MCKENZIE INTERCHANGE PROJECT

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

PREPARED FOR:

URBAN systems

URBAN SYSTEMS LTD.

MAY 2016

REVISION 1

BKL Consultants in Acoustics

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EXECUTIVE SUMMARY

BKL Consultants Ltd. (BKL) has been retained by Urban Systems Ltd. Ltd. (USL) to provide an environmental noise assessment for the proposed McKenzie Interchange Project (the Project), located in Saanich, BC. The Project includes the construction of a partial clover leaf interchange at the intersection of Highway 1 and Admirals Road and McKenzie Avenue and additional lanes on Highway 1 and McKenzie Avenue.

BKL's environmental noise assessment aimed to

- identify noise-sensitive land uses potentially impacted by traffic noise within the Project construction limits;
- evaluate existing noise conditions at potentially impacted noise-sensitive receivers;
- predict the future noise environment 10 years after Project completion;
- assess the noise impact of the Project according to criteria outlined in the *2014 Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways* (the Policy) published by the Ministry of Transportation and Infrastructure (MOTI); and
- evaluate preliminary noise mitigation strategies where warranted by the Policy.

To predict Project-related traffic noise and assess the impacts of such noise against the Policy criteria, BKL created a 3-D noise model that considered

- the results of baseline noise measurements conducted in September 2015 and March 2016;
- existing and projected future traffic volumes;
- the topography and ground conditions within the Project site; and
- the geometry of the new roadways and interchange alignment.

BKL compared post-Project (10 years after Project completion) noise predictions to pre-Project levels in order to rate impacts at the noise-sensitive land uses as Minor, Moderate or Severe. According to the Policy, residential land uses effected by Moderate and Severe impacts should be considered for mitigation.

According to BKL's assessment, predictions and analysis, 76 of 174 residences in the study area lie in Moderate noise impact zones. Furthermore, two residences lie in Severe noise impact zones. Finally, two schools, École Marigold Elementary and St. Joseph's Elementary, have classrooms that would be exposed to noise levels that exceed the maximum one-hour equivalent noise level threshold outlined in the Policy.

BKL assessed 3 metre tall noise walls at six residential locations, with the following results:

- Five of the six noise walls would be acoustically effective; noise received at the first floor of fronting residences would be reduced on average by 5 dBA or more.
- The estimated installed cost of the noise walls exceeds the Policy's cost guidelines; therefore, increasing wall heights or lengths further may not be cost effective.

BKL also assessed the acoustical performance of noise walls at the educational facilities, with the following results:

- A noise wall that is 3 metres high and 140 metres long would provide adequate mitigation at École Marigold Elementary.
- A noise wall that is 5 metres high and 120 metres long was predicted to provide a noise benefit of 6 dBA for the portable classroom at St. Joseph's Elementary; however, the resulting classroom noise level would still be 4 dBA above the criterion.
- Additional mitigation should be investigated for the St. Joseph's Elementary portable classroom, including providing alternative ventilation so that windows can be closed and building facade improvements in order to determine the best means to meet the Policy criterion.

BKL recommends that further noise mitigation detailed design be undertaken in accordance with the Policy.

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List of Abbreviations and Acronyms

Abbreviation/Acronym	Definition
AADT	annual average daily traffic
ANSI	American National Standards Institute
µPa	micropascal
BKL	BKL Consultants Ltd.
dB	decibel
dBA	A-weighted decibel
HVAC	heating, ventilation and air conditioning
ISO	International Organization for Standardization
km	kilometre
km/h	kilometres per hour
L_d	daytime (7 am to 10 pm) equivalent sound level
L_{dn}	day-night equivalent sound level
L_{eq}	equivalent sound level
$L_{eq(max\text{-}hr)}$	maximum one-hour equivalent sound level
L_n	nighttime (10 pm to 7 am) equivalent sound level
m	metre
MOTI	British Columbia Ministry of Transportation and Infrastructure
the Project	McKenzie Interchange Project
the Policy	2014 *Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways*
USL	Urban Systems Ltd.

1 INTRODUCTION

BKL Consultants Ltd. (BKL) has been retained by Urban Systems Ltd. (USL) to provide an environmental noise assessment for the proposed McKenzie Interchange Project (the Project). Because it involves an upgrade of an existing numbered highway, the Project requires a noise impact study to determine the potential need for mitigation according to the criteria outlined by the BC Ministry of Transportation and Infrastructure (MOTI) in *2014 Policy for Assessing and Mitigating Noise Impacts from New and Upgraded Numbered Highways* (The Policy).

This report documents existing noise exposure levels predicted at noise-sensitive land uses near the Project, the future noise climate predicted 10 years after the completion of the Project, noise impact assessment results and potential noise mitigation options.

2 PROJECT DESCRIPTION

The Project scope includes

- a new interchange at the intersection of Highway 1 and Admirals Road / McKenzie Avenue
- a pedestrian overpass for Galloping Goose Trail across McKenzie Avenue and replacement of the pedestrian overpass crossing Highway 1, and
- widening the highway and McKenzie Avenue.

The Project area spans a distance of approximately 2 kilometres along Highway 1 and the sections of Admirals Road / McKenzie Avenue directly to the north and south of the intersection. The surrounding properties are mainly residential land use with the exception of three schools northwest of the intersection.

Figure 2-1: Study Area and Project Limits

The final interchange design is a partial cloverleaf with Highway 1 passing underneath Admirals Road / McKenzie Avenue. On the north side of Highway 1, Galloping Goose Trail will pass over

McKenzie Avenue on a pedestrian bridge. To either side of the pedestrian bridge, embankments will be built sloping down to connect to the existing Galloping Goose Trail. This design will improve traffic flow and pedestrian and cycling safety.

McKenzie Avenue will be widened to include another southbound lane. The additional lane will extend north of Highway 1, continuing past Burnside Road and ending before the Interurban Road overpass.

3 STUDY OBJECTIVES

The objectives of this noise impact study were to

- identify noise-sensitive land uses potentially impacted by the Project;
- evaluate existing noise conditions at potentially impacted noise-sensitive receivers;
- predict the future noise environment 10 years after Project completion;
- assess the noise impact according to the Policy; and
- evaluate noise mitigation options where warranted by the Policy.

4 ASSESSMENT CRITIERIA

The Policy outlines the required methodology for assessing the impact of traffic noise. It also describes mitigation considerations for noise-sensitive land uses adjacent to the new construction or upgrading of a numbered highway. According to the Policy, noise-sensitive land uses include residences; educational facilities, such as schools, preschools and commercial daycare centres; hospitals; libraries; churches; museums; passive parks and other land uses where quiet and tranquility are essential attributes.

Eligible noise-sensitive land uses must predate the highway project by receiving planning approvals prior to the first public announcement of the highway project or designation (through gazetting) of the affected lands as potential future highway rights-of-way.

4.1 Residences

For residential land uses, the Policy sets noise impact thresholds to identify areas where noise mitigation consideration is warranted. The Policy quantifies its thresholds with the noise metric outdoor day-night average sound Level (L_{dn}). This metric is similar to the 24-hour equivalent sound level (L_{eq24}) but it applies a 10 dBA penalty to nighttime noise to account for the public's greater sensitivity to noise between 10 pm and 7 am.

Post-project (10 years after project completion) noise predictions are compared to pre-project levels in order to rate impacts at the noise-sensitive receivers as Minor, Moderate, or Severe. Residential land uses within the Moderate and Severe impact zones are considered for mitigation.

According to the Policy, the main objective of noise mitigation is to reduce the total post-project noise exposure at fronting residences by at least 5 dBA. A noise reduction of 5 dBA corresponds to approximately a 30% decrease in perceived loudness and is considered the smallest noise reduction that is clearly noticeable.

The Policy also gives benchmark mitigation cost guidelines for residential units that are directly benefiting from the noise mitigation based on the noise impact situation for that unit. The Policy reads:

> *"[The] benchmark mitigation cost guideline … [is] $25,000 per directly-benefiting residential unit in Moderate noise impact situations, and $40,000 per directly-benefiting residential unit in Severe noise impact situations."*

4.2 Educational Facilities

For educational land uses, the Policy sets a criterion based on the loudest one-hour equivalent sound level, $L_{eq(max\text{-}hr)}$, inside classrooms. The Policy states:

> *Mitigation measures will be considered at educational facilities where it is anticipated that… the post-project traffic noise levels, ten years after the project completion, will reach $L_{eq(max\text{-}hr)}$ 40 dBA inside classrooms or other highly noise-sensitive spaces.*

5 STUDY AREA

The study area extends from Eaton Avenue along Highway 1 to Interurban Road and includes sections of Admirals Road and McKenzie Avenue near the intersection at Highway 1. The south extent along Admirals Road is at the Esson Road intersection and the north extent along McKenzie Avenue is near the Interurban Road overpass. The exact extents were determined by the available ground elevation contours provided by USL.

The study area should include all residential and non-residential noise-sensitive land uses where the Policy threshold criteria could potentially be exceeded. On this basis, all first and second row housing and schools fronting the Project extents have been included. The first row of noise-sensitive buildings have the greatest chance of exceeding the Policy noise criteria because the allowable Project noise increase becomes smaller as the existing noise exposure increases (i.e., as the setback distance from the highway decreases, existing levels increase since the highway is the dominant existing noise source in all cases for the Project.)

Using these guidelines, there are approximately 174 first and second row noise-sensitive residential land uses, and 3 noise-sensitive educational facilities. The study area has been divided into six groups of residences in similar acoustical environments. Figure 5-1 identifies the receiver groups and shows the study area.

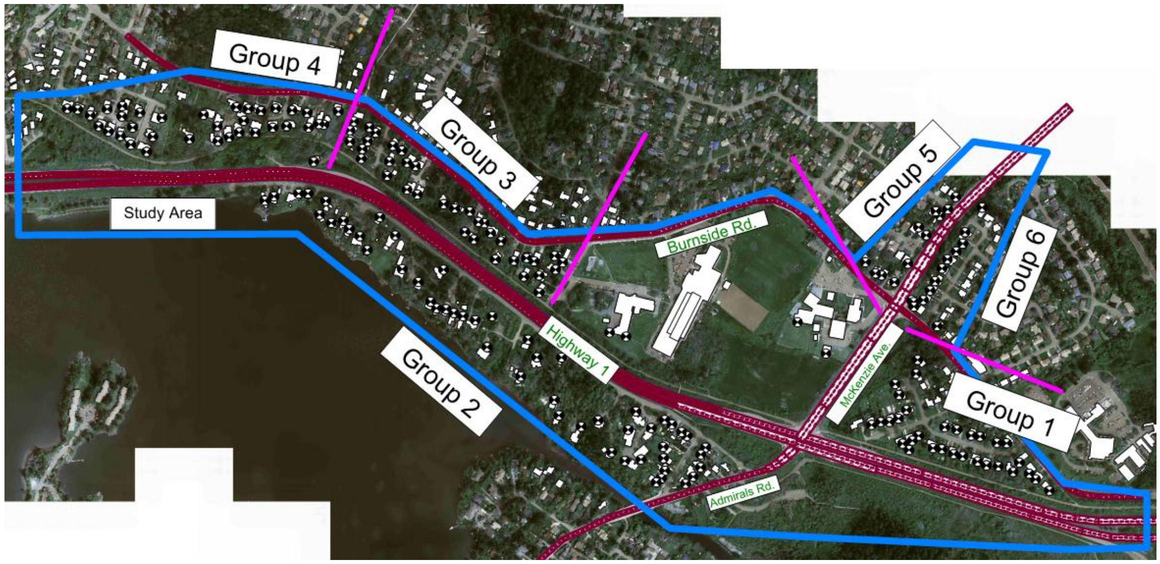

Figure 5-1: Study Area and Receiver Groupings

6 EXISTING NOISE CONDITIONS

Baseline noise monitoring was conducted on September 21–22, 2015, and March 3–4, 2016, to measure the existing noise exposure at locations within the study area. Measurements were taken at five residential sites (R1, R2, R4, R5, R6) for 24 hours each. Thirty-minute measurements were performed at a sixth residential site, R3, and inside three classrooms (S1-S3). The 30-minute measurements were performed simultaneously with 24-hour noise measurements so that the variation in traffic noise throughout the day could be calculated.

The following sound level meters were used: Brüel & Kjær 2250, Larson Davis 820 and 01dB DUO. All meters meet the Type 1 specifications in ANSI S1.4:1983. The sound level meters were field calibrated before and after each measurement using a Brüel & Kjær Type 4230 calibrator. Weather conditions during the measurement periods were clear with no significant wind.

6.1 Baseline Monitoring at Residences

Table 6-1 lists the long-term noise monitoring locations at the residential sites.

Table 6-1: Baseline Measurement Locations at Residences

Location	Address	Description	Height Relative to Ground [m]
R1	1181 Portage Road	▪ At north side of property ▪ 26 m from Hwy 1 centreline	1.5
R2	1085 Burnside Road	▪ At south side of property ▪ 36 m from Hwy 1 centreline	1.5
R3	3151 Esson Road	▪ At northeast corner of property ▪ 65 m from Hwy 1 centreline	1.5
R4	3241 Admirals Road	▪ At southwest corner of property ▪ 44 m from Hwy 1 centreline	2.5
R5	700 Burnside Road W	▪ At southwest corner of property ▪ 24 m from McKenzie Ave centreline	2.5

Location	Address	Description	Height Relative to Ground [m]
R6	715 Snowdrop Ave	▪ At east end of property ▪ 18 m from McKenzie Ave centreline	2.5

Table 6-2 below shows the measured pre-Project noise level at each location and the relevant noise impact thresholds from the Policy.

Table 6-2: Residential Monitoring Results and Noise Impact Thresholds

Measurement Location	Pre-Project L_{dn} [dBA]	Post-Project Noise Threshold Total L_{dn} [dBA]	
		Moderate Impact	Severe Impact
R1	74	65.0	75.0
R2	71	65.0	74.5
R3	63*	65.0	68.7
R4	67	65.0	71.3
R5	70	65.0	73.6
R6	75	65.0	75.0

** Calculated based on 30-minute measurement and nearby 24-hour measurement*

According to the Policy, the noise exposures at R1, R2, R4 and R5 already exceed the Moderate impact threshold, and the noise exposure at R6 is at the Severe impact threshold. This means that the maintenance of current traffic noise at these locations post-project would present at least a Moderate impact.

6.2 Baseline Monitoring at Educational Facilities

The short-term monitoring locations in the schools are shown below in Table 6-3. At each school, one to two classrooms that were exposed to the highest level of road traffic noise were chosen for monitoring.

Table 6-3: Short-Term Measurement Locations

Location	Educational Facility	Room(s)
S1	École Marigold Elementary	13
S2	Spectrum Community School	317 and 324
S3	St. Joseph's Elementary School	103 and Portable

The estimated $L_{eq(max\ hr)}$, calculated based on the short-term measurement results and hourly noise level variation from the nearest 24-hour baseline measurement, is shown in Table 6-4.

Table 6-4: School Measurement Results and Noise Impact Threshold

Location	Room	Measured L_{eq} [dBA]	Estimated $L_{eq(max\ hr)}$ [dBA]	Noise Impact Threshold [dBA]
S1	13	44	46	40
S2	317	34	36	40
	324	34	36	40
S3	Portable	51	54	40
	103	38	41	40

According to the Policy, École Marigold Elementary and St. Joseph's Elementary already exceed the 40 dBA threshold in the most affected classrooms.

7 NOISE MODELLING METHODOLOGY

7.1 Acoustical Model

Transportation noise levels have been predicted using the French standard for road traffic noise prediction, NMPB-Routes-1996 (NMPB 1996), implemented in the outdoor sound propagation software Cadna/A, version 4.6. *The Good Practice Guide for Noise Mapping* points out that this standard is recommended by the European Commission as current best practice to obtain accurate prediction results (WG-AEN 2007).

NMPB-Routes-96 specifies octave band sound power levels for roadways, dependant on traffic volumes, average travel speed, percentage of heavy vehicles (i.e., trucks, buses), road gradient and flow conditions (continuous, accelerating, decelerating vehicles). BKL has found that this standard provides a high level of agreement with traffic noise measurements conducted in BC.

First order reflections were considered in the acoustic model. Model calculations were performed in octave bands, considering ground cover, topography and shielding objects (see following sections).

7.1.1 Ground Absorption

The acoustic properties of the ground surface can have a considerable effect on the propagation of noise. Flat, non-porous surfaces such as concrete, asphalt, buildings, calm water, etc., are highly reflective to noise, and have a ground constant of G=0. Soft, porous surfaces such as foliage, loam, soft grass, fresh snow, etc., are highly absorptive to noise and have a ground constant of G=1.

In order to approximate the ground effect on sound propagation, the ground surface has been modelled as absorptive (G=1) throughout except for road surfaces where the ground constant was set to G=0.

7.1.2 Meteorological Conditions

A temperature of 10 °C and relative humidity of 80 per cent were used in the model settings to best represent weather conditions based on the selection available in Cadna/A. Favourable sound propagation was assumed to occur for 50 per cent of the time during the day and 100 per cent of the time during the night.

Variations in temperature and humidity generally have little effect on the overall noise propagation.

7.1.3 Topography and Obstacles

The intervening terrain has been modelled by directly importing ground contours of the area provided by USL. Ground contours were imported at a 1-metre elevation resolution. Future ground contour were modified based on the Project alignment geometry provided.

Building outlines were provided by USL and imported directly into the noise model.

7.1.4 Roadway Geometry

The existing highway alignment was modelled using aerial photographs provided by USL.

Future Highway 1, interchange ramps, McKenzie Avenue, and Admirals Road alignments were provided by USL and imported directly into the noise model.

7.1.5 Traffic Inputs

Future (2018 and 2038) highway traffic data was provided by McElhanney in their report "Traffic Analysis Report – DRAFT" dated January 5, 2016. The future 2018 and future 2038 traffic volumes were averaged to estimate highway traffic volumes 10 years after Project completion (2028). Daily traffic volumes were calculated based on the assumption that the AADT is 10 times that of the PM peak hour. Both the 2015 and 2028 AADT values which were used in the model are listed in Table 7-1. Future truck percentages were assumed to remain the same as existing.

Table 7-1: Increases from 2014 to 2028 in Annual Average Daily Traffic

Road	Section	Direction	2015 AADT	2028 AADT
Highway 1	West of McKenzie	Westbound	41900	47925
	West of McKenzie	Eastbound	29700	34605
	East of McKenzie	Westbound	23800	27225
	East of McKenzie	Eastbound	23100	27010
Admirals Road	South of Highway 1	2-way	5700	10550
McKenzie Avenue	North of Burnside Road	2-way	29260	33315
	South of Burnside Road	2-way	31100	35675
Burnside Road	Entire Study Area	2-way	9750	10800
Highway 1 and McKenzie Interchange	Admirals to Highway 1 Eastbound on-ramp	1-way	-	1283
	Highway 1 to Admirals	1-way	-	514

Road	Section	Direction	2015 AADT	2028 AADT
Ramps	Eastbound off-ramp			
	Highway 1 to McKenzie Eastbound bus loop off-ramp	1-way	-	4375
	McKenzie to Highway 1 Westbound on-ramp	1-way	-	12092
	Highway 1 to McKenzie Westbound off-ramp	1-way	-	883

Traffic was modelled at the future design's posted speed limits in the future scenario. Current traffic speeds are lower than posted speed limits near the McKenzie intersection due to congestion. Existing modelled speeds were determined using our baseline noise measurements as noted in Section 7.2.

Traffic was corrected for either "accelerating" or "decelerating" noise emissions near the McKenzie intersection following best practice (WG-AEN 2007). Future off- and on-ramp traffic was also modelled using accelerating or decelerating noise emissions, as appropriate. All other road traffic was modelled for "continuous flow" conditions. Roadways were modelled with standard asphaltic pavement, except for elevated roadways (e.g., bridges, overpasses) which were modelled with standard concrete pavement.

7.2 Model Calibration

The noise model was calibrated using the baseline location results described in Section 6. The major noise sources are road traffic from Highway 1 and McKenzie Avenue, and were modelled to show accurate correlation between the measurement and the noise model. Other roads were not included in the model. A scaling factor was used so the predicted existing noise levels in the model were within 1 dBA of the measured levels. This factor was also applied to the future traffic volumes.

7.3 Receivers

For all assessments, calculations were performed using point receivers at each noise-sensitive land use identified in the study area, e.g., residences and schools. The noise impact assessment was based on noise received at the second floor of dwellings, assumed to be a height of 4.3 metres above the ground. This was a conservative assumption because traffic noise levels were the same or higher at the second floor compared to the ground floor level. However, noise mitigation effectiveness was assessed at two heights: the first floor receiver height was set at 1.5 metres above the ground and the second floor receiver height was set at 4.3 metres above the ground. For schools, the noise impact assessment was based on noise received at the midpoint height of the five noise exposed classrooms, as measured in the field.

Average noise contours were predicted on 5 metre by 5 metre grids at a height of 4.3 metres. Figure 7-1 shows an example 3-D view of receivers placed on building facades.

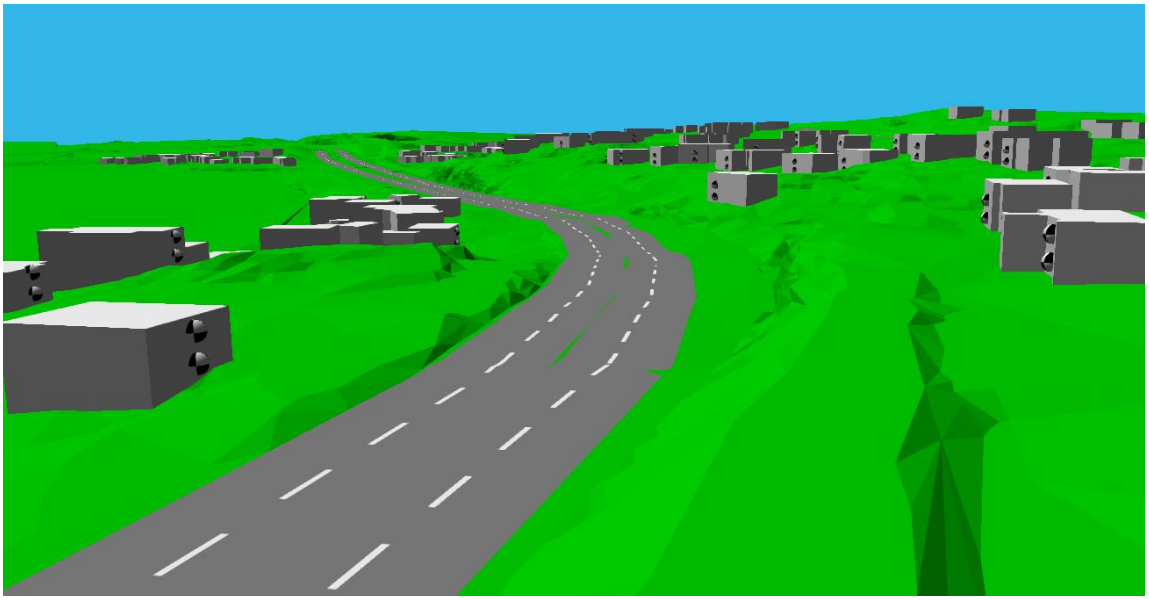

Figure 7-1: Example 3-D View of Noise Source, Ground Contours and Receivers

8 NOISE PREDICTION RESULTS

8.1 Existing Scenario 2015

Figure 8-1 shows a contour plot of predicted existing L_{dn} traffic noise levels. Calculated results in tabulated form at individual receivers are shown in Appendix C. The graphical contours are based on interpolation of predictions made on a 5 metre by 5 metre grid at receiver height of 4.3 metres. The predictions for individual receivers are based on specific coordinates of each point; therefore, the tabulated levels should be taken as more accurate in the event of any discrepancies.

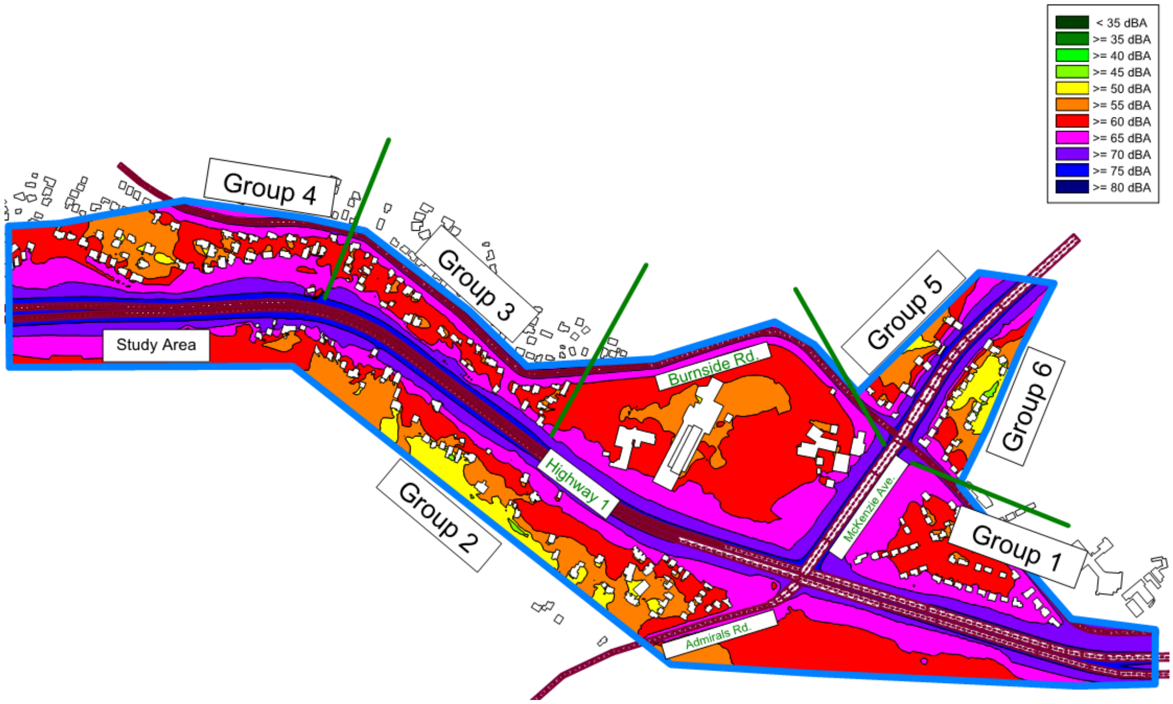

Figure 8-1: Predicted Existing Noise Contours

8.2 Future Scenario 2028

Figure 8-2 shows a contour plot of predicted future L_{dn} traffic noise levels. Calculated results in tabulated form at individual receivers are shown in Appendix C. The graphical contours are based on interpolation of measurements made on a 5 metre by 5 metre grid at receiver height of 4.3 metres. The predictions for individual receivers are based on specific coordinates of each point; therefore, the tabulated levels should be taken as more accurate in the event of any discrepancies.

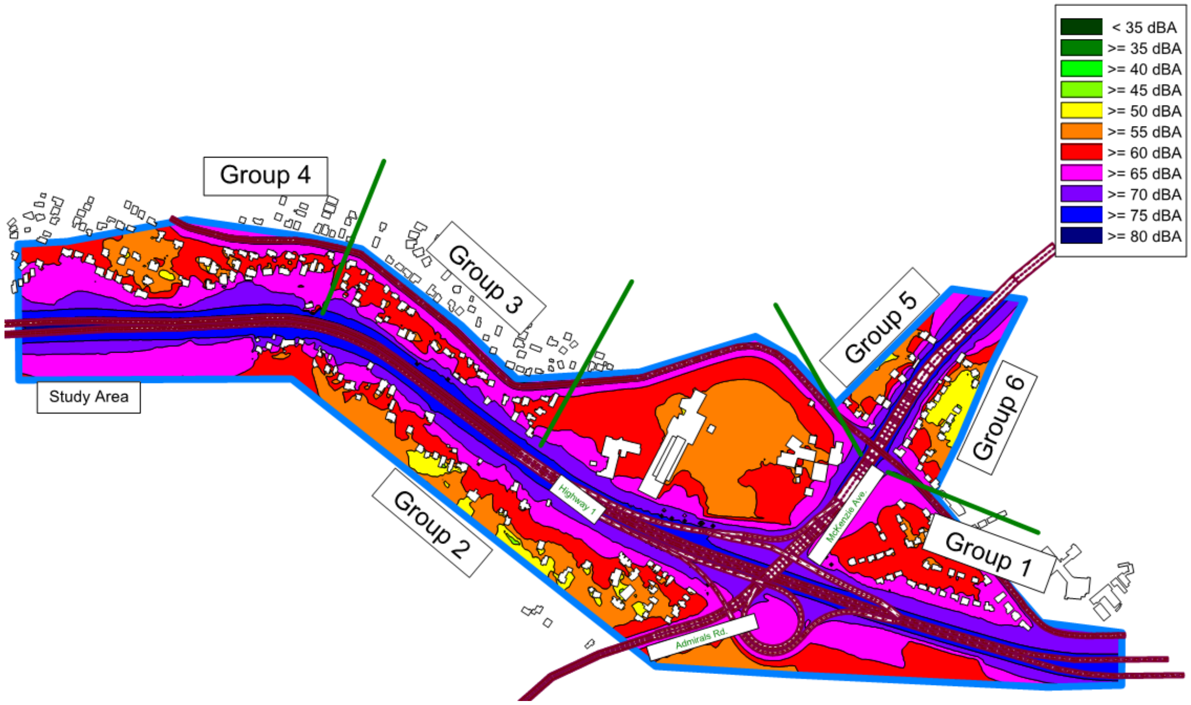

Figure 8-2: Predicted Future Noise Contours

9 NOISE IMPACT ASSESSMENT

9.1 Residences

Table 9-1 summarizes the number of residences and impacts in each group. The charts in Figure 9-1 and Figure 9-2 show a graphical comparison of Project noise to the Policy in each group. Detailed tabulated results for each receiver are presented in Appendix C.

In general, the increase in total L_{dn} noise levels is less than 4 dBA. The Policy assigns a Moderate impact if the baseline noise environment is predicted to be 65 dBA regardless of any increase. The two Severe impacts found in Group 3 are a result of direct exposure from Highway 1 and relatively high increases in total noise level. These two factors result in the Severe impact threshold being exceeded. Most Moderate impacts are a result of a predicted baseline L_{dn} of 65 dBA or greater.

Table 9-1: Noise Impact Assessment Summary for Residences

Group	Extent	Number of Residences	Number of Moderate Impacts	Number of Severe Impacts
1	Northeast of interchange	30	13	0
2	Southwest of interchange	52	21	0
3	Northwest of interchange – East of Wilkinson	35	12	2

Group	Extent	Number of Residences	Number of Moderate Impacts	Number of Severe Impacts
	Road			
4	Northwest of interchange – West of Wilkinson Road	36	16	0
5	North of Burnside Road - West of McKenzie Avenue	10	8	0
6	North of Burnside Road - East of McKenzie Avenue	11	6	0
	Total	174	76	2

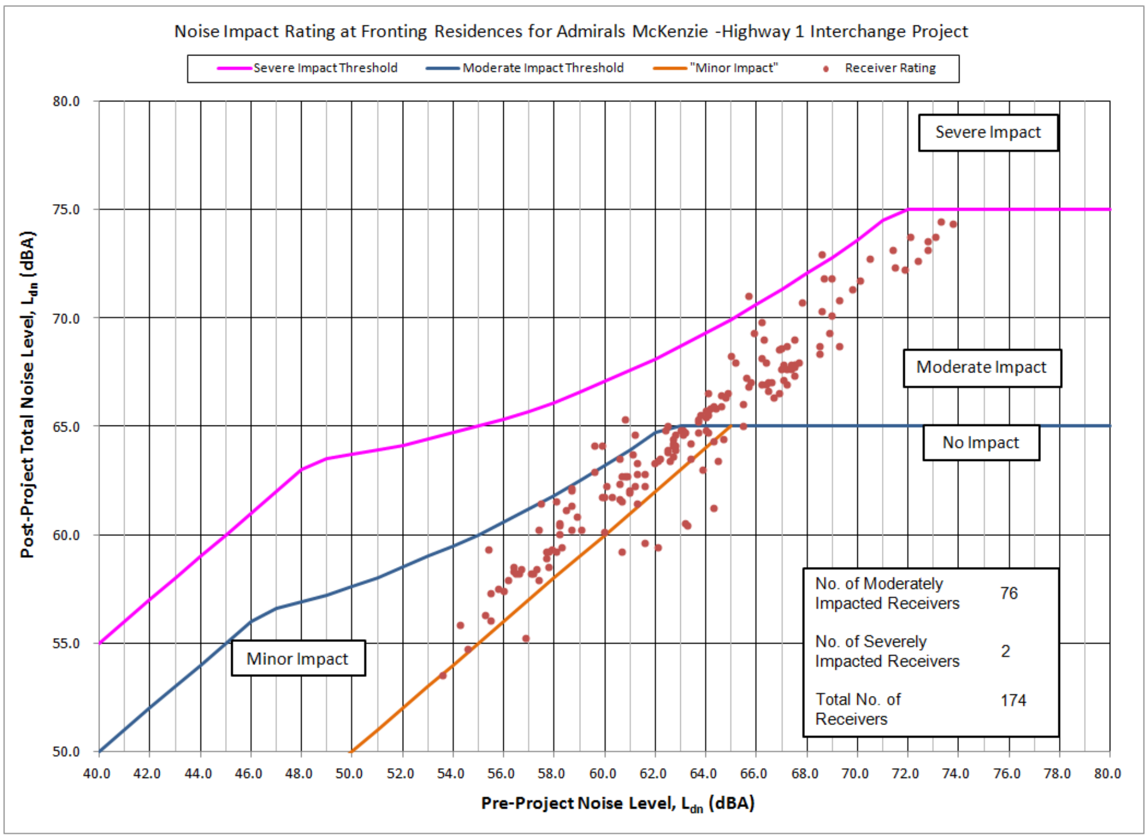

Figure 9-1: Comparison of Pre- and Post-Project Noise

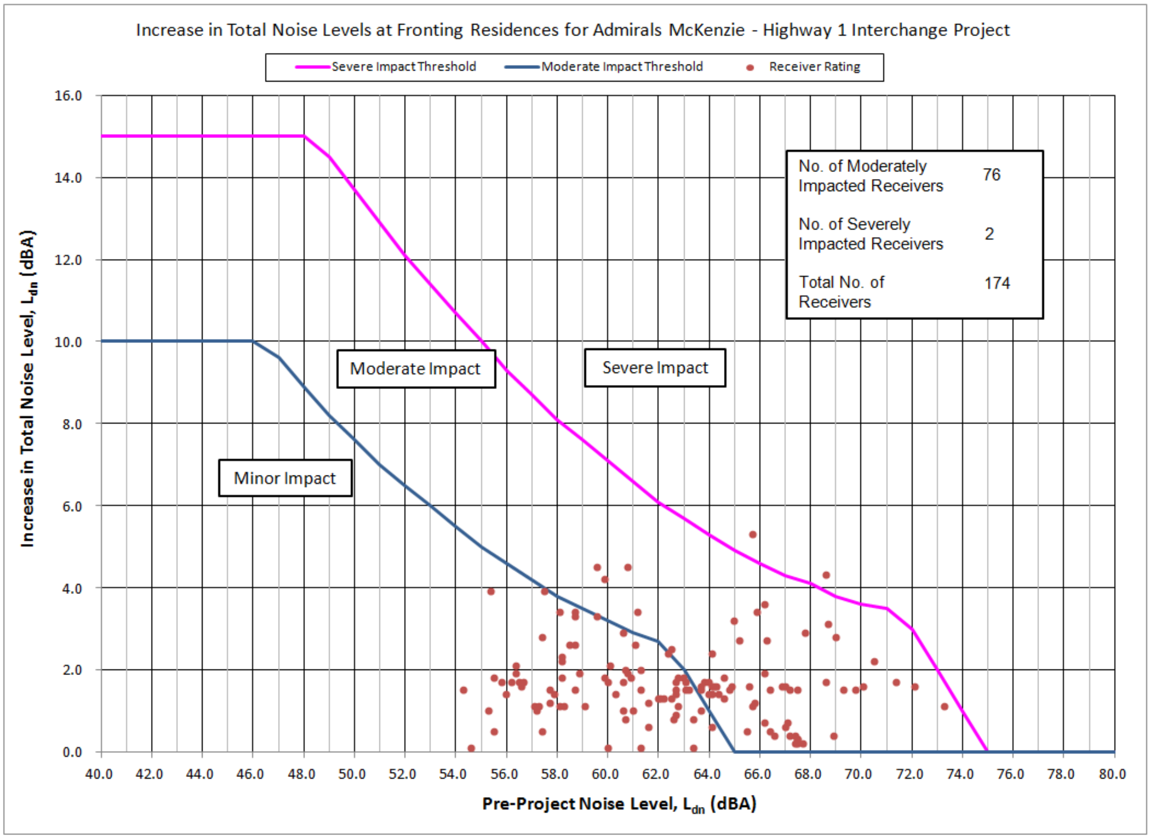

Figure 9-2: Increase in Noise Relative to Pre-Project Noise

9.2 Educational Facilities

Three schools (École Marigold Elementary, Spectrum Community and St. Joseph's Elementary) were identified in the study area. Future 2028 noise levels at the identified, worst affected classrooms were predicted using the noise model. Noise at École Marigold and Spectrum increased and remained the same respectively, while the raised Galloping Goose Trail resulted in a decrease in noise exposure at St. Joseph's. Table 9-2 below summarizes the noise impact at the school receivers.

Table 9-2: Predicted Noise Impact for Educational Facilities Pre-Mitigation

School	Room	Future 2028 $L_{eq(max\text{-}hr)}$ [dBA]	Noise Impact Threshold $L_{eq(max\text{-}hr)}$ [dBA]	Criterion Exceeded?	Exceedance [dBA]
S1	13	48	40	Yes	8
S2	317	36	40	No	-
	324	36	40	No	-
S3	Portable	50	40	Yes	10
	103	36	40	No	-

10 TRAFFIC NOISE MITIGATION

Noise mitigation was considered for all residences in Moderate or Severe impact situations and all educational facilities with predicted classroom levels exceeding the applicable criterion. Figure 10-1 below shows the residences and schools which warrant noise mitigation consideration.

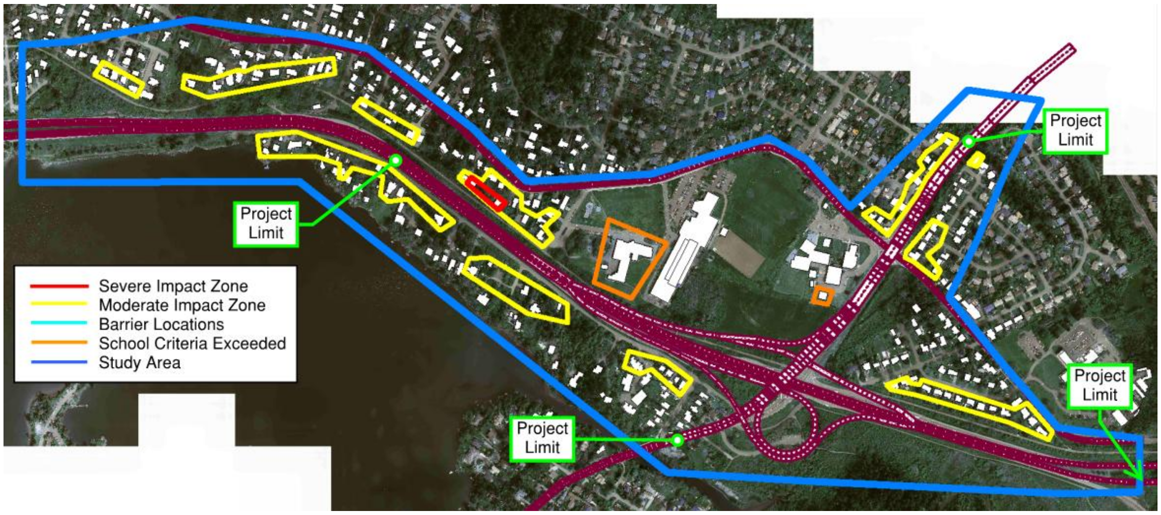

Figure 10-1: Moderately or Severely Impacted Dwellings in the Study Area

In general, noise mitigation options include

- constructing noise barriers, e.g., noise walls or earth berms;
- using low-noise pavements on roadways;
- controlling noise at the receiver by upgrading facades, e.g., adding storm windows, where residential unit density is low;
- improving HVAC systems in classrooms to eliminate the need to open windows where open windows are currently required; and
- reducing vehicle speeds or truck percentages.

10.1 Residences

10.1.1 Proposed Noise Wall Locations and Geometry

The 3-D model considered six noise walls at fronting groups of residences identified as Moderately or Severely impacted. These six noise walls were studied for acoustical effectiveness and cost effectiveness. The extent and setback of each wall alignment was chosen to provide the best insertion loss (i.e., noise benefit) for the impacted dwellings behind the wall.

The Policy states that a vertical noise barrier (wall) is limited to 5 metres in height. For this preliminary study, results for 3 metre high walls were provided for comparison with acoustical and cost effectiveness criteria. Where a wall of 3 metres did not meet the acoustical criteria, increasing the wall height could be considered in the detailed design phase, if cost-effective. Table 10-1 below describes noise wall locations and lengths.

Table 10-1: Noise Wall Numbering, Location and Geometry

Wall	Wall Location	Number of Fronting Residences	Wall Length [m]	Wall Height [m]
1	▪ Northeast of interchange ▪ At south edge of Galloping Goose Trail	13	400	3
2	▪ Southwest of interchange ▪ Between Highway 1 and Portage Road	19	1050	3
3	▪ Northwest interchange ▪ South edge of Galloping Goose Trail	11	500	3
5	▪ West of McKenzie Avenue, North of Burnside Road ▪ At edge of right-of-way	5	240	3
6a	▪ East of McKenzie Avenue, North of Burnside Road ▪ At edge of right-of-way	4	90	3
6b	▪ East of McKenzie Avenue, approaching Interurban overpass ▪ At edge of right-of-way	1	50	3

For each wall the setback distance was chosen with consideration for site-specific geographical contours and with the goal of maximizing the wall's acoustical effectiveness. The locations of each wall were confirmed as being within the MOTI right-of-way. Wall alignments and labelling can be found in Figure 10-2.

Figure 10-2: Wall Alignments and Labelling

Mitigation for Group 4 was reviewed but not further advanced because noise walls were predicted to be acoustically ineffective at any location, even at a height of 5 metres. This was due to the distance and height of the residences relative to the highway and the elevation profile of the intervening terrain. These residences are also beyond the project limit and as such do not qualify for noise mitigation according to the Policy.

10.1.2 Wall Insertion Loss Predictions

The performance of a noise barrier is very sensitive to the height of the receiver. Along the extent of the Project the majority of dwellings have a second storey. Hence, the insertion loss for a particular wall was predicted both at the first and second floor of each affected residence. Table 10-2 summarizes the mitigation effectiveness of each proposed wall.

Table 10-2: Summary of Proposed Wall Alignments

Wall	Average Noise Benefit at Fronting Residences		% of Fronting Residences with at Least 5 dBA Noise Benefit	
	First Floor [dBA]	Second Floor [dBA]	First Floor [dBA]	Second Floor [dBA]
1	4	2	31%	8%
2	6	5	68%	58%
3	5	4	64%	64%
5	12	3	100%	20%
6a	6	3	100%	0%
6b	7	4	100%	0%

At the first floor, Wall 1 does not have an average noise benefit that meets the 5 dBA criterion. Only Wall 2 meets the 5 dBA average noise benefit at the second floor for a 3 metre wall. Appendix C shows the noise impact and the insertion loss provided for each residence. Appendix D summarizes the insertion loss in a histogram for each wall for the effected fronting residences.

Predicted noise contours of the future 2028 scenario with the modelled 3 metre height noise walls are shown in Figure 10-3. The difference in noise exposure between the existing noise levels and those post-mitigation is shown in Figure 10-4. Both figures show noise levels at a height of 4.3 metres.

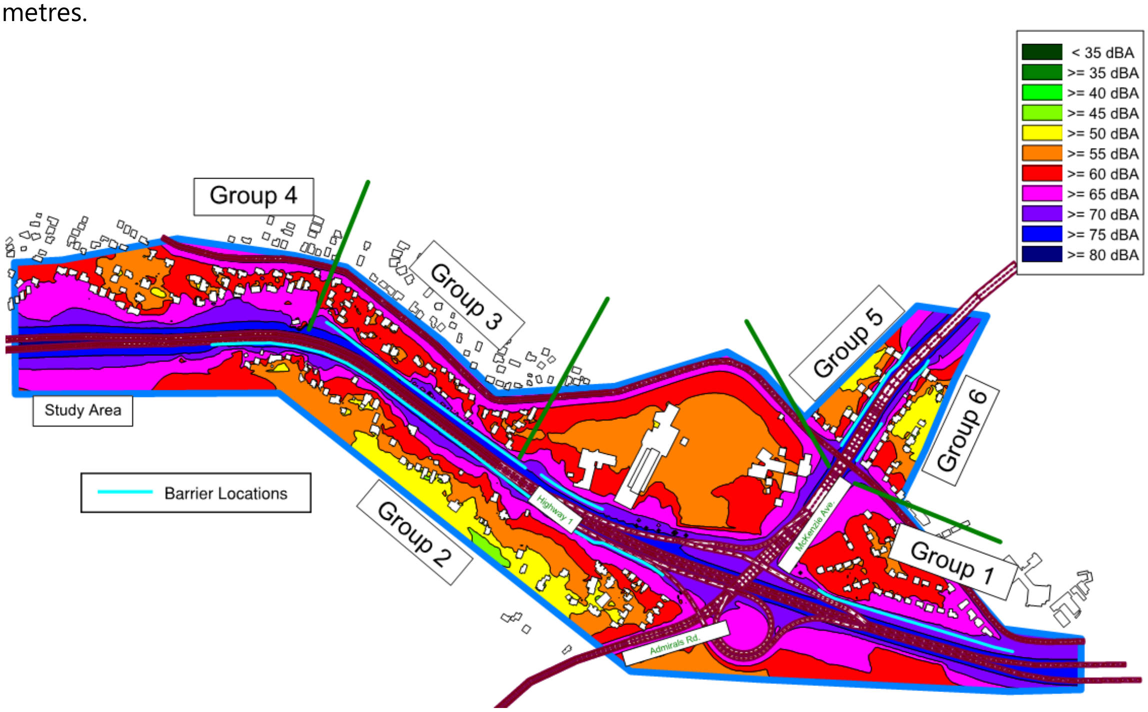

Figure 10-3: Predicted Future Noise Contours with Modelled Noise Walls

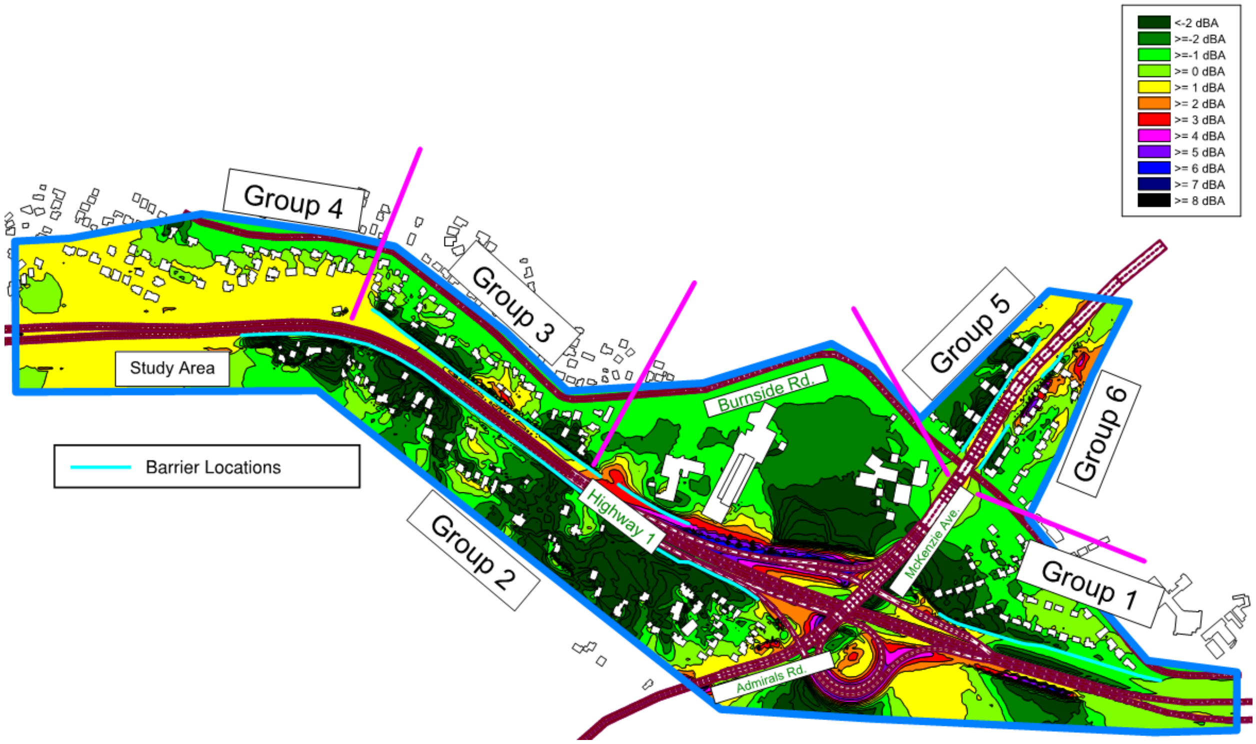

Figure 10-4: Predicted Increase in Noise from Existing to Future with Mitigation

10.1.3Cost-benefit Considerations

Sixty-one Moderately impacted and two Severely impacted residences would directly benefit from the modelled noise walls. Using the Policy benchmark cost guidelines, a budget of $1,605,000 would be warranted for residential noise mitigation measures. Assuming an installed cost of $300 per square metre, 1,783 metres of 3 metre high noise wall could be constructed.

Table 10-3 shows the predicted cost associated with each proposed noise wall alignment.

Table 10-3: Cost Estimate of Proposed Wall Alignments

Wall	Wall Height [m]	Wall Length [m]	Estimated Installed Cost
1	3	400	$360,000
2	3	1,050	$945,000
3	3	500	$450,000
5	3	240	$216,000
6a	3	95	$85,500
6b	3	50	$45,000
Total		2335	$2,101,500

The estimated installed cost of noise walls is higher than the benchmark mitigation cost guidelines. As noted in the Policy, "The costs and benefits of mitigation measures must be weighed by MOTI Project Managers based on the particular conditions and considerations of each project."

10.2 Educational Facilities

Based on the results in Section 9, the Policy's 40 dBA criterion at educational facilities would be exceeded at some classrooms in two schools: École Marigold Elementary and at the portable at St. Joseph's Elementary. A noise wall was modelled at each facility to predict mitigated Project noise levels.

To meet the criterion at École Marigold Elementary, a 3 metre noise wall was modelled on the north side of the Galloping Goose Trail. The model predicted an insertion loss of 8 dBA at the worst affected classrooms which would result in meeting the 40 dBA criterion. Assuming an installed cost of $300 per square metre, the installed cost of this noise wall would be $126,000.

Mitigation for the portable at St. Joseph's Elementary was reviewed by not further advanced because noise walls were preliminarily predicted to provide less than the 10 dBA noise benefit required to meet the criterion. It was found that a 120 metre long, 5 metre high noise wall along McKenzie Drive would give a noise benefit of 6 dBA. Other forms of noise mitigation such as facade, window, or HVAC improvements would need to be investigated to meet the Policy criterion.

11 CONCLUSIONS AND RECOMMENDATIONS

BKL was retained by USL to conduct a noise impact assessment for the McKenzie Interchange Project. The noise impact assessment was completed by performing a baseline noise survey, modelling baseline and future noise levels, rating future noise levels using the MOTI Policy, and modelling and predicting the effectiveness of potential mitigation strategies.

The analysis concluded that, out of 174 residences, there are 76 residences with a Moderate noise impact and two with a Severe noise impact. Two schools, École Marigold Elementary and St. Joseph's Elementary (at its portable classroom), were also found to exceed the maximum one-hour equivalent noise levels outlined by the Policy.

Noise mitigation in the form of noise walls can be an effective approach to meet the Policy criteria. Three metre high noise walls were modelled and most were found to be acoustically effective. However, the estimated installed cost would exceed the Policy's residential noise mitigation cost guidelines so increasing noise wall heights further may not be cost effective. A noise wall was also found to provide insufficient noise mitigation for the portable classroom at St. Joseph's Elementary; additional mitigation options would need to be investigated, including providing alternative ventilation so that windows can be closed and building facade improvements.

We recommend that further noise mitigation detailed design be undertaken in accordance with the Policy.

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APPENDIX A GLOSSARY

A-weighting – A standardized filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive. Also written as dBA.

ambient/existing level – The pre-project noise or vibration levels.

critical ratio (CR) - The ratio between the power in the pure tone at threshold and the power per hertz (spectrum level) of the background noise.

decibel – The standard unit of measurement for sound pressure and sound power levels. It is the unit of level that denotes the ratio between two quantities that are proportional to pressure or power. The decibel is 10 times the logarithm of this ratio. The reference pressure used for airborne sound is 20 µPa, while the typical reference pressure used for underwater sound is 1 µPa. Also written as dB.

equivalent sound level - The steady level that would contain the same amount of energy as the actual time-varying level. Although it is, in a sense, an "average," it is strongly influenced by the loudest events because they contain the majority of the energy.

frequency – The number of times that a periodically occurring quantity repeats itself in one second.

frequency spectrum – Distribution of frequency components of a noise or vibration signal.

hertz – The unit of acoustic or vibration frequency representing the number of cycles per second.

impulsive sound – Non-continuous sound characterized by brief bursts of sound pressure. The duration of a single burst of sound is usually less than one second.

intermittent – Non-continuous or transient noise or vibration that occurs at regular or irregular time intervals with each occurrence lasting more than about five seconds.

metric – Measurement parameter or descriptor.

noise - Noise is unwanted sound that carries no useful information and tends to interfere with the ability to receive and interpret useful sound.

Noise-sensitive receivers – A place occupied by species with a high sensitivity to noise.

octave bands – A standardized set of bands making up a frequency spectrum. The centre frequency of each octave band is twice that of the lower band frequency.

sound – The fluctuating motion of air or other elastic medium which can produce the sensation of sound when incident upon the ear.

sound power – The total sound energy radiated by a source per unit time.

APPENDIX B INTRODUCTION TO SOUND AND ENVIRONMENTAL NOISE ASSESSMENT

B.1 General Noise Theory

The two principal components used to characterize sound are loudness (magnitude) and pitch (frequency). The basic unit for measuring magnitude is the decibel (dB), which represents a logarithmic ratio of the pressure fluctuations in air relative to a reference pressure. The basic unit for measuring pitch is the number of cycles per second, or hertz (Hz). Bass tones are low frequency and treble tones are high frequency. Audible sound occurs over a wide frequency range, from approximately 20 Hz to 20,000 Hz, but the human ear is less sensitive to low- and very high–frequency sounds than to sounds in the mid-frequency range (500 to 4,000 Hz). “A-weighting” networks are commonly employed in sound level meters to simulate the frequency response of human hearing, and A-weighted sound levels are often designated “dBA” rather than “dB”.

If a continuous sound has an abrupt change in level of 3 dB it will generally be noticed, while the same change in level over an extended period of time will probably go unnoticed. A change of 6 dB is clearly noticeable subjectively and an increase of 10 dB is generally perceived as being twice as loud.

B.2 Basic Sound Metrics

While the decibel, or A-weighted decibel, is the basic unit used for noise measurement, other indices are also used to describe environmental noise. The equivalent sound level, abbreviated L_{eq}, is commonly used to indicate the average sound level over a period of time. The L_{eq} represents the steady level of sound which would contain the same amount of sound energy as the actual time-varying sound level. Although the L_{eq} is an average, it is strongly influenced by the loudest events occurring during the time period because these events contain most of the sound energy. Another common metric used is the L_{90}, which represents the sound level exceeded for 90 per cent of a time interval and is typically referred to as the background noise level.

The L_{eq} can be measured over any period of time using an integrating sound level meter. Some common time periods used are 24 hours, noted as the L_{eq24}, daytime hours (7 am to 10 pm), noted as the L_d, and nighttime hours (10 pm to 7 am), noted as the L_n. As the impact of noise on people is judged differently during the day and during the night, 24-hour noise metrics have been developed that reflect this.

The day-night equivalent sound level (L_{dn}) is one metric commonly used to represent community noise levels. It is derived from the L_d and the L_n with a 10 dB penalty applied to the L_n to account for increased human sensitivity to nighttime noise.

APPENDIX C NOISE IMPACT ASSESSMENT RESULT TABLE

Names of residences are grouped according to zones as shown in Figure 5-1 and counted starting from west to east. The noise impact of each dwelling was assessed at the second floor height of 4.3 metres above the ground.

Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G1 - 001	68.9	69.3	0.0	3.8	0.4	Moderate	4.5	0.7
G1 - 002	67.3	67.6	0.0	4.3	0.3	Moderate	3.5	1.2
G1 - 003	66.6	67	0.0	4.3	0.4	Moderate	2.4	0.9
G1 - 004	64.1	64.7	1.0	5.3	0.6	Minor	1.4	0.5
G1 - 005	67.6	67.8	0.0	4.1	0.2	Moderate	2.4	0.7
G1 - 006	62.8	63.6	2.0	5.7	0.8	Minor	0.2	0.2
G1 - 007	67.5	67.8	0.0	4.1	0.3	Moderate	2.2	0.6
G1 - 008	63	63.9	2.0	5.7	0.9	Minor	0.1	0.2
G1 - 009	67.7	67.9	0.0	4.1	0.2	Moderate	3.6	1.0
G1 - 010	63.5	64.2	1.0	5.3	0.7	Minor	0.3	0.2
G1 - 011	67.5	67.7	0.0	4.1	0.2	Moderate	4.0	1.2
G1 - 012	62.6	63.4	2.0	5.7	0.8	Minor	0.6	0.4
G1 - 013	67.4	67.6	0.0	4.3	0.2	Moderate	3.9	1.2
G1 - 014	61.7	62.2	2.7	6.1	0.5	Minor	0.4	0.4
G1 - 015	67.4	67.7	0.0	4.3	0.3	Moderate	3.9	1.4
G1 - 016	61.3	61.4	2.9	6.6	0.1	Minor	1.0	0.9
G1 - 017	67	67.6	0.0	4.3	0.6	Moderate	3.9	1.5
G1 - 018	67.1	67.8	0.0	4.3	0.7	Moderate	5.0	2.3
G1 - 019	63.8	64.7	1.0	5.3	0.9	Minor	5.4	3.2
G1 - 020	65.5	66	0.0	4.6	0.5	Moderate	4.9	4.2
G1 - 021	61.5	59.6	2.7	6.1	-1.9	Minor	0.1	0.1
G1 - 022	66.4	66.9	0.0	4.6	0.5	Moderate	4.8	5.0
G1 - 023	60.7	59.2	2.9	6.6	-1.5	Minor	2.8	2.0

Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G1 - 024	62.1	59.4	2.7	6.1	-2.7	Minor	2.5	2.9
G1 - 025	63.3	60.4	2.0	5.7	-2.9	Minor	4.2	3.0
G1 - 026	64.3	61.2	1.0	5.3	-3.1	Minor	4.0	2.2
G1 - 027	63.2	60.5	2.0	5.7	-2.7	Minor	0.0	0.0
G1 - 028	64.5	63.3	0.0	4.9	-1.2	Minor	0.0	0.0
G1 - 029	64.6	64.3	0.0	4.9	-0.3	Minor	0.0	0.0
G1 - 030	63.8	62.9	1.0	5.3	-0.9	Minor	0.1	0.0
G2 - 001	64.6	65.9	0.0	4.9	1.3	Moderate	0.9	0.7
G2 - 002	60.9	62.7	2.9	6.6	1.8	Minor	2.2	0.7
G2 - 003	60.7	61.5	2.9	6.6	0.8	Minor	0.1	0.0
G2 - 004	61	62	2.9	6.6	1.0	Minor	0.0	0.0
G2 - 005	65.7	66.8	0.0	4.6	1.1	Moderate	3.3	1.5
G2 - 006	62.2	63.5	2.7	6.1	1.3	Minor	0.0	0.0
G2 - 007	66.2	66.9	0.0	4.6	0.7	Moderate	3.7	2.0
G2 - 008	68.5	68.3	0.0	3.8	-0.2	Moderate	3.5	2.3
G2 - 009	55.5	56	4.6	9.3	0.5	Minor	0.1	0.1
G2 - 010	69.3	68.7	0.0	3.8	-0.6	Moderate	3.9	2.4
G2 - 011	55.3	56.3	5.0	10.0	1.0	Minor	1.2	1.6
G2 - 012	57.7	58.9	3.8	8.1	1.2	Minor	4.0	0.3
G2 - 013	57.1	58.2	4.2	8.7	1.1	Minor	0.1	0.1
G2 - 014	58.3	59.4	3.8	8.1	1.1	Minor	0.0	0.0
G2 - 015	63.4	63.5	2.0	5.7	0.1	Minor	5.3	3.1
G2 - 016	53.6	53.5	5.5	10.7	-0.1	Minor	0.3	0.2
G2 - 017	67.5	67.3	0.0	4.1	-0.2	Moderate	5.6	3.1
G2 - 018	61.6	62.8	2.7	6.1	1.2	Minor	5.6	3.8
G2 - 019	54.3	55.8	5.5	10.7	1.5	Minor	5.2	5.3
G2 - 020	54.6	54.7	5.0	10.0	0.1	Minor	4.0	3.7
G2 - 021	59.9	61.7	3.2	7.1	1.8	Minor	5.5	6.0

Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G2 - 022	57.4	57.8	4.2	8.7	0.4	Minor	6.2	4.0
G2 - 023	69	71.8	0.0	3.8	2.8	Moderate	7.8	4.7
G2 - 024	56.9	55.2	4.2	8.7	-1.7	Minor	6.0	4.0
G2 - 025	60	60	3.2	7.1	0.0	Minor	7.1	5.9
G2 - 026	65.2	67.9	0.0	4.9	2.7	Moderate	8.8	3.9
G2 - 027	66.3	69	0.0	4.6	2.7	Moderate	6.5	5.1
G2 - 028	60.6	61.6	2.9	6.6	1.0	Minor	7.5	6.1
G2 - 029	66.2	69.8	0.0	4.6	3.6	Moderate	9.1	5.8
G2 - 030	57.5	61.4	3.8	8.1	3.9	Minor	9.1	7.4
G2 - 031	60.8	65.3	2.9	6.6	4.5	Moderate	7.2	7.0
G2 - 032	59.6	62.9	3.2	7.1	3.3	Minor	7.1	5.8
G2 - 033	58.7	62	3.5	7.6	3.3	Minor	6.2	4.3
G2 - 034	58.5	61.1	3.5	7.6	2.6	Minor	3.7	4.3
G2 - 035	68.7	71.8	0.0	3.8	3.1	Moderate	-0.2	2.1
G2 - 036	58.2	60.4	3.8	8.1	2.2	Minor	6.8	5.0
G2 - 037	57.4	60.2	4.2	8.7	2.8	Minor	5.4	6.6
G2 - 038	61.3	63.3	2.9	6.6	2.0	Minor	7.3	3.9
G2 - 039	60.1	62.2	3.2	7.1	2.1	Minor	5.7	5.4
G2 - 040	69.3	70.8	0.0	3.8	1.5	Moderate	7.9	8.2
G2 - 041	73.3	74.4	0.0	2.0	1.1	Moderate	7.6	6.8
G2 - 042	56.2	57.9	4.6	9.3	1.7	Minor	5.0	4.1
G2 - 043	64	65.4	1.0	5.3	1.4	Moderate	5.8	4.6
G2 - 044	63	64.8	2.0	5.7	1.8	Minor	4.3	4.1
G2 - 045	66.2	68.1	0.0	4.6	1.9	Moderate	3.0	4.0
G2 - 046	60.3	61.7	3.2	7.1	1.4	Minor	4.1	2.9
G2 - 047	69.8	71.3	0.0	3.6	1.5	Moderate	7.9	4.9
G2 - 048	60.8	62.7	2.9	6.6	1.9	Minor	6.2	5.5
G2 - 049	71.4	73.1	0.0	3.5	1.7	Moderate	9.1	9.2

Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G2 - 050	72.1	73.7	0.0	3.0	1.6	Moderate	9.1	6.0
G2 - 051	70.1	71.7	0.0	3.6	1.6	Moderate	9.0	7.2
G2 - 052	68.6	70.3	0.0	3.8	1.7	Moderate	6.8	6.2
G3 - 001	58.1	61.5	3.8	8.1	3.4	Minor	4.7	3.7
G3 - 002	59.9	64.1	3.2	7.1	4.2	Moderate	5.5	4.5
G3 - 003	58.2	60.5	3.8	8.1	2.3	Minor	3.8	2.7
G3 - 004	62.4	64.8	2.7	6.1	2.4	Moderate	6.0	5.0
G3 - 005	70.5	72.7	0.0	3.5	2.2	Moderate	8.3	7.0
G3 - 006	60.6	63.5	2.9	6.6	2.9	Minor	6.3	4.1
G3 - 007	61.1	63.7	2.9	6.6	2.6	Minor	4.0	3.4
G3 - 008	67.8	70.7	0.0	4.1	2.9	Moderate	7.7	6.5
G3 - 009	65	68.2	0.0	4.9	3.2	Moderate	7.5	5.7
G3 - 010	61.2	64.6	2.9	6.6	3.4	Moderate	2.4	3.0
G3 - 011	68.6	72.9	0.0	3.8	4.3	Severe	7.4	4.4
G3 - 012	59.6	64.1	3.2	7.1	4.5	Moderate	1.8	3.2
G3 - 013	55.4	59.3	5.0	10.0	3.9	Minor	1.1	3.5
G3 - 014	58.7	62.1	3.5	7.6	3.4	Minor	1.5	2.3
G3 - 015	65.7	71	0.0	4.6	5.3	Severe	3.3	2.4
G3 - 016	58.7	61.3	3.5	7.6	2.6	Minor	2.4	0.9
G3 - 017	65.9	69.3	0.0	4.6	3.4	Moderate	1.1	0.6
G3 - 018	63.7	65.2	1.0	5.3	1.5	Moderate	1.9	2.1
G3 - 019	62.8	64.6	2.0	5.7	1.8	Minor	2.7	2.8
G3 - 020	62.5	65	2.0	5.7	2.5	Minor	7.0	5.3
G3 - 021	60.6	62.3	2.9	6.6	1.7	Minor	1.4	1.3
G3 - 022	60	61.7	3.2	7.1	1.7	Minor	2.2	1.9
G3 - 023	64.1	66.5	1.0	5.3	2.4	Moderate	8.2	6.1
G3 - 024	56.4	58.3	4.6	9.3	1.9	Minor	0.9	0.7
G3 - 025	56.4	58.5	4.6	9.3	2.1	Minor	2.1	1.5

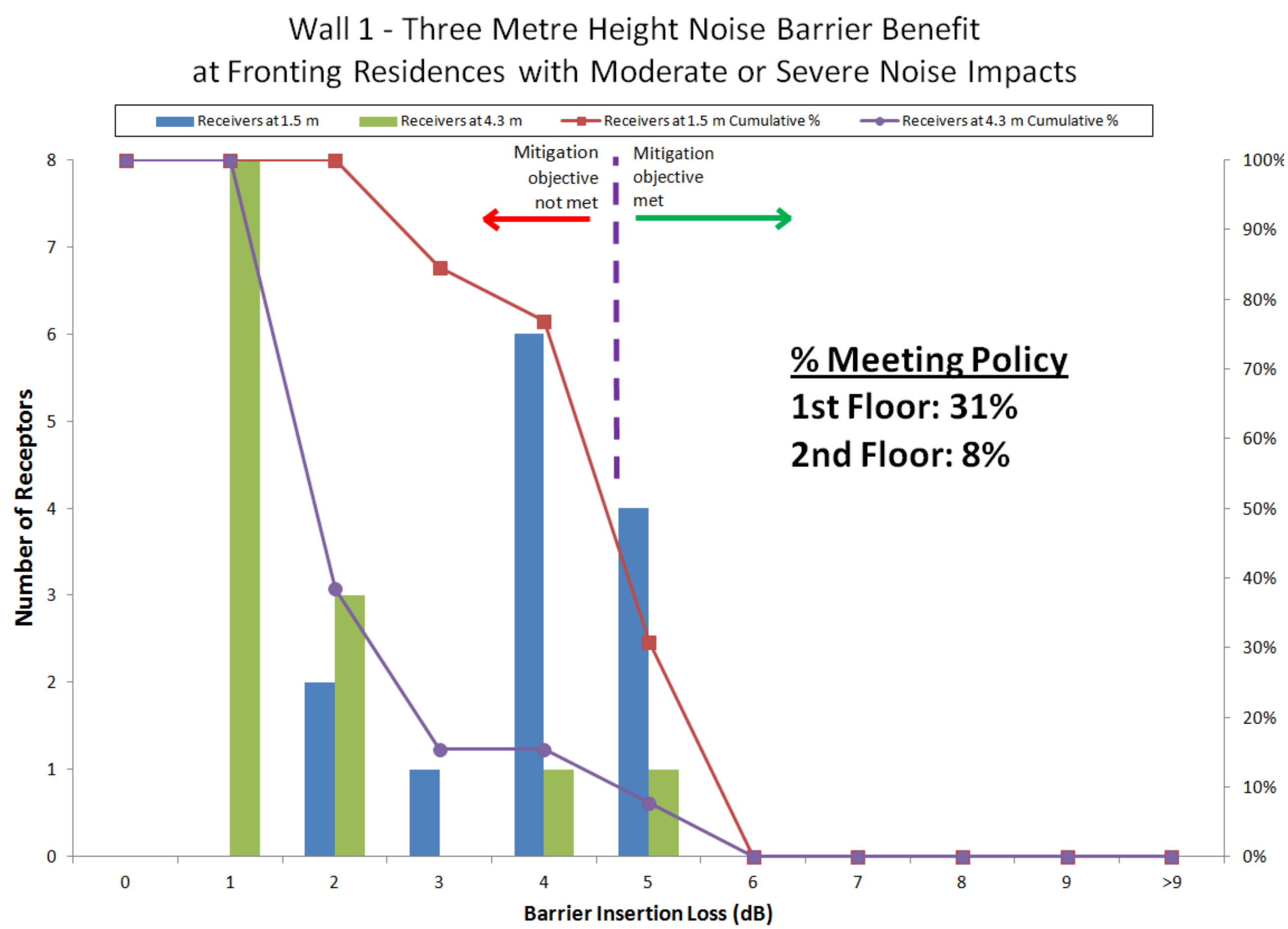
Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G3 - 026	63.1	64.8	2.0	5.7	1.7	Minor	3.3	1.7
G3 - 027	64.6	66.4	0.0	4.9	1.8	Moderate	5.3	4.6
G3 - 028	58.1	59.2	3.8	8.1	1.1	Minor	0.2	0.9
G3 - 029	58.2	60	3.8	8.1	1.8	Minor	0.3	1.0
G3 - 030	60.7	62.7	2.9	6.6	2.0	Minor	2.3	1.9
G3 - 031	63.2	64.7	2.0	5.7	1.5	Minor	1.9	2.4
G3 - 032	66.9	68.5	0.0	4.3	1.6	Moderate	6.3	5.9
G3 - 033	58.9	60.8	3.5	7.6	1.9	Minor	0.6	0.7
G3 - 034	57.3	58.4	4.2	8.7	1.1	Minor	0.7	0.5
G3 - 035	62.7	64.4	2.0	5.7	1.7	Minor	0.9	0.5
G4 - 001	61.3	62.8	2.9	6.6	1.5	Minor	0.6	0.6
G4 - 002	64.1	65.5	1.0	5.3	1.4	Moderate	0.3	0.1
G4 - 003	64.4	65.8	1.0	5.3	1.4	Moderate	0.2	0.2
G4 - 004	65.8	67	0.0	4.6	1.2	Moderate	0.1	0.3
G4 - 005	64.8	66.3	0.0	4.9	1.5	Moderate	0.2	0.1
G4 - 006	62.7	64.1	2.0	5.7	1.4	Minor	0.2	0.0
G4 - 007	57.9	59.3	3.8	8.1	1.4	Minor	0.1	0.1
G4 - 008	64.9	66.5	0.0	4.9	1.6	Moderate	0.3	0.3
G4 - 009	62	63.3	2.7	6.1	1.3	Minor	0.4	0.1
G4 - 010	65.6	67.2	0.0	4.6	1.6	Moderate	0.3	0.2
G4 - 011	62.5	63.8	2.0	5.7	1.3	Minor	0.2	0.1
G4 - 012	67	68.6	0.0	4.3	1.6	Moderate	0.1	0.1
G4 - 013	62.1	63.4	2.7	6.1	1.3	Minor	0.0	0.1
G4 - 014	62.7	64.2	2.0	5.7	1.5	Minor	0.1	0.0
G4 - 015	66.4	67.9	0.0	4.6	1.5	Moderate	0.0	0.0
G4 - 016	59.1	60.2	3.5	7.6	1.1	Minor	0.1	0.0
G4 - 017	67.2	68.7	0.0	4.3	1.5	Moderate	0.1	0.0
G4 - 018	67.5	69	0.0	4.1	1.5	Moderate	0.0	0.0

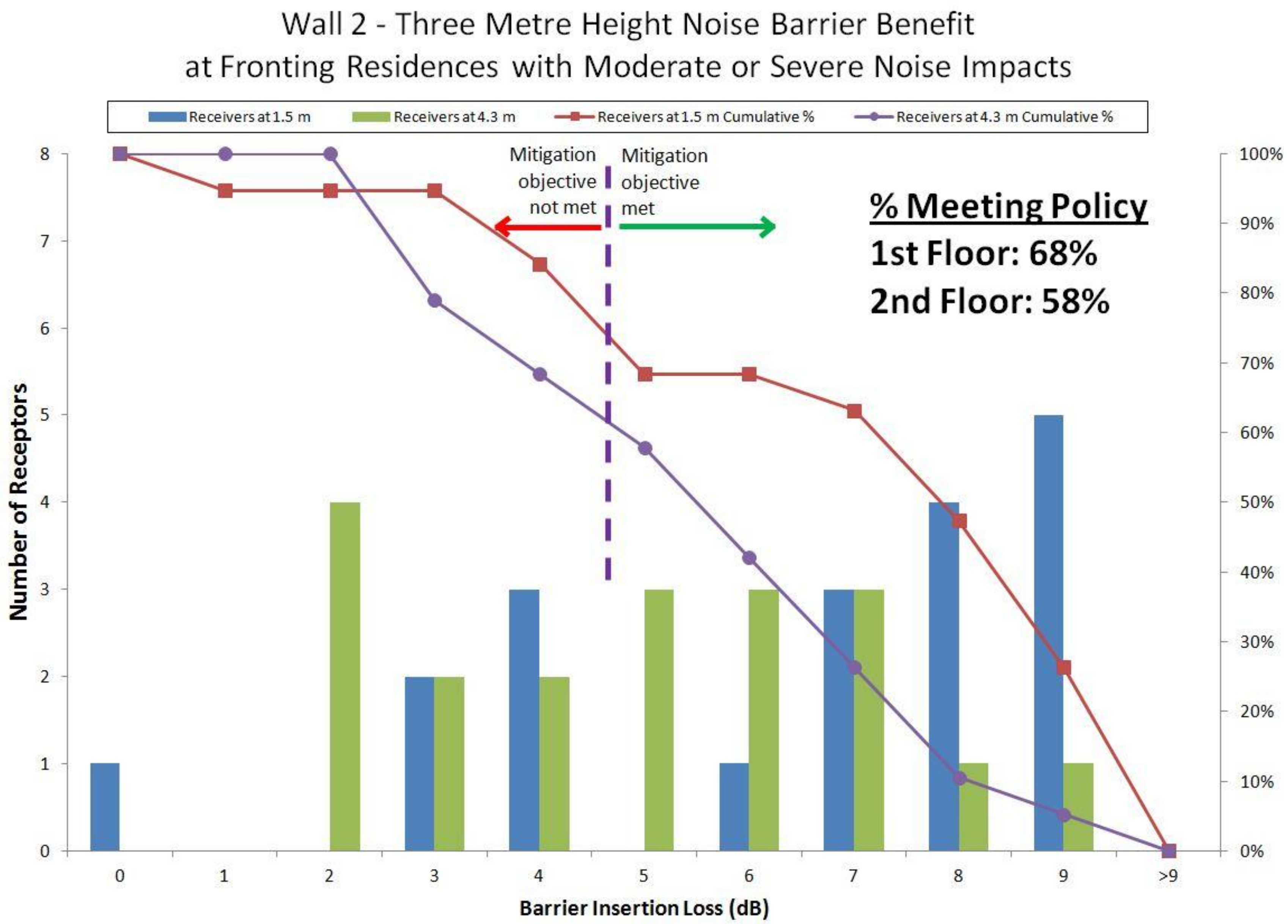
Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G4 - 019	57.7	59.2	3.8	8.1	1.5	Minor	0.1	-0.1
G4 - 020	56	57.4	4.6	9.3	1.4	Minor	0.2	0.0
G4 - 021	64.2	65.8	1.0	5.3	1.6	Moderate	0.1	0.1
G4 - 022	57.2	58.2	4.2	8.7	1.0	Minor	0.0	0.0
G4 - 023	55.8	57.5	4.6	9.3	1.7	Minor	-0.1	0.0
G4 - 024	63.8	65.5	1.0	5.3	1.7	Moderate	0.0	0.0
G4 - 025	55.5	57.3	4.6	9.3	1.8	Minor	-0.2	0.0
G4 - 026	56.6	58.2	4.2	8.7	1.6	Minor	-0.1	0.1
G4 - 027	64	65.7	1.0	5.3	1.7	Moderate	0.0	0.0
G4 - 028	56.5	58.2	4.2	8.7	1.7	Minor	-0.1	0.0
G4 - 029	56.7	58.4	4.2	8.7	1.7	Minor	-0.1	0.0
G4 - 030	63.7	65.3	1.0	5.3	1.6	Moderate	0.0	0.0
G4 - 031	64.3	65.9	1.0	5.3	1.6	Moderate	0.0	0.0
G4 - 032	58.7	60.2	3.5	7.6	1.5	Minor	0.0	0.0
G4 - 033	64.1	65.7	1.0	5.3	1.6	Moderate	0.0	0.0
G4 - 034	63.1	64.6	2.0	5.7	1.5	Minor	0.0	0.0
G4 - 035	62.5	63.9	2.0	5.7	1.4	Minor	0.0	0.0
G4 - 036	62.8	64.1	2.0	5.7	1.3	Minor	0.0	0.0
G5 - 001	73.1	73.8	0.0	2.0	0.7	Moderate	11.4	0.8
G5 - 002	73.8	74.3	0.0	1.0	0.5	Moderate	15.3	2.3
G5 - 003	66.4	67	0.0	4.6	0.6	Moderate	7.3	6.4
G5 - 004	72.3	72.6	0.0	3.0	0.3	Moderate	8.7	2.4
G5 - 005	66.3	65.9	0.0	4.6	-0.4	Moderate	0.0	0.0
G5 - 006	66.8	66.2	0.0	4.3	-0.6	Moderate	0.0	0.0
G5 - 007	65.4	64.7	0.0	4.9	-0.7	Minor	0.1	0.0
G5 - 008	72.9	73.1	0.0	2.0	0.2	Moderate	14.8	2.8
G5 - 009	72.9	73.5	0.0	2.0	0.6	Moderate	12.2	4.7
G5 - 010	61	62	2.9	6.6	1.0	Minor	4.4	3.7

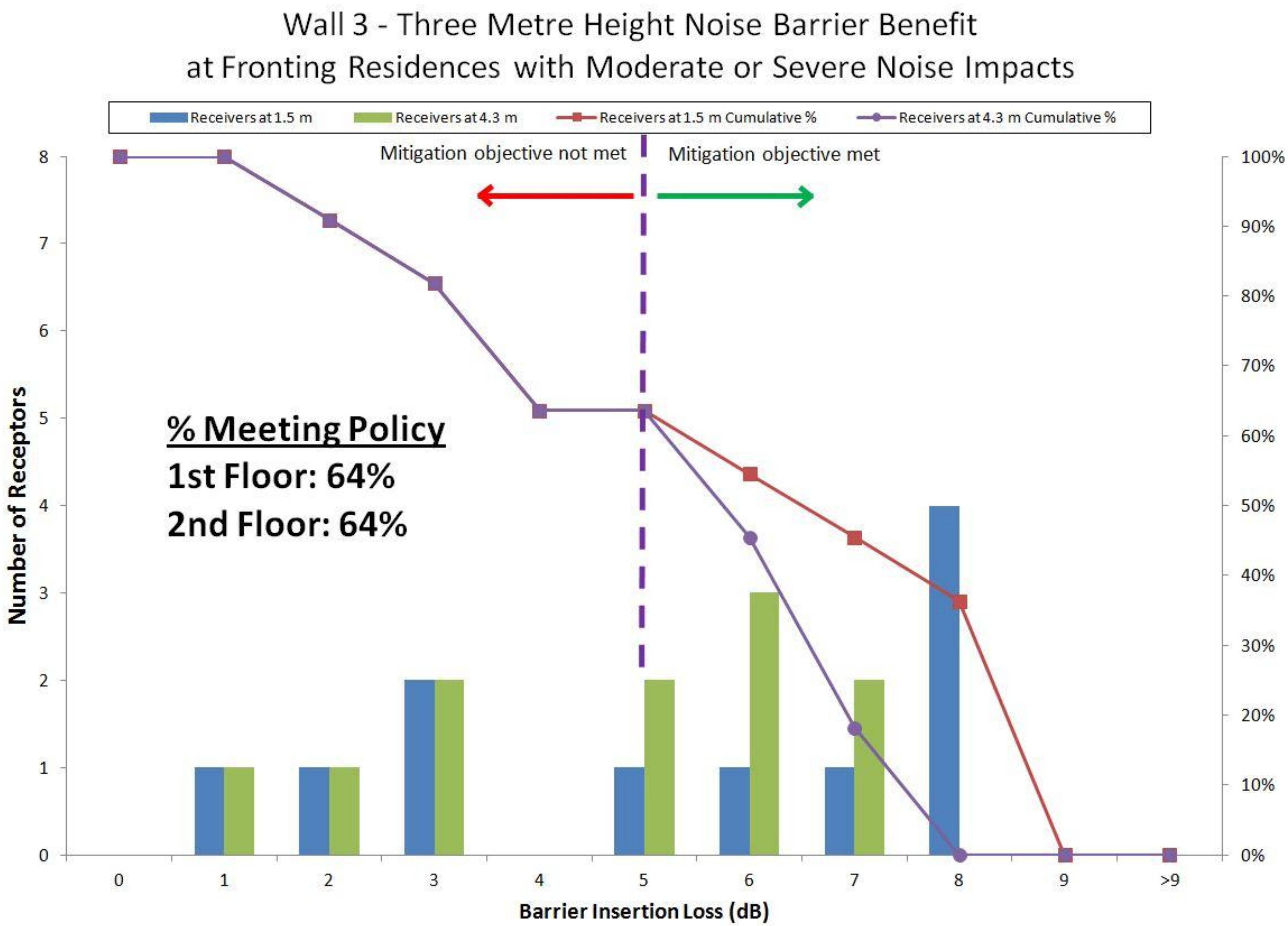
Name (Group – No.)	L_{dn} (dBA)		Allowable Increase in L_{dn} (dBA)		Predicted Change (dBA)	Noise Impact	Predicted Insertion Loss (dBA)	
	Pre-Project	Post-Project	Moderate Impact	Severe Impact			1st Floor (1.5 m)	2nd floor (4.3 m)
G6 - 001	71.6	72.3	0.0	3.0	0.7	Moderate	7.0	3.9
G6 - 002	63.8	64.6	1.0	5.3	0.8	Minor	0.7	-0.1
G6 - 003	57.7	58.4	3.8	8.1	0.7	Minor	0.2	-0.4
G6 - 004	57.8	59.2	3.8	8.1	1.4	Minor	0.3	-0.3
G6 - 005	61.3	62.2	2.9	6.6	0.9	Minor	0.3	-0.6
G6 - 006	64.3	64.3	1.0	5.3	0.0	Minor	-0.2	1.0
G6 - 007	66.5	66.6	0.0	4.3	0.1	Moderate	4.6	3.0
G6 - 008	67.1	67.1	0.0	4.3	0.0	Moderate	5.7	3.8
G6 - 009	68.4	68.5	0.0	4.1	0.1	Moderate	8.8	4.2
G6 - 010	71.5	72	0.0	3.0	0.5	Moderate	6.1	2.7
G6 - 011	66.7	66.3	0.0	4.3	-0.4	Moderate	0.0	0.1

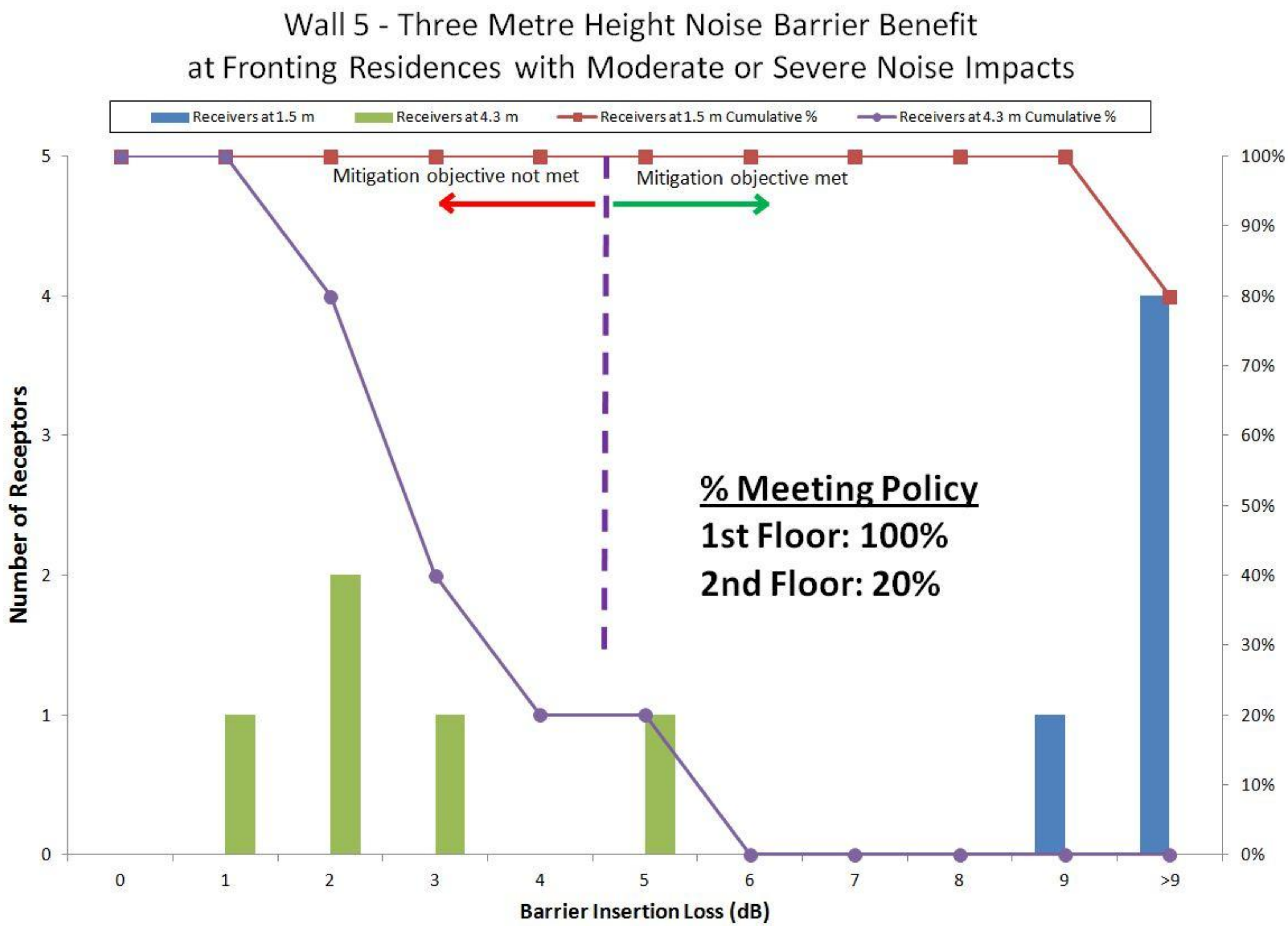
APPENDIX D BARRIER INSERTION LOSS HISTOGRAM

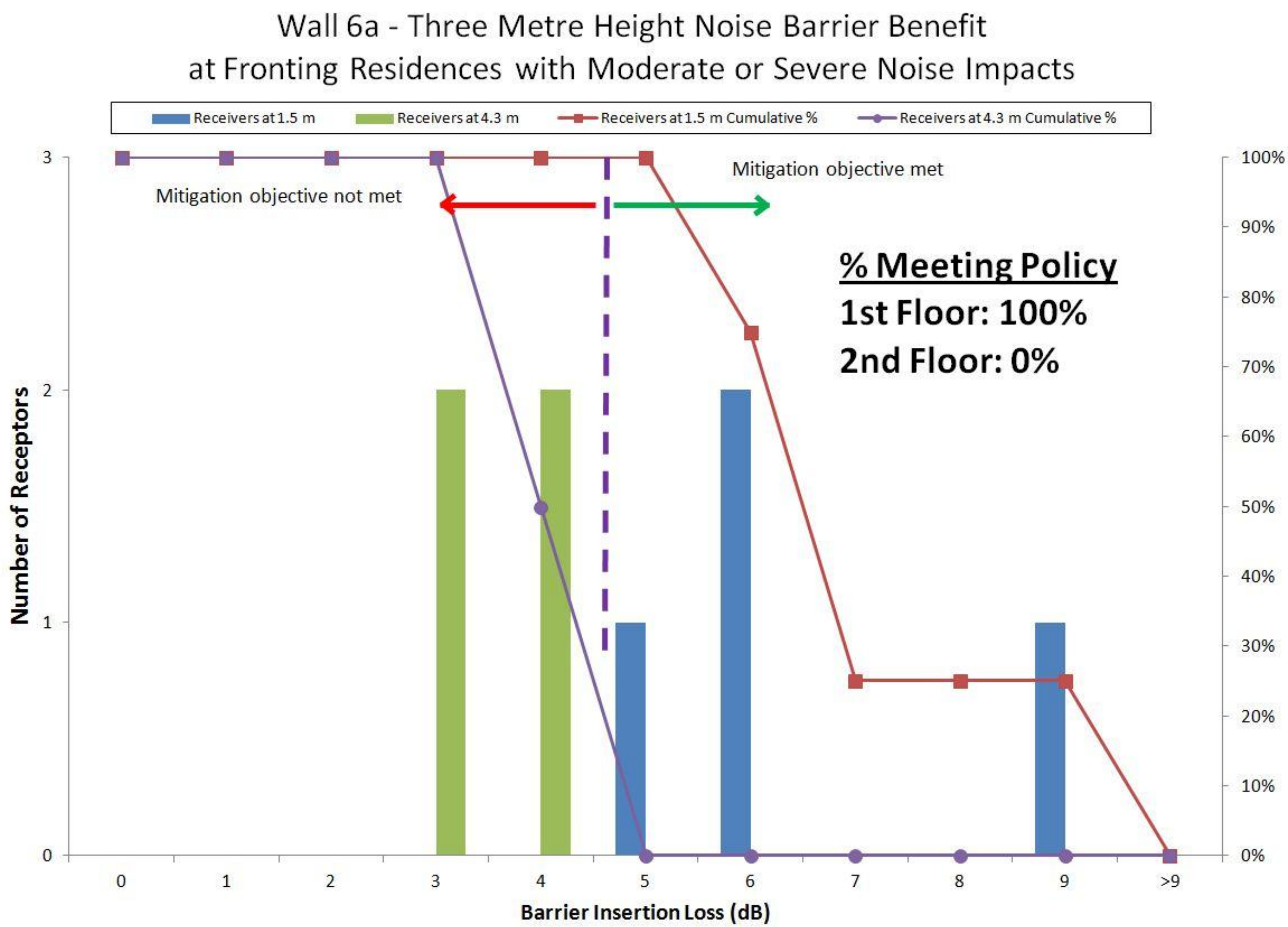
The following figures show the barrier insertion loss at each fronting residence receiving benefit from walls 1 to 6a. Wall 6b is not shown because it serves one residence. The noise impact assessment results for Wall 6b are that it provides a 7 dB barrier insertion loss at the first floor (1.5 metre) receiver and a 4 dB barrier insertion loss on the second floor (4.3 metre) receiver for the residence. Therefore, it meets the 5 dB Policy criteria on the first floor, but not on the second.




Wall 2 - Three Metre Height Noise Barrier Benefit
at Fronting Residences with Moderate or Severe Noise Impacts
Receivers at 1.5 m
Receivers at 4.3 m
Receivers at 1.5 m Cumulative %
Receivers at 4.3 m Cumulative %
Mitigation objective not met
Mitigation objective met
% Meeting Policy
1st Floor: 68%
2nd Floor: 58%
Number of Receptors
Barrier Insertion Loss (dB)
0 1 2 3 4 5 6 7 8 9 >9
0 1 2 3 4 5 6 7 8
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%


Wall 3 - Three Metre Height Noise Barrier Benefit
at Fronting Residences with Moderate or Severe Noise Impacts
Receivers at 1.5 m
Receivers at 4.3 m
Receivers at 1.5 m Cumulative %
Receivers at 4.3 m Cumulative %
Mitigation objective not met
Mitigation objective met
% Meeting Policy
1st Floor: 64%
2nd Floor: 64%
Number of Receptors
Barrier Insertion Loss (dB)
0
1
2
3
4
5
6
7
8
9
>9
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Wall 5 - Three Metre Height Noise Barrier Benefit
at Fronting Residences with Moderate or Severe Noise Impacts
Receivers at 1.5 m
Receivers at 4.3 m
Receivers at 1.5 m Cumulative %
Receivers at 4.3 m Cumulative %
Mitigation objective not met
Mitigation objective met
% Meeting Policy
1st Floor: 100%
2nd Floor: 20%
Number of Receptors
Barrier Insertion Loss (dB)
0
1
2
3
4
5
6
7
8
9
>9
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%


Wall 6a - Three Metre Height Noise Barrier Benefit
at Fronting Residences with Moderate or Severe Noise Impacts
Receivers at 1.5 m
Receivers at 4.3 m
Receivers at 1.5 m Cumulative %
Receivers at 4.3 m Cumulative %
Mitigation objective not met
Mitigation objective met
% Meeting Policy
1st Floor: 100%
2nd Floor: 0%
Number of Receptors
Barrier Insertion Loss (dB)
0
1
2
3
4
5
6
7
8
9
>9
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%