and Sovereign Point. None of the options involve significant relocation or widening of the existing alignment. None of the options will significantly alter the separation distance between SH1 and sensitive receptors. Any difference in air quality effects between the options will, therefore, be dependant of the level of service achieved by each option – improved levels of service are likely to result in decreased exhaust emission rates per vehicle. Options 2 to 5 will see a material improvement in the level of service achieved during times of congestion, and therefore a '+1' score. Option 1 will be similar to the baseline, and therefore scored '0'.					Traffic migration from Hutt Road to SH1 will be same under options 2-5. Traffic volumes on Hutt Rd will not be exacerbated by option 1. Air quality benefits are related to journey time (being an indication of congestion) as incorporated into the journey time reliability indicator.
	Social well-being and health - noise impacts	Adverse effects over and above the existing environment are no more than minor	**0**	**0**	**0**	**0**	**0**	For this project, the traffic volumes and separation distances do not alter sufficiently under any of the options being considered to make a calculable or even a measurable difference, compared with the "do nothing" option for the design year. Consequently the MCA ranking for each of the options being considered is 0 (Neutral). In terms of traffic noise, none of the options considered for this project will adversely affect people's wellbeing and health over and above the "do nothing" noise environment for the corresponding design year.					This assessment has been carried out assuming that the road surface for any additional lane construction will be the same as that of the existing road surface. In the case of the Wellington Urban Motorway this is OGPA. In order to assess the effects of traffic noise, reference has been made to NZS New Zealand Standard NZS 6806:2010 "Acoustics - Road-traffic noise - New and altered roads". This is currently the only applicable standard for such assessment.
	Sustainability	The project takes account of whole-of-life sustainability criteria	**0**	**-1**	**-2**	**-2**	**-3**	Sustainability is ranked from a high level assessment of resource use (e.g. concrete, aggregate, steel, bitumen) and construction fuel (e.g. fill excavation/haulage). Increasingly negative rankings reflect increased resource usage (i.e. decreasing environmental sustainability).					The sustainability assessment has not considered the overall environmental sustainability and economic viability or justification of the project (i.e. project considerations). Highway maintenance requirements are captured by other indicators. Assumption that electricity consumption of ITS network will not be material in the overall sustainability assessment. No assessment of highway user fuel efficiency/operating costs in this indicator.
Objective totals			0	-3	-4	-5	-6						
Objective average score			0.0	-0.5	-0.7	-0.8	1.0						

OPTIONS — RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)

Project Outcomes	Criteria Heading	Measure	1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
The solution can be delivered effectively	Resource consent / planning approval process	The project is straightforward to consent	**0**	**-1**	**-1**	**-2**	**-2**	Compared with the do nothing baseline, options 3 and 4 may require both city council (outline plan) and regional council (stormwater) consents. Option 4 and 5 likewise, with an additional consenting risk of works outside the existing highway designation and potentially additional stormwater consenting issues. Overall, it is expected that consenting of any option will be straightforward.					Current designation boundary has yet to be confirmed. Designation boundary has been assumed based on legal property boundaries adjoining State Highway 1.
	Land acquisition	No significant land acquisition issues	**0**	**-1**	**-1**	**-1**	**-1**	Based on the current understanding of the designation boundary, it is considered that all options will be accomodated within the existing designation boundary, albeit that options 4 and 5 in particular will be close to the boundary in places. Options 2-5 may have some property access and use issues in relation to stormwater discharge and construction works and are therefore scored -1 compared to the do nothing baseline.					Current designation boundary has yet to be confirmed. Designation boundary has been assumed based on legal property boundaries adjoining State Highway 1.
	Contractibility	The project can be staged as required and can be constructed effectively	**0**	**-3**	**-3**	**-2**	**-2**	Contractibility for options 1 to 5 were considered by grouping the options based on similar construction activities. This gave three basic construction scenarios. The first scenario being Minor Works, second being HSR and CALR, and the third being Four Lanes and Four Lanes with improved ATMS. The first construction scenario scored 0 because the physical works are relatively minor, and does not require any work to the Thorndon Viaduct. The second scenario was scored -3. This was due to the limited space along the alignment in terms of width which increases the construction difficulty. This was also seen as a higher risk due to the potential replacement of the median barrier. Physically creating the space to carry out this work safely would require some significant work because physical widening works were nil to minor. The third scenario gives the most space for physical works to be carried out and was scored -2. The initial idea was to widen out into the coastal side first and then to carry out works on the median corridor. This gives opportunity to create the most room for median works and also provide efficiencies in gantry and drainage works as most of this work falls within the widening envelope. Please note that the second and third construction scenarios both have the Thorndon Viaduct widening as part of the scope so it was not seen as a differentiator between the scores.					
		Objective totals	0	-5	-5	-5	-5						
		Objective average score	0.0	-1.7	1.7	-1.7	-1.7						

Project Outcomes	Criteria Heading	Measure	OPTIONS: 1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS): Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
The solution fits with NZTA's economic strategy	Strategic fit	Aligns with NZTA's strategic investment direction	0	1	1	2	2	According to the NZTA Planning Programming and Funding Manual, Strategic Fit focuses on the problem, issue or opportunity being addressed. The overarching problem on this stretch of motorway is congestion and journey time reliability during peak periods. By default any improvements to RoNS have a strategic fit rating of high (i.e. they will score 0 or above in terms of MCA criteria)					Refer to design summary sheets and cross sections Refer to Wellington Regional Land Transprt Strategy, Hutt Corridor Plan, Ngauranga to Airport Corridor Plan and Otaki to Ngauranga Corridor Plan Refer to GPS 2 on Transport
								This option is aimed at improving journey time reliability but does not necessarily remove any capacity constraints or provide additional network security or resillience. While the option may provide minor additonal capacity through increased management of traffic flow it does not provide any additional physcial capacity. The existing 3 lane peak hour capacity is not sufficient for peak hour demand now or into the future. Hence no real improvement over the do nothing.	As above the increased management results in minor capacity improvements across all lanes, however this option provides an additonal lane of capacity during peak hours, provides addtional resilience and network security because the lane can be opened at any time. The option improves journey time reliability because of the reduced congestion during peak hours, however it may increase travel time because of reduced peak hour travel speeds (80kph)	As per option 2, however the addtional lane of capacity is provided at all times. Because the highway is not congested at all times, there is no difference between the MCA weightingfor option 2 and option 3	The addtional capacity provided by the fourth lane removes a capacity constraint. The addtion of a shoulder provides increased network security and resilience as there is more road space to work with during incidents.	The additonal benefits offered by the increased ATM do not provide that much additonal used capacity on what will largely be an uncongested section of motorway apart form when non-recurrent events or incidents occur	
	Effectiveness	Provides for an effective long-term, integrated and enduring solution that is part of an accepted strategy	0	1	2	2	3	The effectiveness rating considers the contribution that each of the options makes to achieving the potential identified in the strategic fit assessment and to the purpose of the LTMA and the relevant NZTA objectives. Higher ratings are provided to proposals that provide long term, integrated and enduring solutions. Each option has been weighed against the assessment criteria contained in the Planning Programming and Funding manual					Refer to design summary sheets and cross sections Refer to Wellington Regional Land Transprt Strategy, Hutt Corridor Plan, Ngauranga to Airport Corridor Plan and Otaki to Ngauranga Corridor Plan Refer to GPS 2 on Transport
								Meets the minimum criteria of potential identified in the strategic fit rating, the purpose of the LTMA and the relevant NZTS objectives. Early indications from the BCR indicate that it is not affordable, because the benefits do not outweigh the costs	Meets the minimum criteria of potential identified in the strategic fit rating, the purpose of the LTMA and the relevant NZTS objectives. Early indications from the BCR indicate that it is affordable, because the benefits outweigh the costs, however the potential for future and sustainable growth within the network is limited by the constrianed nature of the design	Meets the minimum criteria of potential identified in the strategic fit rating, the purpose of the LTMA and the relevant NZTS objectives. Early indications from the BCR indicate that it is affordable, because the benefits outweigh the costs. The potential for future growth within the network is addressed by the width of the corridor, but is not addressed by a more efficeint means of managing flow.	Meets the minimum criteria of potential identified in the strategic fit rating, the purpose of the LTMA and the relevant NZTS objectives. Early indications from the BCR indicate that it is affordable, because the benefits outweigh the costs, The potential for future growth within the network is addressed by the width of the corridor and is made more sustainable by the increased managment of flow within the network.		

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Project Outcomes	Criteria Heading	Measure	1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
	OPTIONS							RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)					
The solution fits with NZTA's economic strategy	Economic efficiency	Benefit Cost Ratio	0	1	3	2	2	The journey time benefits in the AM peak hour inbound towards the CBD and outbound away from the CBD in the PM peak are minor, and with the anticipated cost estimates (land acquisition, design, construction, maintenance), despite being the lowest of the five options, the annualised benefits are not sufficient to outweigh the costs. The safety benefits are predicted to be the second lowest of the five options. The caveat to all of this is that SATURN cannot model the benefits brought about by improving ATMS; there is the potential for benefits to be realised from improving ATMS, ie benefits such as 'smoothing' traffic flows, reducing concertina effects etc, which may elevate the BCR.	The journey time benefits associated with HSR are deemed significant in the AM peak inbound (approx. 1 min) and moderate in the PM peak outbound (approx. 18 seconds). The absolute numbers may appear small, but considering the length of the SH1 between Ngauranga and the Aotea Quay off-ramp (2.65km inbound; 2km outbound), these predicted journey time savings are very good and reflect average speed increases of approximately 35km/hr when compared to the Do Minimum. The safety benefits are predicted to be high in the HSR option (third highest of all options) and journey time reliability is predicted to increase too (note: journey time reliability assumed to be 5% of journey time benefits).	The highest scoring option and the rationale behind this stems from Inter-peak benefits associated with the additional lane during this time period and the prediction of achieving the highest safety benefits (ie highest predicted reduction in annual crashes). Considering the inter-peak period as on the ground now, there would be very little, if any, benefit from introducing a fourth lane. However, the traffic modelling has assumed a high growth land-use scenario and as we forecast towards 2016 and 2026, the anticipated growth in all time periods increases. Therefore with the introduction of a fourth lane in the inter-peak time period, we see some journey time benefits, despite the fact the current 3 lanes can accommodate the anticipated growth. In modelling terms, congested journey times make use of V/C, and hence as the inter-peak volume over capacity (V/C) on SH1 inbound increases from 50% in the 2009 base year to 68% in the 2026 Do Minimum, and in the outbound direction the V/C increases from 46% in the 2009 base year to 56% in 2026 Do Minimum, the model will, and is, returning inter-peak journey time benefits in the CALR option with the additional fourth lane. The low cost estimates for CALR and HSR are very similar, and so with the added journey time and the highest safety benefits, CALR receives the highest BCR score.	The journey time benefits for Option 4 are slightly improved over Option 3 due to road capacity assumed to be slightly greater since we have four lanes plus a 2.5m shoulder, rather than four lanes plus a 1.5m shoulder, and are the highest when compared to the Do Minimum. This option has the second highest estimated design and construction costs and the lowest safety benefits, which lowers the BCR.	The journey time, de-congestion, journey time reliability and vehicle operating cost benefits are assumed to be the same as Option 4 because SATURN cannot model the effects of ATMS. The estimated design and construction costs are the highest of all options (marginally greater than Option 4) but the safety benefits are predicted to be the highest, along with the CALR option.	Please refer to ATM Standard's Review Report on TeamView for information regarding modelling methodology and key modelling assumptions BCR for Option 1 - benefits constrained to SH1 section between Ngauranga and Aotea Quay BCR for Options 2 to 5 - benefits based on 'global' network area and assuming Option 1 as Do Minimum; and Option 2 takes in as input AM and PM CALR benefits Congestion Reduction Value based on links with volume/capacity > 70% Range of BCRs based on low and high cost estimates for each option Journey Time Reliability benefits assumed to be 5% of journey time savings Cost per accident (fatal, serious, minor) taken from EEM manual, Tables A6.21 (e,f,g) - all vehicles on roads with 100km/hr speed limit. Non-injury accidents not considered Number of crashes in the Hazard Log, by time period and severity, are for the period 2005-2009. To obtain the average number of crashes per year we have simply divided the 2005-2009 total number by 4. There has been no attempt to adjust the number of average crashes in the two forecast years; we maintain the 2009 levels Accident costs from EEM are in 2006 prices; they have been inflated to 2009 prices by 14% 2002 values of time inflated to 2009 base by 22% Appraisal period of 30 years with a discount rate of 8% - first year when benefits are realised is 2016; benefits 'flat line' following 30 year appraisal period Cost estimates do not include Optimism Bias but includes funding risks 'Demand' demand used as opposed to 'Actual' demand Safety benefits and cost estimates are the only differentiators between Four Lanes plus Shoulder and Four Lanes plus Shoulder plus ATM Option 5 has not been modelled. Instead the journey time, de-congestion, journey time reliability and vehicle operating cost benefits are assumed to be the same as Option 4

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Project Outcomes	Criteria Heading	Measure	1 Three Lanes plus Minor Works	2 Hard Shoulder Running	3 Controlled All Lane Running	4 4 Lanes + Hard Shoulder	5 4 Lanes + Shoulder + ATM	Op 1 - Three Lanes plus Minor Works	Op 2 - Hard Shoulder Running	Op 3 - Controlled All Lane Running	Op 4 - 4 Lanes + Hard Shoulder	Op 5 - 4 Lanes + Shoulder + ATM	ASSUMPTIONS
			OPTIONS					**RATIONALE BEHIND THE SCORES (INPUT BY EXPERTS)**					
The solution fits with NZTA's economic strategy	Local business impacts	Consideration of economic impact on local businesses	0	0	0	0	0	Option 1 is considered to have negligible impact on local businesses. There will be no significant negative impact associated with implementation/construction, however the benefits in terms of increased State Highway capacity are also considered slight.	All options scored zero for this criterion. However, this is not because there is no impact on local businesses, more because the negative and positive impacts are deemed to cancel each other out. There will be some negative impacts during construction. It is likely that any widening required will have a slight impact on the Interisland Line operations. Furthermore there is likely to be some construction traffic and disruption/reduced capacity during the construction phases. However, once the improvements "go live" there will be improved capacity resulting in improved access to markets, and greater journey time reliability for freight traffic accessing the port.				Local business impacts are deemed to include the impact on businesses in the immediate vicinity of the Ngauranga to Aotea Quay corridor only. This will include Centreport, Kiwirail and the businesses in the Hutt Road corridor. Impacts on businesses will consist of two facets - the impact of implementing the option, and the impact the option has once implemented
	Wider economic impacts	Consideration of wider economic impacts (regional and national level)	0	1	1	1	1	As option 1 has little impact on capacity, the impact on the wider economy is likely to be less than minor. Some reliability benefits may result in a slight reduction in transport related costs, however these were not deemed significant enough to warrant a score greater than zero.	All options scored one for this criterion. This was because they were all deemed to result in increased capacity on the key access route into Wellington and therefore result in some benefits to the Wellington economy. In effect, all options deliver 33% extra capacity through an extra lane (at least during peak periods) and this, coupled with the rest of the Wellington RoNS projects will result in improved access to Wellington (including the CBD, port and airport) for businesses and travelling members of the general public. The options that include enhanced ATMS may deliver slightly higher wider economic benefits, however this was not considered sufficient to warrant scoring these options any more than one.				Wider economic benefits are benefits to the wider Wellington region and beyond. In general these are delivered through increased capacity on the road network, greater route choice, improved access to key transport (and other) services and reduced transport costs
Objective totals			0	5	7	7	8						
Objective average score			0.0	1.0	1.4	1.4	1.6						

Overall Scores

	1	2	3	4	5
Non-weighted Score	2.9	1.9	5.5	2.6	6.0

5 Overall Scores

This section provides a sensitivity analysis of the MCA undertaken of the five options assessed. The intention is to consider the MCA under a variety of criteria weightings to ensure that the weightings alone have not overly influenced the outcome. Each of the objective/outcomes criteria is given a bias weighting to assess the outcome (each criteria in turn given a high weighting of 70% with the remaining six objective criteria receiving 5%). In addition, some of the sub-criteria are tested to ensure end results, as follows:

- The sub-criteria of economic fit is removed to check that economic factors alone has not overly influenced the outcome;
- The social factors of driver stress and an intuitive system are removed for a similar reason – these criteria were identified as influential differentiator for HSR and also potentially double-counting with other related measures such as journey time reliability. In addition these social factors are also given bias to check results.
- Each of the seven objective outcomes criteria is given an equal weighting (approximately 14%).
- The weightings presented at the workshop are incorporated, providing a potential scenario of the relative significance between the objectives outcomes (being journey time reliability 25%; best use of existing asset 15%; compliance 10%; safety 10%; environment 10%; delivery 5%; economic fit 25%).

		3 Lanes + Minor Works	Hard Shoulder Running (HSR)	Controlled All Lane Running (CALR)	4 Lanes + Hard Shoulder	4 Lanes + Shoulder + ATM
1	Journey efficiency (bias 70%)	0.6	1.6	2.0	1.8	2.1
2	Best use (bias 70%)	0	0.5	1.0	1.5	0.8
3	Compliance (bias 70%)	1.5	0.5	1.6	1.5	2.0
4	Safety (bias 70%)	0.8	0.8	1.3	0.5	1.5
5	Environment (bias 70%)	0.2	-0.3	-0.3	-0.6	-0.5
6	Delivery (bias 70%)	0.2	-1.0	-0.9	-0.1	-0.8
7	Economic (bias 70%)	0.2	0.7	1.4	1.2	1.6
8	Social factors only	1	-1.5	1	1	2.0
9	Social factors removed	0.5	1.4	1.6	1.1	1.6
10	Economic fit removed	0.6	0.3	0.7	0.2	0.8
11	Equal weighting of objectives (14%)	0.5	0.4	0.8	0.4	0.9
12	Workshop weightings	0.4	0.9	1.4	1.1	1.5
Average Weighted Score		**0.5**	**0.4**	**0.8**	**0.4**	**0.9**

In terms of the assessment of options, key findings are:

1. There was sufficient differentiation between the options to show those options that more positively contribute to the project objectives than others. Principally, Option 3 (CALR) and Option 5 (4 lanes + shoulder + ATM) had a more positive overall contribution than Options 1, 2 and 4. Options 3 and 5 scored well against the measures of journey time reliability, compliance and safety.
2. Overall, all options had a positive contribution in relation to the 'do nothing' option.

Appendix T

Wellington Operation Management Level Assessment Literature Review

Report

Ngauranga to Aotea Quay Wellington Operational Management Level Assessment Literature Review

Prepared for New Zealand Transport Agency (NZTA)

By Beca Infrastructure Ltd (Beca)

17 August 2011

Revision History

Revision N°	Prepared By	Description	Date
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Action	Name	Signed	Date
Prepared by	Anita Lin	[signature]	21/10/2011
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on behalf of	Beca Infrastructure Ltd		

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1 Introduction

Based on the Literature review documented in section 2 the Levels of Operational Management have been developed. These Levels of Operations Management are as follow:

- Do Nothing - The intended purpose is for all road users to have fully uncontrolled access without any operational management, information or control.
- Monitoring - The intended purpose is to monitor the movement and performance of the traffic flow and direct emergency services to incidents on the network.
- Information - The intended purpose is to provide information to drivers on the performance of the road network.
- Control
    - Speed Management - The intended purpose is to manage the performance of the road network through speed management to reduce flow breakdown and reduce travelling too fast and loss of control hazards.
    - Queue Protection - The intended purpose is to manage the performance of the road network through queue management to address secondary crashes.
    - Lane Control - The intended purpose is to manage incident and maintenance activities through lane management.
    - Access Management - The intended purpose is to manage the access of vehicles onto the motorway to address flow breakdown at the on ramp merge, reduce tailgating hazards and improve the overall performance of the network.
    - Fully Managed - The Intended purpose is to fully manage the carriageway to maximise the performance of the network to cover the traffic demands during the peak traffic flow periods and when an incident occurs.
- Transport Network Integration (Strategic) - Management of whole transport system including integration with other modes (passenger transport (buses, Rail, Ferries, airports), walking, cycling) to allow users to make the best informed decision on transport mode and route.

Appendix A outlines the Levels of Operational Management in terms of tools (Technology, Public Education, Enforcement and Operability) and measures (Capacity, Travel Time Savings, Journey Time Reliability, Impact on Peak Period, Safety, and Customer Satisfaction)

2 Literature Review

2.1 Monitoring

Reference 3

Intelligent transportation systems (ITS) provide a proven set of strategies for addressing the challenges of assuring safety and reducing congestion, while accommodating the growth in transit ridership and freight movement. ITS improve transportation safety and mobility, and enhance productivity through the use of advanced communications, sensors, and information processing technologies encompassing a broad range of wireless and wireline communications-based information and electronics. When integrated into the transportation system's infrastructure, and into vehicles themselves, these technologies relieve congestion, improve safety, and enhance American productivity.

This report presents information on the performance of deployed ITS, as well as information on the costs, deployment levels, and lessons learned regarding ITS deployment and operations. The report, and the collection of four Web-based resources upon which it is based, have been developed by the U.S. DOT's ITS Joint Program Office (JPO) to support informed decision making regarding ITS deployment.

To support the deployment of ITS and to address the challenges facing the U.S. transportation system, the JPO has developed a suite of knowledge resources. This collection of Web-based resources provides ready access to information supporting informed decision making regarding deployment and operation of ITS to improve transportation system performance. Information presented in these online knowledge resources is the basis for this document. The four knowledge resources are the ITS Benefits Database (www.itsbenefits.its.dot.gov), ITS Costs Database (www.itscosts.its.dot.gov), ITS Deployment Statistics Database (www.itsdeployment.its.dot.gov), and the ITS Lessons Learned Knowledge Resource (www.itslessons.its.dot.gov).

This report discusses 17 different areas of ITS application. These chapters are divided into two sections discussing technologies deployed on the transportation infrastructure and those deployed within vehicles. The 14 different infrastructure applications discussed can be grouped into ITS strategies applied to roadways, transit, management and operations of transportation systems, and freight movement. Lessons learned during ITS planning, implementation, and deployment, highlighted throughout the report, are discussed in a chapter following the review of ITS applications and summarized at the conclusion of this executive summary.

2.2 Information

In Arizona and Missouri a survey of tourists found that those who used advanced traveller information systems believed the information they received save them time. (Reference 10)

Summary Information

This study examined the I-40 Traveller and Tourist Information System (TTIS) in Arizona, and the Branson Travel and Recreation Information Program (TRIP) in Missouri. The objective of the study was to evaluate the degree to which advanced traveller information systems (ATIS) could help improve mobility, increase access, reduce congestion, stimulate economic development, and improve safety in rural tourism areas.

The Branson TRIP system was designed as a regional ATIS to provide comprehensive information on tourist attractions, weather, traffic, and road construction in the Branson/Tri-Lakes area. To address traffic congestion, the TRIP system expanded the existing ITS infrastructure and developed internet sites, highway advisory radio (HAR), traffic detection equipment, and variable message signs (VMS). A central database was designed to collect, coordinate, and disseminate the traveller information.

The I-40 TTIS was designed to provide tourists with traveller information on the I-40 corridor, which provides access to the Grand Canyon and 20 other major parks and recreation areas. Arizona's Highway Closures and Restrictions System (HCRS) served as a central database for collection and dissemination of TTIS traveller information. The HCRS was designed to collect information from public safety professionals, construction workers, road weather information systems, and other surveillance and detection equipment.

Methodology

Based on workshop meetings and collaboration with local partners in each area, the evaluators decided to use tourist intercept surveys, focus groups, and qualitative interviews to evaluate the impact of traveller information system on customer (tourist) satisfaction in each area. The following list summarizes the survey sample size in each area.

I-40 in Arizona:

- 2,174 tourists were approached (intercepted).
- 1,712 completed the screener.
- 813 completed the detailed questionnaire.

Branson, Missouri:

- 1,803 tourists were intercepted.
- 1,689 completed the screener.
- 640 completed the detailed questionnaire.

Originally, the deployment plans were designed to provide travellers with real-time information during the summer tourist season in an effort to alert travellers of incidents, congestion, and changing road conditions via the phone system, informational kiosks, websites, and variable message signs, route signs, and highway advisory radio (HAR). However, due to technical issues associated with real-time information dissemination and the limited deployment of kiosks with access to special internet sites, the overall awareness of ATIS was limited during the survey. The systems deployed by late summer did not include real-time information on major incidents, road closures, or weather conditions.

Findings

The following results were presented in the report:

I-40 Tourist Satisfaction

Tourists interviewed in Arizona were pleased with travel conditions irrespective of awareness or use of traveller information systems. Seventy-eight (78) percent of travellers surveyed in Arizona were aware of at least one deployed ATIS component, and 45 percent of travellers surveyed used the system. However, because the evaluation effort took place early in the deployment phase only 10 to 20 percent of tourists were aware of the kiosks, websites, or interactive phone systems, and less than 10 percent were users of any one of these services.

Over 50 percent of tourists interviewed in Arizona agreed or strongly agreed that the information they received saved them time. In addition, over 70 percent of the tourists who received information over the internet thought the information save them time. A smaller number of tourists (35 to 63 percent) reported the information made it easier to get to their destination.

Branson Tourist Satisfaction

Tourists who were aware of at least one traveller information system component were more satisfied with the travel conditions on the current and previous trip than the tourists who were unaware of the traveller information system. 85 percent of travellers surveyed in Branson were aware of at least one deployed ATIS component, and 48 percent of the travellers surveyed used the system. However, because the evaluation effort took place early in the deployment phase only 10 to 20 percent of tourists were aware of the kiosks, websites, or interactive phone systems, and less than 10 percent were users of any one of these services.

Over 50 percent of the respondents indicated the information (excluding radio) saved them time. A smaller number of respondents (30 to 40 percent) indicated the information from the toll-free telephone information service, the website, and kiosks made it easier to get to their destination.

In Paris there are over 350 VMS on the ring motorway (Reference 9)

Kronborg (2001) found that 80% of the drivers preferred to be informed of the travel time rather than queue lengths. Another survey conducted in Paris (MV2, 1997 cited by Lai) revealed that:

- 97% of drivers were aware of the existence of VMS;
- 62% of drivers completely understood the information presented on VMS;
- 84% considered the information presented to be useful; and
- 46% had on at least one occasion diverted in response to the travel time information.

2.3 Control (Reactive to Proactive)

2.3.1 Speed Management

Automated speed enforcement in England has increased capacity by 5 to 10 percent (Reference 1)

Summary Information

This research was a "scan team" effort jointly sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB). During a two-week period in May 1998, the team visited with transportation officials in Gothenburg, Sweden; Frankfurt, Cologne, and Bonn, Germany; Paris, France; and London and Birmingham, England to identify noteworthy practices and technologies that may have value in the United States.

Findings

According to England officials, automated enforcement is important in maintaining compliance with variable speed limits. Detectors identify vehicles exceeding the speed limit while cameras mounted on overhead freeway signs photograph the license plate. The system has shown a very high compliance rate with speed limits, an increase in capacity by 5 percent to 10 percent, and a 25 percent to 30 percent decrease in rear-end accidents on the approaches to queues on the freeway.

An automated speed enforcement system deployed in Korea reduced crash frequency by 28 percent and decreased crash fatalities by 60 percent (Reference 12).

Summary Information

The Korean National Police Agency (NPA) Automated Speed Enforcement (ASE) system performed speed measurement and vehicle license plate identification using inductive loop detectors, digital cameras (1024 by 1024 resolution), and neural network imaging identification software at 32 field stations. The local imaging information was transmitted to a number of central locations where the data was recorded and processed by automatic written notice senders.

The effectiveness of the ASE system was studied using crash data collected before and after system deployment. The "before data" was collected from April 1996 to July 1997, and the "after data" was collected from April 1997 to March 1998.

Results

During the first year of operations in the study area annual fatalities decreased 60 percent (107 to 43) and the total number of accidents decreased 28 percent (801 to 576). Vehicle speed data collected after ASE deployment showed average vehicle speeds were reduced, and speed distributions were more uniform. Short headway times of 1 second were most common on road sections 500 meters upstream and 500 meters downstream of enforcement points. Longer headways times of 1.5 seconds were most common adjacent to enforcement points.

Notes: The "after data" was limited and represented only one year of operations. It was unknown if reductions in accidents and fatalities could be sustained.

Advanced traffic management systems in the Netherlands and Germany reduced crash rates by 20 to 23 percent (Reference 14).

Summary Information

This research was a "scan team" effort jointly sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB). During a two-week period in May 1998, the team visited with transportation officials in Gothenburg, Sweden; Frankfurt, Cologne, and Bonn, Germany; Paris, France; and London and Birmingham, England to identify noteworthy practices and technologies that may have value in the United States.

Findings

A traffic management system of detection, lane control, variable message signs, and variable speed limits is used in Gothenburg, Sweden. Called Motorway Traffic Management it used in the Lundby tunnel and utilizes a system of loop detectors and video cameras to measure traffic volumes and speeds, for classifying vehicles, and for incident detection. Information is provided to motorist through a series of variable message signs. Lane control and variable speed limits are used to control traffic flow. Similar systems have provided a variety of documented benefits. In Amsterdam, the system reportedly reduced the "overall accident rate" by 23 percent, reduced the "serious accident rate" by 35 percent, and reduced the "secondary accident rate" by 46 percent. In Germany, the accident rate fell by 20 percent in areas where variable speed limit signs and lane control signals were used to warn drivers of congested conditions on the A5 autobahn between Bad Homburg and Frankfurt/West. On a comparable section of autobahn without control, accidents increased by 10 percent in the same time period.

In England, a variable speed limit system on the M25 freeway increases average travel times, but promotes proper following distances between vehicles and creates smoother traffic flow (Reference 15).

Summary Information

Speed limits were adjusted in response to the level of congestion on the M25, one of the most congested freeways in England. Using dynamic message signs (DMS) and loop detectors measuring traffic density and speed, speed limits were lowered in increments as congestion increased. Speed cameras were used to enforce the speed limits, resulting in 26,000 fines.

The study found that motorists were more inclined to keep to their lane when a "faster lane" no longer existed. They were also more inclined to keep to the inside lane and to keep proper distances between successive vehicles, resulting in smoother traffic flow which actually increased average travel times of traffic. Results show that traffic accidents decreased by 28 percent during the 18 months of operation.

A survey of motorists in Copenhagen, Denmark, found that 80 percent of respondents were satisfied with variable speed limits and the traveller information posted on dynamic message signs (Reference 11).

<u>Summary Information</u>

This report examines a temporary traffic management system implemented in association with a work zone in Copenhagen, Denmark. Dynamic message signs and traffic detectors were deployed on freeways surrounding the work zone to support dynamic route information at diversion points and the implementation of variable speed limits (VSL). The temporary system was deployed in response to expected increases in accidents and congestion as a result of a roadway expansion project on the Køge Bugt Motorway where four lanes were expanded to six lanes between summer 2002 and summer 2003. The road construction project involved several changes in road geometry within the work zone.

The impact of variable speed limits and dynamic route advisory messages posted on dynamic message signs in the study area was evaluated by collecting traffic volume and speed data from loop detectors and machine vision license plate detectors before and after deployment. A questionnaire distributed to approximately 2,500 motorists generated a response rate of 24 percent (600 questionnaires) enabling and assessment of customer satisfaction with the systems.

<u>Findings</u>

Variable Speed Limits

The variable speed limit system deployed as part of this project was implemented to the south of the work zone, enabling the adjustment of speed limits for northbound vehicles approaching the work zone during the morning rush. DMS were also deployed on the southbound portion of the freeway, allowing speed limits to be adjusted in response to recurring afternoon congestion at an interchange at the southern end of the study area.

The VSL system experienced considerable technical difficulties during the deployment which likely had a negative influence on the impacts of the system. Problems included displaying incorrect speed limits for up to 18 percent of the morning rush hour periods, and difficulties in responding to congestion during the afternoon peak periods (DMS signs going blank, or displaying incorrect speed limits).

Questionnaire responses supported these findings. Numerous complaints were documented in reference to the speed limits being set too low for prevailing traffic conditions. In addition, several respondents noted flaws in the speed limits displayed. The questionnaire also found that after the implementation of the variable speed limit system 46 percent of respondents felt safer, 4 percent felt less safe, and the remaining 50 percent did not feel any more or less safe.

Dynamic Route Information

The dynamic route information system experienced considerable technical and implementation difficulties that likely influenced the response of travellers to the posted messages. These included inaccurate estimates of the delays on the two routes and a complicated series of messages used to display delay information on the dynamic message signs.

The questionnaires distributed to travellers found that 80 percent of the motorists participating in the survey were favourably disposed to both the variable speed limits and dynamic route information signs. However, the comments received regarding the accuracy of the delay messages and the appropriateness of the posted variable speed limits indicated that both systems were currently operating unsatisfactorily.

Notes: The author concluded that "the results achieved on the Køge Bugt Motorway may not apply to other, better performing, applications. Hence, similar applications of a higher technical standard may prove to have greater positive impact on drivers' behaviour.

2.3.2 Lane Management

It was estimated that variable speed limit signs and lane control signals installed on the autobahn in Germany would generate cost savings due to crash reductions that would be equal to the cost of the system within two to three years of deployment (Reference 17)

Summary Information

This research was a "scan team" effort jointly sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board (TRB). During a two-week period in May 1998, the team visited with transportation officials in Gothenburg, Sweden; Frankfurt, Cologne, and Bonn, Germany; Paris, France; and London and Birmingham, England to identify noteworthy practices and technologies that may have value in the United States.

Findings

A traffic management system of detection, lane control, variable message signs, and variable speed limits is used in Gotherberg, Sweden. Called Motorway Traffic Management it used in the Lundby tunnel and utilizes a system of loop detectors and video cameras to measure traffic volumes and speeds, for classifying vehicles, and for incident detection. Information is provided to motorist through a series of variable message signs. Lane control and variable speed limits are used to control traffic flow. Similar systems have provided a variety of documented benefits. In Amsterdam, the system reportedly reduced the "overall accident rate" by 23 percent, reduced the "serious accident rate" by 35 percent, and reduced the "secondary accident rate" by 46 percent. In Germany, the accident rate fell by 20 percent in areas where variable speed limit signs and lane control signals were used to warn drivers of congested conditions on the A5 autobahn between Bad Homburg and Frankfurt/West. On a comparable section of autobahn without control, accidents increased by 10 percent in the same time period.

The Germans estimated that the payback in savings from the reductions in accidents would equal the cost of the system within two to three years after deployment.

2.3.3 Queue Protection

Evaluating the benefits of MIDAS automatic queue protection (Reference 18)

Summary Information

The study has estimated that, on average, the safety benefit of MIDAS automatic queue protection had a value of £49,000 per km per year of motorway route. The associated congestion relief benefit had a value of £11,000 per km per year at the time when the study was conducted. The corresponding value of accident savings on the 800 km on which MIDAS was then operated was £39 million per year and the associated delay savings were £9 million per year.

The benefits were dependent on the traffic flow, so that on a busy motorway carrying 180,000 vehicles per day, the safety benefits were estimated to be £74,000 per km per year together with congestion relief benefits of £30,000 per km per year.

MIDAS studied here was provided as part of a package of improvements, such as the provision of new message signs and new fibre cables, over a number of years. As these works have varied between schemes it is not possible to give a precise cost for just MIDAS. However recent installations indicate that MIDAS costs are in the order of £210,000 per km, which demonstrates that MIDAS continues to provide good value for money. MIDAS is currently operated on over 1000km of motorway route delivering safety and congestion benefits of over £60m per year.

2.3.4 Access Management

A simulation study of existing ITS (traveller information, ramp metering, and DMS) on a Detroit freeway demonstrated how these technologies can increase average vehicle speed, decreased average trip time, and reduce commuter delay by as much as 22 percent (Reference 3).

Summary Information

This study used simulation techniques to evaluate the impacts of ITS on the John C. Lodge freeway in Detroit, Michigan. The study was able to discount freeway bias (driver preference for freeways) and analyse the system and facility level benefits of ITS currently deployed in the corridor.

ITS in the corridor consisted of internet-based pre-trip advanced traveller information systems (ATIS), highway advisory radio (HAR), ramp metering, and dynamic message signs (DMS). The performance of these systems was analysed through a series of simulations that evaluated four alternatives:

- No-ITS.
- Ramp metering.
- Variable message signs.
- Existing-ITS (ATIS, HAR, ramp metering, and DMS).

The INTEGRATION simulation model was used to generate peak PM arterial and freeway corridor conditions for roughly 40,000 to 50,000 vehicles per hour during 80 different scenarios of impedance (varied weather, incident patterns, etc.). The model was calibrated using flow and speed data derived from field observations.

Field data indicated that under typical peak hour conditions, freeway bias could not exist because average freeway travel speeds were higher than those on arterials. The lack of available data on freeway speeds during incidents precluded an analysis of freeway bias during incidents.

The simulation results indicated existing ITS technologies in the corridor (ATIS, HAR, ramp metering, and DMS) increased average vehicle speed up to 5.4 mi/h, decreased average trip time by approximately 4.6 minutes, and reduced commuter delay by as much as 22 percent.

Freeway management systems employ traffic detectors, surveillance cameras, and other means of monitoring traffic flow on freeways to support the implementation of traffic management strategies such as ramp meters, lane closures, and variable speed limits (VSL) (Reference 3).

Benefits

A study of the six-week shutdown of the ramp meters in Minneapolis-St. Paul, Minnesota, found that ramp meters were responsible for a:

- 21% crash reduction;
- 10% increase in the volume of traffic accommodated by area freeways; and
- 22% decrease in travel times.

Traveller opinions of the system improved with the implementation of a modified operating strategy after the shutdown. The new operating strategy used fewer ramp meters, operating for a shorter period of time each day, with faster metering rates. Support for complete shutdown of the system dropped from 21% prior to the shutdown to just 14% of survey respondents after the system modifications.

A simulation study of the system found 2-55% fuel savings for vehicles traveling along two corridors in the city, under varying levels of travel demand.

Highway Agency Ramp Metering Operational Assessment demonstrated that Ramp Metering has had a positive impact on journey times and traffic flows on the mainline carriageway when installed at carefully selected locations on the motorway network. (Reference 4)

Summary Information

The results demonstrate that the delays Ramp Metering can have upon on slip road traffic is more than outweighed by the benefit received by vehicles on the mainline carriageway, with a close link between the level of savings on the mainline and the level of delay on the slip road.

The overall increase in peak period traffic flows observed on the mainline after the installation of Ramp Metering varies by site with individual increases in traffic flow ranging from 1% to 30%. However, it should be noted that at a number of sites traffic flows remained relatively unchanged or reduced slightly post Ramp Metering.

Despite the increases in traffic flow the implementation of Ramp Metering has resulted in overall journey time savings on the mainline during peak periods of up to 40% with an average journey time saving for mainline traffic of 13% across all sites evaluated.

The average on-slip delay per vehicle with Ramp Metering operational ranged from 8 seconds to 78 seconds; however the sites with the highest delay on the slip road in general also delivered the highest benefit on the mainline.

In many cases, Ramp Metering operation has led to a delay in the onset of flow breakdown and/or earlier recovery from flow breakdown conditions.

The initial economic assessment of Ramp Metering was undertaken on the basis of an assumed 5% reduction in delay for mainline traffic, which resulted in a 7% First Year Rate of Return (FYRR) averaged across all thirty sites. The revised economic assessment, which has been based upon the observed mainline journey time savings, together with the calculated slip road delays, indicates that Ramp Metering yields significantly higher returns than those assumed in the initial evaluation, with

FYRR ranging from 7% through to 98%, with an average FYRR for those sites evaluated of 34%. The observed FYRRs are much higher than those derived in the initial economic assessment due to the fact that the actual journey time savings, as a result of implementing RM, are much higher than those assumed in the initial appraisal.

The operational assessment of Ramp Metering has indicated that the system has resulted in significant benefits to the travelling public on the mainline of the motorway in terms of journey time savings, increased speeds, increased traffic flows and more stable conditions. In addition the system results in economic benefits with significant returns in its first year of operation, despite delays being experienced by slip road traffic.

Operationally Ramp Metering has therefore proved to be a great success.

The Auckland Motorway Alliance Customer Survey 2011 recorded that the favourable response to ramp signals seen last year was repeated with 64% of respondents answering "Yes" when asked "Taking into account the effects on the motorway and on local streets, on balance, are ramp signals a useful way to control traffic?, and 36% saying "No" – an extra year's experience does not seem to have increased or decreased acceptance (Reference 8).

Summary Information

Ninety six percent of respondents had used an on-ramp with ramp signalling (up from 92% in 2009). Only 8% reported feeling unsafe (2% "very", 6% "quite") driving on the on-ramp where it merges into the one lane after the traffic lights. When asked, "Taking into account effects on the motorway and on local streets, on balance, are ramp signals a useful way to control traffic?" 64% said "Yes" and "32%" said "No" (with 4% undecided. The consistency with the response from 2009 suggests that on-going experience with ramp signals does not change people's assessment of them either way.

The comments accompanying these assessments mirror those in 2009 with negative responses asserting that ramp signals interrupt/slow flow onto motorway shifting the jams onto the ramps and further back, and causing increased congestion of local roads/streets. Again stopping at the ramp signals was seen by some respondents to cause aggression/racing/risk and to result in an unsafe merge speed as vehicles are accelerating from a standing start, a particular issue on short ramps. Again there was reference to people simply ignoring the signals and queries about the timing sequences which were not always consistent with the traffic volumes on the motorway and are perceived to be sometimes operating unnecessarily. The Greenlane roundabout was again mentioned as a specific location where the ramp signals are perceived to cause significant congestion/delays on the local roads.

Positive comments approving ramp signals largely endorsed the way that traffic entering the motorway was controlled, and perceived positive impact on driver behaviour by making the merging manoeuvre much more considered. The comment was also made that for those travellers getting on at the start of the motorway, ramp signals helped produce an easier journey!

2.4 Management (Proactive)

ATM results are encouraging (as reported in the 12 month performance results) (**Reference 2**):

- Average journey time has improved by up to 24% in worst PM peak periods;
- Drivers are now better able to predict their journeys with a 22% reduction in Journey Time Variability;

- Early indications are that Safety has improved considerably with the Personal Injury Accident (PIA) rate falling from 5.2 per month to 1.5 per month; and
- Positive environmental impact despite traffic growth: resulting in reductions in emissions and noise levels.

Reference

Reference 1: ITS Benefits - Automated Speed Enforcement
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/BA6880215FC47BAA8525733A006D4C11?OpenDocument&Query=BApp

Reference 2: M42 Active Traffic Management Pilot Project – M42 ATM Pilot 6 Month Performance Review , September 2007

Reference 3: U.S Department of Transport - Intelligent Transport Systems Benefits, Cost, Deployment and Lessons Learned, 2008 Update

Reference 4: Highway Agency – Ramp Metering Operational Assessment, April 2008

Reference 5: Transport Scotland – Approach and Methodology for Managed Motorway for Scotland Feasibility Study, June 2010

Reference 6: Highway Agency – Ramp Metering Summary Report, November 2007

Reference 7: Highways Agency – M25 Control Motorways Summary Report, March 2007

Reference 8: Auckland Motorway Alliance, General Customer Survey results, 2010

Reference 9: IPENZ Transportation Group Conference Paper, Auckland, March 2011- Display Of Travel Time On Auckland Motorways Variable Message Signs, September 2010

Reference 10: ITS Benefits – Impact of Advanced Traveller Information Systems
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/A92C72A81C4C0D6185256B96004D63ED?OpenDocument&Query=BApp

Reference 11: ITS Benefits – impact of variable speed limits and dynamic route advisory messages
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/B7244A72DE6C7EBA8525733A006D5EF2?OpenDocument&Query=BApp

Reference 12: ITS Benefits – Impact of Automated Speed Enforcement

http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/E3D512F0F38DD85285256B6000627E82?OpenDocument&Query=BApp

Reference 13: ITS Benefits – Impact of Advanced Regional Traffic Interactive Management and Information System
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/5D7D72890B07350B8525733A006D4B57?OpenDocument&Query=BApp

Reference 14: ITS Benefits – Impact of Advanced Traffic Management Systems
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/8DDB26FF17ED408E8525733A006D4C3B?OpenDocument&Query=BApp

Reference 15: ITS Benefits – Impact of Variable Speed Limit Systems on the M25
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/8FD5EA59EFFF390F852569610051E25B?OpenDocument&Query=BApp

Reference 16: Highway Agency – Variable Mandatory Speed Limits Enforcement National Guidance Frameworks, July 2010

Reference 17: ITS Benefits – Impact of Variable Speed Limits Signs and Lane Control Signals installed on the Autobahn in Germany
http://www.itsbenefits.its.dot.gov/its/benecost.nsf/ID/5F01DD9F62A2282C8525733A006D4BEA?OpenDocument&Query=BApp

Reference 18: Evaluating the benefits of MIDAS automatic queue protection, Steve Tucker, Highways Agency and Ian Summersgill, John Fletcher, David Mustard, TRL, tec October 2006

Double click to add Dividers

Appendix A

Levels of Operations Management

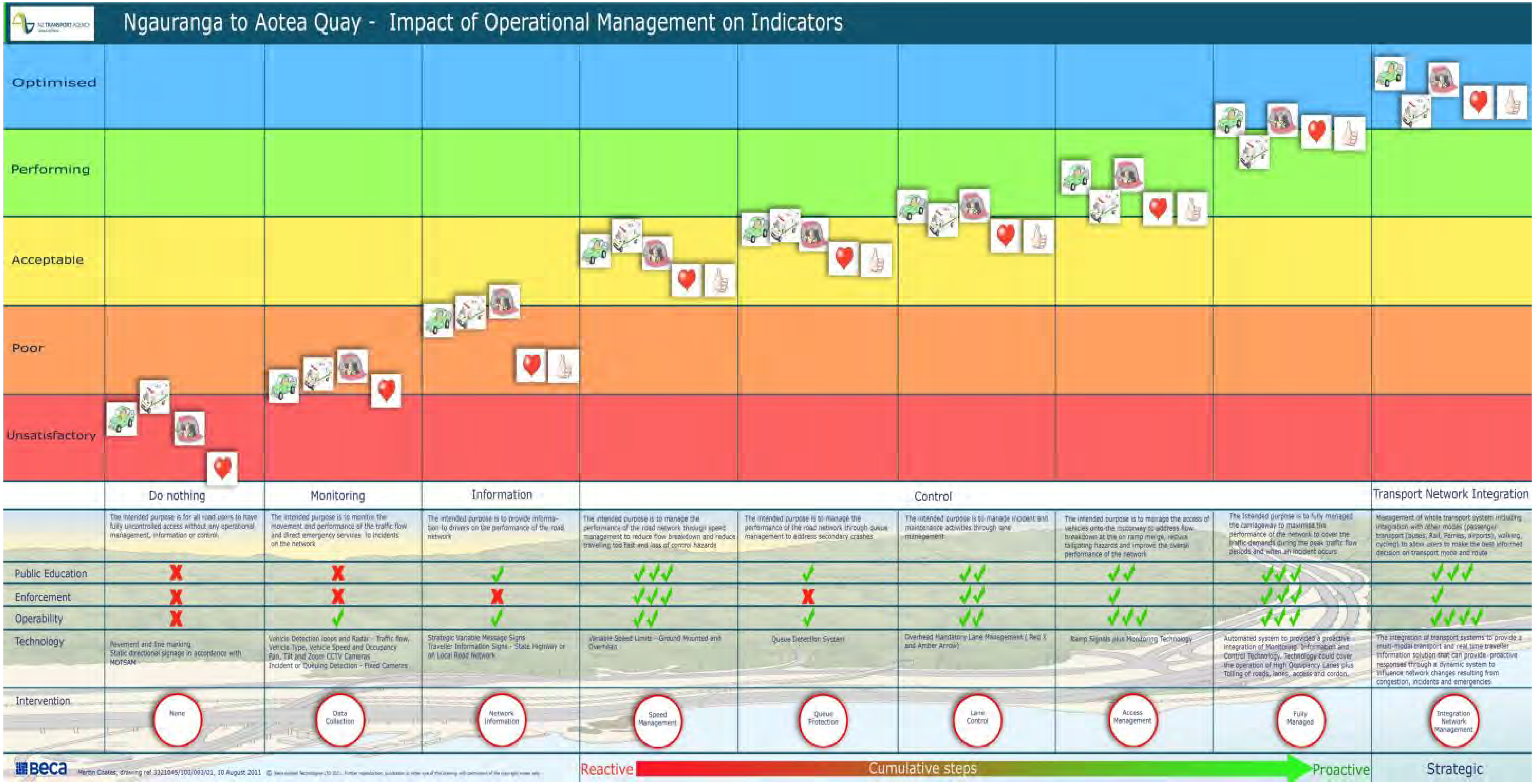
Ngauranga to Aotea Quay Wellington Operational Management Level Assessment

Operational Management						Measures					
Level of Operational Management	Interventions	Technology	Public Education	Enforcement	Operability[1]	Capacity Vehicles per Hour	Travel Time Savings	Journey Time Reliability	Impact Peak Period	Safety	Customer Satisfaction
Purpose											
Do Nothing											
The intended purpose is for all road users to have fully uncontrolled access without any operational management, information or control.	None	Pavement and line marking Static directional signage in accordance with MOTSAM	Road Opening Notice	Standard Police Enforcement	No operation required	2 Lanes: 2400 - 3800 3 Lanes: 3600 - 5700 4 Lanes: 4800 - 7600	Baseline	Can expect a very low level of journey time reliability during peak traffic and incident conditions	Baseline	Baseline	
	Research References										
Monitoring											
The intended purpose is to monitor the movement and performance of the traffic flow and direct emergency services to incidents on the network	Data Collection	Vehicle Detection loops and Radar - Traffic flow, Vehicle Type, Vehicle Speed and Occupancy Pan, Tilt and Zoom CCTV Cameras Incident or Queuing Detection - Fixed Cameras	No Education Required	Standard Police Enforcement	Operators required to watch vehicles using in CCTV, respond to incidents by actively directing emergency services those incidents. Extra staff would be required to process and analysis network date from vehcile detection devices.	2 Lanes: 2400 - 3800 3 Lanes: 3600 - 5700 4 Lanes: 4800 - 7600	Can expect no change on the baseline	Can expect a very low level of journey time reliability during peak traffic. Traffic Operators can direct emergency services more quickly to incidents so these can be removed allowing traffic flows to recover quicker. Range: 0 - 30% during incidents 29% in incident duration - Maryland, USA	Can expect no change on the baseline	It is expected that there could be a small reduction in secondary incidents	
	Research References							Reference 3	Reference 3	Reference 3	
Information											
The intended purpose is to provide information to drivers on the performance of the road network	Network Information	Strategic Variable Message Signs Traveller Information Signs - State Highway or on Local Road Network	Some level of Public Education required to inform drivers of the purpose of the signs would improve driver understanding	Standard Police Enforcement	Operators would be required to actively set messages on VMS signs to warn drivers of incident, maintenance, queues and monitor. Operators would need to monitor and analysis traveller information provided to VMS signs. Maybe a requirement for 24/7 operation to cover maintenance works and incidents depending on the size of network.	2 Lanes: 2400 - 3800 3 Lanes: 3600 - 5700 4 Lanes: 4800 - 7600	Can expect no change on the baseline	Can expect a low level of journey time reliability during peak traffic. Traffic Operators can inform/warn drivers of traffic flow condition and incidents ahead, allowing drivers act appropriately	Can expect no change on the baseline	Can be expected to reduce tailgating and change in vehicle speed hazards Range: 2- 13% reduction in injury crashes â 2.8% - Texas, USA	50% considered time saved - Arizona, USA 35-63% considered it easier to get to destination - Arizona, USA 97% of drivers were aware of the existence of VMS 62% of drivers completely understood the information presented on VMS 84% considered the information presented to be useful 46% had on at least on occasion diverted in response to the travel time
	Research References									Reference 3 and Reference 5	Reference 10 and Reference 9
Control (Reactive to Proactive)											
The intended purpose is to manage the performance of the road network through speed management to reduce flow breakdown and reduce travelling too fast and loss of control hazards	Speed Management	Variable Speed Limits - Ground Mounted and Overhead Variable Mandatory Speed Limits - Ground Mounted and Overhead		Enforcement is necessary to gain the benefits of introducing speed management	Operators would be required to watch, respond and actively implement operational management plans to set varable speed limits to manage congestion effect resulting from incidents and peak traffic flow conditions. An MOU will be required with the Police to enforce mandatary variable speed limits.	2 Lanes: 3000 - 4000 3 Lanes: 4500 - 6000 4 Lanes: 6000 - 8000 á 5-10% - UK	Can expect the average travel time may increase depending on the level of reactive to proactive control â 2% accident duration	Can expect a medium level of journey time reliability during peak traffic and incidents.	Can expect no change on the baseline â 3.2% AM/PM Peak - Kentucky/Cincinatti, USA	Can be expected to reduce tailgating, change in vehicle speed, hazardous state around driving too fast hazards Range: 10 - 30% â 25-30%, UK â 28%, Korea â 23%, Netherlands â 10-15%, UK	80% satisfied - Copenhagen, Denmark 60% of drivers believed controlled motorways in the UK had provided improvements
	Research References					Reference 1	Reference 5		Reference 13	Reference 15, Reference 12, Reference 14, and Reference 16	Reference 11 and Reference 7
The intended purpose is to manage the performance of the road network through queue management to address secondary crashes	Queue Protection	Queue Detection System		Standard Police Enforcement	Operator would only be required to watch, as these systems are usually automated interms of detecting queues and setting a response. An operator would be required to be trained to analysis the performance of the automated system and calibrate as required.	2 Lanes: 2400 - 3800 3 Lanes: 3600 - 5700 4 Lanes: 4800 - 7600	Can expect no change on the baseline	Can expect an improvement in journey time reliability during peak traffic and incidents conditions from warning drivers of queues ahead and reducing secondary crashes	Can expect no change on the baseline	Can be expected to reduce tailgating and unsafe lane changing hazards Range: 10 - 20% reduction in secondary incidents	
	Research References									Reference 5	
The intended purpose is to manage incident and maintenance activities through lane management	Lane Control	Overhead Mandatory Lane Management (Red X and Amber Arrow)		Enforcement is necessary to ensure the appropriate level of safety	Operators would be required to watch, respond and actively implement incident management plans by set lane control signs during incidents. For maintenance activities the operator would be required to liaise with the STSM when implemening temporary traffic management. There will be a need for 24 hour operation.	2 Lanes: 2400 - 3800 3 Lanes: 3600 - 5700 4 Lanes: 4800 - 7600	Can expect no change on the baseline	Can expect an improvement in journey time reliability during incidents and maintenance works.	Can expect no change on the baseline	Can be expected to reduce unsafe lane changing and merging and diverging hazards Range: 5 - 10%	
	Research References										
The intended purpose is to manage the access of vehicles onto the motorway to address flow breakdown at the on ramp merge, reduce tailgating hazards and improve the overall performance of the network	Access Management	Ramp Signals plus Monitoring Technology	A high level of Public Education is required to inform drivers on the purpose of the system, signs and how it will be operated to provide a high level of compliance at all time of operation.	Directed Police Enforcement	Operator would only be required to watch as access management system will be automated and only respond and actively control the system if queues on the local network exceed maximums. Extra staff required to monitor the operation and analysis traffic data to optimise the system settings.	2 Lanes: 3200 - 4100 3 Lanes: 4800 - 6150 4 Lanes: 6400 - 8200 á 5-30% - various countries á 10% - Minnesota, USA á 14% - Auckland NZ á 1-30% - various	Can expect to reduce average travel time during peak periods. Range: 5 - 20% â 22% travel time - Detroit (with VMS) â 22%, travel time - Minnesota, USA â 13% travel time - UK â 14% travel time - Auckland NZ	Can expect an high level of journey time reliability during peak traffic flow conditions by managing the flow of traffic onto the motorway. During incidents traffic flows can recover quicker by managing the flow upstream of the incident bottleneck. Range: 20 - 90% improvement á 91% - Auckland NZ	Can expect a reduction in peak spreading Range: 5 - 22% â 40% peak period travel time - M42, UK â 22% peak period travel time - Auckland NZ	Can be expected to reduce tailgating and unsafe lane changing hazards Range: 15 - 25% reduction in injury crashes â 21% crash reduction - Minnesota, USA â 24% crash reduction - Auckland NZ	Auckland Protest web site of 1400 respondents commented that 66% though the ramp metering system was good. Auckland Motorway Alliance customer survey: The favourable response to ramp signals seen last year was repeated with 64% of respondents answering "Yes" when asked "Taking into account the effects on the motorway and on local streets, on balance, are ramp signals a useful way to control traffic?, and 36% saying "No" – an extra year's experience does not seem to have increased or decreased acceptance
	Research References					Reference 3 and Reference 4	Reference 3 and Reference 4		Reference 6	Reference 3	Reference 8
Management (Proactive)											
The Intended purpose is to fully manage the carriageway to maximise the performance of the network to cover the traffic demands during the peak traffic flow periods and when an incident occurs	Fully Managed	Automated system to provided a proactive integration of Monitoring. Information and Control Technology. Technology would cover the operation of High Occupancy Lanes plus Tolling of roads, lanes, access and cordon.	Public Education is required to inform drivers on the purpose of the system, signs and how it will be operated to provide a high level of compliance at all time of operation.	Enforcement is necessary to gain the full benefits and required level of safety	The systems will be complex and require a high level of trained operator and analysts. Operators would be required watch, respond and actively implement part and full time peak periods operational plans as well as complex incident management plans that would use the full carriageway width to maximise capacity. 24/7 traffic operations centre would be required.	2 Lanes: 3400 - 4200 3 Lanes: 5100 - 6300 4 Lanes: 6800 - 8400 á 7% - ATM Pilot, UK	Can expect to reduce average travel time during peak periods. Range: 5 - 10% â 22% - Detroit, USA â 24% - Average journey time has improved in worst PM peak periods - UK	Can expect an high level of journey time reliability during peak traffic flow conditions with a fully managed system. Range: 20 - 90% improvement á 27% - Drivers are now better able to predict their journeys with a 27% reduction in journey time variability - UK	Can expect a reduction in peak spreading Range: 5 %	Can be expected to reduce all associated major hazards Range: 25 - 30% reduction in injury crashes â 50% - ATM Pilot, UK	Approximately 66% of drivers felt that ATM would benefit the motorway network - UK
	Research References					Reference 2	Reference 3 and Reference 2	Reference 2		Reference 2	Reference 2
Transport Network Integration (Strategic)											
Management of whole transport system including integration with other modes (passenger transport (buses, Rail, Ferries, airports), walking, cycling) to allow users to make the best informed decision on transport mode and route	Integration Network Management	The integration of transport systems to provide a multi-modal transport and real time traveller information solution that can provide proactive responses through a dynamic system to influence network changes resulting from congestion, incidents and emergencies	A continuous level of Public Education/advertising is required to inform drivers of the information provided by the system to make informed travel decisions	No addition enforcement above fully managed system above	The systems will be complex and require a high level of trained operators and analysts. Operator would be required to watch and respond and actively management the statehighway and local arterial road network. TOC staff would be required to actively provide traveller information, multi-modal services, data broker services and systems, media broadcasts, etc. 24/7 multi agency operations centre. MOU with passenger transport agencies and authorities.	2 Lanes: 3400 - 4200 3 Lanes: 5100 - 6300 4 Lanes: 6800 - 8400	Can expect to reduce average travel time during peak periods. Range: 10 - 25%	Can expect the highest level of journey time reliability during all traffic flow conditions (Peak, Incident, Weather, Civil Emergency) Range: 20 - 90% improvement	Can expect a reduction in peak spreading Range: 10 - 35%	Can be expected to reduce all associated major hazards Range: 25 - 30% reduction in injury crashes	
	Research References										

Notes
1 The level of operability is dependent on the size of the network being monitored in terms of length of network and number of cameras, traffic signals and VMS signs.

Appendix U

Impact of Operational Management on Indicators


Ngauranga to Aotea Quay - Impact of Operational Management on Indicators
Optimised
Performing
Acceptable
Poor
Unsatisfactory
Do nothing
Monitoring
Information
Control
Transport Network Integration
The intended purpose is for all road users to have fully uncontrolled access without any operational management, information or control.
The intended purpose is to monitor the movement and performance of the traffic flow and direct emergency services to incidents on the network
The intended purpose is to provide information to drivers on the performance of the road network
The intended purpose is to manage the performance of the road network through speed management to reduce flow breakdown and reduce travelling too fast and loss of control hazards
The intended purpose is to manage the performance of the road network through queue management to address secondary crashes
The intended purpose is to manage incident and maintenance activities through lane management
The intended purpose is to manage the access of vehicles onto the motorway to address flow breakdown at the on ramp merge, reduce tailgating hazards and improve the overall performance of the network
The Intended purpose is to fully managed the carriageway to maximise the performance of the network to cover the traffic demands during the peak traffic flow periods and when an incident occurs
Management of whole transport system including integration with other modes (passenger transport (buses, Rail, Ferries, airports), walking, cycling) to allow users to make the best informed decision on transport mode and route
Public Education
Enforcement
Operability
Technology
Pavement and line marking
Static directional signage in accordance with MOTSAM
Vehicle Detection loops and Radar - Traffic flow, Vehicle Type, Vehicle Speed and Occupancy
Pan, Tilt and Zoom CCTV Cameras
Incident or Queuing Detection - Fixed Cameras
Strategic Variable Message Signs
Traveller Information Signs - State Highway or on Local Road Network
Variable Speed Limits - Ground Mounted and Overhead
Queue Detection System
Overhead Mandatory Lane Management (Red X and Amber Arrow)
Ramp Signals plus Monitoring Technology
Automated system to provided a proactive integration of Monitoring, Information and Control Technology. Technology could cover the operation of High Occupancy Lanes plus Tolling of roads, lanes, access and cordon.
The integration of transport systems to provide a multi-modal transport and real time traveller information solution that can provide proactive responses through a dynamic system to influence network changes resulting from congestion, incidents and emergencies
Intervention
None
Data Collection
Network Information
Speed Management
Queue Protection
Lane Control
Access Management
Fully Managed
Integration Network Management
Beca
Reactive
Cumulative steps
Proactive
Strategic