Kings Hill Water and Wastewater Infrastructure

Noise and Vibration Assessment

S180828RP1 Revision A

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Resonate

Document Information

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Revision Table

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0	19 August 2019	Draft Issue	Ben Masson	Andrew Parker
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Glossary

'A' Weighted	A spectrum adaption that is applied to measured noise levels to approximate human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm, as defined in the NPI. (See NPI)
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Evening	Between 6 pm and 10 pm, as defined in the NPI. (See NPI)
Feasible and reasonable	Consideration of best practice noise and vibration mitigation measures taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.
Frequency	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.
Hz	Hertz—units of frequency.
L_{eq}	Equivalent Noise Level—energy averaged noise level over the measurement time.
Leq, (15 min)	A-weighted energy averaged noise level over a 15-minute period. Used in the EPA Interim Construction Noise Guideline (ICNG).
Leq, (15 hour)	A-weighted energy averaged noise level over the 15-hour daytime period from 7 am to 10 pm. Used in the EPA Road Noise Policy (RNP).
Leq, (9 hour)	A-weighted energy averaged noise level over the 9-hour night-time period from 10 pm to 7 am. Used in the EPA Road Noise Policy (RNP).
mm/s	Millimetres per second—unit of vibration velocity.
$m/s^{1.75}$	Units of VDV.
Night-time	Between 10 pm on one day and 7 am on the following day, as defined in the NPI. (See NPI).
Noise Management Level (NML)	Construction noise management level. Where the construction noise levels are above the NML, additional consideration of feasible and reasonable noise mitigation is required.
NPI	New South Wales EPA Noise Policy for Industry, 2017.
Peak Particle Velocity (PPV)	The maximum speed of a particle in a particular component direction due to vibration during a measurement.
Rating Background Level (RBL)	The Rating Background Level for each period is the median value of the average background values for the period over all of the days measured. There is an RBL value for each period (day, evening and night).
Vibration	Refers to the oscillation of an object back and forth, normally the ground.
Vibration Dose Value (VDV)	A measure used to assess the level of vibration over a defined time period, such as a day, evening or night. Often used for the assessment of intermittent construction vibration that may rise and fall across a day.

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1 Introduction

Resonate Consultants Pty Ltd (Resonate) has been engaged on behalf of Arcadis Australia Pacific Pty Ltd to provide a noise and vibration specialist study for inclusion into the Kings Hill Water and Wastewater Infrastructure Proposal Environmental Impact Statement (EIS).

This objective of this report is to identify, assess and recommend mitigation measures for potential construction and operational noise and vibration impacts associated with the proposal.

1.1 Project Background

Kings Hill Development Pty Ltd (KHD) is seeking approval for the development of a water and waste water supply pipeline and a waste water pumping station (the Proposal) to support the development of the Kings Hill Urban Release Area (Kings Hill URA). The Kings Hill URA was rezoned in 2010 to support a mix of general residential, mixed use and local centre land uses. It is expected to comprise in excess of 3,500 residential dwellings developed over a twenty-five-year period. Key development features of the Kings Hill URA will also include the provision of utilities and supporting infrastructure, including a Pacific Highway grade separated interchange, stormwater channel and water and wastewater infrastructure. There is currently no water and wastewater infrastructure present with the capacity to service Kings Hill URA.

1.2 Proposal Site

The Proposal is located within Port Stephens Local Government Areas (LGA), approximately 4 kilometres north of Raymond Terrace, 25 kilometres north of Newcastle and 135 kilometres north of Sydney. The Proposal stretches approximately 6.7 kilometres (the Proposal Site) between Raymond Terrace in the south, and Kings Hill URA in the north. The location of the Proposal site is shown in Figure 1.

Figure 1 Proposal location

The Proposal Site includes the footprints of the wastewater pumping station, water pipeline and wastewater pipeline, in addition to buffer areas and temporary construction compounds.

1.3 Proposal Description

An Environmental Impact Statement (EIS) to be prepared for the Proposal seeking approval as Designated Development under Part 4 of the *Environmental Planning and Assessment 1979* (EP&A Act).

The key compounds of the Proposal would include:

- Installation of a water and wastewater pipelines, approximately 6.7km and 4.2km in length, respectively. These pipelines would be located within a joint corridor. This would require vegetation clearing, trenching and underboring for the pipes to be laid.
- Construction of a wastewater pumping station (WWPS) within the eastern catchment of Kings Hill URA, including installation of electrical components, mechanical installations of pumps, valves and fittings, and construction of adjacent hardstand areas.
- Restoration of area upon completion of pipe laying, including backfilling the trench and restoring all surfaces to their pre-construction condition where practicable.
- Connection of the proposed infrastructure to existing Hunter Water services.

The water pipeline would connect to existing Hunter Water infrastructure in the south and the Kings Hill URA in the north, while the wastewater pipeline would connect to the proposed WWPS in Kings Hill URA and existing Hunter Water infrastructure in the south.

The wastewater infrastructure included in the Proposal is discussed below:

A WWPS would be designed and constructed in accordance with Hunter Water Corporation's (HWC) specifications within the south-eastern portion of Kings Hill URA. Underground infrastructure would generally include (but not be limited to):

- An induct and educt vent pipe
- Stop valves and reflux valves
- A valve pit
- A wet well constructed of concrete with gas-tight cover
- A collecting maintenance hole and flow relief structure pipework
- Water service pipes
- Electrical conduits and connections.

Above ground infrastructure would include:

- An induct vent cover
- An educt vent stack
- A valve pit cover
- A maintenance hole cover
- The outlet point of the flow relief structure
- A water meter
- A standpipe and yard tap
- Septicity management system
- An electrical switchboard and connection box
- A concrete hardstand area and access track
- Security fencing, gates and/or chains, as required.

A flow relief structure would be incorporated into the WWPS design as an emergency precaution due to the potential for sewer overflows to occur. The structure would ensure flow relief occurs at a planned rather than an unplanned location. The exact location of the WWPS would be determined during detailed design. Figure 2 identifies the area within which a final location would be chosen. A pump station design report would be issued to HWC for review and approval during detailed design. This report would consider multiple aspects as required by HWC guidelines, including a separate Emergency Relief Overflow Structure Report that would provide further detail on the Emergency Relief Structure (ERS).

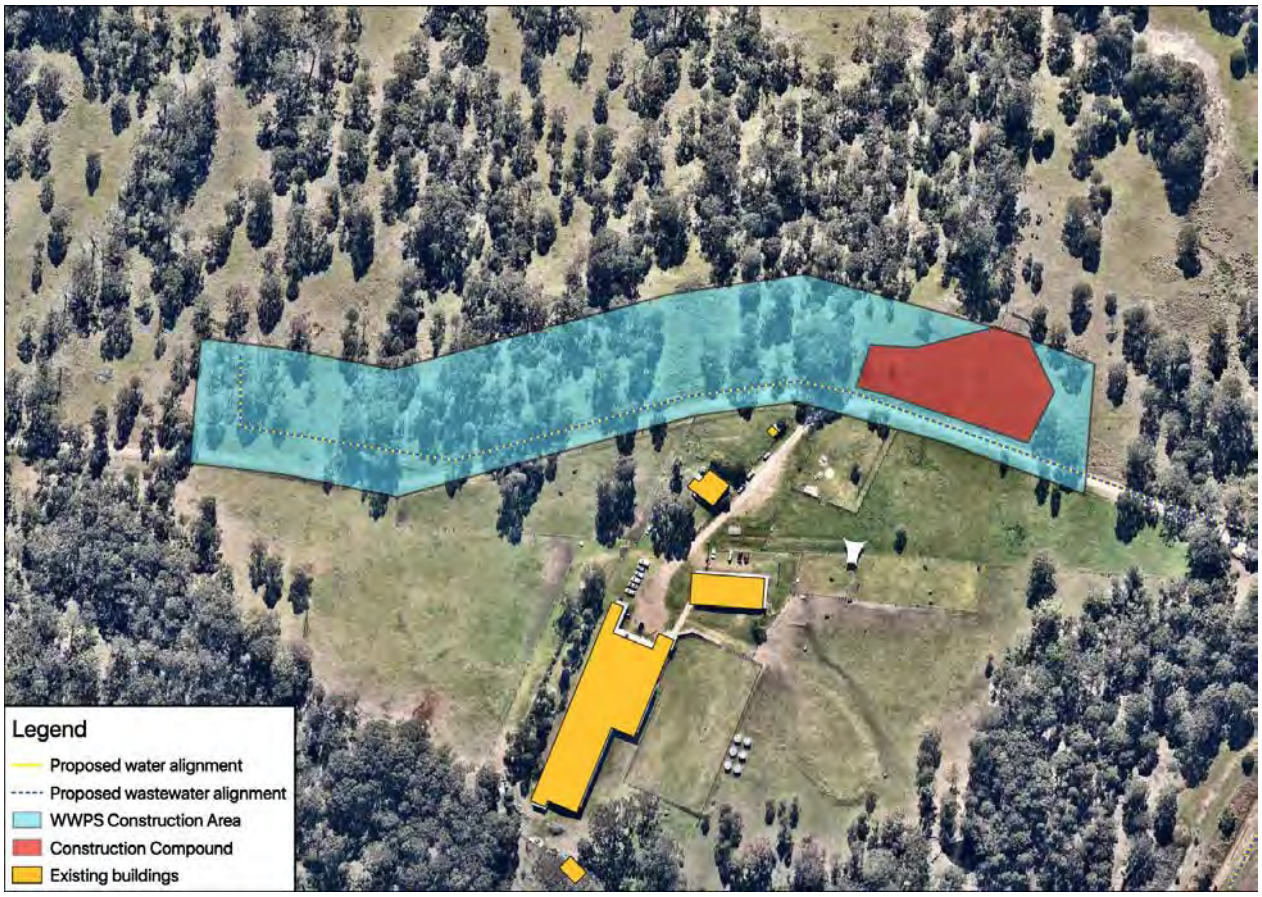


Figure 2 Area for WWPS construction

2 Existing ambient noise environment

2.1 Noise monitoring

Unattended noise monitoring was conducted between Tuesday 30th July 2019 and Wednesday 14th August 2019. Due to a noise logger being damaged by wildlife, additional unattended monitoring was conducted in Location 1 between 5th Sept2019 and 17th September 2019. Unattended and attended noise measurements were undertaken to determine the existing ambient noise levels at the Proposed site.

The existing ambient acoustic environment is controlled by road traffic noise from the Pacific Highway and surrounding local roads as well as wildlife noise including birds.

2.2 Equipment

Noise logging was conducted using Rion NL-42 and Rion NL-52 noise loggers bearing the serial numbers 820994, 946978, 946983 and 946974. Field calibration was conducted at the commencement and conclusion of the logging period and no significant calibration drift was observed.
The noise logger was configured to record all relevant noise indices, including background noise (L_{A90}) and equivalent continuous noise levels (L_{Aeq}). Samples were accumulated at 15-minute intervals. The time response of the logger was set to 'fast'.

Attended measurements were conducted using a Bruel & Kjaer 2250 sound level meter bearing the serial number 2506777. Field calibration was conducted before and after the measurements and no significant calibration drift was observed. Each measurement was for a period of 15 minutes with the time response of the meter set to 'fast'.

Noise measurements were taken in general accordance with Australian Standard AS1055.1 *Acoustics-Description and measurement of environmental noise*.

2.3 Weather conditions

It is a requirement that noise data is captured during periods of favourable weather conditions avoiding adverse impacts of wind and rain on background noise levels. In order to assess weather conditions for the measurement period, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) weather observation station IDN 601801 at William Town.

Noise data has been excluded from the processed results if:

- Rain was observed during a measurement period, and/or
- Wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground.

The BOM wind speed data obtained for this report was measured at a height of 10 m above ground level. It is therefore necessary to apply a correction factor in order to estimate the wind speed at the height of the logger (1.5 m).

The methodology to formulate a correction factor has been derived[1]. The correction multiplier for the measured wind speed at 10 m is derived by the following formula:

$$W_{1.5} = W_{10} \times \left(\frac{M_{1.5,cat}}{M_{10,cat}} \right)$$

where:
$W_{1.5}$ = Wind speed at height of 1.5 m
W_{10} = Wind speed at height of 10 m
$M_{1.5,cat}$ = AS 1170 multiplier for receiver height of 1.5 m and terrain category
$W_{10,cat}$ = AS 1170 multiplier for receiver height of 10 m and terrain category

[1] Gowen, T., Karantonis, P. & Rofail, T. (2004), Converting Bureau of Meteorology wind speed data to local wind speeds at 1.5m above ground level, Proceedings of ACOUSTICS 2004

Noise logging data that has been excluded due to adverse weather conditions is identified in the overall summary and daily noise logging graphs presented in Appendix A.

2.3.1 Noise measurement locations

Unattended noise logging was conducted at the locations labelled L1 to L4 as shown on Figure 3. Operator attended noise measurements were conducted at the locations labelled A1 to A4 as shown in Figure 3.

Figure 3 Attended and unattended noise monitoring locations

2.4 Noise measurement results

2.4.1 Unattended noise measurement results

Unattended noise monitoring was conducted to establish the existing ambient noise environment for the purpose of this noise assessment report at locations representative of the nearest sensitive receivers. The resultant noise levels are summarised in Table 1. Detailed noise logger graphs and information describing each measurement location are provided in Appendix A.

Table 1 Unattended noise measurement results

Noise logger location label	Rating Background Level (RBL), dB(A) L_{90}[1]			Ambient noise level, dB(A) L_{eq}		
	Day 7 am—6 pm	Evening 6 pm—10 pm	Night 10 pm—7 am	Day 7 am—6 pm	Evening 6 pm—10 pm	Night 10 pm—7 am
L1 (Near 3219 Pacific Hwy)	48	48[2]	40	58	58	56
L2 (Near 34 Rees James Rd)	45	43	38	61	58	52
L3 (Near 8 Rees James Rd)	42	41	33	59	59	49
L4 (17F Irrawang St – Raymond Terrace Vacation Care)	45	38	37	58	52	50

(1) The Rating Background Level is a measure of the typical minimum steady background noise level for each time of day.

(2) The measured RBL for the evening period at Location 1 was 50 dB(A). It has been reduced to equal to the daytime RBL in-line with the procedure of the NPI.

2.4.2 Attended noise measurement results

Table 2 below provides a summary of the attended noise measurement results.

Table 2 Operator-attended short-term noise measurement results summary

Attended measurement location label	Length (min:sec)	L_{eq} dB(A)	L_{Fmax} dB(A)	L_{10} dB(A)	L_{90} dB(A)
A1 - Daytime	15:00	55	64	57	51
A2 – Daytime	15:00	53	66	56	49
A3 – Daytime	15:00	54	74	52	38
A4 – Daytime	15:00	47	62	51	41

Notes and observations taken during the attended noise measurements are presented in Table 3.

Table 3 Notes taken during attended measurements

Attended measurement location	Notes
A1	The noise levels, measured in the free field, were controlled by distant traffic noise from the Pacific Highway and the local road. There was presence of nature sounds. The maximum sound level was generated by one passing jet fighter.
A2	The noise levels, measured in the free field, were controlled by distant traffic noise from the Pacific Highway. The maximum sound level was generated by a car passby on the nearby local road.
A3	The noise levels, measured in the free field, were controlled by distant traffic noise from the Pacific Highway and Adelaide Street. Sparse traffic on Rees James Road. The maximum sound level was generated by a car passby on the nearby local road.
A4	The noise levels, measured at 1 metre from the façade, were controlled by local traffic noise from Irrawang Street. Sparse traffic on Rees James Road. The maximum sound level was generated by a car passby on the nearby local road.

2.5 Noise catchment areas

Four Noise Catchment Areas (NCAs) have been determined to be relevant for this Proposal, given the similarity of nearby sensitive receivers (both in ambient noise environment and type) that surround the Proposal site and those further offset. The majority of sensitive receiver buildings that surround the Proposal site are typically residential dwellings interspersed with commercial, educational and other non-residential receiver types.

These NCAs are shown on Figure 4 and described in Table 4.

Table 4 Description of receivers for each Noise Catchment Area

Noise Catchment Area	Location	Description of receivers within catchment
1	East and west sides of Pacific Highway.	• Medium to high density residential • Irrawang Public School • Irrawang High School • Muree Golf Club • Raymond Terrace Public School • Raymond Terrace wastewater treatment works
2	East and west side of the Pacific Highway extending from south of Richardson Road to the intersection Adelaide Street and Pacific Highway.	• Medium density residential • Church for the Nations • Grahamstown Public School • TLC Early Learning Centre • Raymond Terrace Baptist Church • Raymond Terrace Community Church
3	West of Pacific Highway and north of the intersection between Adelaide Road and Pacific Highway.	• Low to medium density residential
4	Surrounding the northern extent of the Proposal site.	• Low density residential • Riding for the Disabled Association, NSW • Future residential developments

Figure 4 Noise catchment areas

3 Construction noise and vibration criteria

3.1 Construction noise criteria

3.1.1 Interim Construction Noise Guideline (DECC)

The *Interim Construction Noise Guideline* (ICNG), prepared by the NSW Department of Environment & Climate Change (DECC) and released in 2009, details construction noise assessment criteria and calls for the application of feasible and reasonable measures to mitigate construction noise and vibration. For the purpose of this assessment, the ICNG has been used for the assessment of construction noise and vibration.

The ICNG defines various working hours for which different construction noise assessment procedures apply. Standard working hours, during which the majority of construction work will occur, are:

- 7 am to 6 pm, Monday to Friday
- 8 am to 1 pm, Saturday
- No work on Sundays or public holidays.

Any works outside of these hours would be classified as Out of Hours Works (OoHW).

The ICNG also prescribes noise management levels (NMLs) depending on the time that construction work is to be carried out. These NMLs should be achieved at noise sensitive locations where it is feasible and reasonable to do so.

3.2 Noise management levels

The ICNG outline methodologies for determining Noise Management Levels (NMLs) for construction work based on classification of potentially noise affected receiver land use type.

3.2.1 Residential and aged care land uses

Table 5 presents the NMLs for residential and aged care receivers for both standard working hours and periods outside of the standard working hours. The NMLs apply at the property boundary most exposed to construction noise. If the residence is more than 30 metres from the boundary, the NML applies to the most noise affected position within 30 metres of the residence.

Table 5 Noise Management Levels for residential land uses (ICNG)

Time of day	Noise Management Level (NML), $L_{Aeq(15\text{-}minute)}$	Description
Standard hours: 7 am to 6 pm, Monday to Friday 8 am to 1 pm, Saturday	Noise affected RBL +10 dB(A)	May be some community reaction to noise. Actions: Where the predicted or measured construction noise level exceeds the noise-affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.

Time of day	Noise Management Level (NML), $L_{Aeq(15\text{-}minute)}$	Description
	Highly noise affected >= 75 dB(A)	May be strong community reaction to noise. Actions: Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Out of Hours Work (OoHW)	Noise affected RBL +5 dB(A)	Actions: Strong justification typically required for these works. All feasible and reasonable work practices should be adopted. Where all feasible and reasonable work practices have been adopted and noise level is more than 5 dB(A) above the NML, negotiation should be undertaken with the community.

Out of hours works can cover day evening and night-time periods over the course of a week. Table 6 details the schedules of hours for OOHW day, evening and night.

Table 6 Schedule of construction hours

Standard Hours	Monday to Friday	7am to 6pm
	Saturday	8am to 1pm
OOHW Day	Saturday	7am to 8am & 1pm to 6pm
	Sunday	7am to 6pm
OOHW Evening	Monday to Friday	6pm to 10pm
	Saturday	6pm to 10pm
	Sunday	6pm to 10pm
OOHW Night	Monday to Friday	10pm to 7am
	Saturday	10pm to 7am
	Sunday	10pm to 7am

The project specific noise management levels for residential and aged care facilities are included in Table 7 based on the procedure in Table 5.

Table 7 Project specific NML's for residential receivers

Residential	Noise Management Levels, $L_{Aeq(15\text{-}minute)}$ dB			
	Standard Hours Day	OOHW Day	OOHW Evening	OOWH Night
NCA 1	55	50	43	42
NCA 2	52	47	46	38
NCA 3	55	50	48	43
NCA 4	58	53	53	45

3.2.2 Other sensitive land uses

The ICNG also establishes NMLs for other sensitive land uses. Table 8 summarises the NMLs for those other sensitive land uses identified within the Proposal site.

Table 8 Noise Management Levels for other land uses (ICNG)

Land use	Noise Management Level, $L_{Aeq(15\text{-}minute)}$[1]
Classrooms at schools and other educational institutions	Internal noise level – 45 dB(A) (55 dB(A) external)[2]
Places of worship	Internal noise level – 45 dB(A) (55 dB(A) external)[2]
Active recreation areas (characterised by sporting activities and activities that generate their own noise or focus for participants, making them less sensitive to external noise intrusion).	External noise level – 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (i.e. reading and meditation).	External noise level – 60 dB(A)
Community centres	Dependent on the intended use. Refer to the recommended 'maximum' internal levels in AS/NZS 2107.

(1) Applies when premises are in use.

(2) A factor of 10 dB attenuation has been applied assuming windows open across the façade. This 10 dB has been included to achieve an external noise level.

The ICNG recommends internal NMLs for certain receiver types. It is considered more practical from an assessment perspective to establish external NMLs for all receivers. Due to the low measured ambient background noise levels in the area, it has been assumed that most receivers would have open windows in order to maximise natural ventilation. Typically, a facade insertion loss performance of 10 dB may be achieved where windows are open. For this reason, a NML of $L_{Aeq(15\text{-}minute)}$ 55 dB has been established for educational and places of worship land uses.

3.2.3 Commercial and industrial premises

The ICNG recommends NMLs for commercial and industrial land uses that are applicable during the time of day for which they are occupied. The external noise levels recommended are:

- industrial premises – external $L_{Aeq(15\text{-}minute)}$ 75 dB.
- commercial premises – external $L_{Aeq(15\text{-}minute)}$ 70 dB.
- other businesses that may be very sensitive to noise where the noise level is project specific.

Other noise sensitive commercial premises, such as cafes and restaurants, should be assessed on a project-by-project basis in consideration of the recommended maximum internal noise levels provided by AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors.*

3.2.4 Sleep disturbance screening criterion

The ICNG references NSW EPA's sleep disturbance screening level which is described as a L_{Amax} level that should not exceed the RBL by more than 15 dB. For this project, the sleep disturbance screening criteria are:

- NCA1: 52 dB(A).
- NCA2: 48 dB(A).
- NCA3: 53 dB(A).
- NCA4: 55 dB(A).

These criteria would only apply during night-time out of hours works if conducted.

3.2.5 Ground-borne noise

Ground-borne noise is unlikely to be a controlling factor with respect to construction noise impacts. Air-borne noise levels will exceed the ground-borne noise levels. As such a detailed ground-borne noise assessment is not required for this Proposal.

3.3 Construction vibration criteria

Ground vibration generated by construction can have a range of effects on buildings and building occupants, with the main effects generally classified as:

- Human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- Effects on building structures – vibration that may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on building contents and structural damage. Building occupants will normally feel vibration readily at levels well below those that may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[2].
- British Standard BS 7385 Part 2-1993 Evaluation and Measurement for Vibration in Buildings.
- NSW Environmental Protection Agency's Human comfort: Assessing Vibration – a technical guideline (the Guideline).

3.3.1 Cosmetic and structural damage

The DIN 4150-3 structural and cosmetic damage assessment criteria for different types of buildings are presented in Table 9. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended in Table 9 would not necessarily result in damage. Rather it recommends these values as maximum levels of short-term construction vibration at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects. DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as the standard considers a reduction in serviceability of the structure is deemed to have occurred if:

- Cracks form in plastered surfaces of walls.
- Existing cracks in the building are enlarged.
- Partitions become detached from loadbearing walls or floors.

[2] German Standard DIN 4150-3, 1999, Structural Vibration – Part 3: Effects of vibration on structures.

Table 9 DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV) mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	< 10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

The guideline values from BS7385 relating to cosmetic damage from transient vibration are reproduced in Table 10.

Table 10 Transient vibration guide values for cosmetic damage (BS7385)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		Frequency range	
		4-15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

(1) Note: Values referred to are at the base of the building.

(2) Note: For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

DIN4150 and BS7385 state that exceedances of the guidance values do not necessarily mean that damage will occur, but that more detailed analysis may be required in order to quantify the site-specific relationship between vibration levels, strain and the potential for damage. If required, the additional analysis may include more detailed vibration, strain or displacement measurements combined with engineering analysis.

BS7385 also states that a building of historical value should not (unless it is structural unsound) be assumed to be more vibration sensitive.

3.3.2 Human comfort

The ICNG recommends that vibration from construction works be assessed under the EPA's *Assessing Vibration – a technical guideline* (the Guideline). The vibration assessment criteria defined in this guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).
- The majority of construction works as part of the proposal would be expected to be intermittent in nature with the potential for some impulsive activities (e.g. demolition works).

Table 11 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted Root-Mean-Square vibration velocity levels (V_{rms}). The Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

Table 11 Daytime V_{rms} management levels for continuous and impulsive vibration

Receiver	Continuous vibration V_{rms}, mm/s		Impulsive vibration V_{rms}, mm/s	
	Preferred	Maximum	Preferred	Maximum
Residences – daytime	0.2	0.4	6	12
Residences – night-time	0.14	0.28	2	4
Offices, schools, place of worship	0.4	0.8	13	26
Workshops	0.8	1.6	13	26

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 12.

Table 12 VDV management levels for intermittent vibration

Receiver	VDV – Intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Residences – daytime	0.2	0.4
Residences – night-time	0.13	0.26
Offices, schools, places of worship	0.4	0.8
Workshops	0.8	1.6

4 Construction noise and vibration assessment

4.1 Construction methodology

Construction for the Proposal would be likely to begin in the first quarter of 2020 and last approximately nine months. Construction would be likely to occur concurrently in multiple decentralised work zones, and as such work would be at various stages at different points within the Proposal site. Construction in the vicinity of Adelaide Street between William Bailey Street and the Sleepy Hill Motor Inn, as well as construction through Newbury Park, would occur between March and July only. Construction along the remainder of the alignment would throughout the construction program.

The final construction program would be determined prior to construction and be subject to the timing of the KHD URA development (subject to approvals and market demands).

An indicative sequence of construction is provided in Table 13. The construction works have been divided into seven 'works stages' which are interrelated and would potentially overlap. Subject to confirmation from the construction contractor, the order and staging of these construction works periods may change.

For this assessment the works have been assessed in two main categories; linear (along the construction alignment) and compound areas.

4.1.1 Linear construction works

Table 13 Construction staging

Stage	Description
Stage 1	Site establishment including compound operation
Stage 2	Vegetation clearing
Stage 3	Trenching and underboring
Stage 4	Installation of water and wastewater pipelines
Stage 5	WWPS construction
Stage 6	Connection to existing to HWC infrastructure
Stage 7	Site restoration

The following types of plant and equipment are likely to be used for the works:

- Excavators
- Tipper truck
- Light vehicles
- Flat-bed delivery trucks
- Roller
- Skid steers
- Street sweeper
- Water carts
- Boring machines
- Jackhammers
- Mobile crane
- Backhoes
- Compactor
- Concrete agitators (or similar)
- Concrete pumps
- Concrete saws

- Air compressor
- Dozers
- Mulchers
- Piling rigs
- Forklifts
- Small earthmoving equipment
- Welder

The indicative plant and equipment presented in Table 14 have been assumed for each of the construction activities.

Table 14 Indicative plant per stage and total Sound Power Level for each activity

Stage	Plant and equipment	Plant items	Lw, dB(A)
Site establishment	Dump truck	1	110
	Compressor 8.5 m^3/min	1	102
	Forklift	1	106
	Generator	1	103
	Ute/crew truck	1	103
	Bulldozer D9	1	116
	Excavator	1	110
	Total Lw[1]	**N/A**	**118**
	Total Lw including operating times[2]	**N/A**	**116**
Vegetation clearing	Chainsaw	1	107
	Chipper/mulcher	1	116
	Backhoe with auger	1	111
	Excavator	1	110
	Dump truck	1	110
	Bulldozer D9	1	116
	Total Lw[1]	**N/A**	**121**
	Total Lw including operating times[2]	**N/A**	**119**
Trenching and underboring	Excavator with hammer	1	122
	Excavator	1	110
	Backhoe with auger	1	111
	Dump truck	1	110
	Piling Rig (Bored)	1	111
	Water cart	1	107
	Total Lw[1]	**N/A**	**123**
	Total Lw including operating times[2]	**N/A**	**119**
Installation of water and wastewater pipelines	Excavator	1	110
	Dump truck	1	110
	Franna crane	1	98

Stage	Plant and equipment	Plant items	Lw, dB(A)
	Quick-cut saw	1	114
	Plate compactor/wacker packer	1	106
	Total Lw[1]	**N/A**	**117**
	Total Lw including operating times[2]	**N/A**	**116**
WWPS construction	Excavator	1	110
	Tracked mobile crane	1	98
	Excavator with hammer	1	122
	Dump truck	1	110
	Hand tools (electric)	1	102
	Concrete agitator	1	109
	Water cart	1	107
	Concrete Vibrator	1	113
	Total Lw[1]	**N/A**	**123**
	Total Lw including operating times[2]	**N/A**	**119**
Connection to existing HWC infrastructure	Ute/crew truck	1	103
	Hand tools (electric)	1	102
	Traffic control vehicle	1	103
	Franna crane	1	98
	Portable Generator 2.5 kV*A	1	98
	Hand tools (pneumatic)	1	114
	Total Lw[1]	**N/A**	**115**
	Total Lw including operating times[2]	**N/A**	**112**
Site restoration	Excavator	1	110
	Street sweeper	1	108
	Generator	1	103
	Asphalt paver	1	112
	Roller (vibratory)	1	109
	Water cart	1	107
	Dump truck	1	110
	Pavement profiler	1	117
	Total Lw[1]	**N/A**	**120**
	Total Lw including operating times[2]	**N/A**	**119**

(1) Total Lw is based on the plant items operating for the entire duration of a 15 minute period.

(2) In practice not all plant items are likely to operate during the entire duration of a 15-minute period. Hence, the resulting Lw including operating times is generally lower than the total Lw.

4.1.2 Compound areas

A minimum of five compound would be established as presented in Figure 1. These compound areas would be set up during the site establishment stage and would be utilised throughout the construction of the Proposal. The primary compound area would be located within KHD-owned land at the northern extent of the Proposal. Secondary compounds would be located on HWC-owned land south of Grahamstown Spillway, Rees James Road near Kuranga Avenue, land between Rees James Road and Adelaide Street and adjacent to the existing water pump station on Irrawang Street.

It is anticipated that the compound areas would generally include, but not be limited to, the following:

- Site shed (office) and amenities
- Staff parking areas
- Equipment storage
- Laydown areas for construction materials (e.g. pipes, fittings, pre-cast concrete components)
- Stockpiling of excavated materials and soil
- Bunded chemical and/or fuel storage areas.

Additional compound areas may be required during construction of the Proposal. The location of these would be determined prior to and during construction. To ensure that associated impacts are minimised, any compound areas would comply with the following criteria for site selection:

- Readily available access to the local road network
- Relatively level land
- Greater than 50m from a watercourse
- Greater than 50m from threatened species and endangered ecological communities
- Greater than 100m from a residential dwelling
- No requirement to remove any native vegetation
- No impact on any heritage items (indigenous or non-Indigenous)
- Not unreasonable affect the land use of adjacent properties.

Compound areas would be temporary in nature and removed from site upon completion of the works.

4.1.3 Site access and traffic management

The majority of the alignment of the Proposal is on the road verge, and therefore access would be via the adjacent roads. The two locations where this would not be feasible would be:

- Hunter Water land – the water and wastewater pipelines would be constructed adjacent to an existing gravel track that runs beneath existing overhead power lines. Site access to Hunter Water-owned land would be through gates at the northern end of Rees James Rd and the Riding for Disabled lot.
- KHD site – the existing access track to the site would be adopted, ensuring that safe access is maintained
- Traffic management would likely be required where open trenching occurs in close proximity to local roads (therefore requiring a minimum safe distance for workers from live traffic) and where underboring is proposed to occur, such as (but not limited to) under Adelaide Street in Raymond Terrace. No traffic management along the Pacific Highway is anticipated to be required.

Open trenching along the road verge in front of residential properties may result in temporary changes to property access, where open trenching intersects driveways. Temporary pedestrian diversions would likely be required where open trenching conflicts with public footpaths. Further details of site access and traffic management associated with the Proposal would be described and assessed in the EIS.

4.2 Predicted airborne noise levels

A 3D noise model has been developed using SoundPLAN v8.1 to predict the potential impacts of the construction works/activities that are to be conducted during the construction phase of the project. This noise modelling takes into account the following:

- Local topography
- Ground absorption
- Concawe noise prediction methodology for the environmental assessment
- Indicative building footprints and heights.

For construction works that occur during standard hours, the ICNG defines the following noise impacts:

- Noise affected – where the relevant NML is exceeded and community reaction may occur.
- Highly noise affected – where the predicted noise levels exceed 75 dB(A) and community may have a strong reaction to the works.

This noise assessment has been conducted under the assumption that all works will occur at the minimum distance to each receiver, thus the predicted noise levels can be considered worst case.

Noise levels for each construction stage have been predicted in the form of noise contours as presented in Appendix B.

Generally, works associated with a linear infrastructure proposal would progress along the alignment such that the maximum noise levels would not be experienced for the duration of the construction program at all receiver locations.

There would be some semi-permanent work sites (such as construction compounds). Potential noise impacts associated with the compounds are discussed below.

It is understood that certain construction stages have the potential to be undertaken concurrently with other stages along the alignment. The noise impacts, while partially impacted by separation between work zones, would generally be controlled by the construction works operating in closest proximity to the noise sensitive receiver in question.

A summary of potential noise impacts within each NCA is provided in Table 15. The range of predicted noise levels is provided together with the minimum distance between the Proposal footprint and nearest sensitive receivers. The noise level ranges result from the varying offset distances between the Proposal alignment and sensitive receivers (noise levels reduce with increase in distance) and the varying construction stage sound power levels.

A summary of predicted noise levels within each NCA is provided within the subsequent sections.

Table 15 Summary of predicted noise levels per NCA

NCA	NML, $L_{eq(15\text{-}minute)}$ dB(A)				Predicted range of noise levels per works grouping, $L_{eq(15\text{-}minute)}$ dB(A)			Minimum distance (receiver – works), (m)
	Day	Day OoHW	Evening	Night	Stages 1 & 4	Stage 2,3,5 & 7	Stage 6	
1	55	50	43	42	<45 to >85	<45 to >85	<45 to >85	5
2	52	47	46	38	<45 to >85	<45 to >85	<45 to >85	5
3	55	50	48	43	45 to >85	50 to >85	45 to >85	5
4	58	53	53	45	65 - 75	70 - 80	61 - 71	25

(1) Note: Construction stages with similar sound power levels have been grouped in this table.

4.2.1 Noise Catchment Area 1

Residential receivers

- The predicted construction noise levels within this NCA range between being less than 45dBA to being greater than 85 dBA. This means that noise levels at residential receivers range between not exceeding the NML and being considered as highly-noise affected during standard construction hours.
- Noise levels at residential receivers within 115m of the boundary of the construction footprint are predicted to be in the highly noise affected category depending on the stage of work in closest proximity to the receivers. These receivers are located adjacent to Adelaide Street and Irrawang Street, where the works would be conducted.
- It should be noted that standard construction hours NML exceedances (noise levels exceeding 55 dB(A) are predicted at receiver locations up to approximately 700m from the construction footprint for the noisiest construction stages. Mitigation measures would apply for these locations as described in Section 5.
- The majority of works would be conducted linearly along the alignment in gradual stages (i.e. works would not occur at the same location for the duration of the construction period). Works would generally be conducted progressively along the alignment however some works may occur in discreet locations along the alignment as required.
- Activities requiring the use of highly noise intensive plant items would result in the highest noise levels at sensitive receiver locations. High noise intensity plant items are planned for use in all stages of Proposal construction. Typical construction activities and associated plant items likely to result in the highest NML exceedances at sensitive receiver locations are listed below:
    - Demolition of existing road infrastructure including the use of concrete saws, excavators, dump trucks and jackhammers.
    - Vegetation clearing and grubbing including the use of chain saws and mulchers.
    - Trenching, backfill and compaction including the use of excavators and wacker packers
    - Pavement construction including the use of asphalt profilers and street sweepers.
- If OOWH works are required within this NCA NML exceedances ranging from 0 dB, to greater than 40 dB are likely. These OOHW would be assessed in detail during the detailed design phase of the Proposal if required.

Other sensitive land uses

Other sensitive land uses within NCA 1 include places of worship, schools, outdoor recreational and commercial receivers.

- Educational Facilities
    - Irrawang Pubilc school is located adjacent to the construction alignment along Adelaide Street. Noise levels ranging between 50 dB(A) to 75 dB(A) are predicted at this location depending on the offset to the construction activity in question, noting that the school comprises numerous buildings at varying offset distances from the project alignment. This would represent an exceedance of up to 20 dB of the applicable NML for educational facilities.
    - Marginal exceedances of the NML for the Irrawang High School and Raymond Terrace Public School are predicted. These exceedances would be in the range of approximately 1 dB to 3 dB.
    - St Brigid's Primary School would also be located in close proximity to the works occurring on Irrawang Street. Noise levels ranging between 60 dB(A) to 85 dB(A) are predicted at this location depending on the offset to the construction activity in question, noting that the school comprises numerous buildings at varying offset distances from the project alignment. This would represent an exceedance of up to 30 dB of the applicable NML for educational facilities.
    - Raymond Terrace Vacation Care is located adjacent to the southern extent of the construction works on Irrawang Street. Exceedances in the range of 25 dB to 30 dB are predicted across this receiver.
- Active Recreation
    - Muree Golf Course and Boomerang Park would be located adjacent to the works on Irrawang Street. Exceedances of greater than 20 dB are predicted on the areas in closest proximity to the works. Noise levels are predicted to comply with the NML for active recreation areas at an offset distance of 250 m from the construction footprint.
    - Places of Worship

- Saint Andrews Presbyterian Church would be located approximately 100 m away from the works on Irrawang Street. Noise levels are predicted to be approximately 70 dB(A). This would be an approximate 15 dB exceedance from works in closest proximity.
- St Birgid's Catholic Church would be located directly adjacent to the works on Irrawang Street. An exceedance of approximately 30 dB has been predicted for this receiver.

- Exceedances of the respective NMLs are expected at these locations for the majority of construction works occurring along the alignment. Mitigation measures would apply for these receivers as described in Section 5.

Wildlife area with Grey-headed Flying-fox camp

The *Biodiversity Development Assessment Report* by Arcadis identifies that there is a camp of Grey-headed Flying - foxes near the development site. The Grey-headed Flying-fox is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The location of the camp is in NCA 1 and approximately 50 m northwest of the development site adjacent to Adelaide Street as shown in the map in Appendix C. This is a nationally important camp called the "Raymond Terrace Flying-fox camp (Camp ID 265).

To minimise construction impacts, including construction noise, the *Biodiversity Development Assessment Report* has recommended that construction within a radius of 250 m of the camp should be limited to months of March to July to minimise potential impacts to breeding and heat-stressed individuals. The following construction noise mitigations proposed by the *Biodiversity Development Assessment Report* will be required:

- Reasonable and feasible noise mitigation measures would be implemented when any works occur within 250 metres of the Grey-headed Flying-fox Camp (between March and July) and would include the installation of temporary noise barriers. Examples of a mobile enclosure and demountable noise barriers are shown in Figure 5.
- The Grey-headed Flying-fox camp would be monitored at regular intervals (daily) by a suitably qualified ecologist during any construction activities occurring within 250 metres of the camp (between March and July) to detect any stress response signs. Noise monitoring would occur concurrently to determine if the stress response may be construction noise induced. If a stress response is detected, works would cease and mitigation measures would be reviewed/amended.
- Construction activities within 100 metres of the Grey-headed Flying-fox camp generating noise above average background levels would be limited to a maximum of 2.5 hours in any 12 hour period, preferably at sunrise/sunset or during the night.

4.2.2 Noise Catchment Area 2

Residential receivers

- The predicted construction noise levels within this NCA range between being less than 45 dB(A) to being greater than 85 dBA. This means that noise levels at residential receivers range between not exceeding the NML and being considered as highly-noise affected during standard construction hours.
- Noise levels at residential receivers within 50m of the boundary of the construction footprint are predicted to be in the highly noise affected category depending on the stage of work in closest proximity to the receivers. These receivers are located adjacent to Adelaide Street, where the works would be conducted.
- It should be noted that standard construction hours NML exceedances (noise levels exceeding 52 dB(A) are predicted at receiver locations up to approximately 450m from the construction footprint for the noisiest construction stages. Mitigation measures would apply for these locations as described in Section 5.
- The majority of works would be conducted linearly along the alignment in gradual stages (i.e. works would not occur at the same location for the duration of the construction period). Works would generally be conducted progressively along the alignment however some works may occur in discreet locations along the alignment as required.
- Activities requiring the use of highly noise intensive plant items would result in the highest noise levels at sensitive receiver locations. High noise intensity plant items are planned for use in all stages of project construction. Typical construction activities and associated plant items likely to result in the highest NML exceedances at sensitive receiver locations are listed below:
  - Demolition of existing road infrastructure including the use of concrete saws, excavators, dump trucks and jackhammers.
  - Vegetation clearing and grubbing including the use of chain saws and mulchers.

- Trenching, backfill and compaction including the use of excavators and wacker packers
- Pavement construction including the use of asphalt profilers and street sweepers.

- If OOWH works are required within this NCA NML exceedances ranging from 0 dB, to greater than 40 dB are likely. These OOHW would be assessed in detail during the detailed design phase of the proposal if required.

Other sensitive land uses

Other sensitive land uses within NCA 2 include places of worship, schools, outdoor recreational and commercial receivers.

- Educational Facilities
  - Grahamstown Public School is located approximately 1400m from the construction footprint. Noise levels up to 45 dB(A) are predicted at this location depending on the offset to the construction activity in question, noting that the school comprises numerous buildings at varying offset distances from the project alignment. Noise levels are predicted to comply with the NML for educational facilities.
  - TLC Early Learning Centre is located approximately 600m from the construction footprint. Noise levels up to 50 dB(A) are predicted at this location depending on the offset to the construction activity in question. Noise levels are predicted to comply with the NML for educational facilities.
- Active Recreation
  - Lakeside Leisure Centre is predicted to have noise levels less than 45dB(A) and therefore noise levels are predicted to comply with the NML for active recreation facilities.
  - Raymond Terrace Off-Lead Dog Exercise is predicted to have noise levels less than 50dB(A) and therefore noise levels are predicted to comply with the NML for active recreation facilities.
- Places of Worship
  - Raymond Terrace Community Church would be located close to works on Adelaide Street. Noise levels at the church are predicted to be approximately 70 dB(A). This would be an approximate 15 dB exceedance from works in closest proximity.
  - Church of the Nations is predicted to have noise levels less than 50dB(A) and therefore noise levels are predicted to comply with the NML for places of worship.
  - Raymond Terrace Baptist Church is predicted to have noise levels less than 45 dB(A) and therefore noise levels are predicted to comply with the NML for places of worship.
- Exceedances of the respective NMLs are expected at these locations for the majority of construction works occurring along the alignment. Mitigation measures would apply for these receivers as described in Section 5.

4.2.3 Noise Catchment Area 3

Residential receivers

- The predicted construction noise levels within this NCA range between 45dB(A) to greater than 85 dB(A). This means that noise levels at residential receivers range between not exceeding the NML and being considered as highly-noise affected during standard construction hours.
- Noise levels at residential receivers within 50m of the boundary of the construction footprint are predicted to be in the highly noise affected category depending on the stage of work in closest proximity to the receivers. These receivers are located adjacent to Rees James Road, where the works would be conducted.
- It should be noted that standard construction hours NML exceedances (noise levels exceeding 55 dB(A) are predicted at receiver locations up to approximately 300m from the construction footprint for the noisiest construction stages. Mitigation measures would apply for these locations as described in Section 5.
- The majority of works would be conducted linearly along the alignment in gradual stages (i.e. works would not occur at the same location for the duration of the construction period). Works would generally be conducted progressively along the alignment however some works may occur in discreet locations along the alignment as required.
- Activities requiring the use of highly noise intensive plant items would result in the highest noise levels at sensitive receiver locations. High noise intensity plant items are planned for use in all stages of project construction. Typical construction activities and associated plant items likely to result in the highest NML exceedances at sensitive receiver locations are listed below:
  - Demolition of existing road infrastructure including the use of concrete saws, excavators, dump trucks and jackhammers.
  - Vegetation clearing and grubbing including the use of chain saws and mulchers.

- Trenching, backfill and compaction including the use of excavators and wacker packers
- Pavement construction including the use of asphalt profilers and street sweepers.

- If OOWH works are required within this NCA NML exceedances up to 40 dB are likely. These OOHW would be assessed in detail during the detailed design phase of the proposal if required.

Other sensitive land uses

Other sensitive land uses within NCA 3 include schools, and commercial receivers.

- Educational Facilities
  - KiddyHawk Family Day Care and Preschool is approximately 300m from the construction footprint. Noise levels up to 55dB(A) are predicted at this location depending on the offset to the construction activity in question, noting that the school comprises numerous buildings at varying offset distances from the project alignment. Noise levels are predicted to comply with the NML for educational facilities.
- Mitigation measures may apply for these receivers as described in Section 5 if exceedances occur during construction.

4.2.4 Noise Catchment Area 4

Residential receiver

- The residential receiver located near the RDA is predicted to have a noise level of approximately 80 to 85dB(A). This is considered as being highly noise affected.
- Activities requiring the use of highly noise intensive plant items would result in the highest noise levels at sensitive receiver locations. High noise intensity plant items are planned for use in all stages of project construction. Typical construction activities and associated plant items likely to result in the highest NML exceedances at sensitive receiver locations are listed below:
  - Demolition of existing road infrastructure including the use of concrete saws, excavators, dump trucks and jackhammers.
  - Vegetation clearing and grubbing including the use of chain saws and mulchers.
  - Trenching, backfill and compaction including the use of excavators and wacker packers
  - Pavement construction including the use of asphalt profilers and street sweepers.
- If OOWH works are required within this NCA NML exceedances greater than 40 dB are likely. These OOHW would be assessed in detail during the detailed design phase of the proposal if required.

Other sensitive land uses

- Active Recreation
  - NCA 4 includes Riding for the Disabled Association of NSW. This facility is categorised as active recreation. At the main building, noise levels are predicted to be between 65 to 70dB(A) depending on facade orientation. Open outdoor areas of the site range from 55 to over 85 dB(A) as it approaches the construction footprint.
- Exceedances of the respective NMLs are expected at these locations for the majority of construction works occurring along the alignment. Mitigation measures would apply for these receivers as described in Section 5.

4.3 Compound areas

Noise levels for the operation of the compounds have been predicted in the form of noise contours as presented in Appendix B.

The predicted construction noise levels associated with the proposed operation of the five construction compound areas range between 0 dB(A) at remote receivers and 80 dB(A) at the nearest noise sensitive receiver locations as shown in the noise contour maps in Appendix B related to Stage 1 - Site establishment.

The predicted maximum levels are a result of general works and operation of the compounds including storage and movement of materials and staff car parking. There would be potential for sleep disturbance if the compound areas were to operate outside of standard construction hours. This is particularly relevant for the compound areas in NCA 1, NCA 2, the southern area in NCA 3 and NCA 4.

It is recommended that all relevant mitigation measures described in Section 5 be implemented in order to minimise the potential noise impacts from the operation of the compound areas.

4.4 Construction vibration

4.4.1 Minimum working distances

The minimum working distances, based on BS7385 and OH&E guidelines, for building damage should be complied with at all times. The distances are noted as being indicative and are likely to vary depending on the particular item of plant and local geotechnical conditions. The minimum working distances apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.
In relation to human comfort, the minimum working distances relate to continuous vibration. For most construction activities, vibration emissions would be intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods may be allowed.

Table 16 presents the recommended minimum working distances for vibration intensive plant.

Table 16 Recommended minimum working distances from relevant vibration intensive plant

Plant Item	Rating/Description	Minimum Working Distance – Cosmetic Damage[1] (BS7385)	Minimum Working Distance – Human Response (OH&E Guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

4.4.2 Vibration intensive activities

Generally, the separation distance from the nearest receivers is sufficient to mitigate the potential vibration impacts. As such it is considered that structural or cosmetic damage impacts from vibration intensive works are generally unlikely for the adjacent receivers, however some cosmetic damage may be caused by the use of the vibration intensive equipment on the residential boundary when works are located less than 10 m from the boundary of the construction footprint.

Where work is proposed within the safe working distances the mitigation measures outlined in Section 5 should be implemented to reduce the impacts as far as practicable.

4.5 Construction Traffic

Access to the compound and the general construction zone is likely to require the use of local roads. This would represent a temporary change in road traffic noise levels at directly affected receivers. Common construction traffic includes light vehicles, including utes and heavy construction vehicles such as dump trucks and concrete agitators.

It is understood that up to 55 staff, with the potential for up to 35 staff on-site at one time in the work-zone throughout the construction period, may access the construction area per day. In addition, it is estimated that there are 25 trucks per day bringing materials to the site. The primary road traffic noise source at sensitive receivers located adjacent to the Proposal is the Pacific Highway carrying in excess of 10,000 vehicles per day. An increase of approximately 35 vehicles for staff and 25 trucks bringing materials per day would not represent an increase in noise levels exceeding 2 dB. Hence, further detailed assessment of construction traffic noise is not warranted.

However, there may be a more localised increases in noise levels at construction access points and should be further assessed during the detailed construction planning phase. It is recommended that all mitigation measures be implemented in order to minimise the potential noise impacts from construction traffic on local roads.

Construction traffic related noise impacts should be further reviewed as part of a site-specific Construction Noise and Vibration Management Plan (CNVMP).

5 Construction Noise and Vibration Mitigation

5.1 Noise Mitigation Measures

The mitigation measures described below should be implemented where reasonable and feasible to do so. The noise mitigation measures would be further defined and confirmed as part of the CNVMP for implementation of the CEMP.

5.1.1 Community Consultation

- A contact phone number should be provided for the community and a complaint response procedure implemented on site.
- Community consultation should be undertaken in accordance with HWC requirements, which include 10 days' notice for night work, if required.

5.1.2 Working hours

- Works should be programmed to occur during standard working hours only as defined by the ICNG:
  - 7 am to 6 pm, Monday to Friday
  - 8 am to 1 pm, Saturday
  - No work on Sundays or public holidays.
- If works must occur out of hours for justified reasons (e.g. worker safety or reduction of impact on traffic), preference should be given to day and/or evening time works (i.e. between 7 am and 10 pm).
- If works must occur out of hours, noise intrusive works should be completed before 10 pm where feasible to do so.
- If works must occur out of standard hours, a detailed out of hours noise assessment should be conducted prior to the work being undertaken.

5.1.3 Worksite training

- Worksite induction training should include education for workers on noise and vibration issues related to the works. Workers should be advised to avoid shouting or whistling on site near sensitive receivers.
- 'Toolbox talks' should be held at regular intervals during construction so that all workers on the site are aware of current noise issues and the mitigation measures being implemented on site at the time.

5.1.4 Site and equipment management including compound areas

Site and equipment management procedures should include the following:

- Processes and equipment that generate lower noise levels should be selected where feasible.
- Noisy plant should be located as far away from residences as is practical to allow efficient and safe completion of the task.
- The potential shielding provided by imperforate barriers and/or hoarding will provide a reasonable reduction in noise levels.
- A potential mitigation method to reduce the noise impacts of the compound areas would include the installation of hoardings on the boundary.
- Plan the layout of compound areas such that site sheds (for example) would act as noise barriers between noisy activities and nearby sensitive receivers.
- Equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use.
- Where materials are to be dropped into an empty truck tray or disposal bin and may cause a loud noise, the tray/bin should be lined with soil or an equivalent material to reduce impact noise where feasible.
- Truck operators should ensure tailgates are cleared and locked at the point of unloading.
- Works should be planned to minimise the noise from reversing signals.
- Warning horns should not be used as signalling devices.
- Two-way radios should be set to the minimum effective volume.
- Noise associated with packing up plant and equipment at the end of works should be minimised.
- Equipment should be well maintained.
- Equipment not in use on site should be shut down.
- Tasks should be completed using the minimum feasible power and equipment.

- Traffic practice controllers should be used to prevent vehicles and equipment queuing, idling or reversing near residences.

5.1.5 Specific noise mitigation near Grey-headed Flying-fox camp

- Reasonable and feasible noise mitigation measures would be implemented when any works occur within 250 metres of the Grey-headed Flying-fox Camp (between March and July) and would include the installation of temporary noise barriers. Examples of a mobile enclosure and demountable noise barriers are shown in Figure 5.
- The Grey-headed Flying-fox camp would be monitored at regular intervals (daily) by a suitably qualified ecologist during any construction activities occurring within 250 metres of the camp (between March and July) to detect any stress response signs. Noise monitoring would occur concurrently to determine if the stress response may be construction noise induced. If a stress response is detected, works would cease and mitigation measures would be reviewed/amended.
- Construction activities within 100 metres of the Grey-headed Flying-fox camp generating noise above average background levels would be limited to a maximum of 2.5 hours in any 12 hour period, preferably at sunrise/sunset or during the night.

Figure 5 Example of a demountable noise barrier (Photo from Flexshield.com.au)

5.2 Vibration mitigation measures

- The safe working distances for heritage, residential and commercial buildings should be maintained as per Section 4.4.1.
- All plant should be properly maintained.
- Low vibration alternatives for plant should be implemented where possible.
- Plant that have high and low vibration operating settings should be run on the lowest effective vibration setting.
- Truck movements along uneven surfaces should be restricted to minimum speed adjacent to vibration sensitive receivers.
- Where vibration intensive works are required to be undertaken within the specified minimum working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

5.3 Out of hours works

- If works are required to be conducted outside of standard working hours, a site specific out of hours assessment of impacts would be required in order to determine appropriate noise and vibration mitigation measures.

5.4 Construction noise and vibration management plan

- A Construction Noise and Vibration Management Plan (CNVMP) would be prepared to manage noise impact associated with the Proposal.

6 Operational noise criteria

Noise emissions from industrial noise sources should be designed to comply with the requirements of the NSW *Noise Policy for Industry* (NPI, NSW Environment Protection Agency 2017). The NPI applies to noise emissions from the operation of fixed facilities such as a train stabling yard.

The NPI sets two separate noise criteria to meet desirable environmental outcomes:

- Intrusiveness – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the RBL measured for different time periods in the environment. The intrusiveness criteria are measured over a 15-minute period.
- Amenity – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significantly exceed the amenity criteria. As the amenity criteria is provided in the NPI document as a period level i.e. between 7am and 6pm for daytime activities, 3 dB is added to the amenity noise level to approximately represent a 15-minute period for direct comparison to the intrusiveness criterion. For new noise sources 5 dB must be subtracted from the amenity criterion to minimise noise creep over time as more noise sources are introduced to an area.

Internal and external noise criteria are also set by the NPI for non-residential land uses such as hospital wards, educational facilities and active recreation areas.

Both intrusiveness and amenity criteria are derived from the ambient noise survey and the NPI. They are then compared with each other and the lowest and most stringent noise level is adopted to represent the project specific noise criterion for the relevant time period, day, evening and night-time.

Data processing for noise emission criteria

In order to determine mechanical services noise emission criteria, data from the 'background' logger was processed according to the procedures and time periods in the NSW Noise Policy for Industry (NPI) time periods as follows:

- NPI Daytime: 07:00 to 18:00
- NPI Evening: 18:00 to 22:00
- NPI Night-time: 22:00 to 07:00

It is necessary to establish a representative noise level for each of these time periods. We have used the procedures in the NSW NPI to derive a representative background noise level (a Rating Background Level or RBL) for the daytime, evening and night-time periods. An RBL is the median of the lowest 10th percentile of the background L_{A90} samples in each daytime, evening and night-time measurement period.

6.1.1 Derivation of noise emission criteria

Project specific criteria have been established in accordance with the NPI. In determining existing levels for amenity criteria, it is appropriate to exclude any noise source other than the contribution from industrial sources. Amenity levels for noise sensitive receiver locations are split into the following classifications; rural, suburban and urban. These classifications are based upon the existing noise levels of the surrounding area and noted dominant noise sources taken during attended and unattended measurements at these locations. The NPI project specific criteria are presented in Table 17.

Table 17 NPI Project specific criteria

Location	Noise Level (dB re 20 µPa) during Period		
NCA 1			
Residential receivers	**NPI Daytime** 07:00 – 18:00	**NPI Evening** 18:00 – 22:00	**NPI Night-time** 22:00 – 07:00
Rating Background Level (RBL) – L4	45	38	37

Location	Noise Level (dB re 20 µPa) during Period		
Intrusive criterion (RBL + 5 dB)	50	43	42
Amenity Criterion (suburban)[1]	55	45	40
NPI Project specific criteria	50	43	40
NCA 2			
Residential receivers	**NPI Daytime** 07:00 – 18:00	**NPI Evening** 18:00 – 22:00	**NPI Night-time** 22:00 – 07:00
Rating Background Level (RBL) – L3	42	41	33
Intrusive criterion (RBL + 5 dB)	47	46	38
Amenity Criterion (suburban)[2]	55	45	40
NPI Project specific criteria	47	45	38
NCA 3			
Residential receivers	**NPI Daytime** 07:00 – 18:00	**NPI Evening** 18:00 – 22:00	**NPI Night-time** 22:00 – 07:00
Rating Background Level (RBL) – L2	45	43	38
Intrusive criterion (RBL + 5 dB)	50	48	43
Amenity Criterion (traffic dominated)	46	43	37
NPI Project specific criteria	46	43	37
NCA 4			
Residential receivers	**NPI Daytime** 07:00 – 18:00	**NPI Evening** 18:00 – 22:00	**NPI Night-time** 22:00 – 07:00
Rating Background Level (RBL) - L1	48	48	40
Intrusive criterion (RBL + 5 dB)	53	53	45
Amenity Criterion (traffic dominated)	43	43	41
NPI Project specific criteria	43	43	41

(2) An urban classification has been adopted for this NCA based on the measured RBLs and noted noise sources.

(3) A suburban classification has been adopted for this NCA based on the measured RBLs and noted noise sources.

(4) The project-specific criteria are the lowest of the Intrusive criterion and the Amenity criterion for new sources for each time period.

7 Operational noise assessment

The purpose of the operational noise assessment is to determine the operational noise emissions associated with the proposed WWPS infrastructure in accordance with the requirements of the NPI. The WWPS has been assessed and is the only above ground infrastructure that has the potential to produce noise impacts. All other infrastructure is either low noise emitting or is underground.

7.1 Methodology

The following approach has been made in conducting this assessment:

- The minimum distance between the pipeline alignment and the nearest potentially affected cadastral boundary of existing or future (proposed residential land development to the north of the site) has been used in the calculations. This assumes that the nearest point of the WWPS is no closer than the minimum assumed distances.
- Specific plant selections or specific locations have not been made at this stage. As such a maximum total allowable sound power level for the WWPS has been calculated that would allow for compliance with the NPI criteria to be achieved. This calculation was based upon the most stringent night-time criterion of 41 dB(A) in NCA 4 where the WWPS is located.

A flow relief structure would be incorporated into the WWPS design as an emergency precaution due to the potential for sewer overflows to occur. The structure would ensure flow relief occurs at a planned rather than an unplanned location. The exact location of the WWPS would be determined during detailed design. Figure 2 identifies the area within which a final location would be chosen. A pump station design report would be issued to HWC for review and approval during detailed design. This report would consider multiple aspects as required by HWC guidelines, including a separate Emergency Relief Overflow Structure Report that would provide further detail on the Emergency Relief Structure (ERS).

7.2 Predicted noise levels

The maximum allowable sound power level for the proposed WWPS are presented in Table 18. The detailed design must assess operational noise emissions from all noise sources in context of their final position such that compliance with the NPI criteria is achieved. Figure 2 shows the WWPS construction area.

Table 18 Maximum total allowable sound power level for the WWPS

Sensitive Receiver	Minimum Distance (m)	Maximum Total allowable Sound Power Level (dB(A))	Resulting Noise Level dB(A)	Meets Criterion? ×/✓
Kings Hill URA	7	66	41	✓
Riding for the Disabled NSW	10	69	41	✓

7.3 Managing operational noise from the WWPS

Section 5.6.13 of the Hunter Water Corporation Water and Sewer Design Manual (Water Pumping Stations) provides an overview of design expectations with respect to operational and occupational noise from the WWPS. Section 5.6.13 is reproduced below for reference.

‘Noise generated by electric motors, pumps and variable speed drives is to be limited to acceptable levels both within the station and outside where it may affect adjoining properties. This can be assisted by installing low speed pumps, premium efficiency (low noise) motors, building insulation and filters etc. on the VSD’s.

The use of acoustic covers over pumpsets to reduce noise to acceptable levels is not permitted as this can make visual inspections and maintenance access difficult.

Internal noise levels must be controlled for operator comfort in accordance with OH&S requirements. Noise levels within the pumping station building or pit are not to exceed 85 dB(A) measured at 1m from the source. Noise levels

outside the building or pit type station, measured at the nearest boundary, are not to exceed the level criteria of the Department of Environment and Conservation (DEC), Environment Protection and Regulation Division, noise control guide for the particular location as set out in the Noise Guide for Local Government. This can be obtained from *www.epa.nsw.gov.au/noise*.

For pit type stations, the covers of the pit may need to be insulated with noise absorption and deadening material. Provide documentary evidence that the installation will comply with the designated noise levels at the time of submitting the final design.'

In summary, the following measures must be implemented:

- The pump room or pit cover must be designed such that noise emissions from the room or pit complies with the operational noise requirements of the NPI at the boundary of the nearest potentially affected receiver.
- Noise levels inside the pump room or pit must not exceed 85 dB(A).
- Maximising the distance between the WWPS and the nearest sensitive receiver locations would also allow for noise emissions at the nearest potentially affected receivers to be minimised. Noise emissions should be a consideration in the final position of the WWPS.
- The maximum allowable sound power levels presented in Table 18 are a guide noting that the final position of the WWPS is not confirmed.

If acoustic control measures are appropriately implemented the Proposal is anticipated to comply with the noise criteria.

8 Conclusion

Resonate Consultants has been engaged by Arcadis Australia Pacific to prepare a noise and vibration specialist study for inclusion into the Kings Hill Water and Wastewater Infrastructure Project review of environmental factors.

Unattended noise surveys and operator-attended noise measurements were undertaken to properly characterise the prevailing ambient noise environment within the investigation area at various locations around the construction footprint.

Four noise catchment areas were defined based on similarity of ambient noise environment for the receivers in each location and noise and vibration criteria were determined on this basis.

Operational noise criteria were determined in accordance with the NPI and an operational noise assessment was conducted to determine noise emissions associated with the proposed WWPS infrastructure. Operational noise management measures were determined in order to control noise levels to be within the established criteria.

Noise management levels were determined in Section 3 in accordance with the ICNG. Criteria are outlined for standard hours, out of work hours day/evening/night for each NCA. Vibration criteria were also determined and included pertaining to; cosmetic and structural damage and human comfort.

A construction noise and vibration assessment was conducted and predictions were made at nearby receivers. A summary of impacts by NCA and receiver type was included in Section 4.2. Some receivers within the noise catchment areas did not exceed the criteria and are expected to comply with the daytime NMLs. Sensitive receivers located close to the Proposal site (including residential, active recreation, educational and places of worship) are predicted to exceed the NMLs. Those located directly adjacent to compound areas are likely to be in the highly noise affected category when work is occurring at their location. The linear infrastructure works would move progressively along the alignment and hence maximum noise impacts would generally be transitory.

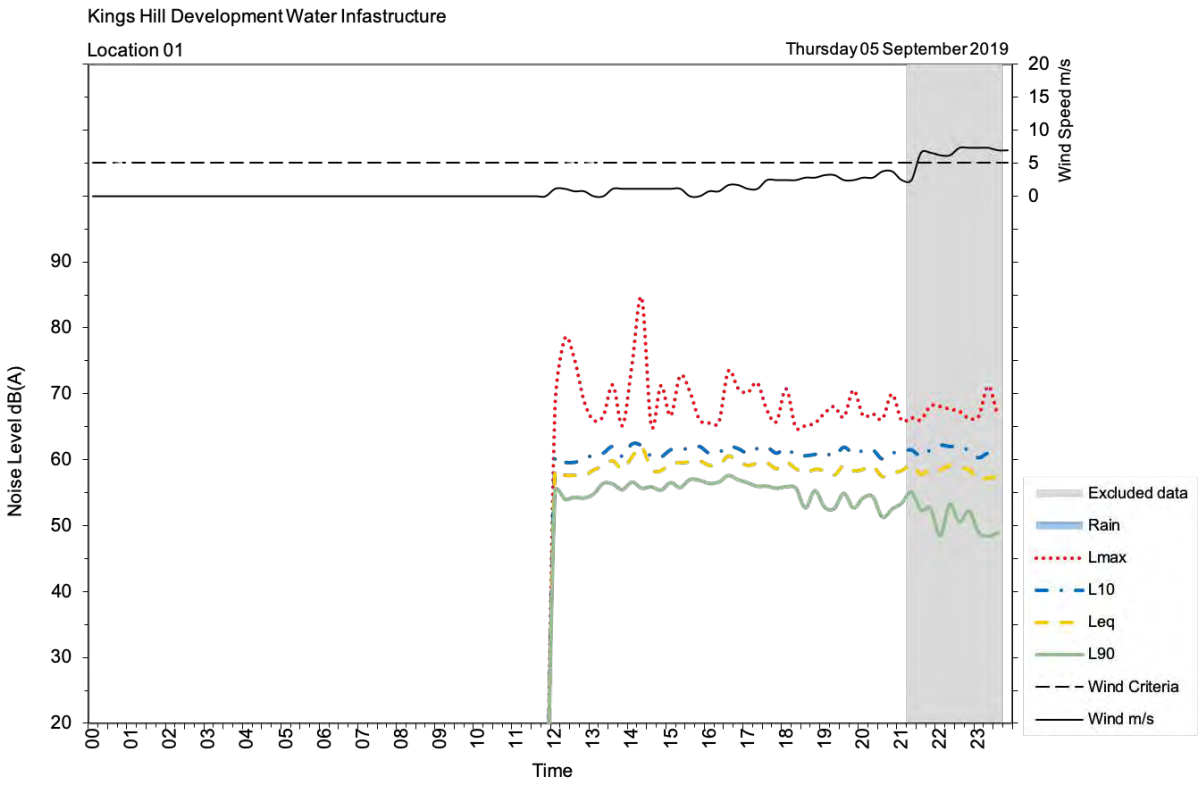
Noise and vibration mitigation measures were discussed in Section 5 and include community consultation, working hours, worksite training, site and equipment management, and vibration specific measures.

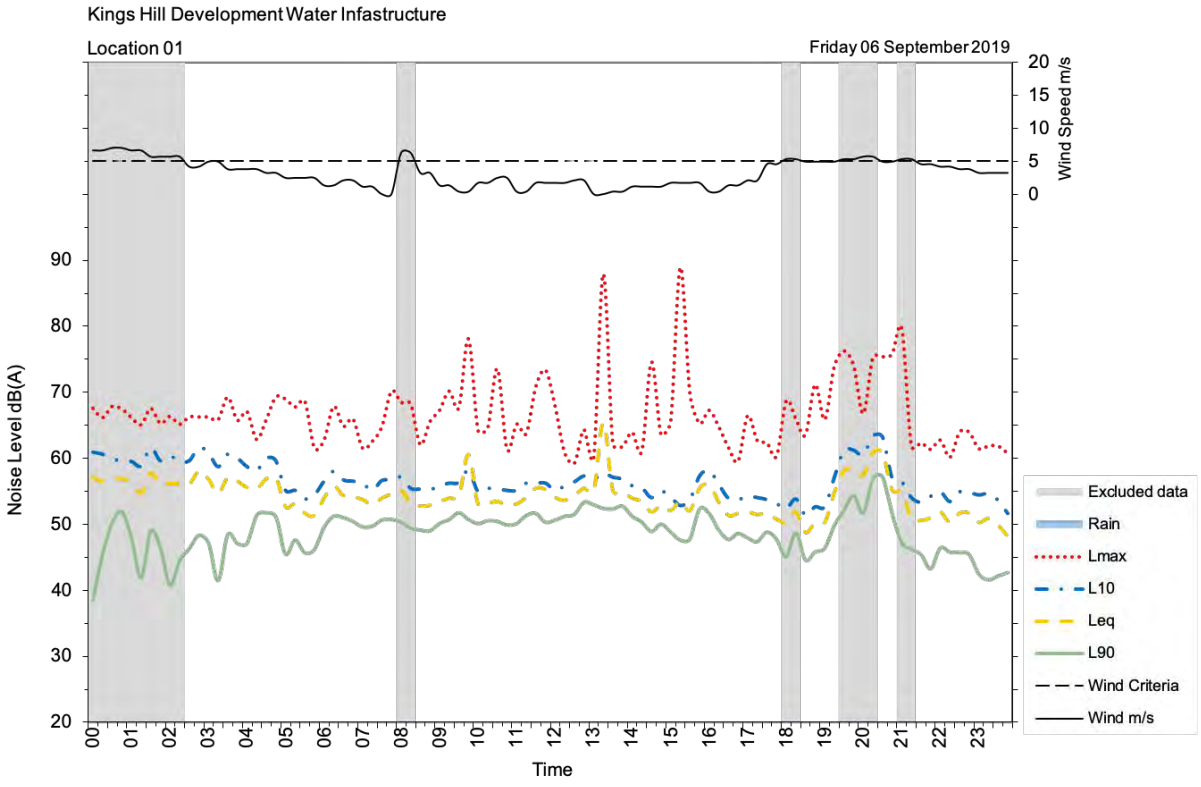
The majority of work would be conducted during standard construction hours. However, if out of hours works are required, site specific assessments would be required in order to determine appropriate and targeted noise and vibration mitigation measures.

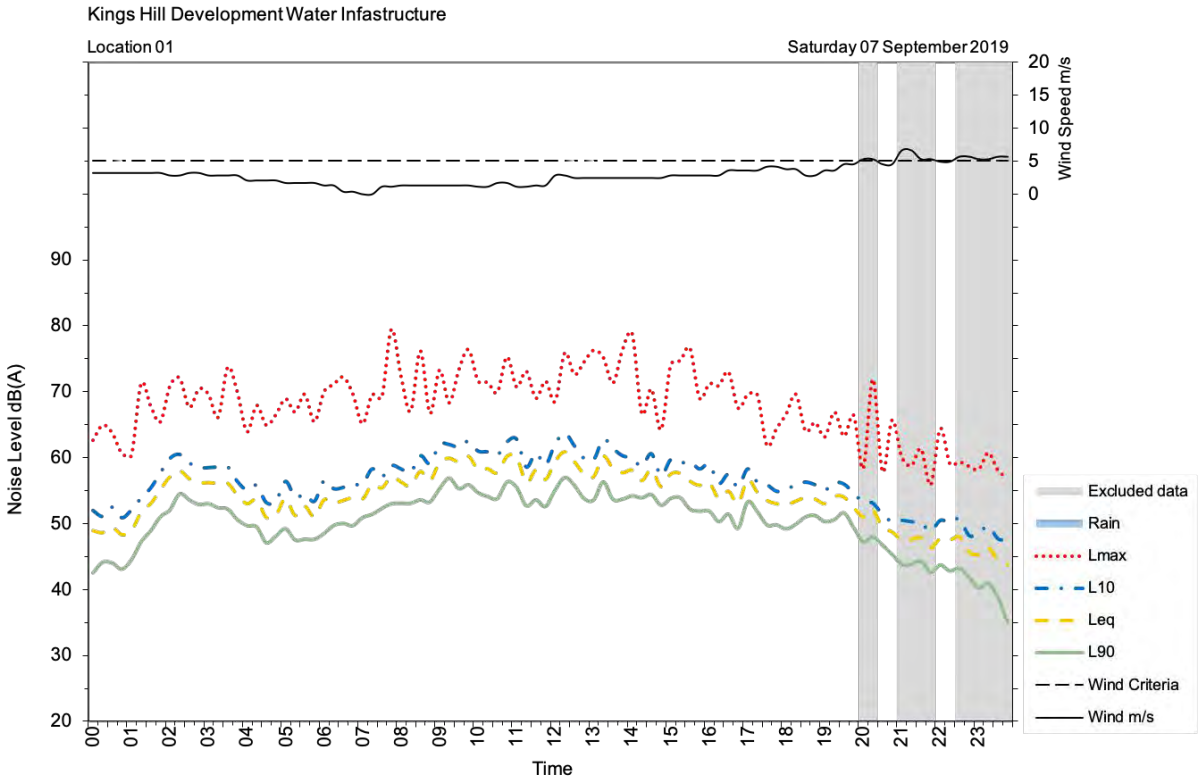
Appendix A

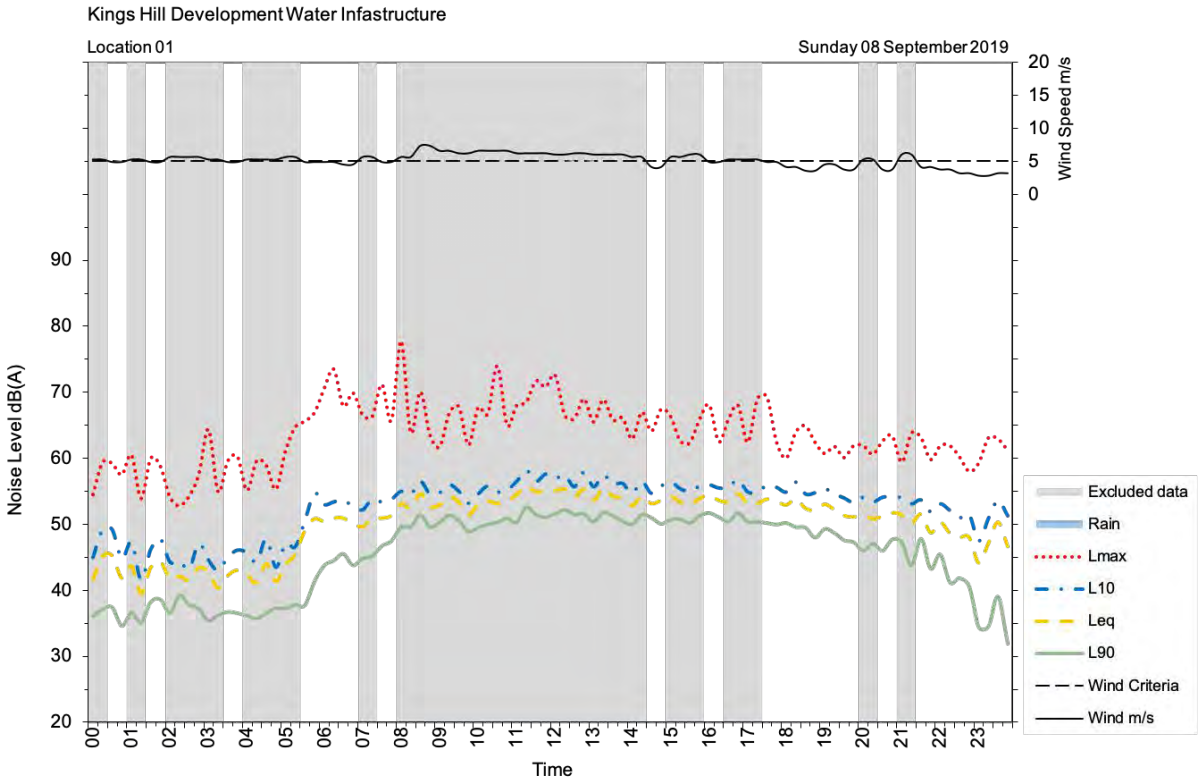
Unattended noise monitoring results

Address	Adjacent to 3219 Pacific Highway
Measurement location	Location 1
Measurement details	L_{A90}, L_{Aeq}, L_{A10}, L_{Amax},
Logging period	Thursday 5th September 2019 to Tuesday 17th September
Attended monitoring notes	The noise levels, measured in the free field, were controlled by distant traffic noise from the Pacific Highway and the local road. There was presence of nature sounds too. The maximum sound level was generated by one passing jet fighter.

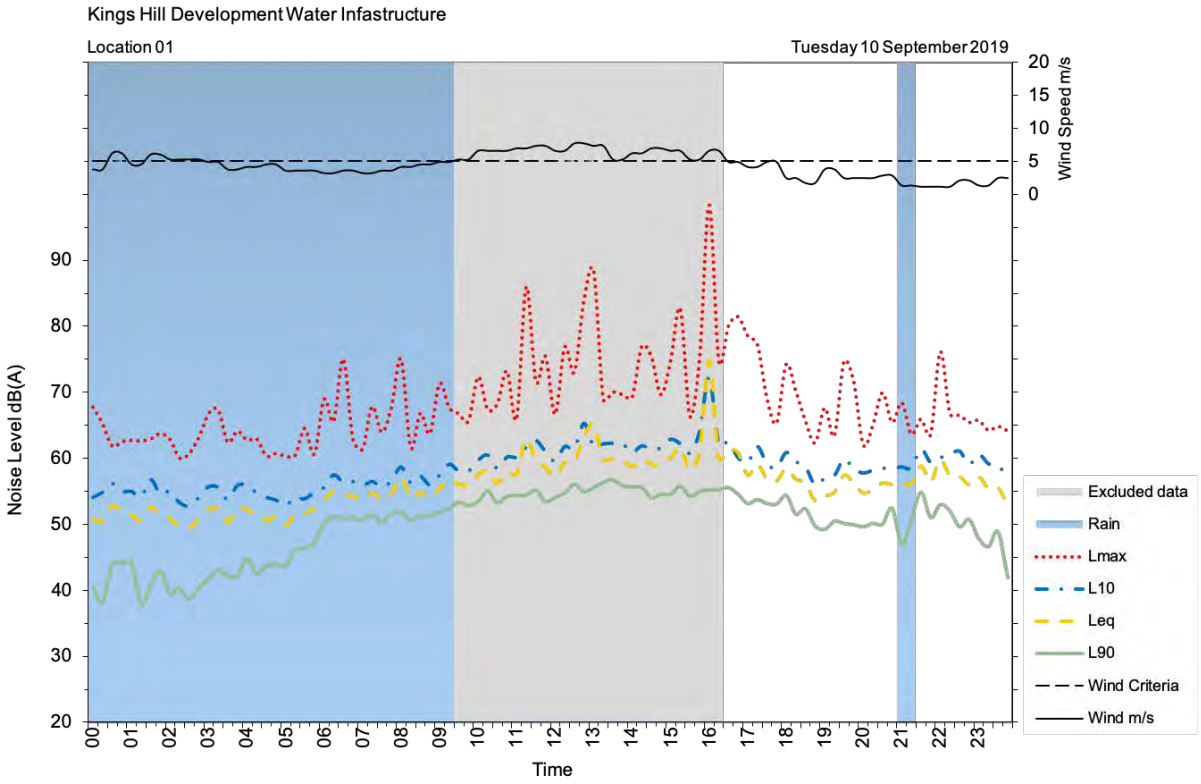

Kings Hill Development Water Infastructure
Location 01
Thursday 05 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

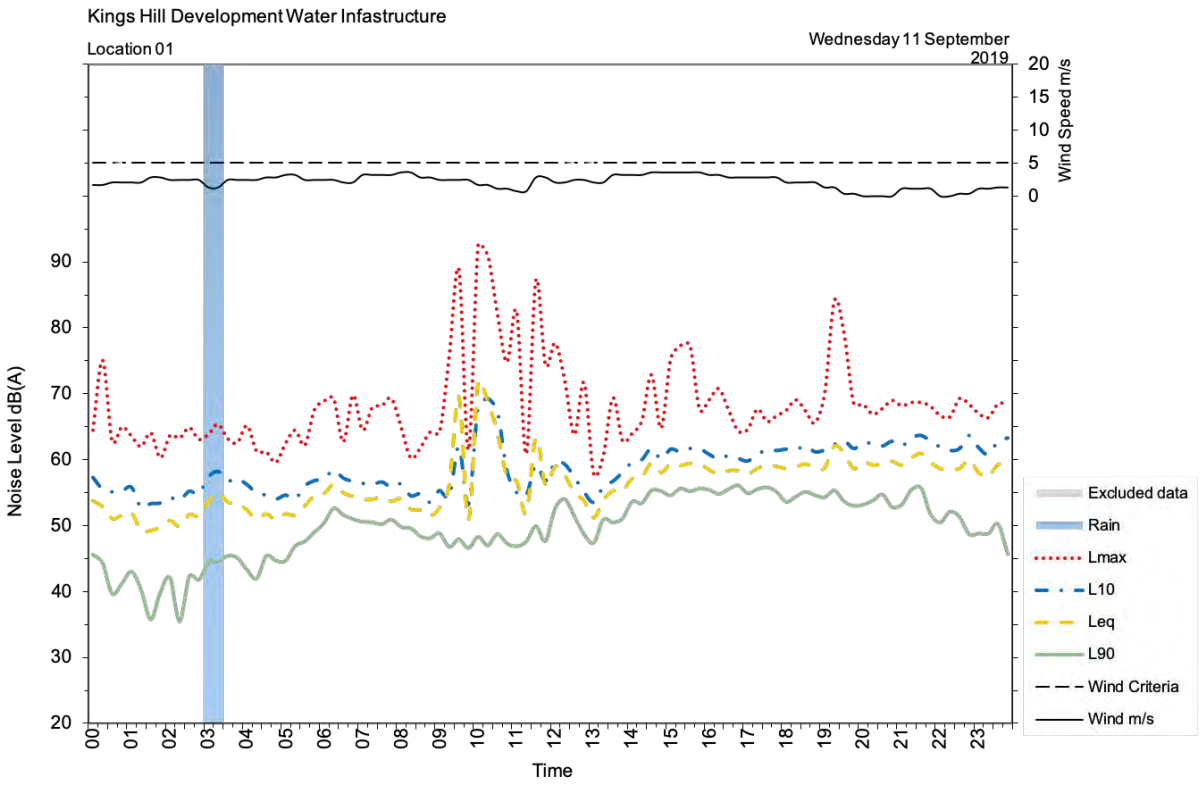

Kings Hill Development Water Infastructure
Location 01
Friday 06 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

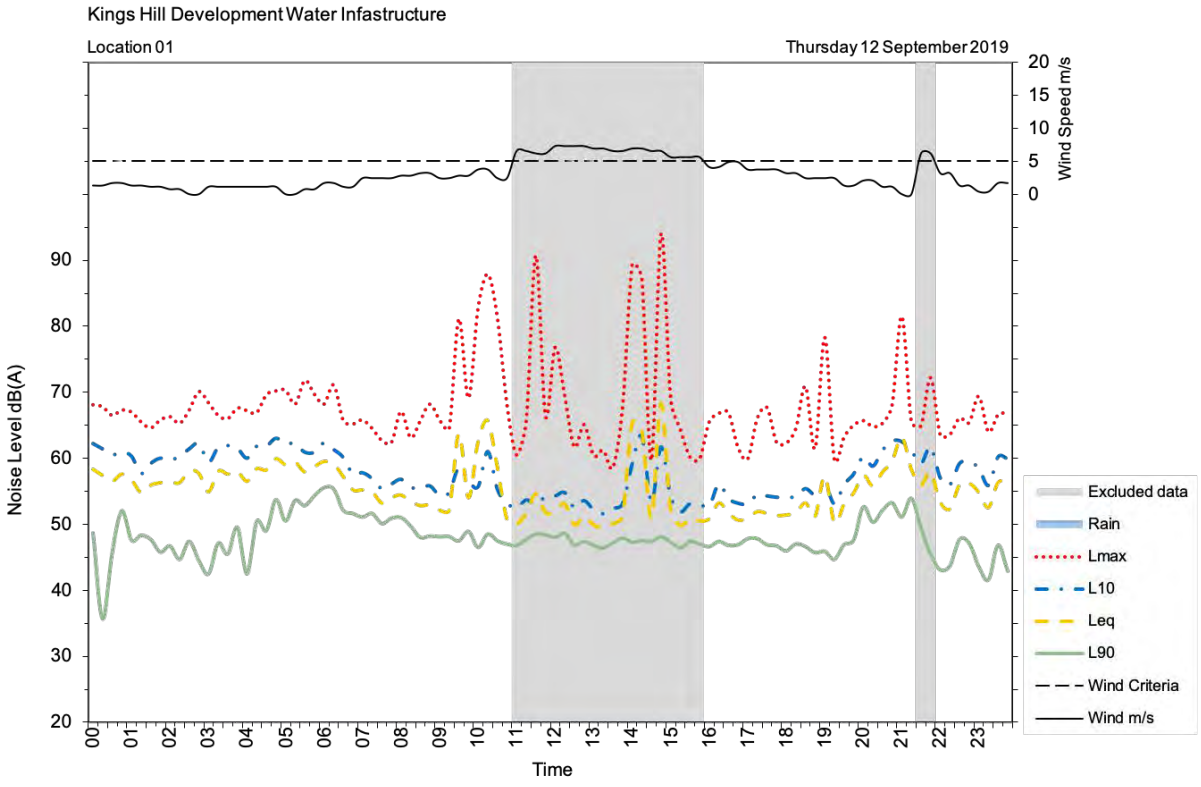

Kings Hill Development Water Infastructure
Location 01
Saturday 07 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

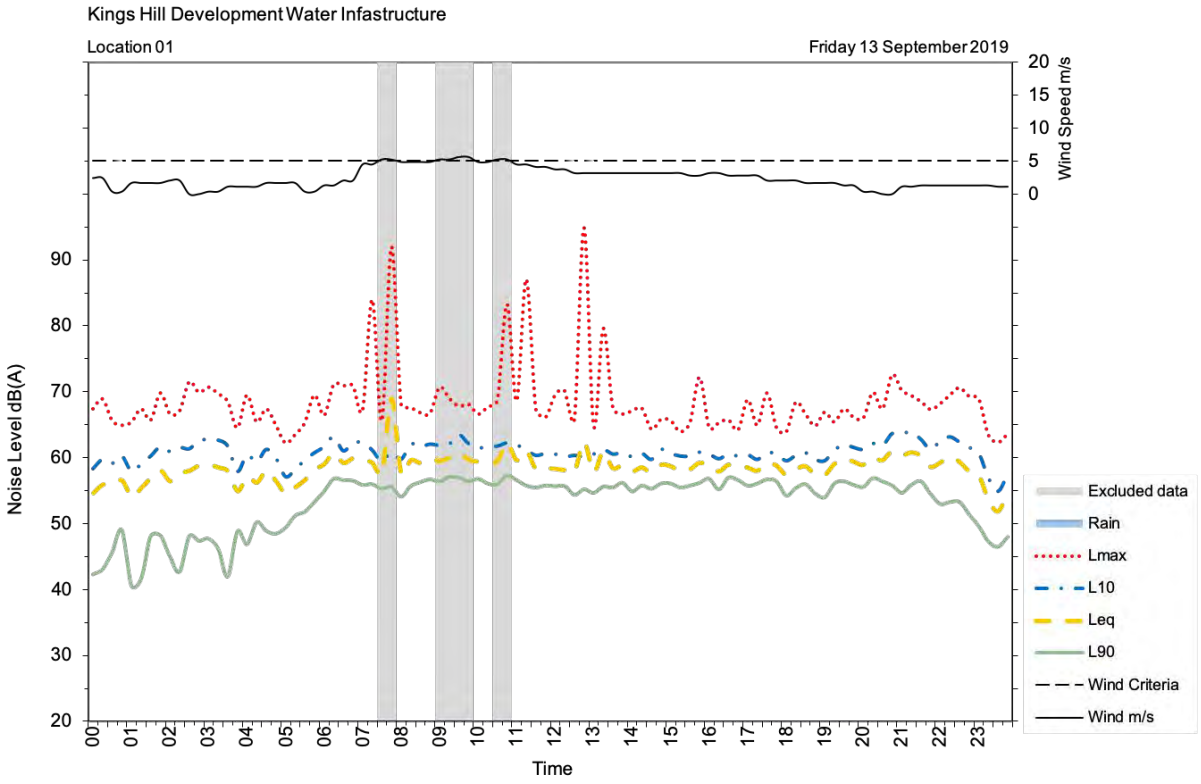

Kings Hill Development Water Infastructure
Location 01
Sunday 08 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

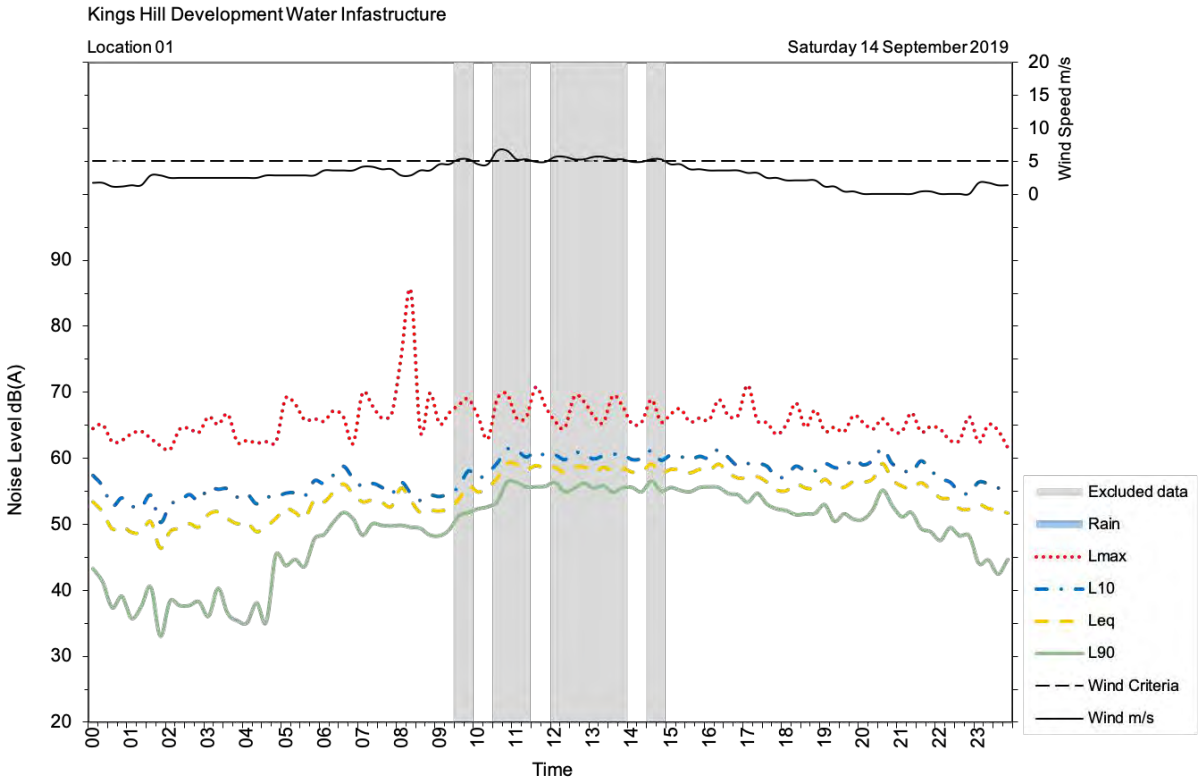

Kings Hill Development Water Infastructure
Location 01
Monday 09 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

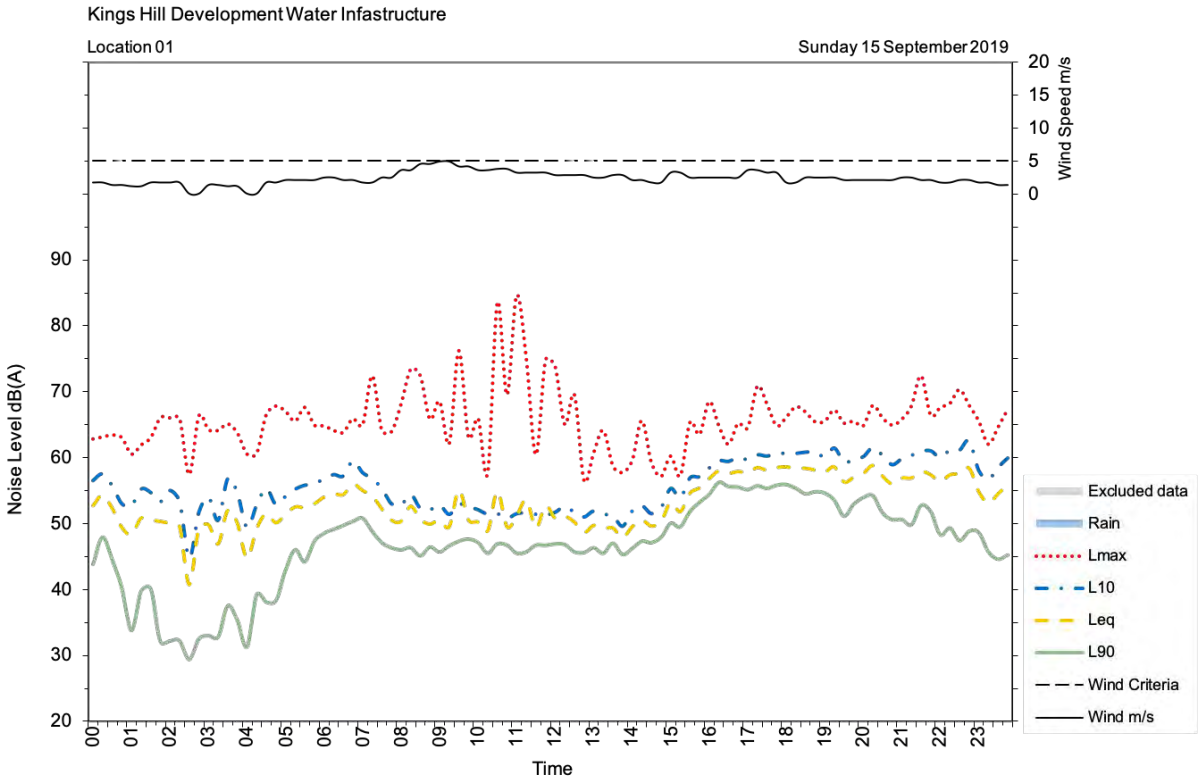

Kings Hill Development Water Infastructure
Location 01
Tuesday 10 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

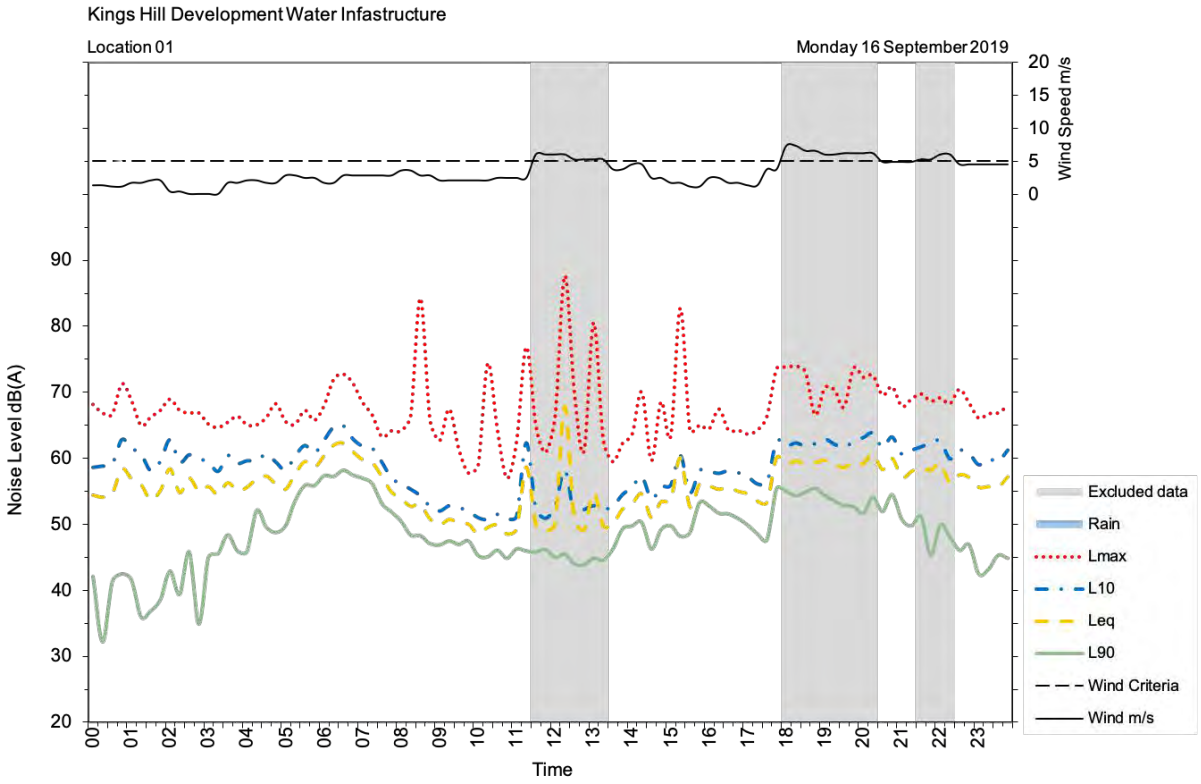

Kings Hill Development Water Infastructure
Location 01
Wednesday 11 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

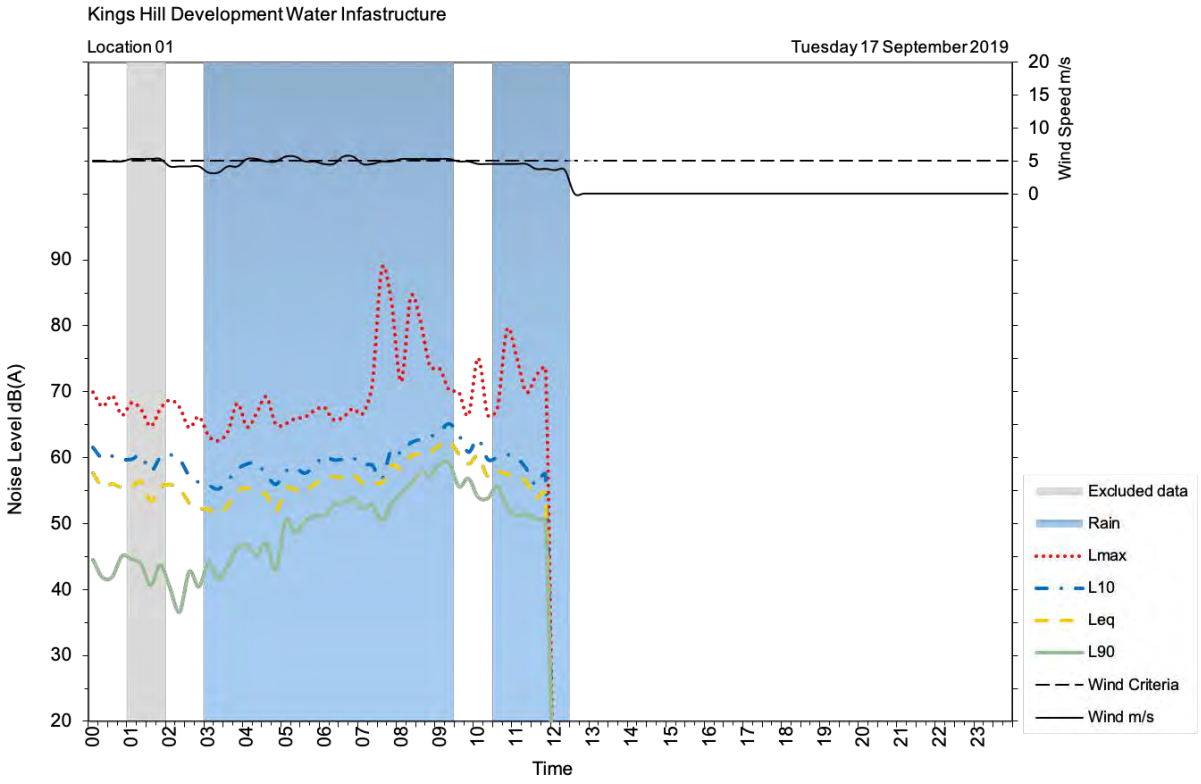

Kings Hill Development Water Infastructure
Location 01
Thursday 12 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infastructure
Location 01
Friday 13 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

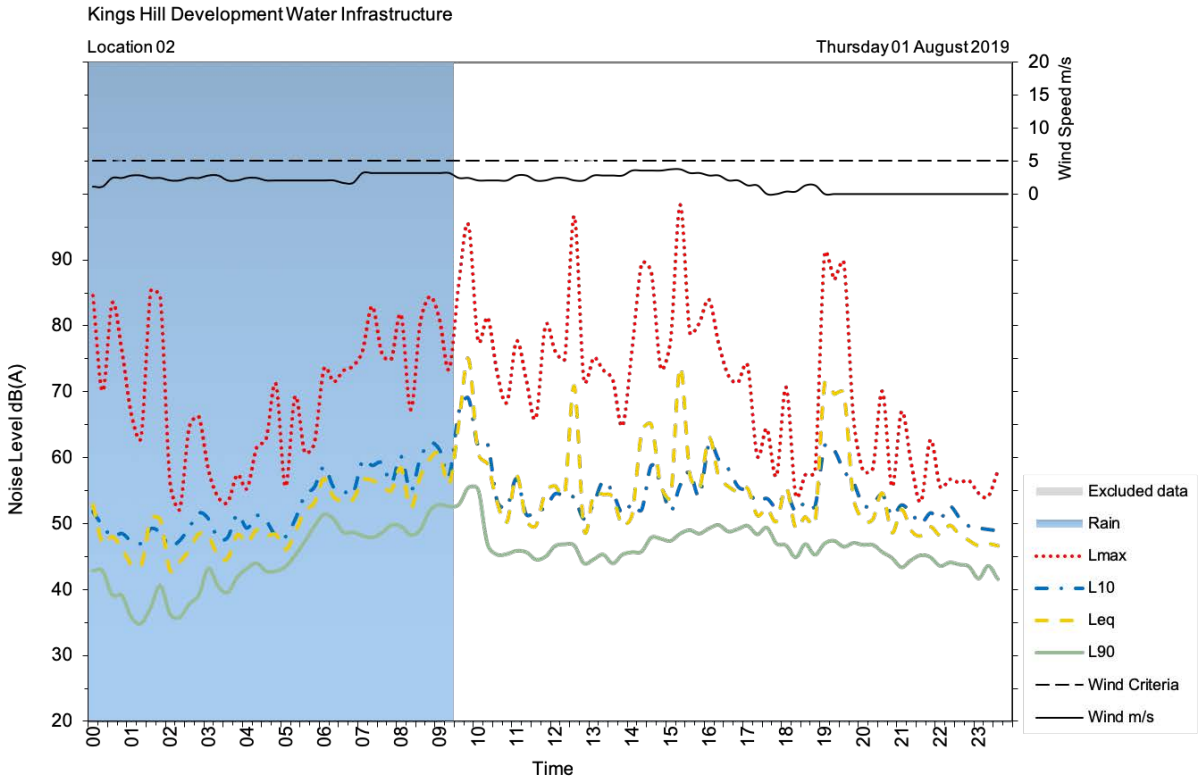

Kings Hill Development Water Infastructure
Location 01
Saturday 14 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

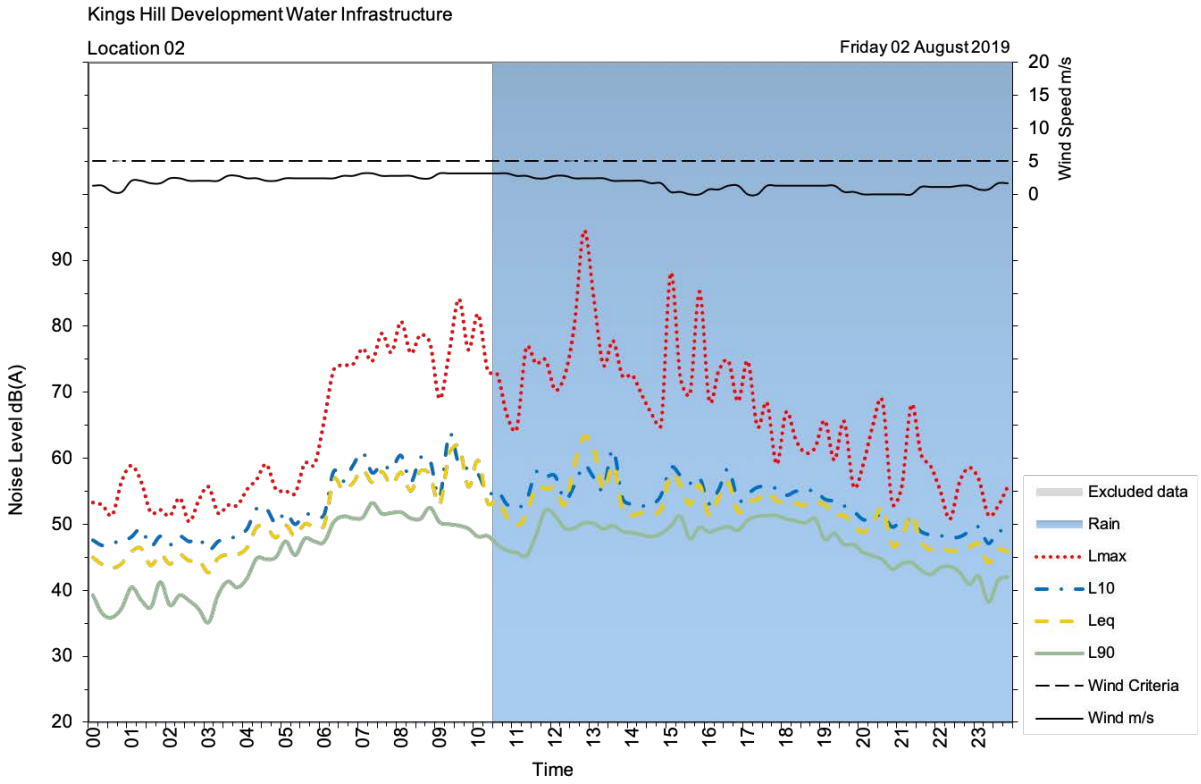

Kings Hill Development Water Infastructure
Location 01
Sunday 15 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

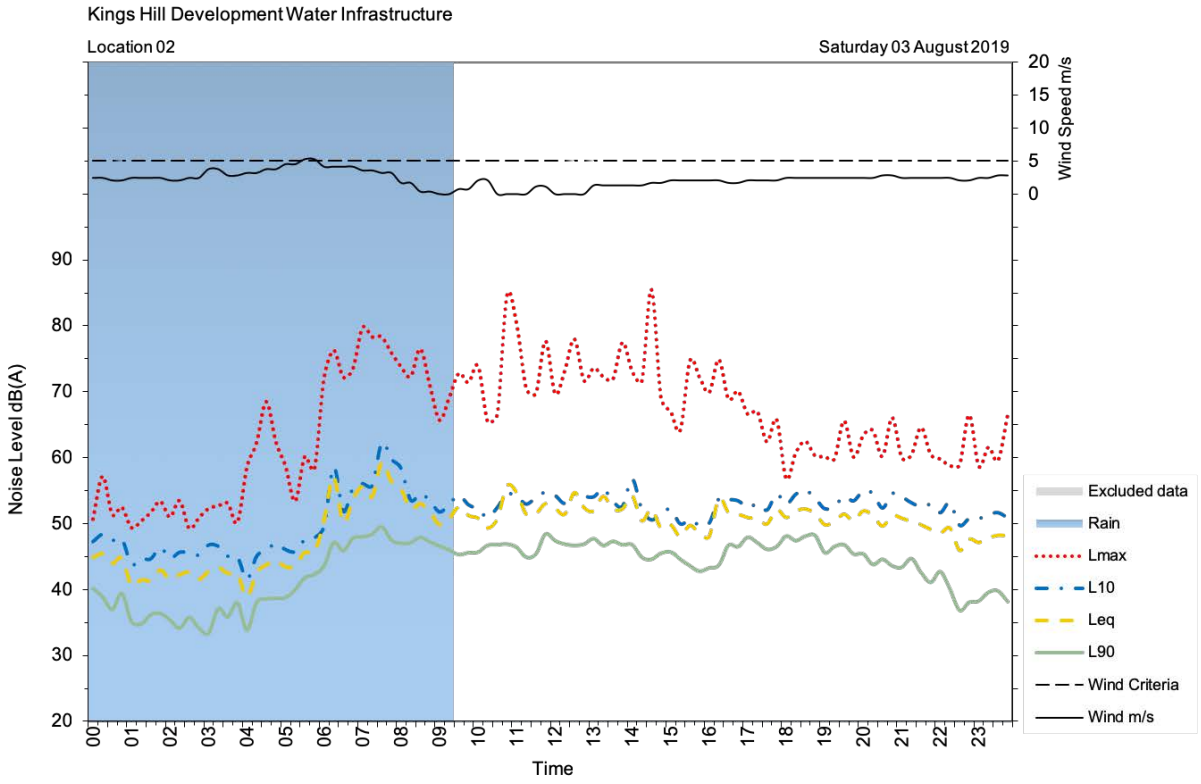

Kings Hill Development Water Infastructure
Location 01
Monday 16 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

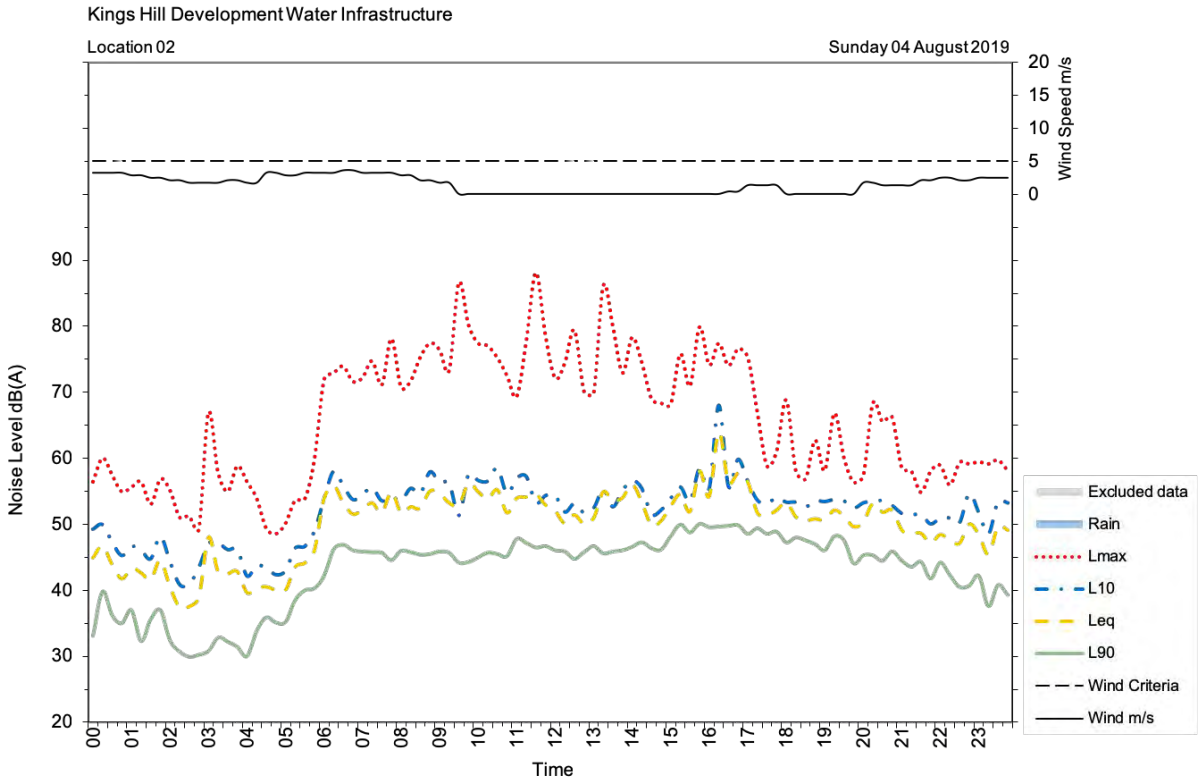

Kings Hill Development Water Infastructure
Location 01
Tuesday 17 September 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

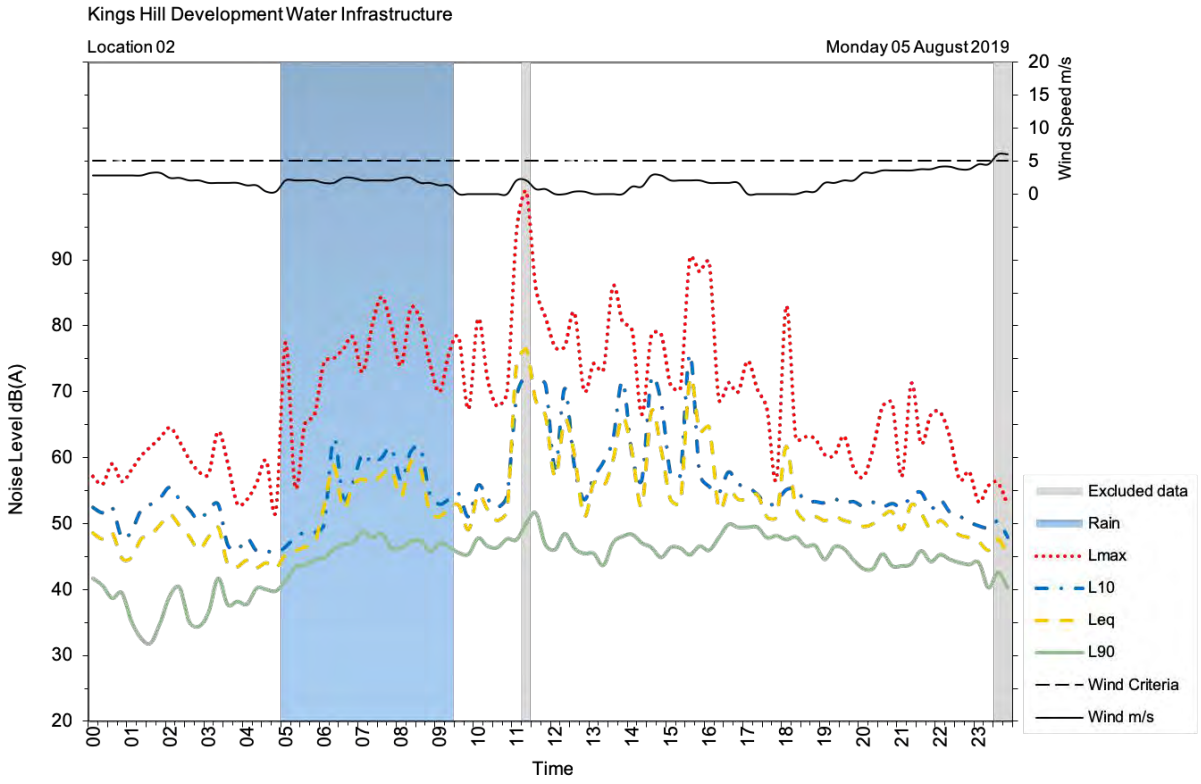
Address	Adjacent to 34 Rees James Road
Measurement location	Location 2
Measurement details	LA90, LAeq, LA10, LAmax,
Logging period	Tuesday 30th July 2019 to Wednesday 14th August
Attended monitoring notes	The noise levels, measured in the free field, were controlled by distant traffic noise from the Pacific Highway. The maximum sound level generated by a car passby on the nearby local road.

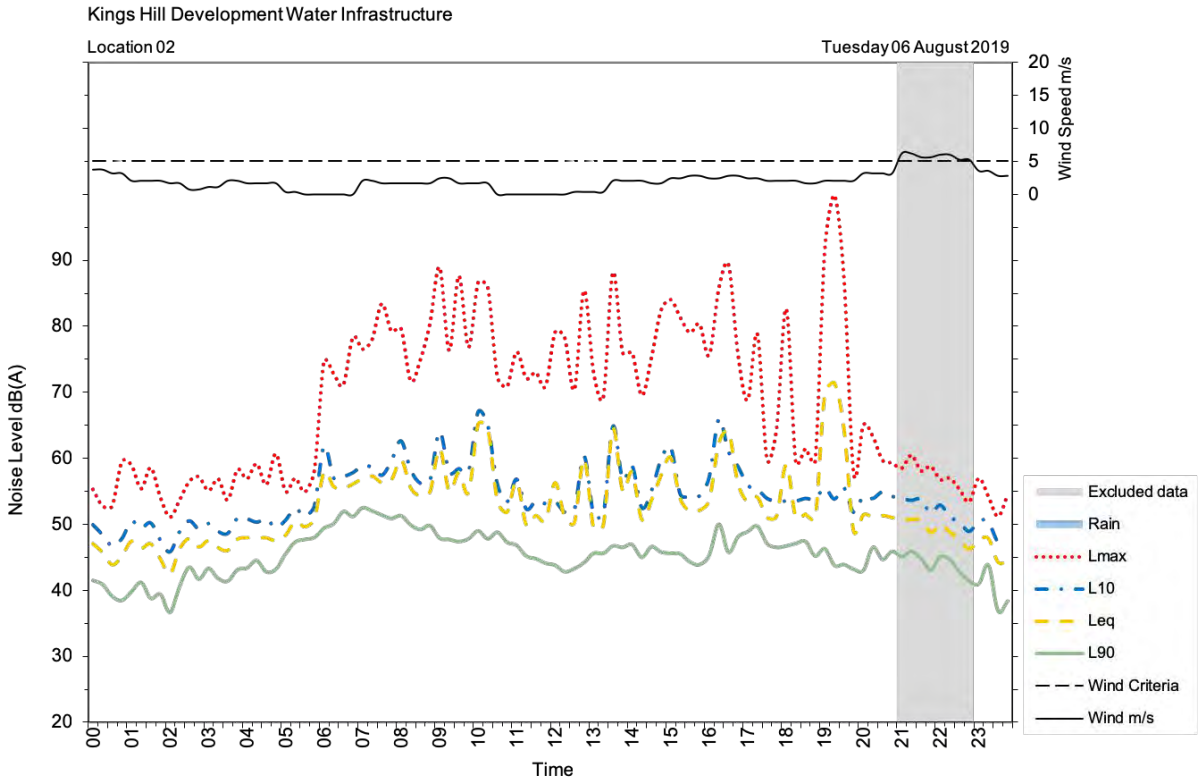

Kings Hill Development Water Infrastructure
Location 02
Thursday 01 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

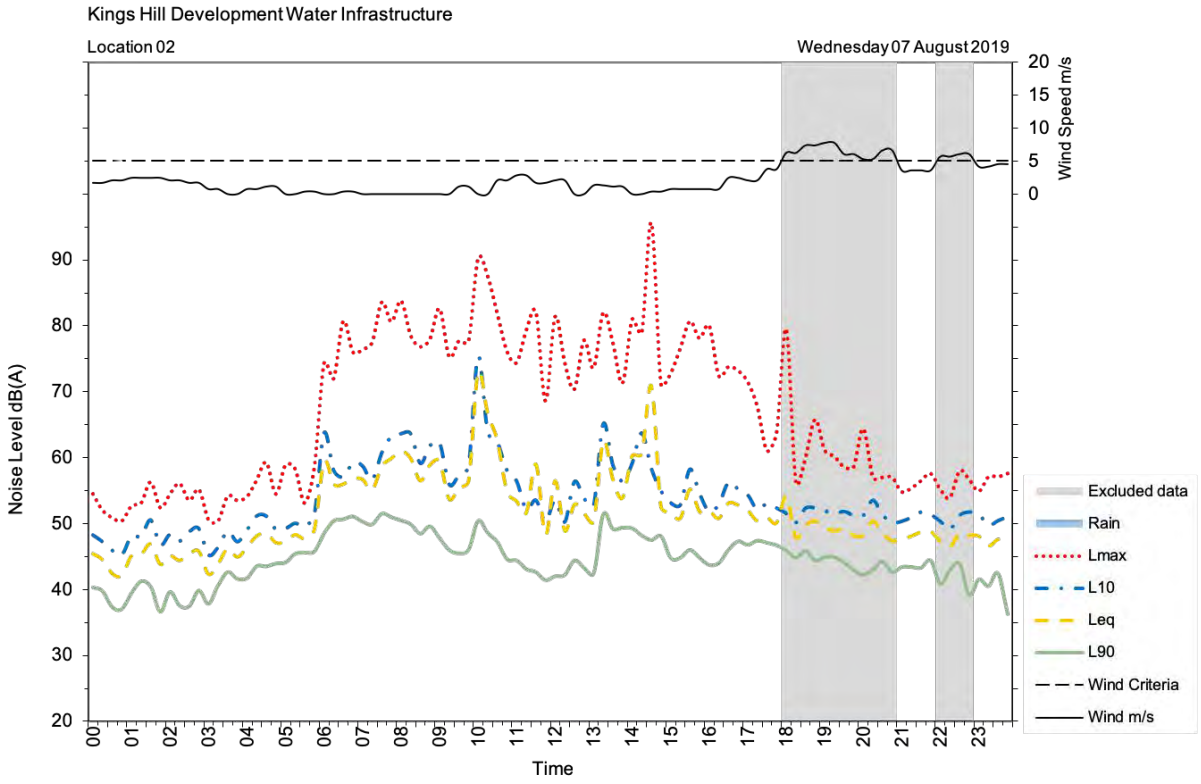

Kings Hill Development Water Infrastructure
Location 02
Friday 02 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

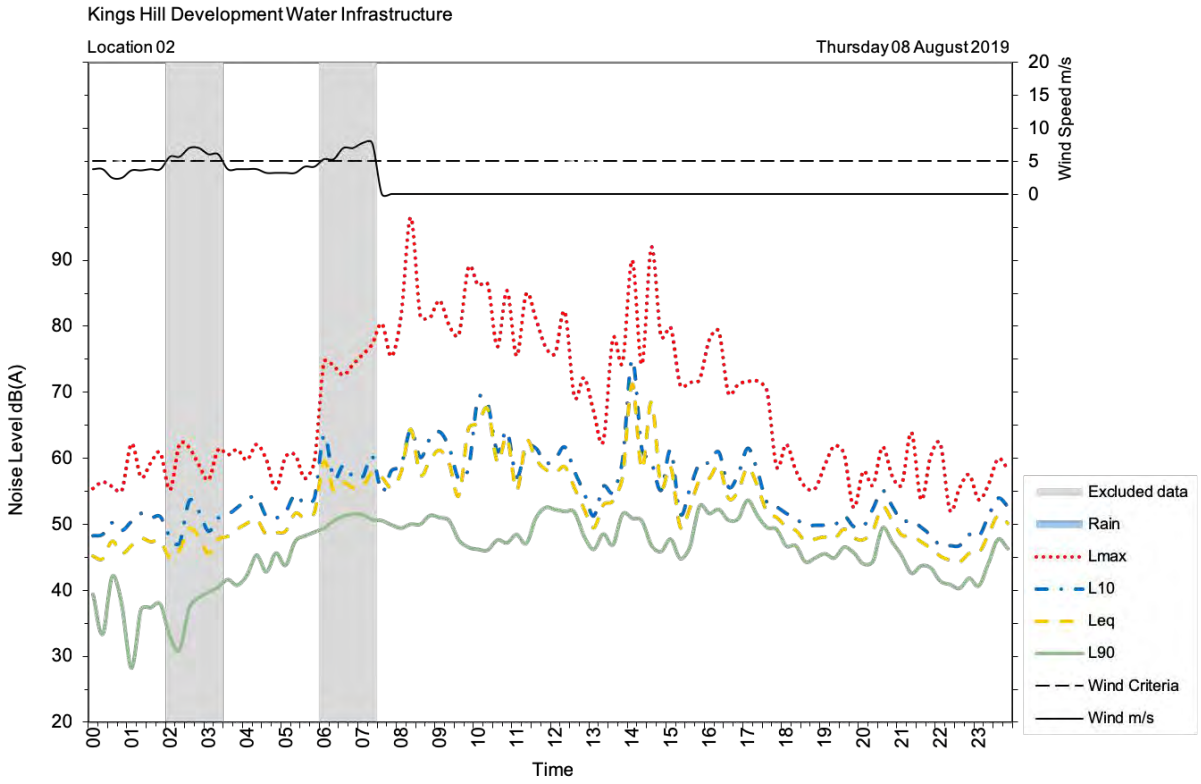

Kings Hill Development Water Infrastructure
Location 02
Saturday 03 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

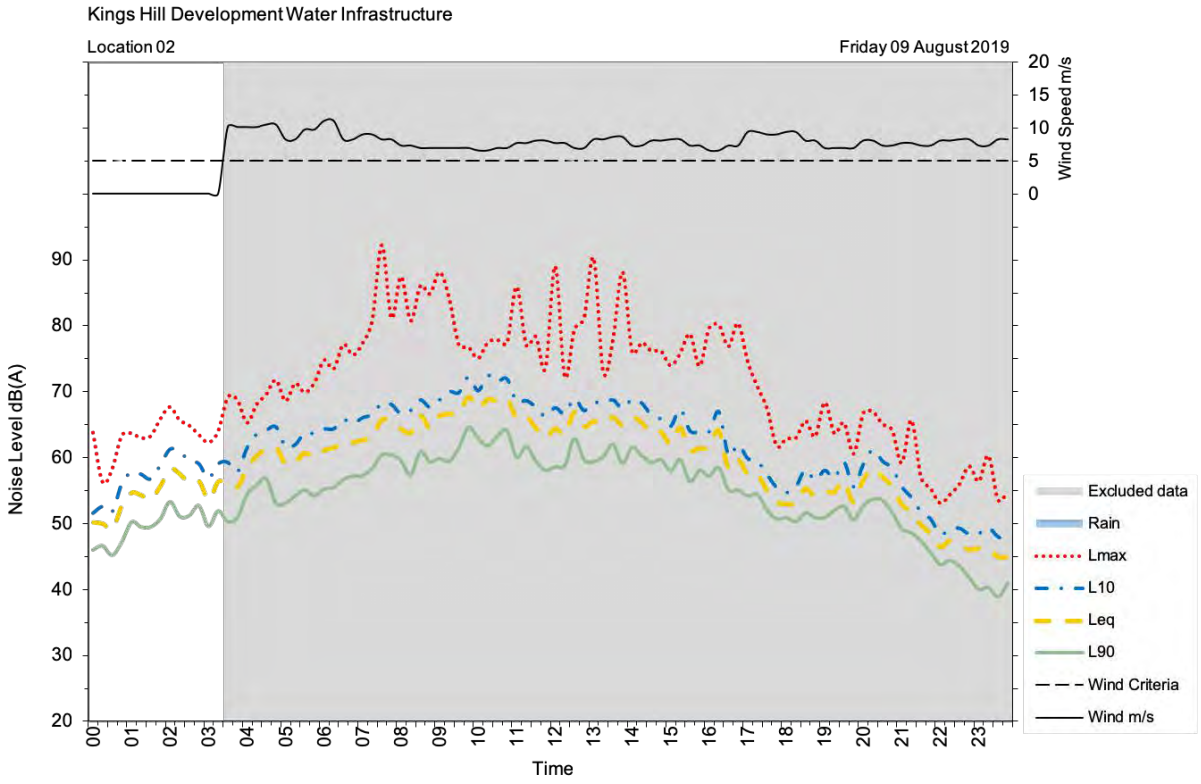

Kings Hill Development Water Infrastructure
Location 02
Sunday 04 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

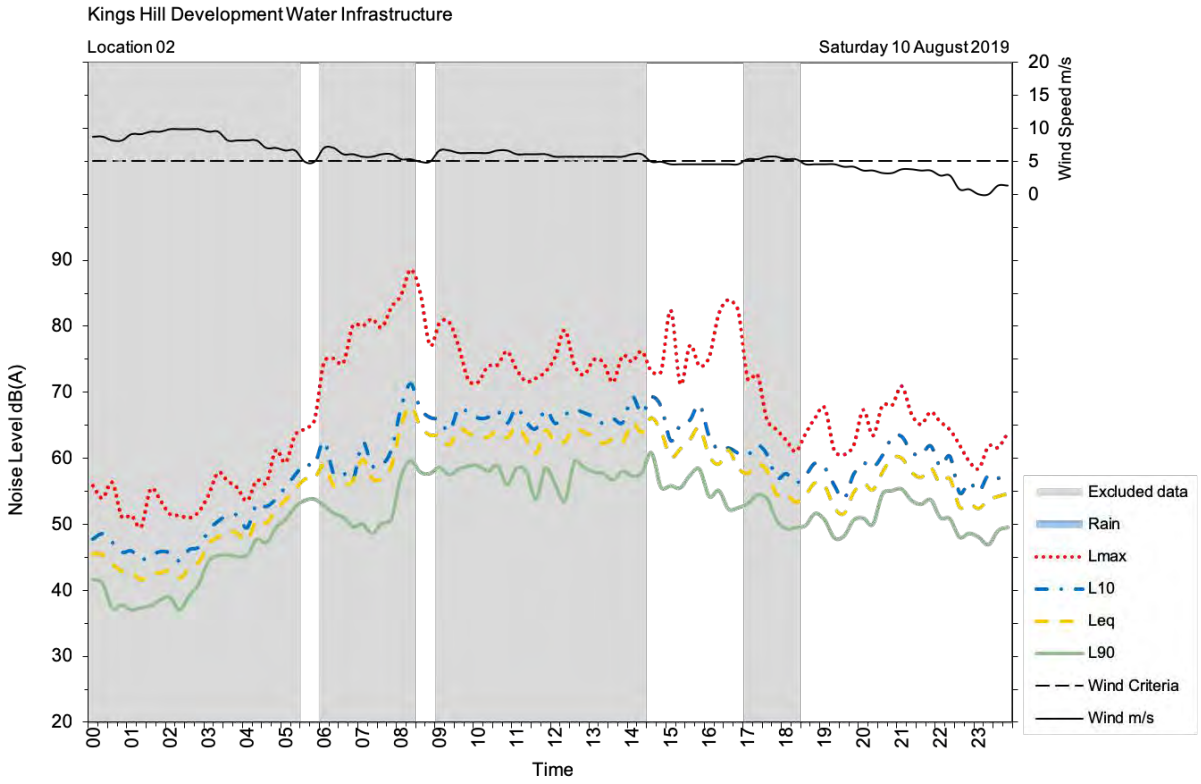

Kings Hill Development Water Infrastructure
Location 02
Monday 05 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

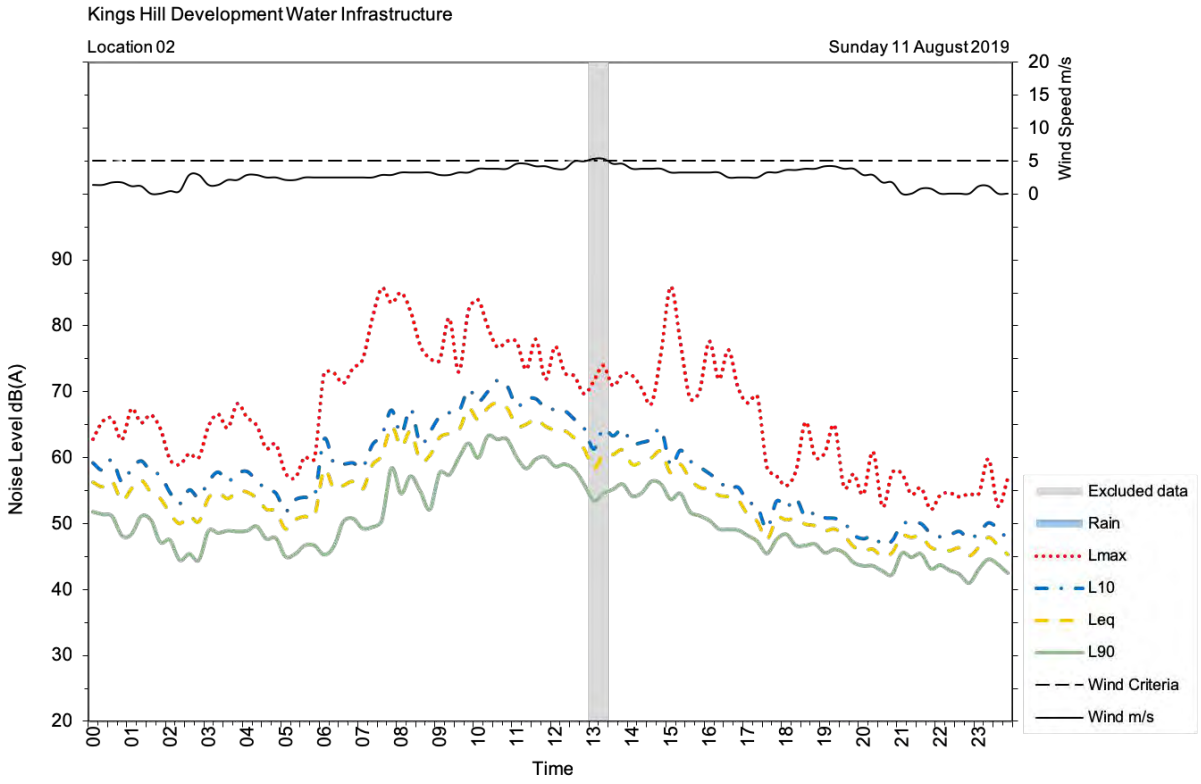

Kings Hill Development Water Infrastructure
Location 02
Tuesday 06 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

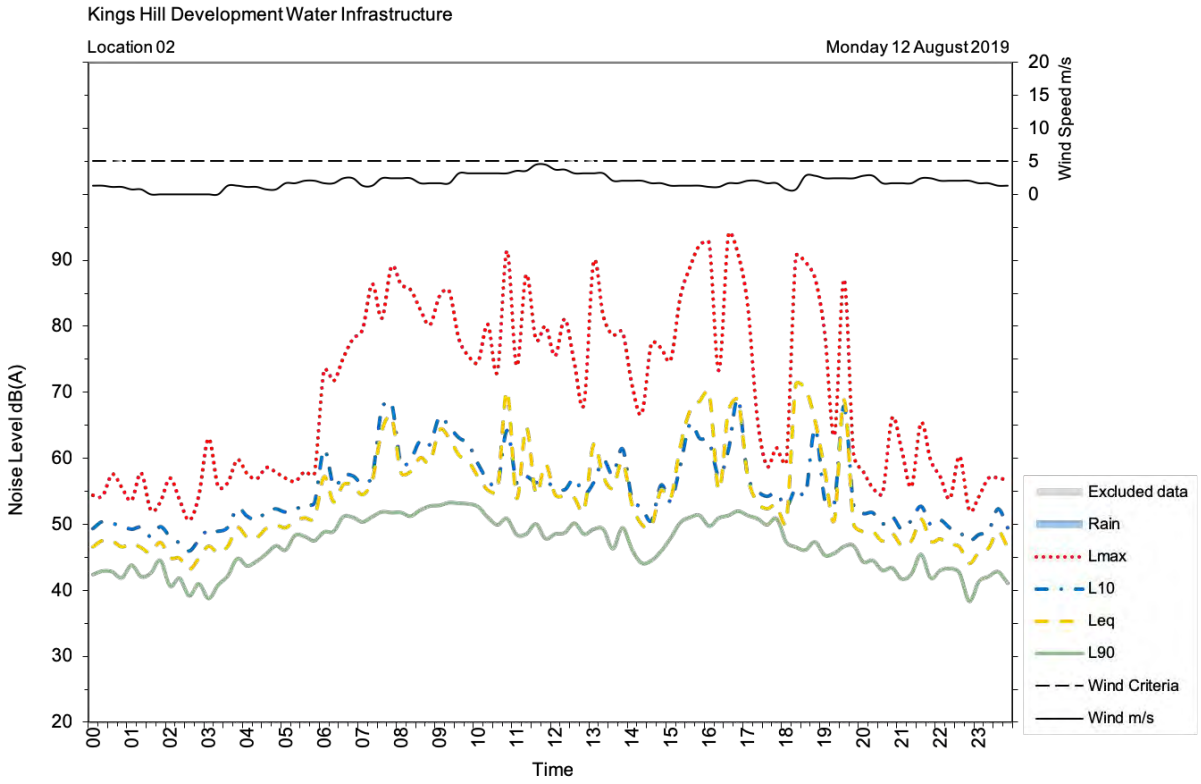

Kings Hill Development Water Infrastructure
Location 02
Wednesday 07 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infrastructure
Location 02
Thursday 08 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infrastructure
Location 02
Friday 09 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infrastructure
Location 02
Saturday 10 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infrastructure
Location 02
Sunday 11 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Kings Hill Development Water Infrastructure
Location 02
Monday 12 August 2019
Noise Level dB(A)
Wind Speed m/s
Time
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s