VicRoads

Western Highway Project – Section 3: Ararat to Stawell

Noise and Vibration Impact Assessment Report

November 2012

This Noise and Vibration Assessment Report *("Report"):*

1. *Has been prepared by GHD Pty Ltd ("GHD") for VicRoads;*
2. *May only be used for the purpose of informing the Environment Effects Statement and Planning Scheme Amendment for the Western Highway Project (and must not be used for any other purpose); and*
3. *May be provided to the Department of Planning and Community Development for the purpose of public exhibition as part of the Environment Effects Statement and Planning Scheme Amendment for the Western Highway Project.*

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in Section 4. 'Methods' in this Report.

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), as specified in Section 4. 'Methods' and throughout this Report.

GHD excludes liability for errors in, or omissions from, this Report arising from or in connection with any of the assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation. GHD has not, and accepts no responsibility or obligation to update this Report to account for events or changes occurring subsequent to the date that the Report was signed.

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Executive Summary

VicRoads is progressively upgrading the Western Highway as a four-lane divided highway between Ballarat and Stawell (Western Highway Project). The Western Highway Project consists of three sections, to be constructed in stages. Section 3 (Ararat to Stawell) of the Western Highway Project (the Project) is the subject of this report.

On 27 October 2010, the Victorian Minister for Planning advised that an Environment Effects Statement (EES) would be required to identify the anticipated environmental effects of the Project. GHD has been commissioned by VicRoads to undertake a noise and vibration impact assessment for Section 3 of the Project as part of the EES.

Following a multi-criteria assessment of numerous potential alignment options, VicRoads selected a single alignment for the Project (the Alignment or Alignment Option) which was subject to the risk and impact assessment presented in this report. The Alignment Option is outlined in Section 6.1 of this report.

The purpose of this Report is to assess the proposed alignment against the scenario of leaving the existing highway unchanged with regards to operational and construction noise and vibration impacts.

This report, together with other technical reports prepared by GHD and other consultants as part of the EES, will inform VicRoads' of the suitability of the proposed alignment and its impacts.

The EES scoping requirements for the noise and vibration impacts assessment of the Project are detailed in Section 2 of this report. In summary, the following is required:

- The ambient noise environment to be characterised and sensitive receivers identified;
- Identification and assessment of the potential for increased noise levels during construction and operation from all project-related sources at different periods during the day; and
- Identification of management and mitigation measures to ensure the Project will comply with applicable policies.

The impact assessment undertaken by GHD involved an assessment of construction and subsequent operational noise and vibration impacts from the Project and any mitigation requirements necessary to help minimise any potential impacts to ensure the Project would comply with applicable policy.

In summary, the assessment identified the following eight potential impact and risk pathways from the construction stage of the Project as well as its subsequent operation:

- Daytime construction noise impacts at an individual sensitive receiver;
- Daytime construction noise impacts near a group of sensitive receivers;
- Evening construction noise impacts (6 pm – 10 pm);
- Night construction noise impacts (10 pm – 7 am);
- Site compound noise impacts during construction;
- Vibration impacts during construction;

- Highway operation noise impacts where the *VicRoads Traffic Noise Reduction Policy 2005* applies; and
- Highway operation noise impacts where *VicRoads Traffic Noise Reduction Policy 2005* does not apply.

Overall, the proposed alignment reduces noise levels at the majority of sensitive receivers (dwellings) in the Great Western township by moving the existing road alignment further away from houses. Slightly more dwellings would experience a clearly noticeable noise reduction of 5 dB(A) or more in 2026, than a clearly noticeable increase in noise levels of 5 dB(A) or more in 2026 due to the proposed alignment. However, in the absence of mitigation nine houses would experience a doubling (an increase of 10 dB(A) or more) in noise levels compared to a do nothing scenario. In areas where impacts are unavoidable, suitable mitigation measures can be incorporated to reduce the risks to acceptable levels.

The proposed alignment also has relatively few (14) houses within 50-60 m of the construction zone minimising the number of buildings potentially impacted by vibration.

Glossary of Terms

Abbreviation	Definition
AWS	Automatic Weather Station
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dB(A)	'A-weighted' decibel measurement. Developed in the 1930s as a way to represent the sound frequency sensitivity of the human ear. Frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.
$L_{Aeq\ (Time)}$	Equivalent sound pressure level is the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring. This is considered to represent ambient noise.
$L_{A90\ (Time)}$	The A-weighted sound pressure level that is exceeded for 90 percent of the time over which a given sound is measured. This is considered to represent the background noise.
$L_{A10\ (Time)}$	The arithmetic average of the sound pressure level that is exceeded for 10 percent of the time specified. This is considered representative of the average maximum noise
$L_{A10\ (18\ hr)}$	The arithmetic average of the L_{A10} levels for the 18-hour period between 6am and midnight
$L_{A10\ (12\ hr)}$	The arithmetic average of the L_{A10} levels for the 12-hour period between 6am and 6pm
$L_{Aeq\ (16\ hr)}$	The L_{Aeq} noise level for the period 6 am to 10 pm. (Day and Evening)
$L_{Aeq\ (15\ hr)}$	The L_{Aeq} noise level for the period 7 am to 10 pm. (Day and Evening)
$L_{Aeq\ (9\ hr)}$	The L_{Aeq} noise level for the period 10 pm to 7 am. (Night).
$L_{Aeq\ (8\ hr)}$	The L_{Aeq} noise level for the period 10 pm to 6 am. (Night).
PFI	Persistent Feature Identifier
Peak Particle Velocity	This is the current practice for assessments of the risk of structural damage to buildings using measurements of Peak Particle Velocity (PPV) ground vibration which is the maximum sum of three vectors.
PONL	Project Objective Noise Level
RTN	Road Traffic Noise.

Abbreviation	Definition
Sensitive Receiver/Receptor	A sensitive receiver/receptor can be defined as any dwelling; caretakers house; library; educational institution; childcare centre; kindergarten; hospital; surgery or other medical institution including an institutional home; commercial and/or retail activity (such as any, hotel, motel, caravan park or tourist establishment).
Sound Pressure Level (SPL)	The Sound Pressure level is the change in air pressure above and below the average atmospheric pressure (amplitude) cause by a passing pressure wave (20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level of 20 micropascals); this is then converted to decibels and can be abbreviated as SPL or L_p The SPL can be calculated as: $$SPL\ or\ Lp = 10\ Log_{10}\left(P^2 / P_0^2 \right)\ [dB]$$ or more simply $$SPL\ or\ Lp = 20\ Log_{10}\ P + 94\ \ [dB]$$ Where: SPL or L_p = Sound Pressure Level P = Root-mean-square (rms) sound pressure (Pascals or Pa) P_0 = International reference pressure 20 micropascals.
Sound Power Level (PWL)	This is defined as the average rate at which sound energy is radiated from a sound source and is measured in watts (W). The Sound Power Level can be abbreviated as PWL or L_w. The PWL can be calculated as: $$PWL\ or\ Lw = 10\ Log_{10}\left(W / W_0 \right)\ \ [dB]$$ or more simply $$PWL\ or\ Lw = 10\ Log_{10}(W) + 120\ \ [dB]$$ Where: PWL or L_w = Sound Power Level W = acoustic energy of the source given in watts (W) W_0 = International reference sound power of 10^{-12} Watt (W)
Vibration	The variation in magnitude of a quantity which describes the motion or position of a mechanical system, when the magnitude is alternately greater and smaller than some average value or reference.

Abbreviation	Definition
The Project	The Project can be defined as the duplication of the existing Western Highway commencing at Pollard Lane, Ararat and extends for approximately 24 km to Gilchrist Road, Stawell. The Project provides two lanes in each direction and associated intersection upgrades to improve road safety, and facilitate the efficient movement of traffic.
Project Area	The project area encompasses a corridor extending generally up to 1500 m either side (east and west) of the edge of the road reserve, except around Great Western where the project area extends up to 1800 m (encompassing the extent of new alignment possibilities).
Study area	The study area for the noise assessment is the same as the Project area and is approximately 24 km long, commencing at Pollard Lane, Ararat and finishing at Gilchrist Road, Stawell and extends outward to the east and west to the centreline, see Figure 1 and Figure 2
Section 3	The Western Highway (A8) is being progressively upgraded as a four-lane divided highway for approximately 110 km between Ballarat and Stawell and consists of three stages, illustrated in Figure 1: • Section 1: Ballarat to Beaufort • Section 2: Beaufort to Ararat • Section 3: Ararat to Stawell Section 3 (Ararat to Stawell) of the Western Highway Project (Project) is the subject of this report.
Alignment	The proposed alignment commences from Ararat, the existing carriageway is duplicated to the east, crossing the railway via a new bridge adjacent to the existing Armstrong Deviation Bridge. A new dual carriage highway provides for a north-eastern bypass of Great Western, commencing near Delahoy Road and passing through part of the former Great Western landfill and a quarry, meeting the existing highway alignment again near Briggs Lane. The existing carriageway is duplicated to the west until Hurst Road. Oddfellows Bridge at Harvey Lane would be upgraded to accommodate one carriageway crossing of the railway, and a second bridge would be constructed for the other carriageway further west. Overall, the proposed alignment involves two crossings of the Melbourne to Adelaide railway, eight crossings of major waterways and 26 minor waterways (tributaries, drainage lines and irrigation channels), and bypasses of both Armstrong and Great Western townships.

1. Introduction

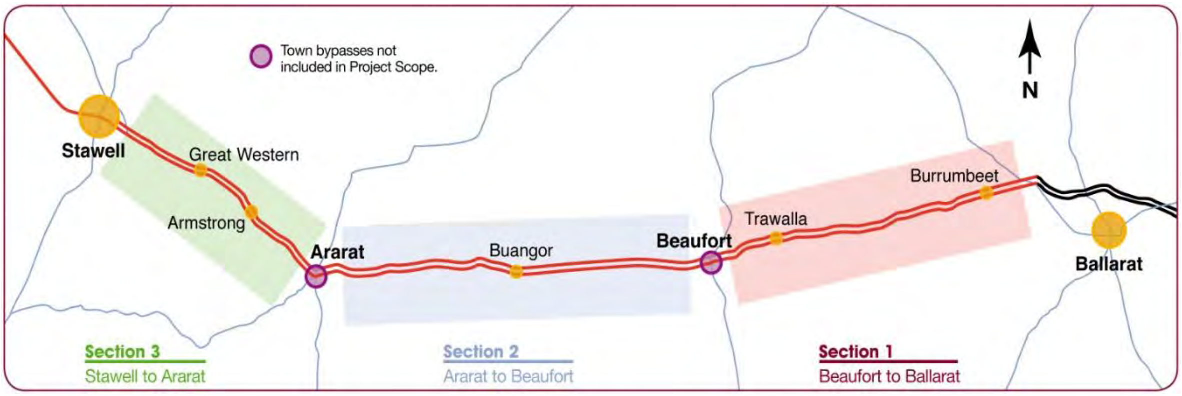
1.1 Background

The Western Highway (A8) is being progressively upgraded as a four-lane divided highway for approximately 110 kilometres (km) between Ballarat and Stawell. As the principal road link between Melbourne and Adelaide, the Western Highway serves interstate trade between Victoria and South Australia and is the key corridor through Victoria's west, supporting farming, grain production, tourism and a range of manufacturing and service activities. Currently, more than 5500 vehicles travel on the highway west of Ballarat each day, including 1500 trucks.

The Western Highway Project (here within described as 'the Project') consists of three stages:

- Section 1: Ballarat to Beaufort
- Section 2: Beaufort to Ararat
- Section 3: Ararat to Stawell

Figure 1 The Western Highway Project



Works on an initial 8 km section between Ballarat and Burrumbeet (Section 1A) commenced in April 2010 and will be completed in 2012. Construction for Section 1B (Burrumbeet to Beaufort-Carngham Road) commenced in early 2012 and is expected to be completed by June 2014. The last 3 km section from Beaufort-Carngham Road to Smiths Lane in Beaufort (Section 1C) commenced in late 2011 and will finish in 2012. Separate Environment Effects Statements (EESs) and Planning Scheme Amendments (PSAs) must be prepared for both Sections 2 and 3. It is expected that Sections 2 and 3 will be completed and opened in stages through to 2016, subject to future funding.

Section 2 of the Project commences immediately west of the railway crossing (near Old Shirley Road) west of the Beaufort township and extends for a distance of approximately 38 km to Heath Street, Ararat.

Section 3 of the Project commences at Pollard Lane, Ararat and extends for approximately 24 km to Gilchrist Road, Stawell.

The EES will focus on assessment of the proposed ultimate upgrade of the Western Highway between Beaufort and Stawell to a freeway standard complying with the road category 1 of VicRoads Access Management Policy (AMP1). The project includes a duplicated road to allow for two lanes in each direction separated by a central median.

The EES has also considered a proposed interim upgrade of the Western Highway to a duplicated highway standard complying with the VicRoads Access Management Policy AMP3. When required, the final stage of the project is proposed to be an upgrade to freeway standard complying with AMP1.

The proposed interim stage of the Project (AMP3) would provide upgraded dual carriageways with wide median treatments at key intersections. Ultimately, the Western Highway is proposed to be a freeway (AMP1) where key intersections would be grade separated, service roads constructed and there would be no direct access to the highway.

To date $505 million has been committed for the Western Highway Project by the Victorian Government and the Australian Government as part of the Nation Building Program.

Highway improvements for the three sections between Ballarat and Stawell will involve:

- Constructing two new traffic lanes adjacent to the existing highway, separated by a central median.
- Converting the existing highway carriageway to carry two traffic lanes in one direction.
- Constructing sections of a new four-lane divided highway on a new alignment.

In addition to separating the traffic lanes, highway safety would be improved with sealed road shoulders, safety barriers, protected turning lanes, intersection improvements, and service lanes for local access at some locations.

Town bypasses of Beaufort and Ararat are not included in the current proposals. Beyond Stawell to the Victorian border, ongoing Western Highway improvements would continue with shoulder sealing works, new passing lanes and road surface improvements.

The aims/objectives of this Project are to:

- Provide safer conditions for all road users by:
  - Reducing the incidence of head-on and run-off-road crashes;
  - Improving safety at intersections; and
  - Improving safety of access to adjoining properties.
- Improve efficiency of freight by designing for High Productivity Freight Vehicles.
- Provide adequate and improved rest areas.
- Locate alignment to allow for possible future bypasses of Beaufort and Ararat.

1.2 Project and Study Areas

1.2.1 Project Area

The project area was defined for the purposes of characterising the existing conditions for the Project, and to consider alignment alternatives. The project area encompasses a corridor extending generally up to 1500 metres (m) either side (east and west) of the edge of the road reserve, except around Great Western where the project area extends up to 1800 m (encompassing the extent of new alignment possibilities).

1.2.2 Study Area

The study area for the noise and vibration impact assessment is the same as the Project area and is approximately 24 km long, commencing at Pollard Lane, Ararat and finishing at Gilchrist Road, Stawell and extends outward to the east and west to the centreline as described in Section 1.2.1, see Figure 1 and Figure 2.

1.2.3 Proposed Alignment

A multi-criteria assessment of alignment options was conducted based on information from the existing conditions assessments. The outcome was the selection of a proposed alignment for further consideration in the EES for Section 3. The proposed alignment and associated construction corridor are the subject of the risk and impact assessment presented in this report and are described in more detail in Section 6. The assessment of alignment options and selection of the proposed alignment is documented in Chapter 5 of the EES, and in the Options Assessment report (Technical Appendix to the EES).

1.3 The Assessment

The scope of the assessment responds to the EES scoping requirements set out in Section 2 of this Report, is informed by consideration of the existing conditions and applies a methodology for risk and impact assessment as detailed later in this Report. The whole of the Project area was assessed, including a long list of options. The existing conditions assessment is set out in Sections 4.1 and 5 of this report. The existing conditions assessment informed the ultimate selection of an “alignment option". The alignment was then subject to the risk and impact assessment outlined in Sections 4.2 and 6 of this Report.

2. EES Scoping Requirements

The EES draft evaluation objectives and EES scoping requirements for the noise and vibration impact assessment are outlined below.

2.1 EES Objectives

For the noise and vibration aspects of the Western Highway Project, the relevant draft evaluation objectives outlined in the EES Scoping Requirements are:

- To minimise air emissions, noise, visual, landscape and other adverse amenity effects, during the construction and operation of the proposed duplicated highway to the extent practicable; and
- To avoid or minimise disruption and other adverse effects on infrastructure, land use (including agriculture) and households, as well as road users resulting from the construction and operation of the highway duplication.

2.2 EES Scoping Requirements

The EES scoping requirements for the noise and vibration aspects are as follows:

- Characterise the ambient noise environment and identify sensitive receptors in the project area;
- Identify and assess the potential for the project to increase noise levels at sensitive receptors during construction and operation. The assessment should include an estimation of noise from all project-related sources and at different periods during the day, to establish likely noise levels to be experienced at sensitive receptors; and
- Identify proposed design and management measures to avoid, mitigate and manage any potential noise effects on sensitive receptors during construction and subsequently, to ensure the project would comply with applicable policy.

This assessment is to be in the context of current government policy and practicable noise mitigation options, with respect to road management and environment protection.

3. Legislation, Policy and Guidelines

3.1 Construction Noise and Vibration

In assessing the noise and vibration impacts of road construction, the following standards, and guidelines are of significance;

- EPA - Noise Control Guidelines Publication 1254, 2008;
- EPA – Environmental Guidelines For Major Construction Sites Publication 480,1996;
- VicRoads – Noise Guidelines – Construction and Maintenance Works 2007;
- Australian Standard – AS 2436:2010 – Guide to noise and vibration control on construction, demolition and maintenance sites;
- British Standard – BS 5228.2:2009 – Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration;
- British Standard – BS 6472 – 2008, Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting;
- German Standard DIN 4150-3:1999 Structural Vibration – Part 3: Effects of vibration on structures; and
- NSW RTA Environmental Noise Management Manual (ENMM) 2001.

3.1.1 Commonwealth

Construction Noise

There is currently no Commonwealth policy or Act relating to construction noise assessment that is relevant to the Project.

Construction Vibration

The British Standard (BS) 6472 – 2008, *Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting* (BS 6472) is commonly recognised across Australia as the preferred standard for assessing 'human comfort'.

Australian standard 2670.1-2001 (ISO 2631-1:1997), *Evaluation of human exposure to whole body vibration, Part 1: General requirements* gives further guidance on whole-body vibration evaluation methods and possible health effects but does not contain vibration exposure limits (Standards Australia, 2001).

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance limiting vibration is attained by reference to German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures* (Standards Deutch, 1999).

3.1.2 State

Construction Noise

EPA Noise Control Guidelines 2008 provide a schedule of working hours and noise limits for construction sites. These are broken up into normal working hours, weekend/evening work hours and the night period and are presented in Table 1.

Table 1 Construction work hours (Environment Protection Authority (EPA), 2008)

Time	Work Hours	Noise Limit
Normal Working Hours	7 am to 6 pm Monday to Friday 7 am to 1 pm Saturdays	There are no limiting noise criteria for the daytime period, however there is still a duty to minimise noise impacts on the surrounding environment.
Weekend Work Hours and Evening Work Hours	6 pm to 10 pm Monday to Friday 1 pm to 10 pm Saturdays 7 am to 10 pm Sundays and Public Holidays	Noise level at any residential premises not to exceed background noise by: • 10 dB(A) or more for up to 18 months after Project construction commencement; and • 5 dB(A) or more after 18 months.
Night Period	10 pm to 7 am Monday to Sunday	Noise inaudible within a habitable room of any residential premises

The EPA Publication 1254, 2008 makes an allowance for unavoidable construction works through the night provided that residents are notified of the intended work, its duration and times of occurrence. The EPA Publication 1254, 2008 and Publication 480, 1996 provides mitigation measures that need to be considered.

Construction Vibration

Construction vibration can be separated into two major subgroups:

- Vibration effects on human comfort; and
- Vibration effects on structural integrity of buildings and infrastructure.

These groups are described in more detail below.

Human Comfort Vibration Criteria

The *British Standard BS 6472 – 2008,* human comfort peak vibration dose value ranges for daytime and night time periods are shown in Table 2. The intermittent vibration dose values are generally applicable to most construction works. *BS 6472 – 2008* provides indicator values whereby no comment would be made by the occupants of the building, values for when a comment may be possible, and values for when an adverse comment is likely to be made.

*BS 5228.2 – 2009, Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration (*BS 5228.2) recommends that the guidance values presented in Table 3 are more appropriate for construction works as it is easier to assess the intermittent vibration criteria against a peak value rather than a dose value. *BS 5228.2 – 2009* also recognises that higher vibration levels are tolerable for short-term construction projects as undue restriction on vibration levels can substantially prolong construction works and result in greater annoyance.

Table 2 Vibration dose value ranges and probabilities for adverse comment within residential buildings ($m/s^{1.75}$) (Standards United Kingdom, 2008)

Location	Low probability of adverse comment [1]	Adverse comment possible	Adverse comment probable [2]
Residential buildings 16 hour day (0700 – 2300 hrs)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night (2300 to 0700 hrs)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

1. Below these ranges adverse comment is not expected.
2. Above these ranges adverse comment is very likely.

* m/s: metres per second

Table 3 Guidance on effects of vibration levels (Standards United Kingdom, 2009)

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.30 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments would cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

***** mm/s: millimetres per second

Structural Damage Vibration Criteria

Currently, there is no Australian Standard that set the criteria for the assessment of building damage caused by vibration. Guidance limiting vibration is attained by reference to the German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures* (Standards Deutch, 1999)

Table 8 of *DIN 4150-3: 1999* presents guideline values for the maximum absolute value of the velocity *"…at the foundation of various types of building. Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible*."

Measured values exceeding those listed in Table 4 *"…does not necessarily lead to damage; should they be significantly exceeded, however further investigations are necessary."*

Table 4 Guideline values for short term vibration on structures (Standards Deutch, 1999)

Line	Type of Structure	Guideline Values for Velocity, (mm/s)		
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[a]
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design.	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10

[a] Where frequencies are above 100 Hz the values given in this column may be used as minimum values.

3.2 Road Traffic Noise

In assessing the noise impacts of road developments, the following legislation, standards, and guidelines are of significance:

- *Environment Protection Act (1970);*
- *Transport Integration Act (2010);*
- VicRoads – Traffic Noise Reduction Policy, February 2005;
- VicRoads – Interpretation and Application of VicRoads Traffic Noise Reduction Policy 2005;
- VicRoads – Traffic Noise Measurement Requirements for Acoustic Consultants, November 2005; and
- Australian Standard – AS 2702-1984: Acoustics-Methods for the Measurement of Road Traffic Noise;

3.2.1 Commonwealth

There is currently no Commonwealth policy or Act relating to operational road traffic noise or vibration assessment that is relevant to the Project.

3.2.2 State

Environment Protection Act (1970) - Victoria

The *Environment Protection Act 1970* (EP Act) defines the environment as:

"*…the physical factors of the surroundings of human beings including the land, water, atmosphere, climate, sound, odours, tastes, the biological factors of animals and plants and the social factor of aesthetics."*

The EP Act 1970 sets out a structure for the protection of the Victorian environment. Part 3, Section 16, of the EP Act 1970 gives authority to the Governor in Council to create State Environment Protection

Policies (SEPP's) to be *"observed with respect to the environment generally or in any portion or portions of Victoria or with respect to any element or elements or segment or segments of the environment".*

Transport Integration Act (2010)

The *Transport Integration Act 2010* sets out a vision, objectives and principles for transport in Victoria. It makes clear that the transport system needs to be integrated and sustainable - in economic terms, in environmental terms and in social terms. It requires all Victorian transport agencies to work together towards the common goal of an integrated and sustainable transport system.

Part 2 of the Act includes a vision statement, objectives, principles and a statement of policy and principles. Part 2, Division 2, Section 10 of the Act outlines the transport objectives with regard to environmental sustainability, these are:

"The transport system should actively contribute to environmental sustainability by:

(a) protecting, conserving and improving the natural environment;

(b) avoiding, minimising and offsetting harm to the local and global environment, including through transport-related emissions and pollutants and the loss of biodiversity;

(c) promoting forms of transport and the use of forms of energy and transport technologies which have the least impact on the natural environment;

(d) improving the environmental performance of all forms of transport and the forms of energy used in transport."

VicRoads – Road Traffic Noise Reduction Policy (2005)

There is currently no State Environment Protection Policy (SEPP) for road traffic noise along State-controlled roads within Victoria. Instead, traffic noise along these roads is controlled using the VicRoads – Traffic Noise Reduction Policy 2005. The policy seeks to regulate noise levels on existing roads and also where a new alignment is built.

New Alignment and Corridor Expansion Works

The VicRoads – Traffic Noise Reduction Policy seeks to limit noise at sites where arterial roads and freeways are built on new alignments or existing networks are widened as follows (VicRoads, 2005):

- Category A – For residential dwellings, aged person homes, hospitals, motels, caravan parks and other buildings of a residential nature, the noise level objective would be 63 dB(A) $L_{A10\ (18hr)}$. measured between 6 am and midnight;
- Category B – For schools, kindergartens, libraries and other noise sensitive community buildings, the noise level objective would be 63 dB(A) $L_{A10\ (12hr)}$ measured between 6 am and 6 pm; and
- Where the noise level adjacent to Category A or B buildings prior to road improvements is less than 50 dB(A) $L_{A10\ (18hr)}$,consideration would be given to limiting the noise level increase to 12 dB(A). If the decision is made not to do this, the reasons would be documented.

Existing Road Corridor Works (Retrofitting)

The Traffic Noise Reduction Policy (VicRoads, 2005) seeks to mitigate noise at sites where arterial roads and freeways exceed a 68 dB(A) $L_{A10\ (18hr)}$ trigger level. Mitigation is achieved by retrofitting barriers, bridge parapets, crash barriers, and upgrading of road surfaces in order to attenuate the noise levels to a level below 68 dB(A) $L_{A10\ (18hr)}$ (VicRoads, 2005). The 68 dB(A) trigger level is an 18 hour 'A' weighted arithmetic average from the hours of 6 am to midnight and only applies to Category A and B buildings (see Section 3.2.2). Exceptions to mitigation works around Category A and B buildings apply where land use or ownership has been defined as being a 'non-conforming use'. Other exceptions relate to new buildings or subdivisions being built around existing State controlled roads, planning schemes for new roads, or existing road widening's, and where planning approval was obtained after the commencement of the 'exhibition period' to set aside land for future road developments (VicRoads, 2005).

This Project would be exempt from the retrofitting program as the existing road was built prior to 1979 (VicRoads, 2010).

Application of the VicRoads – Traffic Noise Reduction Policy to the Project

The *VicRoads Traffic Noise Reduction Policy* - 63 dB(A) criterion would apply to areas classified as 'new alignment' due to two or more lanes of the new alignment extending out beyond the current road reserve boundary and buildings previously protected from traffic noise being exposed due to the removal of other buildings to make room for the new alignment. All areas classified as a new alignment are listed below with their related chainage (Ch.) values. Other areas either side of these listed sections are not classed as a new alignment under the policy and have been excluded.

Areas of the Proposed Alignment where the Policy would Apply

- Ch. 11700 to 16200 - 400 m northwest of Delahoy Road through to 45 m northwest of Robinsons Creek near St George Road (bypass of Great Western township); and
- Ch. 23100 to 23900 - 160 m northwest of London Road through to adjacent Robson Road.

Section 2.4 of the *VicRoads' Interpretation and Application of VicRoads Traffic Noise Reduction Policy 2005* (RDN06-01) states that: *if the additional noise level from the new alignment section of the road at a residence is above 63 dB(A) or the level that would have prevailed if the new alignment had not been built, then the VicRoads Policy applies and the noise attenuation should be considered for this property*.

In summary, there are two areas where the policy applies, Ch. 11700 to 16200 and . 23100 to 23900. These two areas of the proposed new alignment are the only areas where two or more lanes of the new alignment extend out beyond the current road reserve boundary. These are also the only areas where noise emissions from the alignment would cause the policy to be "triggered" if the 63 dB(A) criteria is exceeded or the greater than 12 dB(A) criteria are exceeded for houses less than 50 dB(A) prior to road improvements. When an exceedance of any of these criteria occurs, then under the policy VicRoads would then need to consider mitigation. Noise levels at all houses would need to be assessed to see if those areas where the policy applies are causing an exceedance (triggering) of the criteria to determine if mitigation is required.

4. Methods

4.1 Existing Conditions Assessment

Both unattended and attended noise measurements were carried out at six locations along Section 3 (Ararat to Stawell) in order to ascertain what the existing noise levels were along this section of the highway. Four of the loggers were placed at residential locations as close as possible to the existing Western Highway in order to capture current traffic noise for calibration purposes. Two additional locations were chosen based on their amenity value. Amenity value with regard to this noise study was defined as sites that were a significant distance from the existing highway but may be affected by the proposed duplication running close to the property. Amenity site data describes more closely the true background noise of the Project area, excluding or minimising traffic noise.

The purpose of the existing conditions assessment is to define the climate and general weather patterns for the Project and to characterise the existing ambient noise levels in the area. In order to achieve this, attended and unattended noise measurements were taken and local meteorology recorded to assess the climate and weather patterns. Information collected was then used for calibrating noise models. Data measured during the adverse conditions was excluded. The predicted noise and vibration impacts of the proposed alignment were then determined using this information and existing and future predicted traffic flows.

Sections 4.1.1 to 4.1.5 describe how existing conditions were quantified and what general assumptions were made.

4.1.1 Noise Monitoring

Noise measurements at the six separate locations were undertaken with consideration given to AS2702:1984 – *Acoustics – Methods for the Measurement of Road Traffic Noise*. A summary of the noise measurement methodology for each location is provided below:

- Seven days of unattended noise logging was carried out, and a subset selected for analysis based on meteorological conditions;
- A set of 15 minute attended noise measurements were carried out at each site during deployment of the logger instruments;
- Noise measurements were undertaken with logger microphones 1 m from the representative building façades (where possible) and 1.5 m above the ground surface (Standards Australia, 1984) (VicRoads, 2005).
- The noise measurements excluded noise from extraneous noise sources, for example construction noise, chainsaw and lawn mower operations, as well as other unexplained erroneous peaks in noise charts and L_{eq} values;
- The rainfall and wind speed during the period of noise measurements was measured locally at Amenity Site 1 using a Davis 'Precision Weather Station – Vantage Vue' and checked against the Bureau of Meteorology (BOM) site at Stawell;
- Average 15 minute wind speeds greater than 3 m/s at the logger microphone, or average rainfall greater than 0.3 mm/hr were both defined as "adverse weather" conditions. Noise data collected during hours with adverse weather were discarded and replaced with interpolated data; and

- Noise measurements used in analysis were conducted during normal traffic flow conditions i.e. on weekdays and outside school holiday periods and public holidays.

The $L_{A10\ (18\ hr)}$, $L_{eq\ (15\ hr)}$, $L_{eq\ (16\ hr)}$, $L_{eq\ (8\ hr)}$, $L_{eq\ (9\ hr)}$ noise level descriptors were processed for each hourly time interval over the logging period. All values were taken from three of the seven days in the monitoring period (consecutive days), excluding weekends and days of adverse weather or atypical conditions.

4.1.2 Instrumentation and Quality Control

All noise monitoring instruments were in current National Association of Testing Authorities (NATA) calibration at the time of use. All instruments were field-checked and calibrated both before and after noise measurements were undertaken. No discrepancies in excess of 1 dB were noted throughout the monitoring exercise as is required under Section 5.1.7 of the Australian Standard AS 2702:1984. Logger details and pre and post calibrations are shown in Appendix A.

4.1.3 Monitoring Locations

A total of six noise monitoring locations along the Western Highway - Section 3 were chosen as representative of the Project. Locations were chosen based on proximity to the highway, ease of access, absence of extraneous noise from other sources such as transformers, usefulness as a model calibration site or amenity value site, and property owner co-operation.

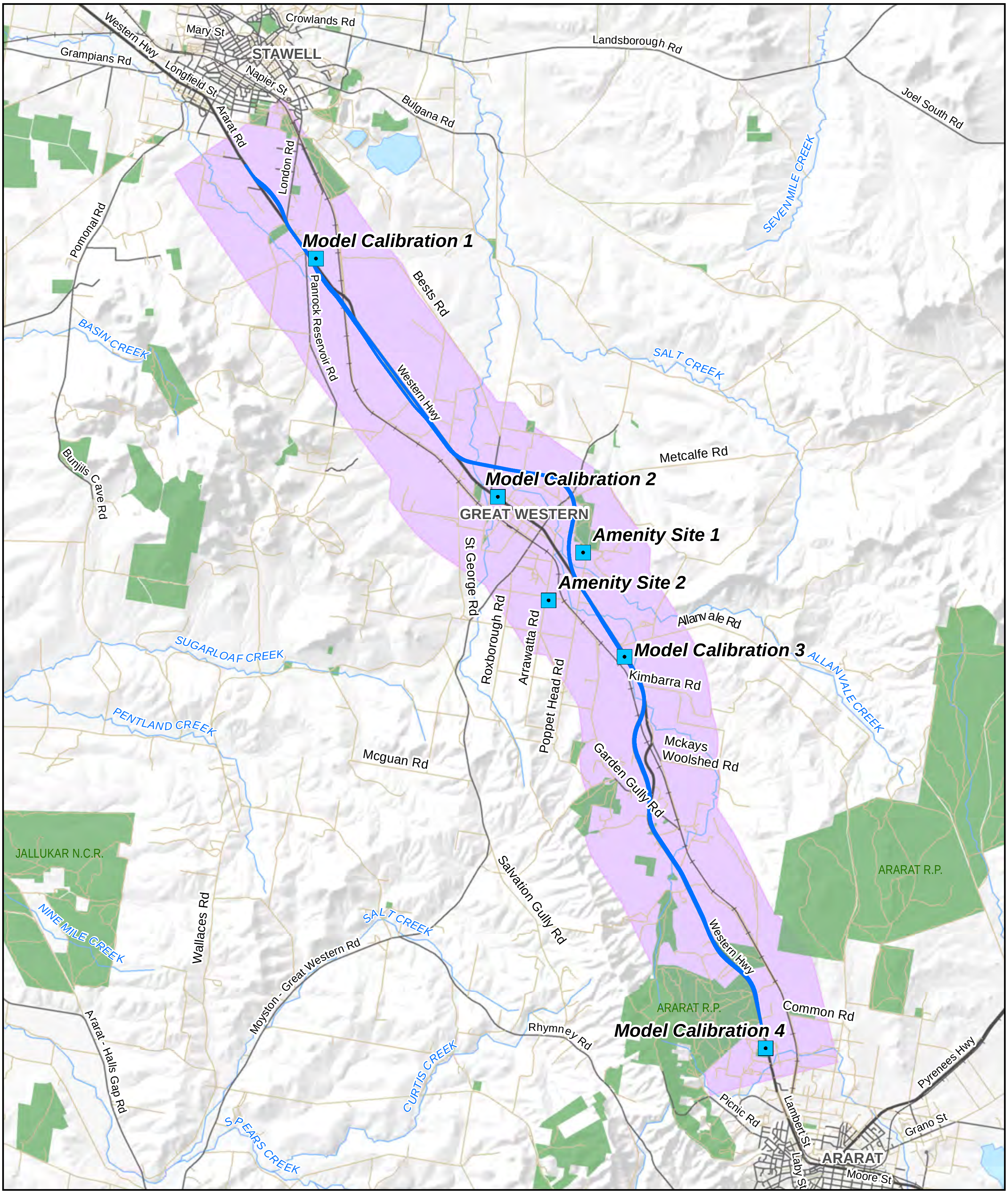
Values at amenity sites were not used for model calibration due to their large distances from the road and increased topography effects. Amenity sites were more about establishing background noise levels set back from the existing highway and were not designed for calibration purposes.

All six logger sites used for measurement of existing conditions were in Category A (residential) locations. While no measurement sites were located in Category B locations, a school (Great Western Primary School) was noted in the township of Great Western on Stephenson Street, and would be of interest as a sensitive receiver. Hence, both 63 dB(A) $L_{A10\ (12hr)}$ and 63 dB(A) $L_{A10\ (18hr)}$ values are relevant in this study. No logger was placed at the Great Western Primary School in order to prevent extraneous noise from students and school activities affecting the measurement. However, the model calibration logger at Site 2 was located approximately 700 m northwest of the primary school and so would give good indication of the traffic noise levels in this area in the predictive model. The closest school to the proposed alignment near Ararat is the Ararat West Primary School and the closest school in Stawell to the proposed alignment is the Marrang Kindergarten. Both of these educational institutes were outside the study area and are not expected to be significantly affected by the Project. A library search along the Project found Stawell Library on Sloane Street, Stawell and Ararat Regional Library on Barkly Street, Ararat, however both of these were outside the study area and are not expected to be significantly affected by the Project.

A summary of the six noise monitoring locations is presented in Table 5 and as a map in Figure 2. Photographs of the individual sites are presented in and Appendix B which shows the positions of the survey sites and their proximity to the highway.

Table 5 Noise monitoring locations

Site	Location	GPS Coordinates	Distance to Highway	Microphone Position
Model Calibration Site 1	2460 Western Highway, Stawell,	E 0659655 N 5892727	85 m	3 m from façade 1.5 above ground
Model Calibration Site 2	9-11 Main Street, Great Western	E 0663809 N 5887298	13 m	1 m from façade 1.5 above ground
Model Calibration Site 3	1301 Western Highway, Ararat	E 0666703 N 5883641	34 m	1 m from façade 1.5 above ground
Model Calibration Site 4	309 Western Highway, Ararat	E 0669924 N 5874710	17 m	1.5 m from façade 1.5 above ground
Amenity Site 1	134 Wattle Gully Road, Great Western	E 0665760 N 5886022	484 m	1.5 m from façade 1.5 above ground
Amenity Site 2	588 Garden Valley Road, Ararat	E 0664973 N 5884934	772 m	2 m from façade 1.5 above ground



LEGEND

- Noise Monitoring Location
- Proposed Alignment
- Study Area
- Highway
- Sealed road (arterial & local)
- Unsealed road
- Parks

Paper Size A4

0 0.5 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 54

N

GHD

CLIENTS | PEOPLE | PERFORMANCE

vicroads

VicRoads
Western Highway Project

Ararat to Stawell
Study Area and Noise Logger Locations

Job Number	31-27558
Revision	B
Date	13 Nov 2012

Figure 2

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

G:\31\27558\GIS\Maps\Deliverables\Stage 3\RISK AND IMPACT ASSESSMENT\04_AIR_NOISE\3127558_S3_002_Noise_Loggers_A4P.mxd

Data source: DSE, VicMap, 2012; VicRoads, 2011; GHD, Design, 2012. Created by:splaird

**Figure 3	Noise monitoring locations**

Calibration Site 1

2460 Western Highway

Calibration Site 2

9-11 Main Street, Great Western

Calibration Site 3

1301 Western Highway

Calibration Site 4

309 Western Highway

Amenity Site 1

134 Wattle Gully Road

Amenity Site 2

588 Garden Valley Road

4.1.4 Weather Conditions

The VicRoads measurement requirement guidelines (VicRoads, 2005) also specify that:

- The effect of wind noise on the microphone shall be at least 10 dB(A) below the received noise levels. To ensure the above condition applies, appropriate windshields shall be fitted to the microphone for the duration of the measurement period;
- The component of the wind speed from the road to the measuring station and vice versa shall not exceed 3 m/s for any significant period/s during the conducting of measurements;

- The wind speed at the microphone in any direction should not exceed 10 m/s; and
- Occasional light showers during the measuring periods are acceptable. However, when there are periods of heavy rain or continuous light rain measuring shall be abandoned.

Meteorological data was collected at Amenity Site_01 using a Davis Vantage Vue-Pro portable weather station and was used to validate the noise measurements. Average 15 minute wind speeds greater than 3 m/s in any direction at the logger microphone, or average rainfall greater than 0.3 mm/hr were both defined as "adverse weather" conditions. Noise data collected during hours with adverse weather were excluded from the dataset. The location of Amenity Site_01 is displayed in Figure 2 and the placement of the weather station is displayed in Figure 4.

Figure 4 Weather station placement

View looking toward the existing Western Highway

4.1.5 Assumptions

The following assumptions have been made during the course of this noise study:

- All noise logging, calibration and meteorological equipment used was in good working order during the entire period of deployment;
- No animals or people interfered with the equipment during the deployment;
- Traffic flows and ratios of light to heavy traffic were typical of the area being measured; and
- Train noise was not considered an issue at noise monitoring sites due to the distance from site, topography and its transient nature.

4.2 Impact and Risk Assessment

The following impact assessment methodology was used to determine the noise and vibration impact pathways and risk ratings for the Project:

1. Determine the impact pathway (how the Project impacts on a given noise and vibration value or issue).
2. Describe the consequences of the impact pathway.

3. Determine the maximum credible 'consequence level' associated with the impact. Table 6 provides guidance criteria for assigning the level of consequence. The method for defining these criteria is described in Section 4.2.1.
4. Determine the likelihood of the consequence occurring to the level assigned in step 3. Likelihood descriptors are provided in Table 7 below; and
5. Using the Consequence Level and Likelihood Level in the Risk Matrix in Table 8 to determine the risk rating.

Table 6 Consequence table for noise and vibration impacts

Insignificant	Minor	Moderate	Major	Catastrophic
Applicable standards met at all sensitive receptors *(e.g. dwellings, schools, hospitals), at all times.*	*Isolated and temporary exceedance of standards at a sensitive* receptor	*Exceedance of applicable standards in a local area*	*Exceedance of applicable standards in a number of local areas*	*Widespread exceedance of applicable standards across the region*

Table 7 Likelihood Guide

Descriptor	Explanation
Almost Certain	The event is expected to occur in most circumstances
Likely	The event will probably occur in most circumstances
Possible	The event could occur
Unlikely	The event could occur but not expected
Rare	The event may occur only in exceptional circumstances

Table 8 Risk Matrix

Likelihood	Consequence Level				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

4.2.1 Consequence Criteria

Consequence criteria range on a scale of magnitude from "insignificant" to "catastrophic". Magnitude was considered a function of the size of the impact; the spatial area affected and expected recovery time of the environmental system. Consequence criteria descriptions indicating a minimal impact over a local area, and with a recovery time potential within the range of normal variability were considered to be at the insignificant end of the scale. Conversely, catastrophic consequence criteria describe scenarios involving a very high magnitude event, affecting a State-wide area, or requiring over a decade to reach functional recovery.

Consequence criteria for noise and vibration were selected for each level of magnitude based on whether an exceedance of an applicable standard (outlined in Section 3) would occur at a sensitive receiver such as a residential dwelling, school or hospital and if an exceedance occurred what the spatial spread of that exceedance would be. Generally, a more localised exceedance would incur a lower penalty (magnitude) than an exceedance over a larger region.

Results of the risk assessment are described in Section 6.4 and Table 25.

4.3 Construction Vibration Assessment

The construction vibration assessment was based on a review of commonly used guidelines such as:

- British Standard – BS 6472 – 2008, *Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting;*
- British Standard – BS 5228.2:2009 – Code of Practice for noise and vibration control on construction and open sites: Part 2 Vibration; and
- German Standard DIN 4150-3:1999 Structural Vibration – Part 3: Effects of vibration on structures

These guidelines were used for establishing base vibration criteria for use in the assessment of building damage caused by vibration (see, Table 4) and also human discomfort due to vibrations occurring inside dwellings (see, Table 2 and Table 3). Typical vibration levels for several commonly used items of construction equipment at varying distances from source (Peak mm/s) were calculated using the base criteria derived from the above standards and the regression analysis formula $V = D^{-n}$, as described in Section 6.5 and tabulated in Table 26.

Following this an assessment of the number and locations of residential receivers within 50-60 m from the construction zone were identified and tabulated in Table 27. Mitigation measures are discussed in Section 7.1.

4.4 Construction Noise Modelling

The construction noise assessment has been modelled based on an indicative section of the Project around Briggs Lane where there would be one carriageway south bound and one carriageway north bound as well as a service road both to the east and west of the alignment (i.e. four carriageways would be required to be constructed). This area was chosen as it was relatively flat and the construction zone would contain both an east and west carriageway and accompanying service road either side of the alignment. It is expected that noise levels would increase in more elevated areas when noise sources are higher and decrease in areas where cutting would be required due to shielding of noise sources.

Several assumptions have been made in the model on what types of equipment would be used, the number of items of equipment used and the proportion of time each item would be used during the construction day and as such, modelling results should only be used for guidance purposes only. Construction model assumptions are summarised in Section 4.4.2 and Section 4.4.4 below.

4.4.1 Model Selection

Acoustic modelling was undertaken using CadnaA V4.2.141 noise modelling software to predict the effects of industrial noise generated by the Project. CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation according to the selected noise prediction method (algorithm). The algorithm used for construction modelling was the CONCAWE algorithm which takes into account terrain topography, ground absorption, atmospheric absorption and relevant shielding objects in the calculations.

CONCAWE is a mathematical model developed to predict community noise levels from petrochemical and industrial plant for a range of meteorological conditions. A full description of the mathematical model is provided in the report prepared for the Conservation of Clean Air and Water in Europe (CONCAWE) titled *CONCAWE Report No. 4/81 –The propagation of noise from petroleum and petrochemical complexes to neighbouring communities*, (Manning, 1981). The CONCAWE prediction method is widely used in a range of environmental scenarios for predicting noise impacts of mines, power stations, and other industry.

4.4.2 Model Scenario

Construction modelling was based on an indicative two (2) kilometre section of the Project where the proposed alignment would require the construction of four carriageways (east and west bound carriageways and one service road either side). Results are displayed in Section 6.6.

Receiver locations were evenly spaced at 100 m intervals both east and west of the 2 km sub section of the Project, radiating out perpendicular from the central point of the model, 1 km to the east and west of the construction activity, see Figure 5.

Meteorological conditions were chosen with a moderate wind stability class “F” and a wind speed of two metres per second. This scenario was considered suitable as a general worst case scenario for noise emissions both east and west of the alignment. It should be noted however, that is unlikely for a wind stability class “F” to occur during the daytime as this generally represents a temperature inversion. Inversions of this type normally occur during cool clear evenings when air close to the ground cools at a rate faster than the air above it, resulting in the warmer air above acting as ‘cap’ and increasing sound wave reflection back toward the ground surface. These meteorological conditions were selected in order to capture what impacts would occur should construction continue into the evening or night–time periods where a criteria of 10 dB(A) above background should not be exceeded for evening time works during the first 18 months and then 5 dB(A) above background after 18 months and should not be audible within a habitable room of any residential premises during the night, see Table 1. Evening and night-time background values measured at amenity sites 1 and 2 ranged from 37-45 dB(A) L_{A90} in the evening and 34-36 dB(A) L_{A90} during the night-time, see Table 21 and Table 22. Hence conservatively, construction values during the evening and night-time periods should not exceed an external noise level of 47 and 34 dB(A) for the first 18 months and 42 and 34 dB(A) following this for evening and night-time construction respectively.

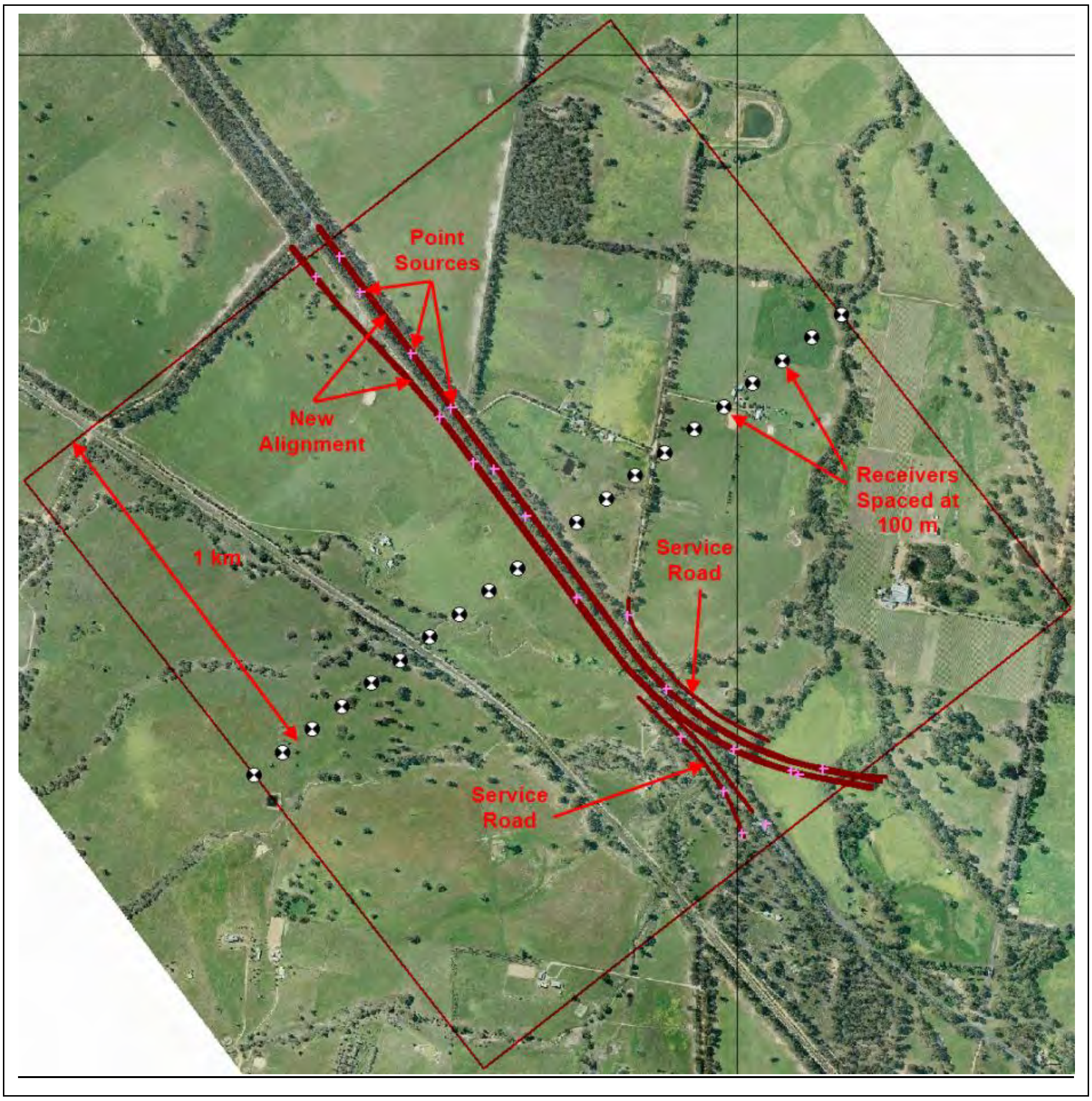
Scenario 1 – Time Weighted

Several types of equipment where placed as point sources along the 2 km section at varying intervals, see Table 9. Each piece of equipment was then time weighted (in minutes) based on its predicted usage throughout one single 11 hour weekday (Monday to Friday) construction period, where the contractor would start work at 7 am and finish at 6 pm, see Table 9. Sound power levels (SWL) and noise emission spectrums for each item of equipment used in the model are summarised in Table 10 and results are displayed in Table 28 and Table 29.

Scenario 2 – Full Load

Several types of equipment where placed as point sources along the 2 km section at varying intervals as per scenario 1, see Table 9. Each piece of equipment was then assumed to be running at full load for the entire 11 hour period in of one typical construction day (7 am to 6 pm), all other variables were the same as in scenario 1. Results are displayed in Table 28 and Table 29.

Figure 5 Indicative construction model (Briggs Lane)



4.4.3 Model Configuration

The following general settings were used in the model:

- CONCAWE industry algorithm was used;
- A Digital Terrain Map (DTM) was created using topography with a 1 metre resolution for the Briggs Lane area;
- Modelling was based on atmospheric conditions of 10 degrees Celsius and 70 percent humidity;
- A search radius greater than the construction area was used to ensure all sources were captured in the model;
- Equipment noise was modelled as point sources;
- Heights of 3 m were selected for noise emissions from all types of equipment;
- All receiver heights were at 1.5 m above the ground (relative to DTM);
- A general ground absorption coefficient of 0.5 was used throughout the model to mimic open topography with mixed trees, soil, and hard stand areas; and
- Reference times in the model were for daytime construction from 7 am to 6 pm (Monday Friday).

4.4.4 Construction Noise Modelling Assumptions (Time Weighted)

The following assumptions have been made regarding the construction noise assessment:

- All construction would occur during the “Normal working hours” as described in both the EPA Noise Control Guidelines – Publication 1254 and the VicRoads Noise Guidelines – Construction and Maintenance Works 2007 (Environment Protection Authority (EPA), 2008) and (VicRoads, 2007);
  - Daytime period of 7 am to 6 pm (Monday Friday); and
  - Daytime period of 7 am to 1 pm (Saturdays);
- *Backhoe* – Two pieces of equipment were included in the model and were assumed they would operate for approximately 20 minutes in each hour on average over a single construction period (7 am to 6 pm);
- *Dump Truck* – Four trucks were modelled over the 2 km section and were assumed they would each operate for approximately 11 minutes in each hour on average, with each truck travelling at 20 kilometres per hour (km/h), requiring 6 minutes to traverse the 2 km section and a further 5 minutes for manoeuvring for each load. Equating to four loads off site each hour throughout the 2 km section;
- *Bulldozer* – Four bulldozers were modelled over the 2 km section and were assumed they would each operate for approximately 30 minutes in each hour on average;
- *Water Truck* – Two water trucks were modelled over the 2 km section. It was assumed they would each do a single pass through the area once every hour at a speed of 20 km/h, requiring 6 minutes to traverse the 2 km section, equating to 132 minutes of total operation time over the 11 hour period;
- *Front End Loader* – Two front end loaders were modelled working together with the bull dozers, dump trucks and excavators. These were assumed to operate for approximately 20 minutes in each hour on average, equating to 220 minutes of total operation time over the 11 hour period;
- *Grader* – Two Graders were modelled working together along the 2 km section on either side of the construction zone. Graders were assumed to operate for 30 minutes in each hour on average, equating to 330 minutes of total operation time over the 11 hour period;

- *Excavator* – Two excavators were modelled working together with the bull dozers, dump trucks and front end loaders. These were assumed to operate all the time loading dump trucks, manipulating cut and fill and preparing batter slopes; and
- *Roller* – Two rollers were assumed to be working 75 percent of the of the time on either side of the construction zone preparing base material for approximately 45 minutes on average each hour.

4.4.5 Equipment Modelled

Table 9 shows the equipment used in the noise model, while Table 10 shows the corresponding sound power levels and associated spectra and heights above ground for each type of equipment. Lw values for each item of equipment were derived from mid-point values as described in table A1 of Australian Standard AS 2436:2010 - *Guide to noise and vibration control on construction, demolition and maintenance sites* (Standards Australia, 2010).

Table 9 Proposed schedule of construction equipment

Indicative Construction Equipment	Daytime Operating Time [a] (minutes) (7 am to 6 pm Monday to Friday)	Quantity of Each Type of Equipment Used Within the Model
Backhoe	220	2
Dump Truck	121	4
Bulldozer	330	4
Water Truck	66	2
Front End Loader	220	2
Grader	330	2
Excavator	660	2
Roller	495	2

Note: Operating time in minute's relates to the time weighted model only. The full load noise model has all equipment operating at all times.

Table 10 Equipment sound power levels SWL (10^{-12} Watt)

Plant Item	Source Height	L_w dB(A)	Octave Centre Frequency (Hz)/ dB (linear)								
			31.5	63	125	250	500	1000	2000	4000	8000
Backhoe	3 m	104	126	120	108	107	101	96	90	88	84
Dump Truck		117	128	123	121	117	114	111	109	102	97
Bulldozer		108	115	110	100	101	108	101	102	92	81
Water Truck		107	109	113	111	107	104	101	99	92	92
Front End Loader		113	100	103	111	109	111	107	106	101	92
Grader		110	127	122	121	112	105	102	100	91	82
Excavator		99	102	103	104	100	96	93	91	85	77
Roller		108	106	101	104	110	107	103	99	92	84

4.5 Operational Noise Modelling

The operational noise impact assessment is based on noise modelling of future traffic volumes along the proposed alignment. Road traffic noise predictions were undertaken using the United Kingdom *Department of Transport Calculation of Road Traffic Noise* (CoRTN) algorithm. The CoRTN algorithm is recognised and accepted by EPA and VicRoads and if required, can be adapted to Australian conditions through research undertaken by the Australian Road Research Board. The CoRTN algorithm does not take into account atmospheric conditions, The CoRTN algorithm is integrated into CadnaA noise modelling software version 4.2.141.

4.5.1 Timing

It is expected that construction activity would be undertaken over a period of approximately 2 years beginning in 2014 with a forecasted completion date of late 2016. Therefore, for the purposes of this assessment the following dates have been assumed for operation of Section 3:

- Year 2016 (Nominal Project Completion Year).
- Year 2026 (10 Years post Nominal Project Completion Year).

Minor variations to the completion dates would have a negligible effect on the predicted effects.

The VicRoads Road Design Note 6-1b Interpretation and Application of VicRoads Traffic Noise Reduction Policy 2005 (2010) outlines a 10 year Project Objective Noise Level (PONL), as follows:

- *'The Project Objective Noise Level (PONL) is the noise level objective for a specific road project to be achieved for at least 10 years after completion of the project'*
- *'…Where noise barriers are used they should be designed to achieve the PONL or less for ten years after opening, taking into account predicted traffic growth.'*
- *'For "limiting noise next to new or improved roads", the noise level objective will take into account predicted traffic volumes 10 years after opening of the project. This criterion has applied to all new projects for the past 20+ years…..'*

Therefore this report includes noise levels for both 2016 and 2026.

4.5.2 Road Traffic Data

Observed existing road traffic volume measurements collected between Harvey Lane and Panrock Reservoir Road by VicRoads during May 2012 were used for this assessment.

Predicted 7 day and 5 day average daily traffic volumes and heavy vehicle percentages for the years 2011 (back prediction), 2016 and 2026 were calculated by GHD's Traffic and Transport specialist team for use in this assessment. The 7 day average traffic volumes from the monitoring location were then adjusted for use with the CoRTN algorithm for use in calculating the $L_{A10\ (18hr)}$ noise levels in the CadnaA software package. The volumes do not include a seasonal adjustment factor. The 7-day volumes were used as an approximate AADT, however, to calculate the actual AADT for the Section 3 of the Western Highway, the following would be required:

- A seasonal adjustment factor; and
- A permanent traffic volume count station located along the Highway.

Note: that in accordance with AustRoads publications (Austroads Incorporated, 2002) and other national road policies, common practice when assessing road traffic noise impacts is to use the Annual Average Daily Traffic (AADT). The definition of AADT is the total volume of traffic recorded at a specific road location taken over a calendar year and divided by the number of days in that year.

Observed existing and predicted road traffic volume for the years 2011, 2016 and 2026 are displayed in Table 11 and Table 12 respectively. Final CoRTN adjusted values for use in the models are displayed in Table 13. Details on how present volumes have been estimated are available in the Traffic and Transport Assessment Report 2012 prepared for this EES (GHD Pty Ltd, 2012).

Service Roads for the predicted 2016 and 2026 years were assumed to contain five percent of the daily traffic volume of the main alignment with the same percentages of heavy vehicles utilising these areas, giving daily traffic volumes on service roads and intersections of 304 and 356 vehicles per day for the 2016 and 2026 years respectively (see Table 13).

Table 11 Observed traffic volumes for existing highway Ararat to Stawell (May 2012)

Location	7-day Volumes – Vehicles Per Day (vpd)			5-day Volumes – (weekday) Vehicles Per Day (vpd)		
	Average Daily Volumes	% Heavy Vehicles	Average Heavy Vehicles Per Day	Average Daily Volumes	% Heavy Vehicles	Average Heavy Vehicles Per Day
Western Highway Between Harvey Lane and Panrock Reservoir Road	6074	29%	1748	6462	32%	2061

Table 12 Predicted traffic volumes for years 2011 through 2040

Value	Western Highway Between Harvey Lane and Panrock Reservoir Road				
	2011	2012	2016	2026	2040
7 day average vpd	5979	6074	6470	7575	9447
%hv (7 day)	29%	29%	29%	29%	30%
7 day average heavy vehicles per day	1718	1748	1875	2232	2850

Table 13 Final traffic volumes used in noise prediction models

CoRTN Adjustment	Western Highway Between Harvey Lane and Panrock Reservoir Road				
	2011	2012	2016	2026	2040
7 Day LA10 18hr as per CoRTN	5620	5709	6082	7121	8880
7 Day One Way Volumes	2810	2855	3041	3560	4440
7 Day Heavy Vehicle Percentage	29%	29%	29%	29%	30%
Service Roads and Intersections (5% of the 7 Day Average)	-	-	304	356	-

4.5.3 Noise Model Verification

The CoRTN algorithm and noise modelling process was validated against the attended and unattended road traffic noise monitoring described in Section 5 by utilising the forecasted traffic counts for the same period post adjusted for use in CoRTN, see Table 13. Traffic flows and ratios of light to heavy traffic have been assumed to be typical of the area being measured. The model is deemed to be verified if the average difference between the measured and calculated values of the descriptors is within +/-2 dB(A).

A comparison of the modelling and monitoring results is shown in Table 14. The predicted results and measured results have an acceptable variance of within 2 dB(A). The predicted results included a façade correction of + 2.5 dB(A) and -1.7 dB(A) CoRTN correction for Australian road traffic conditions (Austroads Incorporated, 2002).

Table 14 Noise model verification dB(A)

Location	ID	Attended Measurements (15 min) ($L_{A10\ 18hr}$)	Unattended Measurements(3 days) ($L_{A10\ 18hr}$)	Model Calibration ($L_{A10\ 18hr}$)	Variation ($L_{A10\ 18hr}$)
Model_CalibrationSite_01	MC_01	62.0	62.1[1]	62.5[2]	0.4
Model_CalibrationSite_02	MC_02	70.6	71.6[1]	70.0[2]	-1.6
Model_CalibrationSite_02 (Category B Receivers)	MC_02		71.7[1] ($L_{A10\ 12hr}$)	70.1[2] ($L_{A10\ 12hr}$)	-1.6 ($L_{A10\ 12hr}$)
Model_CalibrationSite_03	MC_03	67.6	70.8[1]	67.6[2,3]	0.0
Model_CalibrationSite_04	MC_04	64.9	65.1[1]	66.5[2]	1.4

[1] Includes façade effects (noise reflected from the building façade), [2] Façade corrections applied. [3] Used Attended Measurement for model calibration at this site.

The noise logger at Site 3 was successfully calibrated in the field, however it was noted that the long term unattended noise levels were higher than the short term attended measurements by up to 3 dB(A) and did not agree with other model calibration site measurements. It is considered that there may be some error in the measurement data and all results from Site 3 have been excluded from any further assessment.

Note: Values at amenity sites were not used for model calibration due to their large distances from the road and increased topography effects. Amenity sites were more about establishing background noise levels set back from the existing highway and were not designed for calibration purposes.

4.5.4 Noise Modelling Inputs and Assumptions

The noise model inputs and assumptions are presented in Table 15.

Table 15 Noise model inputs and assumptions

Input / Assumption	Data Incorporated into Noise Model
Traffic Speeds Existing Areas	60-100 km / h. (as signposted)
Traffic Speeds New Alignment	110 km / h. (signposted)
Road Surface Existing	Dense Graded Asphalt (DGA)
Road Surface New Alignment	14 mm spray seal surfacing
VicRoads Road Surface Correction	+2 dB(A) - Noise correction for the noise increase relative to typical Dense Graded Asphalt (DGA) **Note:** Typically +4 dB(A) would be used for 14 mm spray seal however, only +2 dB(A) was used in this assessment to account for future road wear closer to 2026.
Road gradient	Taken into account based on road design and existing topography
Buildings	All affected buildings located in the Project area were included in the model in order to predict building wake effects on any adjacent sensitive receiver sites.
Façade correction	+2.5 dB(A) to account for sound reflected from building façade then -1.7 dB(A) to account for Australian conditions (Austroads Incorporated, 2002).
Receiver Heights	1.5 m above building ground level
Receiver Locations	All receiver points were located in such a manner as to predict the highest possible influence at the building façade from the proposed alignment.
Ground Absorption	G = 0.5 where 0 is non-porous ground and 1 is porous ground
Ground Topography	The digital terrain model with a 1 m resolution has been fitted to the new road alignment, assuming batter slopes of 1:4.
Category A: Receiver Modelling	Day time period was set 18 hours (6 am to midnight), $L_{A10\ 18hr}$
Category B: Receiver Modelling	Day time period was set 12 hours (6 am to 6 pm), $L_{A10\ 12hr}$
Service Roads and Intersections	Service roads and Intersections were assumed utilised by a 5 percent proportion of the CoRTN corrected Average Daily Traffic Volumes.

This noise and vibration impact assessment report provides an assessment of areas of potential impact based on the concept design developed for the purposes of the EES. The extent and location of noise mitigation would be defined following the completion of construction and any post construction monitoring in accordance with Section 2.6 of the 'Road Design Note 6-1b *Interpretation and Application of VicRoads Traffic Noise Reduction Policy 2005 (2010)'* (VicRoads, 2010).

5. Existing Conditions

Both unattended and attended noise measurements were carried out at six locations. All logger microphone placements were 1.5 m above the ground surface. All calibration sites were located adjacent to the Western Highway and Amenity Sites 1 and 2 were situated further afield in order to capture noise levels from areas along the project area that have lower existing traffic noise levels, but may be greatly influenced by a proposed alignment change.

5.1 Meteorology

The entire study area from Ararat to Stawell can be classified as having a climate of 'temperate' with 'no dry season (warm summer)'. Extreme values in temperature occur, with hot days more frequent at the North-western end and frosty mornings occurring more often at the South-eastern end. The wettest months occur in spring (September – November) with greater rain fall expected at the South-eastern end of the study area. Annual average wind directions are predominately from the south. The Project area experiences seasonal variations to the wind climate, with a shift from south during the warmer months and then to the north with a north-west sector tendency during winter. Winds are lightest during late autumn and winter, so that predicted impacts are likely to be greater in these seasons. Stawell's atmospheric stability class is site-representative for the Project area and is predominately 'neutral' for about one half of all hours but 'stable' for about one third of the time. Neutral conditions would be the most often occurring stability category during construction hours. Local meteorology is discussed in detail in the Air Quality Assessment Report (GHD Pty Ltd, 2012) prepared for the Project.

Some meteorological conditions would have an effect on noise propagation and absorption (Scannell, 2006):

- Temperature – the higher the temperature the higher the noise absorption;
- Temperature inversion – can cause noise to refract ground ward;
- Relative humidity – the higher the humidity the lower the noise absorption.

Wind – noise is refracted differently down wind and upwind of the source, with the speed of noise propagation increasing with decreased air pressure (lower density air). Sound refracts across a wind pressure gradient bending ground ward downwind and sky ward upwind of the source (Scannell, 2006).

5.2 Unattended Noise Monitoring

A summary of unattended noise level measurements are presented in Table 16 below for each site and on a daily basis in Table 17 through to Table 22. Daily noise charts containing L_{A10} L_{A90}, L_{Aeq}, rainfall, and mean wind speed are presented in Appendix C. The summary table and following tables consist of three consecutive days of data from Tuesday 28 June 2011 until Thursday 30 June 2011 unless otherwise stated. When carrying out road traffic noise analysis, all data measured on weekends, school and public holidays and during periods of unsuitable weather are to be excluded as non-representative data (VicRoads, 2005). Poor weather conditions where data may be excluded would include where the component of wind speed from the microphone to the road exceeds 3 m/s briefly or 10 m/s from any direction (VicRoads, 2005) and/or where rainfall exceeds 0.3 mm in any measuring period (in this study the measuring period was every 15 minutes).

Table 16 Overall measured road traffic noise levels (dB)

Site ID	Location	Date Start	Date End	$L_{A10, 18hr}$	$L_{Aeq, 16hr}$	$L_{Aeq, 15hr}$	$L_{Aeq, 9hr}$	$L_{Aeq, 8hr}$
Model Calibration Site 1	2460 Western Highway, Stawell,	28/06/11	01/07/11	62	58	58	58	58
Model Calibration Site 2	9-11 Main Street, Great Western	28/06/11	01/07/11	72	68	68	66	66
Model Calibration Site 3	1301 Western Highway, Ararat	28/06/11	01/07/11	71	67	67	66	66
Model Calibration Site 4	309 Western Highway, Ararat	28/06/11	01/07/11	65*	62*	62*	60*	60*
Amenity Site 1	134 Wattle Gully Road, Great Western	28/06/11	01/07/11	54	55	54	55	56
Amenity Site 2	2460 Western Highway, Stawell,	28/06/11	01/07/11	49	47	48	47	47

* Values have been adjusted in order to remove erroneous data found on Thursday 30 June 2011 from 12:00 to 13:30 hours due to two spikes with unknown origin.

Table 17 Summary of measurements (dB) at 2460 Western Highway (Model Calibration Site 1)

Date	$L_{A10, 18hr}$	$L_{Aeq, 16hr}$	$L_{Aeq, 15hr}$	$L_{Aeq, 9hr}$	$L_{Aeq, 8hr}$
Tuesday 28-06-2011	63	59	60	59	59
Wednesday 29-06-2011	62	58	58	57	57
Thursday 30-06-2011	62	58	58	57	57
Overall	62	58	58	58	58

Distance to the highway was approximately 85 m from the microphone.

Table 18 Summary of measurements (dB) at 9-11 Main Street, Great Western Highway (Model Calibration Site 2)

Date	$L_{A10,\ 18hr}$	$L_{Aeq,\ 16hr}$	$L_{Aeq,\ 15hr}$	$L_{Aeq,\ 9hr}$	$L_{Aeq,\ 8hr}$
Tuesday 28-06-2011	72	68	68	66	66
Wednesday 29-06-2011	72	68	68	66	66
Thursday 30-06-2011	71	68	68	66	66
Overall	72	68	68	66	66

Distance to the highway was approximately 17 m from the microphone.

Table 19 Summary of measurements (dB) at 1301 Western Highway (Model Calibration Site 3)

Date	$L_{A10,\ 18hr}$	$L_{Aeq,\ 16hr}$	$L_{Aeq,\ 15hr}$	$L_{Aeq,\ 9hr}$	$L_{Aeq,\ 8hr}$
Tuesday 28-06-2011	70	66	67	66	66
Wednesday 29-06-2011	71	67	67	66	66
Thursday 30-06-2011	71	67	67	66	66
Overall	71	67	67	66	66

Distance to the highway was approximately 34 m from the microphone.

Table 20 Summary of measurements (dB) at 309 Western Highway (Model Calibration Site 4)

Date	$L_{A10,\ 18hr}$	$L_{Aeq,\ 16hr}$	$L_{Aeq,\ 15hr}$	$L_{Aeq,\ 9hr}$	$L_{Aeq,\ 8hr}$
Tuesday 28-06-2011	65	62	62	60	60
Wednesday 29-06-2011	65	62	62	59	59
Thursday 30-06-2011	65*	62*	62*	59*	59*
Overall	65	62	62	60	60

* Values have been adjusted on Thursday 30 June 2011 in order to remove erroneous data from 12:00 to 13:30 hours due to two spikes with unknown origin.

Distance to the highway was approximately 17 m from the microphone.

Table 21 Summary of measurements (dB) at 134 Wattle Gully Road (Amenity Site 1)

Date	$L_{A10, 18hr}$	$L_{Aeq, 16hr}$	$L_{Aeq, 15hr}$	$L_{Aeq, 9hr}$	$L_{Aeq, 8hr}$	L_{A90}	
Tuesday 28-06-2011	56	56	56	56	56	Day	43
						Evening	45
						Night	36
Wednesday 29-06-2011	53	54	54	54	54	Day	41
						Evening	37
						Night	34
Thursday 30-06-2011	53	54	54	56	57	Day	40
						Evening	39
						Night	36
Overall	54	55	54	55	56	Day	40
						Evening	37
						Night	34

Distance to the highway was approximately 484 m from the microphone.

Table 22 Summary of measurements (dB) at 588 Garden Valley Road (Amenity Site 2)

Date	$L_{A10, 18hr}$	$L_{Aeq, 16hr}$	$L_{Aeq, 15hr}$	$L_{Aeq, 9hr}$	$L_{Aeq, 8hr}$	L_{A90}	
Tuesday 28-06-2011	48	47	48	48	48	Day	35
						Evening	41
						Night	36
Wednesday 29-06-2011	49	47	47	46	46	Day	40
						Evening	38
						Night	34
Thursday 30-06-2011	50	48	48	46	46	Day	41
						Evening	38
						Night	34
Overall	49	47	48	47	47	Day	35
						Evening	38
						Night	34

Distance to the highway was approximately 772 m from the microphone.

5.3 Attended Noise Monitoring

Attended noise measurements were undertaken in order to gain an appreciation of noise sources at different times of the day, at the different sites. A summary of the results of attended noise monitoring is provided in Table 23. Attended noise monitoring was undertaken on 28 June 2011. A summary of weather conditions during attended noise measurements is provided in chart form for each of the sites in Appendix C.

Table 23 Summary of attended noise measurements dB(A) and traffic counts

Site ID	Date	Time	Traffic		Duration	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}	L_{Amin}	Comments
Model Calibration Site 1	28/06/11	9:30	Heavy	15	15 min	58	47	62	69	40	Mostly calm 0-1 m/s from SW, clear sky, sunny, RTN from highway dominant ~40-50 m away. Some bird chirping in traffic lulls, cars ~55-60 dB(A), trucks up to 70 dB(A).
			Light	77							
			Total	92							
Model Calibration Site 2	28/06/11	10:00	Heavy	30	15 min	66	47	71	82	38	No wind, clear sky, sunny, RTN from highway dominant, some dogs barking for a short time. Trucks up to 80 dB(A) and cars up to 70 dB(A).
			Light	81							
			Total	111							
Model Calibration Site 3	28/06/11	11:30	Heavy	15	15 min	64	42	68	79	33	No wind, clear sky, sunny, RTN from highway ~25-30 m away. Some birds chirping in traffic lulls. Trucks ~75 dB(A) cars ~65 dB(A), 35 dB(A) when no traffic.
			Light	66							
			Total	81							
Model Calibration Site 4	28/06/11	12:00	Heavy	25	15 min	62	49	65	79	41	No wind, clear sky, RTN from highway ~20 m away. Some birds chirping, trucks 70 dB(A) cars 60 dB(A), pool between highway and site.
			Light	76							
			Total	101							
Amenity Site 1	28/06/11	11.00	Heavy	30	15 min	54	43	53	79	33	Wind speed 0-1 m/s ESE, mostly calm. Weather station placed onsite. RTN from highway ~45 dB(A), trucks up to 55 dB(A).
			Light	73							
			Total	103							
Amenity Site 2	28/06/11	10.30	Heavy	-	14 min	43	34	45	64	30	No wind, clear sky, RTN in background with trucks audible, birds chirping constantly, levels dropping to ~35 dB(A). Measurement interrupted by owner for a minute hence shorter sample time. Car on nearby local road also.
			Light	-							
			Total	-							

5.4 Existing Conditions Summary

As would be expected, the amenity sites which were situated further away from the existing Western Highway had a lower overall $L_{A10\ (18hr)}$ than the model calibration sites - with 54 dB(A) and 49 dB(A) for Amenity Sites 1 and 2 respectively. Amenity Site 2 is currently below the noise level of 50 dB(A) $L_{A10\ (18hr)}$ described in the VicRoads – Traffic Noise Reduction Policy, February 2005 for both Category A and B buildings as the level in which 'consideration will be given to limiting the noise level increase to 12 dB(A)' $L_{A10\ (18hr)}$.

Model calibration Sites 2 and 3 demonstrated similar traffic noise levels with 72 and 71 dB(A) $L_{A10\ (18hr)}$ respectively. These sites were relatively close to the existing highway at 13 m and 34 m and hence, give a good representation of the traffic noise at these locations. Model calibration Site 1, which was just outside Stawell, was significantly quieter, at 62 dB(A) $L_{A10\ (18hr)}$, as it was set back from the highway approximately 85 m and had some variation in topography and tree density. Model Calibration Site 4 was 65 dB(A) $L_{A10\ (18hr)}$ and was set back 17 m from the road. This site was elevated compared to the road and also had a higher traffic volume and a higher percentage of heavy traffic at 25 percent (see, Table 23).

Model Calibration Sites 2 and 3 were both above the trigger level of 68 dB(A) $L_{A10\ (18hr)}$ described in the VicRoads – Traffic Noise Reduction Policy, February 2005 for initiating the noise abatement program.

Traffic counts were taken from 9:30 hrs to 12:15 hrs during the attended readings and ranged from 81 to 111 vehicles. Counts varied throughout the morning peaking at 111 vehicles during the 10:00 am – 10:15 am reading. The ratio of heavy to light vehicles was randomly spread throughout the measurement period ranging from 16 percent heavy vehicles to 29 percent. Heavy vehicles included buses and all trucks over 3,500 kg Tare weight (visual inspection only).