Portside Building 2

Noise Impact Assessment

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1 INTRODUCTION

Acoustic Logic Consultancy have been engaged by Brookfield Multiplex to conduct an assessment of potential noise impacts associated with the proposed Portside Building 2 development to be located adjacent to the existing Building 3 of the Portside development.

Noise impacts addressed in this document include the following:

- Noise associated with the cruise ship terminal to the South.
- Noise associated with aircraft flyovers; and
- Traffic noise associated with Kingsford Smith Drive to the North.

Noise impacts have been assessed against the Brisbane City Council Noise Impact Planning Scheme Policy (NIAPSP) and associated Noise Methodologies Guidelines.

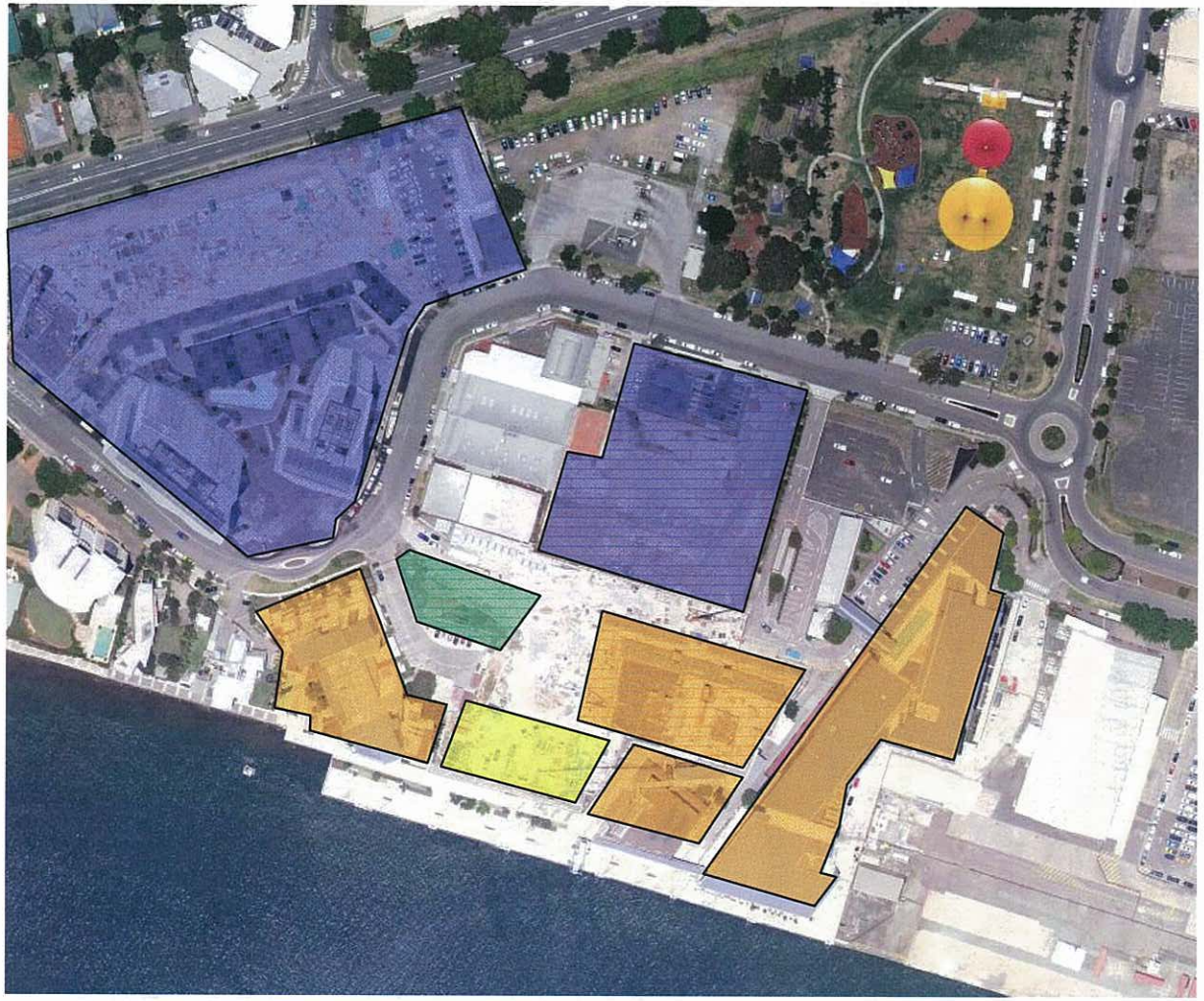
This document also establishes noise emission objectives to govern mechanical plant servicing the development.

2 SITE DESCRIPTION

Portside Building 2 is a residential development to be located along the Brisbane River as part of the Portside development. The building will include:

- A café on the ground level;
- Residential apartments from ground to Level 14;
- Associated residential parking;
- Associated residential facilities.

Traffic to the area is fed from Kingsford Smith Drive along the local streets Harbour Road and Hercules Street. Additional local carriageways are to be constructed as part of the development to service the retail and residential uses.



LEGEND

Proposed Site	
Future Portside Building 5	
Existing Portside Development	
Development by Mirvac and Devine	

Figure 1: Portside Site Survey

3 TRANSPORTATION NOISE INTRUSION

3.1 BASIS OF METHODOLOGY

An investigation of noise intrusion into the proposed development has been carried out for the following reasons, namely:

1. High levels of external noise sources heard within habitable spaces may be disruptive to general day to day activities such as speech communication, listening to the television/stereo, or to sleep. Therefore, such noise needs to be reduced to a level where it is not intrusive upon normal activities.

2. The regulation of external noise sources is seen as an indication of the quality and market position of a development.

As part of this assessment, an investigation into traffic noise has been conducted to ascertain the potential level of noise impact on the future occupants of the building.

3.2 TRANSPORTATION NOISE SOURCES

Transportation noise addressed in this assessment includes the following:

- Traffic noise from Kingsford Smith Drive;
- Aircraft noise associated with the Brisbane Airport; and
- Cruise ship noise associated with the terminal to the East of the site.

Due to the distance between the development and Kingsford Smith Drive, traffic noise impacts are expected to be minimal compared to the cruise ship terminal and aircraft flyovers. Notwithstanding this, traffic noise impacting the façade have been included for clarity.

3.3 TRANSPORTATION NOISE DESCRIPTORS

Traffic noise constantly varies in level, due to fluctuations in traffic speed, vehicle types, road conditions and traffic densities. Accordingly, it is not possible to accurately determine prevailing traffic noise conditions by measuring a single, instantaneous noise level. To accurately determine the effects of traffic noise a 15 minute measurement interval is utilized. Over this period, noise levels are monitored on a continuous basis and statistical and integrating techniques are used to determine noise description parameters. These parameters are used to measure how much annoyance would be caused by a particular noise source.

In the case of environmental noise three principle measurement parameters are used, namely L_{10}, L_{90} and L_{eq}.

The L_{10} and L_{90} measurement parameters are statistical levels that represent the average maximum and average minimum noise levels respectively, over the measurement intervals.

The L_{10} parameter is commonly used to measure noise produced by a particular intrusive noise source since it represents the average of the loudest noise levels produced by the source.

Conversely, the L_{90} level *(which is commonly referred to as the background noise level)* represents the noise level heard in the quieter periods during a measurement interval. The L_{90} parameter is used to set the allowable noise level for new, potentially intrusive noise sources since the

disturbance caused by the new source will depend on how audible it is above the pre-existing noise environment, particularly during quiet periods, as represented by the L_{90} level.

The L_{eq} parameter represents the average noise energy during a measurement period. This parameter is derived by integrating the noise levels measured over the measurement period. L_{eq} is important in the assessment of traffic noise impact as it closely corresponds with human perception of a changing noise environment; such is the character of traffic noise.

4 TRAFFIC NOISE INTRUSION

Traffic noise intrusion has been assessed for ultimate traffic flows along Kingsford Smith Drive against the requirements of Brisbane City Council.

4.1 TRAFFIC NOISE ASSESSMENT CRITERIA

Brisbane City Council, in its Noise Impact Assessment Planning Scheme Policy *(NIAPSP),* identifies a legislative approach to noise, provides noise criteria that can be used to determine noise impacts from noise immissions and emissions and thus permits assessment to determine acoustic ameliorative measures to ensure compliance with the Policy.

Section 6 of the NIAPSP – *"Planning Assessment Methodologies"* dictates that the building envelope of the development is required to achieve the internal design noise levels recommended in Australian/New Zealand Standard AS/NZS 2107:2000 *"Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors"*. These design sound levels are presented in Table 1.

The BCC Noise Methodologies Guidelines adopts a worst hour time descriptor for traffic noise to bedrooms during the night time period of 10pm to 7am. Noise levels within the apartment are to comply with the maximum noise levels for living areas between 7am to 10pm.

Table 1 – Internal Noise Level Criterion

Occupancy/Activity	Time Period	Recommended Design Sound Level dB(A) L_{aeq}
Living Areas	7am – 10pm	45
Sleeping Areas	7am – 10pm	45
	10pm – 7am	40

4.2 TRAFFIC NOISE MEASUREMENTS

Traffic noise levels were established from on-site measurements conducted by Acoustic Logic Consultancy.

4.2.1 Measurement Equipment

Noise measurements were obtained using a Norsonics 118 precision sound level analyser, set to A-weighted fast response. The precision sound level analyser was calibrated before and after the measurements using a Norsonics 1443 precision sound level calibrator. No significant drift was recorded.

4.2.2 Location of Measurements

Noise measurements were conducted along Kingsford Smith Drive in front of the Hamilton Harbour development. Traffic was free flowing during this period with high concentrations of heavy traffic which will be used as a worst case for this assessment.

4.2.3 Traffic Noise Levels

Measured traffic noise levels along Kingsford Smith Drive are presented in the Table below. This noise level will be used as a basis for this assessment in comparison with the ultimate traffic flows for the road. Traffic noise levels have been corrected for façade reflection associated with the hoarding along the Hamilton Harbour site.

Table 2 – Kingsford Smith Drive Traffic Noise Levels

Location	Time	Traffic Noise Level
3m from KSD	6am – 8am	76dB(A) $L_{eq\ 1hour}$

4.3 ULTIMATE TRAFFIC VOLUMES

The ultimate traffic volumes projected for Kingsford Smith Drive have been adopted from traffic counts conducted in 2008. Projected volumes have been determined from the SKM Connell Wagner Airport Link feasibility study.

Table 3 – Ultimate Traffic Volumes

Traffic Volumes	AADT	% Heavy Vehicles
2008	64,906	11
Projected 2022	77,200	11

These traffic volumes have been incorporated into the Calculation of Road Traffic Noise model which has been used to predict noise levels to the development.

4.4 CORTN PARAMETERS

The following parameters have been incorporated in the CoRTN model. These parameters have been used and incorporated into the SoundPlan™ noise modelling software in conjunction with measured worst case noise levels.

Table 4 – CoRTN 2022 Model

Parameter	2008 Traffic Volume (KSD)	Ultimate Traffic Volume AADT (KSD)	Ultimate Traffic Volume 18 hour (KSD)
Traffic Volume	64,906	77,200	71800
Percentage of Heavy Vehicles	11%	11%	11%
Estimated Traffic Speed	60km/h	60 km/h	60km/h

The CORTN modelling software is based around the 18hour time descriptor which typically represents 93% of traffic flows during the 24-hour period.

A set of offset parameters for correlating noise descriptors has previously been published[1] and is based on extensive study of sites in southeast Queensland. The results of these offset parameters are presented in Table 5 and have been used for the purpose of this assessment.

Table 5 - Descriptor Offset Parameter

Descriptor / Parameter	$L_{10\ 18\ Hour}$ Vs. Offset Parameter dB(A)
$L_{10\ 18\ hour}$	0.0
$L_{Aeq\ 24\ hour}$	+3.6
$L_{Aeq\ 1\ hour\ night}$	+3.4
$L_{Aeq\ 1\ hour\ day}$	-0.4
$L_{Aeq\ 1\ hour}$	-0.4
Average $L_{AMAX\ night}$	-0.2
$L_{10\ 12\ hour}$	-1.5

The model has been calibrated using the offset parameters against the measured noise levels during the peak hour period.

[1] Brown, R., *"An Assessment of the Relationship between the $L_{10(18\ hour)}$ Noise Level Parameter and other Road Traffic Noise Level Parameters"*, Proc. Australian Acoustical Society Annual Conference, Gold Coast, 2004.

Table 6 – CoRTN Calibration

Noise Level	Noise Level L_{10} 18-hour	Noise Level L_{eq} 1-hour
CoRTN 2008 @ 3m from curb	76	77
Measured Noise Level @ 3m from curb	-	76

Predicted noise levels using the CoRTN model fall within +/- 1dB(A) of the measured noise levels during a worst 1 hour period and a such will be used for the basis for this assessment.

4.5 PREDICTED TRAFFIC NOISE LEVELS

Traffic noise levels at the worst affected residential façade have been calculated using the Soundplan noise modelling software. The worst case external noise level is 59dB(A) L_{eq}. This level will be used as a basis in comparing the ultimate required noise reduction across the façade in comparison with port and aircraft noise sources.

5 PORT ACTIVITIES NOISE ASSESSMENT

Portside wharf caters for commercial cruise liners which dock at the facility. The potential for noise impact on Building 2 has been assessed for general operation of the port against the requirements of BCC.

5.1 NOISE CRITERIA

Noise impacts from the port operation have been assessed against the requirements of the BCC NIAPSP. Internal noise levels within apartments as part of the development are to comply with Australian and New Zealand Standard AS/NZS 2107:2000 *"Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors"*. These design sound levels are presented in the Table below.

Table 7 – Recommended Design Sound Levels

Occupancy/Activity	Recommended Design Sound Level dB(A) L_{aeq}	
	Satisfactory	Maximum
Living Areas	35	45
Sleeping Areas	30	40
Work Areas	35	45

5.2 PORT NOISE ASSESSMENT

Noise associated with the port have been assessed against noise levels previously measured by this office and used on Portside Building 1, 3 & 7. Noise levels used as a basis for this assessment include the following:

Table 8 – Port Sound Noise Levels

Activity	Distance from Source Noise	Noise Level $L_{eq\ (15\ Min)}$ dB(A)	Noise Level L_1 dB(A)
Berthed Ship (Generators and the like)	25m	68	70
Forklift	10m	72	76
Crain	10m	76	79
Container Loader	10m	74	81

5.3 PORT NOISE LEVELS

The predicted noise levels from the operation of the port have been implemented in the SoundPlan™ noise modelling software. The worst case external noise level is 65dB(A) L_{eq}. This level will be used as a basis in comparing the ultimate required noise reduction across the façade in comparison with traffic and aircraft noise sources.

6 AIRCRAFT NOISE LEVELS

6.1 AIRCRAFT NOISE CRITERIA

The acceptability of aircraft noise exposure is assessed using Australian Standard AS 2021-2000 *"Aircraft Noise Intrusion - Building Siting and Construction"*. The standard sets criteria for allowable levels of aircraft noise exposure depending on the proposed land use for the site being assessed.

The acceptability of a site in terms of aircraft noise exposure is assessed using the Australian Noise Exposure Forecast System *(ANEF).* Three basic parameters influence perception of aircraft noise: the frequency of aircraft movement's overhead, the noise level and duration of individual aircraft movements, and the time of the day in which they occur. ANEF was developed to provide a rating system that reflects actual human response to these factors so that the noise exposure of a particular location can be readily assessed.

The Portside Wharf development is located adjacent to the ANEF 20 contour of the Brisbane Airport Ultimate Capacity ANEF chart which incorporates the proposed New Parallel Runway *(NPR).* This makes the site *"conditionally acceptable"* for use as a residential development subject to compliance with the flyover internal noise levels recommended in AS2021:2000.

AS2021:2000 states that a full evaluation of internal noise levels should be carried out for locations with an aircraft noise exposure close to or exceeding ANEF 20. This full evaluation requires an examination of likely levels of internal noise from aircraft flyovers.

AS2021:2000 stipulates the internal noise levels listed in the Table below for residential buildings. These levels will be used to assess aircraft noise intrusion into the residential levels of the development.

Table 9 – Aircraft Noise Level Criteria

Building Use	Building Type and Activity	Indoor Design Sound Level from Aircraft Flyover, dB(A) L_{max}
Residential	Sleeping areas	50
	Other habitable spaces	55
Retail	Shops, supermarkets, showrooms	75

6.2 AIRCRAFT FLYOVER NOISE LEVELS

Noise intrusion into the mixed use development was assessed using flyover noise levels established using Australian Standard AS2021-2000 for noise associated with aircraft using the Brisbane Airport. Treatments have been designed for the worst case noise level and effective exposure on students within teaching spaces.

Aircraft noise levels have been assessed based on the loudest typical noise level of 83dB(A) L_{AMAX} associated with Boeing 747-400 aircraft taking off from the New Parallel Runway as part of the Brisbane Airport Master Plan.

Table 10 – External Aircraft Noise Levels

Source of Noise	Noise Level dB(A) L_{AMAX}	Internal Criteria dB(A) L_{AMAX}	Required Reduction dB(A)
Aircraft	83	Bedrooms 50	33
		Other habitable spaces 55	28
		Retail 75	8

7 REQUIRED NOISE REDUCTION

The noise levels used for this assessment will be evaluated for the worst case scenario representing the maximum noise reduction required. The predicted noise levels presented above are illustrated below with respect to the maximum reduction required.

Table 11 – Residential Maximum External Noise Sources (Bedrooms)

Source of Noise	Noise Level dB(A)	Internal Criteria dB(A) L_{Aeq}	Internal Criteria dB(A) L_{AMAX}	Required Reduction dB(A)
Traffic	59	40	-	19
Aircraft	83	-	50	**33**
Port Noise	65	40	-	25

On this basis, aircraft noise intrusion will be the primary source of noise impacting future residents as part of the development and as such have been used for this assessment.

8 EVALUATION OF AIRCRAFT NOISE INTRUSION

Aircraft noise intrusion into the proposed Building 2 of the Portside development was assessed using the noise levels established from aircraft flyovers presented in Section 7 which represents the worst typical noise level affecting residential dwellings.

Calculations were undertaken taking into account the orientation of windows, the total area of glazing, facade transmission loss and room sound absorption characteristics. In this way the likely interior noise levels can be predicted.

In all cases, the selected glazing types reduce internal noise levels to within the recommended design sound levels presented in Section 3 of this assessment for the various space types.

8.1 RECOMMENDED CONSTRUCTIONS

These constructions are recommended to comply with the noise objectives stated in Section 3 above.

8.1.1 Glazed Windows and Doors

The recommended glazing assemblies are presented in Table 12 to

Table 14 in order to satisfy the project acoustic objectives presented in Table 9. Thicker glazing may be required for structural, safety or other purposes. Where required to use thicker glazing than that scheduled, this will also be acoustically acceptable.

It is recommended that only window systems having test results indicating compliance with the required ratings obtained in a certified laboratory be used where windows with acoustic seals have been recommended.

Table 12 – Minimum Glazing Requirements

Level	Units	Space	Minimum Glazing Thickness	Minimum STC
Ground	2 Bed (44m^2) Grids 12-14	Bedroom 1	6.38mm Laminated	31
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed (52m^2) Grids 11-13	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	10.38mm Laminated	35
		Living	6.38mm Laminated	31
	2 Bed (47m^2) 2 Bed (48m^2) 2 Bed (52m^2) 2 Bed (50m^2) Grids B-K	Bedrooms	10.38mm Laminated	35
		Living	10.38mm Laminated	35
	2Bed (53m^2) Grids A-B	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	10.38mm Laminated	35
		Living	10.38mm Laminated	35
	2 Bed (46m^2) Grids 5-7	Bedroom 1	10.38mm Laminated	35
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed (45m^2) Grid 3-5	Bedroom 1	6.38mm Laminated	31
		Bedroom 2	10.38mm Laminated	35
		Living	6.38mm Laminated	31
	2 Bed (49m^2) Grids 2-3	Bedrooms	10.38mm Laminated	35
		Living	10.38mm Laminated	35
	2 Bed (41m^2) Grids 1-2	Bedrooms	10.38mm Laminated	
		Living	6.38mm Laminated	31
	2 Bed (42m^2) Grids 1-2	Bedroom 1	10.38mm Laminated	35
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed (82m^2) Grids H-J	Bedroom 1	10.38mm Laminated	35
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31

Table 13 – Minimum Glazing Requirements

Level	Units	Space	Minimum Glazing Thickness	Minimum STC
1	2 Bed (80m^2) Grids 14-15	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	10.38mm Laminated	35
		Living	10.38mm Laminated	35
	1 Bed (51m^2) 2 Bed (79m^2) Grids D-H	Bedroom 1	12.38mm Laminated	36
		Bedroom 2	6.38mm Laminated	31
		Living	6.38mm Laminated	31
	2 Bed (82m^2) Grids H-J	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
2-13	2 Bed (80m^2) Grids 14-15	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	10.38mm Laminated	35
		Living	6.38mm Laminated	31
	2 Bed + Study (80m^2) Grids 13-14	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed (84m^2) Grids 11-13	Bedroom 1	12.38mm Laminated	36
		Bedroom 2	6.38mm Laminated	31
		Living	10.38mm Laminated	35
	2 Bed (81m^2) Grids G-K	Bedrooms	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed (80m^2) Grids D-G	Bedroom 1	10.38mm Laminated	35
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	3 Bed (130m^2) Grids A-D	Bedroom 1 & 3	10.38mm Laminated	35
		Bedroom 2	6mm Float / 50mm airgap / 6mm Float	42
		Living	10.38mm Laminated	35
		Bedroom 2	10.38mm Laminated	35
		Living	6.38mm Laminated	31

Table 14 – Minimum Glazing Requirements

Level	Units	Space	Minimum Glazing Thickness	Minimum STC
2-13	2 Bed + Study ($81m^2$) 1 Bed ($50m^2$) Grids 2-7	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed ($80m^2$) Grids 1-2	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	10.38mm Laminated	35
		Living	6.38mm Laminated	31
	1 Bed ($51m^2$) Grids B-F	Bedroom 1	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed ($82m^{2)}$ Grids H-K	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2	12.38mm Laminated	36
		Living	6.38mm Laminated	31
	2 Bed ($79m^{2)}$ Grids D-H	Bedroom 1	12.38mm Laminated	36
		Bedroom 2	6.38mm Laminated	31
		Living	6.38mm Laminated	31
14	All	Bedroom 1	6mm Float / 50mm airgap / 6mm Float	42
		Bedroom 2 & 3	10.38mm Laminated	35
		Living & Dining	10.38mm Laminated	35

In addition to complying with the minimum scheduled glazing thickness, the STC rating of the glazing fitted into operable frames and fixed into the building opening should not be lower than the values listed in Table 15 for all rooms. Where nominated, this will require the use of acoustic seals around the full perimeter of operable frames and the frame will need to be sealed into the building opening using a flexible 100% polyurethane sealant equal to Selleys Proseries Fireblock.

Where acoustic seals are nominated, these seals shall be equal to Schlegel Q-Lon manufacture. **It is noted that mohair or mohair/plastic fin combination seals are <u>not</u> acceptable.**

Table 15 – Minimum STC of Installed Glazing

Glazing Assembly	Acoustic Seals	Minimum STC Of Installed Glazing
6.38mm Laminated	Yes	31
10.38mm Laminated	Yes	35
12.38mm Laminated	Yes	36
6mm Float / 50mm airgap / 6mm Float	Yes	42

8.1.2 Double Glazing

Double glazing to bedrooms can be reduced to 12.38mm laminated glass on the proviso that the glazing area is reduced to less than $11m^2$ (including frame) and the floor area of the room is more than $10.5m^2$.

8.1.3 External Wall Construction

All external walls will be of concrete/masonry construction and are acoustically satisfactory in order to meet the project acoustic objectives presented in Table 10 of this assessment. No additional acoustic ameliorative measures are required in order to achieve compliance with the project acoustic objectives.

8.1.4 Roof Construction

The roof of Building 2 is nominated as concrete construction and is acoustically satisfactory in order to meet the project acoustic objectives presented in Table 10 of this assessment. No additional acoustic ameliorative measures are required in order to achieve compliance with the project acoustic objectives.

9 NOISE EMISSION ASSESSMENT

Noise emissions from the proposed Building 2 will be primarily associated with mechanical plant servicing the development. Mechanical selections are not yet made available however ALC would recommend an acoustic evaluation of plant is conducted to ensure that acoustic treatments are determined in accordance with the BCC NIAPSP and Noise Methodologies Guidelines.

10 CONCLUSION

This report presents the acoustic assessment of aircraft noise impacts associated with the proposed Building 2 of the Portside development located at Hamilton.

ALC confirm that internal noise levels will comply with the specified criteria on the proviso that the acoustic constructions presented in Section 8 of this report are adopted.

Noise emissions associated with mechanical plant should be addressed prior to occupation to ensure that noise levels comply with BCC noise emission criteria.

We trust this information is satisfactory. Please contact us should you have any further queries.

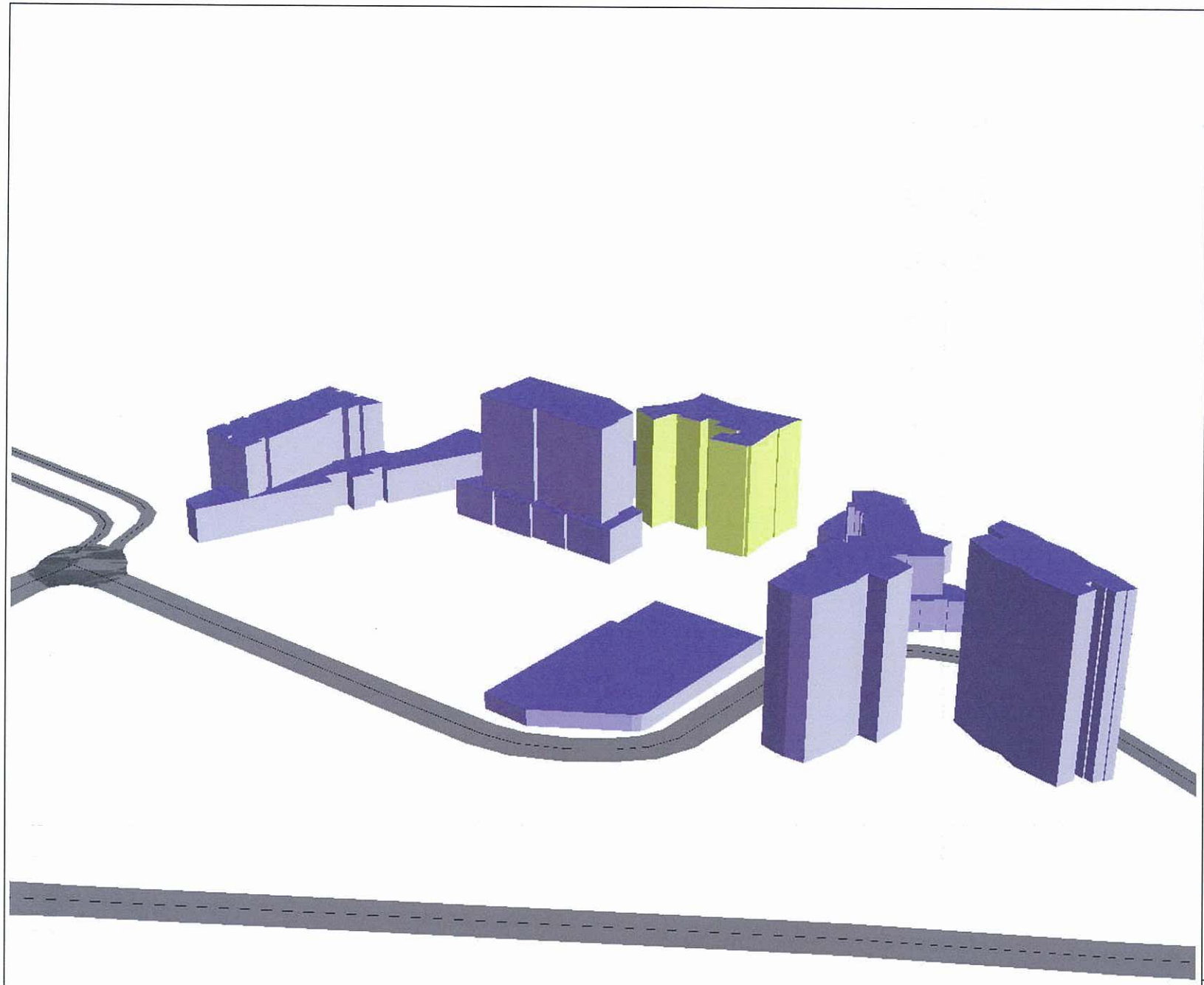
Yours faithfully,

Acoustic Logic Consultancy Pty Ltd
James Small

APPENDIX ONE

SOUNDPLAN NOISE MODELS

Portside
Building 5



SoundPlan Model

Prepared by: J. Small
Date: 10/11/2011

Signs and symbols

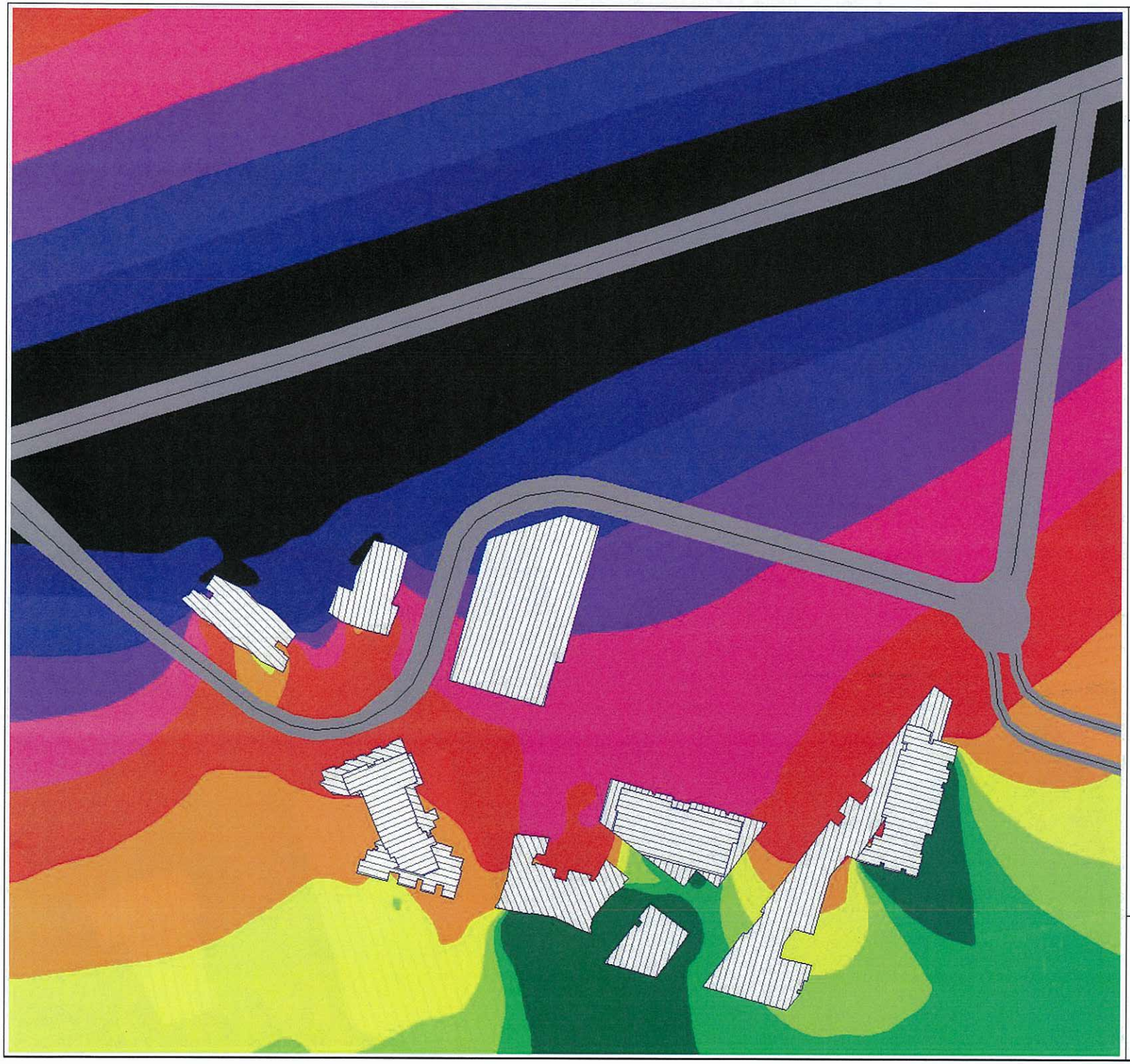
- Surface
- Sensitive Receiver
- Commercial Receiver
- Point source
- Ground absorption
- General residential

Length scale 1:4527

0 25 50 100 150 200 m

N

ACOUSTIC LOGIC



Portside
Building 2

Traffic Noise Prediction

Noise Contours @ RL 30m

Contours include facade reflection

Prepared by: J. Small
Date: 10/11/2011

Noise Level

$L_{eq\ 1hour}$
in dB(A)

- < 50
- 50 - 52
- 52 - 54
- 54 - 56
- 56 - 58
- 58 - 60
- 60 - 62
- 62 - 64
- 64 - 66
- 66 - 68
- 68 - 70
- >=70

Signs and symbols

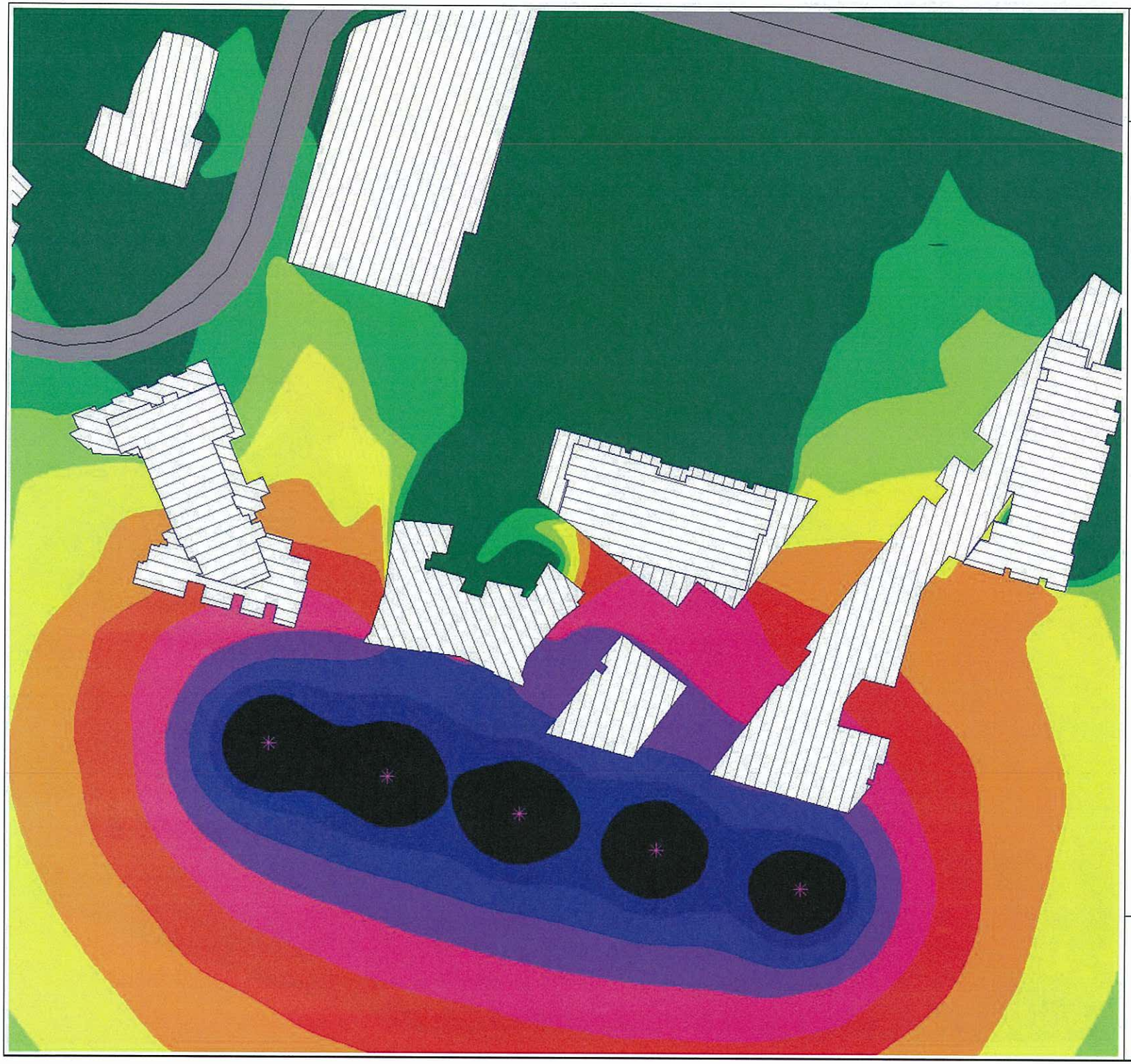
- Surface
- Sensitive Receiver
- Commercial Receiver
- Point source
- Ground absorption

Length scale 1:2500

0 12.5 25 50 75 100 m

N

ACOUSTIC LOGIC



Portside
Building 2

Port Noise Prediction

Noise Contours @ RL 30m

Contours include facade reflection

Prepared by: J. Small
Date: 10/11/2011

Noise Level
$L_{eq\ 1hour}$
in dB(A)

< 50
50 - 52
52 - 54
54 - 56
56 - 58
58 - 60
60 - 62
62 - 64
64 - 66
66 - 68
68 - 70
>= 70

Signs and symbols

- Surface
- Sensitive Receiver
- Commercial Receiver
- Point source
- Ground absorption

Length scale 1:1500

0 10 20 40 60

N

ACOUSTIC LOGIC