Trial Blast Management Strategy

M4-M5 Link Mainline Tunnels

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Document control

Approval and authorisation

Title	M4-M5 Link Mainline Tunnels Trial Blast Management Strategy
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Internal review

Role	Name	Position	Date	Signature
Originator(s)	[redacted]	Environmental Manager	[redacted]	[redacted]
Endorsement		Environment & Sustainability Manager (suitably qualified and experienced person)		
Review		Independent Specialist		
Authorised		Project Director		

Contents

Glossary/Abbreviations

Abbreviation	Expanded text
AA	The Acoustics Advisor for the CSSI
ANZECC	Australian and New Zealand Environment Conservation Council
AS	Australian Standard
BS	British Standard
CBMP	Controlled Blast Monitoring Program
CBMS	Controlled Blast Management Strategy
CCS	Community Communications Strategy
CEMP	Construction Environmental Management Plan
CoA	NSW Minister for Planning's Conditions of Approval
CSSI	Critical State Significant Infrastructure, as described in Schedule 1, the carrying out of which is approved under the terms of the SSI 7485 approval
DPIE	Department of Planning, Industry and Environment
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
EP&A Act	Environmental Planning and Assessment Act 1979
EPL	Environment Protection Licence
ER	The Environmental Representative whose role is defined by the Project's CoAs A19 – A23
ISO	International Organization for Standardization
LSBJV	Lendlease Samsung Bouygues Joint Venture (Contractor)
MIC	maximum explosive weight per delay/maximum instantaneous charge
NAASRA	National Association of Australian State Road Authorities
NATA	National Association of Testing Authorities

Abbreviation	Expanded text
NSW	New South Wales
REMM	Revised Environmental Mitigation Measures as identified from the Submissions and Preferred Infrastructure Report
RL	Reduced Level
SPIR	Submissions and Preferred Infrastructure Report
SSI	State Significant Infrastructure
TfNSW	Transport for NSW
TBMP	Trial Blast Monitoring Program
TBMS	Trial Blast Management Strategy (This document)
WCX	M4-M5 Link Group (WestConnex Transurban)

1 Introduction

1.1 Background

WestConnex is one of the NSW Government's key infrastructure projects which aims to ease congestion, create jobs and connect communities. The 33-kilometre WestConnex motorway will link Sydney's west and south-west with the Sydney Central Business District, Sydney Airport and Port Botany. WestConnex is one component of an integrated solution to meet Sydney's growing transport and infrastructure needs and is consistent with NSW Government transport and planning policies and strategies.

The Proponent for the project was Roads and Maritime Services (Roads and Maritime) who commissioned the WestConnex Transurban to deliver WestConnex. On 1 December 2019 Roads and Maritime were dissolved, with all Roads and Maritime's functions, assets, rights and liabilities being transferred to Transport for NSW (TfNSW). TfNSW are now considered the Proponent.

The WestConnex M4-M5 Link project will be constructed and opened to traffic in two stages:

- Stage 1: M4-M5 Link Mainline tunnels
- Stage 2: Rozelle interchange.

WestConnex Transurban has engaged the Lendlease Samsung Bouygues Joint Venture (LSBJV) to design and construct Stage 1 of the M4-M5 Link project (the Project). The WestConnex M4-M5 Link Mainline Tunnels project will deliver twin mainline motorway tunnels between the New M4 at Haberfield and M8 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction

The project was declared by Ministerial Order to be State Significant Infrastructure (SSI) and Critical State Significant Infrastructure (CSSI), under Section 5.12 (4) and Section 5.13 (previously referred to as 115U(4) and 115V prior to amendment of the *Environmental Planning and Assessment Act 1979* (EP&A Act)) as well as under clause 16 of the State Environmental Planning Policy (State and Regional Development) 2011. The project remains subject to assessment under the EP&A Act and requires the approval of the NSW Minister for Planning. The proposal is critical State significant infrastructure by virtue of Schedule 5, clause 4 of State Environmental Planning Policy (State and Regional Development) 2011.

An Environmental Impact Statement (EIS) (AECOM 2017) was prepared and placed on public exhibition from 18 August 2017 to 16 October 2017. Submissions were received from government, agencies, organisations and the public in repose to the project. A Submissions and Preferred Infrastructure Report (SPIR) was prepared by Roads and Maritime (now TfNSW) in response to submissions received during the exhibition period. The Project was approved by the Minister for Planning on 17 April 2018. A Project Modification report (AECOM 2018) was prepared and placed on public exhibition for 14 days from 12 September 2018. The Project Modification was determined by the Minister for Planning on 25 February 2019.

Section 5.7.3 of the EIS discusses the potential need to blast in order to compete the tunnel excavation. Further it states *"Blasting has the potential to significantly reduce the noise and vibration impacts if managed appropriately. Blasting is proposed as an excavation technique because the vibration impacts from blasting are of a much shorter duration for nearby sensitive receivers compared to the vibration impacts associated with mechanical excavation methods such as roadheaders and rock-breakers."*

Further Section 5.7.3 of Appendix J of the EIS states "*In order to estimate the level of ground vibration resulting from the subject tunnel blasting, the blast vibration "site law" developed from blasting the northern section of the Sydney Harbour Tunnel was employed. Geotechnical conditions for the Sydney Harbour tunnel project included sandstone rock which is considered comparable to the worst-case conditions anticipated for tunnelling works on this project.*

The subject site law for ground vibration is: PVS (mm/s) = 135(R/Q0.5)-1.08."

1.2 Purpose

This Trial Blast Management Strategy (TBMS) has been prepared to outline how LSBJV will comply with the NSW Minister for Planning's Conditions of Approval (CoA) in relation to a trial blast.

A detailed description of the Project is provided in the EIS Chapter 5 (Project Description) and summarised below in Section 1.3.

Implementing the CEMP and Sub-plans effectively will ensure that the project meets the requirements of the CoA, Environment Protection Licence, Revised Environmental Mitigation Measures (REMM), TfNSW Specifications, the EIS and all applicable legislation.

1.3 Project description

WestConnex Transurban has engaged LSBJV to design and construct Stage 1 of the project. The key features of the Mainline tunnels project include:

- Twin mainline motorway tunnels between the M4 East at Haberfield and the M8 at St Peters. Each tunnel would be around 7.5 kilometres long and would generally accommodate up to four lanes of traffic in each direction
- Connections of the mainline tunnels to the M4 East project, comprising:
    - A tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield
    - Entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (constructed as part of the M4 East project)
    - Minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking
- Connections of the mainline tunnels to the M8, comprising:
    - A tunnel-to-tunnel connection to the M8 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters
    - Entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (constructed as part of the M8)
    - Minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking
- Construction of tunnel stubs to provide for future underground connection of the mainline tunnels to the Rozelle interchange and Iron Cove Link
- A motorway operation complex at St Peters (Campbell Road. The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets (the Campbell Road ventilation facility), offices, on-site storage and parking for employees
- Tunnel ventilation systems, including ventilation supply and exhaust facilities, ventilation fans, ventilation outlets and ventilation tunnels
- Fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (constructed as part of M4 East project) for use by the M4-M5 Link project
- Drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities
- Water treatment would occur at the Project operational water treatment facility

- Ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage)
- Emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems
- Utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities
- Temporary construction ancillary facilities to facilitate construction of the project at the following locations:
    - Northcote Street civil and tunnel site (C3a), Haberfield
    - Haberfield civil site (C2b), Haberfield
    - Parramatta Road East civil site (C3b), Haberfield
    - Parramatta Road West civil site (C1b), Ashfield
    - Wattle Street civil and tunnel site (C1a), Haberfield
    - Pyrmont Bridge Road tunnel site (C9), Camperdown/Annandale
    - Campbell Road civil and tunnel site (C10), St Peters

A more detailed description of how the Project would be constructed is provided in Chapter 6 (Construction work) of the EIS and Section 1.3 of the Construction Environmental Management Plan (CEMP), which was updated along with the Construction Noise and Vibration Management Plan and Community Communications Plan, to acknowledge preparation of blasting documentation and blasting as a construction activity in general.

2 Requirements, Approvals, Licensing and Guidelines

2.1 Project Requirements

A summary of relevant Project Approval requirements for the Project TBMS are included in Table 2-1. RMS Specifications are described and responded to in **Appendix A**.

Table 2-1 Requirements for TBMS

<table>
<tr><th>Ref</th><th>Requirement</th><th>How Addressed</th></tr>
<tr><td colspan="3">CoA</td></tr>
<tr><td>A6</td><td>Where the terms of this approval require a document or monitoring program to be prepared or a review to be undertaken in consultation with identified parties, evidence of the consultation undertaken must be submitted to the Secretary with the document. (refer to Project Approval for full condition)</td><td>Section 6.2</td></tr>
<tr><td>A26</td><td>The approved Acoustic Advisor must:
(d) review all noise and vibration documents required to be prepared under the terms of this approval and, should they be consistent with the terms of this approval, endorse them before submission to the Secretary (if required to be submitted to the Secretary) or before implementation (if not required to be submitted to the Secretary);
(refer to Project Approval for full condition)</td><td>Section 6.3</td></tr>
<tr><td>C9 (d)</td><td>The following Construction Monitoring Programs must be prepared in consultation with the relevant authorities identified for each Construction Monitoring Program to compare actual performance of construction of the CSSI against predicted performance.
<table>
<tr><th>Required Construction Monitoring Programs</th><th>Relevant authority(s) and council(s) to be consulted for each Construction Monitoring Program</th></tr>
<tr><td>Blast Monitoring Program</td><td>EPA</td></tr>
</table></td><td>The Blast Monitoring Program is being prepared as a separate document.
Section 5.4</td></tr>
<tr><td rowspan="3">E96</td><td>If blasting is proposed a Blast Management Strategy must be prepared and must include:
(a) sequencing and review of trial blasting to inform blasting;</td><td>Section 3.1</td></tr>
<tr><td>(b) regularity of blasting;</td><td>Section 3.2</td></tr>
<tr><td>(c) intensity of blasting;</td><td>Section 3.4</td></tr>
</table>

Ref	Requirement	How Addressed
	(d) impact mitigation measures including periods of relief; and	Section 4 Section 5
	(e) blasting program.	Section 3.2
E97	The Blast Management Strategy must be endorsed by a suitably qualified and experienced person and reviewed by an independent specialist.	Section 6.3
E98	The Blast Management Strategy must be prepared in accordance with relevant guidelines and in consultation with the EPA to ensure that all blasting and associated activities are carried out so as not to generate unacceptable noise and vibration impacts or pose a significant risk to sensitive receivers.	Section 2.7 Section 6.2
E99	The Blast Management Strategy must be submitted to the Secretary for information no later than one (1) month prior to the commencement of blasting. The Strategy as submitted to the Secretary, must be implemented for all blasting activities.	Section 6.2
E100	Blasting associated with the CSSI must only be undertaken during the following hours: (a) 9:00 am to 5:00 pm, Monday to Friday, inclusive; (b) 9:00 am to 1:00 pm, Saturday; and (c) at no time on Sunday or on a public holiday; or as authorised through an EPL if blasting is proposed outside of these hours. This condition does not apply in the event of a direction from police or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or to prevent environmental harm.	Section 3.2 Section 5.3
REMM		
NV8	A Blast Management Strategy will be prepared and implemented for the project if blasting is proposed. The strategy will: • Identify relevant performance criteria in relation to potential noise and vibration impacts due to blasting with reference to (as a minimum) Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Conservation Council (ANZECC), 1990) and Australian Standard AS 2187.2-2006 Explosives -Environmental management measure Timing Storage, transport and use, Part 2: Use of explosives	Section 3.4
	• Describe trials that will be carried out to confirm vibration levels from blasting and facilitate development of predictive tools to allow potential noise and vibration impacts to be identified	Section 3.1

Ref	Requirement	How Addressed
	• Include details of management measures that will be implemented to ensure compliance with relevant performance criteria	Section 3.3
	• Include details of community consultation requirements prior to commencing blasting. The Blast Management Strategy will be implemented for all blasting carried out as part of the project.	Section 5.2

2.2 Licensing Requirements

The Project currently holds an Environmental Protection License (License – 21149) (the EPL). The appropriate variation to this EPL will be obtained before the commencement of any trial blast activities being carried out.

2.3 Blasting Explosives User Licence

Each trial blast will be controlled by a Shotfirer; whom shall be required to hold a Blasting Explosives User License, as per Part 3 of the Explosives Act 2003.

2.4 SafeWork NSW

Blasting will be undertaken in accordance with the relevant legislation including:

- NSW Explosives Act,
- NSW Explosives Regulation,
- the General explosive licence and security clearance conditions under the NSW explosives act and regulation,
- Australian Explosives Code
- AS2187: Explosives – storage transport and use
- AS4326: The storage and handling of oxidizing agents

A Notification of Blasting Activity will be lodged no less than seven working days before the intended blast date with SafeWork NSW by the holder of a blasting explosives user licence. The notification will be valid for a single event, or for a maximum of three months where there are multiple blasts at the same work location. Any subsequent changes to the notified details must be provided to SafeWork NSW by e-mail prior to the blasting activity (note: the licence holder must retain evidence of the date/time the notification or variation was submitted via e-mail date stamp).

2.5 Security Clearance

Any persons, who will perform any work with explosives without being under the direct supervision of a Shotfirer, will require a security clearance, previously named Unsupervised Handling of Explosives License.

2.6 Hold Points

As per RMS Specification R44 Section 4.6.1, the following hold point is relevant to trial blast works, submissions will be required to be made to M4-M5 Link Group (WCX):

- Process Held: Start of each blast operation.

  Submission Details: At least 24 hours prior, submit details of:

  i. proposed blasting design and estimated vibration and airblast at sensitive receivers; and

  ii. measures to limit noise and to ensure that vibration from blasting does not adversely affect nearby structures.

  Release of Hold Point: The Project Verifier will consider the submitted documents, prior to authorising the release of the Hold Point.

As per G36 Section 4.7 the following hold point is relevant to blasting works:

- Process Held: Commencement of blasting, pile driving, excavation by hammering or ripping, dynamic compaction or demolition operations or any other activities which may cause damage through vibration or air blast.

  Submission Details: At least 10 working days prior, submit to the Nominated Authority a copy of the Building Condition Inspection Reports and Vibration and Air Blast Management Sub-Plan or the combined Noise and Vibration Management Sub-Plan (where controlled blasting is not required).

  Release of Hold Point: The Nominated Authority will consider the submitted documents prior to authorising the release of the Hold Point. The Nominated Authority may request additional information in respect of the proposal and/or submitted documents.

This TBMS is the most relevant management plan in term of trial blasting and is provided to fulfil the Hold Point requirement, a minimum of 10 days prior to the first trial blast.

The requirement and Hold Point submission for Condition Surveys has been implemented from the start of the Project for tunnelling activities and surface activities at which have the potential to cause damage from vibration. This will continue to be implemented throughout the trial blast activities. Conditions Surveys are discussed further in Section 5.1.

2.7 Relevant documents

The following guidelines and industry documents are relevant to this document:

- Explosives Act 2003
- Explosives Regulations 2013
- Code of Practice – WorkCover - Tunnels Under Construction - 2006
- Workplace Relations Ministers' Council – Australian Code for the Transport of Explosives by Road and Rail - 3rd Edition
- Code of Practice – Australian Explosives Industry and Safety Group ANE - 2nd Edition, April 2012
- Code of Practice – AESISG - Mobile Processing Units - 2nd Edition, October 2011
- Code of Practice – Control of Major Hazard Facilities - October 2002
- Australian Code for The Transport of Explosives by Road and Rail - 3rd Edition
- Australian Code for the Transport of Dangerous Goods by Road and Rail - 7th Edition
- Australian Standard 2187.1-1998 Explosives — Storage, transport and use, Part 1: Storage
- Australian Standard 2187.2-2006 Explosives — Storage and use, Part 2: Use of explosives

- RMS Specification R44 – Earthworks (Cl. 4.5; Cl. 4.7 Blasting and ANNEXURE R44/A6 Blasting)
- RMS Specification G36 – Environmental Protection (Management Plan)
- WorkCover Licensing Requirements
- Hazardous Industry Planning Advisory paper No. 6: Hazard Analysis (Department of Planning Jan 2011)
- Assessment Guideline: Multi-Level Risk Assessment (Department of Planning and Infrastructure May 2011)
- Interim Construction Noise Guideline (DECC, 2009).
- Assessing Vibration: A Technical Guideline (DEC 2006).
- Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration (ANZECC, 1990).
- AS 2436-2010 'Guide to Noise Control on Construction, Maintenance and Demolition Sites'.
- AS 1055.1-1997 'Acoustics – Description and measurement of environmental noise, Part 1: General procedures'
- AS1259.2-1990 'Acoustics – Sound Level Meters, Part 2: Integrating – Averaging and carry appropriate NATA (or manufacturer) calibration certificates'.
- BS 7385: Part 2 "Evaluation and measurement of vibration in buildings".
- German DIN 4150: Part 3 – 1999 Effects of Vibration on Structure (DIN, 1999).
- ISO14837-1:2005 – 'Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1 – General guidance'.
- Environment Protection Licence (EPL) #21149.
- Workplace Health and Safety Act 2001.
- Workplace Health and Safety Regulation 2017.

3 Scope of Trial Blasting

3.1 Location and Scope of Trial Blasting

LSBJV are proposing to use controlled blasting methodologies at certain locations between the Pyrmont Bridge Road Ancillary Facility and the Northcote Ancillary Facility where the geology is such that controlled blasting provides a more efficient means of excavation then excavation using road headers or rock breakers. An area of particularly hard rock has been encountered to the north of Pyrmont Bridge Road Ancillary Facility roughly under Johnston Street Annandale.

In order to determine if controlled blasting is viable the attenuation of vibration over distance in the relevant geology must be tested by way of a trial. An appropriate trial location has been identified, as shown in **Appendix B**.

The primary factors known to influence the level of ground vibration from blasting include:

a) The weight of explosive per delay;

b) The distance between the blastholes and the point of measurement;

c) The local geological conditions and the influence of geology and topography on vibration attenuation.

Consistent with the recommendations of the Australian Standard AS2187.2 – Use of Explosives[1], the most common form of the vibration equation to predict the amplitude of ground vibration from blasting at any distance from the blasthole and is given as:

$$PPV = K\left(\frac{d}{\sqrt{w}}\right)^{-\beta}$$

Where:

- d is the distance between the blastholes and the point of measurement;
- w is the maximum instantaneous charge weight per delay;
- K and β are site specific constants.

The K and β are site specific constants that are determined through a trial blast at reduced maximum instantaneous charges (MIC). Once these constants are determined, the relationship between the level of vibration, the quantity of explosive, the amount of rock that will be removed and the distance from the blast can be estimated.

Production blasting is an expensive and time consuming excavation methodology; trial blasting is undertaken in order to determine if the quantities of rock removed per blast is economically viable.

3.2 Blasting Program & Regularity

Upon issuing of this TBMS to DPIE and with all other licensing, approvals and documentation being in place **a trial blast is proposed to occur in July 2020**. The trial blast will be undertaken by **detonating 3 blastholes with reduced MICs over a single day.**

The trial blast will be carried out as per the following hours:

- *9:00 am to 5:00 pm, Monday to Friday, inclusive.*

3.3 Trial Blast Design

As detailed above, due to the location of the trial blasts deep underground and away from the tunnel portal, vibration, and not air blast overpressure, will be the key impact to be monitored.

The trial blast will be completed in a representative geological area along the alignment. The trial blast will not provide any detail on fragmentation, but rather information on the vibration attenuation over distance. These relationships are integral in determining the scale of blasting (i.e. advance rate per day) that can be used.

A series of **three** blastholes will be drilled into the wall of the tunnel to a minimum depth of approximately 3 metres. Into each blasthole, a known quantity of explosive will be loaded and the remining section of the blasthole filled with inert stemming material to control the high-pressure explosive gases. The blastholes will be initiated separately with the results reviewed after each blast to check the vibration level and confirm the explosive loading for the next blast. It is likely that

[1] AS2187.2-2006, “Explosives – Storage, transport and use Part 2: Use of explosives”

therefore could be **several hours** between each blast to account for the analysis of the monitoring data and loading of the subsequent blast holes.

The key aspects include:

a) ***Objective*****:** The objective is to confirm the relationship between vibration level, distance and explosive quantity that will allow confirmation of the scale of blasting that can be undertaken.

b) ***Explosive weight*****:** Explosive weight will be low so as to provide the minimum acceptable level of vibration, **between 5mm and 10mm/s**, so as to gather data near but below that would be required for production blasting. Explosive weights at this level will assist in creating a site law that does not overly rely on extrapolation beyond the vibration levels experienced in the trial blasts.

c) ***Design*****:** The explosive type and trial blast location will be decided depending upon the area of the tunnel that has been advanced at the time of the blast. It is proposed that **three** trial blast holes will be fired.

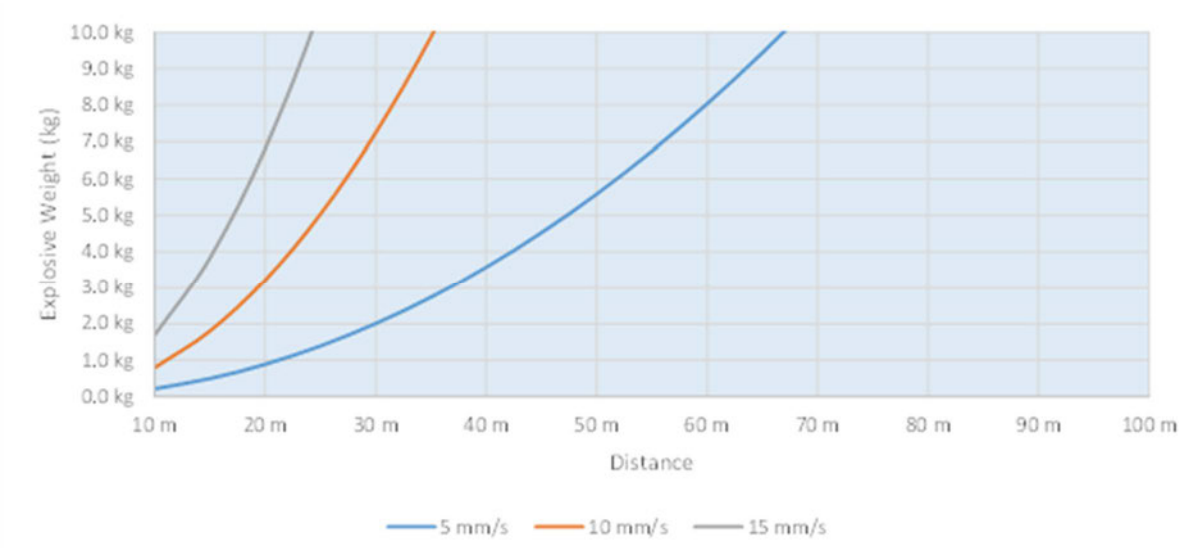
d) ***Firing Plan*****:** The preferable requirement is to initiate multiple holes at different times reviewing the vibration results before proceeding to load and initiate the next hole. This will provide the most relevant data as well as ensuring vibration levels remain compliant.

e) ***Monitoring locations*****:** The number and location of the vibration monitors will vary according to the blast location, however a minimum of **five locations** will be used. There will be no requirement to measure overpressure.

f) ***Analysis*****:** The measured vibration data will be analysed to develop the site-specific vibration relationship.

g) ***Report*****:** A technical letter including the data and analysis methods will be prepared.

The key deliverable for the project will be to confirm the EIS vibration relationship between distance, explosive weight and vibration level. This will control the scale of blasting and confirm the length of advance that can be achieved each day. The EIS relationship is shown below:



3.4 Intensity of blasting

The intensity of the trial blast (explosive weight) will be as low as possible to provide the minimum acceptable level of vibration, ideally between 5mm and 10mm/s so as to gather data near but below that would be required for production blasting. Explosive weights at this level will assist in creating a site law that does not overly rely on extrapolation beyond the vibration levels experienced in the trial blasts. The initial trial blast site law will be developed consistent with Sydney Harbour Tunnel reference project, as detailed in the Project EIS (page 279).

The intensity of the trial blasts will be managed to ensure the vibration performance criteria as specific in the EPL will be achieved.

Monitoring of the trial blast will be undertaken using specialised blast monitoring equipment to record the levels produced as detailed in the Trial Blast Monitoring Program.

3.5 Tunnel Clearance Procedures

All tunnel personnel will be evacuated to a safe working area prior to blasting within the tunnel. Safe working areas will be determined by the shotfirer and will comply with risk management procedures. These areas will contain a permanent source of fresh air and maintain positive means of egress in the event of an emergency. These locations are to be risk assessed individually and comply with WorkCover NSW Work Health and Safety requirements.

Personnel evacuation and tunnel clearance will be controlled by LSBJV under the direction of the shotfirer. An electronic monitoring system which can be monitored from the surface will be the primary means of personnel accountability. All LSBJV personnel, sub-contractors and visitors will use an electronic system as part of the site specific tunnel induction for personnel entering the tunnel area of works.

Blast sentries will be positioned at strategic locations as determined by the shot firer. These guards, under the supervision of the shot firer, will conduct a final tunnel clearance prior to initiation. Upon confirmation to the shotfirer and senior tunnel supervisors that all personnel are evacuated from the defined area as determined by the shot firer, the direction to commence firing procedures will be given. Initiation of the blast will be conducted by the shot firer only when they are satisfied that it is safe to commence firing. The shot firer will have full discretion to terminate the blast sequence at any time if it is determined unsafe to proceed.

Following the blast, tunnel ventilation will allow blast fumes to clear. This complies with the NSW “Tunnels Under Construction Code of Practice 2006” air quality and ventilation systems guidelines. When it is determined safe, the shot firer will inspect the blast location and determine correct detonation. Upon confirmation that the tunnel is safe to enter the all clear will be given by the shot firer and personnel allowed to re-enter the tunnel.

If it is deemed unsafe to enter the blast area, the shot firer will ensure relevant controls are implemented to neutralise and make safe the blast area and ensure geotechnical risks are managed before allowing personnel entry to the tunnel environment.

4 Trial Blast Management

4.1 Pre-Blast Activities

Prior to undertaking trial drilling and blasting, the following actions will be completed:

- Provide reasonable notice of intended blasting and the anticipated impacts on the nearby properties, occupants of these premises;
- Blasting notification to the NSW WorkCover covering the jurisdiction of the proposed blasting activities for the intended period of blasting;

- A condition survey report of adjacent infrastructure, including an assessment of any increased susceptibility of the infrastructure to vibration related effects;
- Preliminary review assessing the expected maximum explosive quantities for control of vibration.

4.2 Blast Notification

A blast notification form will be completed prior to undertaking blasting activities and submitted to the New South Wales WorkCover.

4.3 Design and Layout of Blastholes

Drilling of **three trial blastholes** will be completed using well maintained, hydraulic drill equipment.

Key aspects include:

- The shot firer blasting engineer will establish a drilling pattern, including blasthole depths, and record the information on a blast pattern design worksheet;
- The type and quantity of explosive which will be loaded into each blasthole will be identified and clearly marked on the plan;
- The total quantity of explosive for each blast will be calculated and reconciled against the designed quantity;

The nearest distance to the closest property, or other sensitive receiver or infrastructure, will be used to calculate the expected level of vibration.

4.4 Transport and Storage of Explosives

Transport and storage requirements for blasting activities will be defined by the drill and blast contractor and in accordance with the NSW Explosives Act 2003 and the NSW Explosives Regulation 2013.

Explosives will be stored off site under the appropriate authority license and delivered to site as required. No explosive will be stored on site. The quantity of explosive and detonators will be transported on the day of the blast from the magazines in approved vehicles. Any unused explosive will be returned to the magazine at the completion of loading.

4.5 Priming and Loading of the Blasthole

The following key issues will be included as part of the blasthole priming and loading methods:

- Prior to loading a blasthole, the shotfirer will confirm the depth of the blasthole is consistent with the depth indicated on the blasting plan depth.;
- Where blastholes are loaded with cartridge product, the diameter, length and number of cartridges will be recorded;
- The maximum quantity of explosive loaded into any blasthole will be reported on the blast loading plan;
- The total quantity of explosive loaded into the blast will be reconciled against the quantity indicated on the submitted blast plan. Where the quantities differ, a comment for the variation will be included on the blast loading plan and confirmed as acceptable prior to initiating the blast.

4.6 Initiation

Blasting, including the loading, stemming and sequencing of blastholes will be completed in accordance with all appropriate NSW legalisation. Key issues include:

- The shotfirer will determine the tie up;
- The blast pattern will indicate the proposed tie up sequence, clearly identifying the different delay elements that will be used. This will be used to confirm the explosive quantity will comply with accepted vibration level at the nearest potentially sensitive receiver;
- A timing sequence will be shown and calculate the maximum instantaneous explosive quantity. This quantity of explosive (MIC) will be clearly identified on the loading plan;
- When the total shot has been tied in, all connections will be checked.

4.7 Firing

Firing of the blast will be under the control of the shotfirer. The following key issues will be confirmed:

- The community team have informed the potentially affected persons of the intent to blast;
- The area will be inspected to ensure all personnel are a safe distance from the blasting activities;
- Put in place all control points to block access to the tunnel, including internal access other than ramps, at a safe distance from the blast area. The safe distance will be determined through standard risk assessment procedures;

4.8 Misfires

Should there be a cut-off (severing of the leads to the detonators, either surface or in-hole) during the blast, compliance with the NSW Explosives Act (2003) will be followed. The following checks for cut-offs will be implemented:

- After the blast is fired and the tunnel area has been adequately ventilated, the shotfirer will visually inspect entire shot for evidence of misfires.
- If found, the shotfirer will notify LSBJV immediately along with the blast guards;
- The shotfirer will decide if it is safe to re-fire shot;
- The same method of initiation will be used.

If a misfire (unexploded explosive) is detected during excavation:

- Stay well clear;
- Warn all personnel in the area;
- The project area supervisor will notify the shotfirer immediately;
- A detailed and safe excavation plan will be formulated and implemented.

4.9 Record Keeping

Maintain accurate records of each blast including the details listed below:

a) Date, identification number and time of blast;

b) Location, number and diameter of blast holes loaded;

c) Depth of each drill hole loaded;

d) Inclination of drill holes;

e) Burden(s) and spacing(s);

f) Types and amounts of explosives used;

g) Maximum instantaneous charge;

h) Initiation Plan;

i) Length and type of stemming in each blast hole;

j) Ground vibration at measuring locations.

The records must be written as the holes are loaded, and must be signed by the shotfirer. Provide a copy of the records to the Project Verifier and RMS Representative on the day of the blast.

4.10 Reconciliations and Reporting

The following documents will be compiled:

- A pre-blast sheet confirming that the expected level of vibration at each of the nearest sensitive receivers complies with the vibration limits;
- A completed drilling sheet prepared by the shotfirer showing the measured depth of each blasthole. The sheet will identify and clearly mark any “anomalous” blastholes;
- A blast loading plan showing the depth of each blasthole, quantity of explosive in each blasthole and the uncharged stemming length. The initiation sequence will also be shown.
- Reconciled explosive quantities used versus the designed quantity will also be shown and any variations accounted for;
- A signed blast summary sheet showing that each of these forms been received and no variations between the intended and implemented design exist.

These actions are in accordance with the specifications listed in the Australian Standards AS2187.2 document.

5 Community and Environmental Management

5.1 Property Condition Surveys

Due to the trial blast only using small amounts of MIC, resulting in low levels of vibration, the current property condition surveys boundary of 50m from each side of the tunnel is more than adequate to cover properties at a remote risk of damage.

The condition surveys will contain photographs of the inspected properties and include details of the inspectors’ qualification and expertise, together with a list of any identified defects, where relevant. The reports must be submitted to WestConnex Transurban as per the Hold Point requirements detailed in Section 2.6.

5.2 Community consultation and notification

A Community Communications Strategy (CCS) has been prepared in accordance with CoA B2 to provide an approach to stakeholder and community communications. In accordance with TfNSW Specification G36 Cl 3.7.2, the CCS also includes the process for notifying external stakeholders of new, changed or upcoming construction works.

The CCS has been approved by DPIE prior to the commencement of works, for implementation in accordance with CoA B3. All community consultation, notification and complaints management associated with blasting will be undertaken in accordance with the CCS. The notification will include complaints and enquiries contact information, as required by the EPL.

All residents within the catchment presented in the Appendix B of proposed trial blasting will be notified in writing, as well as any other relevant parties, before blasting commences. Notification will include the likely times, information on expected levels of vibration, frequency and duration of blasting and mitigation measures being implemented.

5.3 Respite

As Per CoA E100 and the Project EPL, trial blasting will only be undertaken during limited windows of opportunity. This allows respite for potentially impacted receivers.

5.4 Monitoring

A Trial Blast Monitoring Program has been prepared to describe how the LSBJV proposes to conduct the monitoring of the trial blast.

The Trial Blast Monitoring Program will be prepared in consultation with EPA and be approved by DPIE prior to commencement of trial blast.

6 Document Review and Approval

6.1 Internal consultation

The development of the TBMS and Trial Blast Monitoring Program involved detailed review of the documentation by LSBJV Environmental Managers, Construction Managers, the Environment and Sustainability Manager and finally the Project Director.

Following LSBJV satisfaction of the documents, a review process was completed with WestConnex Transurban (WCX), TfNSW, Acoustic Advisor (AA) and Environmental Representative (ER) prior to submission of the document to the Department of Planning, Industry and Environment (DPIE).

6.2 External consultation

External consultation for this TBMS was undertaken with EPA as required under CoA E98, to ensure that all blasting and associated activities are carried out so as not to generate unacceptable noise and vibration impacts or pose a significant risk to sensitive receivers. A separate document, Stakeholder Consultation and Comments Tracking Register, has been prepared to detail the consultation response and how stakeholder comments were addressed in accordance with CoA A6.

As required by the CoA E99, this TBMS along with the Stakeholder Consultation and Comments Tracking Register, will be submitted to the Secretary for information one month prior to blasting.

The LSBJV Environment and Sustainability Manager will be the authorised contact person for communications with the relevant stakeholders i.e. TfNSW, WestConnex Transurban, DPIE and the EPA on environmental matters. Liaison will include reporting on the ongoing environmental performance and key environmental matters on the Project to these stakeholders.

In accordance with the TfNSW Specification G36 requirements, two persons have been nominated as available to be contacted by the EPA on a 24-hour basis. For the Project, the LSBJV Project Director and the Environment and Sustainability Manager will be these 24-hour contacts and will be the key emergency response personnel during an environmental site emergency. In accordance

with the TfNSW Specification G36 requirements these two LSBJV staff have the authority to take immediate action to shut down any activity, or to affect any pollution control measure, as directed by an authorised officer of the EPA.

6.3 Review and endorsement

In accordance with CoA E97, this TBMS must be endorsed by a suitably qualified and experienced person and reviewed by an independent specialist.

In accordance with CoA A26(d) the AA must review all noise and vibration documents required to be prepared under the Project Approval and endorse as appropriate prior to submission to the Secretary. Following endorsement from the AA this CBMP will be submitted to DPIE for information.

Appendix A – RMS Specification requirements

Ref	Requirement	How Addressed
R44		
4.6.1	Comply with the requirements of Specification RMS D&C G36 for ground vibration and airblast.	Refer to reference for G36 below.
	The Hold Point in Specification RMS D&C G36 for the submission of the Vibration and Airblast Management Sub-Plan and the Building Condition Inspection Reports applies prior to the commencement of blasting.	Refer to reference for G36 below.
	Include in the Vibration and Airblast Management Sub-Plan a detailed procedure to be followed in the event of a misfire of the charges.	Section 4.8
	Comply with all Government regulations relating to transport, storage, handling and the use of explosives and AS 2187 Parts 1 and 2. Comply also with the requirements of external agencies including, but not limited to, the Environment Protection Authority and the WorkCover Authority, and demonstrate compliance.	Section 2.4 Section External consultation
	Prior to commencement of any blasting activities, obtain all necessary approvals and licences from the appropriate authorities.	Section 2.3, 2.4
	Hold Point (refer to document Section referenced for full detail).	Section 2.6
	Do not use exposed detonating cord in built-up areas.	Detonating cord not to be used
	When blasting operations are being carried out, take precautions relating to the safety of persons and animals. Close any roads likely to be affected by the blasting to traffic and erect the appropriate signs in accordance with Specification RMS D&C G10. Establish a standard warning procedure such as that given in the NAASRA Explosives in Roadworks Users Guide 1982 and observe the procedure at all times.	Section 2.4
	Implement and maintain a community liaison program during blasting activities to keep the community in the vicinity of the Project Works informed of any such activities. Provide information on expected levels of vibration or airblast.	Section 5.2

Ref	Requirement	How Addressed
	For each blast, notify in writing all residents within a radius of 1 km from the location of the proposed blasting, and any other relevant parties, before blasting commences. Notification must include the likely times, frequency and duration of blasting and precautions being taken to ensure that damage to property will not result.	Section 5.2
	Confine your blasting operations to the weekdays of Mondays to Fridays but excluding public holidays, between the hours of 9 am and 3 pm.	Section 3.2 discusses CoA requirements, which supersede this clause.
	Do not detonate a blast prior to the time that has been announced for that blast.	Section 3.2
	Monitor and report the building(s) condition during the blasting operations.	Section 5.1
4.6.2	Maintain accurate records of each blast including the details listed below. (*refer to section referenced in this document for full condition*).	Section 4.9

<table>
<tr><th>Ref</th><th>Requirement</th><th>How Addressed</th></tr>
<tr><td>4.6.3</td><td>The airblast (noise) emanating from blasting operations must not exceed the limits in Annexure R44/A7 (excerpt below) at any noise sensitive location, measured at the noise monitoring location nearest to the noise sensitive location. In general, a monitoring location will be sited at the perimeter of the noise sensitive location at the point closest to the maximum charge.

Limiting Blast Overpressure and Peak Particle Velocity:

<table>
<tr><th>Point of Potential Damage
(within 1 km from the proposed blast site)</th><th>Blast Overpressure Level
(dB[linear])</th><th>Peak Particle Velocity (1)
(mm/s)</th></tr>
<tr><td>Completed and cured bridge structures or substructures (e.g. completed abutment)</td><td>–</td><td>10 mm/s</td></tr>
<tr><td>Bridgeworks and structural retaining walls under construction</td><td>–</td><td>10 mm/s</td></tr>
<tr><td>Residential premises, schools, hospitals and other buildings</td><td>115 dB (2)</td><td>5 mm/s (2)</td></tr>
<tr><td>Building or monument of historical significance</td><td>115 dB</td><td>2 mm/s</td></tr>
</table>
Notes:
(1) Peak Particle Velocity is the vector peak particle velocity, defined as the maximum of the resultant vector particle velocity v_p and is the amplitude of the vector sum of three time-synchronised velocity components directly measured by an instrument.
v_p is determined by the equation $v_p = \sqrt{(v_x^2 + v_y^2 + v_z^2)}$,
where v_x, v_y and v_z are the synchronized instantaneous velocity components in the x, y and z axes respectively.
(2) 5% of readings may exceed 115 dB and 5 mm/s but must not exceed 120 dB and 10 mm/s.</td><td>Section 3.3
Section 5.4</td></tr>
</table>

Ref	Requirement	How Addressed
	Carry out monitoring of airblast to verify that the specified limits are not exceeded. The equipment used for such monitoring must be calibrated annually by a NATA accredited testing facility or manufacturer's facility approved by the RMS Representative. All readings from the monitoring must be reported on test certificates, which must indicate clearly compliance or non-compliance with the requirements of this Specification. Provide a copy of the monitoring record to the RMS Representative.	Section 3.1
	In the event that the measured airblast exceeds the specified limits, suspend further blasting work and take additional steps and precautions to ensure that, for any future blast, the limiting airblast must not be exceeded. Do not resume any blasting until details of the additional steps and precautions have been provided to the RMS Representative.	Section 3.1

<table>
<tr><th>Ref</th><th>Requirement</th><th>How Addressed</th></tr>
<tr><td>4.6.4</td><td>Carry out monitoring of ground vibrations to verify compliance with the limits stated in Annexure R44/A7 (excerpt below). In general, a monitoring location will be sited at the perimeter of the structure or building at the point closest to the maximum charge. The measurement process for determining verification of compliance with the ANZECC criteria must be in accordance with AS 2187.2.

Limiting Blast Overpressure and Peak Particle Velocity:

<table>
<tr><th>Point of Potential Damage
(within 1 km from the proposed blast site)</th><th>Blast Overpressure Level
(dB[linear])</th><th>Peak Particle Velocity (1)
(mm/s)</th></tr>
<tr><td>Completed and cured bridge structures or substructures (e.g. completed abutment)</td><td>–</td><td>10 mm/s</td></tr>
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<tr><td>Building or monument of historical significance</td><td>115 dB</td><td>2 mm/s</td></tr>
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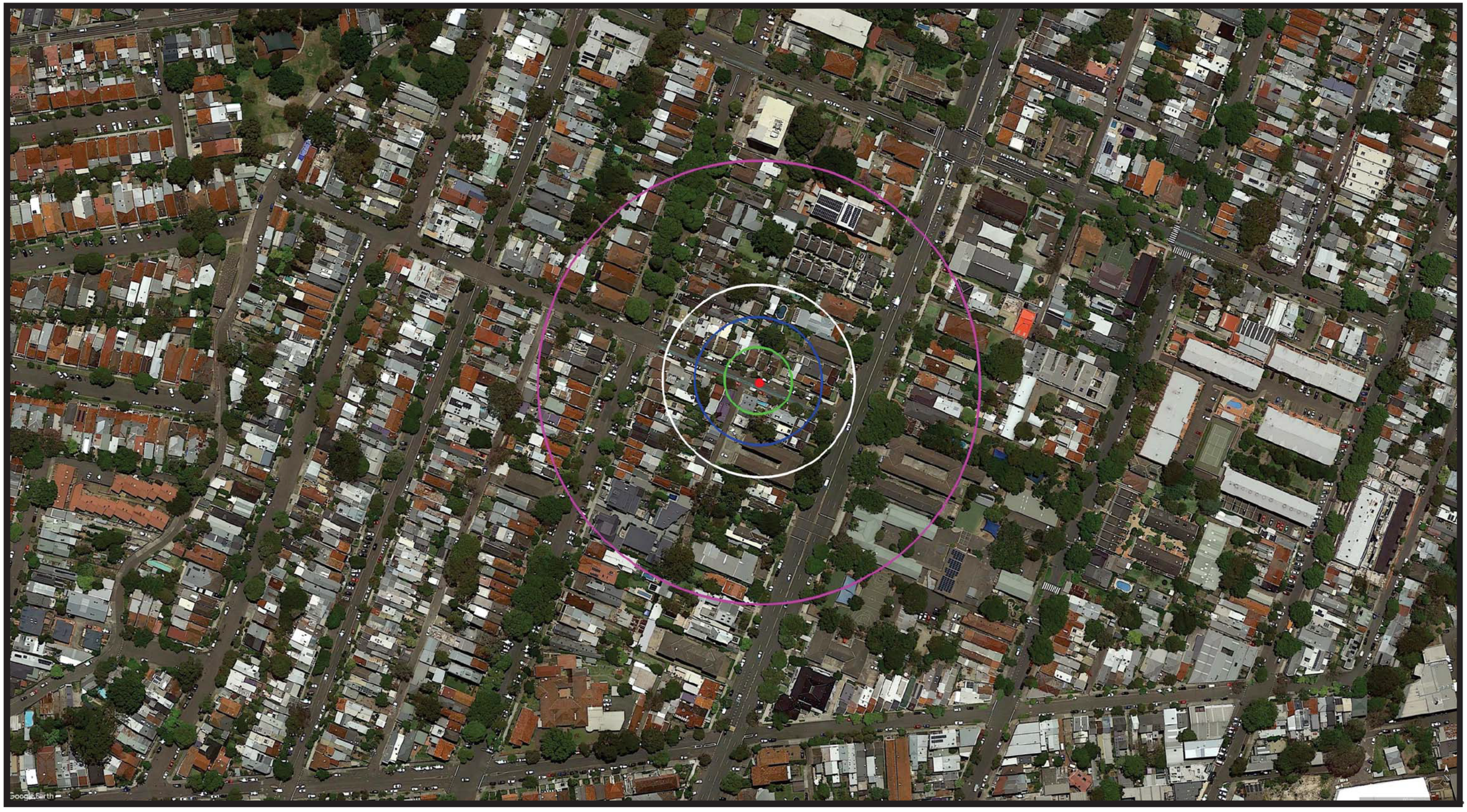
v_p is determined by the equation $v_p = \sqrt{(v_x^2 + v_y^2 + v_z^2)}$,
where v_x, v_y and v_z are the synchronized instantaneous velocity components in the x, y and z axes respectively.
(2) 5% of readings may exceed 115 dB and 5 mm/s but must not exceed 120 dB and 10 mm/s.</td><td>Section 5.4</td></tr>
</table>

Ref	Requirement	How Addressed
4.6.4	The equipment used for monitoring must be calibrated annually by a NATA accredited testing facility or manufacturer's facility approved by the RMS Representative. All readings from the monitoring must be reported on test certificates, which must indicate clearly compliance or non-compliance with the requirements of this Specification. Provide a copy of the monitoring record to the RMS Representative.	Section 5.4
4.6.4	To minimise the risk of peak particle velocity limits being exceeded, develop a blasting site relationship between peak particle velocity, distance and blasting charge.	Section 3.1
4.6.4	For the first blast, set up monitors at not less than five points, at varying distances away from the blasting site. The Maximum Instantaneous Charge for the first blast must not exceed that calculated from the following formula: $$MIC = 0.5\left[\frac{D}{\left[\frac{p.p.v.}{1140}\right]^{-0.625}}\right]^2$$ where MIC = Maximum Instantaneous Charge, in kilograms D = Distance in metres from charge to the point of potential damage $p.p.v$ = limiting peak particle velocity from Annexure R44/A7	Section 5.4
4.6.4	For subsequent blasts, the charge weight and other aspects of blast design may be adjusted provided that further ground vibration monitoring is undertaken and the blasting site relationship re-determined to demonstrate that charge weight limits are not exceeded. Make the graphs available to the RMS Representative, if so requested.	Section 3.1
G36		

Ref	Requirement	How Addressed
4.7	For any blasting activities, comply with the requirements of the ANZECC publication "Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration - September 1990". Where the amenity guidelines are likely to be exceeded, manage the impacts in consultation with, and in accordance with, the requirements stipulated by EPA.	Section 2.7
	The measurement process for determining verification of compliance with the ANZECC criteria will be in accordance with AS 2187.2 Explosives - Storage, Transport and Use, Appendix J - Ground Vibration and Airblast (Informative).	Section 4.4
	Meet the requirements of EPA "Environmental Noise Management Assessing Vibration: A Technical Guideline". Where the requirements are likely to be exceeded, manage the impacts in consultation with, and in accordance with, the requirements stipulated by EPA.	Section 2.7
	To avoid structural damage, carry out construction activities in accordance with the requirements of BS 7385.	Section 2.7
	Where there is a risk that vibration or air blast activities may cause damage to nearby structures and buildings or if these are located within the distance from the construction activity specified in Annexure G36/E, undertake a building condition inspection and prepare a Building Condition Inspection Report for every property or structure likely to be affected.	Section 5.1
	The Building Condition Inspection Reports must contain photographs of the inspected properties and include details of the inspectors' qualification and expertise, together with a list of any identified defects, where relevant. The reports must be submitted to the owner of each property and to the RMS Representative before the commencement of any activities as outlined in the Hold Point below.	Section 5.1
	Prepare, as part of the CEMP, a Vibration and Air Blast Management Sub-Plan as part of the CEMP, or include mitigation strategies within the CEMP, that describes the environmental controls to be implemented during construction to minimise the impact of vibration and air blast on adjacent properties and residents.	Section 2.6
	The Vibration and Air Blast Management Sub-Plan or mitigation strategies must detail how construction vibration and air blast will be managed for various plant items working adjacent to buildings. Keep records as evidence of compliance with these construction vibration and air blast restrictions.	Section 2.6

<table>
<tr><th>Ref</th><th>Requirement</th><th>How Addressed</th></tr>
<tr><td></td><td>Where blasting is not required for the Work Under the deed, vibration mitigation and management measures may be incorporated into a combined Noise and Vibration Management Sub-Plan.</td><td>Section 2.6</td></tr>
<tr><td></td><td>Hold Point (refer to document Section referenced for full detail).</td><td>Section 2.6</td></tr>
<tr><td>ANNEXURE G36/E</td><td>Carry out a Building Condition Inspection for each public utility, structure and building within the distance from the appropriate activity listed below; however, where the risk of damage to an item is assessed to be very low, the requirement for a Building Condition Inspection may be waived with the RMS Representative's agreement.
<table>
<tr><th>Activity</th><th>Distance</th></tr>
<tr><td>Blasting Operations</td><td>(e.g. 500 metres)</td></tr>
<tr><td>Pile Driving</td><td>(e.g. 200 metres)</td></tr>
<tr><td>Excavation by hammering or ripping</td><td>(e.g. 100 metres)</td></tr>
<tr><td>Vibrating Compaction > 7 tonne plant</td><td>(e.g. 50 metres)</td></tr>
<tr><td>Vibrating Compaction < 7 tonne plant</td><td>(e.g. 25 metres)</td></tr>
<tr><td>Demolition of Structures</td><td>(e.g. 50 metres)</td></tr>
</table></td><td>Section 5.1</td></tr>
</table>

Appendix B – Trial Blast Vibration Contour Drawing & Community Notification Catchment



Created using TunnelTRAP Software

Blast area

SCALE

0 25 50 75 100 125m

Vibration Levels

- Expected 2 mm/s Vibration Contour
- Expected 4 mm/s Vibration Contour
- Expected 5 mm/s Vibration Contour
- Expected 6 mm/s Vibration Contour
- Expected 8 mm/s Vibration Contour
- Expected 10 mm/s Vibration Contour

Project Description: WESTCONNEX STAGE 3A - Modelled vibration contours from trial blast based upon an explosive weight of 8 kilograms. Modelling based upon EIS vibration relationship with K=135 and ą=-1.08

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WestConnex M4-M5 Link Tunnels

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Plate No. 4

Date Drawn: 16 July 2020

Revision History
V1: Original

Ref No: WestConnex Stg 3A Trial XP32

Job No: HP2006-1

In preparing this drawing, HP have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request were complete, accurate and up to date. Where we have obtained information from a Government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware why any of the assumptions are incorrect.