Northern Link

Phase 2 – Detailed Feasibility Study

TECHNICAL REPORT NO. 9B

OPERATIONAL NOISE & VIBRATION
ENVIRONMENTAL IMPACT STATEMENT

- 19 September 2008

Executive Summary

1. Introduction

Heggies Pty Ltd (Heggies) has been commissioned by the SKM Connell Wagner Joint Venture (JV) to prepare an assessment of the operational noise and vibration aspects of the Northern Link project for inclusion in the Environmental Impact Statement (EIS).

The specific requirements of the Terms of Reference[1] in relation to operational noise and vibration impacts associated with the project are reproduced below.

- ***Description of Existing Environment***
    - *reviewing available data*
    - *identifying representative existing, committed and approved sensitive places*
    - *conducting additional baseline noise monitoring*
    - *describing existing levels of road traffic noise*

- ***Potential Impacts and Mitigation Measures – Operational***
    - *assess the predicted levels of road traffic*
    - *assess the potential for operational phase vibration and regenerated noise impacts*
    - *analyse significant changes in predictions for traffic noise generation*
    - *assess and document the noise predictions against relevant guidelines and legislation*
    - *compare predicted noise levels with planning levels stated in the Environmental Protection (Noise) Policy 1997 and Department of Main Roads 'Road Traffic Noise Management: Code of Practice 2000' and relevant Australian Standards*
    - *develop likely operational noise and vibration management measures*

Objectives

The objectives of this report in relation to the project description are to:

- address the acoustical requirements detailed in the project's Terms of Reference in relation to the operational phase of the project;
- evaluate the operational noise and vibration impacts at sensitive locations in terms of planning levels identified in the EPP[Noise] and other Guidelines;
- define noise and vibration criteria by which operational noise and vibration impacts at sensitive locations may be evaluated;

- evaluate the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies; and
- recommend appropriate mitigation measures.

2. IMPACT ASSESSMENT CRITERIA

Community Values Relating to Noise and Vibration

The Queensland Environmental Protection (Noise) Policy 1997 defines the values to be protected as the qualities of the acoustic environment that are conducive to:

a. The wellbeing of the community or a part of the community, including its social and economic amenity; or

b. The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Noise Impact Assessment Goals

In the operational phase of the tunnel, potential noise impacts may be associated with traffic at tunnel portals and connecting ramps, toll plazas, traffic changes on surface roads between and beyond tunnel portals, and noise from tunnel ventilation plant.

Regenerated noise from heavy vehicles, particularly those travelling under buildings in shallow tunnel areas is also a potential operational noise issue if the road surface within the tunnel is not well maintained. For well maintained road surfaces, regenerated noise or vibration from an operational road tunnel is not an issue.

Traffic Noise

The EPP (Noise) 1997 planning levels for a Public Road are:

1. For a State-controlled road - 68 dBA $L_{A10(18hour)}$;
2. For all other public roads - 63 dBA $L_{A10(18hour)}$;
3. 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA $L_{Aeq(1hour)}$); and
4. 80 dBA assessed as a single event maximum sound pressure level (80 dBA L_{Amax}).

For this project, surface works on the Western Freeway, Mt Coot-tha Road (between Western Freeway and Milton Road only) and Frederick Street associated with the tunnel would be regarded as upgrading of the existing road network.

For existing residential sites along "Upgraded Existing Roads", Main Road's Code of Practice noise objective is 68 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

Where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved in the design year (2026), Main Roads recommend that treatments for noise attenuation be considered outside the road corridor for individual dwellings.

The range of possible dwelling treatments will be determined by the predicted external noise level at the facade(s) of habitable room(s) as follows:

- Where predicted outdoor noise levels do not exceed the criterion level, no treatment of the dwelling will be offered.
- Where predicted outdoor noise levels exceed the criterion level by 1 dBA or greater, but less than 3 dBA, provide mechanical ventilation so that windows can remain closed or partly closed to reduce the noise entering habitable rooms.
- Where predicted outdoor noise levels exceed the criterion level by 3 dBA or greater, but less than 10 dBA, provide air-conditioning and mechanical ventilation so that windows can remain closed to reduce the noise entering habitable rooms.

  Where predicted outdoor noise levels exceed the criterion level by 10 dBA or greater, provide building upgrade treatments if necessary, air-conditioning and mechanical ventilation in order to meet an internal noise level at least 10 dBA below the external noise criterion level.

The EPP[Noise] does not make any distinction between residences and educational or healthcare facilities - the 63 dBA $L_{A10(18hour)}$ planning level is applied to all these noise sensitive locations. Consistent with the ToR, guidance for the assessment of educational and health care facilities was sought from Main Roads' Code of Practice, where noise mitigation for an "Upgraded Existing Road" is considered on a case-by-case basis for those properties where the following criteria are exceeded:

- $L_{A10(1hour)}$ noise level is greater than 55 dBA (internal); and
- An increase of at least 3 dBA above the pre-construction level.

The 55 dBA $L_{A10(1hour)}$ noise level (internal) for the worst hour is essentially equivalent to the 63 dBA $L_{A10(18hour)}$ external noise goal nominated in the EPP[Noise].

Therefore, for simplicity, educational and health care facilities have been assessed against the 63 dBA $L_{A10(18hour)}$ external noise goal, as for residences adjacent non-stated controlled roads.

It will be important that during the detailed design phase of this project, specific internal $L_{A10(1hour)}$ (worst hour) noise level predictions be undertaken based on actual building facade noise reductions.

Tunnel Ventilation Plant

The EPP[Noise] nominates qualitative characteristics of the noise environment that are to be protected, but does not specify any numerical limits that are applicable to stationary mechanical plant.

The Brisbane City Council's Noise Impact Assessment Planning Scheme Policy (NIAPSP) aims to control 'background creep' by recommending that "*Outside noise levels must not exceed the levels detailed in the table below*:"

Noise area category Appendix A AS1055.2[a]	Permissable level of exceedance of $L_{A90,T}$ for the appropriate time of day		
	Where there is residential development	Where there is no residential development	Where background levels already exceed stated levels in AS1055.2 (i.e. without the proposed development
R1	by 5dB(A)	N/A	The development's noise contribution must still comply with the stated levels in *AS1055.2*
R2	by 5dB(A)	N/A	
R3	by 0dB(A)	by 10dB(A)	
R4			
R5			
R6			

(a) Refer to Appendix A in AS1055.2 for $L_{A90,T}$ levels for the noise area categories

The NIAPSP requirements for the avoidance of 'background creep' are recommended for use on this project. The AS1055 corrections for tonality and impulsiveness will be applied, where necessary.

Regenerated Noise

Vibration generated by heavy vehicles on a poorly maintained roadway can sometimes be heard in nearby buildings as a low frequency "rumbling" sound. The potential for this to occur may be enhanced where the tunnel is situated directly beneath a building. However, for well maintained roadways, regenerated noise is not an issue.

The "satisfactory" noise levels listed in AS/NZS 2107 are recommended as guidance for the purpose of assessing regenerated noise levels within buildings.

3. Identification of Noise Sensitive Buildings

Apart from the residential dwellings that are in the vicinity of the Northern Link connections and route alignment, there is a number of other noise/vibration sensitive locations that have been identified which have been considered in this report when assessing the potential for impacts arising from airborne or regenerated noise and vibration.
They include the following types of facilities:

- Aged care
- Child care
- Place of Worship
- Education
- Heritage
- Commercial

4. Existing Noise and Vibration Environment

Introduction

The aspects of the tunnel infrastructure that are of particular interest in respect of the existing noise environment are those areas in the vicinity of:-

- Construction sites,
- Ventilation Outlets, and
- Tunnel portals and associated connections.

Noise Monitoring Sites

Noise monitoring sites have been selected to be representative of catchments that may be potentially affected by the Northern Link project.

The details of the selected noise monitoring sites, and their relevance to potential tunnel noise issues is summarised in **Table 55**.

Table 5 Noise Monitoring Locations

Location Number	Monitoring Location	Relevance to Tunnel Noise Issues
1	22 Crag Road, Taringa	Operational (surface traffic)
2	115 Elizabeth Street, Toowong	Construction and operational (surface traffic and/or ventilation station) impacts associated with the western portal
3	6 Wool Street, Toowong	Operational (ventilation station) impacts associated with western portal
4	128 Sylvan Road, Toowong	Operational impacts associated with Frederick Street portal
5	29 Valentine Street, Toowong	Construction and operational (surface traffic) impacts associated with Frederick Street portal
6	69 Frederick Street, Toowong	Construction and operational (road traffic) impacts associated with Frederick Street portal
7	9 Victoria Crescent, Toowong	Construction and operational (road traffic) impacts associated with Frederick Street portal
8	5 Clyde Street, Brisbane City	Operational impacts associated with the eastern portals
9	26 Lower Clifton Terrace, Red Hill	Construction and operational (road traffic and ventilation station) impacts associated with the eastern portals
10	7 Westbury Street, Red Hill	Construction and operational (surface traffic) impacts associated with the Kelvin Grove portal
11	Inner Northern Busway (INB), Normanby Station	Construction and operational (surface traffic) impacts associated with the Inner City Bypass (ICB) portal
12	43 Normanby Terrace, Kelvin Grove	Construction and operational (surface traffic) impacts associated with the ICB portal
13	9 Horrocks Street, Toowong	Construction and operational (surface traffic) impacts associated with the western portal
14	QUT, Kelvin Grove Campus	Operational (ventilation station) impacts associated with the eastern portal

Noise monitoring was conducted generally in accordance with Australian Standard AS1055-1997 *Acoustics – Description and Measurement of Environmental Noise* and the Queensland Environmental Protection Agency's *Noise Measurement Manual* 2000. The noise environment in the study corridor is typical of many inner urban areas, in that it is largely determined by road traffic noise. However, at some locations rail noise and/or mechanical plant noise are other significant sources.

The dominant audible sounds at each location are summarised in **Table 77**.

Table 7 Description of Existing Noise Sources

Location Number	Monitoring Location	Dominant Daytime & Evening Noise Sources	Dominant Noise Sources Late at Night
1	22 Crag Road, Taringa	Western Freeway traffic	Western Freeway traffic
2	115 Elizabeth Street, Toowong	Western Freeway traffic	Western Freeway traffic
3	6 Wool Street, Toowong	Western Freeway road traffic and mechanical plant and equipment noise from bus depot	Western Freeway and occasional Miskin Street traffic
4	128 Sylvan Road, Toowong	Milton Road and Sylvan Road traffic	Milton Road and Sylvan Road traffic
5	29 Valentine Street, Toowong	Milton Road and Frederick Street traffic	Milton Road and Frederick Street traffic
6	69 Frederick Street, Toowong	Frederick Street traffic and transformer noise	Frederick Street traffic and transformer noise
7	9 Victoria Crescent, Toowong	Frederick Street traffic	Frederick Street traffic and transformer noise
8	5 Clyde Street, Brisbane City	Musgrave Road and Hale Street traffic	Musgrave Road and Hale Street traffic
9	26 Lower Clifton Terrace, Red Hill	Kelvin Grove Rd and ICB traffic	Kelvin Grove Rd and ICB traffic
10	7 Westbury Street, Red Hill	Kelvin Grove Rd traffic	Kelvin Grove Rd traffic
11	Inner Northern Busway (INB), Normanby Station	Ithaca Street, ICB and INB road traffic and rail traffic (including freight)	Ithaca Street and ICB road traffic and rail traffic (including freight)
12	43 Normanby Terrace, Kelvin Grove	ICB road traffic and rail traffic (including freight)	ICB road traffic and rail traffic (including freight)
13	9 Horrocks Street, Toowong	Mt Coot-tha Rd and Western Freeway traffic	Western Freeway traffic
14	QUT, Kelvin Grove Campus	Victoria Park Road and ICB traffic	ICB traffic

Results of the noise logger measurements were then analysed in terms of:

- Background (L_A90) levels
- L_A10 (18hr) levels for existing road traffic noise
- L_{Aeq} (1hr) – day, evening and night
- Lmax – Average – day, evening and night

Vibration Measurements

Vibration measurements were carried out at various locations to determine existing vibration levels. The summarised results of the vibration measurements are documented in **Table 1313**.

Table 13 Summarised Vibration Measurements

Monitoring Location	Date - Time	Peak Component Particle Velocity (mm/s)	Dominant Frequency (Hz)
1 – Normanby Terrace (behind #43 near cycle path)	29/11/07 – 8:36	0.03	<1.0
2 – Normanby Terrace (along #9)	29/11/07 – 9:07	0.04	<1.0
3 – Normanby Busway Station	29/11/07 – 9:31	0.09	1.2
4 – Kelvin Grove Rd side of 25 Musgrave Rd	29/11/07 – 9:58	0.26	20
5 – Along 25 Upper Clifton Tce	29/11/07 – 10:31	0.09	<1.0
6 – Westbury St Kelvin Grove Rd intersection	29/11/07 – 10:56	0.11	N/A
7 – Toowong Cemetery (south-west corner)	29/11/07 – 11:48	0.05	<1.0
8 – Thorpe St Frederick St intersection	29/11/07 – 12:31	0.07	N/A
9 – In front of 5 Thorpe St	29/11/07 – 12:53	0.02	<1.0

These measurements show that at the majority of the monitoring locations the existing vibration levels are below the threshold level of human perception (~ 0.15 mm/s).

5. Traffic Noise Predictions and Impact Assessment

The CoRTN (Calculation of Road Traffic Noise) 1988 traffic noise prediction procedure was utilised within the SoundPLAN noise prediction software to calculate the traffic noise emissions.

SoundPLAN is a software package which enables compilation of a computer model comprising a 3-D ground map containing ground contours, the final 3-D road design and building locations, traffic volumes, heavy vehicle composition and speed, road pavement characteristics and noise barriers.

Emissions of traffic noise from portal openings have been modelled as area sources in the vertical plane of the portal opening.

Traffic noise predictions have been undertaken for the future predicted levels of road traffic noise with and without the Northern Link project proceeding. The following situations have been modelled in accordance with the ToR:

- **Do Minimum (2014)**
- **With Northern Link (2014)**
- **Do Minimum (2026)**
- **With Northern Link (2026)**

In addition to the modelling scenarios described above, a model was developed to simulate the existing 2007 traffic flows and existing road network for verification of the noise prediction model.

Differences between measured and predicted levels of ± 2 dBA are considered readily acceptable for the purpose of model verification. All the predicted $L_{A10(18hour)}$ noise levels for locations directly adjacent existing roads are within 2 dBA of the measured results therefore the model is considered to be verified.

Barrier Design

Two noise barrier designs have been undertaken for the Northern Link scenarios as outlined below.

'Status Quo' Noise Barrier Option

The objective used to develop the 'Status Quo' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels comparable to the "Do Minimum" option.

'Planning Level' Noise Barrier Option

The objective used to develop the 'Planning Level' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA (non state-controlled roads) or 68 dBA (state-controlled roads) $L_{A10(18hour)}$ planning levels wherever possible.

Discussion of Results – Western Portal Area

2014 "Do Minimum" Results

- All dwellings in the vicinity of the Western Freeway comply with the 68 dBA goal.
- Residences along Miskin Street are predicted to experience noise levels of up to 75 dBA which exceeds the 63 dBA criterion for local roads.
- The dwellings along Frederick Street are predicted to experience noise levels of up to around 76 dBA
- Residences located north of Milton Road, but remote from Frederick Street, are predicted to experience noise levels of up to 75 dBA
- Most dwellings in the vicinity of Milton Road and Sylvan Road are predicted to exceed the 63 dBA criterion by up to 5 dBA.
- All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion, some by up to 18 dBA.
- All dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 13 dBA.

2014 "With Northern Link" Results

- All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion.
- Residences along Miskin Street are predicted to experience noise levels of up to 73 dBA
- The dwellings along Frederick Street are predicted to experience noise levels of around 76 dBA
- Residences located north of Milton Road, but remote from Frederick Street, are predicted to experience noise levels of up to 73 dBA
- Most dwellings in the vicinity of Milton Road and Sylvan Road are predicted to exceed the 63 dBA criterion by up to 5 dBA.
- All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 15 dBA
- All dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA.

Based on these findings, there is a general reduction in 2014 noise levels with the project of around 2 dBA. There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area that are away from the immediate portal would be expected to receive a benefit from the project.

With Barriers Designed to Achieve 2026 'Status Quo' Noise Levels in 2026

- All residences south of the Western Freeway and west of Miskin Street are predicted to comply with the 'Status Quo' noise goal
- The dwellings along Frederick Street are predicted to comply with the 'Status Quo' noise goal with the (Y2026) 'Status Quo' noise barriers in place.
- Residences located north of Milton Road, but remote from Frederick Street are also predicted to comply with the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.
- All dwellings south of Milton Road (between Miskin Street and Croydon Street) are predicted to comply with the 'Status Quo' noise goals with the 'Status Quo' noise barriers in place.
- Most dwellings along Milton Road (east of Croydon Street) are predicted to comply with the 'Status Quo' noise goals. However, one (1) residence on the southern side of Milton Road is predicted to exceed the 'Status Quo' noise goal by 3 dBA. Noise barriers are not a feasible attenuation treatment for this residence due to property access requirements.

- Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place by 2 dBA. Two (2) residences on St Osyth Street are predicted to exceed the 'Status Quo' noise goal by up to 2 dBA. No additional noise attenuation is achievable from the noise barriers at these locations due to property access requirements.

With Barriers Designed to Achieve 63/68 dBA $L_{A10(18hour)}$ Planning Level in 2026

- All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion.

- Residences along Miskin Street are predicted to exceed the 63 dBA criterion by up to 12 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

- The dwellings along Frederick Street are predicted to exceed the 68 dBA criterion by up to 8 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

- Residences located north of Milton Road, but remote from Frederick Street, are predicted to exceed the 63 dBA criterion by up to 7 dBA with the 'Planning Level' noise barriers capped at 8 m. All residences in this area achieve the 'Status Quo' noise goal with the designed 'Planning Level' noise barriers.

- Several dwellings in the vicinity of Milton Road (between Miskin Street and Croydon Street) are predicted to exceed the 63 dBA criterion by up to 4 dBA with the 'Planning Level' noise barriers capped at 8 m. All residences in this area are able to achieve the 'Status Quo' noise goal with the 'Planning Level' noise barriers.

- All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 15 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All but one (1) of these residences achieves the 'Status Quo' noise goal.

- Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All residences are within 2 dBA of the 'Status Quo' noise goals with the 'Planning Level' noise barriers in place.

For properties along Frederick Street where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved, property treatments will be required in accordance with Main Roads' Code of Practice.

2026 "Do Minimum" Results

The "Do Minimum" for 2026 appears to be generally within 1 to 2 dBA of the 2014 "Do Minimum" predictions. Given the difference between these two scenarios is the natural increase in traffic over 12 years, unrelated to the Northern Link project, it would be expected that the two sets of results are very similar.

2026 "With Northern Link" Results

Similar to the "Do Minimum" scenario, the road traffic noise emissions predicted from this scenario are very similar to the results for 2014.

Based on these findings there is a general reduction in 2026 noise levels with the project by around 2 dBA. There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area that are away from the immediate portal would be expected to receive a benefit from the project.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

- All residences south of the Western Freeway and west of Miskin Street are predicted to comply with the 'Status Quo' noise goal.
- The dwellings along Frederick Street are predicted to comply with the 'Status Quo' noise goal with the 'Status Quo' noise barriers.
- Residences located north of Milton Road, but remote from Frederick Street are also predicted to comply with the 'Status Quo' noise goal with the designed 'Status Quo' noise barriers.
- All dwellings south of Milton Road (between Miskin Street and Croydon Street) are predicted to comply with the 'Status Quo' noise goals with the 'Status Quo' noise barriers.
- Most dwellings along Milton Road (east of Croydon Street) are predicted to comply with the 'Status Quo' noise goals. However, one (1) residence on the southern side of Milton Road is predicted to exceed the 'Status Quo' noise goal by 3 dBA. Noise barriers are not a feasible attenuation treatment for this residence due to property access requirements.
- Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 'Status Quo' noise goal with the 'Status Quo' noise barriers by 2 dBA. In addition, two (2) residences on St Osyth Street are predicted to exceed the 'Status Quo' noise goal by up to 2 dBA. No additional noise attenuation is achievable from the noise barriers at these locations due to property access requirements.

It should be noted that changes in noise levels of 2dBA or less are generally considered insignificant in acoustic terms.

This design incorporates a total of 823 linear meters or 4,767 m^2 of barrier to maintain the 'Status Quo' at residential properties.

With Barriers Designed to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective in 2026

- All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion.
- Residences along Miskin Street are predicted to exceed the 63 dBA criterion by up to 10 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.
- The dwellings along Frederick Street are predicted to exceed the 68 dBA criterion by up to 12 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.
- Residences located north of Milton Road, but remote from Frederick Street, are predicted to exceed the 63 dBA criterion by up to 7 dBA with the designed barriers capped at 8 m. All residences in this area achieve the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.
- Several dwellings in the vicinity of Milton Road (between Miskin Street and Croydon Street) are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed noise barriers capped at 8 m, and a 3 m (above pavement height) high barrier on the southern side of the north-bound elevated on-ramp. All residences in this area are able to achieve the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.
- All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 16 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All but one (1) of these residences are able to achieve the 'Status Quo' noise goal.
- Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

This design incorporates a total of 879 linear meters or 6,772 m^2 of barrier to achieve the 63 dBA design target at most residential properties.

For properties along Frederick Street where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved with the design noise barriers, property treatments will be required in accordance with Main Roads' Code of Practice.

Discussion of Results – Eastern Portal Area

2014 "Do Minimum" Results

- The dwellings on the western side of Kelvin Grove Road and south of the tunnel portal area are predicted to experience noise levels up to 72 dBA which exceeds the 63 dBA criterion.

- The dwellings West of Kelvin Grove Road and north of the tunnel portal area are predicted to exceed the 63 dBA criterion by up to13 dBA.

- The dwellings north of the ICB (Normanby Tce) are predicted to experience noise levels up to 70 dBA. The proposed child care centre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 78 dBA, which exceeds the 63 dBA goal.

- The dwellings along the southern side of Gregory Terrace are predicted to experience noise levels up to 77 dBA for all traffic (including traffic on Gregory Terrace itself) and up to 66 dBA for ICB traffic only.

School properties along the ICB

- The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 69 dBA.

- The Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 69 dBA.

- For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA LA10(12hour) planning level for outside education levels. This is considered acceptable.

- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.

- The Brisbane Grammar School Indoor Sports Complex is predicted to experience noise levels of up to 75 dBA.

2014 "With Northern Link" Results

- The dwellings on the western side of Kelvin Grove Road and south of the tunnel portal area are predicted to experience noise levels up to 72 dBA.

- The dwellings West of Kelvin Grove Road and north of the tunnel portal area are predicted to exceed the 63 dBA criterion by up to 14 dBA.

- The dwellings north of the ICB (Normanby Tce) are predicted to experience noise levels up to 74 dBA. The proposed child care centre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 78 dBA.

- The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 77 dBA for all traffic (including traffic on Gregory Tce itself) and up to 66 dBA for ICB and Northern Link traffic only.

School properties along the ICB

- The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 69 dBA.

- The Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 71 dBA.

- For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA $L_{A10(12hour)}$ planning level for outside education levels.

- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level.

- The Brisbane Grammar School Indoor Sports Complex is predicted to experience noise levels of 77 dBA.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

- All dwellings West of Kelvin Grove Road and south of the tunnel portal area are predicted to comply with the 'Status Quo' noise goal with the design noise barriers.

- Most dwellings West of Kelvin Grove Road and north of the tunnel portal area are predicted to comply with the 'Status Quo' noise goal with the design noise barriers. However, one (1) residence on Dalley Street (the nearest eastern property adjacent to Kelvin Grove Road) is predicted to exceed the 'Status Quo' noise goal by 1 dBA with the designed barriers. This is considered an insignificant increase in noise level.

- All dwellings north of the ICB (Normanby Tce) and the proposed child care centre are predicted to comply with the 'Status Quo' noise goals with the designed barriers.

- All dwellings along are predicted to comply with the 'Status Quo' noise goals without the need for noise barriers.

All school properties along the ICB comply with the 'Status Quo' noise goals.

With Barriers Designed to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective in 2026

- Several dwellings West of Kelvin Grove Road and south of the tunnel portal area are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed 8 m noise barriers. All of these residences achieve the 'Status Quo' noise goal with the capped 8 m high barrier.

- Most residences West of Kelvin Grove Road and north of the tunnel portal area are predicted to comply with the 63 dBA criterion with the designed 8 m noise barriers. However, one (1) residence on Kelvin Grove Road and one (1) residence on Dalley Street are predicted to exceed the 63 dBA criterion by up to 10 dBA with the designed barriers.

- Several dwellings In the vicinity of Normanby Terrace, north of the ICB are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed noise barriers. All of these residences achieve the 'Status Quo' noise goal with the (capped) 8 m high barrier. The proposed child care centre is predicted to experience a noise level of 63 dBA.

- The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 76 dBA for all traffic (including traffic on Gregory Tce itself) and up to 65 dBA for ICB and Northern Link traffic only with the designed barriers. All of these residences are able to achieve the 'Status Quo' noise goal.

School properties along the ICB

- The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 66 dBA with a (capped) 8 m high barrier running along the southern edge of the Inner City Bypass. This is above the planning level of 63 dBA $L_{A10(18hour)}$ by 3 dBA.

- The Brisbane Girls' Grammar School buildings are predicted to comply with the 63 dBA $L_{A10(18hour)}$ noise goal with a (capped) 8 m high barrier.

- For the Brisbane Grammar School sports oval south of the rail line, the entire oval is below the 63 dBA $L_{A10(12hour)}$ noise goal with a (capped) 8 m high noise barrier needed for the adjacent classrooms.

- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.

- Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to experience noise levels up to 65 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ by 2 dBA.

2026 "Do Minimum" Results

The "Do Minimum" for 2026 appears to be generally within 1 to 2 dBA of the 2014 "Do Minimum" predictions. Given the difference between these two scenarios is the natural increase in traffic over 12 years, unrelated to the Northern Link project, it would be expected that the two sets of results are very similar.

2026 "With Northern Link" Results

No Mitigation Measures

The predicted levels of road traffic noise emissions in 2026 are very similar to the results of 2014 reflecting the close comparison between the 2014 and 2026 traffic flows.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

- All dwellings West of Kelvin Grove Road and south of the tunnel portal area are predicted to comply with the 'Status Quo' noise goal with the designed noise barriers.

- Most dwellings West of Kelvin Grove Road and north of the tunnel portal *area* are predicted to comply with the 'Status Quo' noise goal with the design noise barriers. However, one (1) residence on Dalley Street (the worst eastern property adjacent to Kelvin Grove Road) is predicted to exceed the 'Status Quo' noise goal by 1 dBA with the designed barriers.

- All dwellings north of the ICB (Normanby Tce) and the propsed child care centre are predicted to comply with the 'Status Quo' noise goals with the designed barriers.

- All dwellings along Gregory Tce are predicted to comply with the 'Status Quo' noise goals without the need for noise barriers.

All school properties along the ICB comply with the 'Status Quo' noise goals.

This design incorporates a total of 1,073 linear meters or 4,762 m^2 of barriers to maintain the 'Status Quo' at residential properties.

With Barriers Designed to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective in 2026

- Several dwellings West of Kelvin Grove Road and south of the tunnel portal area are predicted to exceed the 63 dBA criterion by up to 7 dBA with the designed 8 m noise barriers.

- Most residences West of Kelvin Grove Road and north of the tunnel portal area are predicted to comply with the 63 dBA criterion with the designed 8 m noise barriers. However, one (1) residence on Kelvin Grove Road and one (1) residence on Dalley Street are predicted to exceed the 'Status Quo' noise goal by up to 10 dBA with the designed barriers.

- Several dwellings In the vicinity of Normanby Terrace, north of the ICB are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed 8 m high noise barriers. All of these residences are able to achieve the 'Status Quo' noise goal. The proposed child care centre is predicted to experience a noise level of 64 dBA.

- The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 77 dBA for all traffic (including traffic on Gregory Tce itself) and up to 66 dBA for ICB and Northern Link traffic only with the designed barriers.

School properties along the ICB

- Noise levels at the Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 67 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ by 4 dBA.

- Noise levels experienced at the Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 64 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ by 1 dBA.

- For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA $L_{A10(12hour)}$ planning level for outside education levels. This is considered acceptable.

- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.

- Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to experience noise levels up to 66 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ by 3 dBA.

Should the 2 m high noise barrier recommended adjacent to the parkland (north of Victoria Street on the western side of Kelvin Grove Road) be considered unacceptable from urban design or community reasons, then predicted increases in noise levels for the homes west of this location are all within 2 dBA of the 'Do Minimum' noise level predictions. Consequently, should the noise barrier in this location not be installed, the increase in noise levels due to the project would be considered insignificant.

This design incorporates a total of 2,434 linear meters or 17,879 m^2 of barrier to achieve the 63 dBA $L_{A10(18hour)}$ planning level at residential and educational properties.

Recommended Mitigation Measures

State Controlled Roads: The only state controlled road where there are exceedances of the 68 dBA $L_{A10\ (18\ hour)}$ planning level for this project is Frederick Street. It is unfeasible to build noise barriers to protect these homes due to access requirements. Therefore, in accordance with Main Roads' Code of Practice, property treatments outside the road reserve should be undertaken to achieve an equivalent indoor noise amenity.

Non-State Controlled Roads: For both the Toowong area and the Kelvin Grove area, there are significant numbers of properties that exceed the 'Planning Level' goals with full 8 m high barriers. At 8 m high, noise barriers will also have significant visual and shading issues. 'Status Quo' noise levels can be achieved at almost every location in both areas with somewhat lower barriers. Where the 'Status Quo' noise level cannot be achieved, predicted increases in noise levels between the 'Do Minimum' and 'With Northern Link' are within 2 dBA and are therefore considered insignificant. Therefore, it is recommended that the 'Status Quo' goals be adopted for all non-state controlled roads.

Alternative Mitigation Strategies to Reduce Road Traffic Noise Impacts

During the detailed design phase of the works, consideration should be given to the following options as alternative means of noise control, where noise barriers prove to be unreasonable or feasible:

- Road Surface Treatments:
- Architectural acoustic treatment of existing dwellings
- Use of non-traditional (non-vertical) noise barrier design
- Resumptions:
- Urban Renewal
- Vehicular Speed:
- Reductions in Vehicle Noise Emissions

Vibration and Regenerated Noise

On roadways that are well maintained, regenerated noise and vibration from individual vehicle movements is not considered to result in significant acoustical disruption to residents.

Heggies has recently undertaken specific "operation road tunnel" regenerated noise and vibration measurements above two tunnels – the ICB in Brisbane and the M5 East in Sydney. All results and observations showed regenerated noise and vibration levels to be below the threshold of human perception.

As such, there are no tunnel areas beneath sensitive buildings where it is anticipated that vibration or regenerated noise from truck movements on the carriageways would be an issue provided the road surface is well maintained and free of discontinuities.

6. Traffic Noise on Road Network Remote from the Portal Areas

For the Years 2014 and 2026, the introduction of Northern Link is predicted to result in a small change in the levels of road traffic noise on the wider road network. Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase. **Table 2020** presents a summary of the highest and lowest changes across the wider road network.

- **Table 20 Summary of Changes**

Year	Comparison of Do Minimum to Northern Link	
	Highest Increase	Highest Decrease
2014	+0.8	-1.7
2026	+1.2	-2.4

The expected changes in the traffic noise as a result of the introduction of Northern Link are considered to be minor and not be generally noticeable.

7. Ventilation Noise from Ventilation Stations

At this stage, the proposed mechanical plant selections and associated noise control equipment for the tunnel ventilation system have not undergone detailed design or specification, thus there is no specific acoustic emission data from the facilities. Therefore, this EIS chapter proposes to address whether it is feasible for the ventilation systems to meet normally accepted noise emission performance requirements, based on best practice noise control equipment, and if so, what types of noise control measures may be required.

Whilst the design of the mechanical ventilation system is somewhat preliminary, the following summarises the key design factors that relate to noise.

■ **Table 21 Ventilation Design Factors**

Parameter	Western Ventilation Station	Eastern Ventilation Station
Total extracted air flow (m3/s)	600	600
No. of fans (excluding standby)	4	4
Motor size (kW) (per fan)	400	400
Cross sectional area of duct (m2/s)	45	45

The heights of the discharge stacks will be determined based on wind dispersion modelling, which will be undertaken during the detailed design phase of the works. However, for the purposed of this assessment, a height of 30 m has been adopted.

Receptor Locations

Western Ventilation Outlet

The nearest residential receptors to the western ventilation station location are located in Elizabeth Street, Wool Street and Cross Street on the far side of the Western Freeway.

Eastern Ventilation Outlet

The eastern ventilation station is located in the southern section of the Victoria Park Golf Course.

The nearest residential receptors to this site are located in Victoria Park Road. The nearest sensitive (educational) receptor is QUT.

Target Emission Levels

The nearest assessment locations and design criteria are presented in **Table 2323**.

■ **Table 23 Assessment Locations and Design Criteria for Ventilation Stations**

Portal	Nearest Assessment Point	Representative Noise Monitoring Location	Existing Night-time Background Noise Level (dBA)	Design Criteria (dBA - L90)
Western Portal	Elizabeth St/Cross St	115 Elizabeth St	34	34
Eastern Portal	Victoria Park Rd	43 Normanby Tce	39	39
	QUT	QUT	47 [1]	47

Note 1: Existing daytime level for QUT as night-time level is not applicable.

Noise Level Predictions and Assessment

Calculations of indicative ventilation outlet noise have been carried out for the nearest known residential areas in each of the three portal areas. These calculations include the effect of a 3 m long industrial silencer on the intake and discharge sides of ventilation fans.

Predictions show that no further noise control measures are required to achieve the required noise goals at either ventilation station.

Contents

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
20-1854R3	28/08/2008	Shane Elkin	Shane Elkin	28/08/2008	Final
20-1854R3R1	19/09/2008	Shane Elkin	Shane Elkin	18/09/2008	Final

Distribution of copies

Revision	Copy no	Quantity	Issued to
Rev 0	1	1	CW SKM JV
Rev 1	1	1	CW SKM JV

Printed:	8 October 2008
Last saved:	8 October 2008 12:40 PM
File name:	20-1854R3
Author:	Jennifer Uhr
Project manager:	Shane Elkin
Name of organisation:	Heggies
Name of project:	Northern Link
Name of document:	EIS Noise & Vibration Operational Report
Document version:	Rev 1
Project number:	20-1854

1. Introduction

1.1 Background

Heggies Pty Ltd (Heggies) has been commissioned by the SKM Connell Wagner Joint Venture (JV) to prepare an assessment of the operational noise and vibration aspects of the Northern Link project for inclusion in the Environmental Impact Statement (EIS).

1.2 Terms of Reference

The specific requirements of the Terms of Reference[2] in relation to operational noise and vibration impacts associated with the project are reproduced below.

> ***5.4 Noise and Vibration***
>
> ***5.4.1 Description of Existing Environment***
>
> *The existing noise environment should be assessed by:*
>
> - *reviewing available data from any ambient noise monitoring in the study corridor;*
> - *identifying representative existing, committed and approved sensitive places potentially affected by noise or vibration from the project (which may include receptors beyond the study corridor boundary) and monitoring background noise and vibration for these locations;*
> - *conducting additional baseline noise monitoring at other selected locations; and*
> - *describing existing levels of road traffic noise at representative sensitive places by preparing a 3D noise contour model of noise transmission from the road network in the study corridor boundary for the baseline year, year of opening (2014) and the traffic planning horizon (to 2026).*
>
> ***5.4.3 Potential Impacts and Mitigation Measures – Operational***
>
> *To assess operational impacts, the EIS should:*
>
> - *assess the predicted levels of road traffic noise at representative sensitive places, including areas affected by the project but outside the study corridor, by preparing a 3-D noise contour model of noise transmission from all future and existing road sources that form part of the project, including road sections not subject to upgrading or alteration and critical areas such as portals, new surface roadways and connections, feeder roads impacted by the project and ventilation stations and outlets. This is to be prepared for the year of opening (2014) and the traffic planning horizon (2026);*
> - *assess the potential for operational phase vibration and regenerated noise impacts, particularly with respect to sensitive places;*
> - *analyse significant changes in predictions for traffic noise generation;*
> - *assess and document the noise predictions against relevant guidelines and legislation, particularly in relation to representative sensitive places, potentially affected by the project;*
> - *compare predicted noise levels with planning levels stated in the Environmental Protection (Noise) Policy 1997 and Department of Main Roads 'Road Traffic Noise Management: Code of Practice 2000' and relevant Australian Standards; and*

[2] Queensland Government's Department of State Development and Innovation, *Northern Link Project – Terms of Reference for an Environmental Impact Statement.*

- *develop likely operational noise and vibration management measures for sensitive places. Reference to the EPA's Guideline: "Noise and Vibration from Blasting" should also be made.*

Assessments and monitoring of noise must be conducted in accordance with relevant Environmental Protection Agency guidelines, including the Noise Measurement Manual, Australian Standards and any relevant requirements of the EPP (Noise) and, where relevant, the Department of Main Road's 'Road Traffic Noise Management: Code of Practice 2000'.

1.3 Objectives

The objectives of this report in relation to the project description are to:

- address the acoustical requirements detailed in the project's Terms of Reference in relation to the operational phase of the project;
- evaluate the operational noise and vibration impacts at sensitive locations in terms of planning levels identified in the EPP[Noise] and other Guidelines;
- define noise and vibration criteria by which operational noise and vibration impacts at sensitive locations may be evaluated;
- evaluate the extent of resulting impacts and the scope for the reduction of these impacts through reasonable and feasible mitigation strategies; and
- recommend appropriate mitigation measures.

2. IMPACT ASSESSMENT CRITERIA

2.1 Community Values Relating to Noise and Vibration

The Queensland Environmental Protection (Noise) Policy 1997 defines the values to be protected as the qualities of the acoustic environment that are conducive to:

c. The wellbeing of the community or a part of the community, including its social and economic amenity; or

d. The wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Sleep

A person's ability to sleep is perhaps the most important value that can be impacted by noise and/or vibration. Noise and vibration effects on sleep are generally referred to as sleep disturbance.

Recreation

Recreation is an important aspect of a healthy lifestyle. Recreation may include time spent both indoors and outdoors. In terms of acoustic function, recreation may involve communication with others in verbal conversation or simple enjoyment of an outdoor or indoor soundscape.

Education and Work

The needs of education and work in relation to the acoustic environment relate to the need to be able to communicate effectively either face-to-face or by telephone, and the ability to think or focus on auditory information without undue intrusion from external sources of noise.

Evaluating Impacts

The impact of a project on community values relating to noise and vibration is normally evaluated using statutory regulations and policies which describe acceptable levels of noise and vibration from various sources.

For some types of noise (or vibration) for which specific levels are not listed in statutory regulations or policies, it is common to refer to relevant Australian or internationally recognised standards that define acceptable levels in various human contexts. Such standards can serve an advisory function to regulatory organisations and may be adopted by statutory authorities for the purposes of defining regulatory levels.

2.2 Noise Impact Assessment Goals

In the operational phase of the tunnel, potential noise impacts may be associated with traffic at tunnel portals and connecting ramps, toll plazas, traffic changes on surface roads between and beyond tunnel portals, and noise from tunnel ventilation plant.

Regenerated noise from heavy vehicles, particularly those travelling under buildings in shallow tunnel areas is also a potential operational noise issue if the road surface within the tunnel is not well maintained. For well maintained road surfaces, regenerated noise or vibration from an operational road tunnel is not an issue.

2.2.1 Traffic Noise

Traffic noise criteria applicable to the project are contained in two documents, Queensland's Environmental Protection (Noise) Policy 1997[3] and Road Traffic Noise Management: Code of Practice (Queensland Main Roads, January 2000)[4].

The EPP[Noise] is applicable to all public roads whilst the Code of Practice is only applicable to the State-controlled road network. The sections of road within the study area that are State-controlled are:

- Western Freeway
- Frederick St, Toowong

Unless it is specifically stated, it may be assumed that all traffic noise levels quoted in this report apply to a position one metre in front of the most exposed facade of a noise sensitive building and therefore include the appropriate facade correction.

2.2.1.1 Environmental Protection (Noise) Policy 1997

For noise from activities described as "beneficial assets" (particularly roads, railways and airports), the EPP[Noise] specifies "planning levels" for noise sensitive locations (eg residences, educational and health care facilities) which "may be used as a guide'' when assessing the noise levels from an activity.

The planning levels for a Public Road are:

5. For a State-controlled road - 68 dBA $L_{A10(18hour)}$;
6. For all other public roads - 63 dBA $L_{A10(18hour)}$;
7. 60 dBA, assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10 pm and 6 am (60 dBA $L_{Aeq(1hour)}$); and
8. 80 dBA assessed as a single event maximum sound pressure level (80 dBA L_{Amax}).

3 Referred to within this report as EPP[Noise.
4 Referred to within this report as Code of Practice.

2.2.1.2 Main Roads – Road Traffic Noise Management: Code of Practice

The Main Roads document Road Traffic Noise Management: Code of Practice, provides details for the assessment of road traffic noise for Declared Roads (ie to State-controlled roads). Different criteria and priorities apply dependent on the road type (new or existing access/non-access controlled roads) and to receiver/land usage type (residential, educational and health, or parks and other recreational facilities).

For this project, surface works on the Western Freeway, Mt Coot-tha Road (between Western Freeway and Milton Road only) and Frederick Street associated with the tunnel would be regarded as upgrading of the existing road network.

For existing residential sites along "Upgraded Existing Roads", the Code of Practice noise objective is 68 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

Where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved in the design year (2026), treatments for noise attenuation may be considered outside the road corridor for individual dwellings.

The range of possible dwelling treatments will be determined by the predicted external noise level at the facade(s) of habitable room(s) as follows:

- Where predicted outdoor noise levels do not exceed the criterion level, no treatment of the dwelling will be offered.
- Where predicted outdoor noise levels exceed the criterion level by 1 dBA or greater, but less than 3 dBA, provide mechanical ventilation so that windows can remain closed or partly closed to reduce the noise entering habitable rooms.
- Where predicted outdoor noise levels exceed the criterion level by 3 dBA or greater, but less than 10 dBA, provide air-conditioning and mechanical ventilation so that windows can remain closed to reduce the noise entering habitable rooms.
- Where predicted outdoor noise levels exceed the criterion level by 10 dBA or greater, provide building upgrade treatments if necessary, air-conditioning and mechanical ventilation in order to meet an internal noise level at least 10 dBA below the external noise criterion level.

2.2.2 Educational and Health Buildings

The EPP[Noise] does not make any distinction between residences and educational or healthcare facilities - the 63 dBA $L_{A10(18hour)}$ planning level is applied to all these noise sensitive locations. Consistent with the ToR, guidance for the assessment of educational and health care facilities was sought from Main Roads' Code of Practice, where noise mitigation for an "Upgraded Existing Road" is considered on a case-by-case basis for those properties where the following criteria are exceeded:

- $L_{A10(1hour)}$ noise level is greater than 55 dBA (internal); and
- An increase of at least 3 dBA above the pre-construction level.

The 55 dBA $L_{A10(1hour)}$ noise level (internal) for the worst hour is essentially equivalent to the 63 dBA $L_{A10(18hour)}$ external noise goal nominated in the EPP[Noise] given the below analysis:

1. Main Roads' Code of Practice nominates an internal 55 dBA $L_{A10(1hour)}$ (worst hour) criterion for educational and health care facilities adjacent existing roads.
2. Assuming a 10 dBA facade noise reduction, with windows open, this equates to an external (facade corrected) criterion of 65 dBA $L_{A10(1hour)}$ for the worst or "loudest" hour.
3. It is typically understood (through historical measurement data) that the worst hour of traffic noise is (approximately) 2 to 3 dBA louder than the 18 hour noise level, therefore the equivalent 18 hour noise level is 62 to 63 dBA $L_{A10(18hour)}$.
4. This is potentially up to 1 dBA lower than the 63 dBA $L_{A10(18hour)}$ criterion however a 1 dBA difference in environmental acoustics is considered negligible (given that humans are unable to distinguish changes in noise levels of 2 dBA or less and given the accuracy of environmental noise modelling and measurement) and therefore is justified for this impact assessment.

Therefore, for simplicity, educational and health care facilities have been assessed against the 63 dBA $L_{A10(18hour)}$ external noise goal, as for residences adjacent non-stated controlled roads.

It will be important that during the detailed design phase of this project, specific internal $L_{A10(1hour)}$ (worst hour) noise level predictions be undertaken based on actual building facade noise reductions and internal noise monitoring in the most exposed rooms/spaces used for educational and health care purposes within each facility.

2.2.3 Tunnel Ventilation Plant

The applicable statutory requirement for noise emissions associated with fixed mechanical plant is the Queensland Environmental Protection (Noise) Policy 1997.

The EPP[Noise] nominates qualitative characteristics of the noise environment that are to be protected, but does not specify any numerical limits that are applicable to stationary mechanical plant.

It is generally found that for noise sources which are continuous, like ventilation plant noise, the consideration of 'background creep' will tend to be the controlling issue in the setting of noise goals.

The Brisbane City Council's Noise Impact Assessment Planning Scheme Policy (NIAPSP) aims to control 'background creep' by recommending that "*Outside noise levels must not exceed the levels detailed in the table below*:"

Noise area category Appendix A AS1055.2[a]	Permissable level of exceedance of $L_{A90,T}$ for the appropriate time of day		
	Where there is residential development	Where there is no residential development	Where background levels already exceed stated levels in AS1055.2 (i.e. without the proposed development
R1	by 5dB(A)	N/A	The development's noise contribution must still comply with the stated levels in *AS1055.2*
R2	by 5dB(A)	N/A	
R3	by 0dB(A)	by 10dB(A)	
R4			
R5			
R6			

(a) Refer to Appendix A in AS1055.2 for $L_{A90,T}$ levels for the noise area categories

The traditional license conditions used by the EPA throughout Queensland, which are less stringent than the NIAPSP criteria, are summarised in **Table 1**.

Table 1 Traditional EPA License Requirements for Stationary Plant

Time Period	Level at Receptor Location - $L_{Amax,adj,T}$	
	Residential	Commercial
Day (7 am to 6 pm) Mon to Sat 8 am to 6 pm Sun. & Public Hols.	Background + 5 dBA	Background + 10 dBA
Evening (6 am to 10 pm)	Background + 5 dBA	Background + 10 dBA
Night (10 pm to 7 am/8 am)	Background + 3 dBA	Background + 8 dBA

Noise from large ventilation fans can be tonal. It is common practice in Queensland (as evidenced by the abbreviated adjustment term "adj" in the above EPA conditions) and throughout Australia to penalise noise emissions containing "detectable" tonal characteristics (eg whine, hiss, screech, hum etc). Adjustments consistent with the corrections for tonality described in Clause 6.6 of AS1055.1 *Acoustics - Description and measurement of environmental noise Part 1: General procedures* (1997) should be applied.

The NIAPSP requirements for the avoidance of 'background creep' are recommended for use on this project on the basis that these limits avoid significant perceptible noise impacts and are consistent with traditional EPA licensing practice. The AS1055 corrections for tonality and impulsiveness will be applied, where necessary.

2.2.4 Regenerated Noise

Vibration generated by heavy vehicles on a poorly maintained roadway can sometimes be heard in nearby buildings as a low frequency "rumbling" sound. The potential for this to occur may be enhanced where the tunnel is situated directly beneath a building. However, for well maintained roadways, regenerated noise is not an issue.

The "satisfactory" noise levels listed in AS/NZS 2107 are recommended as guidance for the purpose of assessing regenerated noise levels within buildings during the operational phase of the project. An extract from AS/NZ 2107, for some common areas is presented in **Table 2**.

Table 2 Selection of Design Noise Levels from AS/NZS 2107:2000

Type of Building Occupancy	**Maximum Design Level $L_{Aeq(60second)}$ (dBA)**
Residential buildings (sleeping areas)	40 (near major roads) or 35 (near minor roads)
Residential buildings (living areas)	45 (near major roads) or 40 (near minor roads)
Place of Worship	40 (with speech amplification)
School music rooms	45
School teaching area	45
School library	50
School Gymnasium	55
Commercial buildings – office space	45
Commercial Buildings – retail space	50

3. Identification of Noise Sensitive Buildings

Apart from the residential dwellings that are in the vicinity of the Northern Link connections and route alignment, there is a number of other noise/vibration sensitive locations that have been identified which have been considered in this report when assessing the potential for impacts arising from airborne or regenerated noise and vibration.

Relevant properties have been identified from a variety of sources including the social infrastructure study plans, general project information, site visits and a review of the latest UBD.

Table 3 lists the noise and/or vibration sensitive properties identified within the Northern Link project area. It is noted that some properties have been included, even though they may be considered to be some distance from the actual works.

Table 3 Special Noise/Vibration Sensitive Properties

Type	Facility	Location
Aged Care	The Rosalie Nursing Care Centre	18 Howard Street, Rosalie
	Hilltop Gardens Aged Care	23 Rochester terrace, Normanby
Child care	C&K Rosalie Community Kindergarten and Preschool	cnr Nash & Elizabeth Street, Rosalie
Place of Worship	Toowong Baptist Church	5 Jephson Street, Toowong
	Brisbane New Church	21 Agars Street, Rosalie
	St Brigid's Roman Catholic Church	78 Musgrave Road, Red Hill
	Toowong State School	St Osyth Street, Toowong
	Bible College of Queensland	1 Cross Street, Toowong
	Milton State School	Bayswater Road, Milton
Education	Marist College Rosalie	58 Fernberg Road, Paddington
	Petrie Terrace State School	Moreton Street, Paddington
	Queensland University of Technology (including Institute of Biomedical Innovation, Film and TV studio and proposed recording studio)	Kelvin Grove Campus
	Brisbane Grammar School	Gregory Terrace, Spring Hill
	Brisbane Girls Grammar School	Gregory Terrace, Spring Hill
	St Joseph's College	285 Gregory Terrace, Spring Hill
Heritage	Toowong Cemetery	Mt Coot-tha Road, Toowong
	Brisbane Botanic Gardens	Mt Coot-tha Road, Toowong
Commercial	Red Cross	Kelvin Grove Urban Village
	LaBoite Theatre	Kelvin Grove Urban Village

Other places not specifically identified, such as community facilities, would be treated in the same manner as the surrounding residential properties.

4. Existing Noise and Vibration Environment

4.1 Introduction

A record of existing noise levels provides a baseline for assessment of potential noise emissions associated with construction and operational phases of the tunnel.

The aspects of the tunnel infrastructure that are of particular interest in respect of the existing noise environment are those areas in the vicinity of:-

- Construction sites,
- Ventilation Outlets, and
- Tunnel portals and associated connections.

The existing noise environment will be utilised to assist in the development of criteria for the assessment of noise impacts associated with the project, and be used to determine the reasonableness of providing noise control measures, where the base noise objectives are exceeded.

Existing ambient vibration levels at residences and other sensitive buildings are not normally significant. On maintained roads, ambient vibration levels on building foundations are generally below or near the minimum measurement threshold of regular vibration measurement instrumentation, and below the threshold of perception. A limited amount of ambient vibration measurements were conducted to verify the validity of this generalisation on this project.

The Terms of Reference required the existing noise levels to be described from available ambient noise records and additional noise measurements specifically targeted at assessing the noise environment around surface development associated with the project. In this regard available ambient noise records were found to be too site specific to relate to areas surrounding proposed surface developments. For this reason noise monitoring has been conducted at locations specific to surface developments associated with the project.

Information about the existing noise environment has been obtained from the following sources:-

- Site inspection during peak traffic periods and during quiet late-night periods;
- Unattended continuous measurement of sound pressure levels at eleven locations over a 7 day period.

4.2 Noise Descriptors

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound. Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The noise level descriptors that have been utilised within this report are illustrated in **Figure 1** and described below.

L_{Amax} The maximum A-weighted noise level associated with a noise sampling period.

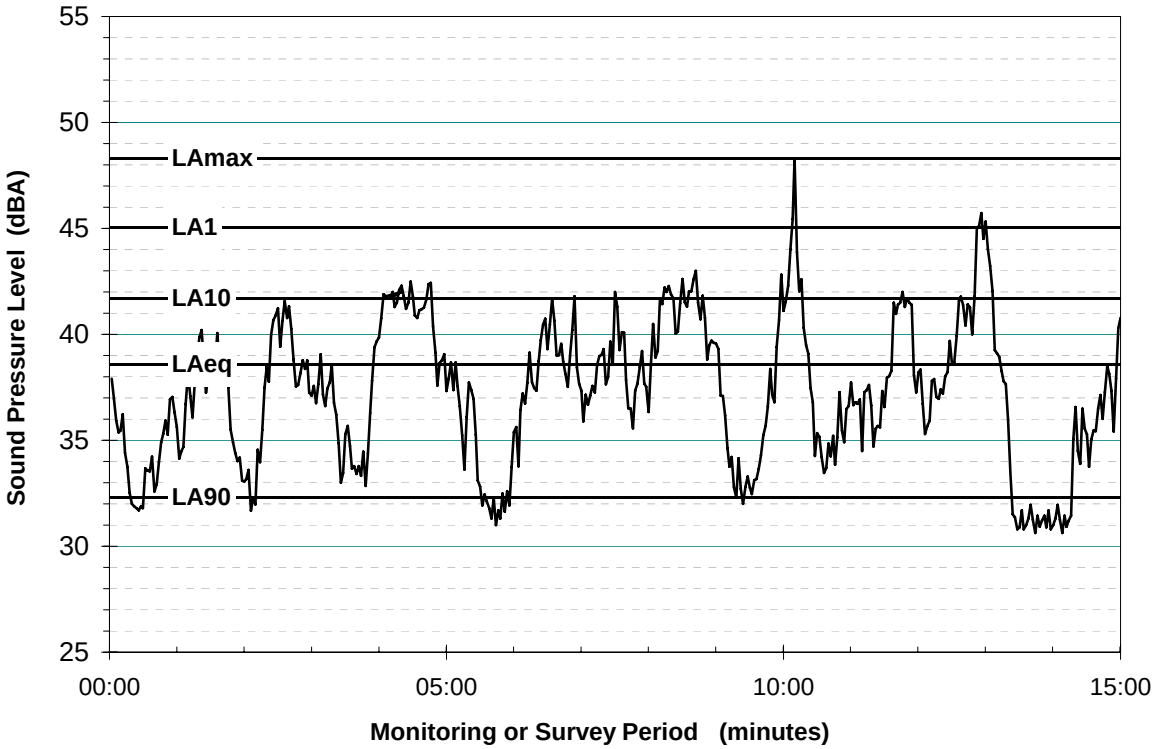
L_{A1} The noise level exceeded for 1% of a given measurement period. This parameter is often used to represent the typical maximum noise level in a given period.

L_{A10} The A-weighted sound pressure level exceeded 10% of a given measurement period and is utilised normally to characterise average maximum noise levels.

L_{Aeq} The average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement period.

L_{A90} The A-weighted sound pressure level exceeded 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the “background” level.

Figure 1 Graphical Display of Typical Noise Indices



When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given location for a particular time of day. A standardised method is available for determining these representative levels. This method produces a level representing the "repeatable minimum" background (LA90) noise level over the relevant daytime, evening and night-time periods, and is referred to as the Rating Background Level (RBL).

Table 4 presents examples of typical noise levels together with a subjective evaluation of the loudness.

Table 4 Typical Noise Levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130 120 110	Threshold of pain Heavy rock concert Grinding on steel	Intolerable Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerb side of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to Quiet
40 30	Inside private office Inside bedroom	Quiet to Very quiet
20	Unoccupied recording studio	Almost silent

The overall level of a sound is usually expressed in terms of dBA, which is measured using the "A-weighting" filter incorporated in sound level meters. These filters have a frequency response corresponding approximately to that of human hearing. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz) and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally as loud, although the perceived loudness can also be affected by the character of the sound (eg the loudness of human speech and a distant motorbike may be perceived differently, although they are of the same dBA level).

A change of up to 3 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

4.3 Noise Monitoring Sites

Noise monitoring sites have been selected to be representative of catchments that may be potentially affected by the Northern Link project. Site selection was focused mainly on residential receivers as they are generally the most noise-sensitive type of development in areas that may be affected by the tunnel.

Only the general location of tunnel portals, construction sites and vent stacks were known at the time of the initial noise logging program conducted during November 2007. Noise logging sites were therefore selected where the existing noise environment would be similar to that of the most exposed residential areas to the indicative locations of these tunnel features.

Development of the Northern Link reference design resulted in the need for two additional noise monitoring sites (Locations 13 and 14) which was completed in May 2008.

The details of the selected noise monitoring sites, and their relevance to potential tunnel noise issues is summarised in **Table 5**.

Figure 2 and **Figure 3** illustrate the noise monitoring locations for the Northern Link project. Photographs showing the noise logger position of each monitoring site are presented in **Appendix A**.

Table 5 Noise Monitoring Locations

Location Number	Monitoring Location	Relevance to Tunnel Noise Issues	Figure Reference
1	22 Crag Road, Taringa	Operational (surface traffic)	Figure 2 and Appendix A
2	115 Elizabeth Street, Toowong	Construction and operational (surface traffic and/or ventilation station) impacts associated with the western portal	Figure 2 and Appendix A
3	6 Wool Street, Toowong	Operational (ventilation station) impacts associated with western portal	Figure 2 and Appendix A
4	128 Sylvan Road, Toowong	Operational impacts associated with Frederick Street portal	Figure 2 and Appendix A
5	29 Valentine Street, Toowong	Construction and operational (surface traffic) impacts associated with Frederick Street portal	Figure 2 and Appendix A
6	69 Frederick Street, Toowong	Construction and operational (road traffic) impacts associated with Frederick Street portal	Figure 2 and Appendix A
7	9 Victoria Crescent, Toowong	Construction and operational (road traffic) impacts associated with Frederick Street portal	Figure 2 and Appendix A
8	5 Clyde Street, Brisbane City	Operational impacts associated with the eastern portals	Figure 3 and Appendix A
9	26 Lower Clifton Terrace, Red Hill	Construction and operational (road traffic and ventilation station) impacts associated with the eastern portals	Figure 3 and Appendix A
10	7 Westbury Street, Red Hill	Construction and operational (surface traffic) impacts associated with the Kelvin Grove portal	Figure 3 and Appendix A
11	Inner Northern Busway (INB), Normanby Station	Construction and operational (surface traffic) impacts associated with the Inner City Bypass (ICB) portal	Figure 3 and Appendix A
12	43 Normanby Terrace, Kelvin Grove	Construction and operational (surface traffic) impacts associated with the ICB portal	Figure 3 and Appendix A
13	9 Horrocks Street, Toowong	Construction and operational (surface traffic) impacts associated with the western portal	Figure 2 and Appendix A
14	QUT, Kelvin Grove Campus	Operational (ventilation station) impacts associated with the eastern portal	Figure 3 and Appendix A

- **Figure 2 Monitoring Locations surrounding Western Portals**

- **Figure 3 Monitoring Locations surrounding Eastern Portals**

4.4 Noise Measurement Methodology

Noise monitoring was conducted generally in accordance with Australian Standard AS1055-1997 *Acoustics – Description and Measurement of Environmental Noise* and the Queensland Environmental Protection Agency's *Noise Measurement Manual* 2000.

A measurement interval of 15 minutes has been utilised for both attended and unattended noise monitoring. For the unattended noise monitoring, the prevailing noise environment was measured in consecutive 15 minute periods for a total survey period of 7 days in accordance with the definition of 'long-term background' levels contained in the EPP[Noise].

4.5 Instrumentation

The instrumentation that was used for the noise monitoring is listed in **Table 6**. The calibration of all instruments was checked before and after monitoring and the difference in noise level was within 1 dBA in all instances.

All instruments were programmed to continuously record A-weighted fast response noise levels over 15 minute sampling intervals.

Table 6 Noise Monitoring Instrumentation

Measurement Location	Instrumentation
All locations	Calibrator, Bruel &Kjaer Type 4231, S/N 2022772
1	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-529
2	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-299-426
3	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-506
4	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-508
5	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-509
6	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-508
7	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-299-426
8	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-301-471
9	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-525
10	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-524
11	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-529
12	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-525
13	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-505
14	Acoustic Research Laboratories Environmental Noise Logger EL316, SN 16-203-508

The limitation as to how low a noise level that can be measured is governed by the combined microphone and electronic noise floor specification. For the instruments utilised, the noise floor is shown below and is well removed from the prevailing noise levels:

- ARL 215 26 dBA
- ARL 315/316 22 dBA

- Rion NA27 15 dBA
- Larson Davis 26 dBA

4.6 Results

4.6.1 Noise

The noise environment in the study corridor is typical of many inner urban areas, in that it is largely determined by road traffic noise. However, at some locations rail noise and/or mechanical plant noise are other significant sources.

Monitoring sites were inspected during morning or afternoon peak traffic times, the evening period and also during the late night/early morning period when background noise is typically quietest. The dominant audible sounds at each location are summarised in **Table 7**. As can be seen in **Table 7,** traffic noise from nearby major roadways was a dominant source of noise at all times of the day.

Table 7 Description of Existing Noise Sources

Location Number	Monitoring Location	Dominant Daytime & Evening Noise Sources	Dominant Noise Sources Late at Night
1	22 Crag Road, Taringa	Western Freeway traffic	Western Freeway traffic
2	115 Elizabeth Street, Toowong	Western Freeway traffic	Western Freeway traffic
3	6 Wool Street, Toowong	Western Freeway road traffic and mechanical plant and equipment noise from bus depot	Western Freeway and occasional Miskin Street traffic
4	128 Sylvan Road, Toowong	Milton Road and Sylvan Road traffic	Milton Road and Sylvan Road traffic
5	29 Valentine Street, Toowong	Milton Road and Frederick Street traffic	Milton Road and Frederick Street traffic
6	69 Frederick Street, Toowong	Frederick Street traffic and transformer noise	Frederick Street traffic and transformer noise
7	9 Victoria Crescent, Toowong	Frederick Street traffic	Frederick Street traffic and transformer noise
8	5 Clyde Street, Brisbane City	Musgrave Road and Hale Street traffic	Musgrave Road and Hale Street traffic
9	26 Lower Clifton Terrace, Red Hill	Kelvin Grove Rd and ICB traffic	Kelvin Grove Rd and ICB traffic
10	7 Westbury Street, Red Hill	Kelvin Grove Rd traffic	Kelvin Grove Rd traffic
11	Inner Northern Busway (INB), Normanby Station	Ithaca Street, ICB and INB road traffic and rail traffic (including freight)	Ithaca Street and ICB road traffic and rail traffic (including freight)
12	43 Normanby Terrace, Kelvin Grove	ICB road traffic and rail traffic (including freight)	ICB road traffic and rail traffic (including freight)
13	9 Horrocks Street, Toowong	Mt Coot-tha Rd and Western Freeway traffic	Western Freeway traffic
14	QUT, Kelvin Grove Campus	Victoria Park Road and ICB traffic	ICB traffic

Results of the noise logger measurements, in the form of a Rating Background Level (refer to **Section 4.2** for a definition of Rating Background Level), are summarised in **Table 8** and provided in detail (including the prevailing weather conditions) in **Appendix B**.

The results in **Table 8** exclude noise monitoring results obtained during periods of high wind speeds (greater than 5 m/s) as recommended in AS 1055.1 and/or rain periods greater than 0.5 mm per 15 minute interval.

The operator-attended noise measurements are summarised in **Table 9**.

Table 8 Summary of (Unattended) Noise Logging Results

Locations		Description	Rating Background Levels minL_{A90} (dBA)		
			Day 7am – 6pm	Evening 6pm – 10pm	Night 10pm – 7am
1	22 Crag Road, Taringa	Front yard of detached single storey dwelling, facing Western Freeway	48	46	39
2	115 Elizabeth Street, Toowong	High side of front yard of detached highset dwelling, Toowong	46	41	34
3	6 Wool Street, Toowong	Front yard of single-storey detached dwelling, Toowong	47	41	37
4	128 Sylvan Road, Toowong	Front yard of block of units	49	44	35
5	29 Valentine Street, Toowong	Front yard (facing towards Milton Road) of detached highset dwelling	53	50	43
6	69 Frederick Street, Toowong	Front verandah of highset detached dwelling	61	48	35
7	9 Victoria Crescent, Toowong	Front yard of detached double-storey dwelling	48	43	35
8	5 Clyde Street, Brisbane City	Front patio of detached single-storey dwelling	54	51	43
9	26 Lower Clifton Terrace, Red Hill	Front yard of detached double-storey dwelling	58	56	45
10	7 Westbury Street, Red Hill	Front yard of detached single-storey dwelling	49	44	34
11	Inner Northern Busway (INB), Normanby Station	Located on parcel of Translink land between Ithaca St and INB east of Normanby Busway Station	56	51	40
12	43 Normanby Terrace, Kelvin Grove	Rear yard (overlooking ICB) of detached highset dwelling	53	52	39
13	9 Horrocks Street, Toowong	Low side yard of highset dwelling	51	48	37
14	QUT, Kelvin Grove Campus	Along south end of block Y1	47	45	43

Table 9 Summary of Operator-Attended (Short-term) Noise Measurements

Measurement Location	Date - Time	Period	L_{A10} (dBA)	L_{Aeq} (dBA)	L_{A90} (dBA)	Discernible Sources
1 – 22 Crag Road	Day	14/11/07 8:42	65	61	50	Traffic on Western Freeway and Crag Road
	Evening	14/11/07 20:15	55	55	49	Traffic on Western Freeway and Crag Road
	Night	15/11/07 1:00	50	49	39	Traffic on Western Freeway and Crag Road
2 – 115 Elizabeth Street	Day	14/11/07 9:04	49	51	43	Traffic on Western Freeway
	Evening	14/11/07 20:42	45	43	40	Traffic on Western Freeway
	Night	15/11/07 1:23	44	41	34	Traffic on Western Freeway
3 – 6 Wool Street	Day	14/11/07 9:27	57	56	46	Western Freeway road traffic and mechanical plant and equipment noise from bus depot
	Evening	14/11/07 21:04	54	52	49	Western Freeway and Miskin Street road traffic (resulting in higher background noise than during the daytime)
	Night	15/11/07 1:43	47	45	41	Western Freeway and Miskin Street road traffic
4 – 128 Sylvan Road	Day	14/11/07 9:48	67	64	51	Milton Road and Sylvan Road traffic
	Evening	14/11/07 19:53	66	61	48	Milton Road and Sylvan Road traffic
	Night	15/11/07 00:38	56	54	39	Milton Road and Sylvan Road traffic
5 – 29 Valentine Street	Day	14/11/07 8:12	59	57	54	Milton Road and Frederick Street traffic
	Evening	14/11/07 19:33	57	55	50	Milton Road and Frederick Street traffic
	Night	15/11/07 00:17	56	52	44	Milton Road and Frederick Street traffic
6 – 69 Frederick Street	Day	22/11/07 10:11	70	67	59	Frederick Street traffic and transformer noise
	Evening	26/11/07 20:54	64	59	42	Frederick Street traffic and transformer noise
	Night	27/11/07 00:31	60	57	39	Frederick Street traffic and transformer noise
7 – 9 Victoria Crescent	Day	22/11/07 9:53	58	55	48	Frederick Street traffic
	Evening	26/11/07 20:34	54	51	42	Frederick Street traffic and transformer noise
	Night	27/11/07 00:47	40	41	33	Frederick Street traffic and transformer noise
8 – 5 Clyde Street	Day	14/11/07 11:17	64	61	56	Musgrave Road and Hale Street traffic
	Evening	14/11/07 19:00	64	62	59	High volumes of traffic on Musgrave Road and Hale Street
	Night	15/11/07 2:09	56	53	41	Musgrave Road and Hale Street traffic

Measurement Location	Date - Time	Period	L_{A10} (dBA)	L_{Aeq} (dBA)	L_{A90} (dBA)	Discernible Sources
9 – 26 Lower Clifton Terrace	Day	14/11/07 10:32	63	60	54	Kelvin Grove Road and ICB road traffic
	Evening	14/11/07 18:14	64	62	57	High traffic volumes on Kelvin Grove Road (predominantly northbound) and ICB
	Night	15/11/07 2:28	54	51	40	Kelvin Grove Road and ICB road traffic
10 – 7 Westbury Street	Day	14/11/07 10:51	66	63	52	Kelvin Grove Road traffic
	Evening	14/11/07 18:34	61	58	50	Kelvin Grove Road traffic and noise from residents
	Night	15/11/07 2:45	53	50	40	Kelvin Grove Road traffic
11 – Normanby Station (INB)	Day	22/11/07 9:10	67	69	62	Ithaca Street, ICB and INB road traffic and rail traffic (including freight)
	Evening	26/11/07 19:56	67	65	62	Ithaca Street, ICB and INB road traffic and rail traffic (including freight)
	Night	27/11/07 1:28	61	59	37	ICB and Ithaca Street traffic
12 – 43 Normanby Terrace	Day	22/11/07 8:45	65	63	60	ICB road traffic and rail traffic (including freight)
	Evening	26/11/07 19:33	60	58	53	ICB road traffic and rail traffic (including freight)
	Night	27/11/07 1:11	56	52	38	ICB road traffic
13 – 9 Horrocks Street	Day	7/05/08 8:58	59	56	51	Mt Coot-tha Road and Western Freeway road traffic
	Evening	6/05/08 19:52	59	56	51	Mt Coot-tha Road and Western Freeway traffic
	Night	7/05/08 1:43	49	45	34	Western Freeway traffic
14 – QUT Kelvin Grove Campus	Day	7/05/08 8:13	57	55	51	Victoria Park Road and ICB traffic
	Evening	6/05/08 19:21	52	50	47	Victoria Park Road and ICB traffic
	Night	N/A	N/A	N/A	N/A	N/A

4.6.2 Analysis of Baseline Noise Levels

The existing noise levels at the reference locations have been examined in relation to the EPP[Noise] planning levels for road traffic noise. This assessment is summarised in **Table 10** for the $L_{A10(18hour)}$ planning levels of 68 dBA for State-controlled roads and 63 dBA for other roads. The planning levels for this parameter can be understood as providing a control on the average maximum level of traffic noise during the day-evening period.

It can be seen in **Table 11** that the maximum night-time $L_{Aeq(1hour)}$ planning level of 60 dBA is exceeded on those properties fronting major roadways. The monitoring positions were selected to represent those properties on the major transport corridors and those set back in the quieter areas, so that construction impacts could be assessed

The analysis in **Table 12** compares the average maximum night-time L_{Amax} values with the 80 dBA L_{Amax} planning level. This planning level can be understood as an attempt to limit the sleep disturbance effects of single-vehicle drive-by events at night.

As roads are regarded under the EPP[Noise] as Beneficial Assets, the Planning Noise Levels for road traffic noise represent a compromise between the need for protection of the public utility of roadways, and the need for protection of the acoustic environment of people in residential places.

Table 10 Analysis of Baseline $L_{A10(18hour)}$ Noise Levels

Ref	Location Description	Assessment of Average Day Evening Traffic Noise $L_{A10(18hour)}$ (dBA)		
		Measured	Planning Level	Excess
1	22 Crag Road, Taringa	59	68	-
2	115 Elizabeth Street, Toowong	52	68	-
3	6 Wool Street, Toowong	55	63	-
4	128 Sylvan Road, Toowong	66	63	**3**
5	29 Valentine Street, Toowong	59	63	-
6	69 Frederick Street, Toowong	73	68	**5**
7	9 Victoria Crescent, Toowong	55	68	-
8	5 Clyde Street, Brisbane City	61	63	-
9	26 Lower Clifton Terrace, Red Hill	66	63	**3**
10	7 Westbury Street, Red Hill	62	63	-
11	Inner Northern Busway (INB), Normanby Station	66	63	**3**
12	43 Normanby Terrace, Kelvin Grove	58	63	-
13	9 Horrocks Street, Toowong	58	63	-
14	QUT, Kelvin Grove Campus	54	63	-

Table 11 Analysis of Night-time Equivalent Average Noise Levels

Ref	Location Description	Assessment of Maximum $L_{Aeq,1hour}$ (dBA) between 10 pm and 6 am		
		Measured	Planning Level	Excess
1	22 Crag Road, Taringa	54	60	-
2	115 Elizabeth Street, Toowong	51	60	-
3	6 Wool Street, Toowong	50	60	-
4	128 Sylvan Road, Toowong	60	60	-
5	29 Valentine Street, Toowong	58	60	-
6	69 Frederick Street, Toowong	70	60	**10**
7	9 Victoria Crescent, Toowong	55	60	-
8	5 Clyde Street, Brisbane City	57	60	-
9	26 Lower Clifton Terrace, Red Hill	63	60	**3**
10	7 Westbury Street, Red Hill	58	60	-
11	Inner Northern Busway (INB), Normanby Station	62	60	**2**
12	43 Normanby Terrace, Kelvin Grove	57	60	-
13	9 Horrocks Street, Toowong	55	60	-
14	QUT, Kelvin Grove Campus	53	60	-

Table 12 Analysis of Baseline Maximum Levels

Ref	Description	Average Levels + (standard deviation) $L_{Amax,15min}$ (dBA)			Planning Level L_{Amax} (dBA)
		Day 6 am – 6 pm	Evening 6 pm – 10 pm	Night 10 pm – 6 am	
1	22 Crag Road, Taringa	74 (4.7)	72 (4.5)	65 (7.3)	80 dBA
2	115 Elizabeth Street, Toowong	67 (4.7)	61 (4.5)	59 (6.2)	80 dBA
3	6 Wool Street, Toowong	70 (5.9)	67 (5.3)	60 (8.1)	80 dBA
4	128 Sylvan Road, Toowong	79 (3.8)	77 (3.1)	74 (3.4)	80 dBA
5	29 Valentine Street, Toowong	72 (4.6)	70 (4.2)	68 (5.1)	80 dBA
6	69 Frederick Street, Toowong	**85** (3.4)	**81** (2.9)	79 (3.5)	80 dBA
7	9 Victoria Crescent, Toowong	71 (5.1)	65 (5.1)	61 (7.7)	80 dBA
8	5 Clyde Street, Brisbane City	75 (4.6)	76 (6.6)	69 (5.5)	80 dBA
9	26 Lower Clifton Terrace, Red Hill	80 (6.3)	75 (4.1)	71 (4.9)	80 dBA
10	7 Westbury Street, Red Hill	72 (4.3)	70 (4.8)	67 (5.0)	80 dBA
11	Inner Northern Busway (INB), Normanby Station	78 (3.3)	77 (3.3)	75 (3.8)	80 dBA
12	43 Normanby Terrace, Kelvin Grove	69 (4.3)	66 (4.3)	63 (5.1)	80 dBA
13	9 Horrocks Street, Toowong	71 (4.3)	68 (3.6)	63 (4.2)	80 dBA
14	QUT, Kelvin Grove Campus	68 (4.9)	63 (4.6)	61 (3.6)	80 dBA

Note: Bold numbers indicate an exceedance of the 80 dBA L_{Amax} planning level.

It can be inferred from **Table 12** and an inspection of the ambient noise monitoring records in **Appendix B** that from time to time, most of the residential location fronting any major roadway experiences maximum pass-by noise events in excess of 80 dBA LAmax. It is therefore concluded that this is not a very useful impact assessment parameter as it does not appear to be achievable in practice even at relatively quiet measurement locations.

4.6.3 Vibration Measurements

In any premises, day-to-day activities (eg, footfalls, closing of doors, etc) will cause levels of vibration in floors and walls that exceed 1 mm/s (sometimes by quite considerable margins), and therefore visible movement and rattling are often observed. In most instances however, such movement is considered normal, and vibration levels of even much greater magnitude do not result in damage to the objects or building contents.

Vibration measurements were carried out at various locations to determine existing vibration levels prior to the start of construction using an Instantel Minimate Vibration Logger (Minimate S/N BE12563, geophone S/N BQ7806). All measurements were taken directly on the ground in the vicinity of the chosen receiver locations. The summarised results of the vibration measurements are documented in **Table 13**.

Table 13 Summarised Vibration Measurements

Monitoring Location	Date - Time	Peak Component Particle Velocity (mm/s)	Dominant Frequency (Hz)
1 – Normanby Terrace (behind #43 near cycle path)	29/11/07 – 8:36	0.03	<1.0
2 – Normanby Terrace (along #9)	29/11/07 – 9:07	0.04	<1.0
3 – Normanby Busway Station	29/11/07 – 9:31	0.09	1.2
4 – Kelvin Grove Rd side of 25 Musgrave Rd	29/11/07 – 9:58	0.26	20
5 – Along 25 Upper Clifton Tce	29/11/07 – 10:31	0.09	<1.0
6 – Westbury St Kelvin Grove Rd intersection	29/11/07 – 10:56	0.11	N/A
7 – Toowong Cemetery (south-west corner)	29/11/07 – 11:48	0.05	<1.0
8 – Thorpe St Frederick St intersection	29/11/07 – 12:31	0.07	N/A
9 – In front of 5 Thorpe St	29/11/07 – 12:53	0.02	<1.0

These measurements show that at the majority of the monitoring locations the existing vibration levels are below the threshold level of human perception (~ 0.15 mm/s). The exception was at Location 4 where heavy vehicles travelling northbound along Kelvin Grove Road (down the hill from Musgrave Road) were generating vibration levels in excess of 0.2 mm/s (peak 0.26 mm/s) due to deformities in the pavement surface.

Existing vibration levels at the nearest corner of the Toowong Cemetery to the Western Freeway tunnel portal were at or below 0.05 mm/s.

Should the study reveal highly sensitive scientific instrumentation in any buildings in the vicinity of the works, additional baseline measurements would fall within the scope of specialist investigations that would be conducted as part of an *Environmental Management Plan*, at the conclusion of the EIS.

5. Traffic Noise Predictions and Impact Assessment

5.1 Modelling Methodology

The CoRTN (Calculation of Road Traffic Noise) 1988 traffic noise prediction procedure was utilised within the SoundPLAN noise prediction software to calculate the traffic noise emissions. SoundPLAN is a software package which enables compilation of a computer model comprising a 3-D ground map containing ground contours, the final 3-D road design and building locations, traffic volumes, heavy vehicle composition and speed, road pavement characteristics and noise barriers. CoRTN is a recommended road prediction technique in Main Roads' Code of Practice and has been the primary validated road traffic noise model used in within Australia for many years.

Receivers were placed at 1.5m above the ground for single story properties and 4.5 m above the ground for two story dwellings. For multistorey buildings the receptor(s) were positioned at the most exposed building level.

Noise barriers, where they have been designed, are based on the results of single-point calculations at defined building facade locations.

Treatment of Noise Emissions from Portals

Emissions of traffic noise from portal openings have been modelled as area sources in the vertical plane of the portal opening. The source sound power for this area source and distribution of sound power over the portal area has been modelled as described by S. Olafsen's Inter-Noise 96 paper titled "*Noise from Road Tunnel Openings – An Engineering Approach*". The propagation of the portal noise emissions has been modelled using the Concawe industrial noise model within the SoundPLAN modelling suite. The noise predictions from the portal noise model has then been added logarithmically to the noise predictions for the standard CoRTN traffic noise predictions to generate overall noise levels for the combination of portals and roadways.

Traffic Noise Composition Assumption

Inherent in the modelling methodology is the assumption that the loudness of the vehicle fleet as a whole would remain static over the period to the Year 2026. On higher speed roads, where tyre noise is a large component of overall vehicle noise, this may be a reasonable assumption. However on other roads with sign-posted speeds of around 60 km/hr, the significance of engine and transmission noise is much greater. It can be anticipated that on these roads, engine and transmission noise will reduce to some extent over time as the overall fleet modernises. It is difficult to predict what the reduction would be, other than to say the assumption of static fleet noise emissions is conservative.

5.2 Choice of Assessment Parameter

The EPP[Noise] Planning Levels are expressed in terms of the $L_{A10(18hour)}$, maximum night-time $L_{Aeq(1hour)}$ and the L_{Amax} measurement parameters.

The L_{Amax} measurement parameter has previously been shown to be a poor indicator of the level of noise impact at residential locations, being both difficult to predict and widely exceeded across the range of ambient monitoring locations utilised in this study.

As long term projections of night-time traffic are not available, it is not feasible to directly calculate future traffic noise impacts in terms of the maximum night-time $L_{Aeq(1hour)}$ parameter. However, predictions of the $L_{Aeq(1hour)}$ parameter could be determined based on the typical 3 dBA offset between the typical maximum night-time $L_{Aeq(1hour)}$ and the $L_{A10(18hour)}$ level, observable from traffic noise records at the reference locations. Analysis of the data for this project indicates the average difference between the $L_{A10(18hour)}$ planning level and the maximum night-time $L_{Aeq(1hour)}$ planning level is 3 dBA, meaning that predictions based on the $L_{A10(18hour)}$ index would also be an indication of the $L_{Aeq(1hour)}$ index. A specific assessment of $L_{Aeq(1hour)}$ predictions would therefore only produce redundant information.

The assessment undertaken in this report has therefore been presented in terms of the $L_{A10(18hour)}$ parameter only.

5.3 Model Scenarios

The EPP[Noise] identifies Planning Levels for traffic noise emissions from roadways, but does not specify what actions should be carried out in response to road developments that may result in exceedances of Planning Levels.

Traffic noise predictions have been undertaken for the future predicted levels of road traffic noise with and without the Northern Link project proceeding. The following situations have been modelled in accordance with the ToR:

- **Do minimum (2014)** - The predictions include all future traffic utilising the existing road corridor in the proposed year of opening (ie 2014), excluding the Northern Link project. This scenario represents the future traffic that would have arisen in the absence of this major transport initiative, and represents the baseline noise projections against which some of the other scenarios are compared.
- **With Northern Link (2014)** - Traffic flows including the Northern Link project in the proposed year of opening (ie 2014). This scenario represents the change in traffic noise, attributable directly to the Northern Link project.

- **Do minimum (2026)** - The predictions include all future traffic utilising the existing road corridor in the design year (ie 2026), excluding the Northern Link project. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared.
- **With Northern Link (2026)** - Traffic flows including the Northern Link project in the design year (ie 2026). This scenario represents the change in traffic noise, attributable directly to the Northern Link project. Noise barrier design has been undertaken for this scenario (see **Section 5.5**).

In addition to the modelling scenarios described above, a model was developed to simulate the existing 2007 traffic flows and existing road network for verification of the noise prediction model.

All the traffic data (including the heavy vehicle content) for these scenarios was supplied by the Joint Venture (JV) and is presented in **Appendix C** to **Appendix G** (inclusive).

5.4 Model Verification

Table 14 compares the measured $L_{A10(18hour)}$ noise levels against the predicted noise levels utilising the (existing) 2007 SoundPLAN model. The traffic data used within the model is based on the provided 2007 traffic flows.

No road surface correction has been applied, as all existing road surfaces are dense graded asphalt.

Table 14 Comparison of Measured and Predicted Noise Levels in 2007

Location	Dominant Source of Traffic Noise	$L_{A10(18hour)}$ Noise Level (dBA)		
		Measured	Predicted	Difference
22 Crag Road, Taringa	Western Fwy	59	59	0
115 Elizabeth Street, Toowong	Western Fwy	52	54	+2
6 Wool Street, Toowong	Western Fwy & Miskin St	54	55	+1
128 Sylvan Road, Toowong	Milton Rd & Sylvan Rd	66	67	+1
29 Valentine Street, Toowong	Frederick St	59	61	+2
69 Frederick Street, Toowong	Frederick St	73	75	+2
9 Victoria Crescent, Toowong	Frederick St	55	55	0
5 Clyde Street, Brisbane City	Musgrave Rd & Hale St	61	63	+2
26 Lower Clifton Terrace, Red Hill	Kelvin Grove Rd & ICB	67 [1]	69	+2
7 Westbury Street, Red Hill	Kelvin Grove Rd	62	61	-1
Inner Northern Busway (INB), Normanby Station	ICB & Ithaca St	66	68	+2
43 Normanby Terrace, Kelvin Grove	ICB	59	59	0
9 Horrocks Street, Toowong	Western Fwy & Mt Coot-tha Rd	59	61	+2
QUT, Kelvin Grove Campus	ICB & Victoria Park Rd	55	57	+2

Note 1: Measured value adjusted to compensate for reduced facade effect at time of measurement.

Differences between measured and predicted levels of ± 2 dBA are considered readily acceptable for the purpose of model verification. All the predicted $L_{A10(18hour)}$ noise levels for locations directly adjacent existing roads are within 2 dBA of the measured results therefore the model is considered to be verified.

5.5 Barrier Design

Where required, the heights of roadside barriers have been determined to achieve the appropriate criterion. A cap on the height of any barrier is set to 8 m, due to consideration of "practicality and feasibility" of construction, aesthetics and other urban design issues such as overshadowing.

Two noise barrier designs have been undertaken for the Northern Link scenarios as outlined below.

'Status Quo' Noise Barrier Option

The objective used to develop the 'Status Quo' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels comparable to the "Do Minimum" option.

1

'Planning Level' Noise Barrier Option

The objective used to develop the 'Planning Level' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA (non state-controlled roads) or 68 dBA (state-controlled roads) $L_{A10(18hour)}$ planning levels wherever possible.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the 'planning' traffic noise levels in accordance with the EPP[Noise] and Code of Practice. In many areas this would require noise controls to account for existing exceedances of the planning levels and/or gradual increases in traffic noise over time, neither of which are attributable to the tunnel project itself.

5.6 Modelling Output

Summary tables documenting the report appendices containing the various colour noise contour plots (for all the modelling scenarios outlined in **Section 5**) are presented in **Table 15** and **Table 16**.

The noise contours provide a representation of the noise level in a particular area of interest. They are provided for information only and are generated for a receiver height 4.5 m above ground level. This height best represents the height of two storey residences in the study area. At any particular residence, the appropriate design height used to calculate the recommended noise barriers may be higher or lower than this 'typical' height. The detailed design of barriers is conducted based on the noise levels at particular residences, where the actual properties of the building are used (ie single story on slab, single story (elevated above the ground), double story etc).

Discussions on the impacts and effects of noise mitigation are presented in **Section 5.7**and **Section 5.8** for the Western and Eastern Portal Areas respectively.

Table 15 Summary of Noise Maps for Western Portal Area

Prediction Scenario	No Mitigation Measures	Barrier Design to maintain Status Quo in 2026	Barrier Design to achieve 63/68 dBA $L_{A10(18hour)}$ in 2026
2014			
Do Minimum	Appendix H1	n/a	n/a
With Northern Link	Appendix H2	Appendix H3	Appendix H4
2026			
Do Minimum	Appendix H5	n/a	n/a
With Northern Link	Appendix H6	Appendix H7	Appendix H8

Table 16 Summary of Noise Maps for Eastern Portal Area

Prediction Scenario	No Mitigation Measures	Barrier Design to maintain Status Quo in 2026	Barrier Design to achieve 63 dBA $L_{A10(18hour)}$ in 2026
2014			
Do Minimum	Appendix I1	n/a	n/a
With Northern Link	Appendix I2	Appendix I3	Appendix I4
2026			
Do Minimum	Appendix I5	n/a	n/a
With Northern Link	Appendix I6	Appendix I7	Appendix I8

5.7 Discussion of Results – Western Portal Area

The appropriate planning level for traffic noise in the Western portal area is 68 dBA $L_{A10(18hour)}$ for residences located in the vicinity of the Western Freeway and along Frederick Street or Mt Coot-tha Road (between the Western Freeway and Frederick Street) and 63 dBA $L_{A10(18hour)}$ for all other residential locations. The noise contours produced for this area are detailed in **Appendix H**, and have been generated 4.5 m above ground level. This height is generally representative of residences in the area.

Receptor locations below the planning level of 63 dBA $L_{A10(18hour)}$ are in a green colour band. Receptor locations within the light to darker red colour bands exceed the planning level of 68 dBA $L_{A10(18hour)}$.

5.7.1 2014 "Do Minimum" Results

Appendix H1 presents the noise contours for 2014, assuming no Northern Link Project, which is referred to as the "Do Minimum" option.

South of the Western Freeway and west of Miskin Street - All dwellings in the vicinity of the Western Freeway comply with the 68 dBA goal. Residences along Miskin Street are predicted to experience noise levels of up to 75 dBA which exceeds the 63 dBA criterion for local roads.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to experience noise levels of up to around 76 dBA which exceeds the 68 dBA criterion. Residences located north of Milton Road, but remote from Frederick Street are predicted to experience noise levels of up to 75 dBA which exceeds the 63 dBA criterion.

East of Miskin Street and south of Milton Road – Most dwellings in the vicinity of Milton Road and Sylvan Road are predicted to exceed the 63 dBA criterion by up to 5 dBA.

Along Milton Road and east of Croydon Street – All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion, some by up to 18 dBA.

Along Croydon Street and south of Milton Road - All dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 13 dBA.

5.7.2 2014 "With Northern Link" Results

No Mitigation Measures

Appendix H2 presents the noise contours for 2014, without any mitigation in place, assuming Northern Link has been constructed.

South of the Western Freeway and west of Miskin Street - All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion. Residences along Miskin Street are predicted to experience noise levels of up to 73 dBA which exceeds the 63 dBA criterion for local roads.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to experience noise levels of around 76 dBA which exceeds the 68 dBA criterion. Residences located north of Milton Road, but remote from Frederick Street are predicted to experience noise levels of up to 73 dBA which exceeds the 63 dBA criterion.

East of Miskin Street and south of Milton Road – Most dwellings in the vicinity of Milton Road and Sylvan Road are predicted to exceed the 63 dBA criterion by up to 5 dBA.

Along Milton Road and east of Croydon Street – All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 15 dBA.

Along Croydon Street and south of Milton Road - All dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA.

Based on these findings there is a general reduction in 2014 noise levels with the project of around 2 dBA. There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area that are away from the immediate portal would be expected to receive a benefit from the project.

With Barriers Designed to Achieve 2026 'Status Quo' Noise Levels in 2026

Appendix H3 presents the noise contours for 2014, with the noise barriers designed to maintain the 'Status Quo' in the design year (2026).

South of the Western Freeway and west of Miskin Street - All residences south of the Western Freeway and west of Miskin Street are predicted to comply with the 'Status Quo' noise goal.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to comply with the 'Status Quo' noise goal with the (Y2026) 'Status Quo' noise barriers in place. Residences located north of Milton Road, but remote from Frederick Street are also predicted to comply with the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.

East of Miskin Street and south of Milton Road – All dwellings south of Milton Road (between Miskin Street and Croydon Street) are predicted to comply with the 'Status Quo' noise goals with the 'Status Quo' noise barriers in place.

Along Milton Road and east of Croydon Street – Most dwellings along Milton Road (east of Croydon Street) are predicted to comply with the 'Status Quo' noise goals. However, one (1) residence on the southern side of Milton Road is predicted to exceed the 'Status Quo' noise goal by 3 dBA due to (1) resumptions resulting in increased exposure and (2) traffic lanes moving closer to the property. Noise barriers are not a feasible attenuation treatment for this residence due to property access requirements.

Along Croydon Street and south of Milton Road - Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place by 2 dBA. Two (2) residences on St Osyth Street are predicted to exceed the 'Status Quo' noise goal by up to 2 dBA. No additional noise attenuation is achievable from the noise barriers at these locations due to property access requirements.

With Barriers Designed to Achieve 63/68 dBA $L_{A10(18hour)}$ Planning Level in 2026

Appendix H4 presents the noise contours for 2014, with the noise barriers designed to maintain the planning noise levels in the design year (2026).

South of the Western Freeway and west of Miskin Street - All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion. Residences along Miskin Street are predicted to exceed the 63 dBA criterion by up to 12 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to exceed the 68 dBA criterion by up to 8 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. Residences located north of Milton Road, but remote from Frederick Street, are predicted to exceed the 63 dBA criterion by up to 7 dBA with the 'Planning Level' noise barriers capped at 8 m. All residences in this area achieve the 'Status Quo' noise goal with the designed 'Planning Level' noise barriers.

East of Miskin Street and south of Milton Road – Several dwellings in the vicinity of Milton Road (between Miskin Street and Croydon Street) are predicted to exceed the 63 dBA criterion by up to 4 dBA with the 'Planning Level' noise barriers capped at 8 m. All residences in this area are able to achieve the 'Status Quo' noise goal with the 'Planning Level' noise barriers.

Along Milton Road and east of Croydon Street – All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 15 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All but one (1) of these residences achieve the 'Status Quo' noise goal.

Along Croydon Street and south of Milton Road - Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All residences are within 2 dBA of the 'Status Quo' noise goals with the 'Planning Level' noise barriers in place.

For properties along Frederick Street where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved, property treatments will be required in accordance with Main Roads' Code of Practice.

5.7.3 2026 "Do Minimum" Results

Appendix H5 presents the noise contours for 2026, assuming no Northern Link Project, which is referred to as the "Do Minimum" option.

The "Do Minimum" for 2026 appears to be generally within 1 to 2 dBA of the 2014 "Do Minimum" predictions that are presented in **Appendix H1**. Given the difference between these two scenarios is the natural increase in traffic over 12 years, unrelated to the Northern Link project, it would be expected that the two sets of results are very similar.

5.7.4 2026 "With Northern Link" Results

No Mitigation Measures

Appendix H6 presents the noise contours for 2026, without any mitigation in place, assuming Northern Link has been constructed.

Similar to the "Do Minimum" scenario, the road traffic noise emissions predicted from this scenario are very similar to the results in **Appendix H2**.

Based on these findings there is a general reduction in 2026 noise levels with the project by around 2 dBA. There is a logical suggestion, that as the tunnel removes traffic from the surface roads, that dwellings in this area that are away from the immediate portal would be expected to receive a benefit from the project.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

The noise barriers required to maintain the 'Status Quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix H7**.

South of the Western Freeway and west of Miskin Street - All residences south of the Western Freeway and west of Miskin Street are predicted to comply with the 'Status Quo' noise goal.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to comply with the 'Status Quo' noise goal with the 'Status Quo' noise barriers. Residences located north of Milton Road, but remote from Frederick Street are also predicted to comply with the 'Status Quo' noise goal with the designed 'Status Quo' noise barriers.

East of Miskin Street and south of Milton Road – All dwellings south of Milton Road (between Miskin Street and Croydon Street) are predicted to comply with the 'Status Quo' noise goals with the 'Status Quo' noise barriers.

Along Milton Road and east of Croydon Street – Most dwellings along Milton Road (east of Croydon Street) are predicted to comply with the 'Status Quo' noise goals. However, one (1) residence on the southern side of Milton Road is predicted to exceed the 'Status Quo' noise goal by 3 dBA due to (1) resumptions resulting in increased exposure and (2) traffic lanes moving closer to the property. Noise barriers are not a feasible attenuation treatment for this residence due to property access requirements.

Along Croydon Street and south of Milton Road - Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 'Status Quo' noise goal with the 'Status Quo' noise barriers by 2 dBA. In addition, two (2) residences on St Osyth Street are predicted to exceed the 'Status Quo' noise goal by up to 2 dBA. No additional noise attenuation is achievable from the noise barriers at these locations due to property access requirements.

It should be noted that changes in noise levels of 2dBA or less are generally considered insignificant in acoustic terms.

This design incorporates a total of 823 linear meters or 4,767 m^2 of barrier to maintain the 'Status Quo' at residential properties.

With Barriers Designed to Achieve 63/68 dBA $L_{A10(18hour)}$ Design Objective in 2026

Appendix H8 presents the noise contours for 2026 incorporating the noise barriers required to achieve the relevant 63/68 dBA $L_{A10(18hour)}$ planning level.

South of the Western Freeway and west of Miskin Street - All dwellings in the vicinity of the Western Freeway comply with the 68 dBA criterion. Residences along Miskin Street are predicted to exceed the 63 dBA criterion by up to 10 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

East of Frederick Street and north of Milton Road - The dwellings along Frederick Street are predicted to exceed the 68 dBA criterion by up to 12 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. Residences located north of Milton Road, but remote from Frederick Street, are predicted to exceed the 63 dBA criterion by up to 7 dBA with the designed barriers capped at 8 m. All residences in this area achieve the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.

East of Miskin Street and south of Milton Road – Several dwellings in the vicinity of Milton Road (between Miskin Street and Croydon Street) are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed noise barriers capped at 8 m, and a 3 m (above pavement height) high barrier on the southern side of the north-bound elevated on-ramp. All residences in this area are able to achieve the 'Status Quo' noise goal with the 'Status Quo' noise barriers in place.

Along Milton Road and east of Croydon Street – All dwellings along Milton Road (east of Croydon Street) are predicted to exceed the 63 dBA criterion by up to 16 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements. All but one (1) of these residences are able to achieve the 'Status Quo' noise goal.

Along Croydon Street and south of Milton Road - Most dwellings along Croydon Street (south of Milton Road) are predicted to exceed the 63 dBA criterion by up to 14 dBA. Noise barriers are not a feasible attenuation treatment for these residences due to property access requirements.

This design incorporates a total of 879 linear meters or 6,772 m^2 of barrier to achieve the 63 dBA design target at most residential properties.

For properties along Frederick Street where the 68 dBA $L_{A10(18hour)}$ criterion cannot be achieved with the design noise barriers, property treatments will be required in accordance with Main Roads' Code of Practice.

5.8 Discussion of Results – Eastern Portal Area

The appropriate planning level for traffic noise in the Eastern Portal Area is 63 dBA $L_{A10(18hour)}$ for all residential locations.

The noise contours produced for the Eastern Portal Area, contained in **Appendix I**, have been generated 4.5 m above ground level. This height is generally representative of two-storey residences in the area.

Receptor locations below the planning level of 63 dBA $L_{A10(18hour)}$ are in a green colour band.

5.8.1 2014 "Do Minimum" Results

Appendix I1 presents the noise contours for 2014, assuming no Northern Link Project, which is referred to as the "Do Minimum" option. There are existing roadside noise barriers along the northern side of the ICB. These have been incorporated into the "Do Minimum" model.

West of Kelvin Grove Road and south of the tunnel portal area – The dwellings on the western side of Kelvin Grove Road and south of the tunnel portal area are predicted to experience noise levels up to 72 dBA which exceeds the 63 dBA criterion.

West of Kelvin Grove Road and north of the tunnel portal area – The dwellings in this area are predicted to exceed the 63 dBA criterion by up to13 dBA.

In the vicinity of Normanby Terrace, north of the ICB – The dwellings north of the ICB are predicted to experience noise levels up to 70 dBA, which exceeds the 63 dBA goal.

The proposed child care centre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 78 dBA, which exceeds the 63 dBA goal.

Gregory Terrace – The dwellings along the southern side of Gregory Terrace are predicted to experience noise levels up to 77 dBA for all traffic (including traffic on Gregory Terrace itself) and up to 66 dBA for ICB traffic only. Both of these predictions exceed the 63 dBA noise goal.

School properties along the ICB

- *Brisbane Boys' Grammar School Buildings* - The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 69 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 6 dBA.
- *Brisbane Girls' Grammar School Buildings* - The Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 69 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 6 dBA.
- *Oval south of rail line* - For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA $L_{A10(12hour)}$ planning level for outside education levels. This is considered acceptable.
- *Oval north of ICB* - For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.
- *Brisbane Boys' Grammar School Indoor Sports Complex* - The Brisbane Grammar School Indoor Sports Complex is predicted to experience noise levels of up to 75 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 12 dBA.

5.8.2 2014 "With Northern Link" Results

No Mitigation Measures (2014)

Appendix I2 presents the noise contours for 2014, assuming Northern Link has been constructed, with all retained existing noise barriers in place but without any additional mitigation.

West of Kelvin Grove Road and south of the tunnel portal area – The dwellings on the western side of Kelvin Grove Road and south of the tunnel portal area are predicted to experience noise levels up to 72 dBA. This exceeds the 63 dBA criterion.

West of Kelvin Grove Road and north of the tunnel portal area – The dwellings in this area are predicted to exceed the 63 dBA criterion by up to 14 dBA.

In the vicinity of Normanby Terrace, north of the ICB – The dwellings north of the ICB are predicted to experience noise levels up to 74 dBA, which exceeds the 63 dBA criterion.

The proposed child care centre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 78 dBA, which exceeds the 63 dBA goal.

Gregory Terrace – The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 76 dBA for all traffic (including traffic on Gregory Tce itself) and up to 65 dBA for ICB and Northern Link traffic only. Both of these predictions exceed the 63 dBA noise goal.

School properties along the ICB

- *Brisbane Boys' Grammar School Buildings*- The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 69 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 6 dBA.
- *Brisbane Girls' Grammar School Buildings*- The Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 71 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 8 dBA.
- *Oval south of rail line*- For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA $L_{A10(12hour)}$ planning level for outside education levels. This is considered acceptable.
- *Oval north of ICB*- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.
- *Brisbane Boys' Grammar School Indoor Sports Complex*- The Brisbane Grammar School Indoor Sports Complex is predicted to experience noise levels of 77 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$, which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 14 dBA.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

Appendix I3 presents the noise contours for 2014, with the noise barriers designed to maintain the 'Status Quo' in the design year (2026).

West of Kelvin Grove Road and south of the tunnel portal area - All dwellings in this area are predicted to comply with the 'Status Quo' noise goal with the design noise barriers.

West of Kelvin Grove Road and north of the tunnel portal area - Most dwellings in this area are predicted to comply with the 'Status Quo' noise goal with the design noise barriers. However, one (1) residence on Dalley Street (the nearest eastern property adjacent to Kelvin Grove Road) is predicted to exceed the 'Status Quo' noise goal by 1 dBA with the designed barriers. This is considered an insignificant increase in noise level.

In the vicinity of Normanby Terrace, north of the ICB - All dwellings north of the ICB and the proposed child care centre are predicted to comply with the 'Status Quo' noise goals with the designed barriers.

Gregory Tce - All dwellings along are predicted to comply with the 'Status Quo' noise goals without the need for noise barriers.

School properties along the ICB –

- *Brisbane Boys' Grammar School Buildings* - All Brisbane Boys' Grammar School Buildings are predicted to comply with 'Status Quo' noise goals.
- *Brisbane Girls' Grammar School Buildings* - All Brisbane Girls' Grammar School buildings are predicted to comply with 'Status Quo' noise goals.
- *Oval south of rail line* - The Brisbane Grammar School sports oval south of the rail line is predicted to experience noise levels that comply with the 'Status Quo' noise goals.
- *Oval north of ICB* - The Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway) is predicted to comply with 'Status Quo' noise goals.
- *Brisbane Boys' Grammar School Indoor Sports Complex* - Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to comply with 'Status Quo' noise goals in 2014.

With Barriers Designed to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective in 2026

Appendix I4 presents the noise contours for 2014, with the noise barriers designed to maintain the planning noise levels in the design year (2026).

West of Kelvin Grove Road and south of the tunnel portal area – Several dwellings in this area are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed 8 m noise barriers. All of these residences achieve the 'Status Quo' noise goal with the capped 8 m high barrier.

West of Kelvin Grove Road and north of the tunnel portal area – Most residences in this area are predicted to comply with the 63 dBA criterion with the designed 8 m noise barriers. However, one (1) residence on Kelvin Grove Road and one (1) residence on Dalley Street are predicted to exceed the 63 dBA criterion by up to 10 dBA with the designed barriers. The residence on Kelvin Grove Road is able to achieve the 'Status Quo' noise goal.

In the vicinity of Normanby Terrace, north of the ICB - Several dwellings in this area are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed noise barriers. All of these residences achieve the 'Status Quo' noise goal with the (capped) 8 m high barrier.

The proposed child care cantre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 63 dBA.

Gregory Terrace – The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 76 dBA for all traffic (including traffic on Gregory Tce itself) and up to 60 dBA for ICB and Northern Link traffic only with the designed barriers. Both of these predictions exceed the 63 dBA noise goal. All of these residences are able to achieve the 'Status Quo' noise goal.

School properties along the ICB –

- *Brisbane Boys' Grammar School Buildings* - The Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 66 dBA with a (capped) 8 m high barrier running along the southern edge of the Inner City Bypass. This is above the planning level of 63 dBA $L_{A10(18hour)}$ which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 3 dBA.
- *Brisbane Girls' Grammar School Buildings* - The Brisbane Girls' Grammar School buildings are predicted to comply with the 63 dBA $L_{A10(18hour)}$ noise goal with a (capped) 8 m high barrier.
- *Oval south of rail line* - For the Brisbane Grammar School sports oval south of the rail line, the entire oval is below the 63 dBA $L_{A10(12hour)}$ noise goal with a (capped) 8 m high noise barrier needed for the adjacent classrooms.
- *Oval north of ICB* - For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.
- *Brisbane Boys' Grammar School Indoor Sports Complex* - Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to experience noise levels up to 65 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 2 dBA.

5.8.3 2026 "Do Minimum" Results

Appendix I5 presents the noise contours for 2026, assuming no Northern Link Project, which is referred to as the "Do Minimum" option.

The "Do Minimum" for 2026 appears to be generally within 1 to 2 dBA of the 2014 "Do Minimum" predictions that are presented in **Appendix H1**. Given the difference between these two scenarios is the natural increase in traffic over 12 years, unrelated to the Northern Link project, it would be expected that the two sets of results are very similar.

5.8.4 2026 "With Northern Link" Results

No Mitigation Measures

Appendix I6 presents the noise contours for 2026, assuming Northern Link has been constructed, with all retained existing noise barriers in place but without any additional mitigation.

The predicted levels of road traffic noise emissions from this scenario are very similar to the results of **Appendix I2**, reflecting the close comparison between the 2014 and 2026 traffic flows.

With Barriers Designed to Maintain 2026 'Status Quo' Noise Levels

The noise barriers required to maintain the 'Status Quo' noise levels (ie to have an acoustic environment, no worse off than would have otherwise occurred due to natural network increases) are presented in **Appendix I7**.

West of Kelvin Grove Road and south of the tunnel portal area - All dwellings in this area are predicted to comply with the 'Status Quo' noise goal with the designed noise barriers.

West of Kelvin Grove Road and north of the tunnel portal area - Most dwellings in this area are predicted to comply with the 'Status Quo' noise goal with the design noise barriers. However, one (1) residence on Dalley Street (the worst eastern property adjacent to Kelvin Grove Road) is predicted to exceed the 'Status Quo' noise goal by 1 dBA with the designed barriers.

In the vicinity of Normanby Terrace, north of the ICB - All dwellings north of the ICB and the proposed child care centre are predicted to comply with the 'Status Quo' noise goals with the designed barriers.

Gregory Tce - All dwellings along are predicted to comply with the 'Status Quo' noise goals without the need for noise barriers.

School properties along the ICB –

- *Brisbane Boys' Grammar School Buildings* - Noise levels at the Brisbane Boys' Grammar School Buildings are predicted to comply with 'Status Quo' noise goals.
- *Brisbane Girls' Grammar School Buildings* - Noise levels experienced at the Brisbane Girls' Grammar School buildings are predicted to comply with 'Status Quo' noise goals.
- *Oval south of rail line* - The Brisbane Grammar School sports oval south of the rail line is predicted to experience noise levels that comply with the 'Status Quo' noise goals.
- *Oval north of ICB* - The Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway) is predicted to experience noise levels which comply with the 'Status Quo' noise goals.
- *Brisbane Boys' Grammar School Indoor Sports Complex* - Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to comply with the 'Status Quo' planning levels.

This design incorporates a total of 1,073 linear meters or 4,762 m^2 of barriers to maintain the 'Status Quo' at residential properties.

With Barriers Designed to Achieve 63 dBA $L_{A10(18hour)}$ Design Objective in 2026

Appendix I8 presents the noise contours for 2026, assuming the Northern Link Project is constructed and incorporate the noise barriers required to achieve the 63 dBA $L_{A10(18hour)}$ planning level.

West of Kelvin Grove Road and south of the tunnel portal area – Several dwellings in this area are predicted to exceed the 63 dBA criterion by up to 7 dBA with the designed 8 m noise barriers.

West of Kelvin Grove Road and north of the tunnel portal area – Most residences in this area are predicted to comply with the 63 dBA criterion with the designed 8 m noise barriers. However, one (1) residence on Kelvin Grove Road and one (1) residence on Dalley Street are predicted to exceed the 'Status Quo' noise goal by up to 10 dBA with the designed barriers. The residence on Kelvin Grove Road is able to achieve the 'Status Quo' noise goal.

In the vicinity of Normanby Terrace, north of the ICB - Several dwellings in this area are predicted to exceed the 63 dBA criterion by up to 4 dBA with the designed 8 m high noise barriers. All of these residences are able to achieve the 'Status Quo' noise goal.

The proposed child care centre on Lot 5 of the Kelvin Grove Urban Village is predicted to experience a noise level of 64 dBA, which exceeds the 63 dBA goal by a marginal 1 dBA.

Gregory Terrace – The dwellings along the southern side of Gregory Tce are predicted to experience noise levels up to 77 dBA for all traffic (including traffic on Gregory Tce itself) and up to 61 dBA for ICB and Northern Link traffic only with the designed barriers. Both of these predictions exceed the 63 dBA noise goal. All of these residences are able to achieve the 'Status Quo' noise goal.

School properties along the ICB –

- *Brisbane Boys' Grammar School Buildings*- Noise levels at the Brisbane Boys' Grammar School Buildings are predicted to experience noise levels up to 67 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 4 dBA.
- *Brisbane Girls' Grammar School Buildings*- Noise levels experienced at the Brisbane Girls' Grammar School buildings are predicted to experience noise levels up to 64 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 1 dBA.
- *Oval south of rail line*- For the Brisbane Grammar School sports oval south of the rail line, a substantial portion (ie approximately the southern half of the oval) is below Main Roads' Code of Practice 63 dBA $L_{A10(12hour)}$ planning level for outside education levels. This is considered acceptable.
- *Oval north of ICB*- For the Brisbane Grammar School oval north of the ICB (west of the Inner Northern Busway), most of the oval exceeds the 63 dBA $L_{A10(12hour)}$ with only approximately 10 - 20% of the oval (closest to the tennis courts) below this level. All of the tennis courts are below this planning level and are therefore considered acceptable.
- *Brisbane Boys' Grammar School Indoor Sports Complex*- Noise levels at the Brisbane Grammar School Indoor Sports Complex are predicted to experience noise levels up to 66 dBA. This is above the planning level of 63 dBA $L_{A10(18hour)}$ which equates to approximately 55 dBA $L_{A10(1hour)}$ internally, assuming a facade noise reduction of 10 dBA, by 3 dBA.

Should the 2 m high noise barrier recommended adjacent to the parkland (north of Victoria Street on the western side of Kelvin Grove Road) be considered unacceptable from urban design or community reasons, then predicted increases in noise levels for the homes west of this location are all within 2 dBA of the 'Do Minimum' noise level predictions. Consequently, should the noise barrier in this location not be installed, the increase in noise levels due to the project would be considered insignificant.

This design incorporates a total of 2,434 linear meters or 17,879 m^2 of barrier to achieve the 63 dBA $L_{A10(18hour)}$ planning level at residential and educational properties.

5.9 Recommended Mitigation Measures

State Controlled Roads: The only state controlled road where there are exceedances of the 68 dBA $L_{A10\ (18\ hour)}$ planning level for this project is Frederick Street. It is unfeasible to build noise barriers to protect these homes due to access requirements. Therefore, in accordance with Main Roads' Code of Practice, property treatments outside the road reserve should be undertaken to achieve an equivalent indoor noise amenity.

Non-State Controlled Roads: For both the Toowong area and the Kelvin Grove area, there are significant numbers of properties that exceed the 'Planning Level' goals with full 8 m high barriers. At 8 m high, noise barriers will also have significant visual and shading issues. 'Status Quo' noise levels can be achieved at almost every location in both areas with somewhat lower barriers. Where the 'Status Quo' noise level cannot be achieved, predicted increases in noise levels between the 'Do Minimum' and 'With Northern Link' are within 2 dBA and are therefore considered insignificant. Therefore, it is recommended that the 'Status Quo' goals be adopted for all non-state controlled roads.

5.10 Relocation of ICB Tunnel Portals Eastward

At the time of completing this noise assessment, consideration was being given to moving the tunnel portals adjacent the ICB (near Normanby Tce) to the east. This is advantageous acoustically as it will keep operation road traffic noise underground in the vicinity of the Normanby Terrace residences and the surrounding (indoor and outdoor) educational areas.

ICB traffic will remain on surface and therefore dominate noise levels on these surrounding noise sensitive location, however for Northern Link Tunnel traffic it is clearly advantageous to remain underground as long as possible, particularly if it moves the portals further away from these sensitive locations.

5.11 Alternative Mitigation Strategies to Reduce Road Traffic Noise Impacts

During the detailed design phase of the works, consideration should be given to the following options as alternative means of noise control, where noise barriers prove to be unreasonable or feasible:

Road Surface Treatments: The prevailing road surface directly influences the noise emissions from the roadway. The use of Open Graded Asphaltic Concrete (OGAC), for example, would result in noise levels that are 3dBA lower than Dense Graded Asphaltic Concrete (DGAC) which is the road surface that has been modelled for all roads in this study. Other similar surfaces include Stone Mastic Asphalt (SMA), where noise reductions of 1 - 2 dBA are reported (compared to DGA), depending on the stone size.

This option has some limitations:

- It is relatively costly to lay.
- It needs to be periodically replaced due to wear.
- In tunnels, OGAC cannot be used as it is a potential fire hazard. In the case of a petrol or other flammable liquid spill the roadway encourages the absorption of the volatile liquid rather than letting it stay on the surface.

Architectural acoustic treatment of existing dwellings: For dwellings along state-controlled roads, architectural acoustic treatments are required where the 68 dBA $L_{A10(18hour)}$ criterion cannot be reasonably and feasibly achieved.

Along local (non state-controlled) roads, it may be possible to provide upgrading to the facade windows and doors in some circumstances as an alternative to noise barriers.

Depending on the extent of impacts, consideration should be given to the supply of fresh air and/or air-conditioning into habitable rooms (allowing the windows to remain closed for noise control purposes) and to the upgrading of facade windows and doors (subject to qualifications).

Use of non-traditional (non-vertical) noise barrier design: In some topographical instances, the use of "curved" noise barriers, or barriers that have a "partial roof" covering a portion of the traffic adjacent the barrier, may be beneficial in further reducing noise levels achieved by traditional vertical barriers. Such 'innovation' should be considered during the detailed design phase of the project. It should be noted however, that:

(a) for "typical situations" where there is not a large difference in the ground elevation between the road and receivers, the literature suggests that such 'innovations' may result in "acoustically negligible" benefits

(b) Such 'innovations' are more expensive than traditional vertical noise barriers

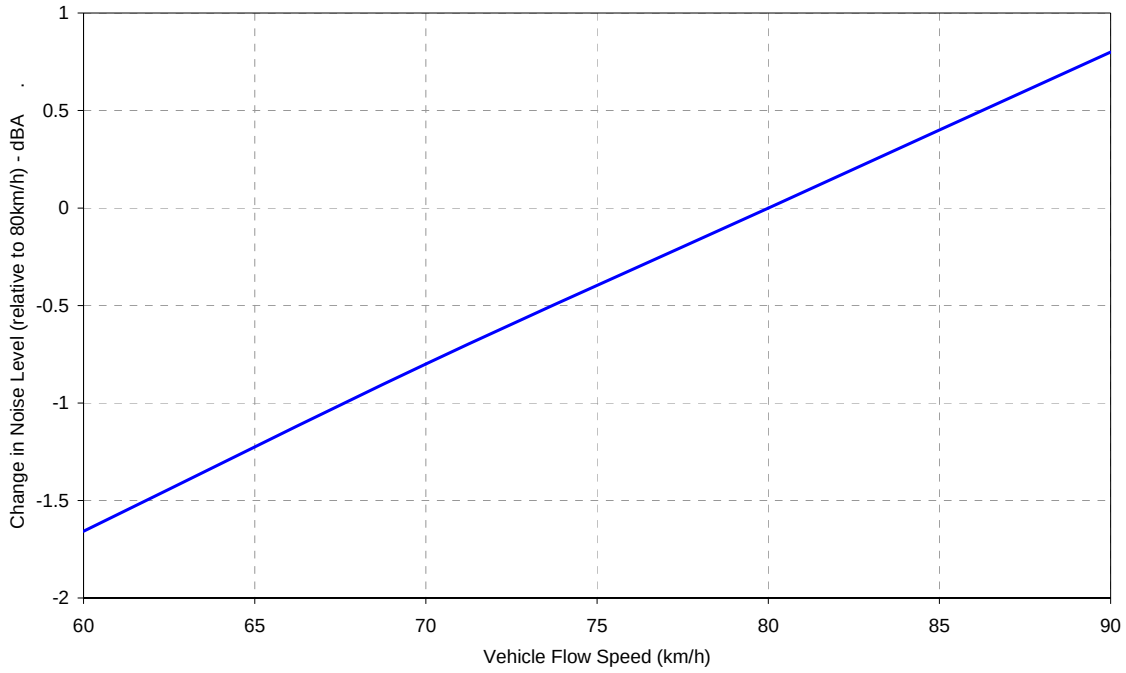
(c) To gain any appreciable acoustic benefit, they need to provide considerable additional mitigation for a significant portion of all dominant road traffic noise contributing to the overall noise level at a receiver. Otherwise, the additional benefit will be "lost" in the other road traffic noise given the logarithmic nature of acoustics.

Resumptions: In consultation with the property owners, Council could consider the purchasing of properties severely impacted by a project.

Urban Renewal: Councils and other authorities can consider an urban renewal program for areas or buildings that are adversely impacted by road traffic noise, replacing noise sensitive buildings (eg homes) with non-noise sensitive buildings (eg commercial).

Vehicular Speed: The overall traffic noise could be reduced by the lowering of the vehicular flow speed. At the higher speeds, noise is emitted from the interaction of the tyres and the roadway, whilst at lower speeds, the noise tends to arise from the engine and exhaust. **Figure 4** presents the relationship between noise level and speed, relative to 80 km/h.

- **Figure 4 Noise Levels and Vehicular Speed**



Reducing road speed is generally not considered a viable form of noise mitigation due to the relatively small changes involved, and it opposes one of the primary functions of road infrastructure projects which is to decrease travel times between destinations.

Reductions in Vehicle Noise Emissions: Noise emissions for new vehicles are defined within the Australian Design Rule 28/01, within the *Motor Vehicles Standard ACT*. Over time, changes to the standards would result in lower noise levels in the community.

5.12 Vibration and Regenerated Noise

On roadways that are well maintained, regenerated noise and vibration from individual vehicle movements is not considered to result in significant acoustical disruption to residents.

Heggies has recently undertaken specific "operation road tunnel" regenerated noise and vibration measurements above two tunnels – the ICB in Brisbane and the M5 East in Sydney. All results and observations showed regenerated noise and vibration levels to be below the threshold of human perception.

As such, there are no tunnel areas beneath sensitive buildings where it is anticipated that vibration or regenerated noise from truck movements on the carriageways would be an issue provided the road surface is well maintained and free of discontinuities.

6. Traffic Noise on Road Network Remote from the Portal Areas

6.1 Assessment Methodology

The effect of tunnel-related traffic on the noise emission from roadways remote from the tunnel connection areas has been assessed. This assessment has been performed by calculating how traffic changes attributable to the tunnel would alter the $L_{A10(18hour)}$ level of noise emission from roadways using the CoRTN[5] prediction algorithms. The $L_{A10(18hour)}$ parameter is the average of the hourly $L_{A10(1hour)}$ traffic noise level between the hours of 6 am and midnight.

6.2 Assessment Criteria

Assuming that the proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18hour)}$ traffic noise emission is summarised in **Table 17**.

Table 17 Relationship Between Traffic Volume Changes and $L_{A10(18hour)}$ Noise Emission

Increase/Decrease in AADT Traffic	Resultant Change in $L_{A10(18hour)}$ Noise Emission
10%	0.4 dBA
25%	1.0 dBA
50%	1.8 dBA
75%	2.4 dBA
100%	3.0 dBA

It can be seen from **Table 17** that a doubling of traffic on a given roadway will result in a 3 dBA increase in the $L_{A10(18hour)}$ emission from this roadway. A change of up to 3 dBA in the level of a dynamic noise, such as passing vehicles is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

It is acknowledged that people will probably notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level.

For assessment purposes it is common to set the threshold of significance in relation to changes to the emission level from roads at 2 dBA. This threshold is adopted in this study.

5 Calculation of Road Traffic Noise - U.K. Department of Transport, Welsh Office.

6.3 Traffic Noise Projections

For this analysis, the traffic speed and road pavement surfaces have all been assumed to remain constant throughout the various scenarios

Traffic projections, supplied by the JV, have been analysed for the opening and design years (ie 2014 and 2026) and for the "Do Minimum" and "With Northern Link" scenarios, for major representative surface roads in the wider vicinity of the portals.

Table 18 2014 Traffic Noise on Road Network Remote from the Portal Areas

Location	Do Minimum		With Northern Link		Change in $L_{A10(18hour)}$ Due to Northern Link
	18hr Traffic Volume	%CV	18hr Traffic Volume	%CV	
Roads in Vicinity of Western Portal					
Western Fwy (Between Mount Coot-tha Rd and Moggill Rd)	80,840	5.1%	102,760	3.7%	0.7
Western Fwy (Between Moggill Rd and Fig Tree Pocket Rd)	62,540	6.4%	75,630	4.5%	0.5
Mount Coot-tha Rd (Between Western Fwy and Frederick St)	69,670	4.2%	61,840	3.5%	-0.7
Mount Coot-tha Rd (North of Western Fwy)	9,730	9.0%	5,230	14.3%	-1.7
Frederick St	30,400	3.5%	29,490	3.2%	-0.2
Milton Rd (Between Croydon St and Park Av)	59,080	5.5%	53,260	5.2%	-0.5
Milton Rd (Between Eagle Tce and Grims St)	57,490	5.9%	51,110	5.7%	-0.6
Coronation Drive (Between Park Rd and Lang Pde)	69,940	6.4%	55,340	6.7%	-0.9
Roads in Vicinity of Eastern Portal					
Hale St	75,440	9.2%	73,170	6.7%	-0.7
Musgrave Rd (West of ICB)	25,810	3.7%	26,470	3.2%	0.0
Musgrave Rd (East of Kelvin Grove Rd)	36,910	6.7%	40,670	6.1%	0.3
Kelvin Grove Rd (North of ICB)	45,620	5.9%	54,900	5.8%	0.8
ICB (Between Kelvin Grove Rd and Bowen Bridge Rd)	96,860	7.2%	113,080	6.7%	0.6

■ **Table 19 2026 Traffic Noise on Road Network Remote from the Portal Areas**

Location	Do Minimum		With Northern Link		Change in $L_{A10(18hour)}$ Due to Northern Link
	18hr Traffic Volume	%CV	18hr Traffic Volume	%CV	
Roads in Vicinity of Western Portal					
Western Fwy (Between Mount Coot-tha Rd and Moggill Rd)	94,360	4.2%	123,670	4.1%	+1.2
Western Fwy (Between Moggill Rd and Fig Tree Pocket Rd)	78,330	4.9%	98,240	4.8%	+1.0
Mount Coot-tha Rd (Between Western Fwy and Frederick St)	77,310	4.9%	66,910	3.3%	-1.1
Mount Coot-tha Rd (North of Western Fwy)	14,350	7.6%	6,650	12.4%	-2.4
Frederick St	33,600	4.4%	29,800	3.8%	-0.7
Milton Rd (Between Croydon St and Park Av)	62,260	5.4%	58,070	4.6%	-0.5
Milton Rd (Between Eagle Tce and Grims St)	58,680	6.0%	55,250	5.1%	-0.5
Coronation Drive (Between Park Rd and Lang Pde)	75,490	6.4%	56,950	6.9%	-1.1
Roads in Vicinity of Eastern Portal					
Hale St	74,880	7.3%	77,920	6.4%	+0.0
Musgrave Rd (West of ICB)	26,960	4.1%	27,750	3.7%	+0.0
Musgrave Rd (East of Kelvin Grove Rd)	43,620	7.3%	49,110	6.4%	+0.3
Kelvin Grove Rd (North of ICB)	51,730	5.7%	62,350	5.9%	+0.9
ICB (Between Kelvin Grove Rd and Bowen Bridge Rd)	104,840	7.1%	128,400	5.8%	+0.6

6.4 Assessment of Traffic Noise Impacts

Table 18 and **Table 19** present the changes in traffic noise levels for "With Northern Link" relative to the "Do Minimum" option for both the year of opening (2014) and the design year (2026).

For the Years 2014 and 2026, the introduction of Northern Link is predicted to result in a small change in the levels of road traffic noise on the wider road network. Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase. **Table 20** presents a summary of the highest and lowest changes across the wider road network.

■ **Table 20 Summary of Changes**

Year	Comparison of Do Minimum to Northern Link	
	Highest Increase	Highest Decrease
2014	+0.8	-1.7
2026	+1.2	-2.4

The expected changes in the traffic noise as a result of the introduction of Northern Link are considered to be minor and not be generally noticeable.

6.5 Mitigation Options

As the highest predicted increase in road traffic noise level is less than 2 dBA, no impact is predicted and therefore no noise mitigation is considered necessary.

However, if strict compliance with the 'Status Quo' noise levels is recommended for roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise as attributable to the tunnel:

- Open-graded or stone mastic asphaltic road surfacing.
- Building insulation upgrade programmes.

Road-side barriers are not a feasible option along many roads due to the requirement for property access from the street frontage.

7. Ventilation Noise from Ventilation Stations

7.1 Introduction

The purpose of this chapter is to assess the noise impact of the tunnel ventilation system during normal tunnel operation. In this context, 'normal' tunnel operation refers to tunnel ventilation induced by either of the two ventilation sites, and excludes emergency in-tunnel fire/smoke scenarios that would trigger the operation of auxiliary in-tunnel jet-fans.

At this stage, the proposed mechanical plant selections and associated noise control equipment for the tunnel ventilation system have not undergone detailed design or specification, thus there is no specific acoustic emission data from the facilities. Therefore, it is not possible to make an exact determination of the noise impact from any of the proposed ventilation systems. In practice the design process begins with agreed noise emission performance requirements which ensure noise impacts are deemed to be acceptable.

This EIS chapter proposes to address whether it is feasible for the ventilation systems to meet normally accepted noise emission performance requirements, based on best practice noise control equipment, and if so, what types of noise control measures may be required.

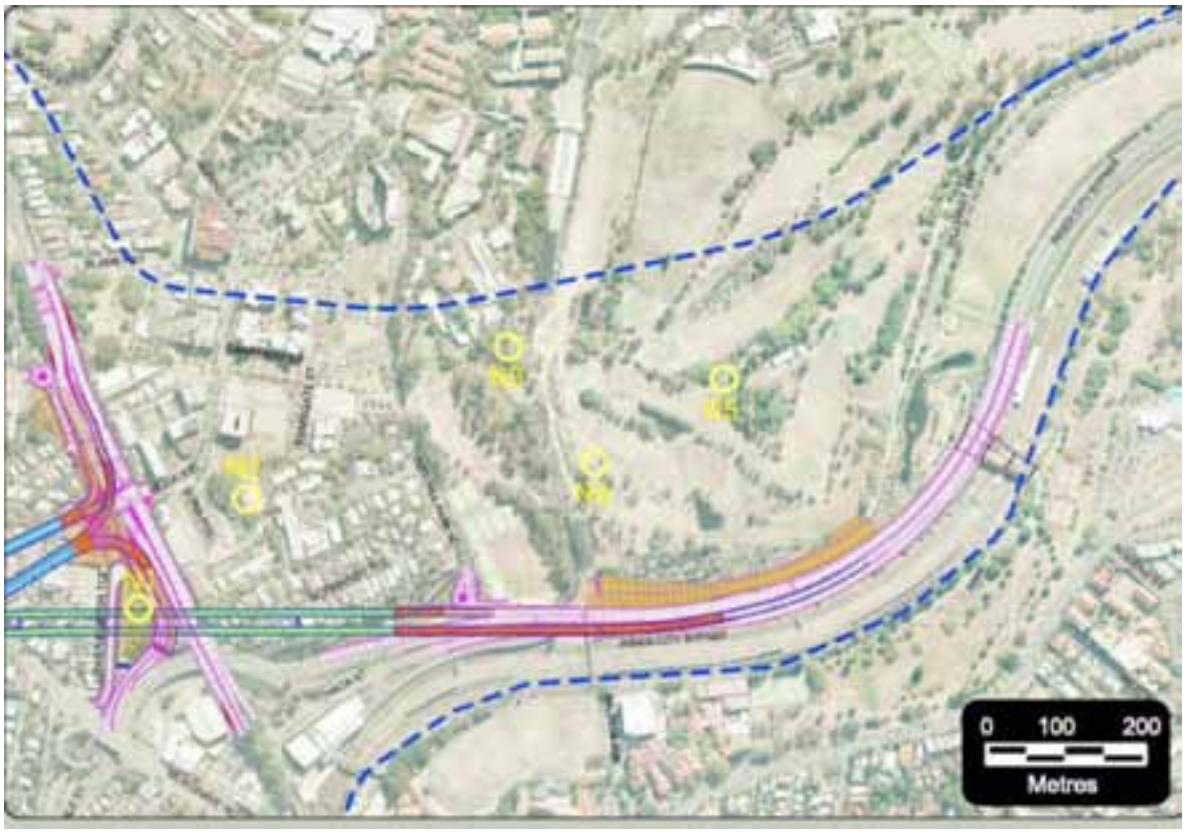
7.2 Description of Ventilation System

It is proposed that there are two ventilation stations. The current preferred sites for the purposes of the EIS are presented in **Figure 5** and **Figure 6**.

- **Figure 5 Preferred Ventilation Station Locations – Western Portal**

1

Figure 6 Preferred Ventilation Station Locations – Eastern Portal



Whilst the design of the mechanical ventilation system is somewhat preliminary, the following summarises the key design factors that relate to noise.

Table 21 Ventilation Design Factors

Parameter	Western Ventilation Station	Eastern Ventilation Station
Total extracted air flow (m3/s)	600	600
No. of fans (excluding standby)	4	4
Motor size (kW) (per fan)	400	400
Cross sectional area of duct (m2/s)	45	45

The ventilation systems are designed to operate under peak hour conditions. At other times, the demand for air flow is lower and the number of fans required to operate is reduced. **Table 22** presents a generalised fan utilisation schedule for various times throughout the day.

Table 22 Utilisation of Ventilation Capacity at Different Times of Day

Time of Day	Ventilation Capacity Utilised
Morning /evening traffic peaks	100%
Day	90%
Evening	66%
Night	50%

The heights of the discharge stacks will be determined based on wind dispersion modelling, which will be undertaken during the detailed design phase of the works. However, for the purposed of this assessment, a height of 30 m has been adopted.

7.3 Receptor Locations

Western Ventilation Outlet

The nearest residential receptors to the western ventilation station location are located in Elizabeth Street, Wool Street and Cross Street on the far side of the Western Freeway.

Eastern Ventilation Outlet

The eastern ventilation station is located in the southern section of the Victoria Park Golf Course.

The nearest residential receptors to this site are located in Victoria Park Road. The nearest sensitive (educational) receptor is QUT.

7.4 Target Emission Levels

In order to minimise the acoustical impacts from the continuous ventilation system, the design criteria for noise emissions from the ventilation stations is set to a level equal to the existing background noise levels, as discussed in **Section 2.2.3**. The nearest assessment locations and design criteria are presented in **Table 23**.

Table 23 Assessment Locations and Design Criteria for Ventilation Stations

Portal	Nearest Assessment Point	Representative Noise Monitoring Location	Existing Night-time Background Noise Level (dBA)	Design Criteria (dBA - L90)
Western Portal	Elizabeth St/Cross St	115 Elizabeth St	34	34
Eastern Portal	Victoria Park Rd	43 Normanby Tce	39	39
	QUT	QUT	47 [1]	47

Note 1: Existing daytime level for QUT as night-time level is not applicable.

1

7.5 Noise Level Predictions and Assessment

Calculations of indicative ventilation outlet noise have been carried out for the nearest known residential areas in each of the three portal areas. These calculations include the effect of a 3 m long industrial silencer on the intake and discharge sides of ventilation fans, hemispherical spreading, the directivity of the discharge and typical worst-case meteorological conditions. Calculations have not taken into account any attenuation from dampers, straight sections of duct or duct bends, and are therefore considered to be conservative.

The generic source data is summarised in **Table 24**, from which the Sound Power Levels was adjusted to reflect the number of fans for each location.

Table 24 Source Data for Ventilation Noise Predictions

Data and Source	Parameter	Weighting	63	125	250	500	1 k	2 k	4 k	8 k
4 off Axial Fan, 110m^3/s @ 1500 Pa (Source: fan supplier)	Sound Power (dB)	Linear	128	127	122	118	121	119	114	108
Insertion loss, 3m 50% channel area industrial silencer (source: silencer supplier)	Insertion loss (dB)	Linear	-12	-19	-36	-43	-47	-28	-18	-16

For the purpose of this assessment, it has been assumed that the fans would be operational during the night (ie 50% capacity).

The sound power level associated with each fan has been obtained by comparing estimated sound power spectra from potential fan suppliers.

Table 25 presents the predicted ventilation noise level at the nearest receiver to each outlet.

Table 25 Additional Attenuation Required (preliminary) for Residential Receivers

Ventilation Station	Predicted Emission Levels	Additional Attenuation Required	Comments
Western	34	Nil	It would be desirable to incorporate some additional attenuation in the low and high frequencies (ie 63 Hz and 2 kHz). In between frequencies do not exhibit any exceedances.
Eastern	38	Nil	It would be desirable to incorporate some additional attenuation in the low and high frequencies (ie 63 Hz and 4 kHz). In between frequencies do not exhibit any exceedances.

The predictions above are considered conservative as they have not accounted for:

- End reflection[6]. - which provides substantial low frequency attenuation;
- Any internal attenuation along the internal duct length, which is particularly effective in reducing high frequency noise.

For QUT, daytime noise levels have been predicted assuming that the fans would be operational at 100% capacity with the following results:

- The predicted noise level at QUT is 40 dBA and therefore no additional attenuation is required. However, it would be desirable to incorporate some additional attenuation in the low and high frequencies (ie 63 Hz and 4 kHz).

Once the fan and system design has progressed, the noise predictions should be reviewed and refined. At this stage it is not possible to provide any specific recommendations, but the levels of attenuation required do not appear to highlight any design problem.

Given the immissions at residential locations are free of distinct tonal characteristics, and are equal to the (night-time) Rating Background Level, it is concluded that it would be feasible for the ventilation outlets to be developed with negligible noticeable noise impact to residents, and in compliance with both the traditional EPA requirements and NIAPSP requirements.

6 *End reflection is where a component of the low frequency noise in a ventilation system, is reflected back into the duct*

8. Conclusions

8.1 Road Traffic Noise Local to Tunnel Portals

8.1.1 General

The EPP[Noise] identifies Planning Levels for traffic noise emissions from roadways, but does not specify what actions should be carried out in response to road developments that may result in exceedances of Planning Levels.

For this project, the Planning Levels from the EPP[Noise] are generally already equalled or substantially exceeded at residential facades facing the major roads that connect to the tunnel.

Main Roads' Code of Practice is also applicable to this study as it outlines Main Roads' strategy to control road traffic noise from State-controlled roads. The sections of road within the study area that are State-controlled are:

- Western Freeway – West of Mt Coot-tha Road,
- Mt Coot-tha Road – between Western Freeway and Frederick Street only.
- Frederick Street – North of Mt Coot-tha Road (including the roundabout and overpass at which it connects to Mt Coot-tha Road).

The following situations have been modelled in accordance with the ToR:

- **Do minimum (2014)** - The predictions include all future traffic utilising the existing road corridor in the proposed year of opening (ie 2014), excluding the Northern Link project. This scenario represents the future traffic that would have arisen in the absence of this major transport initiative, and represents the baseline noise projections against which some of the other scenarios are compared.
- **With Northern Link (2014)** - Traffic flows including the Northern Link project in the proposed year of opening (ie 2014). This scenario represents the change in traffic noise, attributable directly to the Northern Link project.
- **Do minimum (2026)** - The predictions include all future traffic utilising the existing road corridor in the design year (ie 2026), excluding the Northern Link project. This scenario represents the future traffic that would have arisen in the absence of these major transport initiatives, and represents the baseline noise projections against which some of the other scenarios are compared.
- **With Northern Link (2026)** - Traffic flows including the Northern Link project in the design year (ie 2026). This scenario represents the change in traffic noise, attributable directly to the Northern Link project.

Two noise barrier designs have been undertaken for Northern Link, as outlined below.

'Status Quo' Noise Barrier Option

The objective used to develop the 'Status Quo' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to achieve traffic noise levels equal to (or less than) to the "Do Minimum" option.

'Planning Level' Noise Barrier Option

The objective used to develop the 'Planning Level' barrier option for the design year (2026) is to develop road-side noise barriers, where practical and feasible, to limit traffic noise levels to the 63 dBA or 68 dBA (as applicable to local and state controlled roads respectively) $L_{A10(18hour)}$ planning levels wherever possible.

The purpose of this option is to illustrate the scale of noise controls that would be necessary to achieve the "planning" traffic noise levels in accordance with the EPP[Noise] and Code of Practice. In many areas this would require noise controls to account for existing exceedances of the planning levels and/or gradual increases in traffic noise over time that are not attributable to the tunnel.

In general, the recommendation of this assessment is that noise mitigation should be designed for compliance with the 'Status Quo' goals for local roads as there is a large number of homes that already exceed the 'Planning Level' goals. Furthermore, even with 8m high barriers in place, there is a significant number of locations in each surrounding area that do not achieve compliance with the 'Planning Level' goals. In the case of Frederick St, which is the only state controlled road where exceedences of the 68 dBA LA10(18hr) noise goal is predicted, property treatments outside the road reserve are recommended (in accordance with Main Roads Code of Practice) as noise barriers are not feasible given access requirements.

In all areas it is considered that the recommended noise control options in this report represent a starting point for discussions between key stake-holders.

8.1.2 Western Connections

Noise mitigation to achieve the 'Status Quo' where reasonable and feasible is shown in **Appendix H3** and **H7** (for With Northern Link (2014) and With Northern Link (2026)). It should be noted that:

- Compliance with the 'Status Quo' goals are achieved at all properties behind barriers
- Where barriers cannot be built for access requirements, all locations are within 2 dBA of the "do minimum" situation except one property (510 Milton Rd) which has an increase of 3 dBA. Changes in noise levels of 2 dBA or less are generally considered insignificant.

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered. In theory, long continuous commercial or residential building structures could provide noise screening in lieu of barriers, where space permits (eg north-east corner of Toowong roundabout between Milton Rd and Valentine St).

For dwellings along state-controlled roads, architectural acoustic treatments are required (in accordance with Main Roads Code of Practice) where the 68 dBA $L_{A10(18hour)}$ criterion cannot be reasonably and feasibly achieved.

The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated along local roads (ie non state-controlled) as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas.

8.1.3 Eastern Connections

Noise mitigation to achieve the 'Status Quo' where reasonable and feasible is shown in **Appendix I3** and **I7** (for With Northern Link (2014) and With Northern Link (2026)). It should be noted that:

- West of Kelvin Grove Rd – all properties achieve compliance with 'Status Quo' goals except the most eastern property on Dalley St (adjacent Kelvin Grove Rd) where it exceeds by an insignificant 1 dBA. Should the 2 m high noise barrier adjacent the park north of Victoria St be opposed for urban design or community reasons, it is predicted that noise levels behind this barrier would not increase by more than 2 dBA above the "do minimum" situation. Such an increase would generally be considered insignificant.

- East of Kelvin Grove Rd and North of ICB – all properties on Normanby Tce achieve compliance with the 'Status Quo' goals

- Gregory Tce - all properties achieve compliance with the 'Status Quo' goals without the need for a noise barrier

- Educational Facilities – all indoor and outdoor educational areas for BGS and BGGS will comply with the 'Status Quo' goals without the need for a noise barrier

All of the barriers presented are considered to be of a feasible scale but will need to be reviewed in the context of urban renewal concepts along this corridor. Safety issues associated with sight lines would also need to be considered.

The cost effectiveness of the alternative option of upgrading building envelopes could also be investigated along local roads (ie non state-controlled) as an alternative to barriers. An advantage of barriers (as opposed to building upgrades) is that barriers would also control traffic noise increases in outdoor areas. Other alternative noise mitigation options are listed in Section 5.11.

8.2 Road Traffic Noise Remote from Tunnel Portals

For the Years 2014 and 2026, the introduction of Northern Link is predicted to result in a small change in the levels of road traffic noise on the wider road network (ie well removed from the portal areas). Generally noise levels decrease, but at a number of locations the noise levels are predicted to increase.

The expected changes in the traffic noise as a result of the introduction of Northern Link are generally within ± 2 dBA. Such changes are considered to be minor and not to be generally noticeable. As such, no noise mitigation is considered necessary.

However, if strict compliance with the 'Status Quo' noise levels is recommended for roads beyond the immediate tunnel infrastructure, the following options could be explored to mitigate increases in traffic noise as attributable to the tunnel:

- Open-graded or stone mastic asphaltic road surfacing.
- Building insulation upgrade programmes.

Road-side barriers are not a feasible option along many roads due to the requirement for property access from the street frontage.

8.3 Regenerated Noise

Regenerated noise from roadways in shallow tunnel areas is not considered to be an issue for this project provided road surfaces are well maintained.

8.4 Ventilation System Noise

Preliminary calculations of ventilation outlet noise emissions indicate that it would be feasible for noise emissions to comply with the BCC's Noise Impact Assessment Planning Scheme Polices and traditional EPA licensing.

Providing that immissions at residential locations are free of distinct tonal characteristics, and do not exceed background noise levels, the normal licensing requirements would allow the ventilation outlets to be developed with negligible noticeable noise impact to residents.

Appendix A

Report 20-1854R3

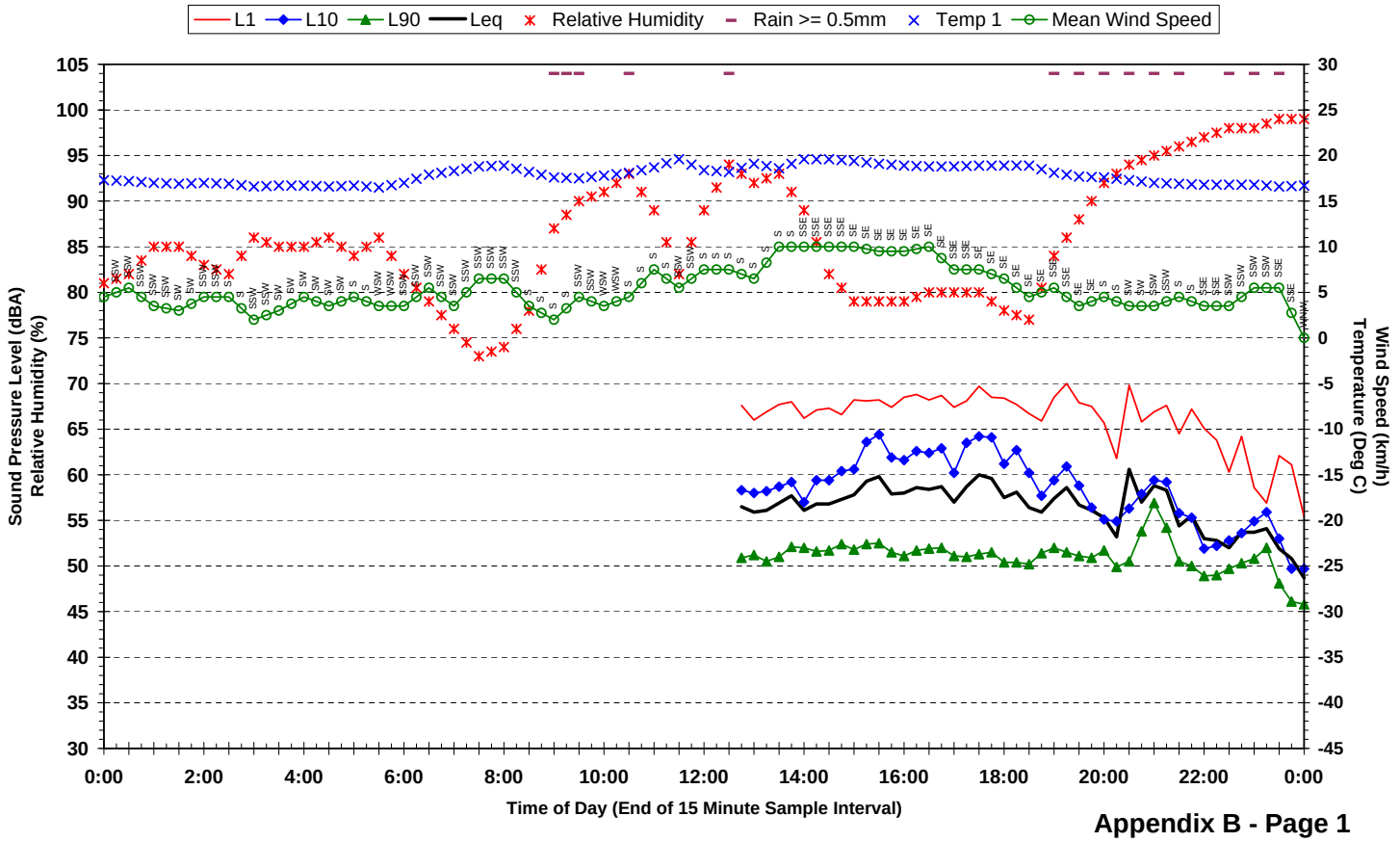
Monitoring Location	Description	Logger Location Image
1 - 22 Crag Road, Taringa	Front yard of detached single storey dwelling at 22 Crag Street, Taringa, facing Western Freeway	
2 - 115 Elizabeth Street, Toowong	High side of front yard of detached highset dwelling at 115 Elizabeth Street, Toowong	
3 - 6 Wool Street, Toowong	Front yard of single-storey detached dwelling at 6 Wool Street, Toowong	
4 - 128 Sylvan Road, Toowong	Front yard of block of units at 128 Sylvan Road, Toowong	

5 - 29 Valentine Street, Toowong	Front yard (facing towards Milton Road) of detached highset dwelling at 29 Valentine Street, Toowong	
6 - 69 Frederick Street, Toowong	Front verandah of highset detached dwelling at 69 Frederick Street, Toowong	
7 - 9 Victoria Crescent, Toowong	Front yard of detached double-storey dwelling at 9 Victoria Crescent, Toowong	
8 - 5 Clyde Street, Brisbane City	Front patio of detached single-storey dwelling at 5 Clyde Street, Brisbane City	
9 - 26 Lower Clifton Terrace, Red Hill	Front yard of detached double-storey dwelling at 26 Lower Clifton Terrace, Red Hill	

10 – 7 Westbury Street, Red Hill	Front yard of detached single-storey dwelling at 7 Westbury Street, Red Hill	
11– Inner Northern Busway (INB), Normanby Station	Located on parcel of Translink land between Ithaca St and INB east of Normanby Busway Station	
12 – 43 Normanby Terrace, Kelvin Grove	Rear yard (overlooking ICB) of detached highset dwelling at 43 Normanby Terrace, Kelvin Grove	
13 – 9 Horrocks Street, Toowong	Low side yard of highset dwelling	
14 – QUT Kelvin Grove Campus	Adjacent to south end of block Y1	

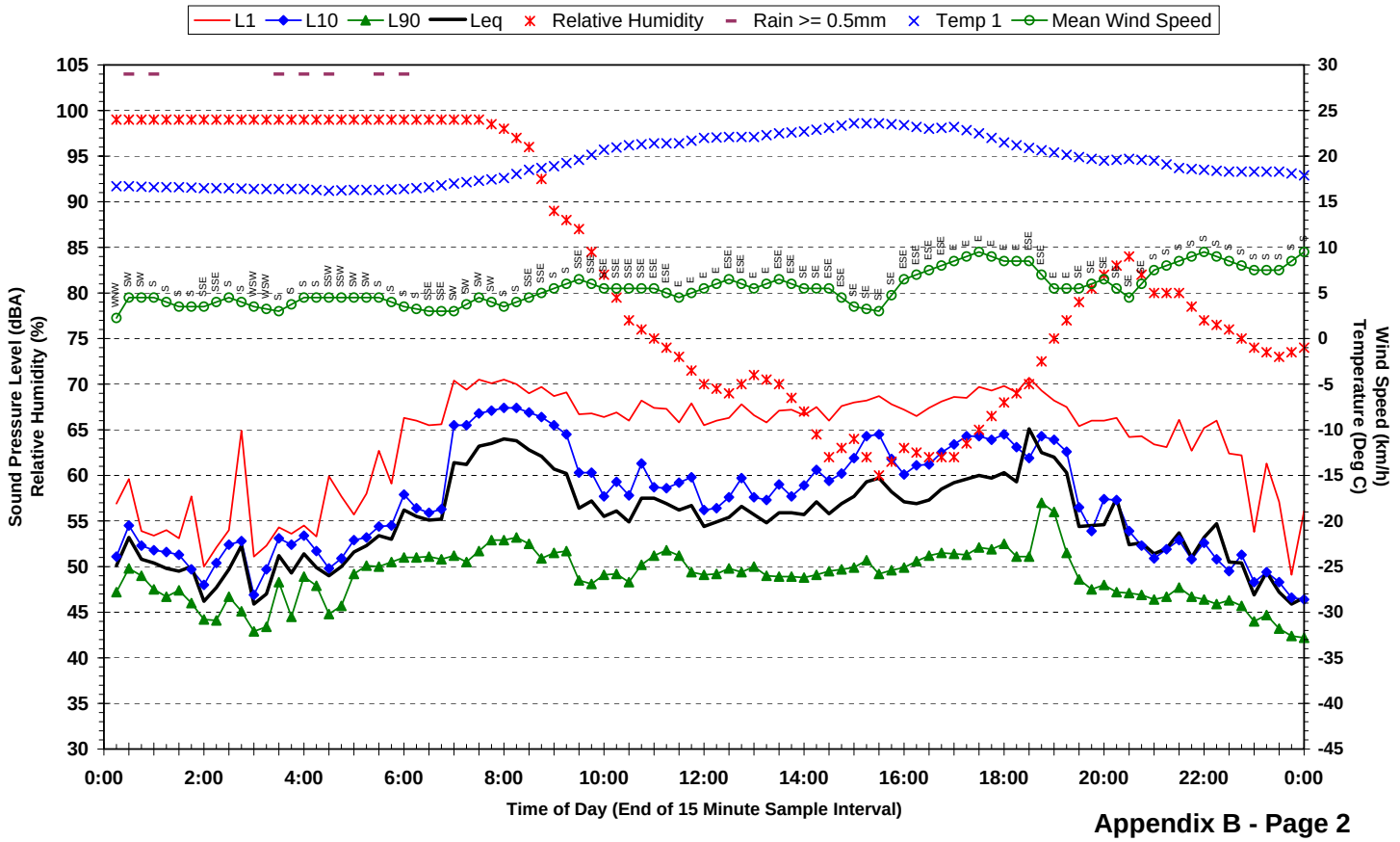
Appendix B
Report 20-1854R3

Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Wednesday 7 November 2007



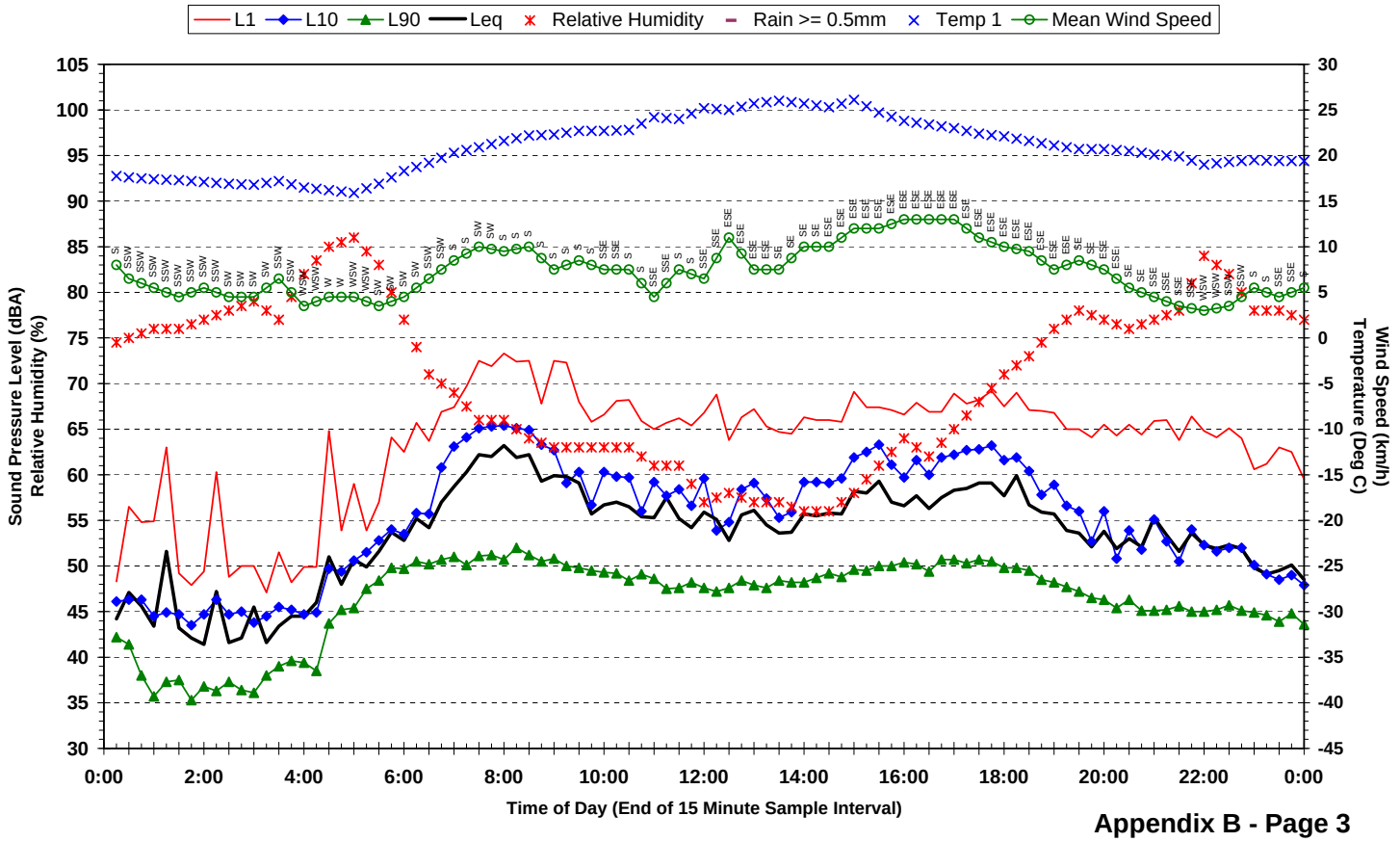
Appendix B - Page 1
Ambient Conditions
Heggies Report 20-1854

Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Thursday 8 November 2007



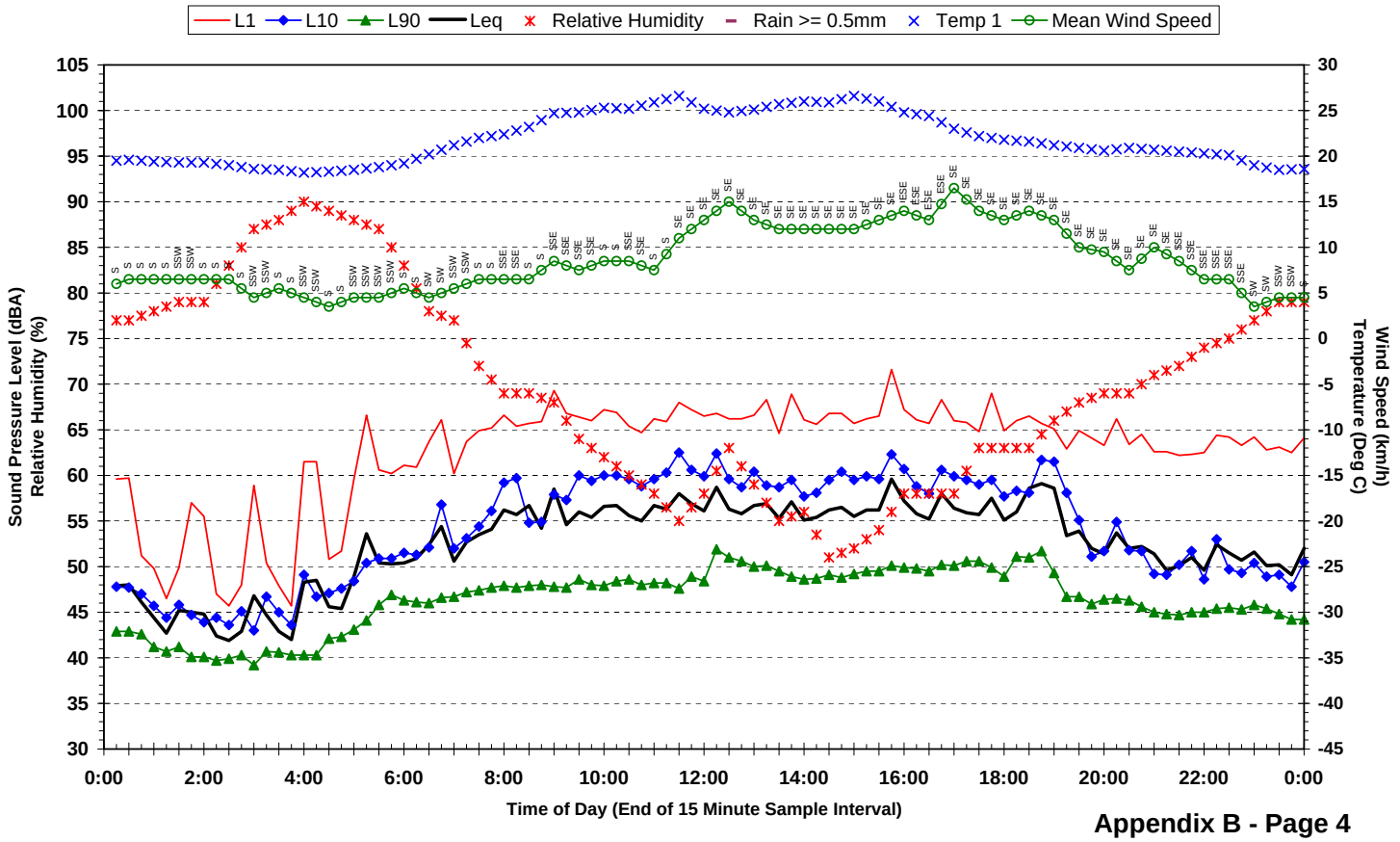
Appendix B - Page 2
Ambient Conditions
Heggies Report 20-1854

Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Friday 9 November 2007



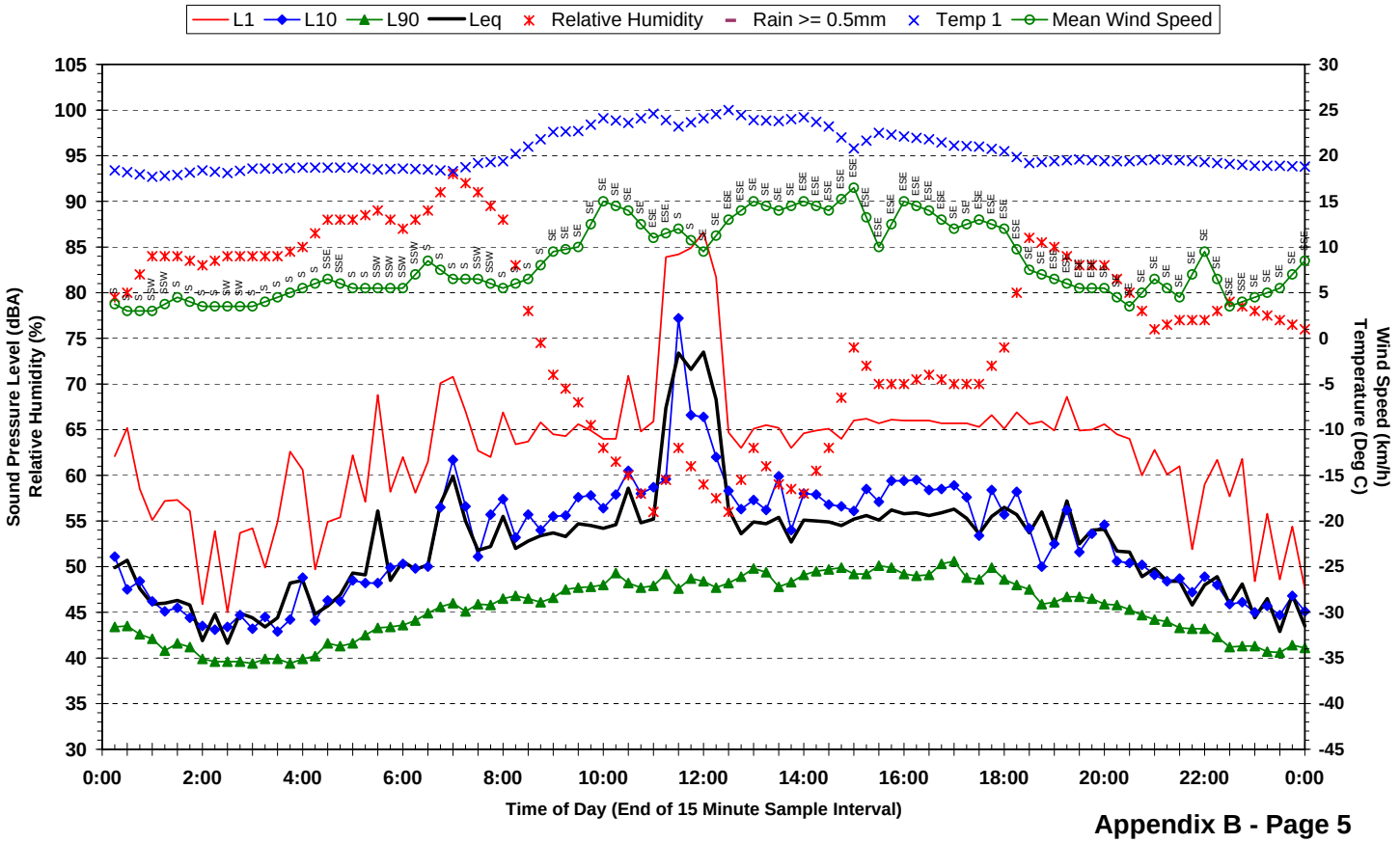
Appendix B - Page 3
Ambient Conditions
Heggies Report 20-1854

Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Saturday 10 November 2007

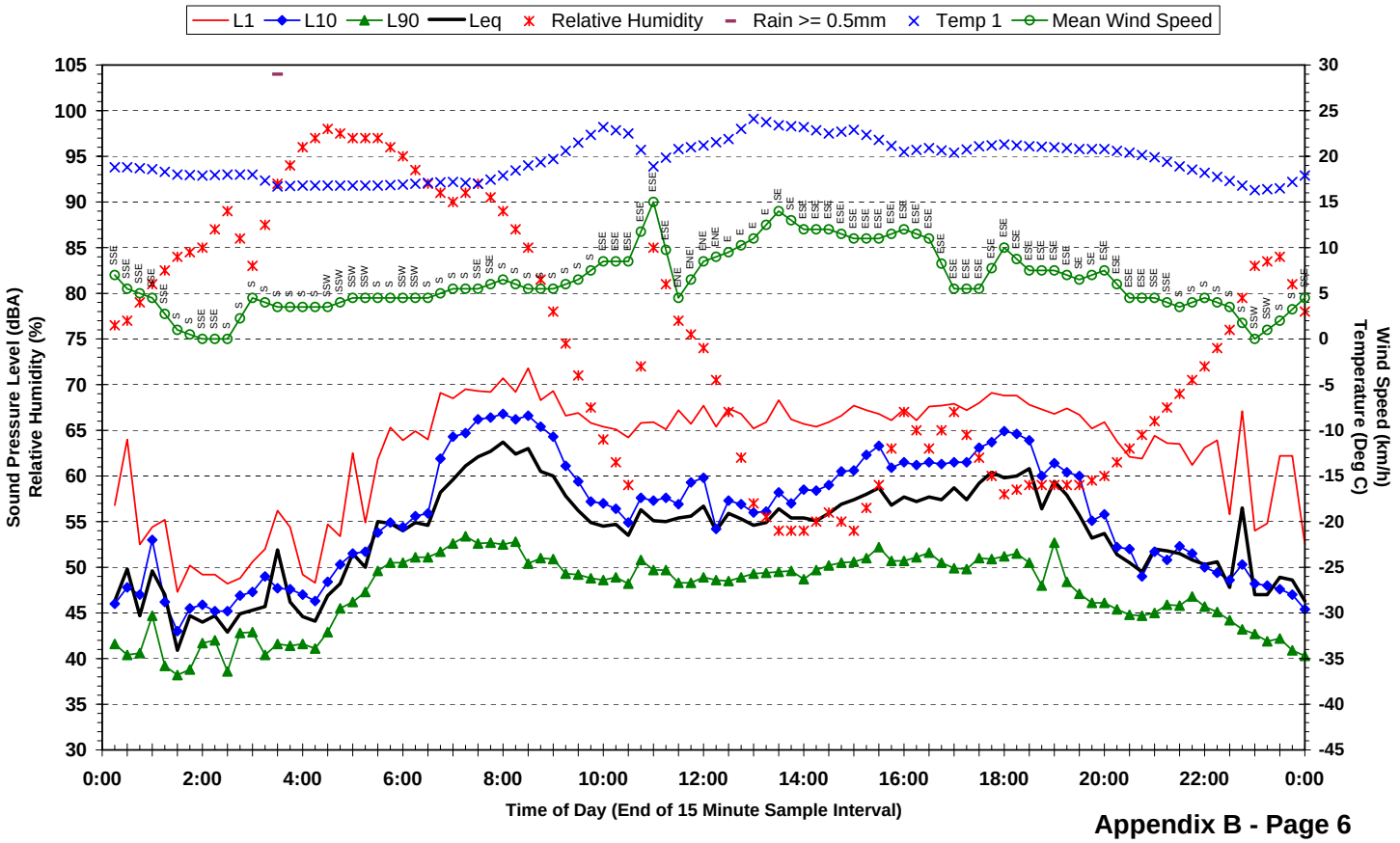


Appendix B - Page 4
Ambient Conditions
Heggies Report 20-1854

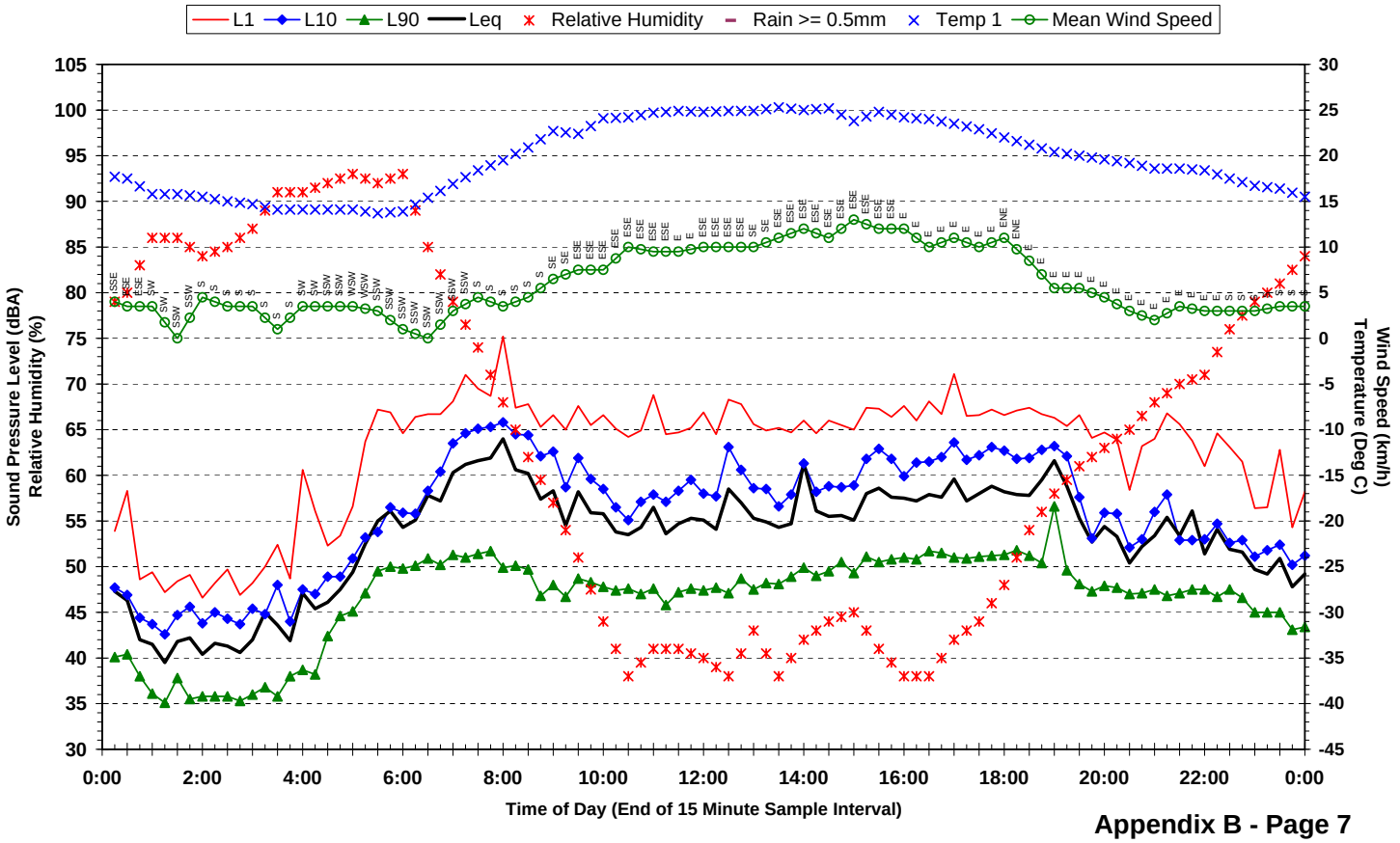
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Sunday 11 November 2007



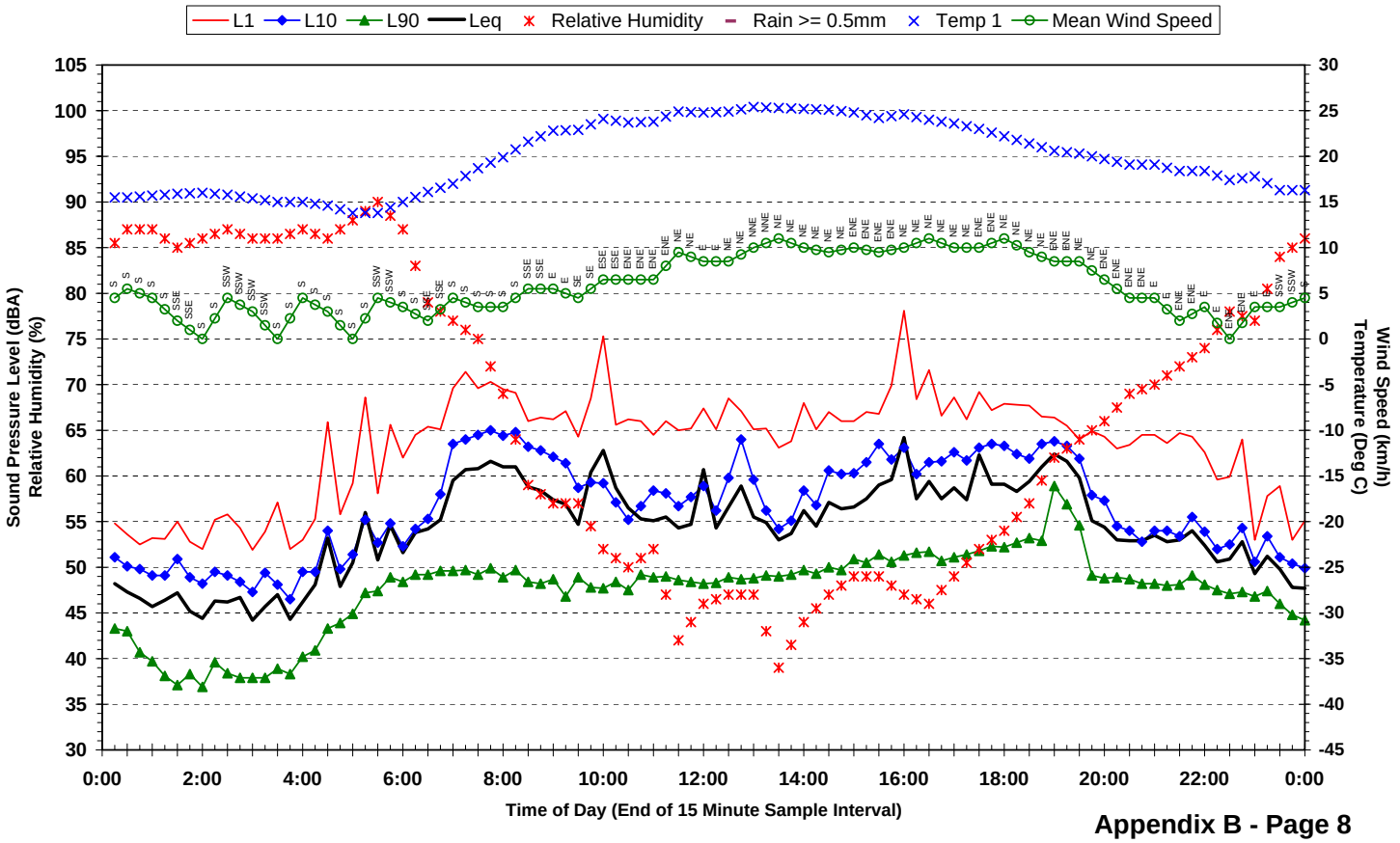
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Monday 12 November 2007



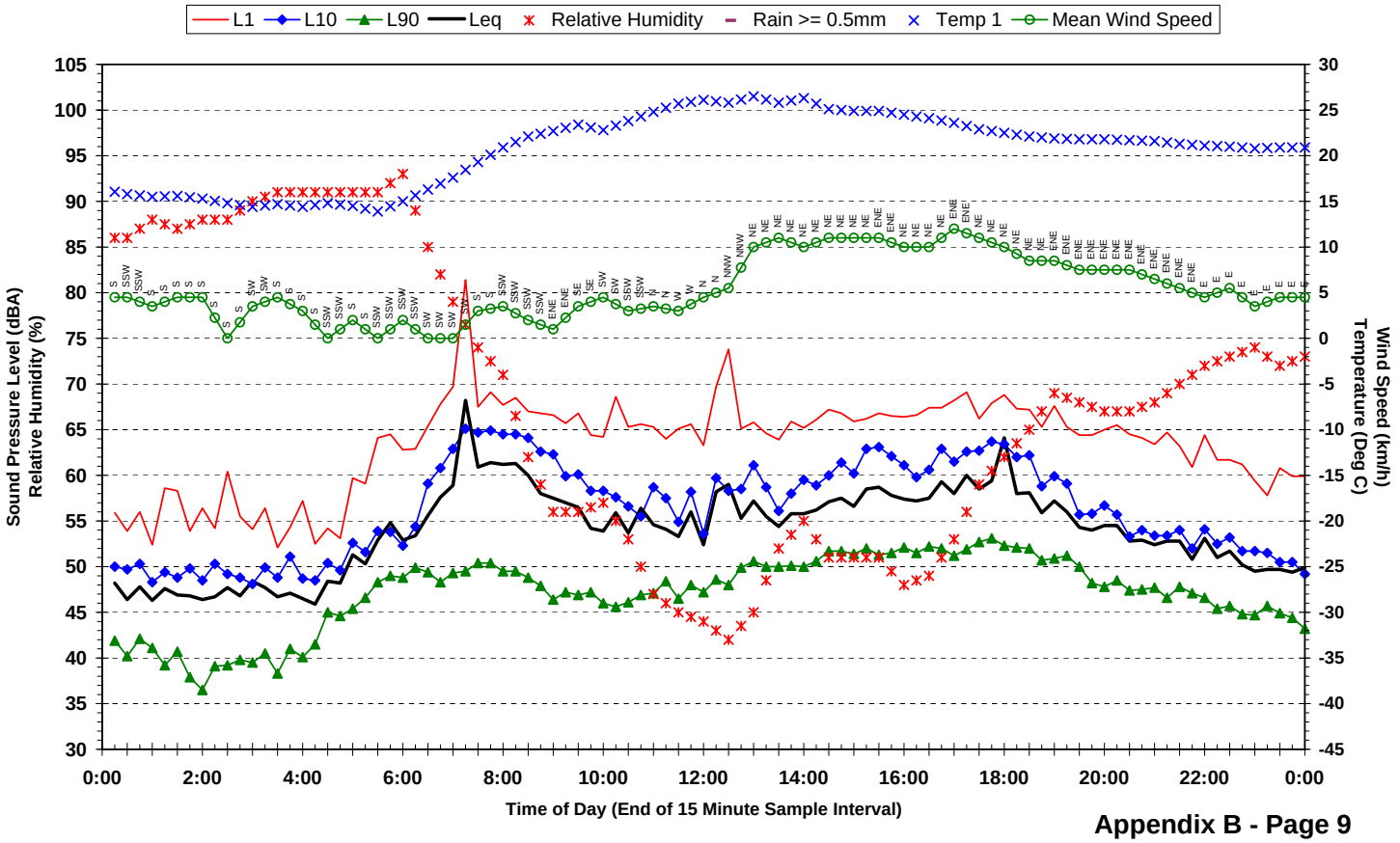
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Tuesday 13 November 2007



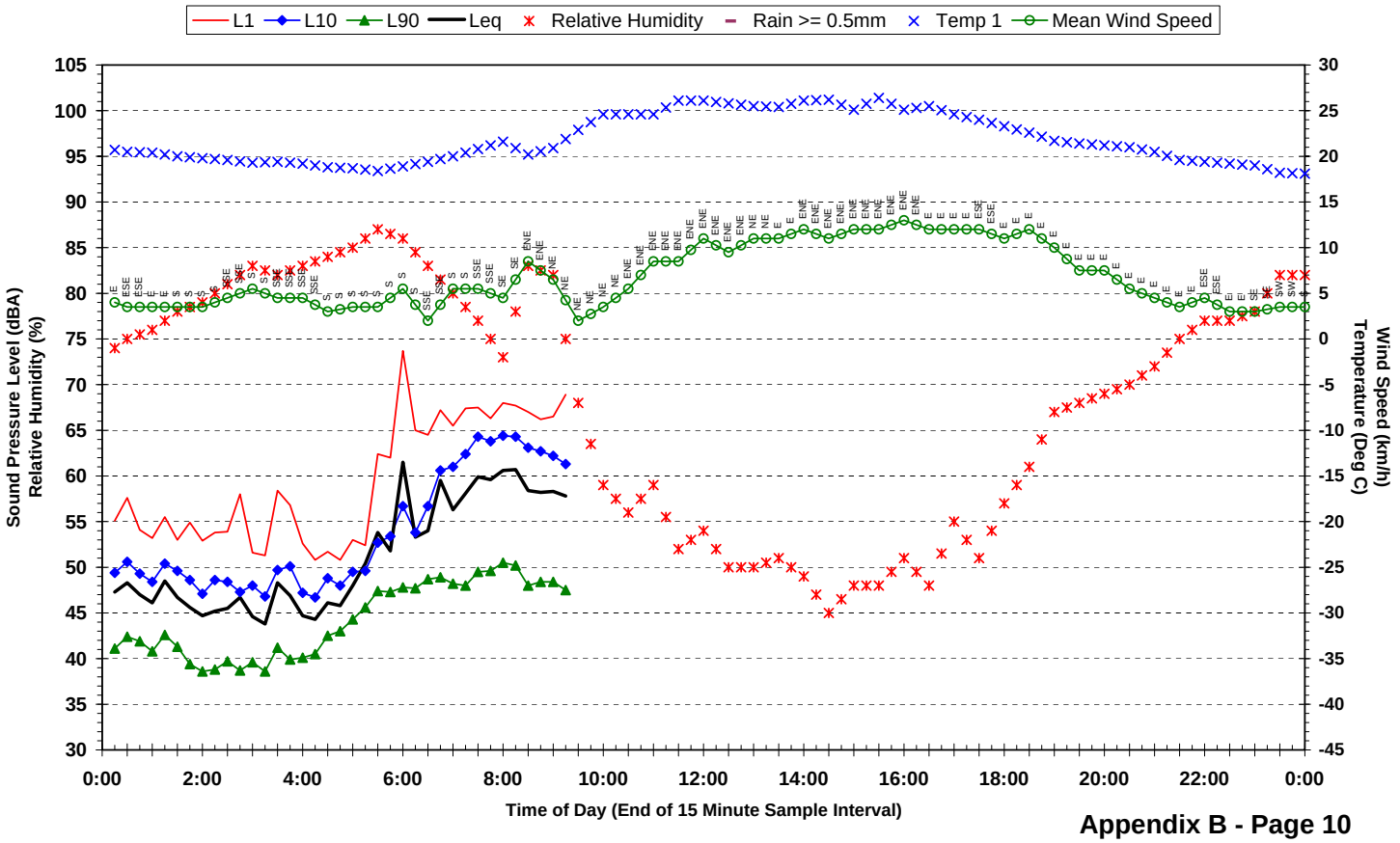
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Wednesday 14 November 2007



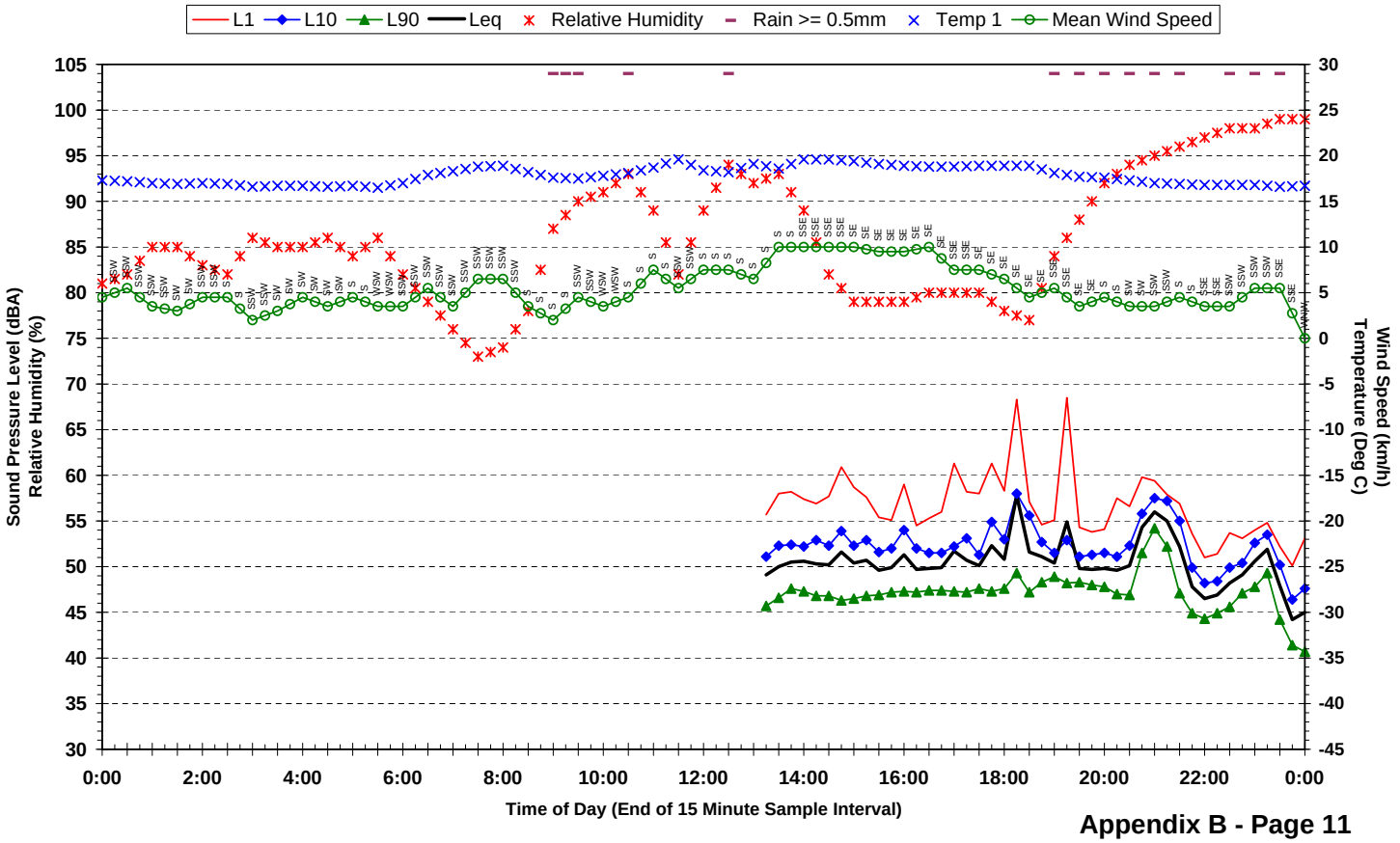
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Thursday 15 November 2007



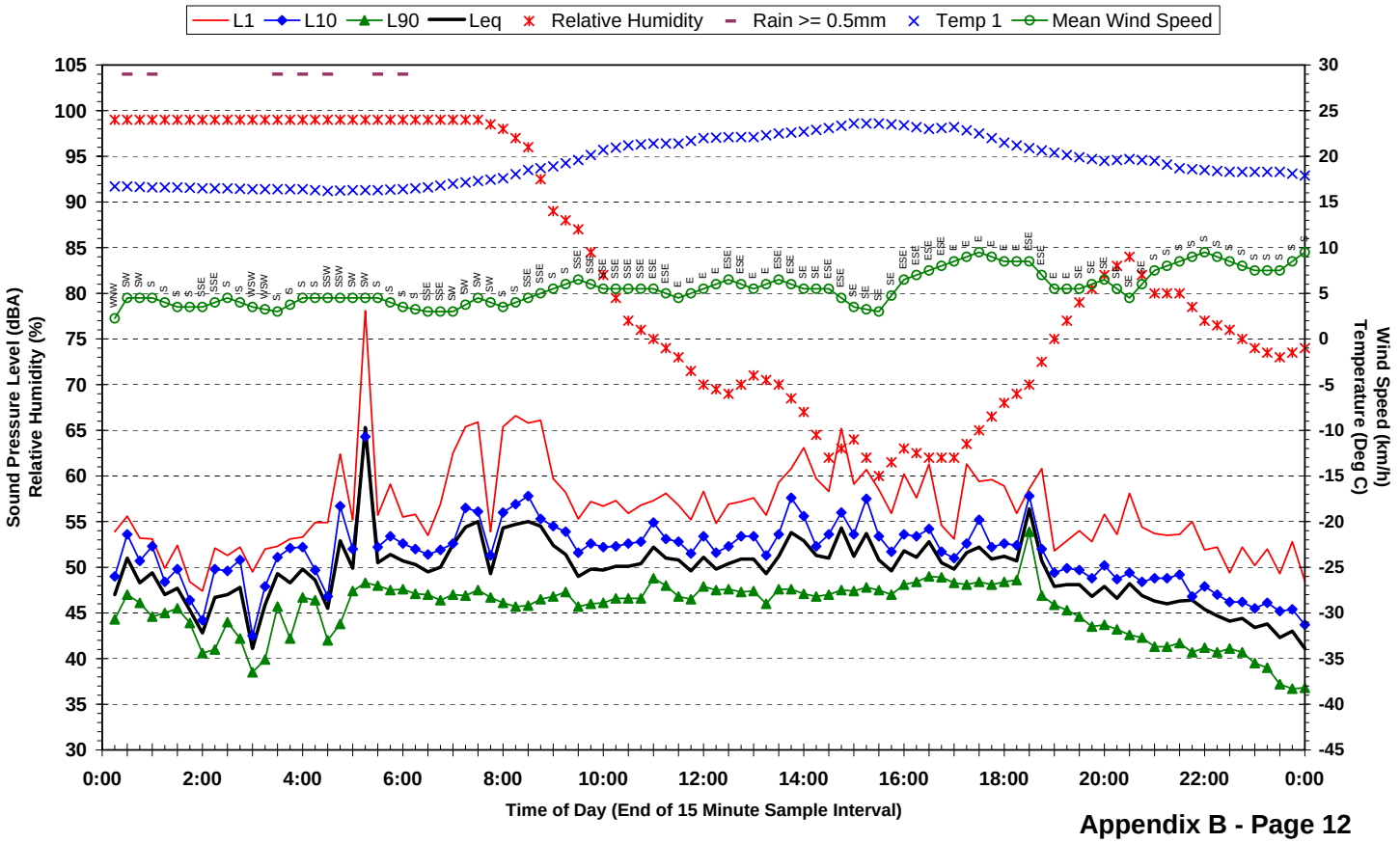
Statistical Ambient Noise Levels
Location 1 - 22 Crag Street, Taringa - Friday 16 November 2007



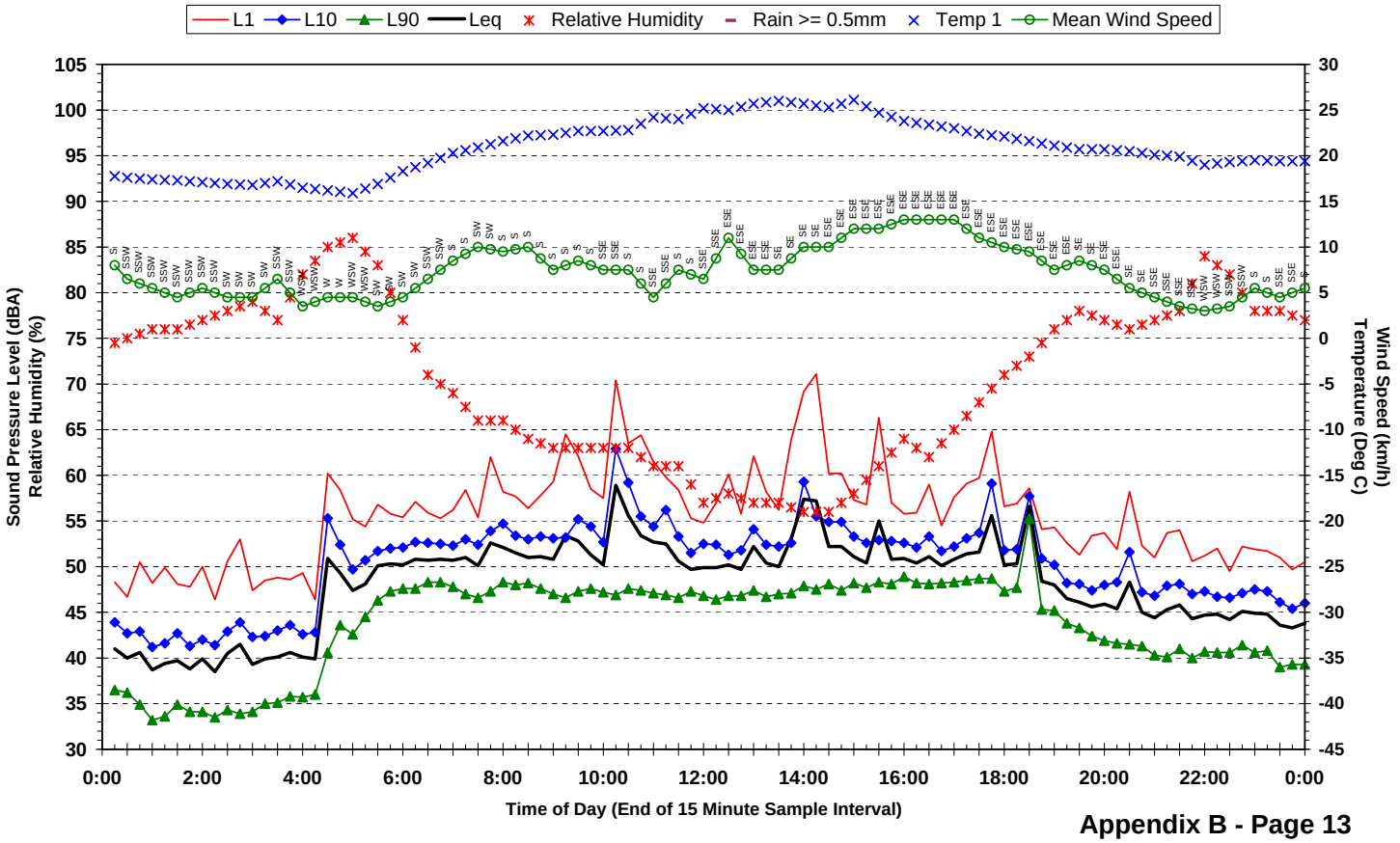
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Wednesday 7 November 2007



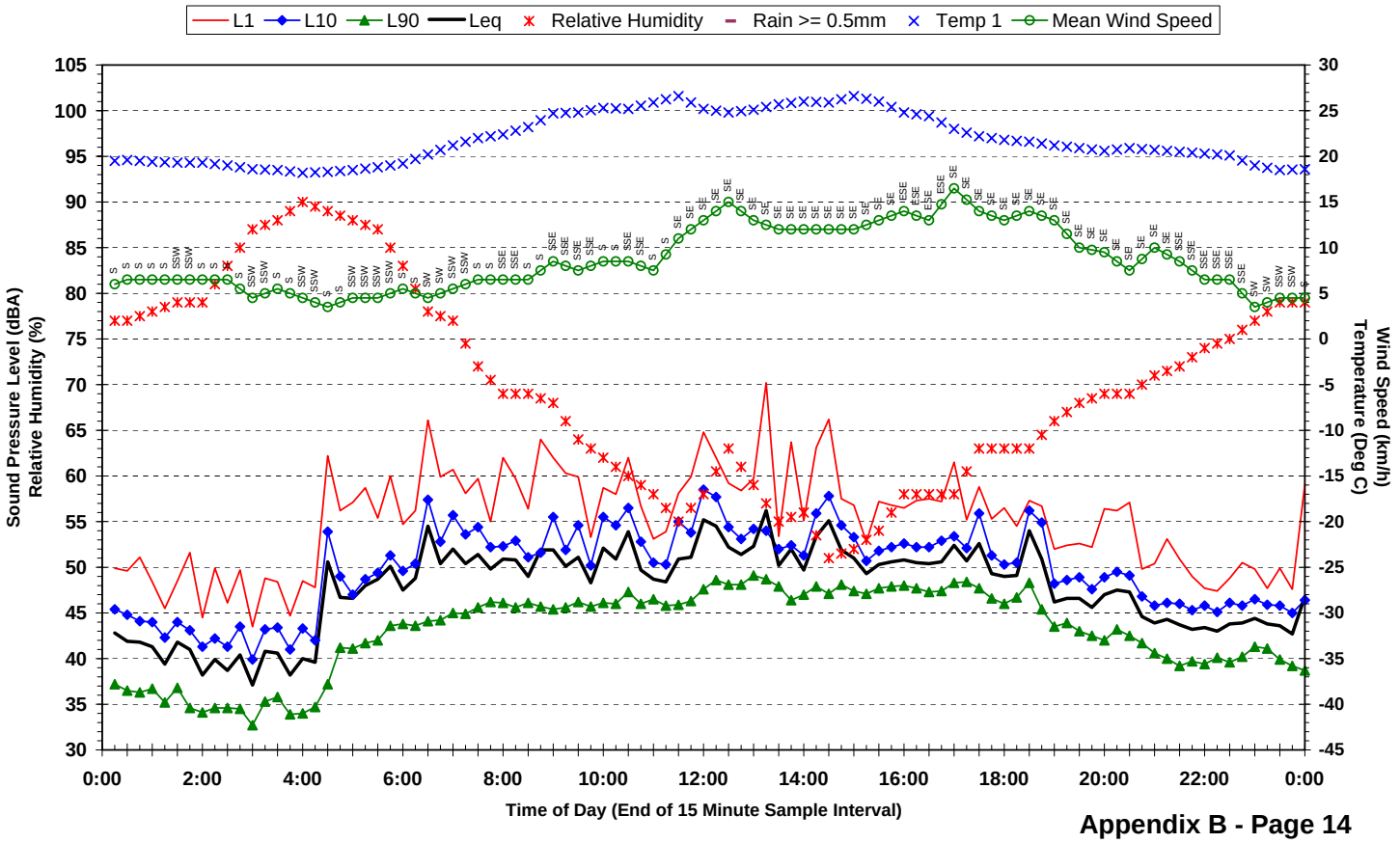
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Thursday 8 November 2007



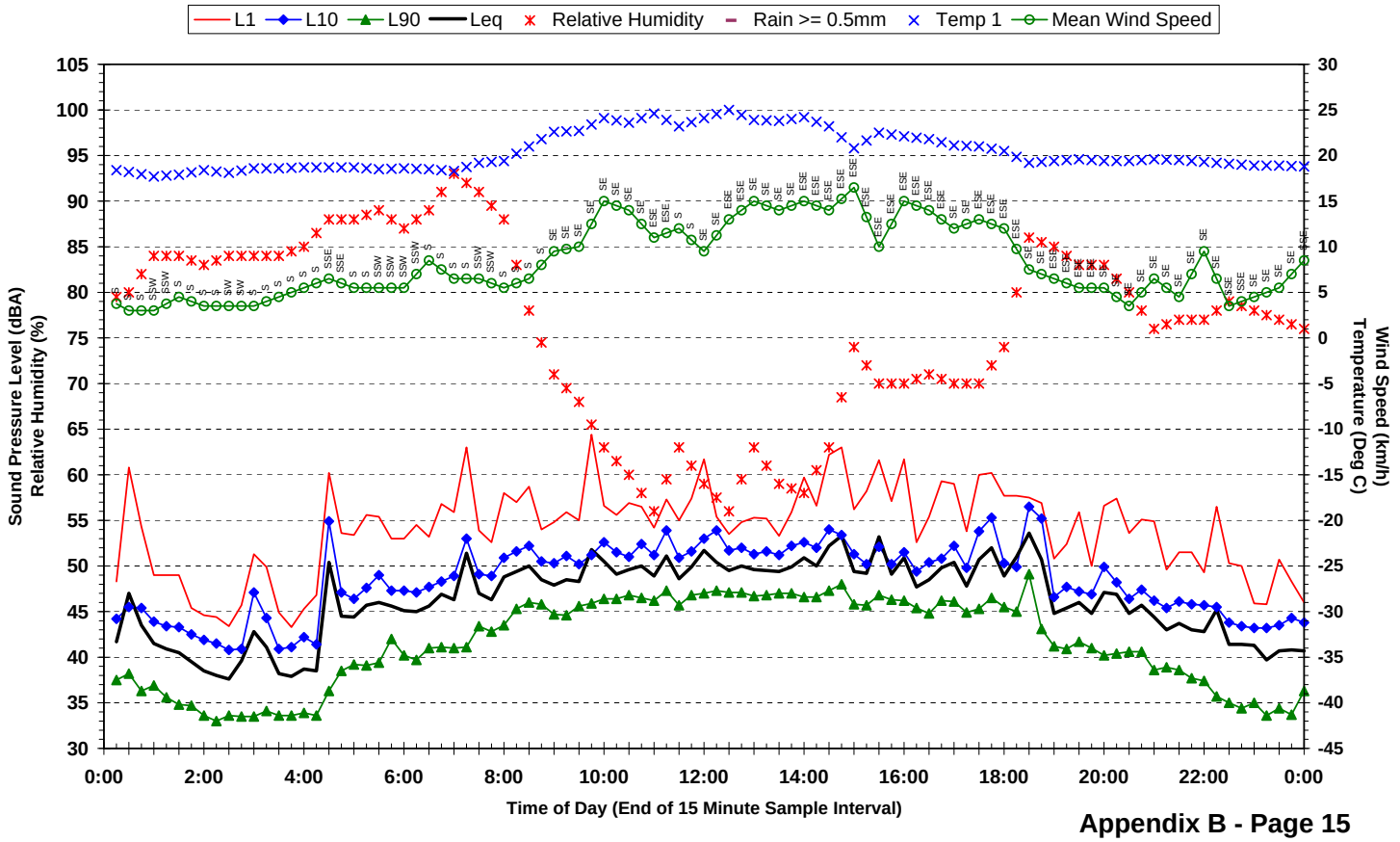
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Friday 9 November 2007



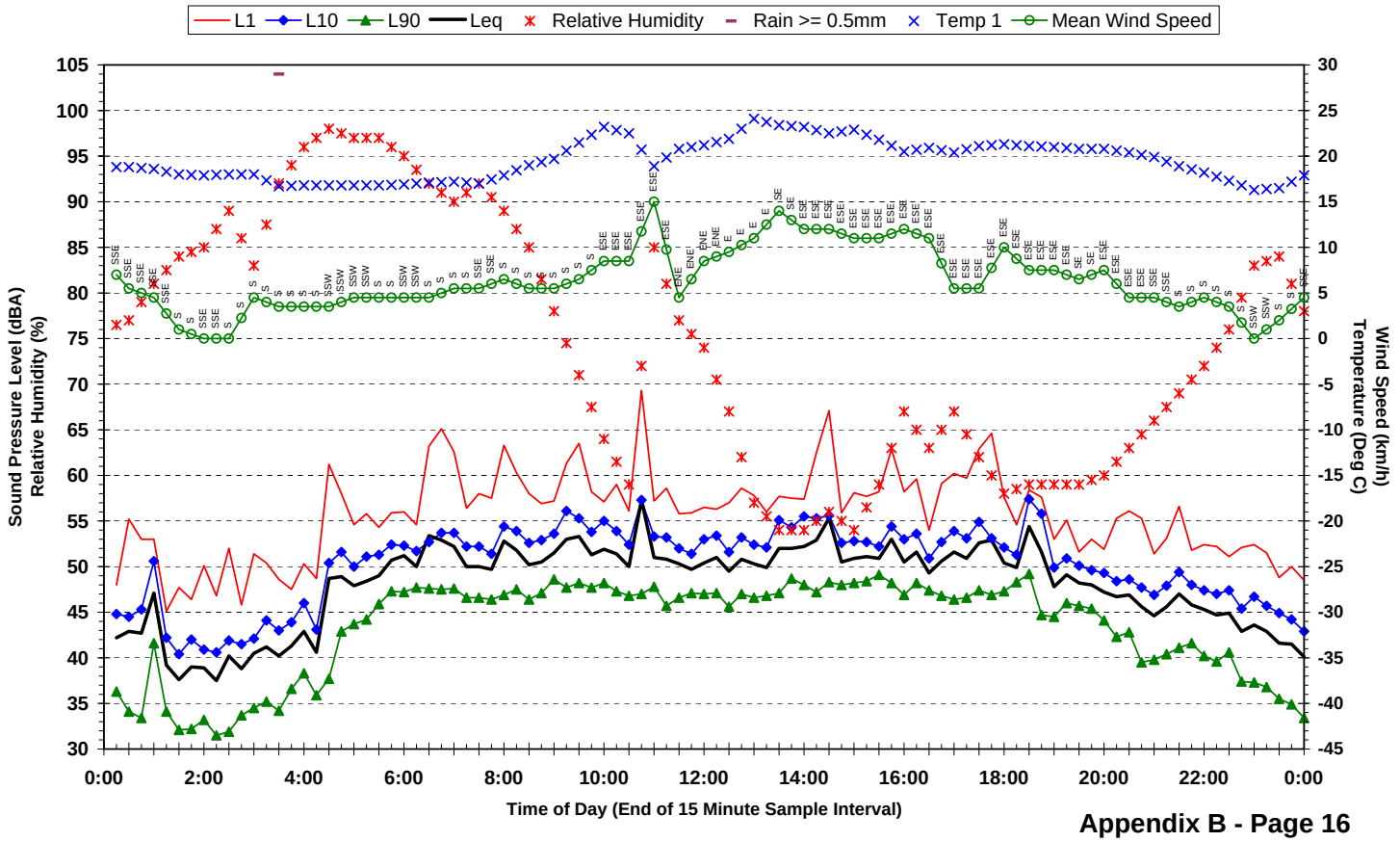
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Saturday 10 November 2007



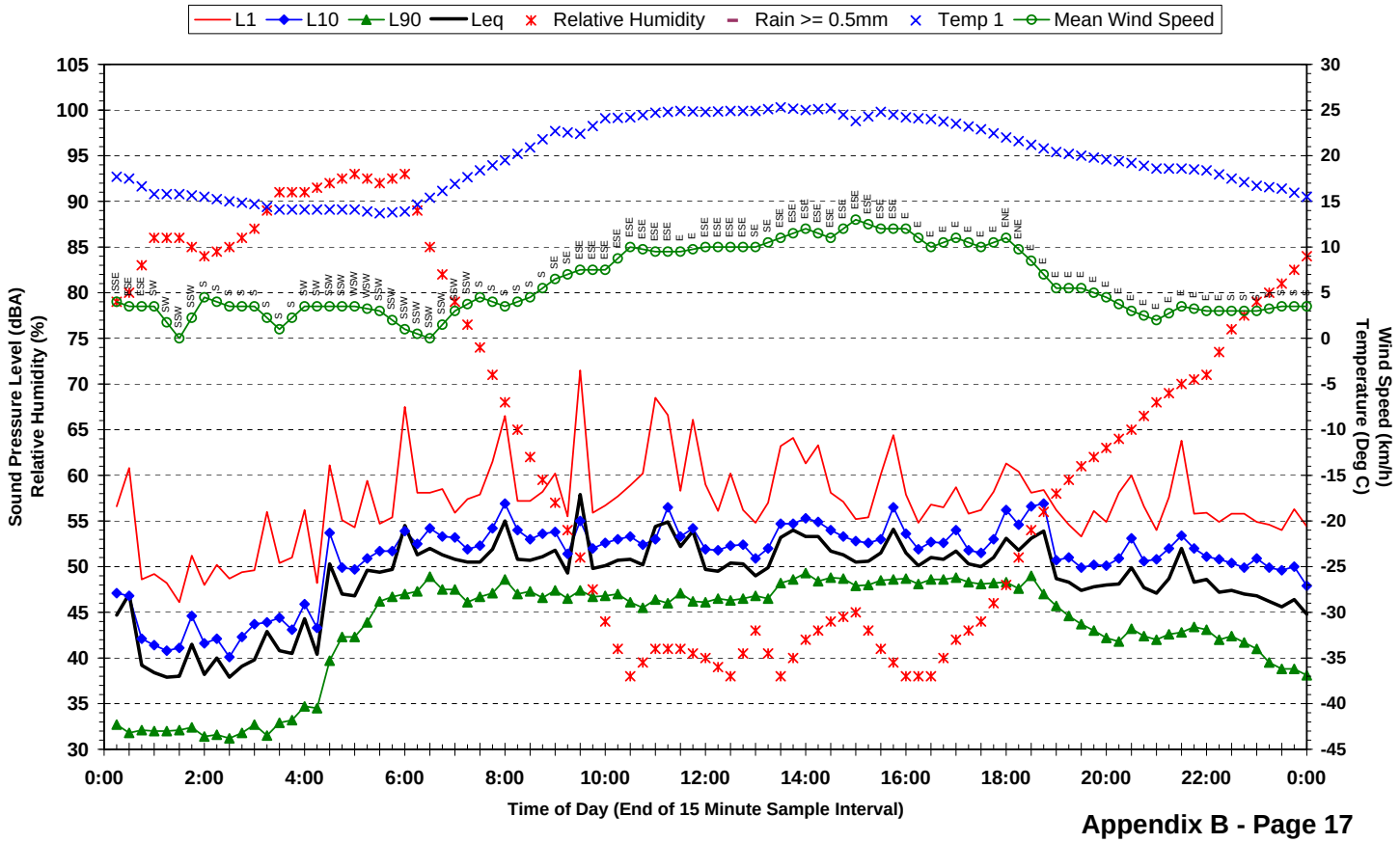
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Sunday 11 November 2007



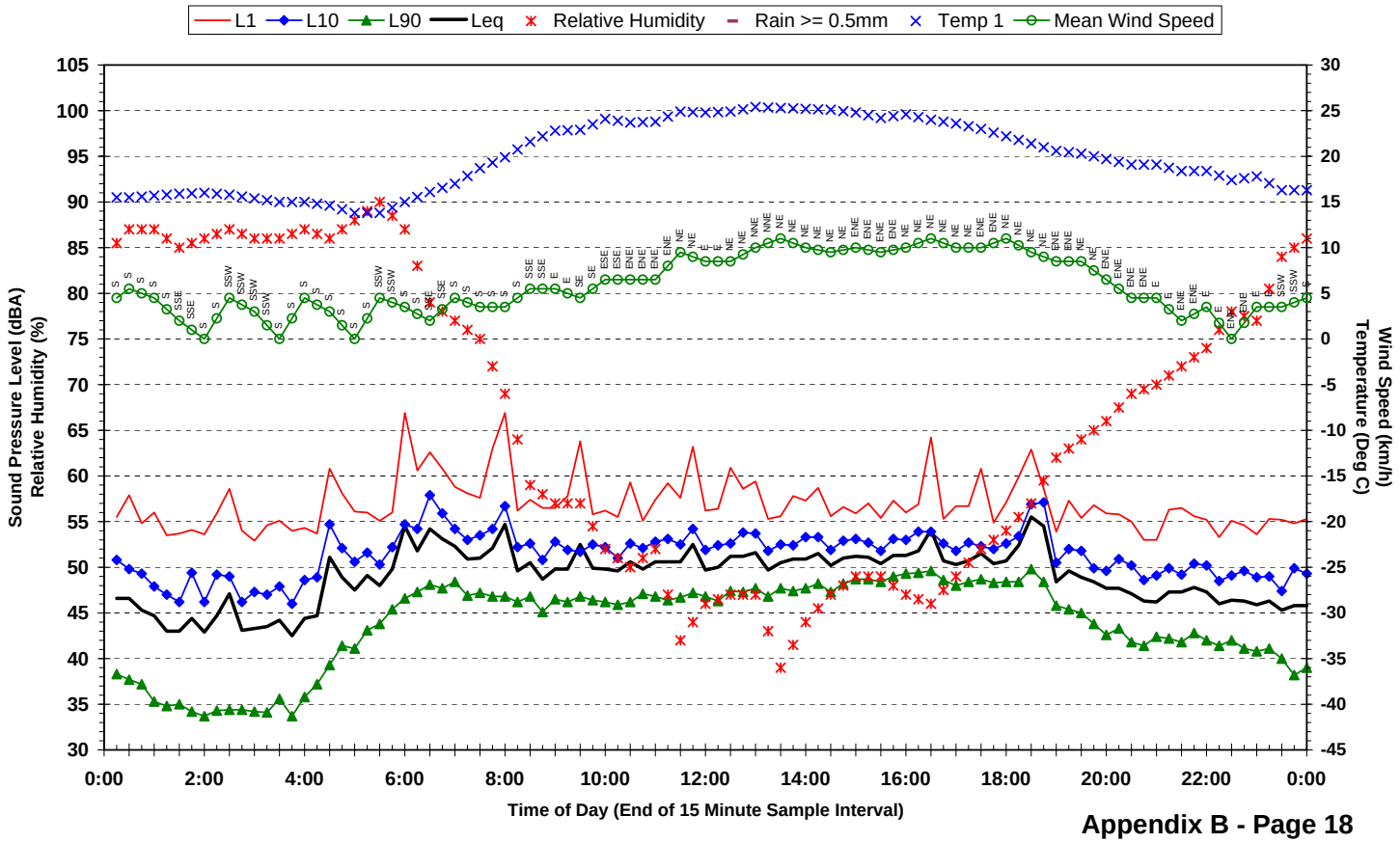
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Monday 12 November 2007



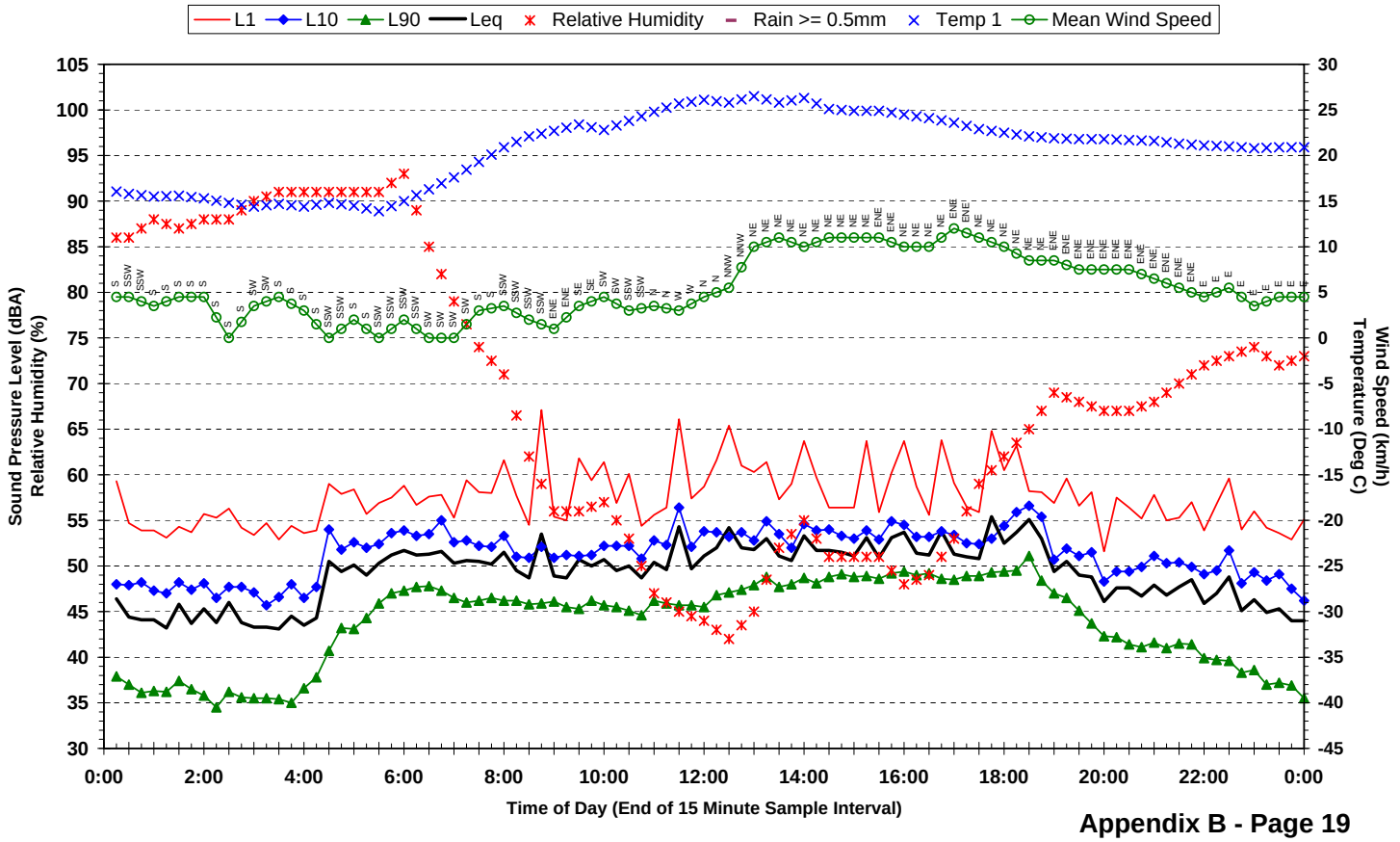
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Tuesday 13 November 2007



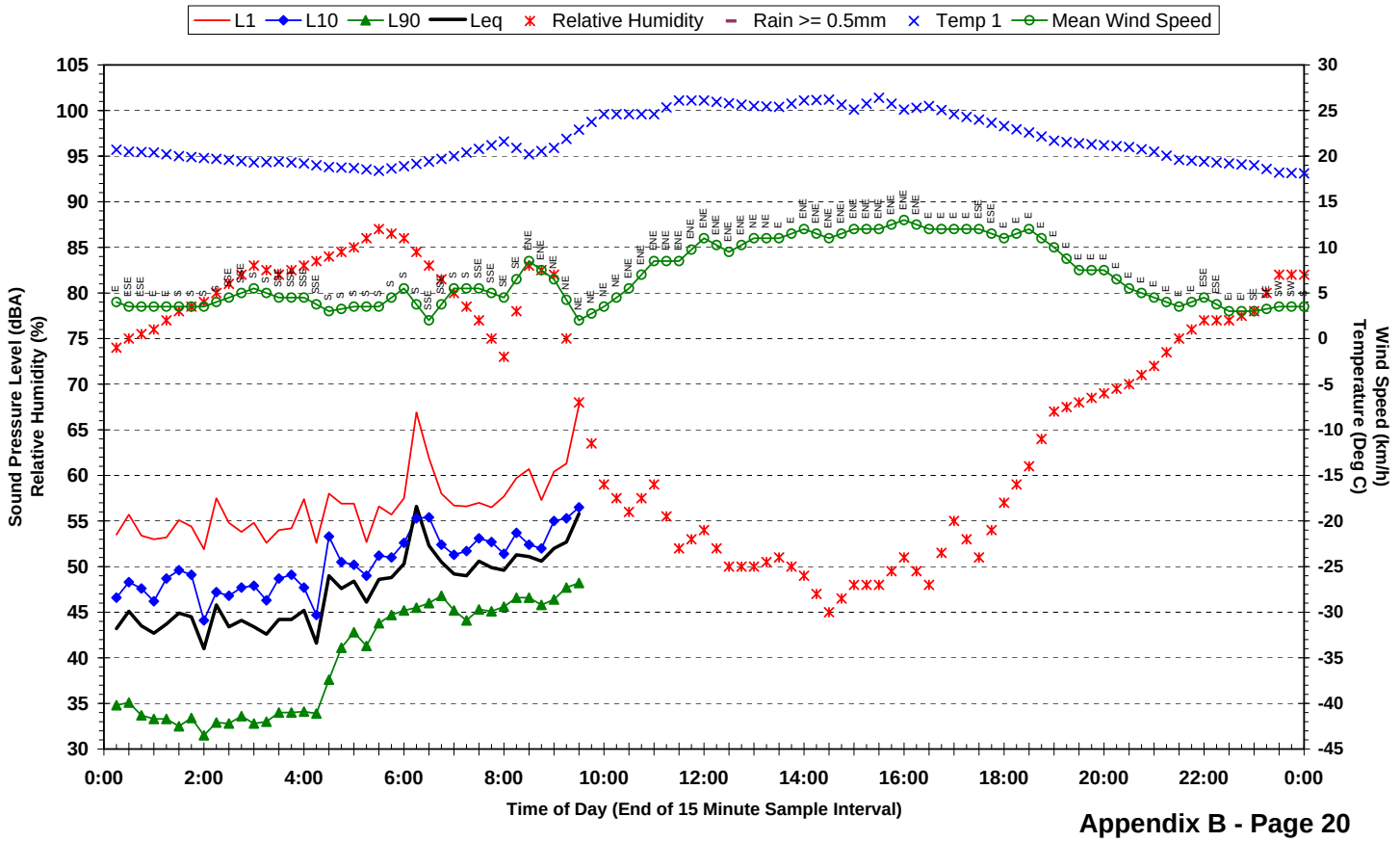
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Wednesday 14 November 2007



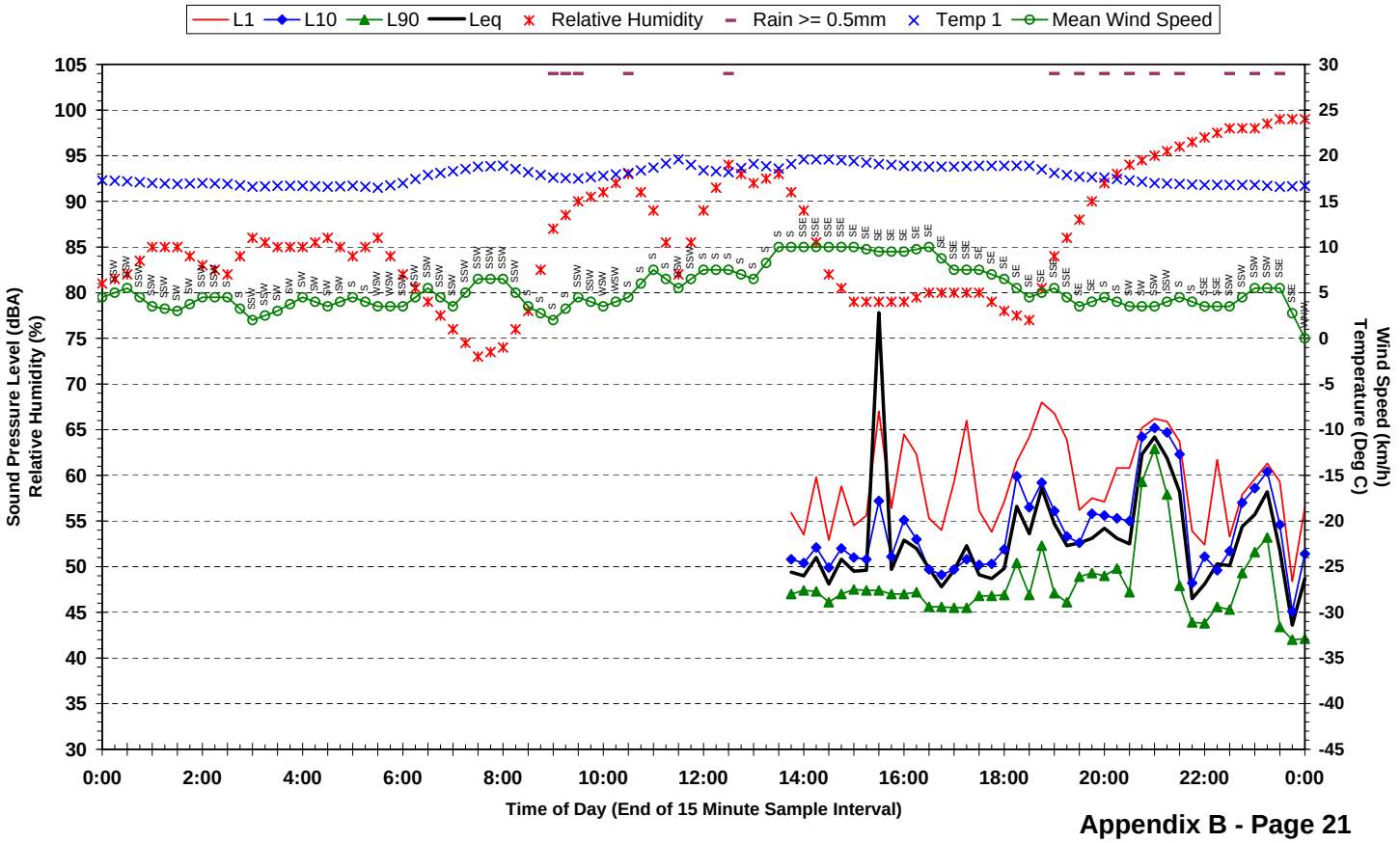
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Thursday 15 November 2007



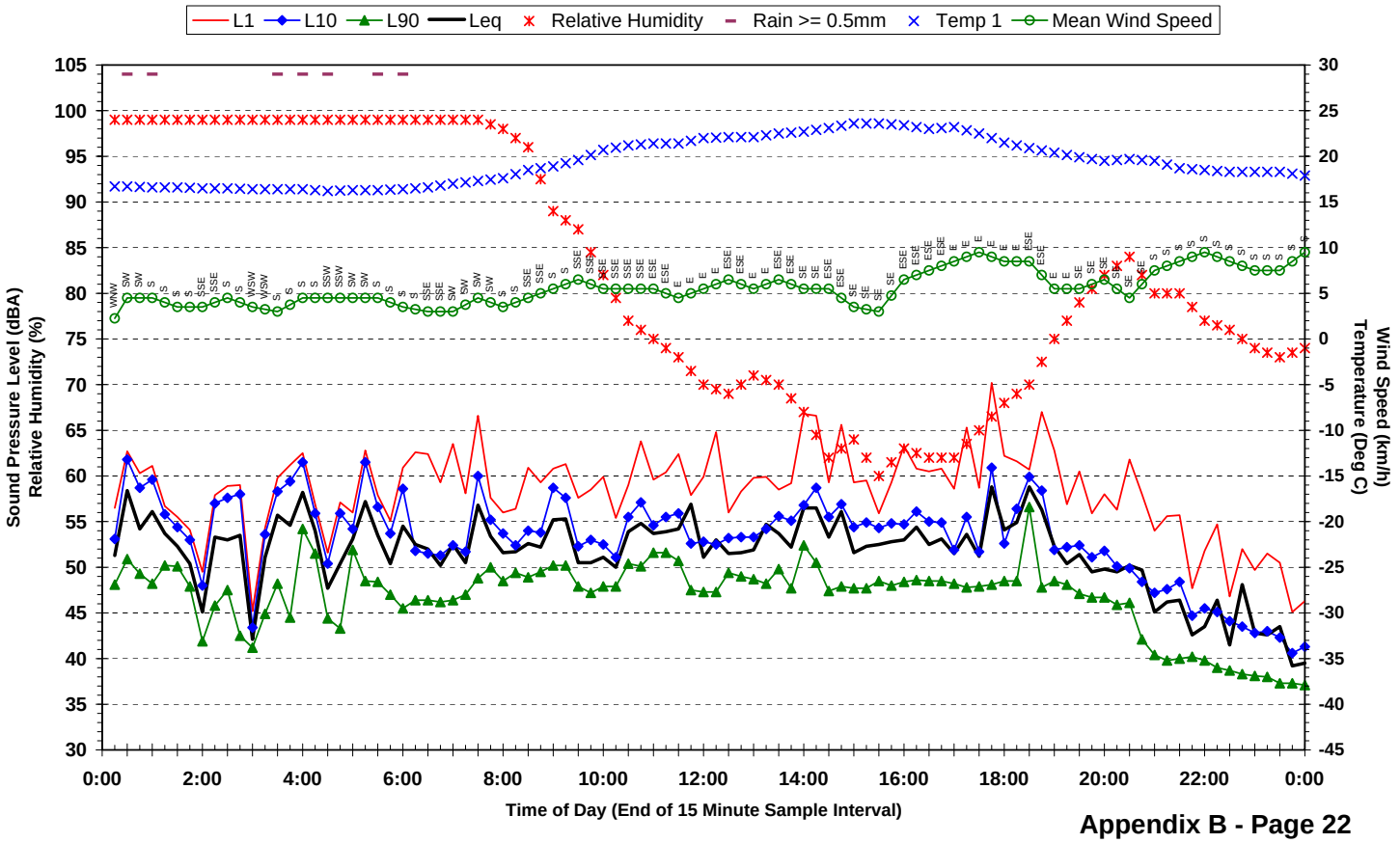
Statistical Ambient Noise Levels
Location 2 - 115 Elizabeth Street, Toowong - Friday 16 November 2007



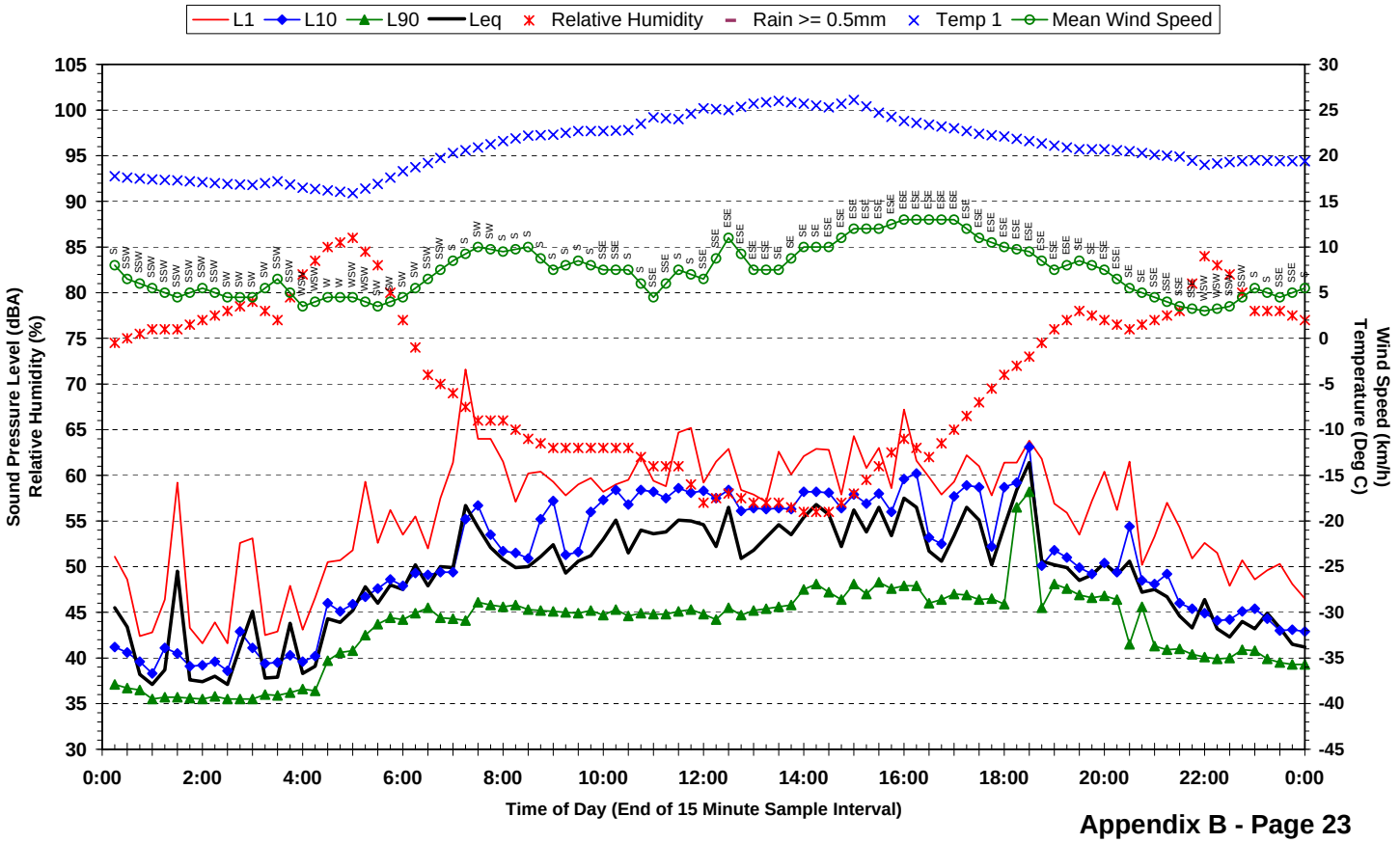
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Wednesday 7 November 2007



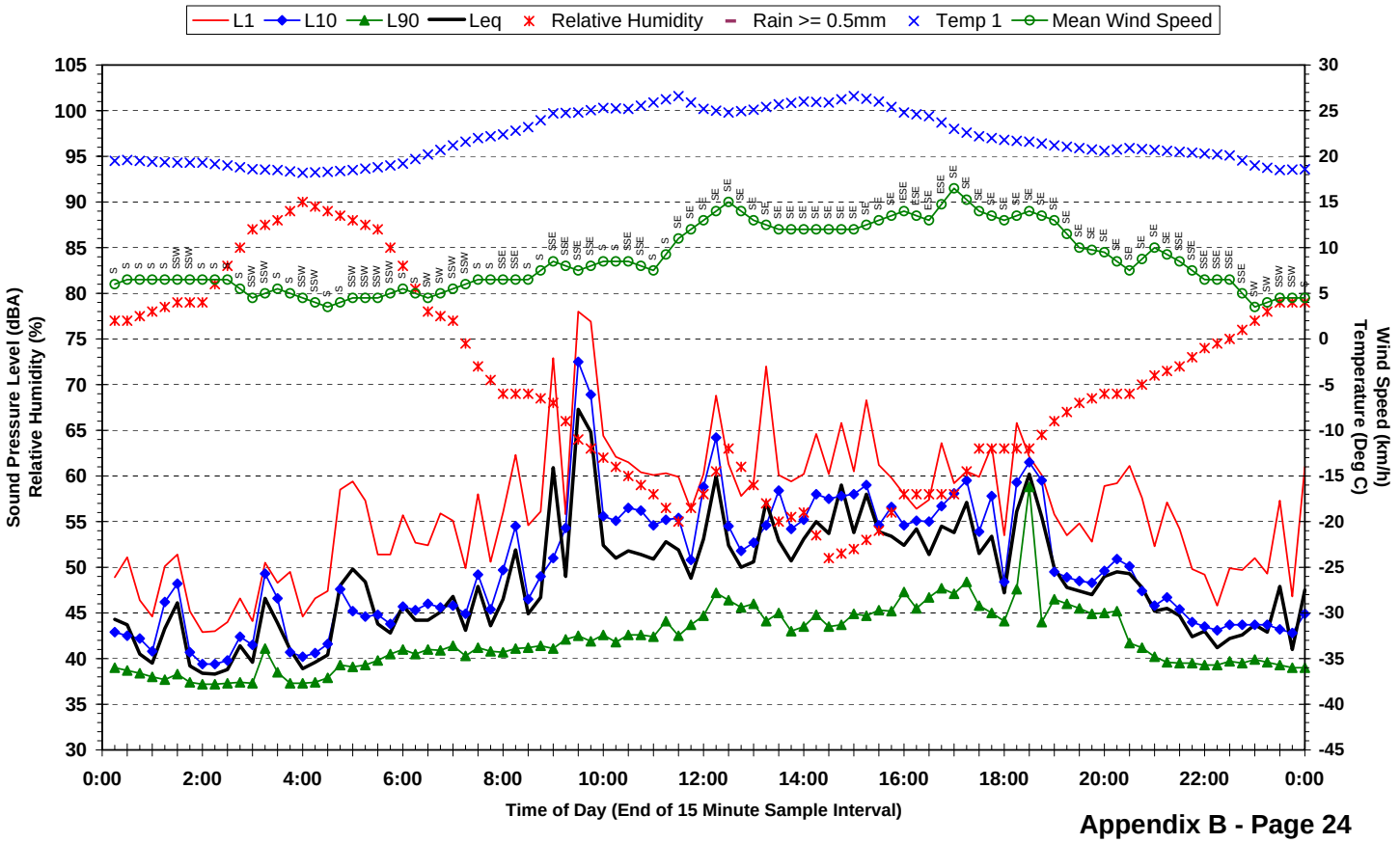
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Thursday 8 November 2007



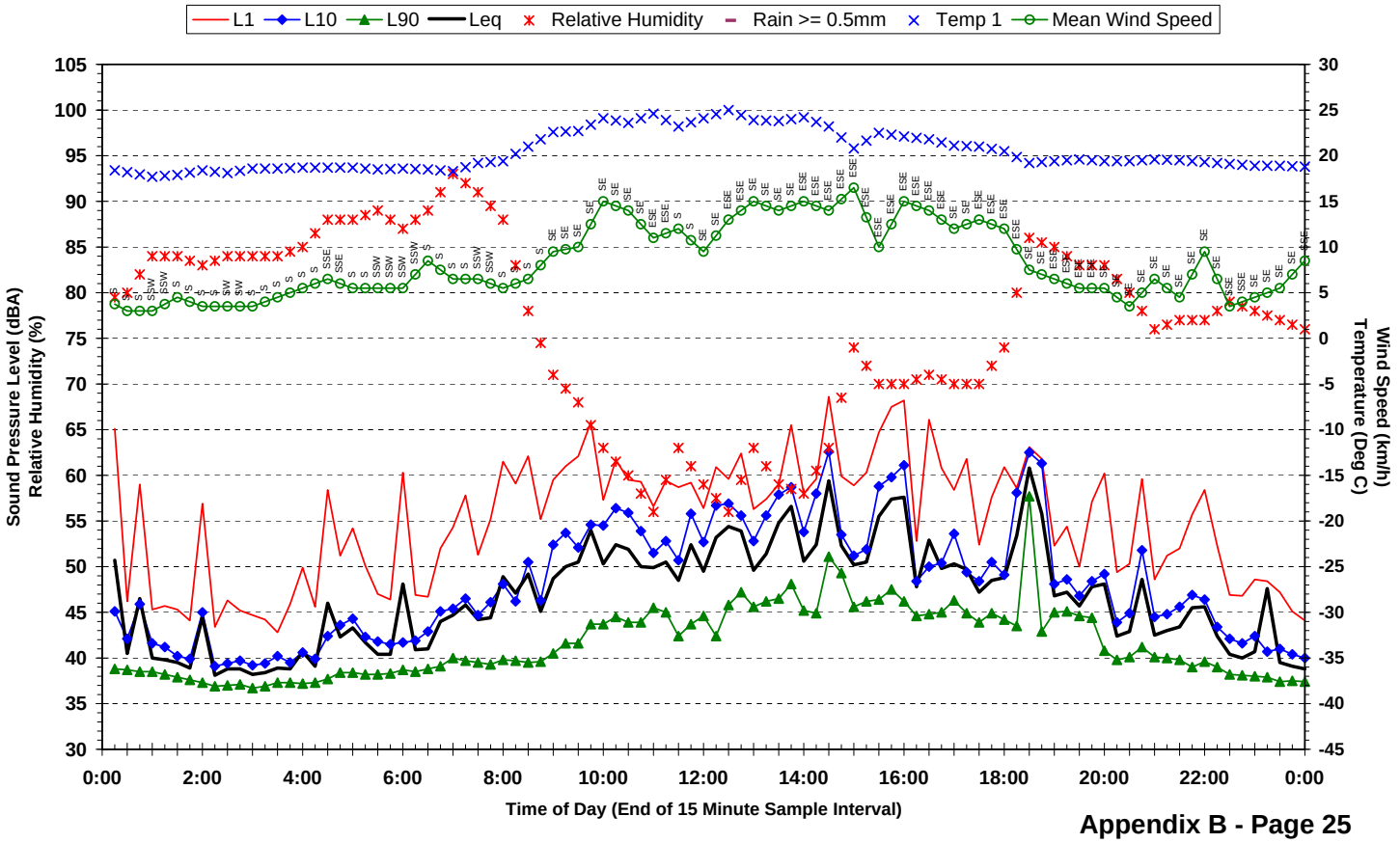
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Friday 9 November 2007



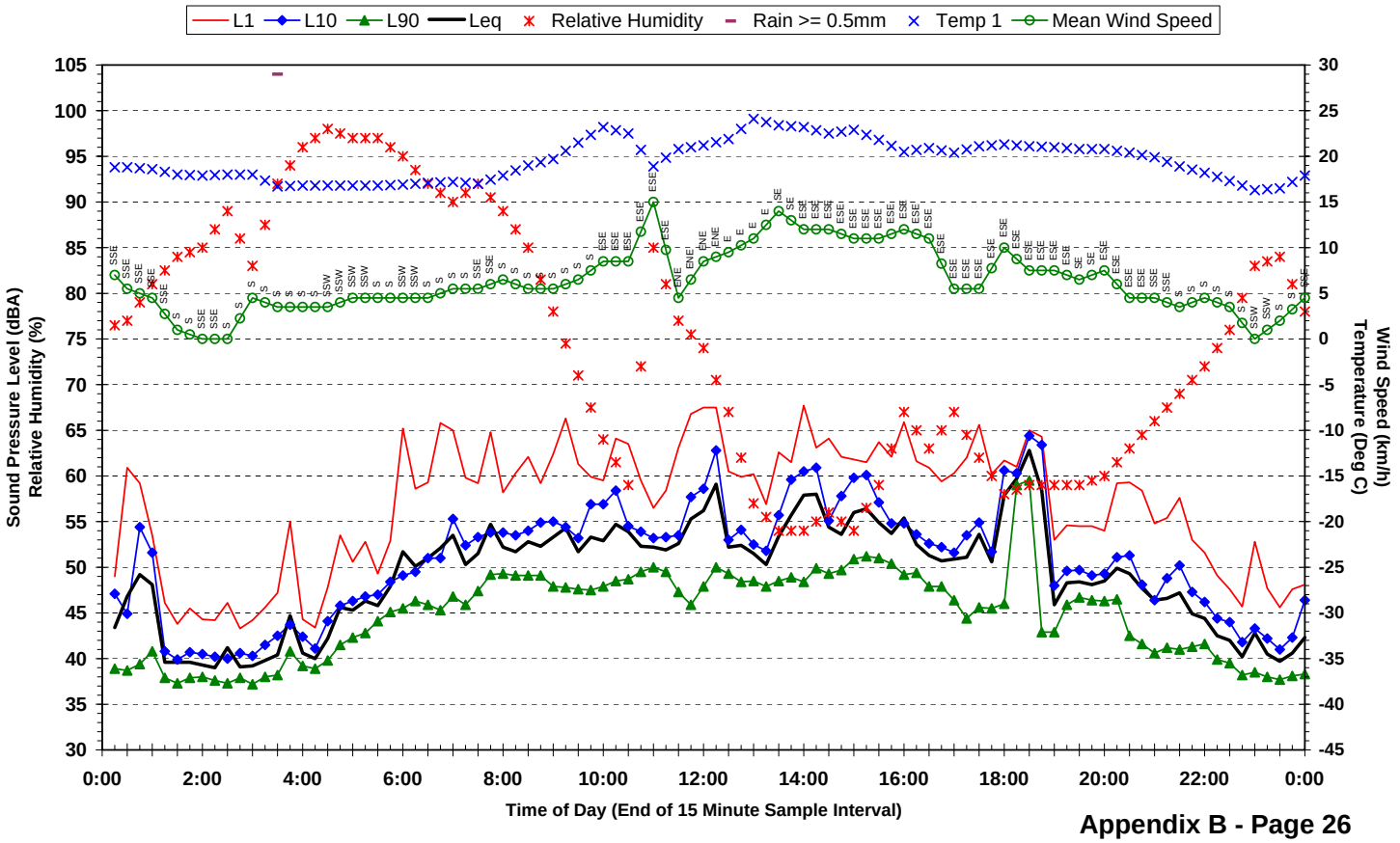
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Saturday 10 November 2007



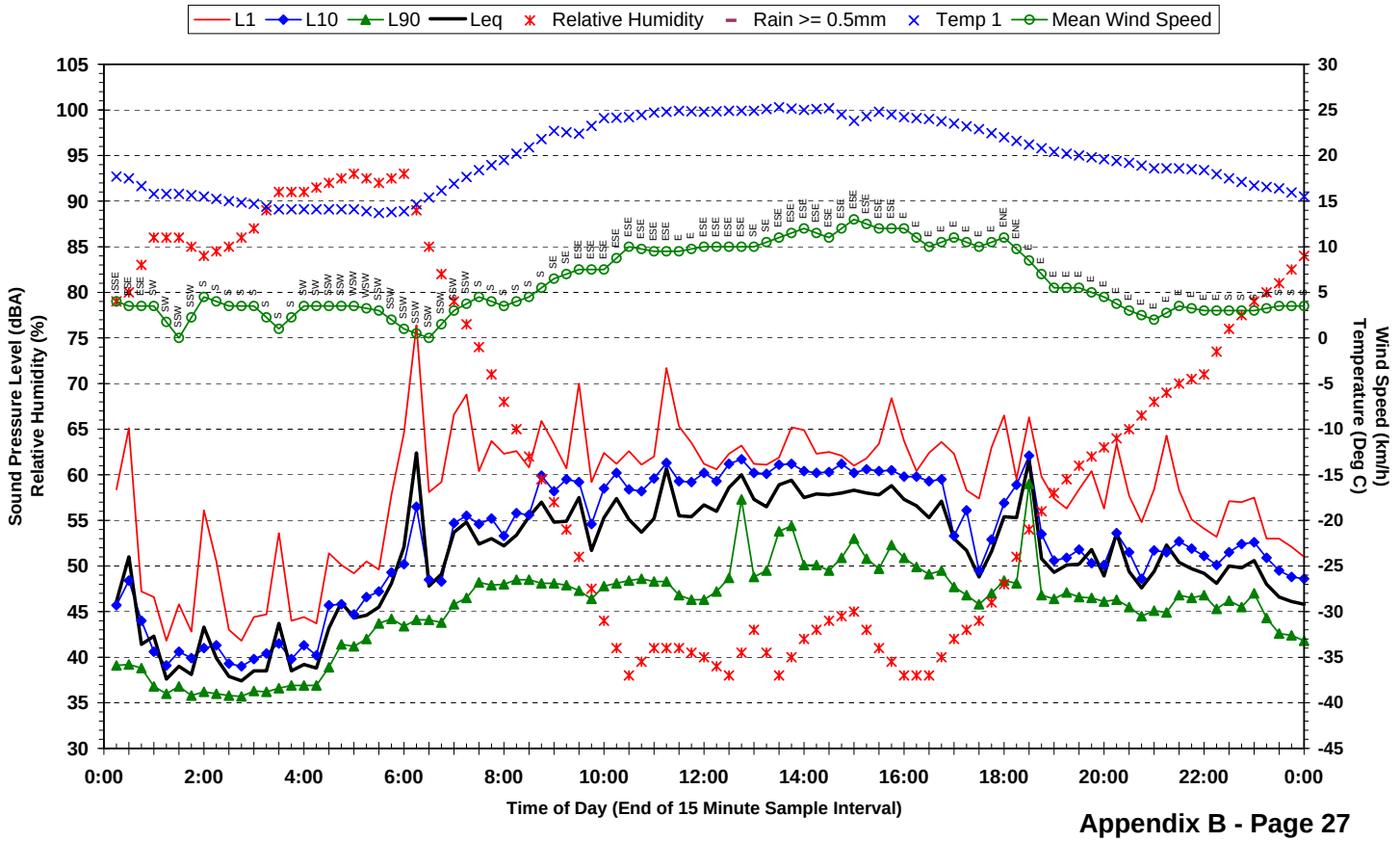
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Sunday 11 November 2007



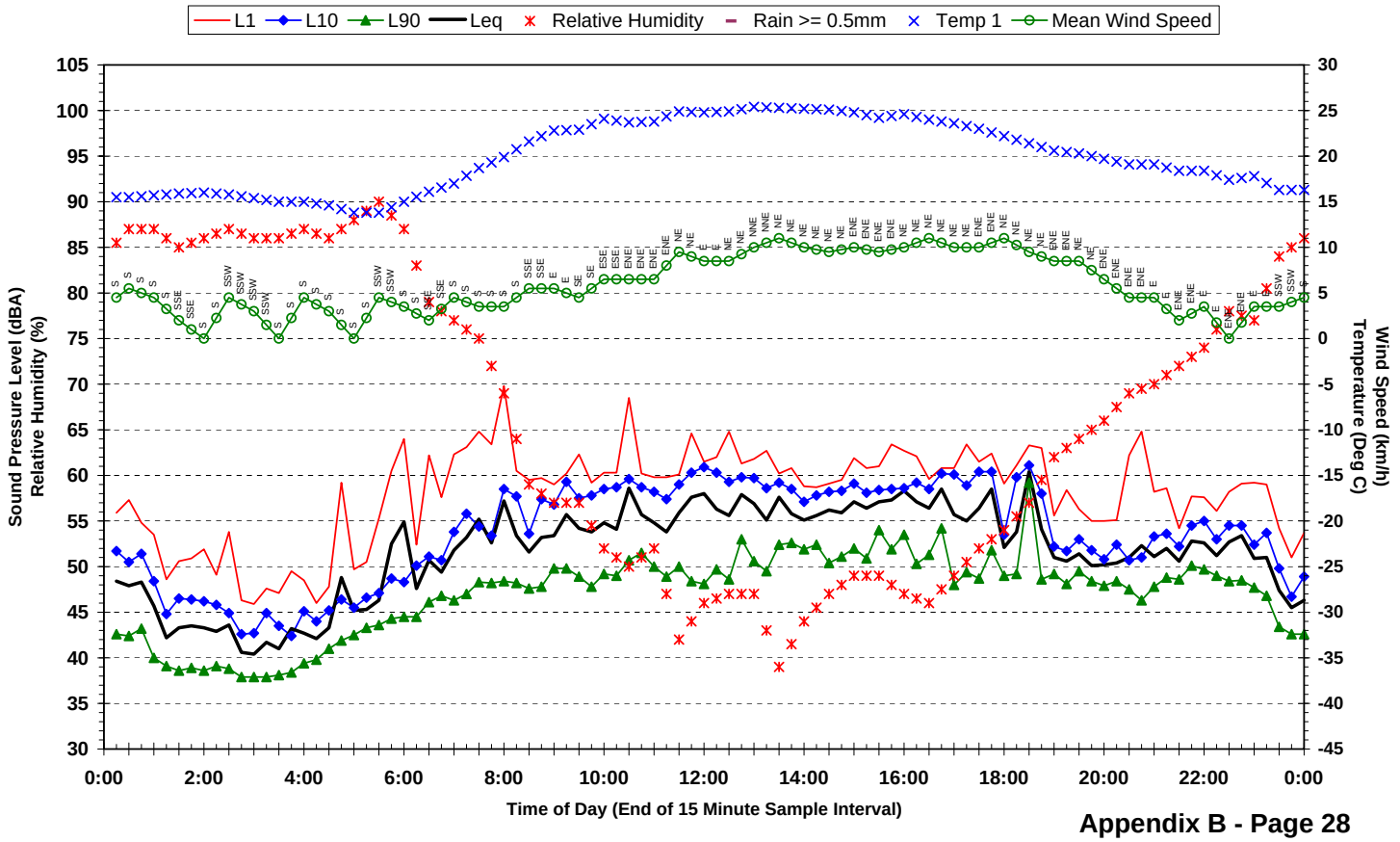
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Monday 12 November 2007



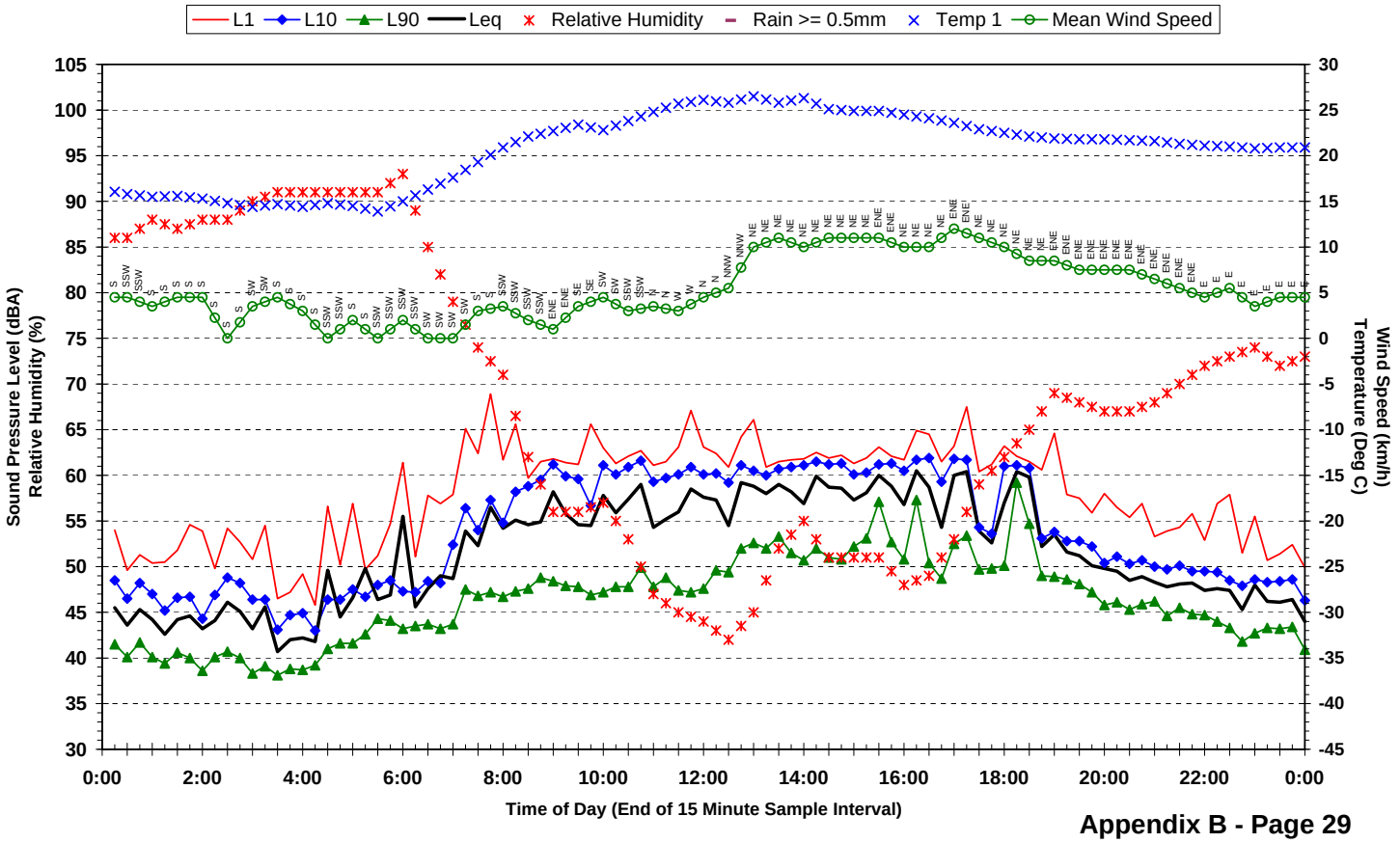
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Tuesday 13 November 2007



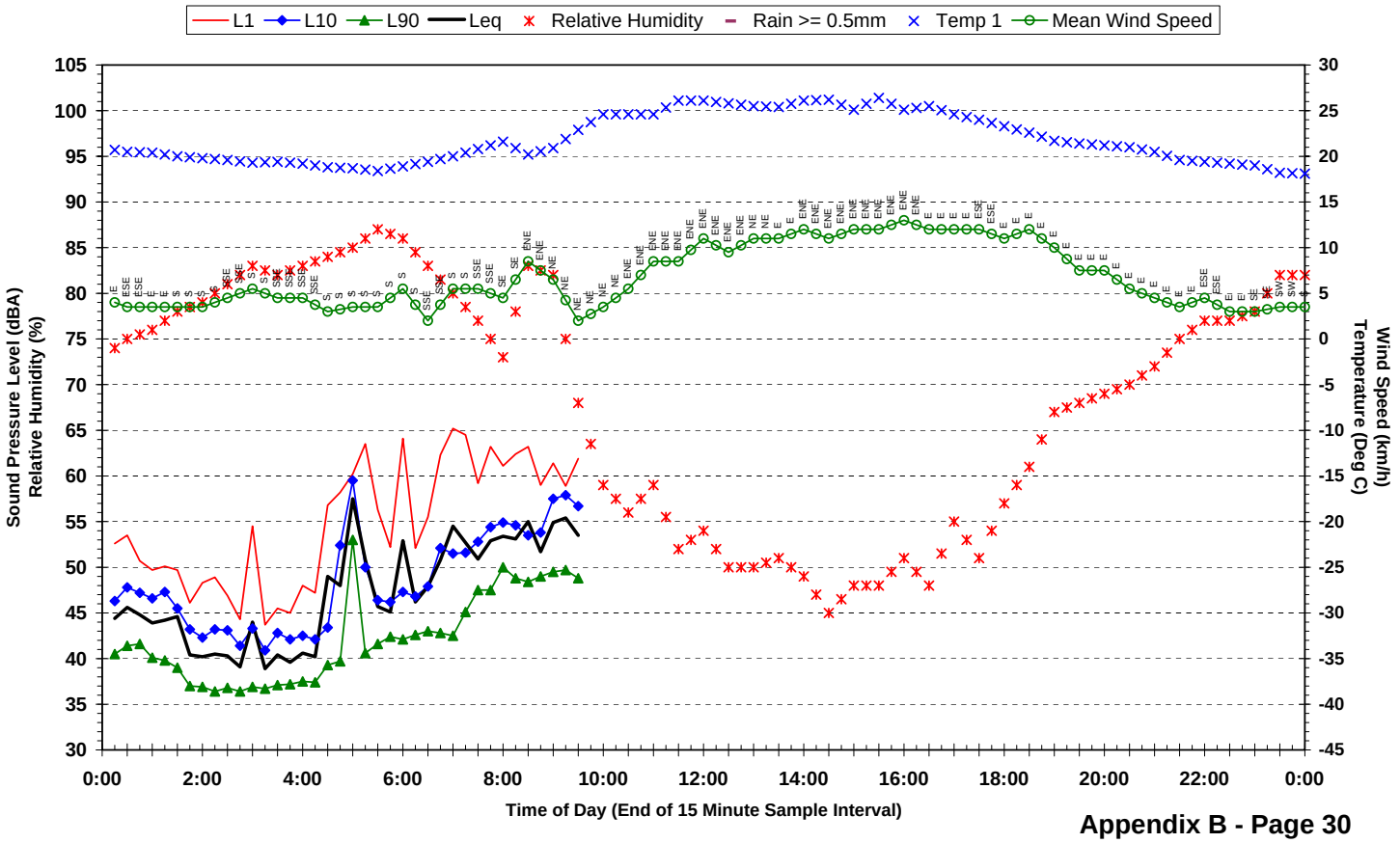
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Wednesday 14 November 2007



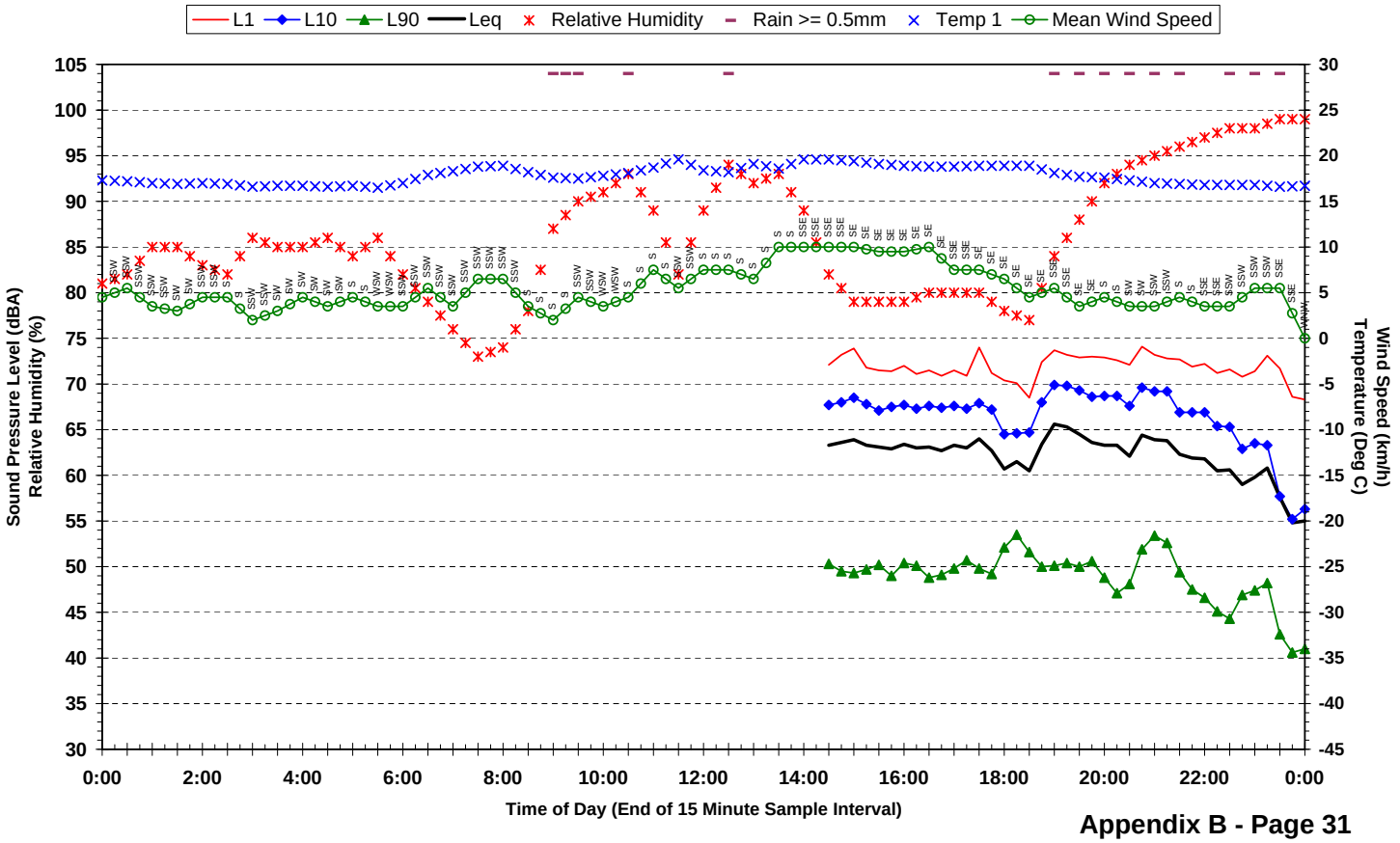
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Thursday 15 November 2007



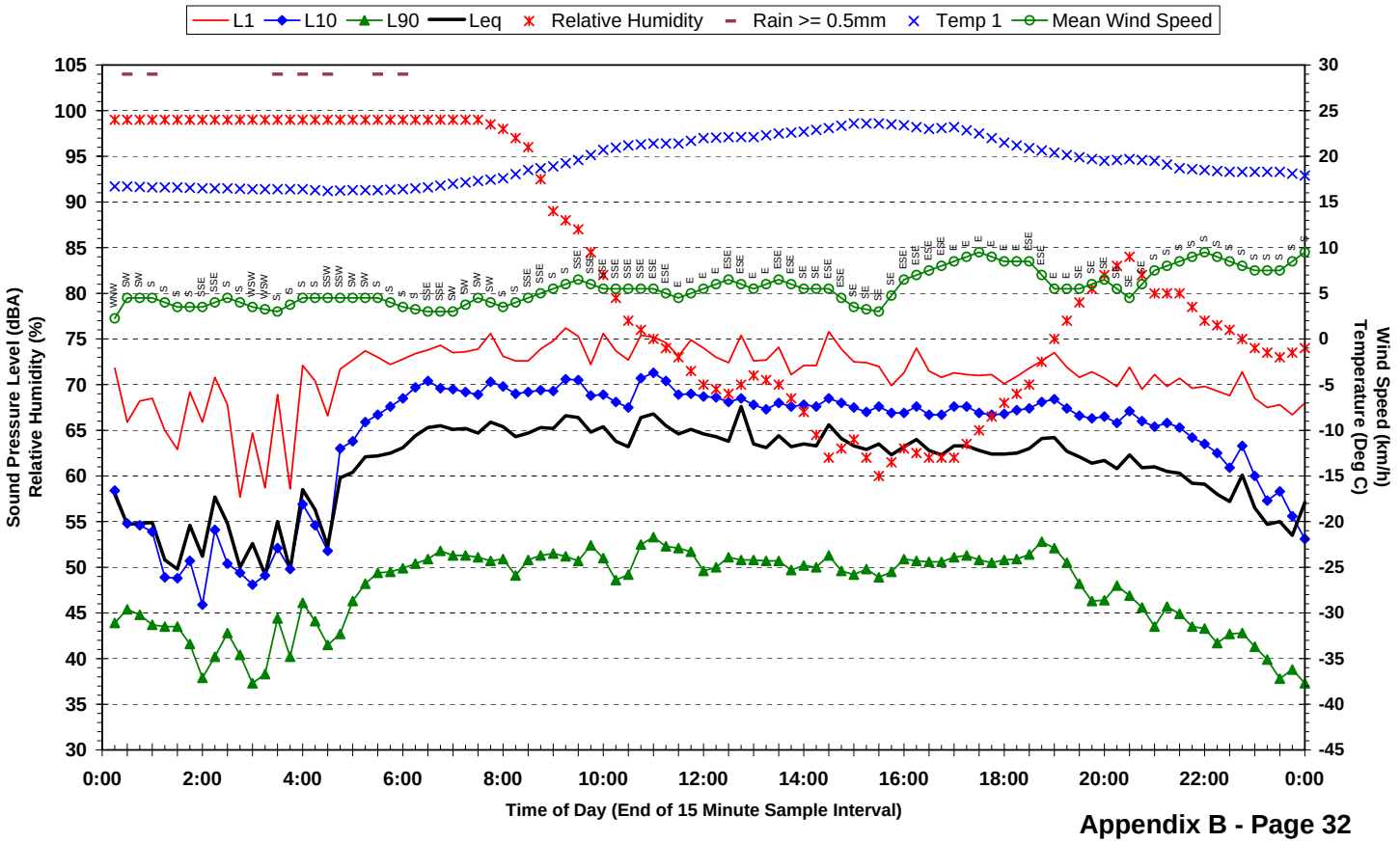
Statistical Ambient Noise Levels
Location 3 - 6 Wool Street, Toowong - Friday 16 November 2007



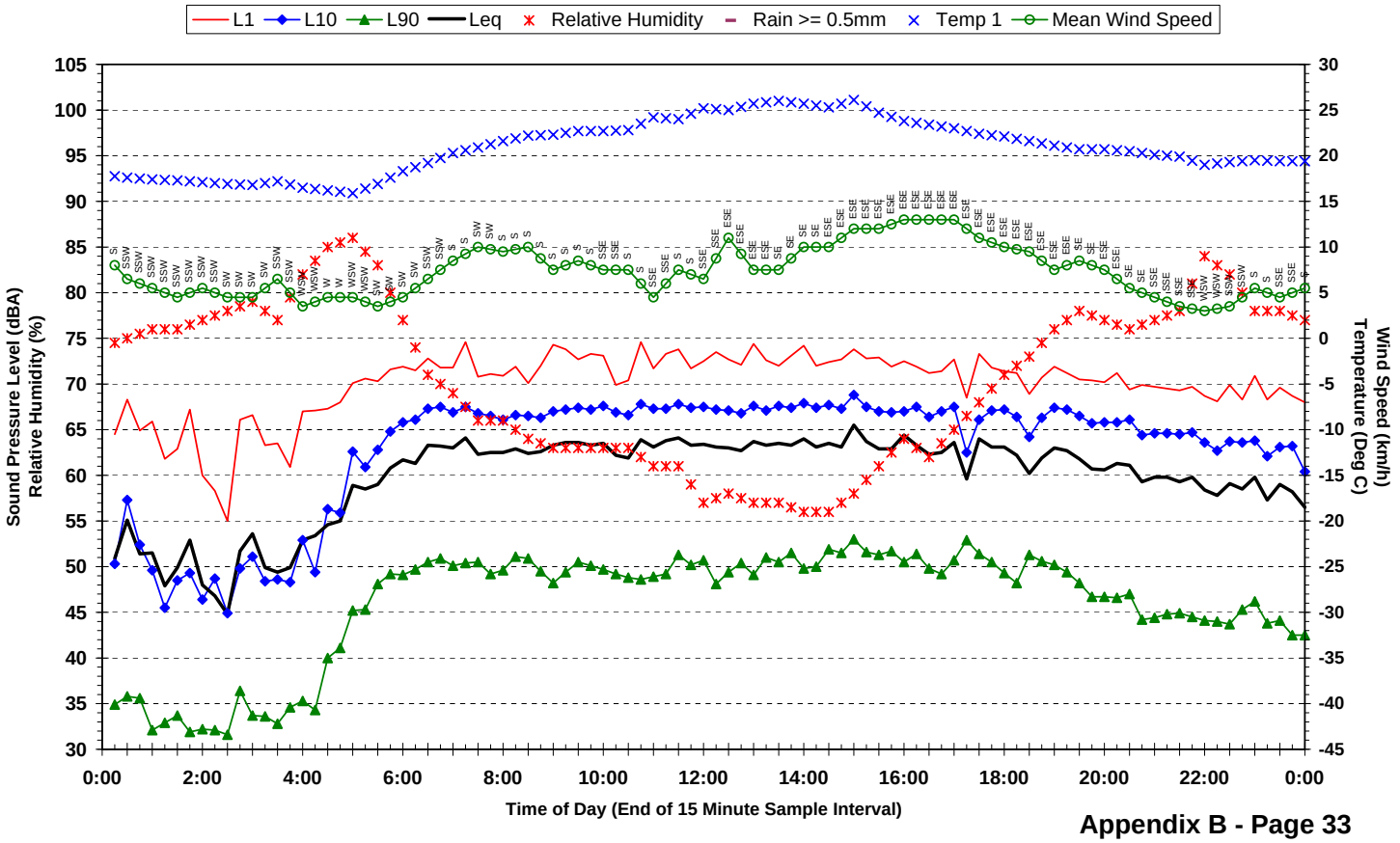
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Wednesday 7 November 2007



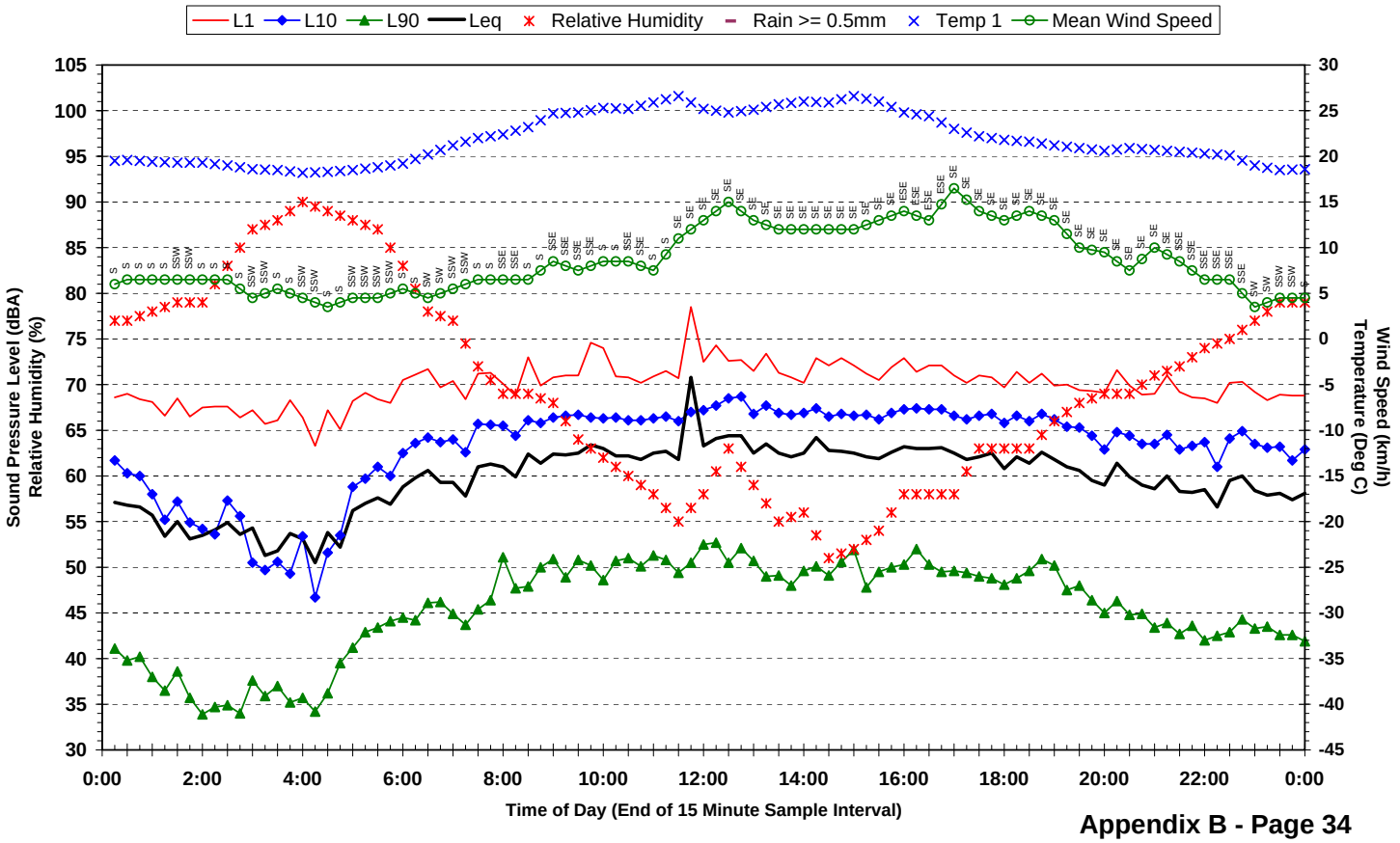
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Thursday 8 November 2007



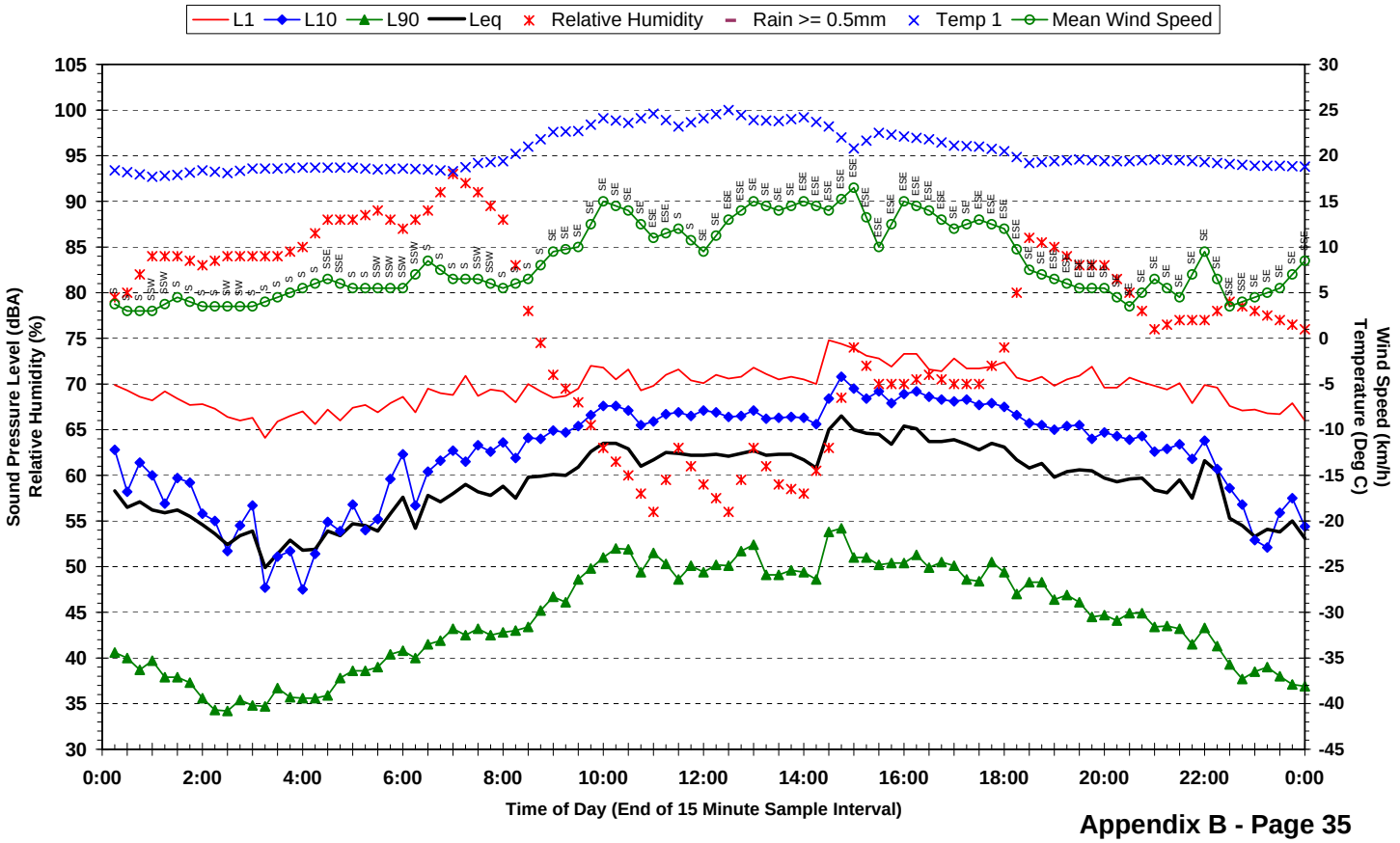
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Friday 9 November 2007



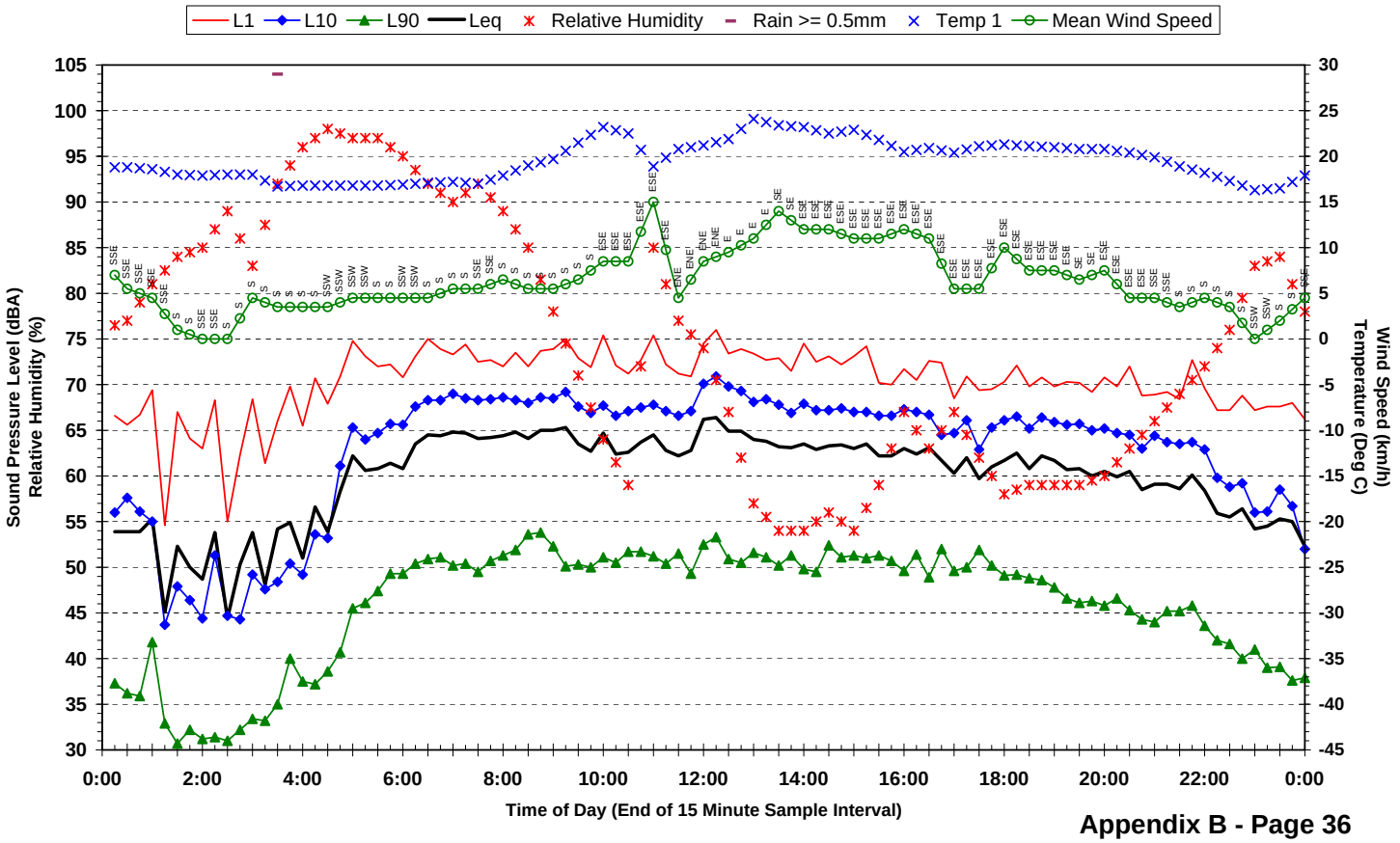
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Saturday 10 November 2007



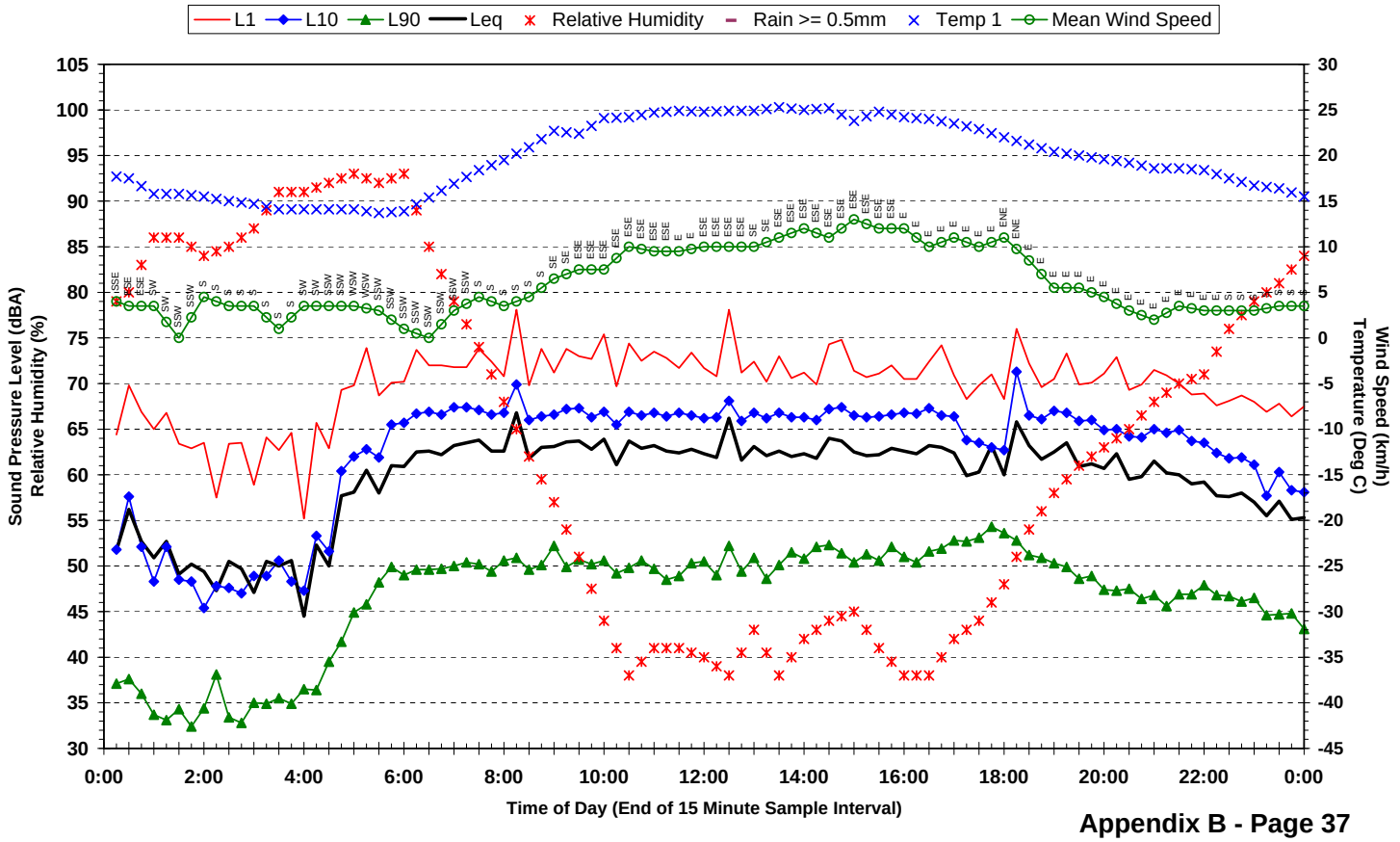
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Sunday 11 November 2007



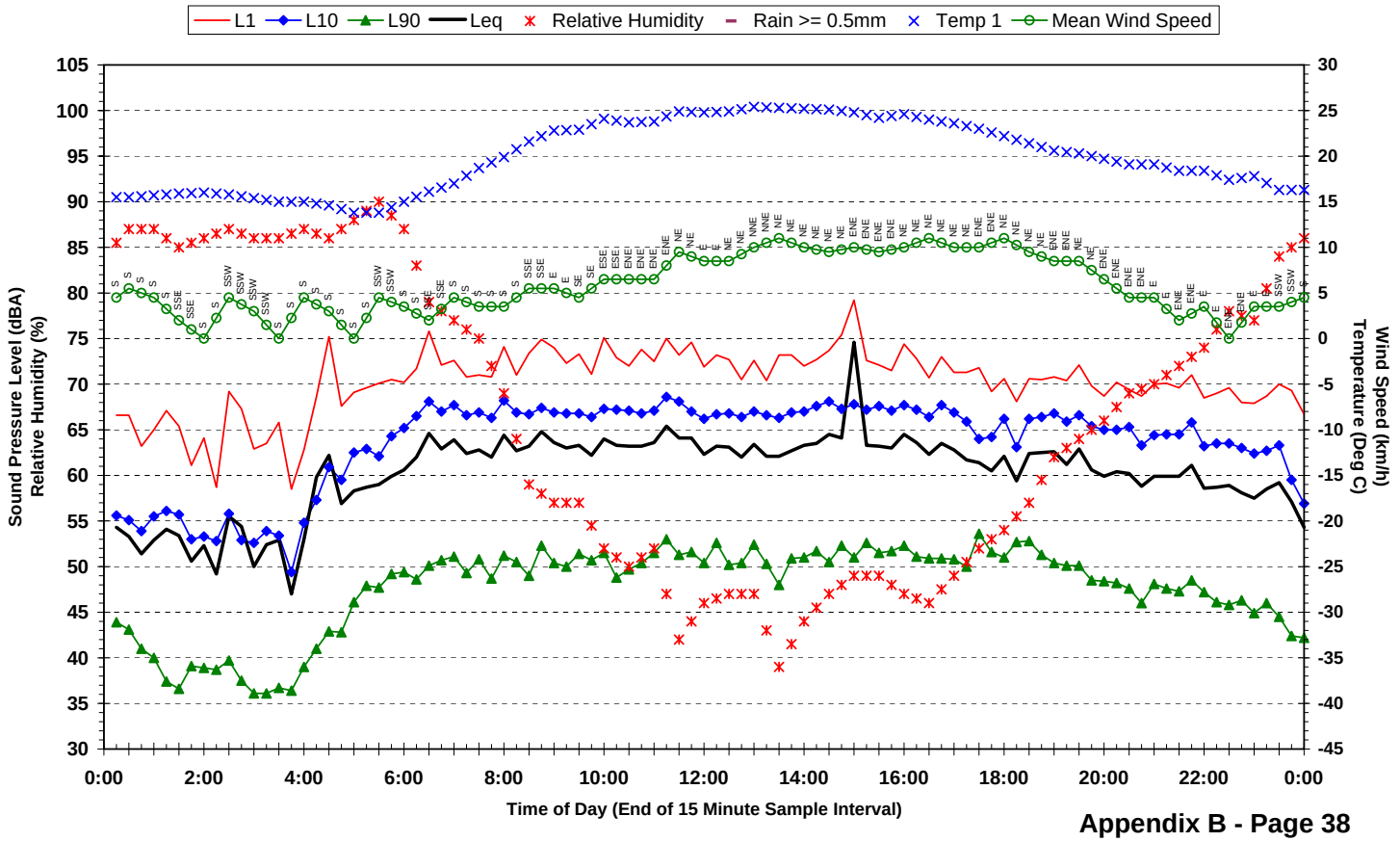
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Monday 12 November 2007



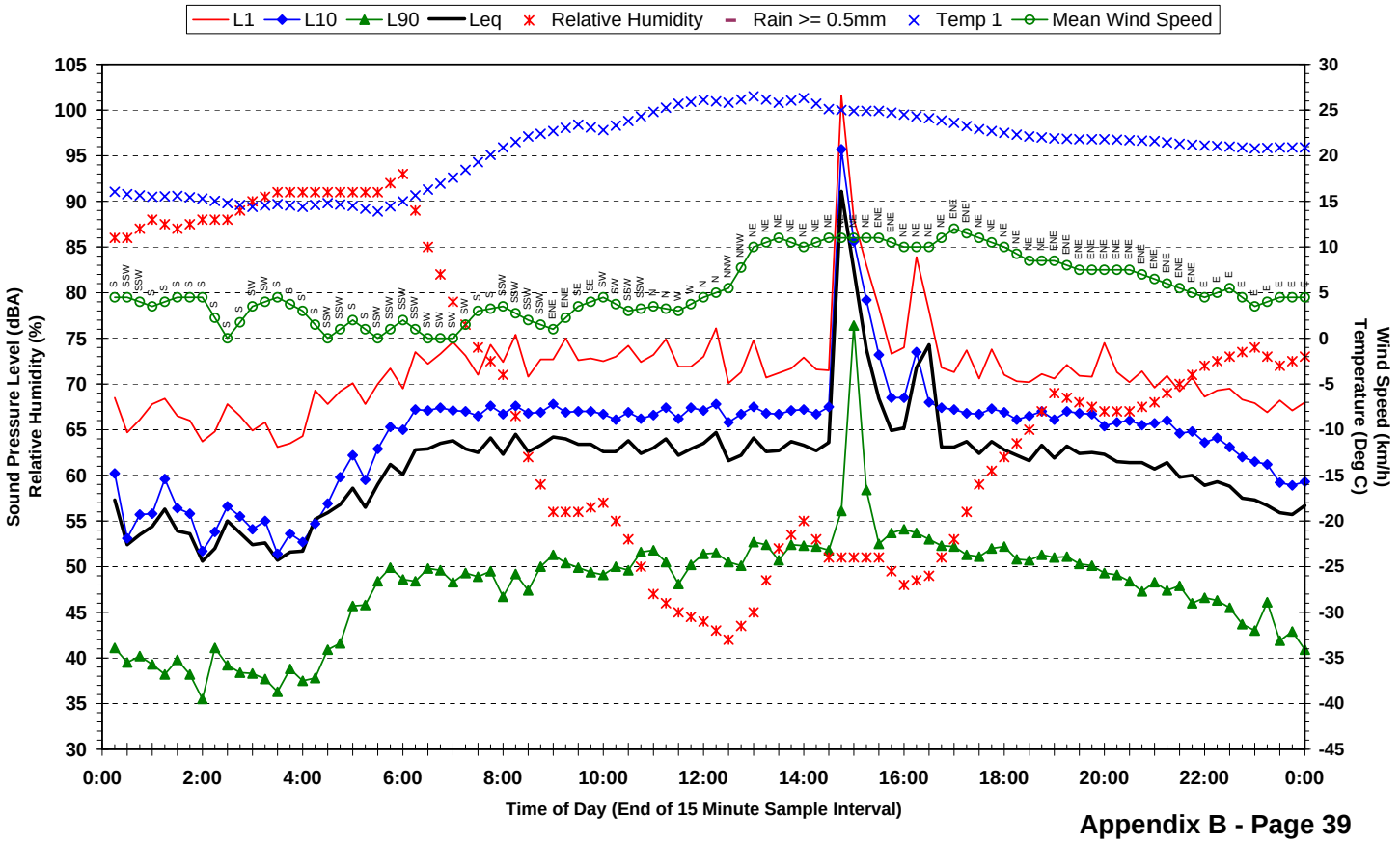
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Tuesday 13 November 2007



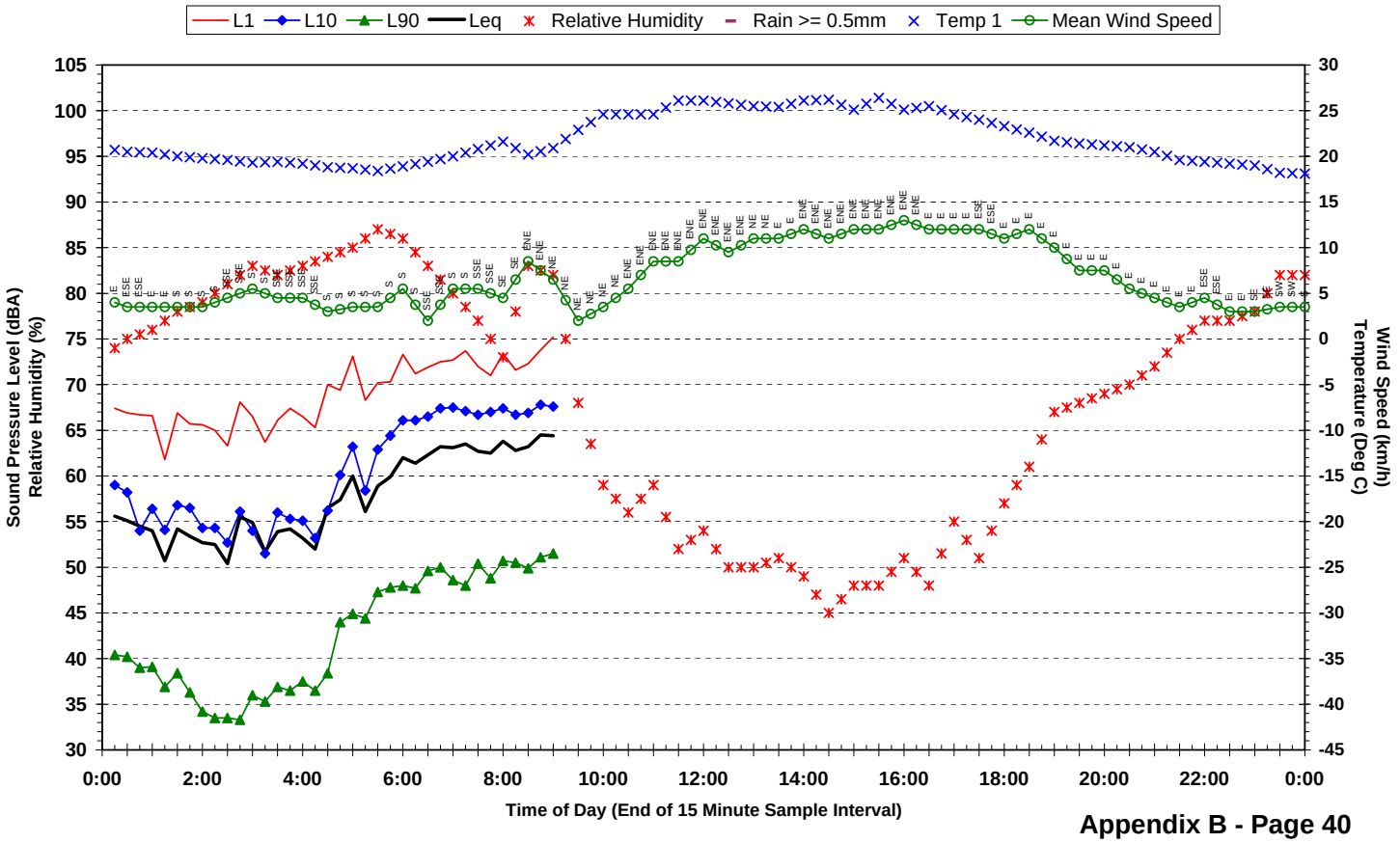
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Wednesday 14 November 2007



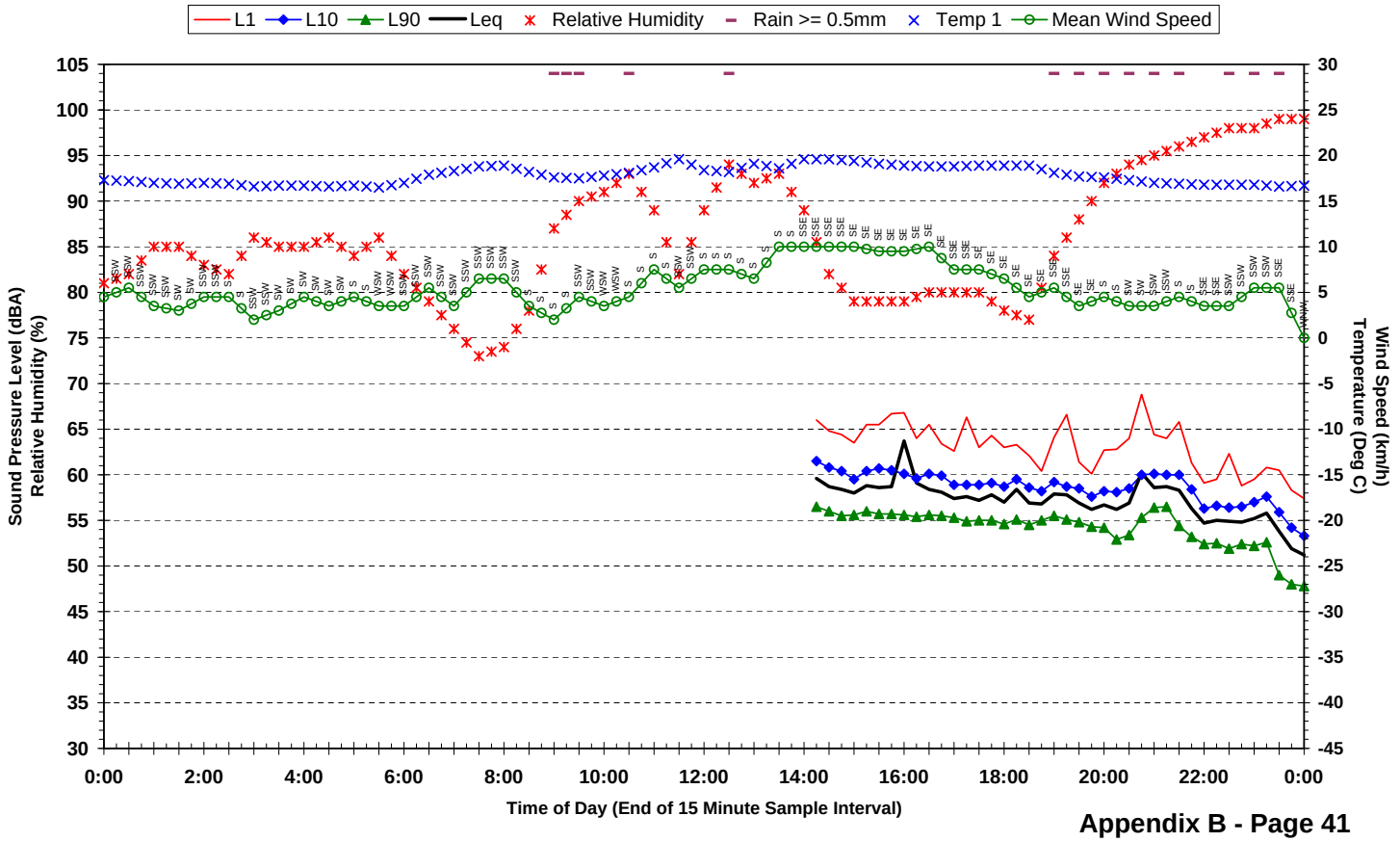
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Thursday 15 November 2007



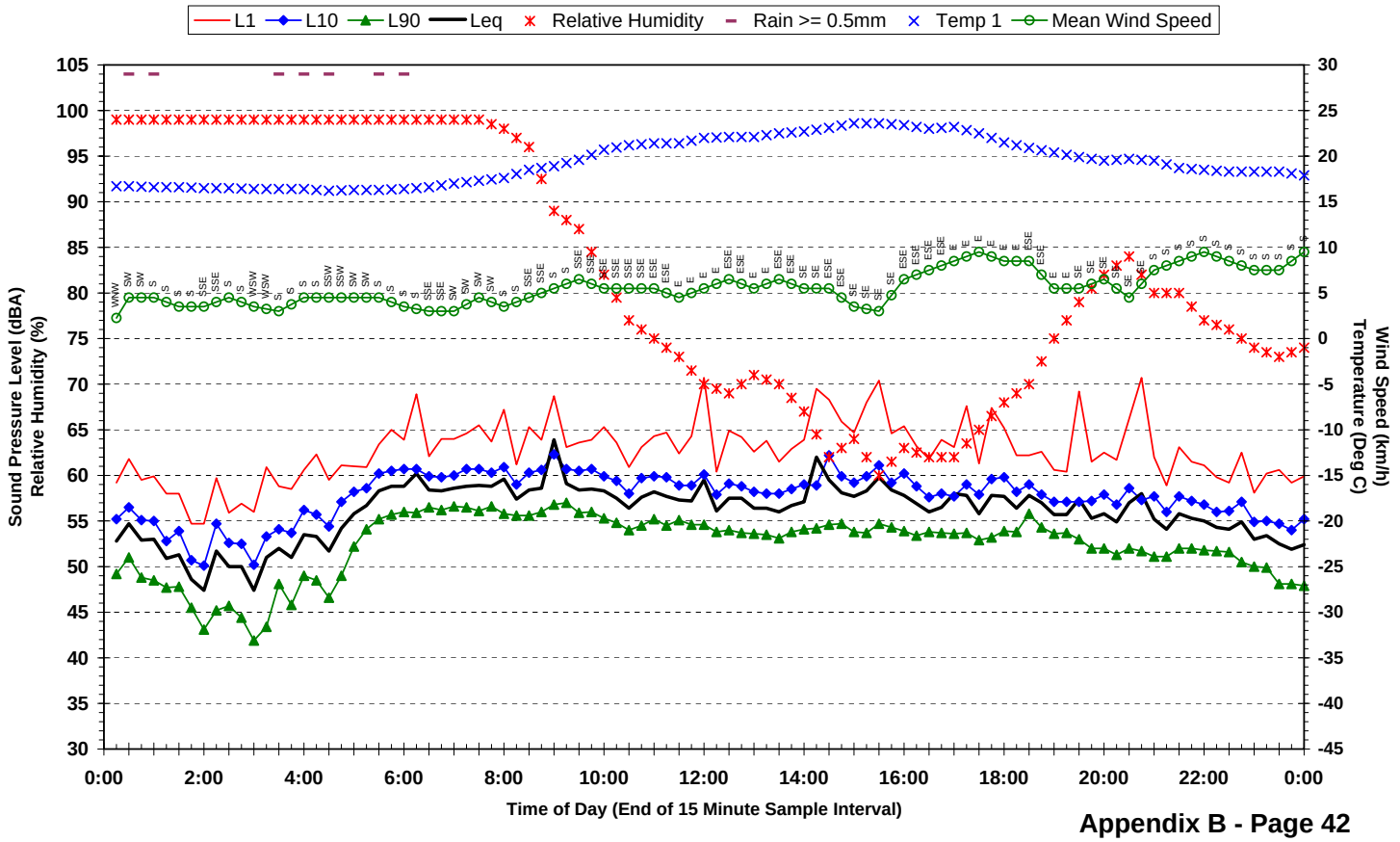
Statistical Ambient Noise Levels
Location 4 - 128 Sylvan Road, Toowong - Friday 16 November 2007



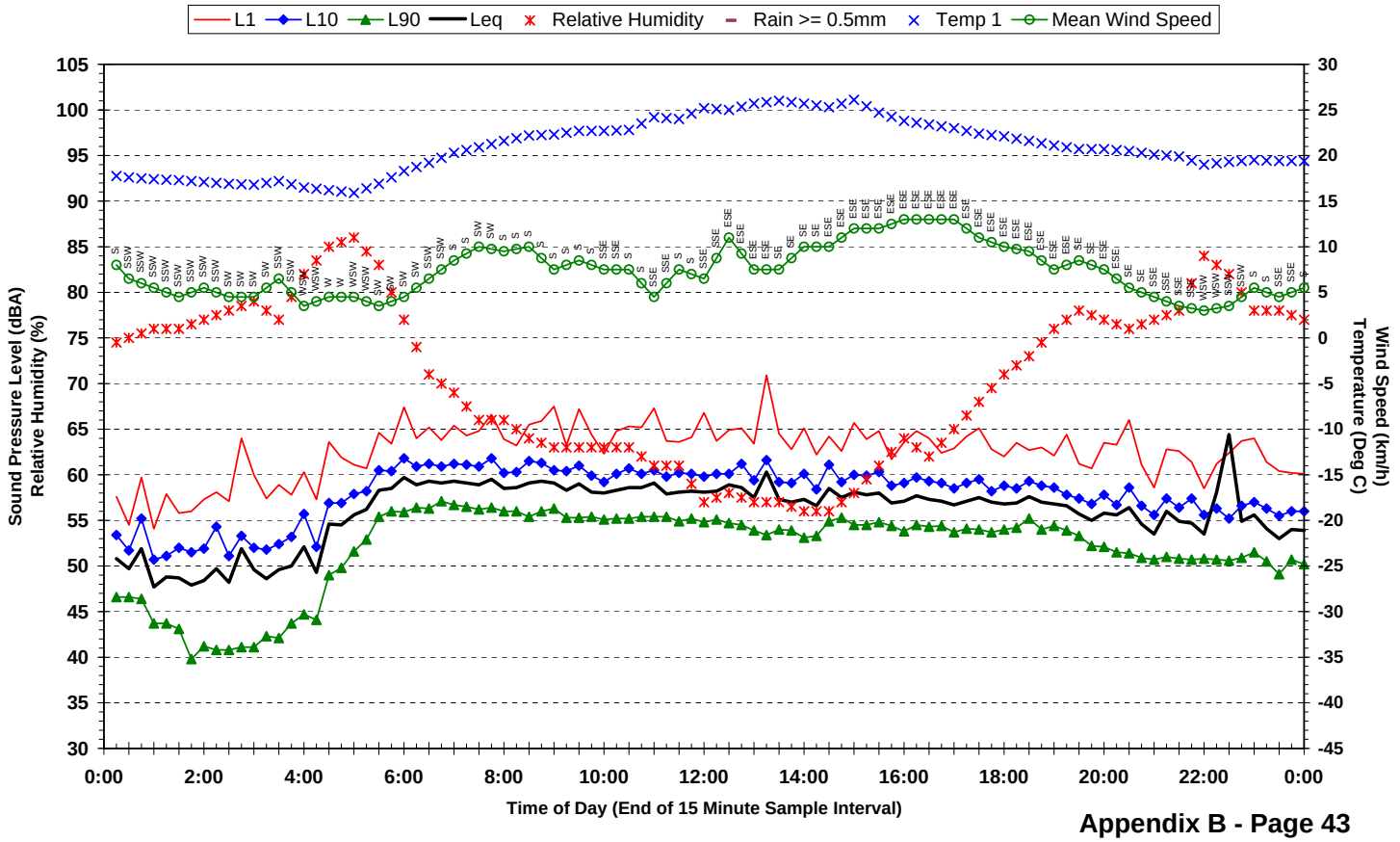
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Wednesday 7 November 2007



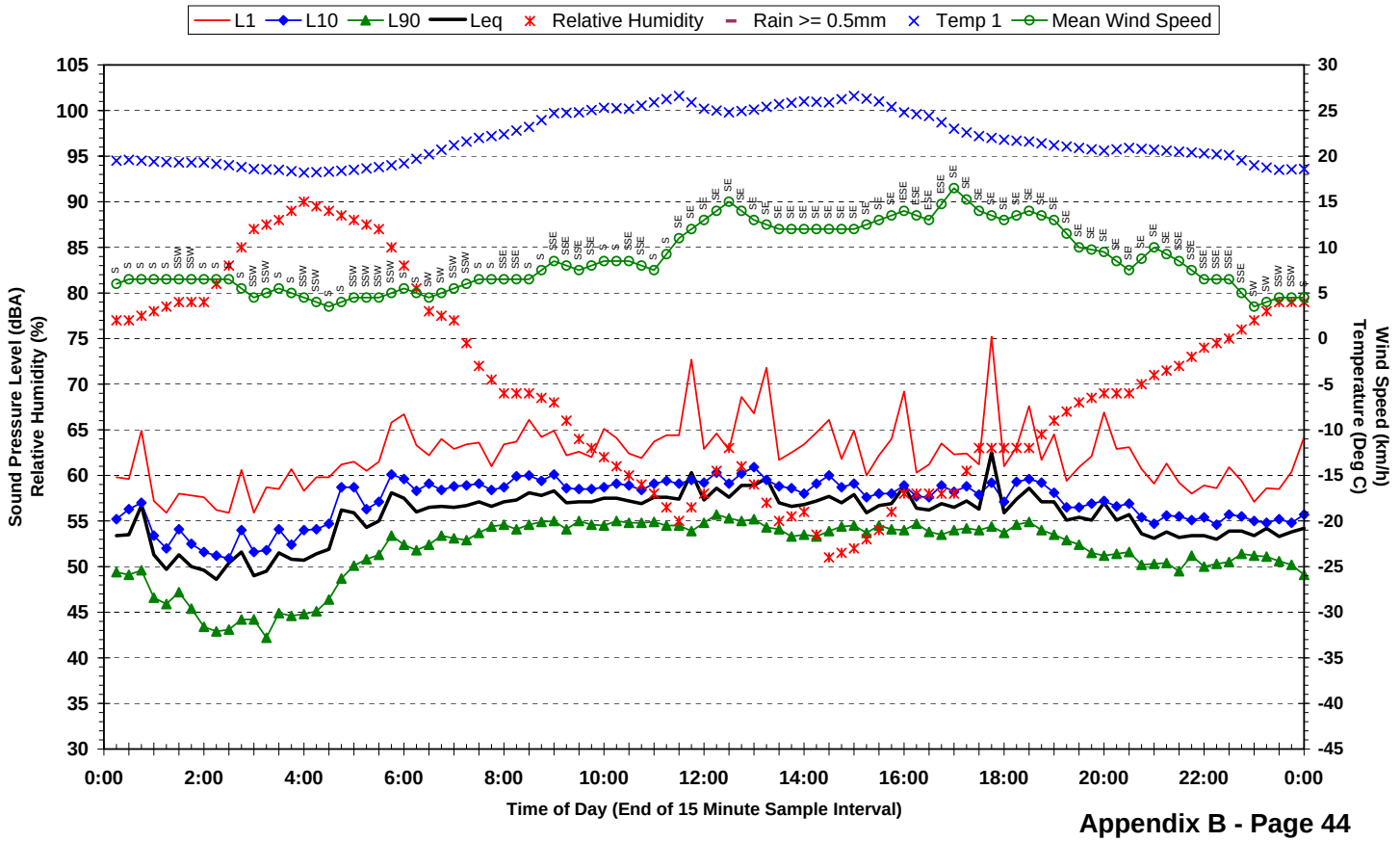
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Thursday 8 November 2007



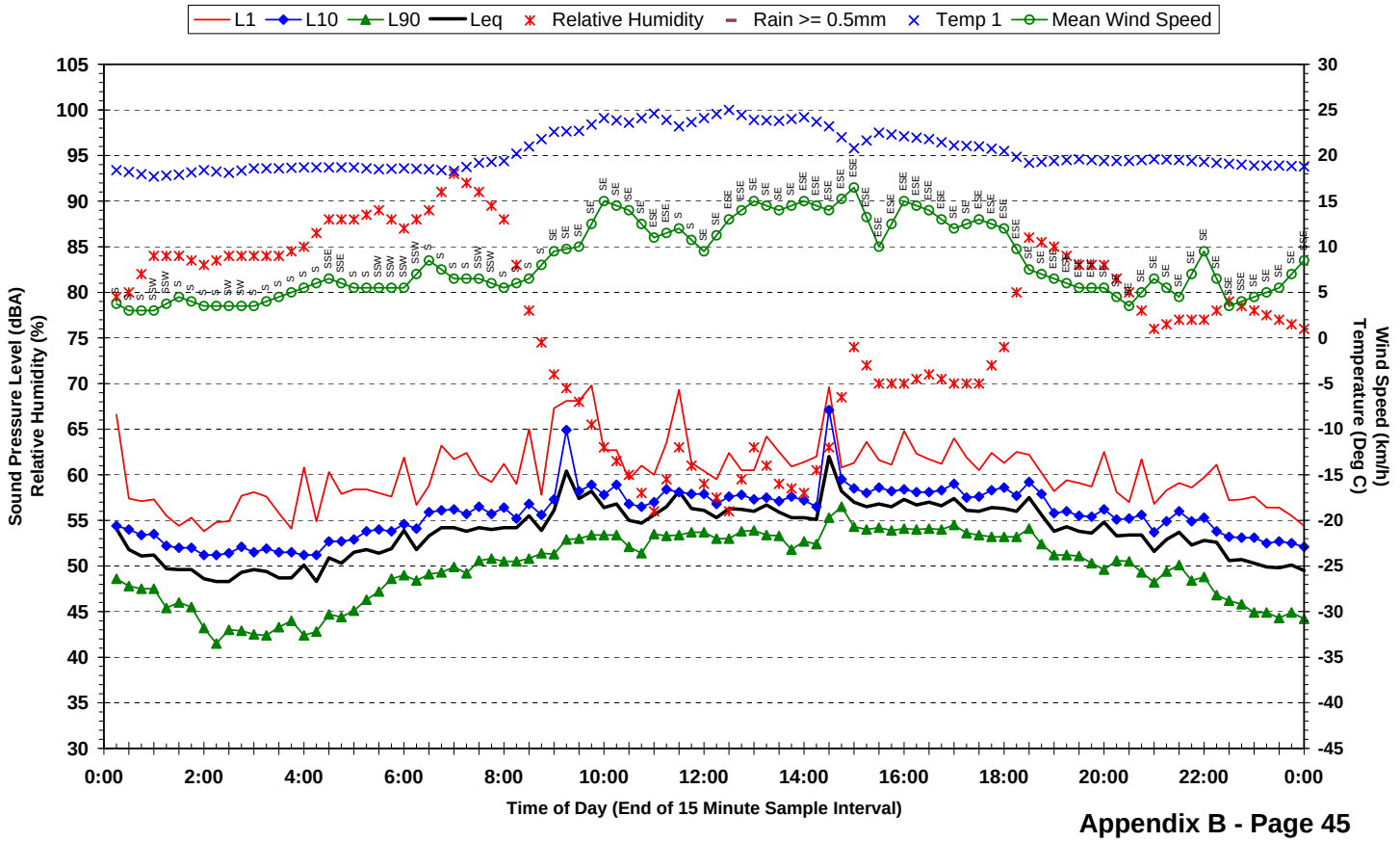
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Friday 9 November 2007



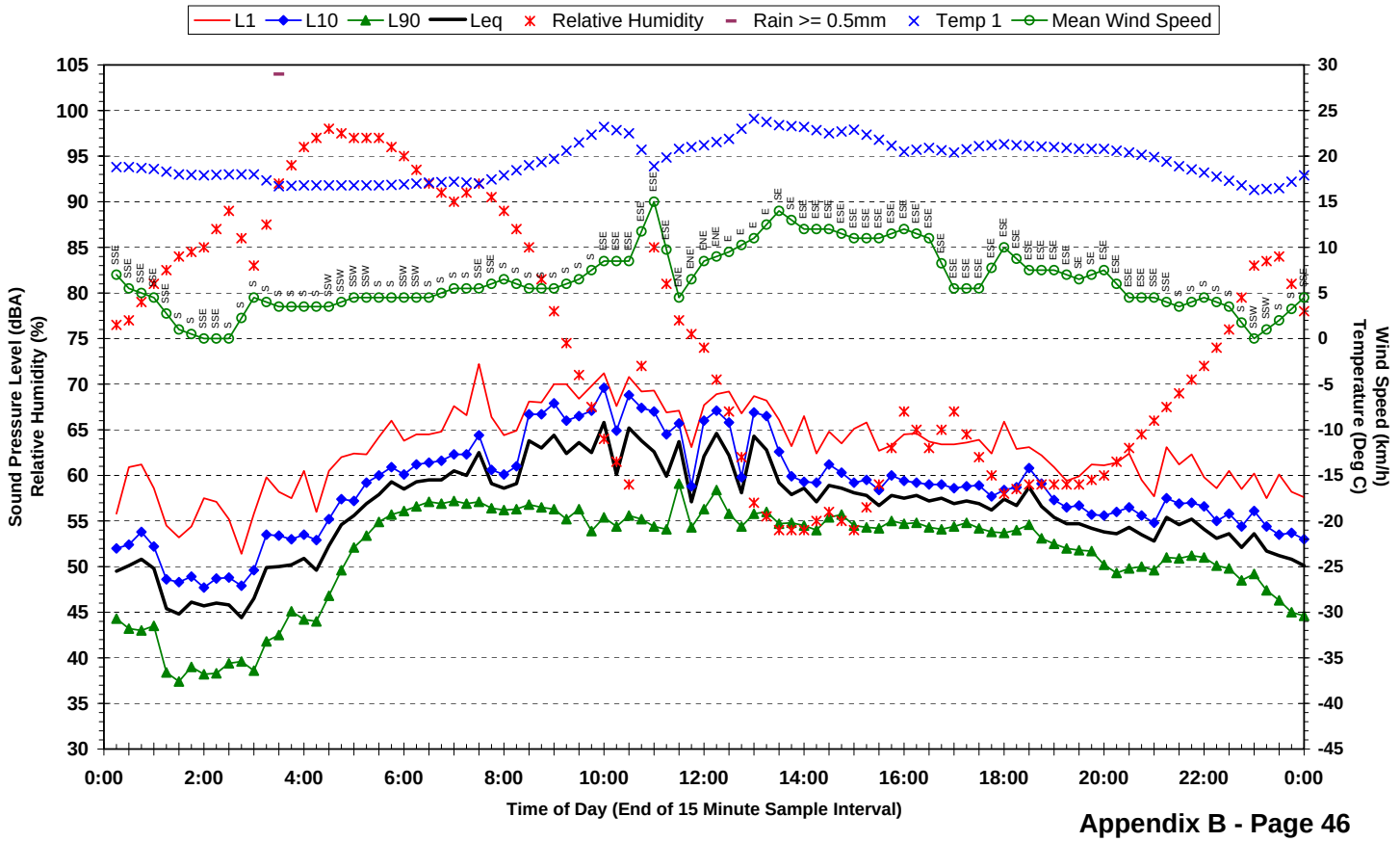
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Saturday 10 November 2007



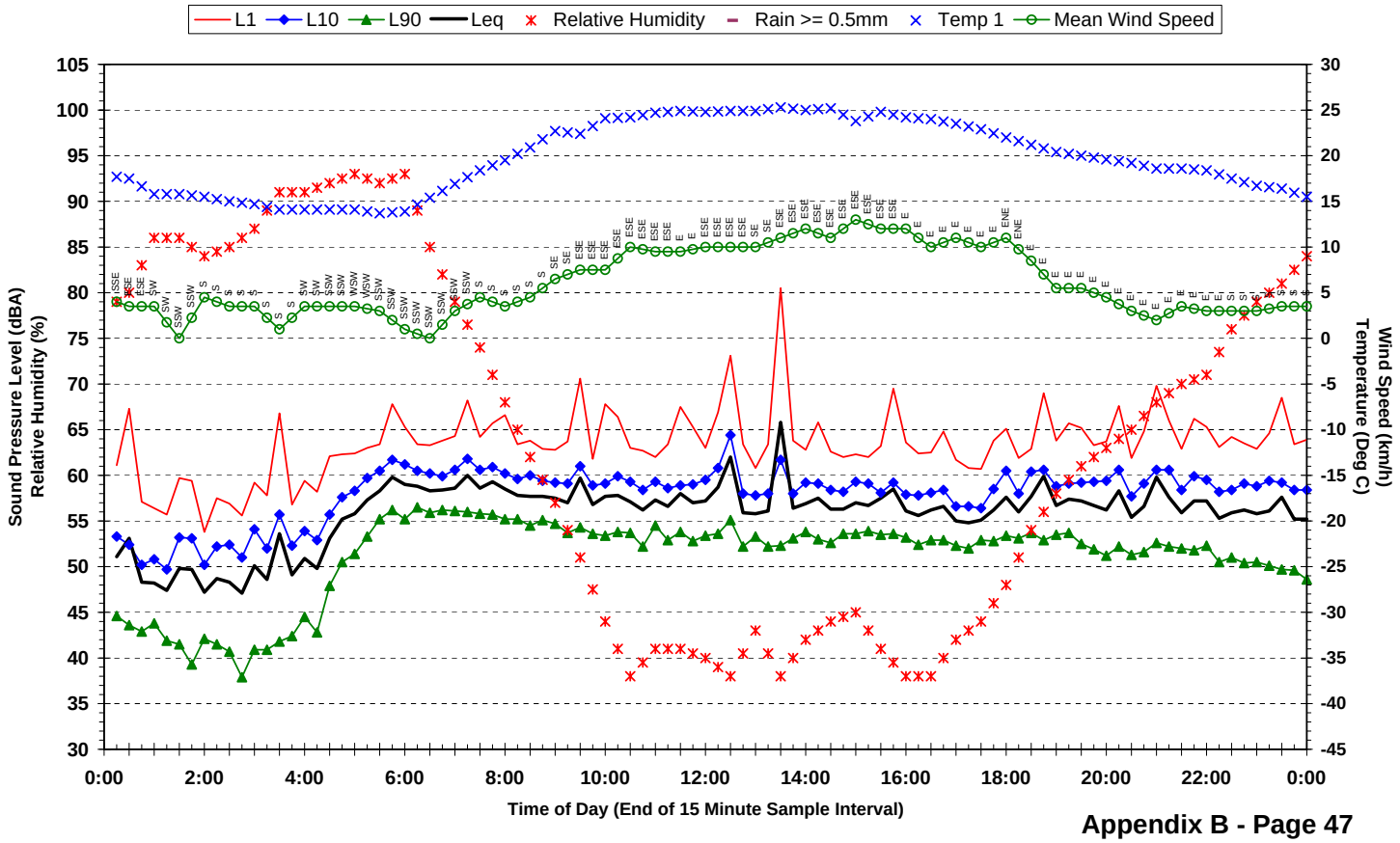
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Sunday 11 November 2007



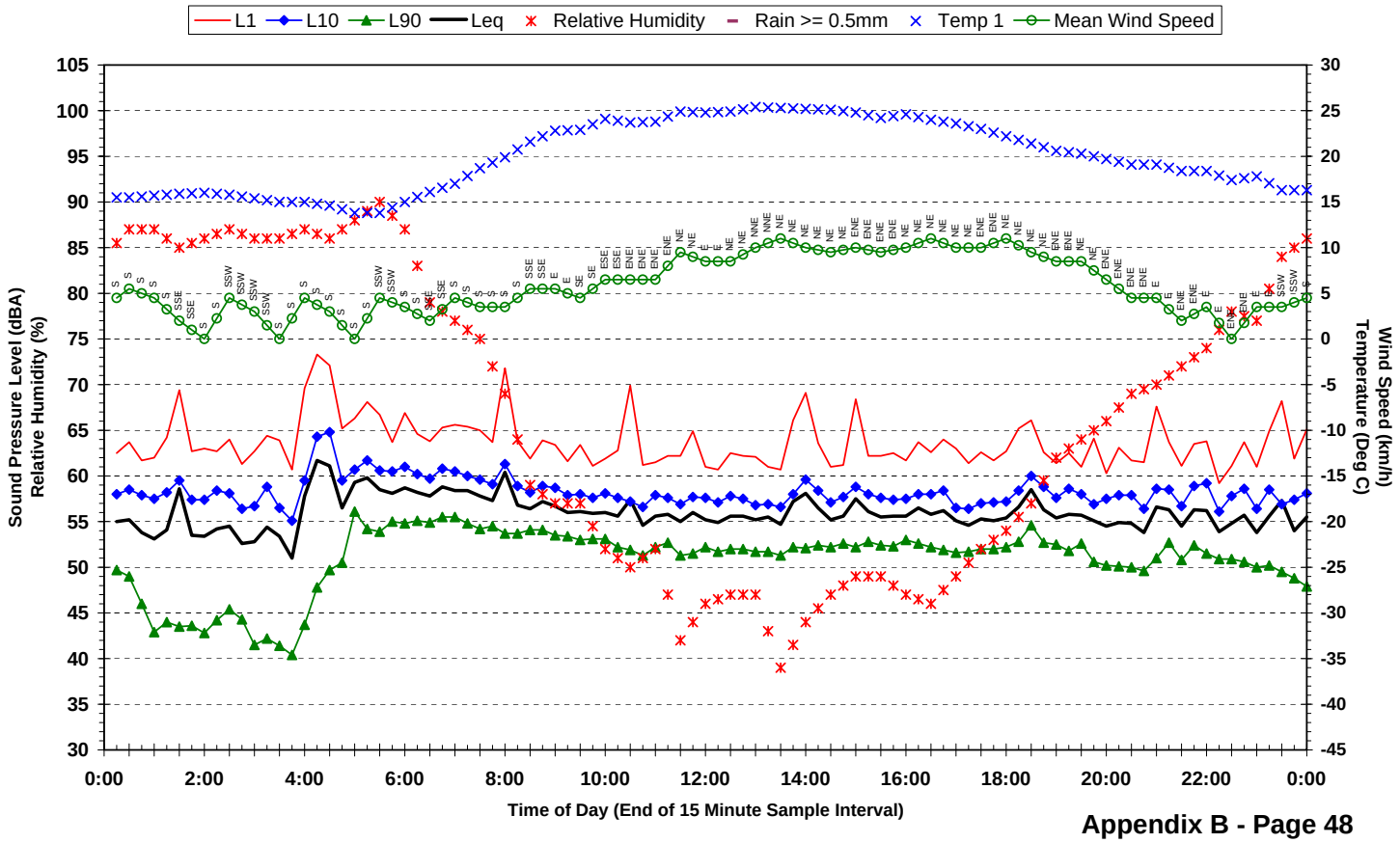
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Monday 12 November 2007



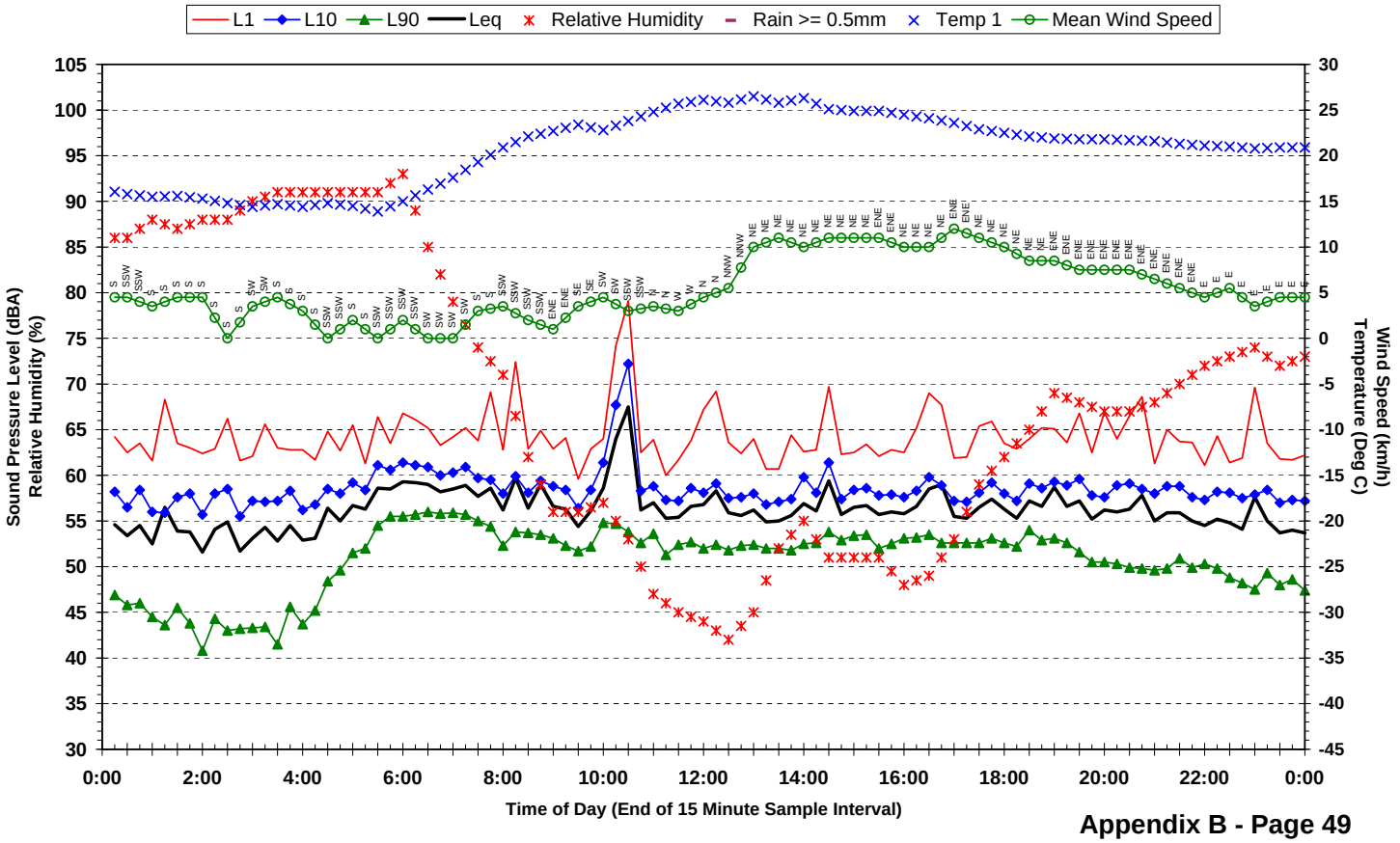
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Tuesday 13 November 2007



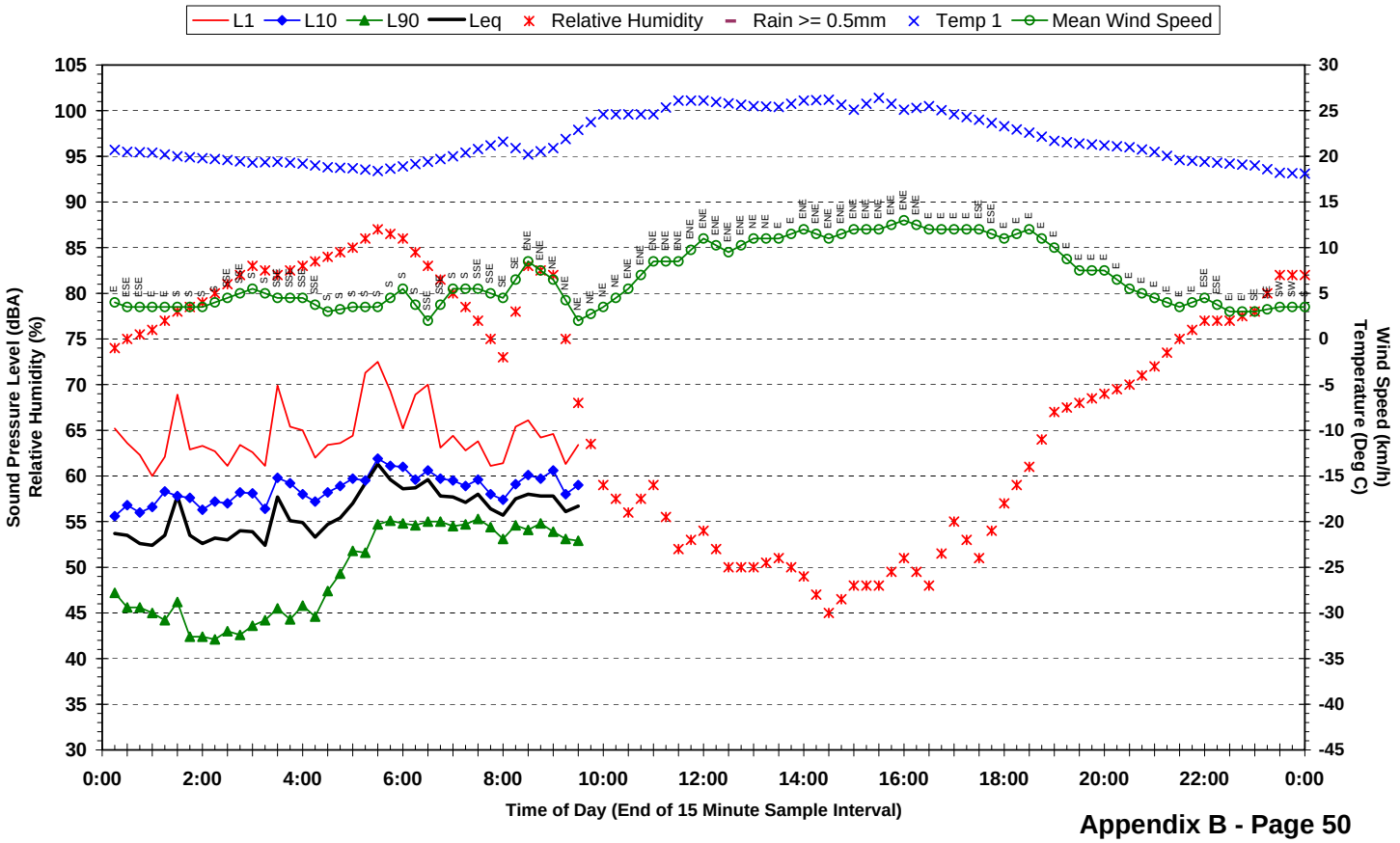
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Wednesday 14 November 2007



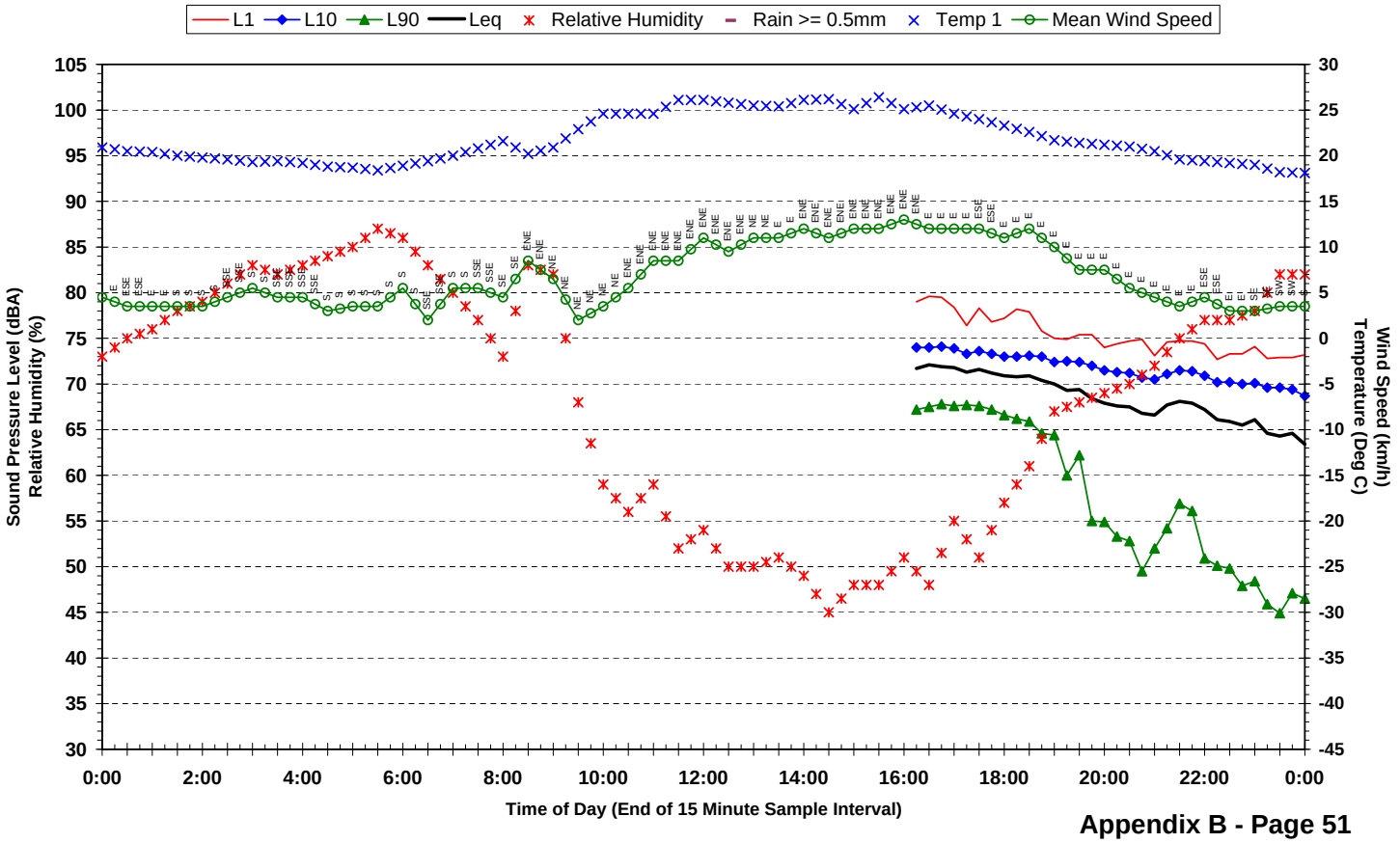
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Thursday 15 November 2007



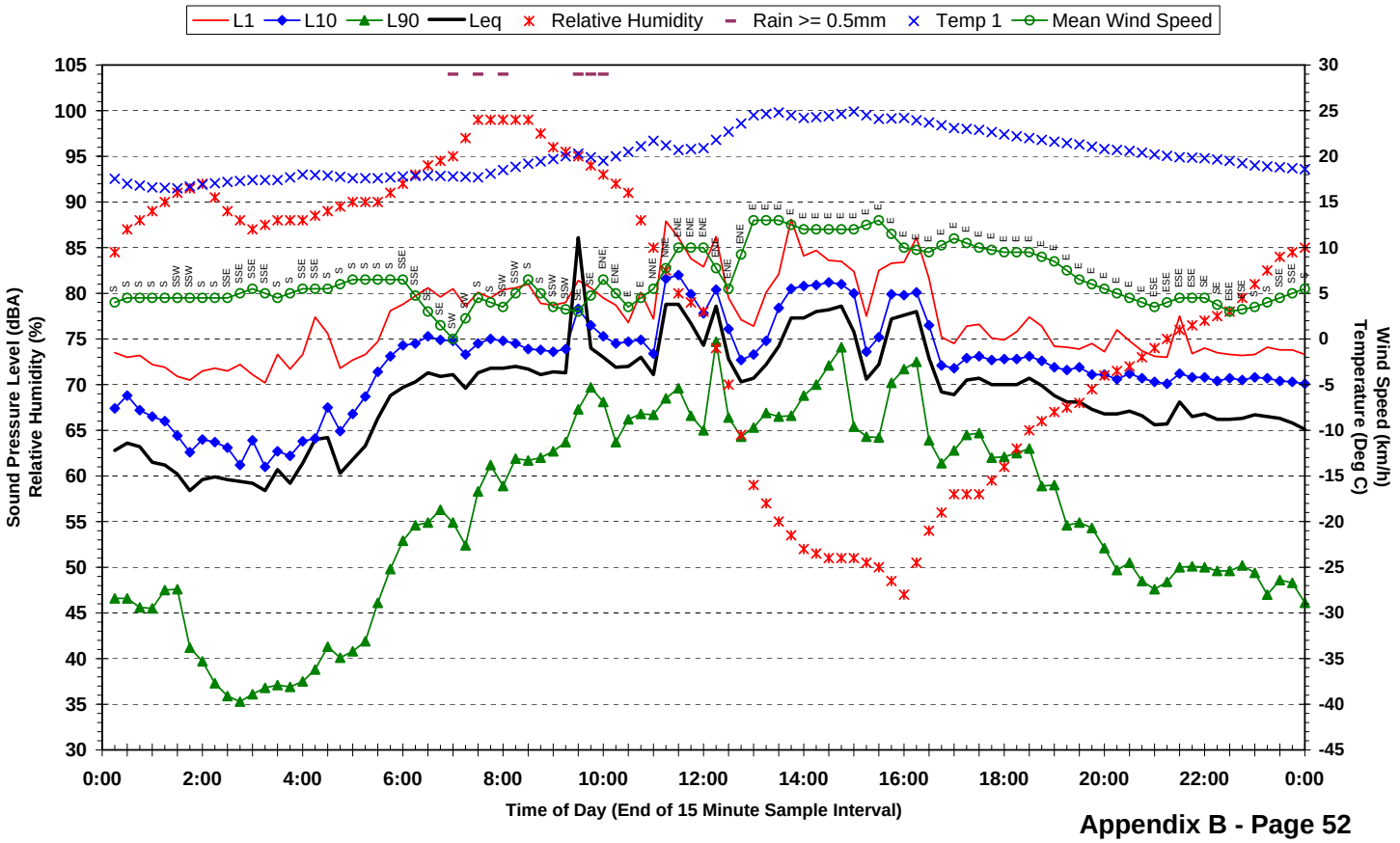
Statistical Ambient Noise Levels
Location 5 - 29 Valentine Street, Toowong - Friday 16 November 2007



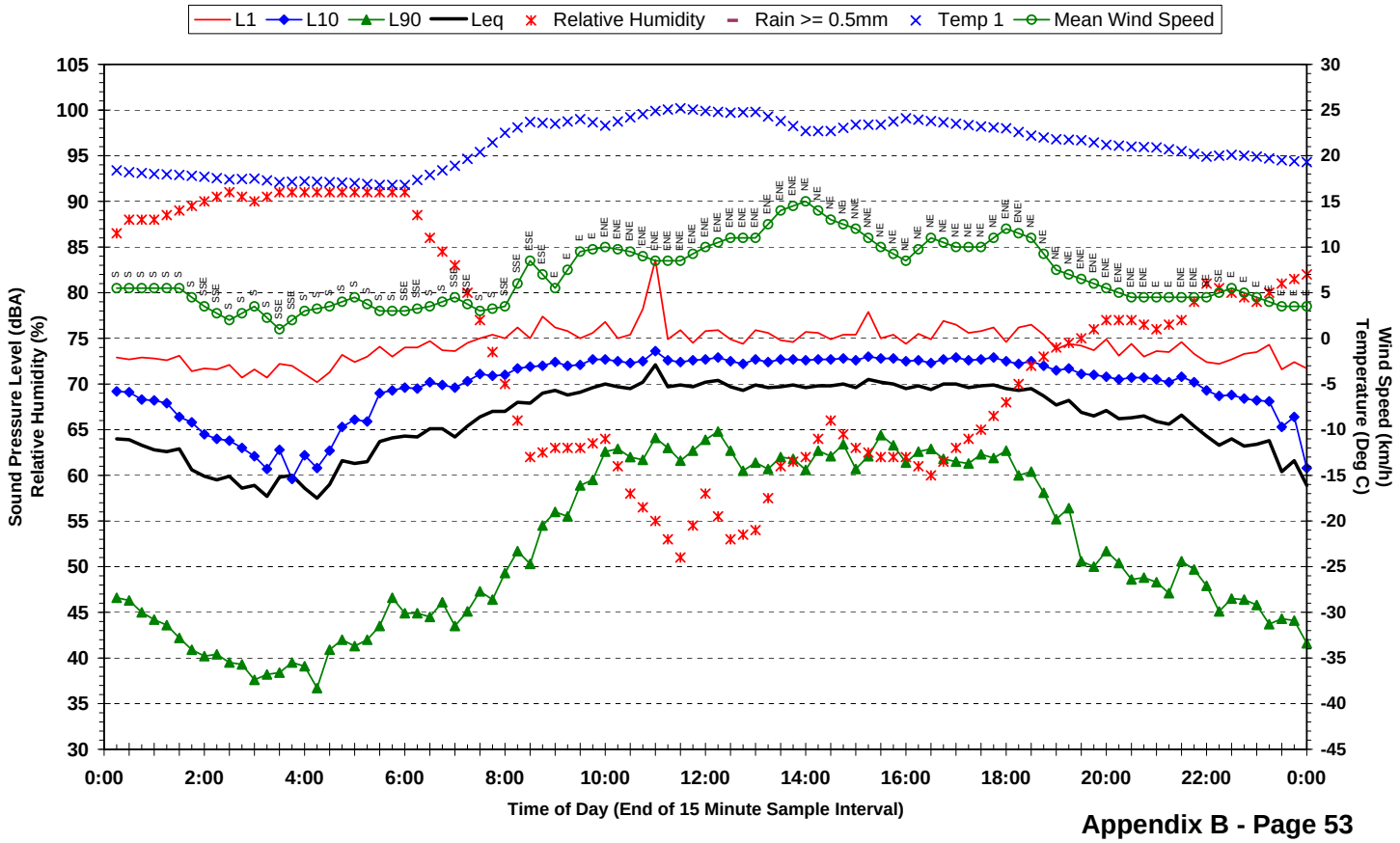
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Friday 16 November 2007



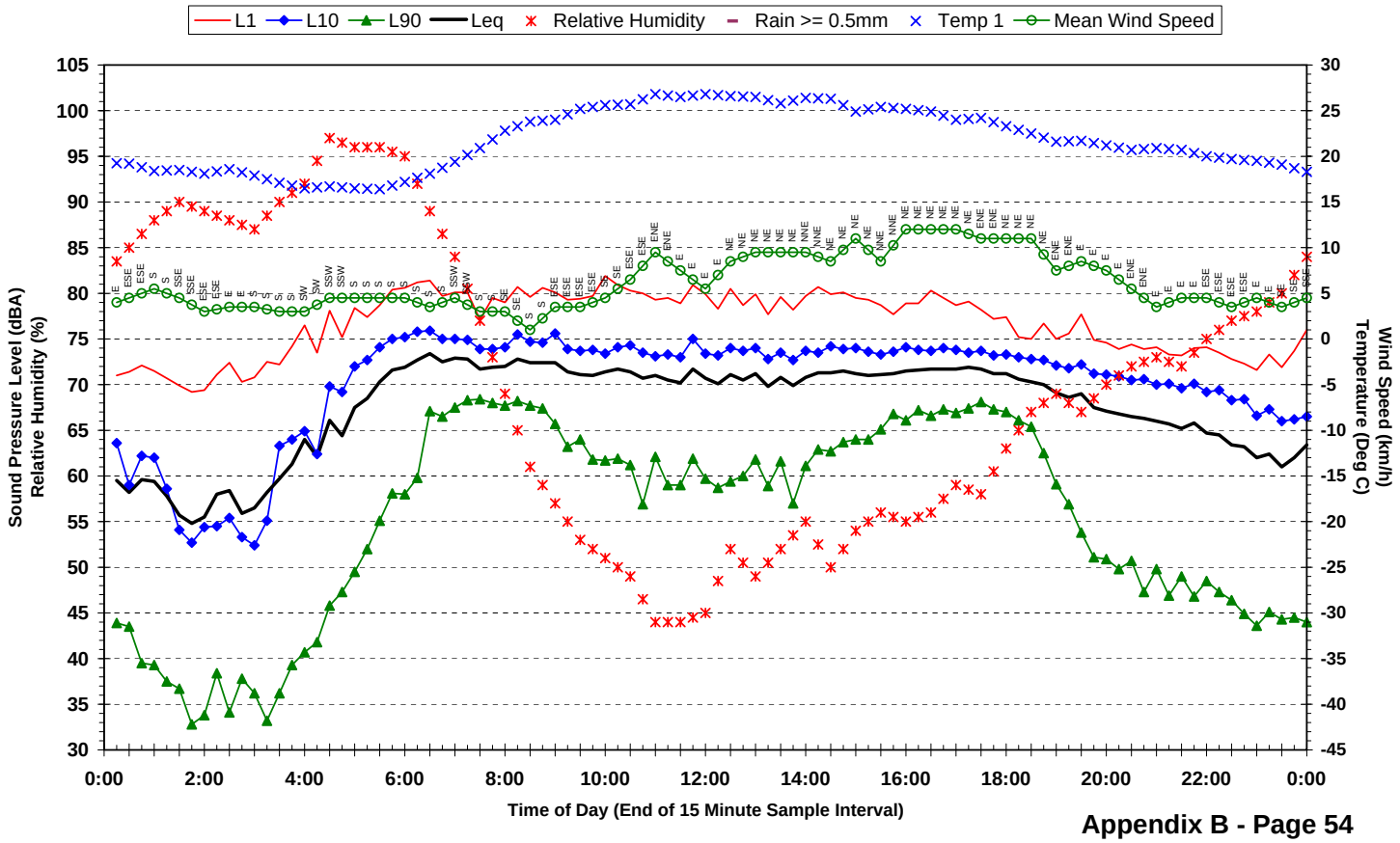
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Saturday 17 November 2007



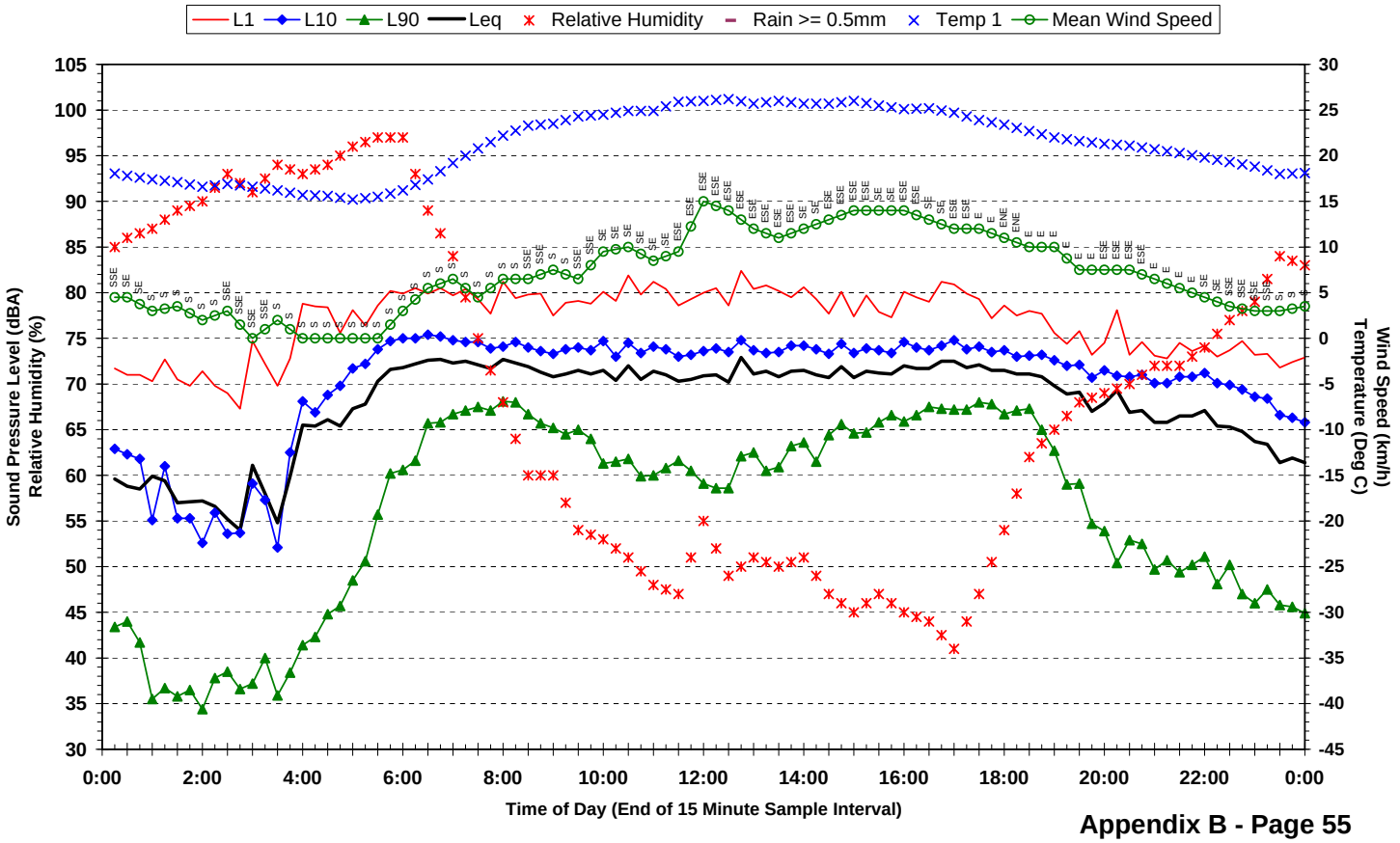
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Sunday 18 November 2007



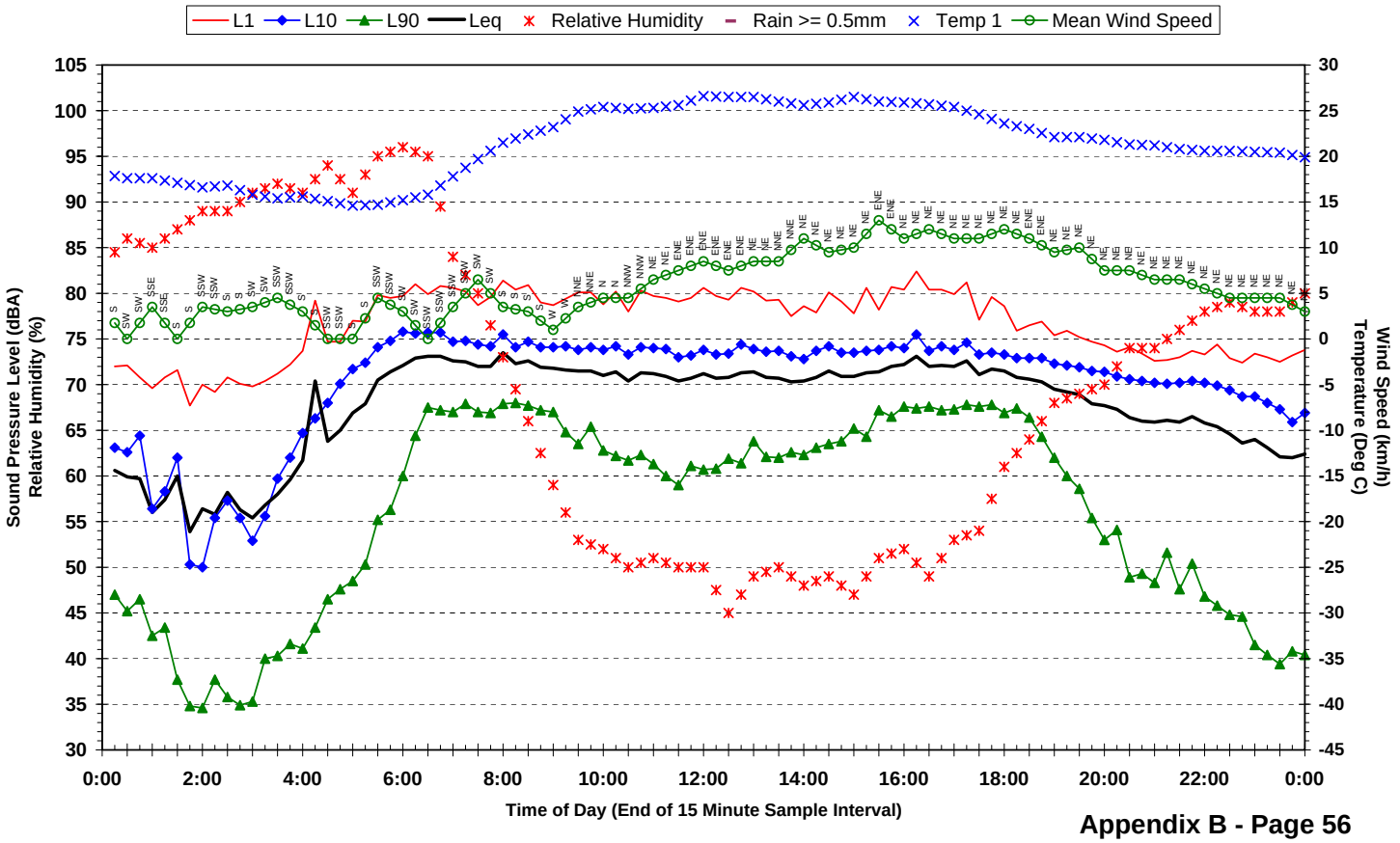
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Monday 19 November 2007



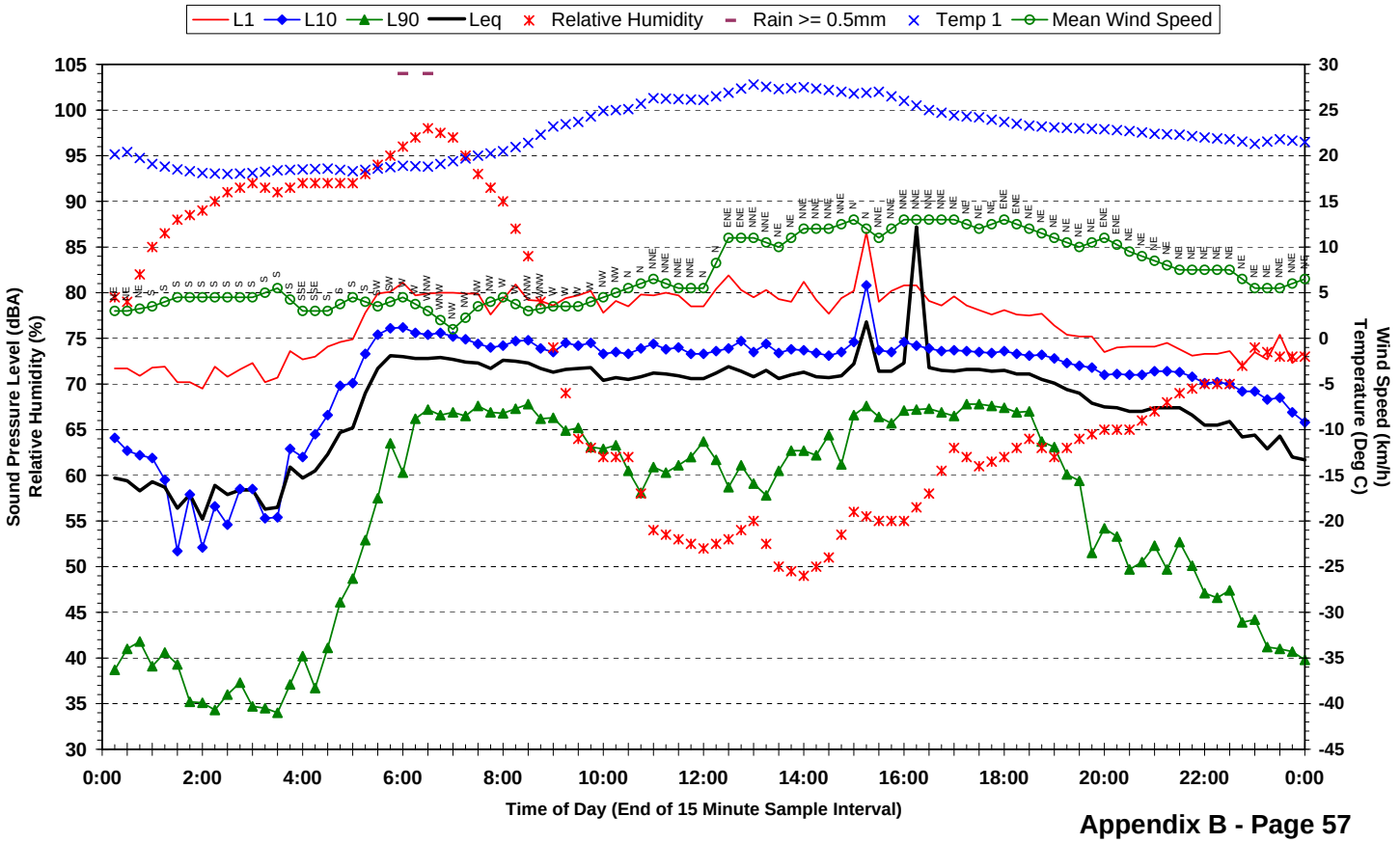
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Tuesday 20 November 2007



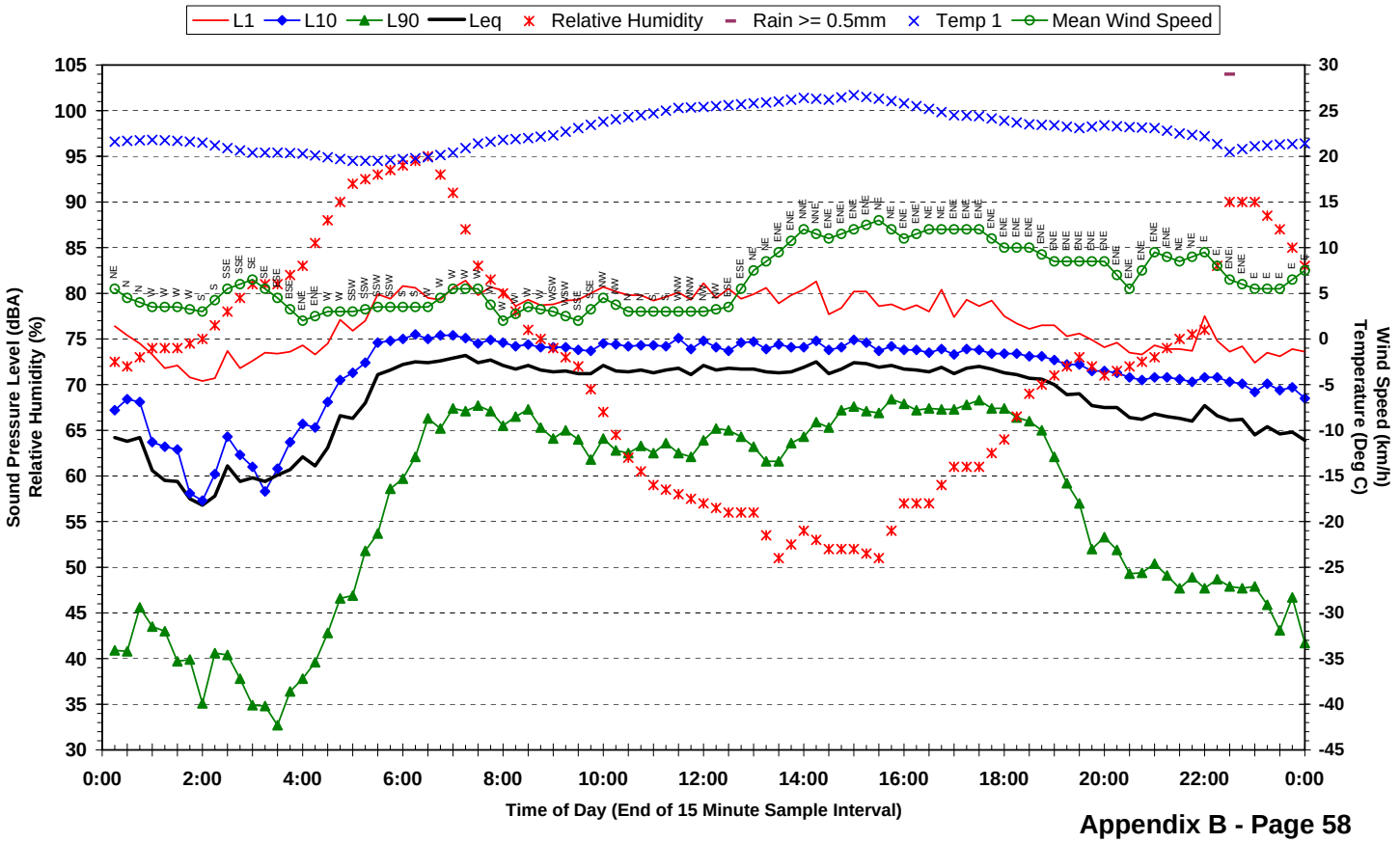
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Wednesday 21 November 2007



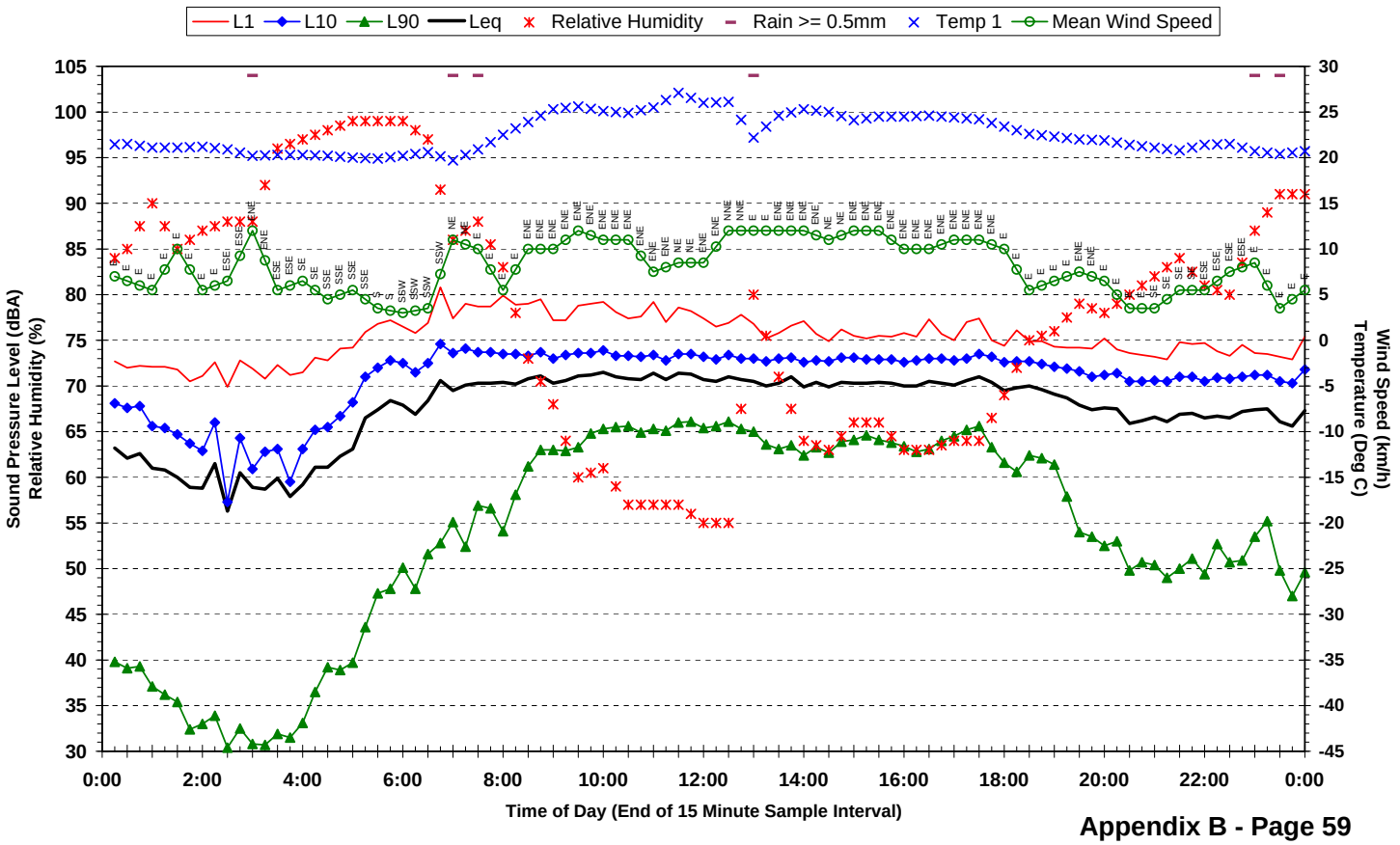
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Thursday 22 November 2007



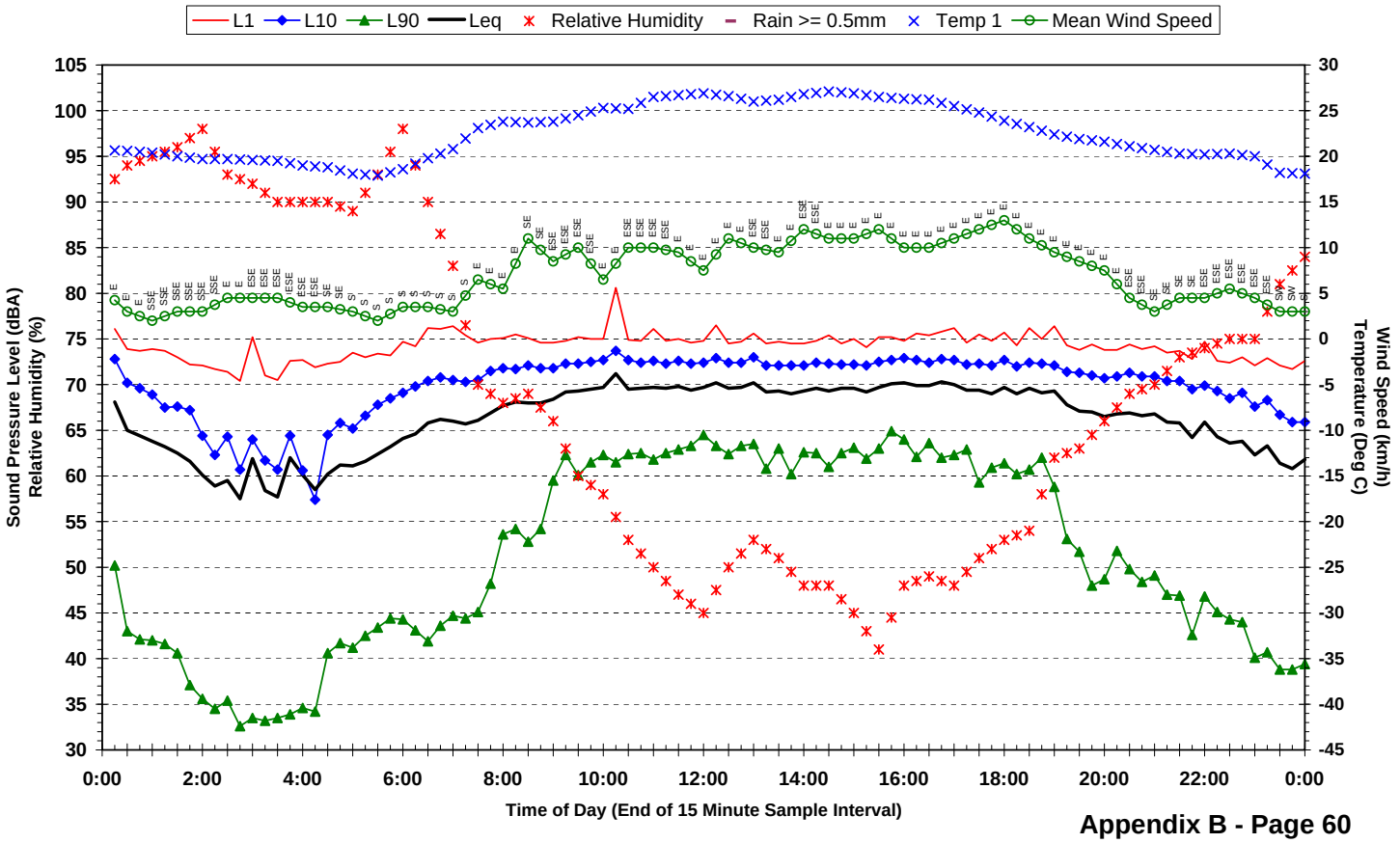
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Friday 23 November 2007



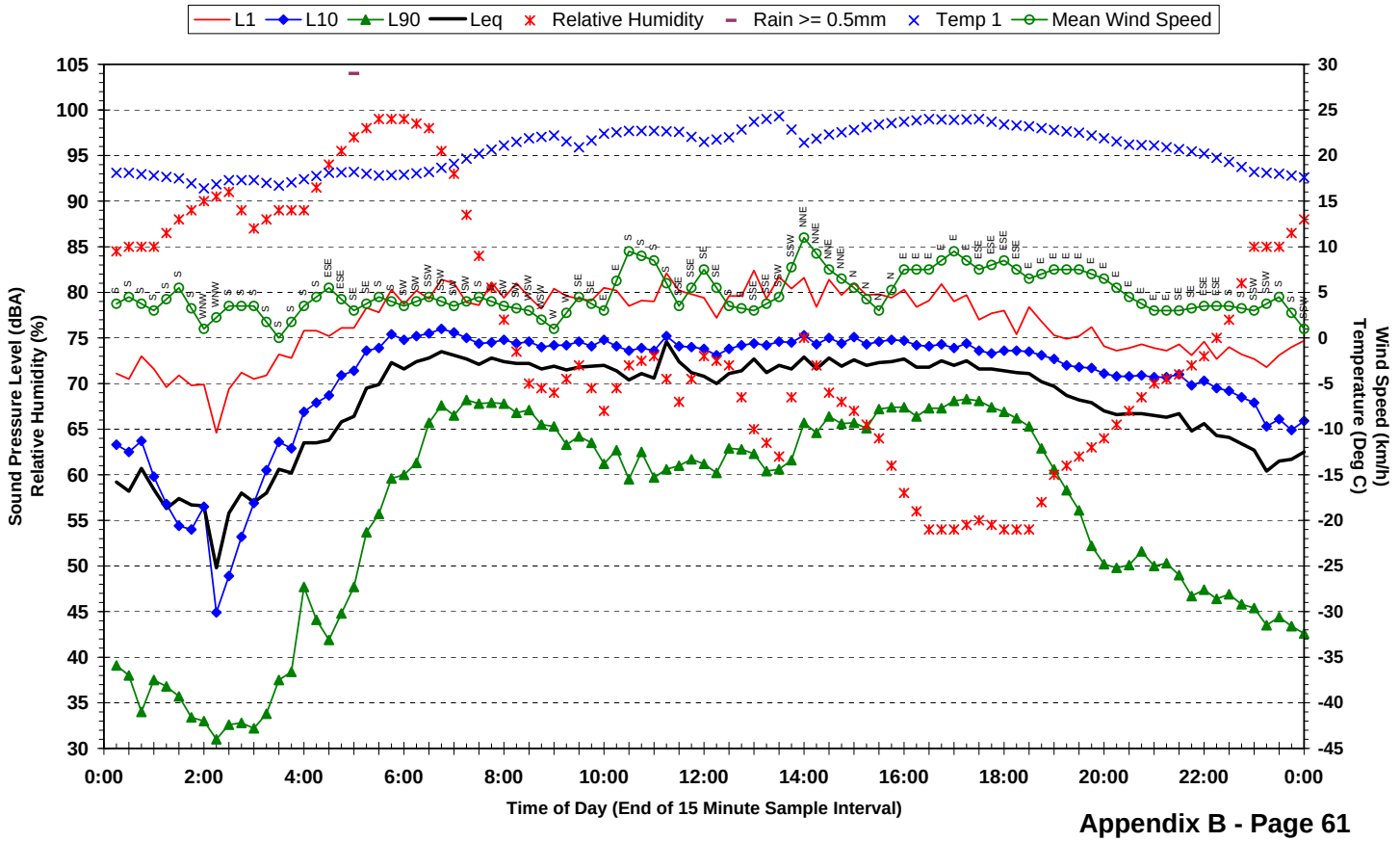
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Saturday 24 November 2007



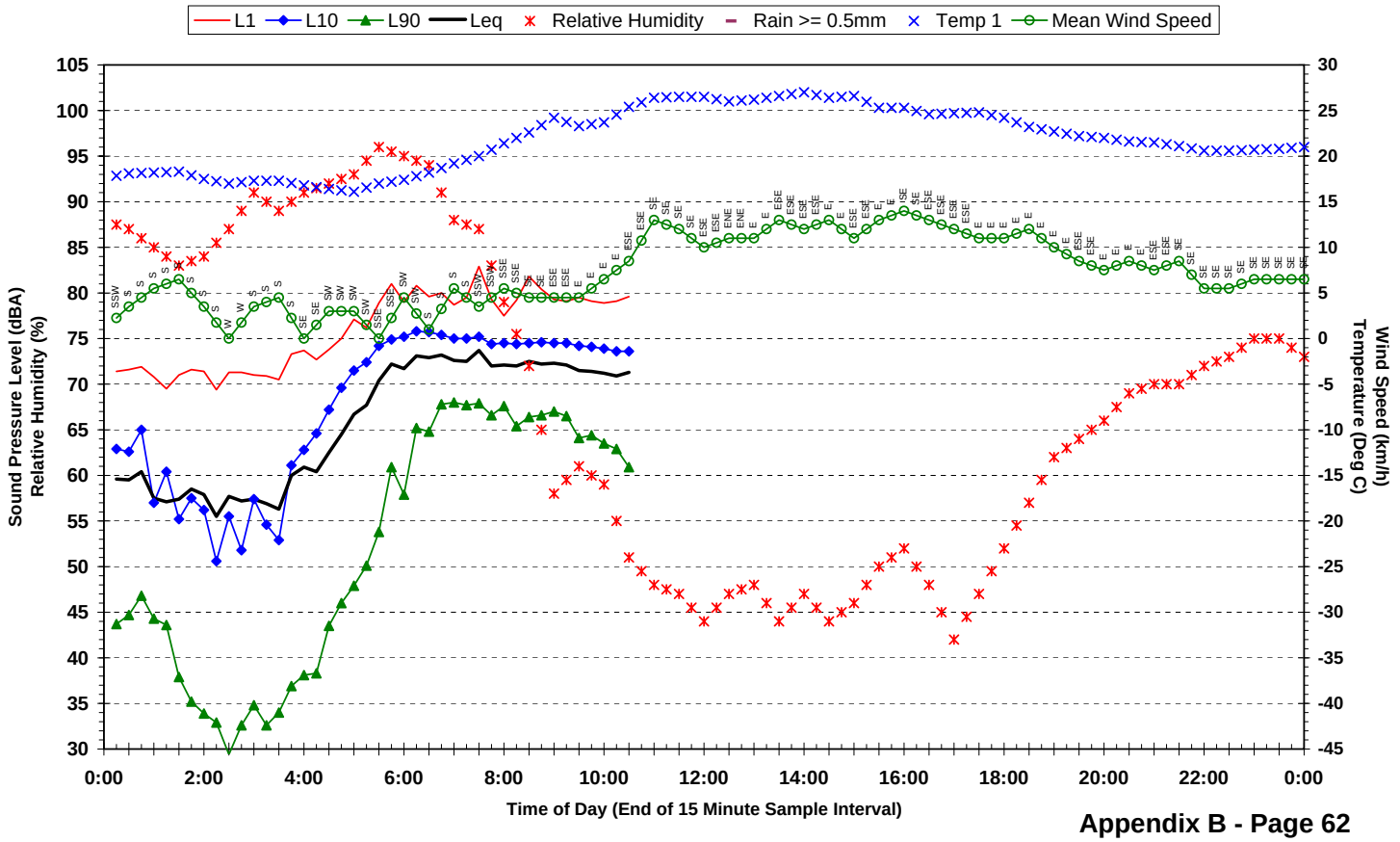
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Sunday 25 November 2007



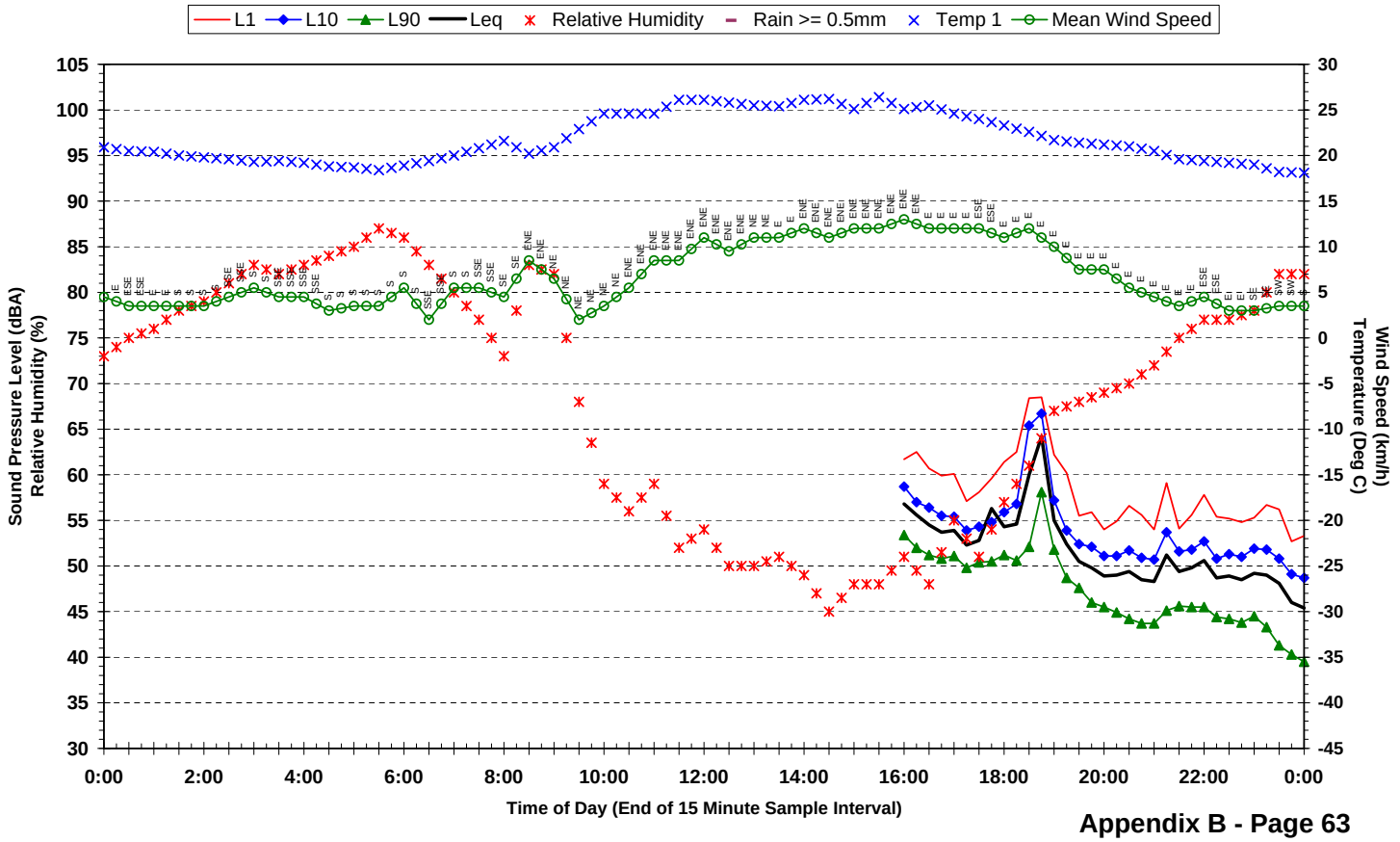
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Monday 26 November 2007



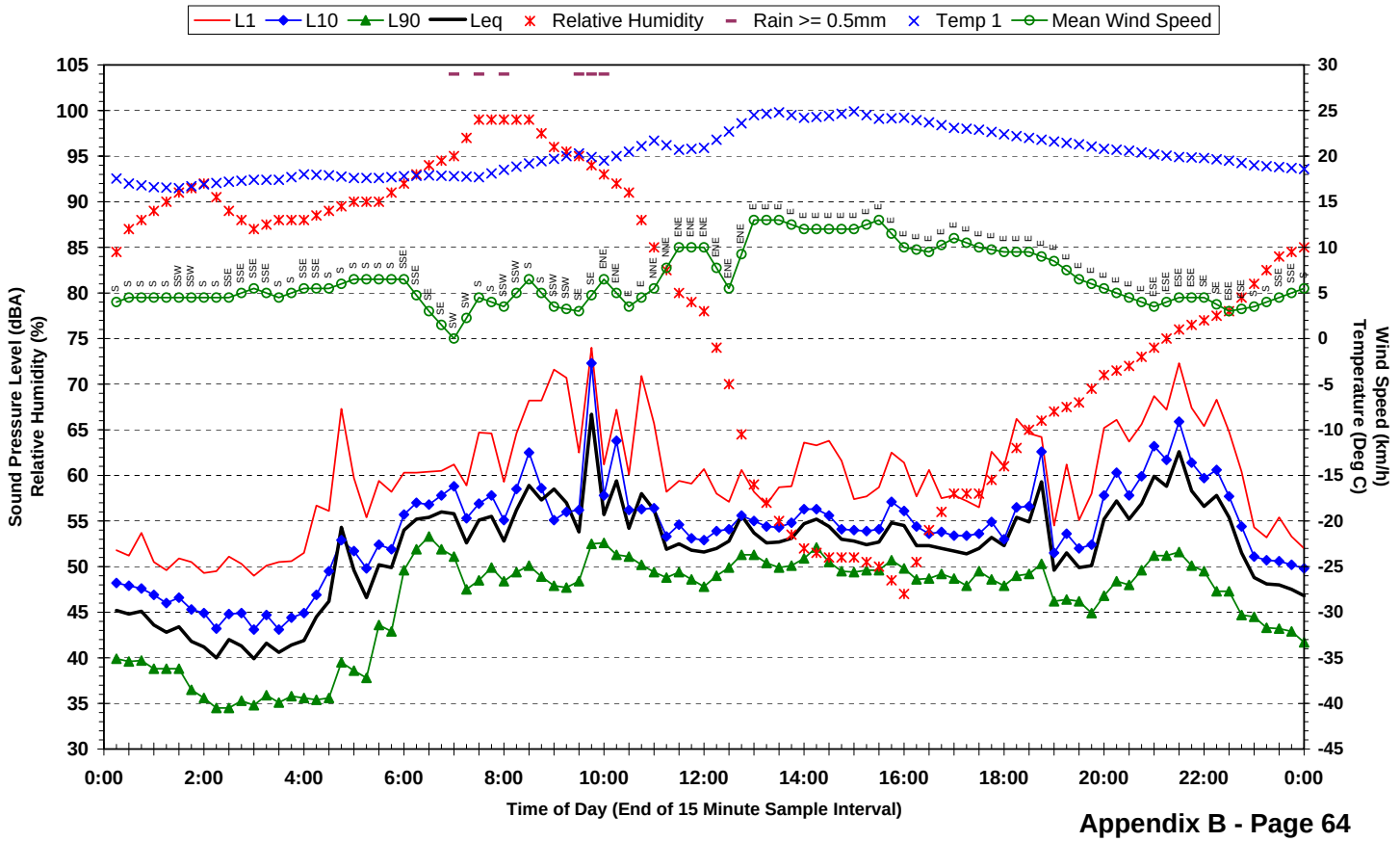
Statistical Ambient Noise Levels
Location 6 - 69 Frederick Street, Toowong - Tuesday 27 November 2007



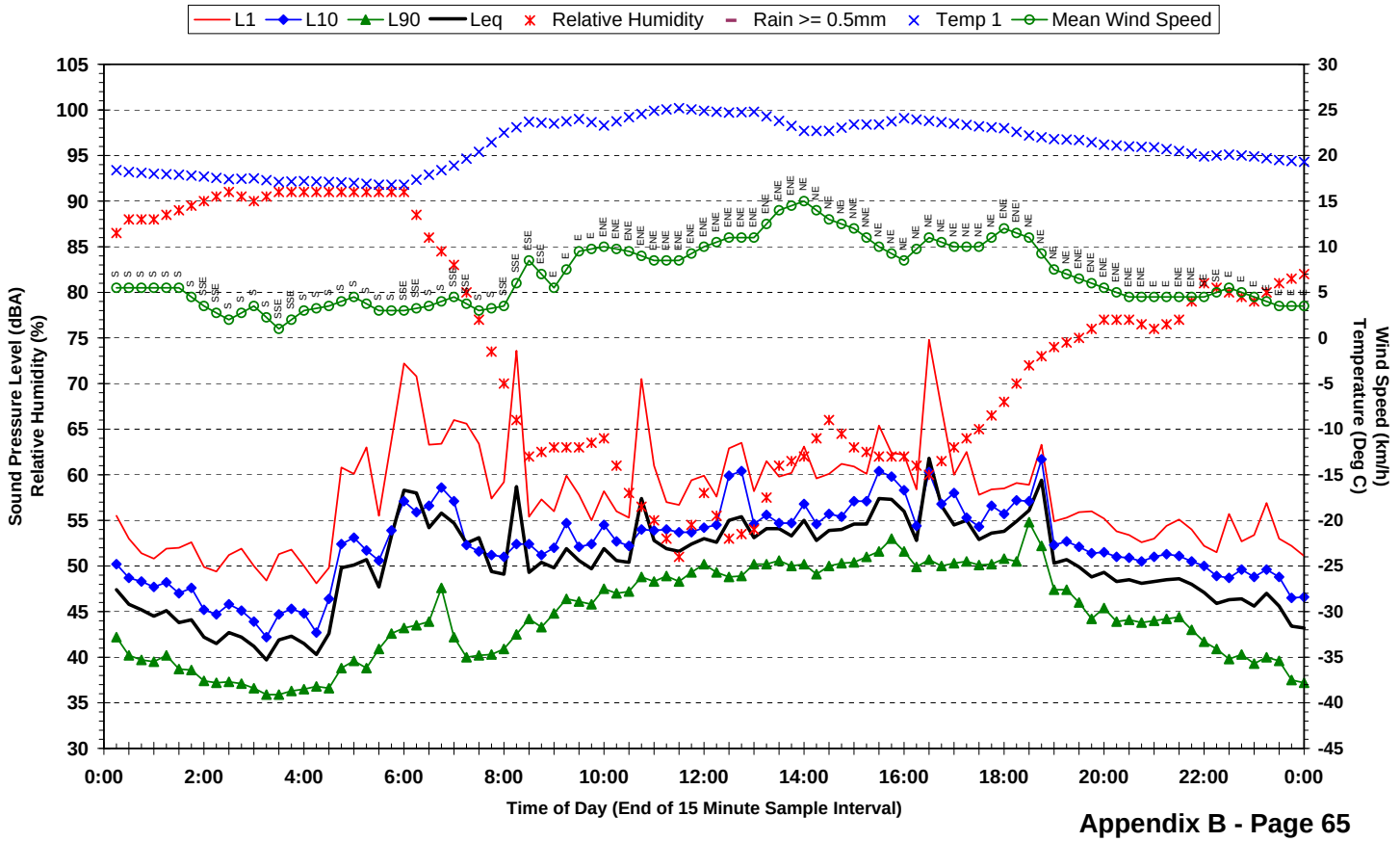
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Friday 16 November 2007



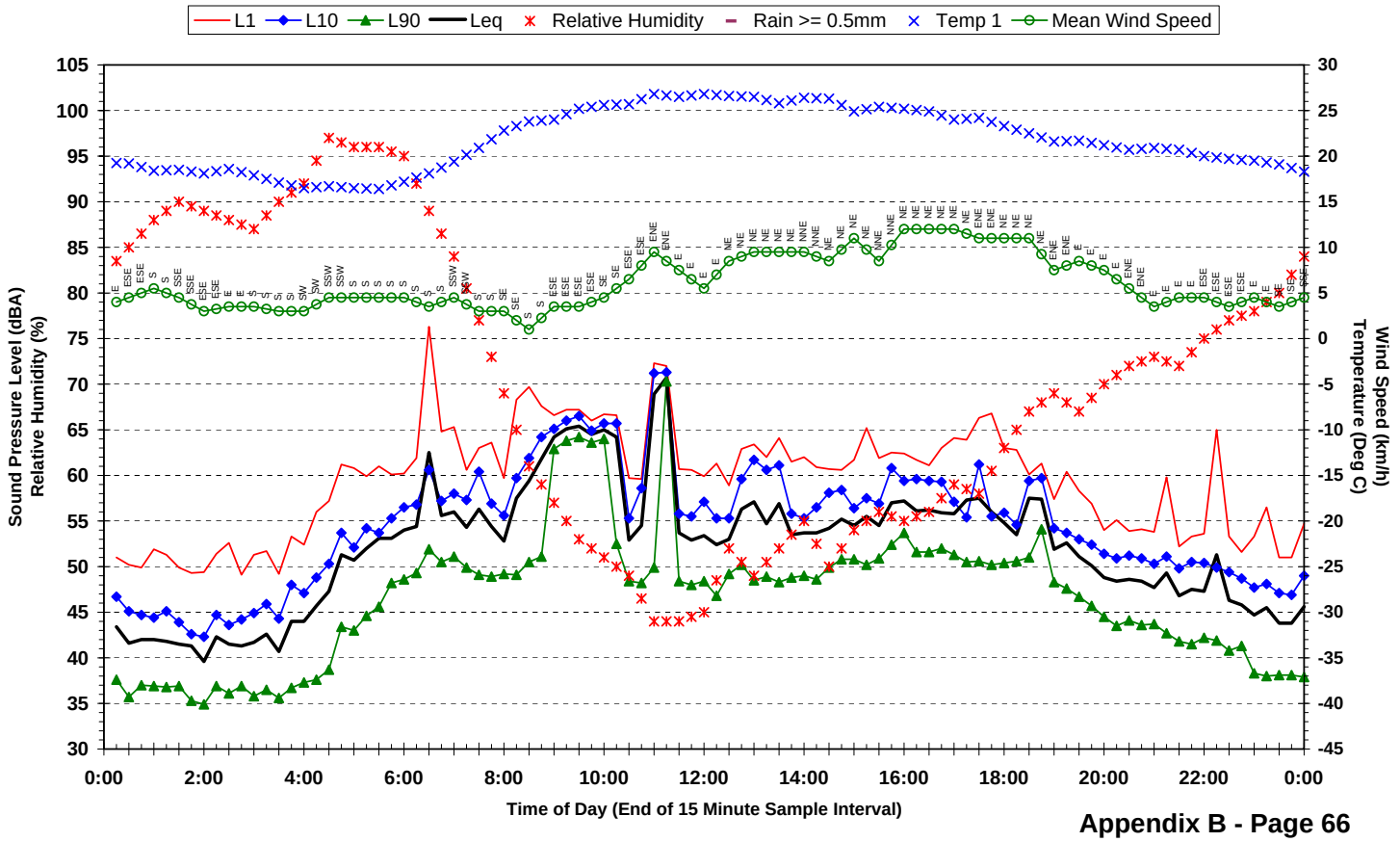
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Saturday 17 November 2007



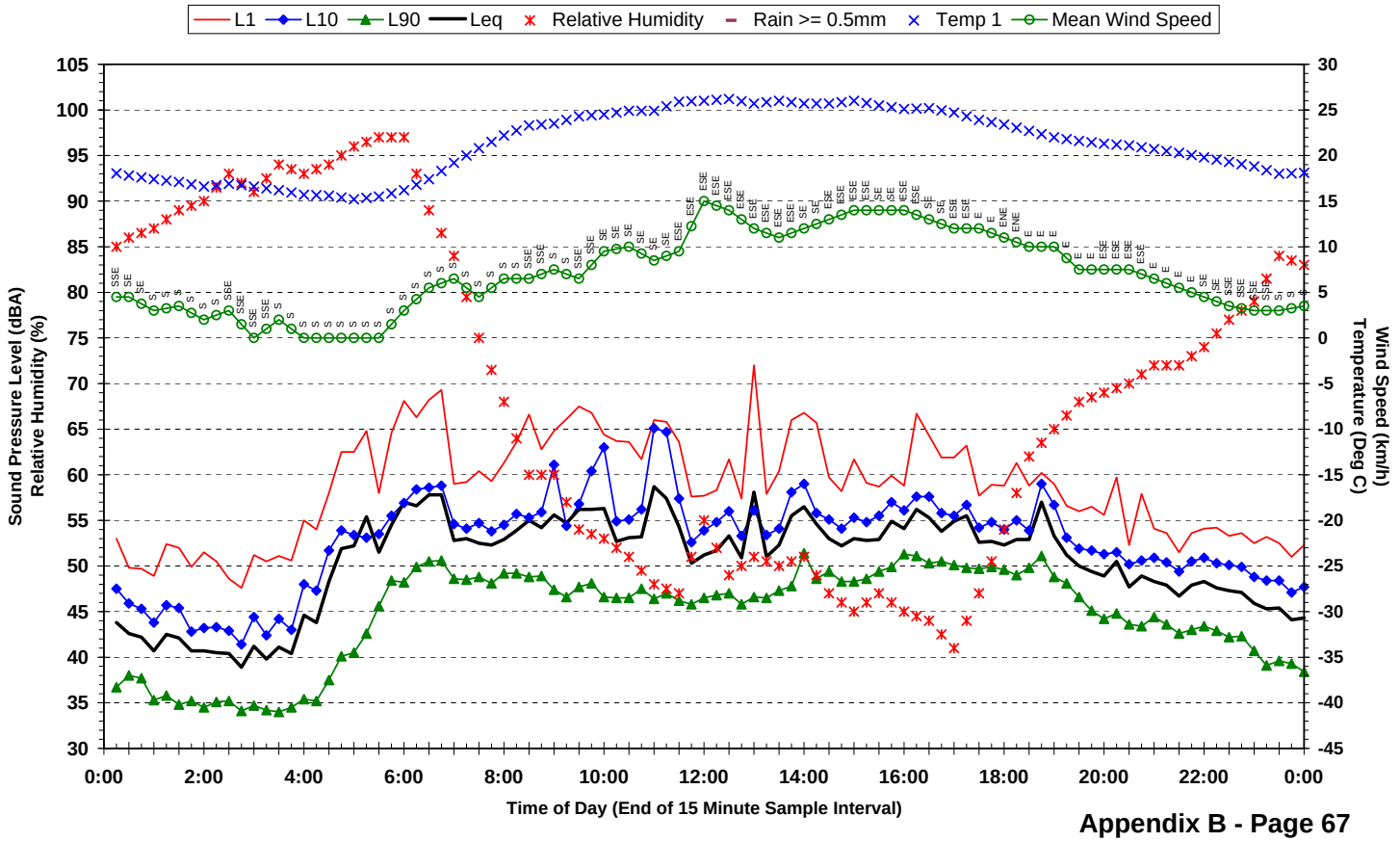
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Sunday 18 November 2007



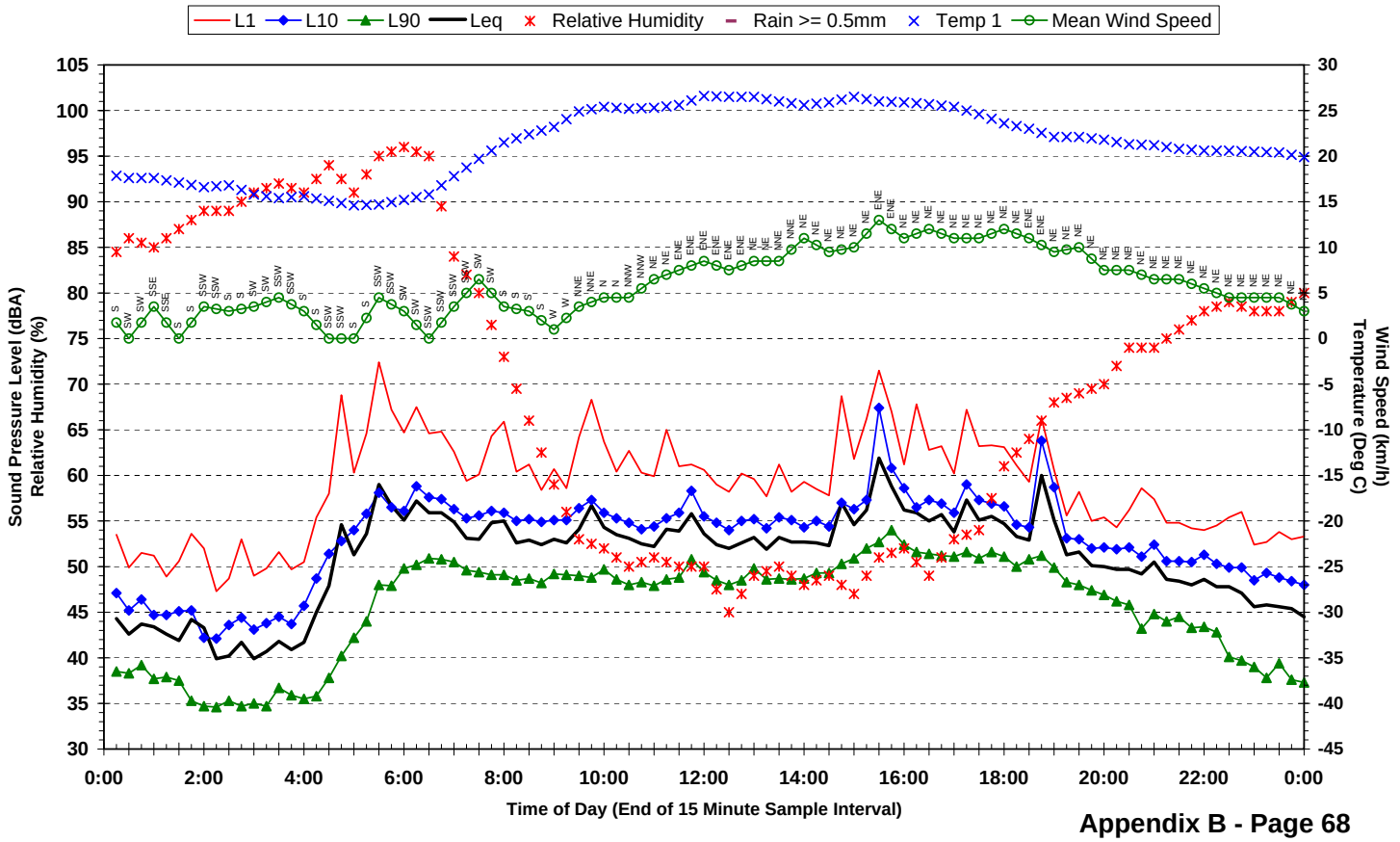
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Monday 19 November 2007



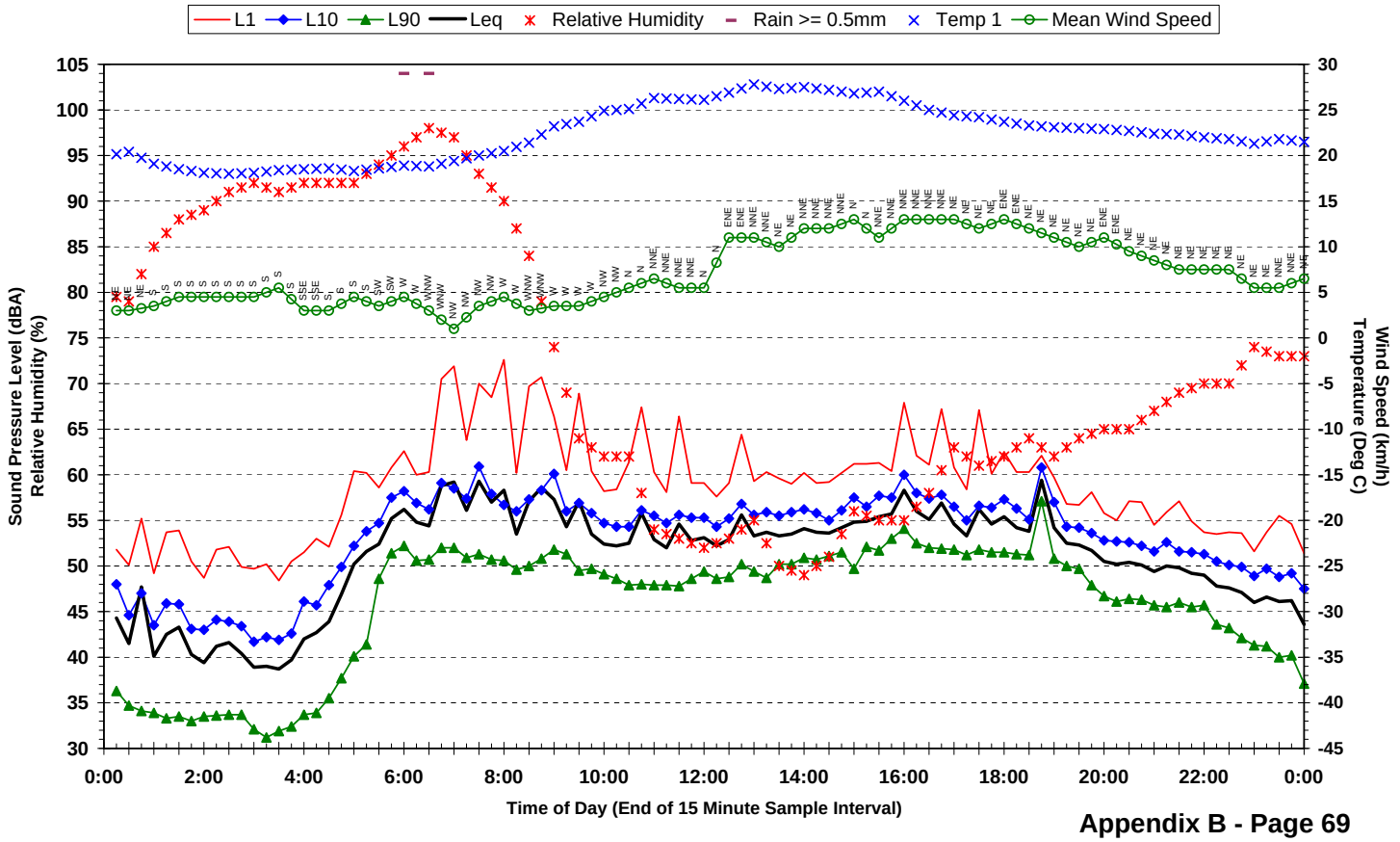
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Tuesday 20 November 2007



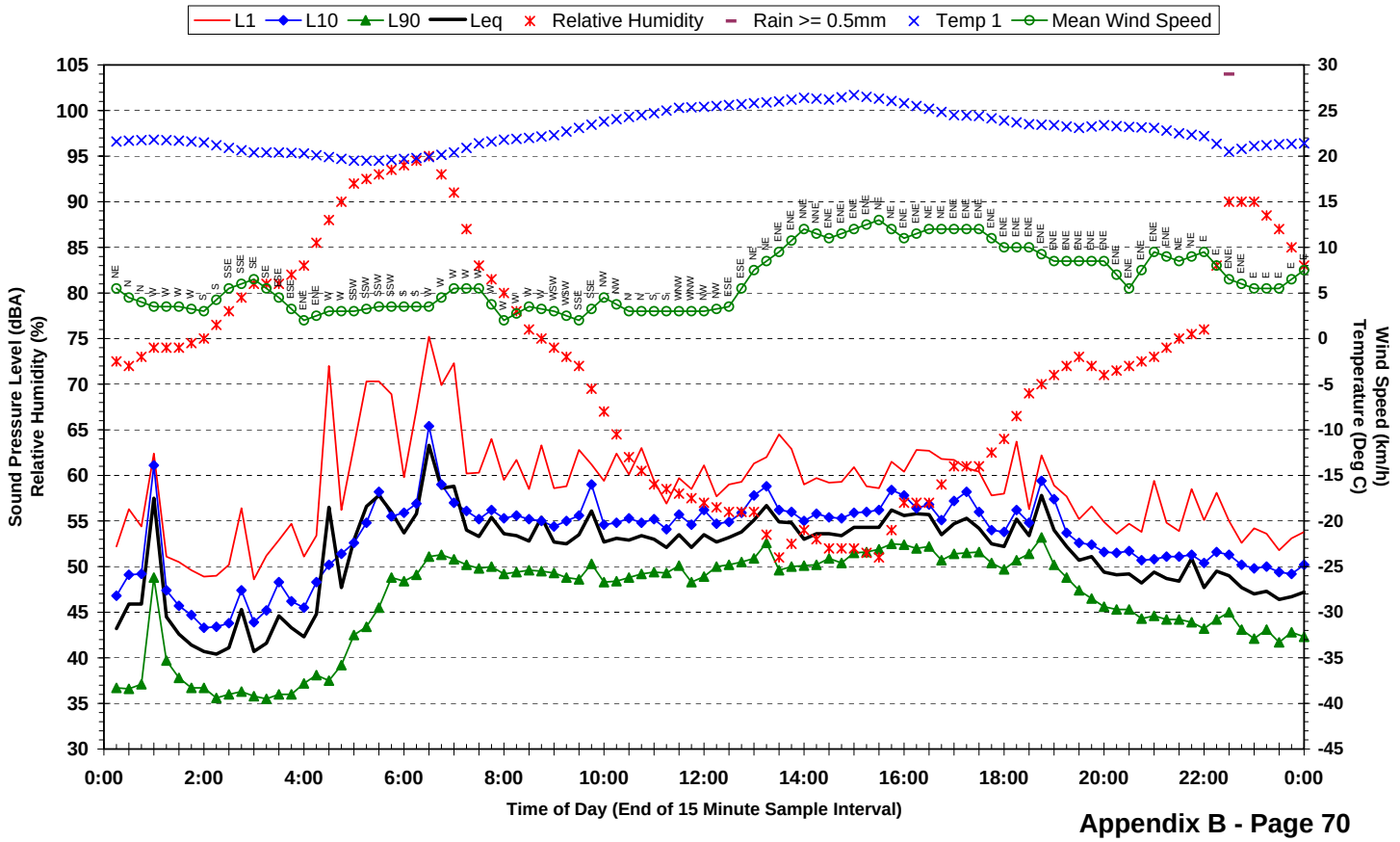
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Wednesday 21 November 2007



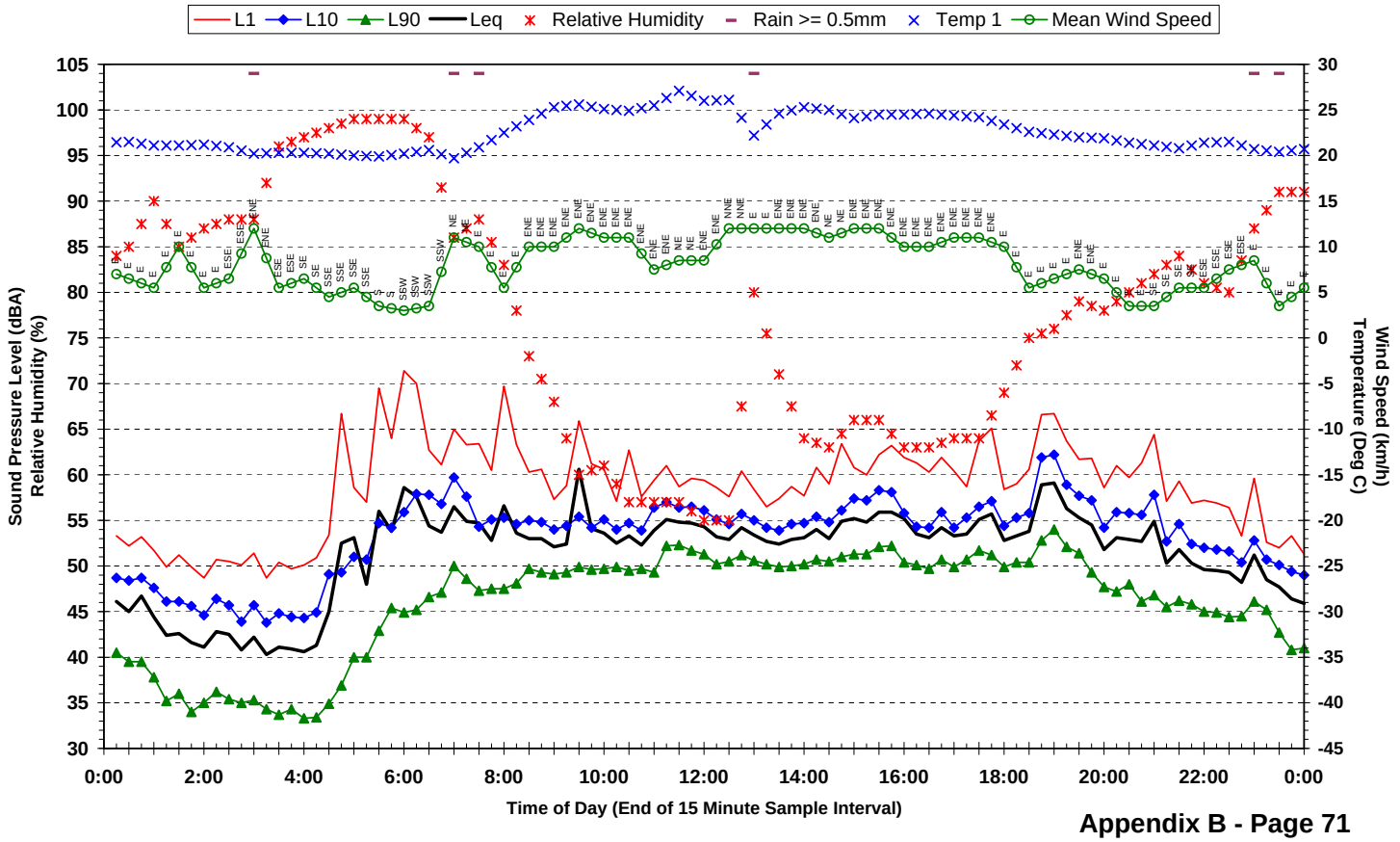
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Thursday 22 November 2007



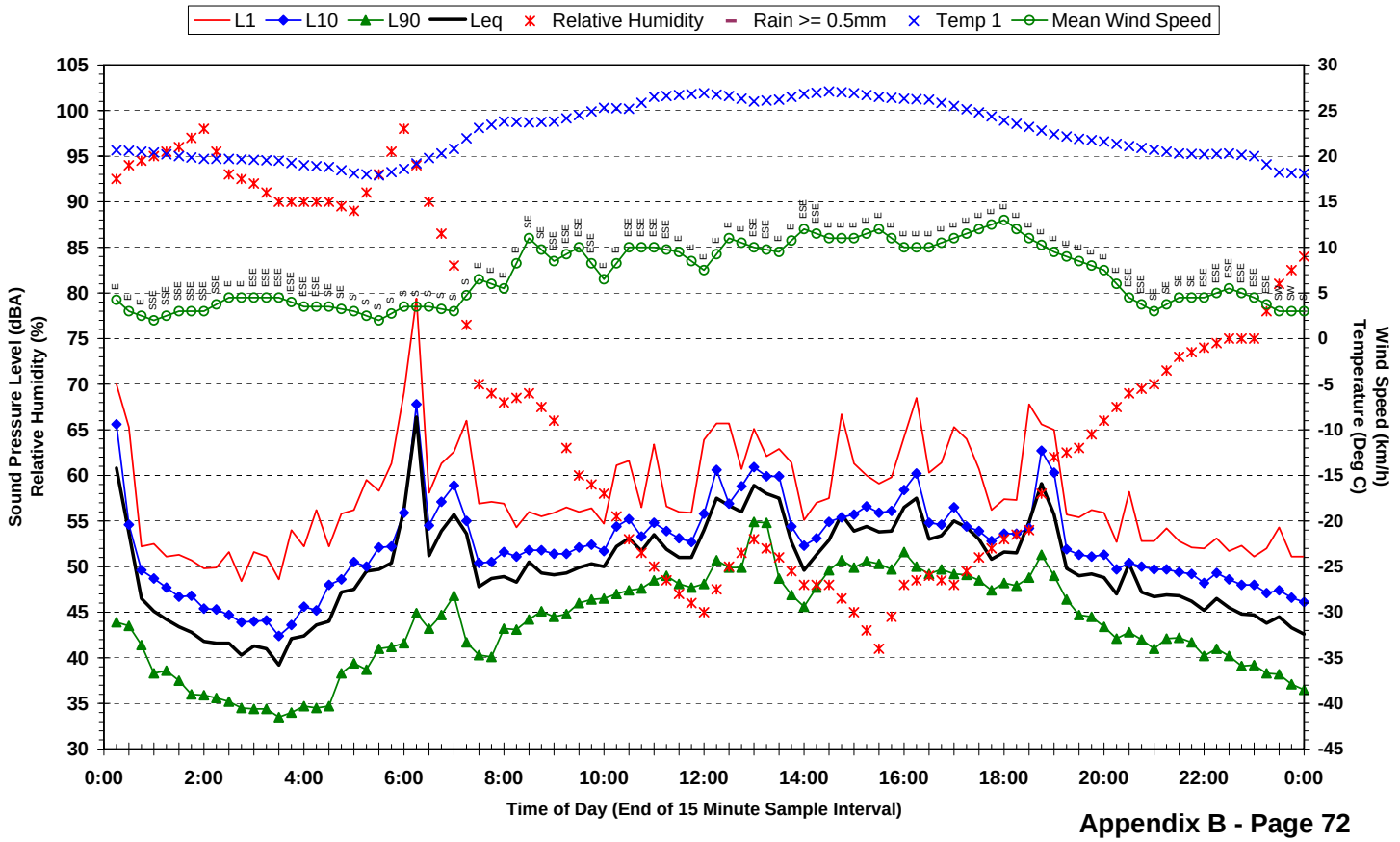
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Friday 23 November 2007



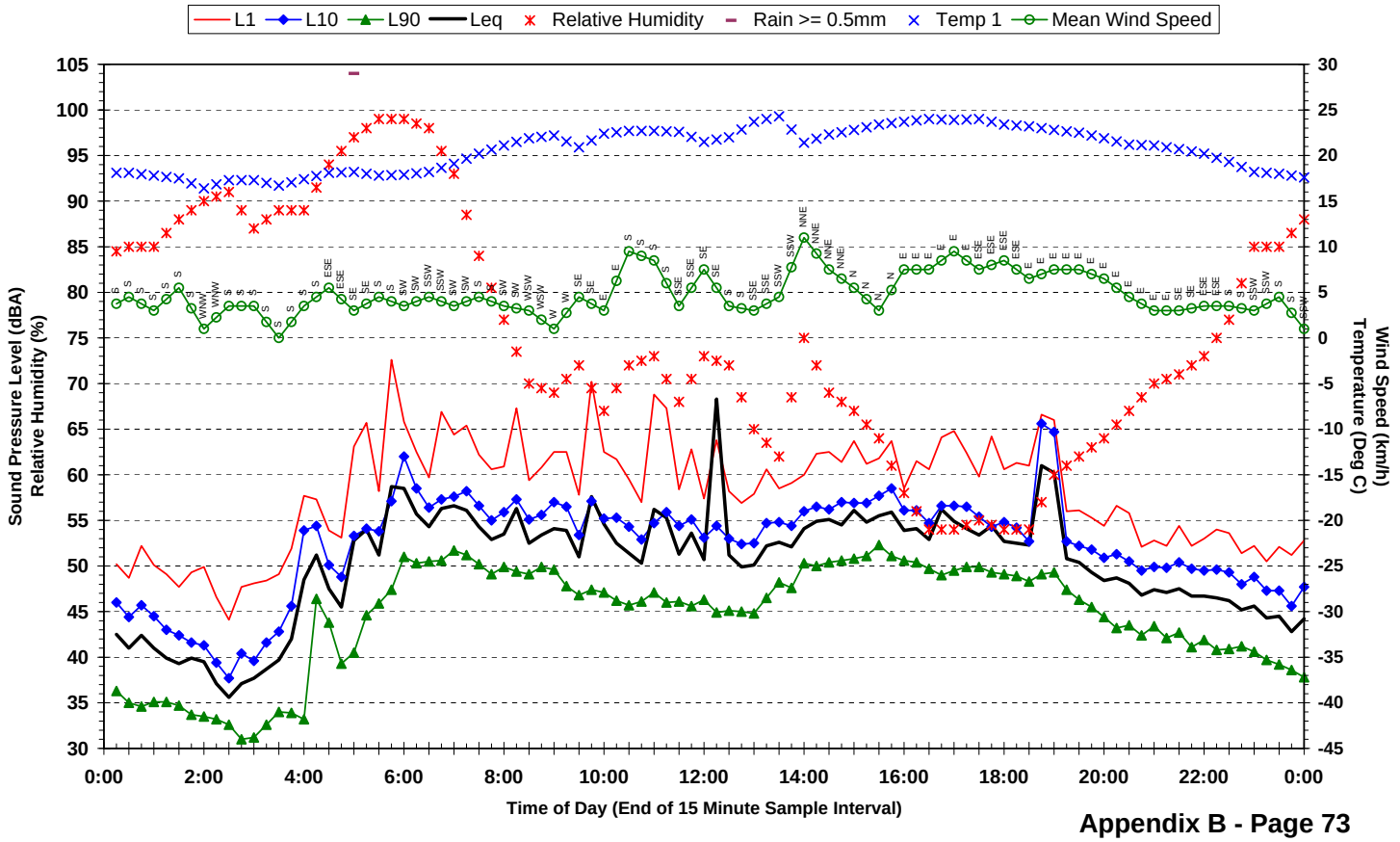
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Saturday 24 November 2007



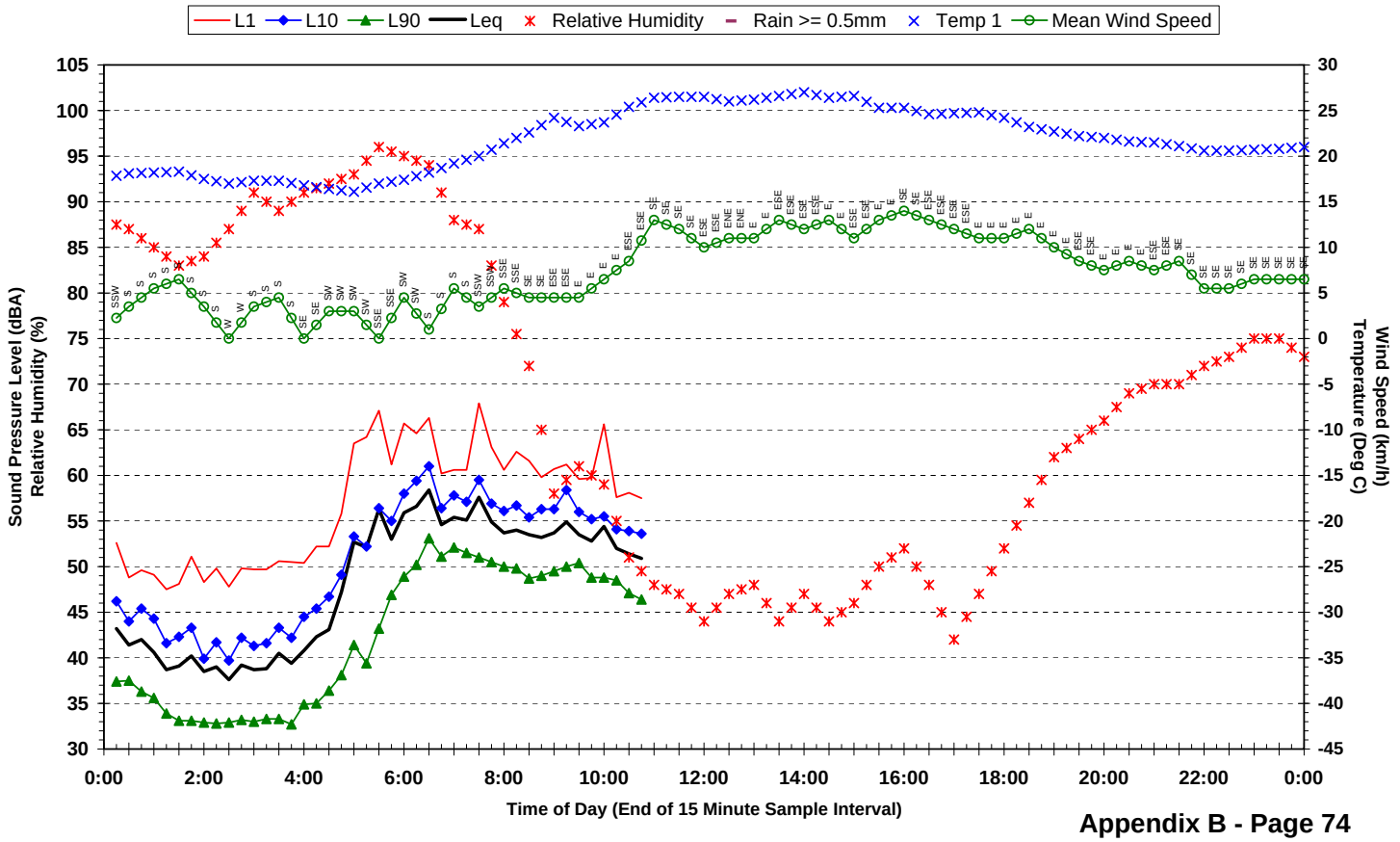
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Sunday 25 November 2007



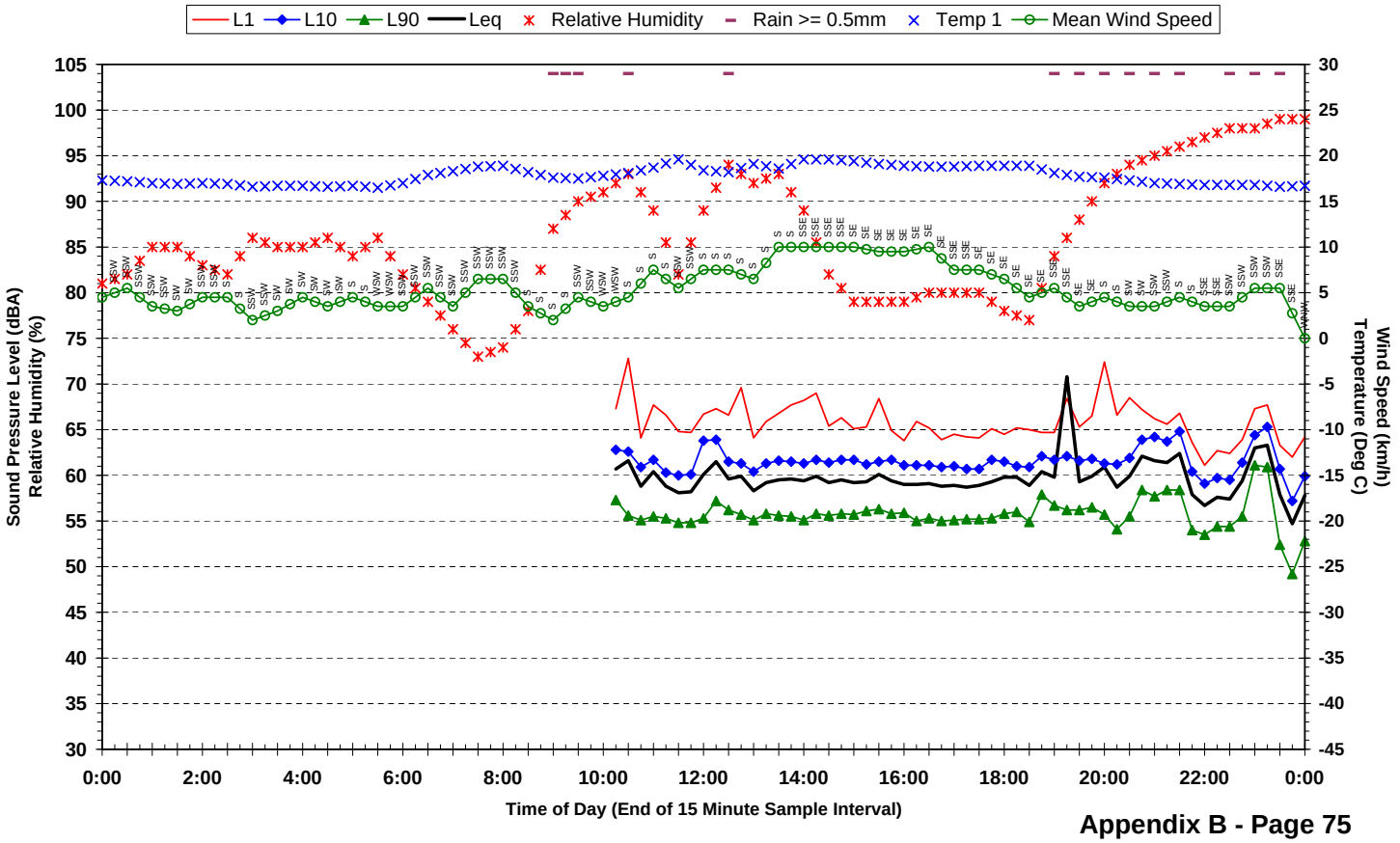
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Monday 26 November 2007



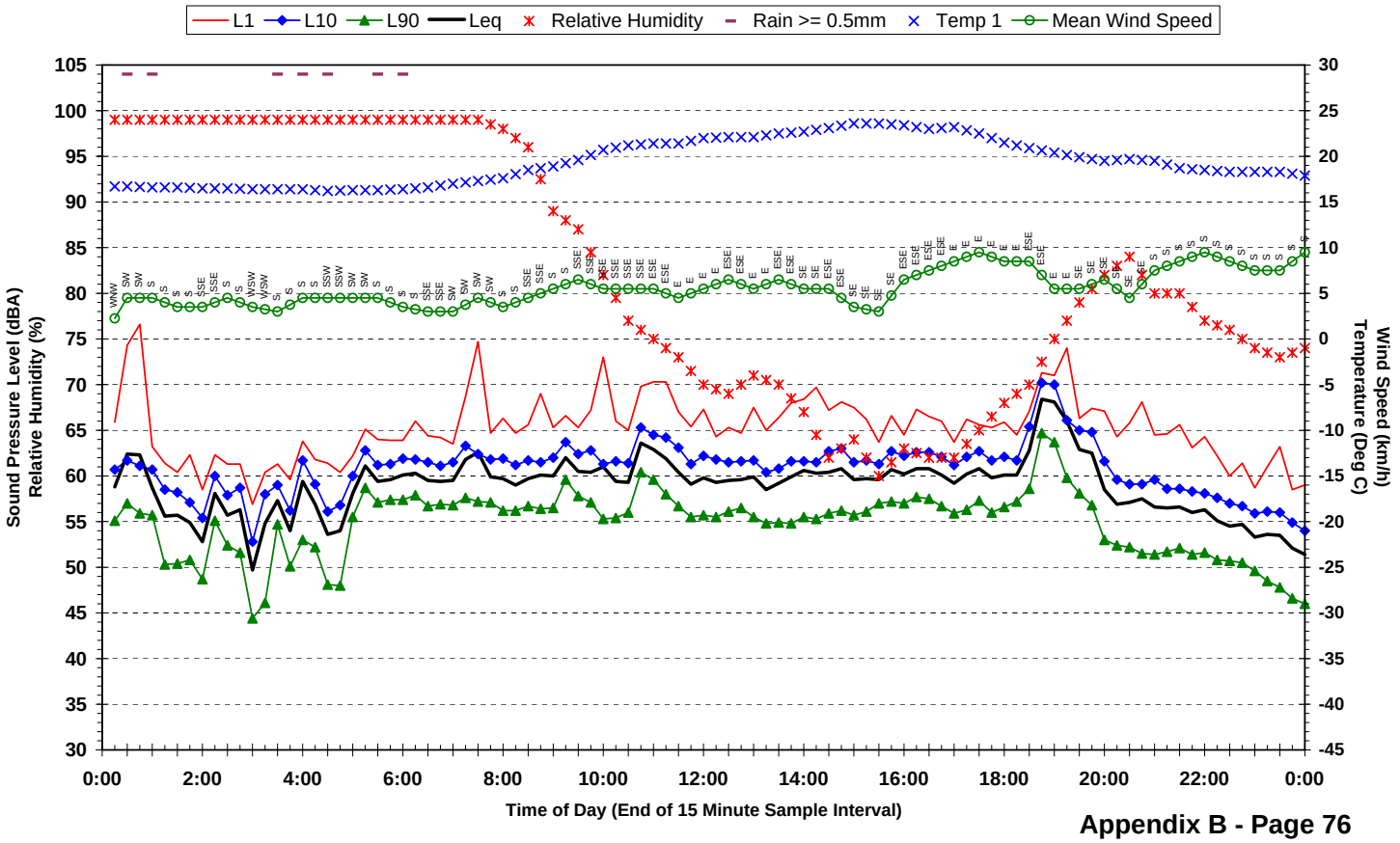
Statistical Ambient Noise Levels
Location 7 - 9 Victoria Crescent, Toowong - Tuesday 27 November 2007



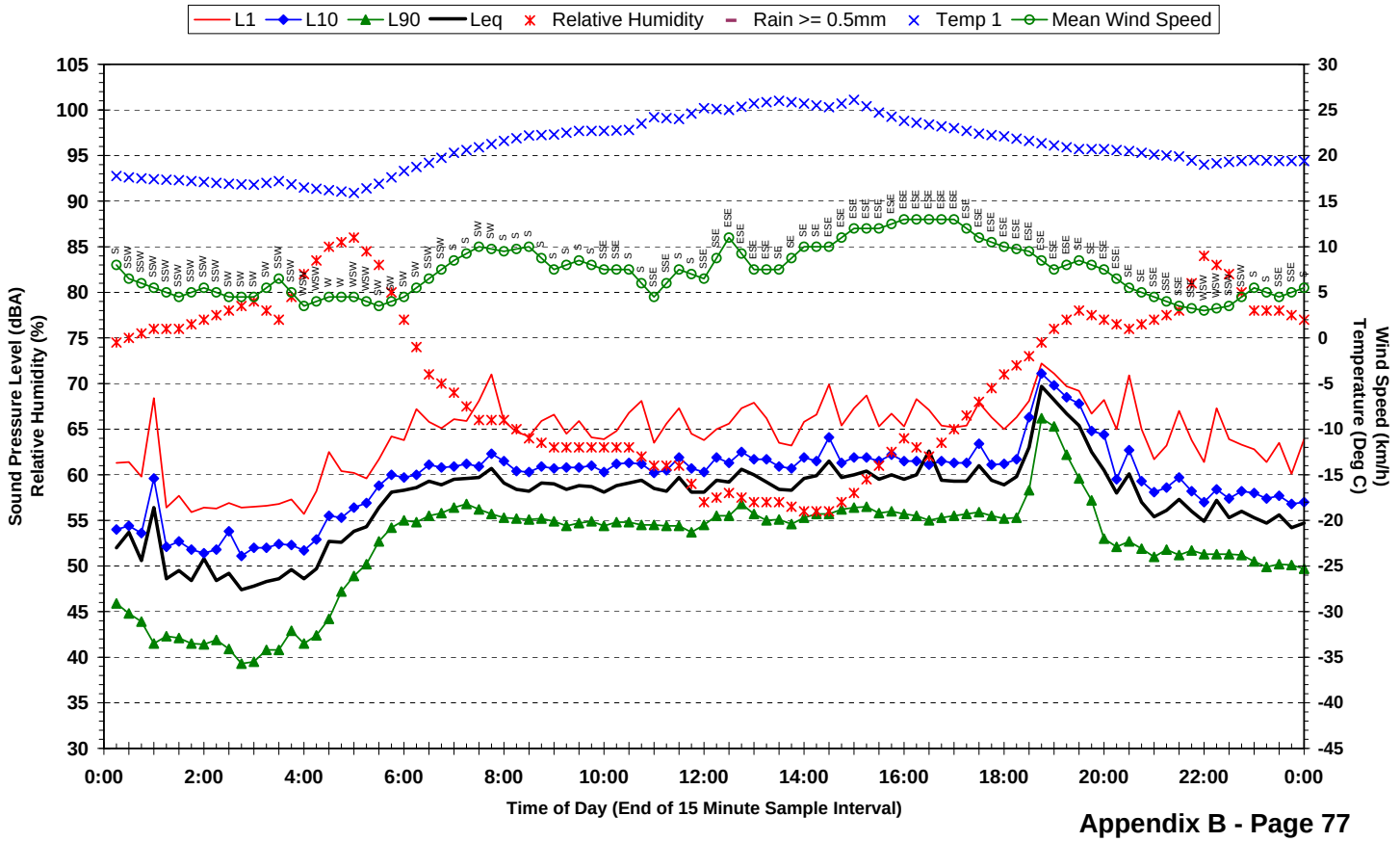
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Wednesday 7 November 2007



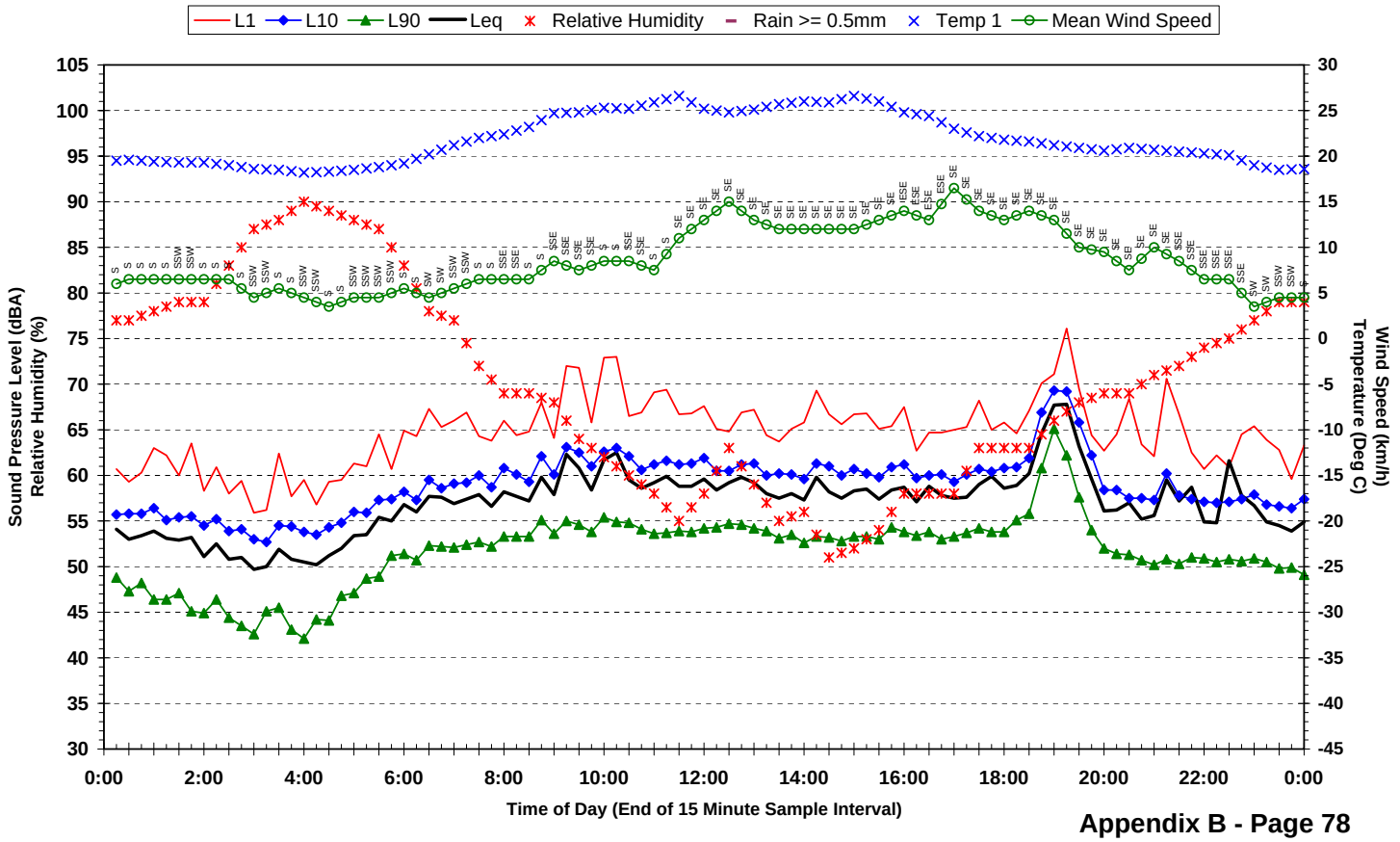
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Thursday 8 November 2007



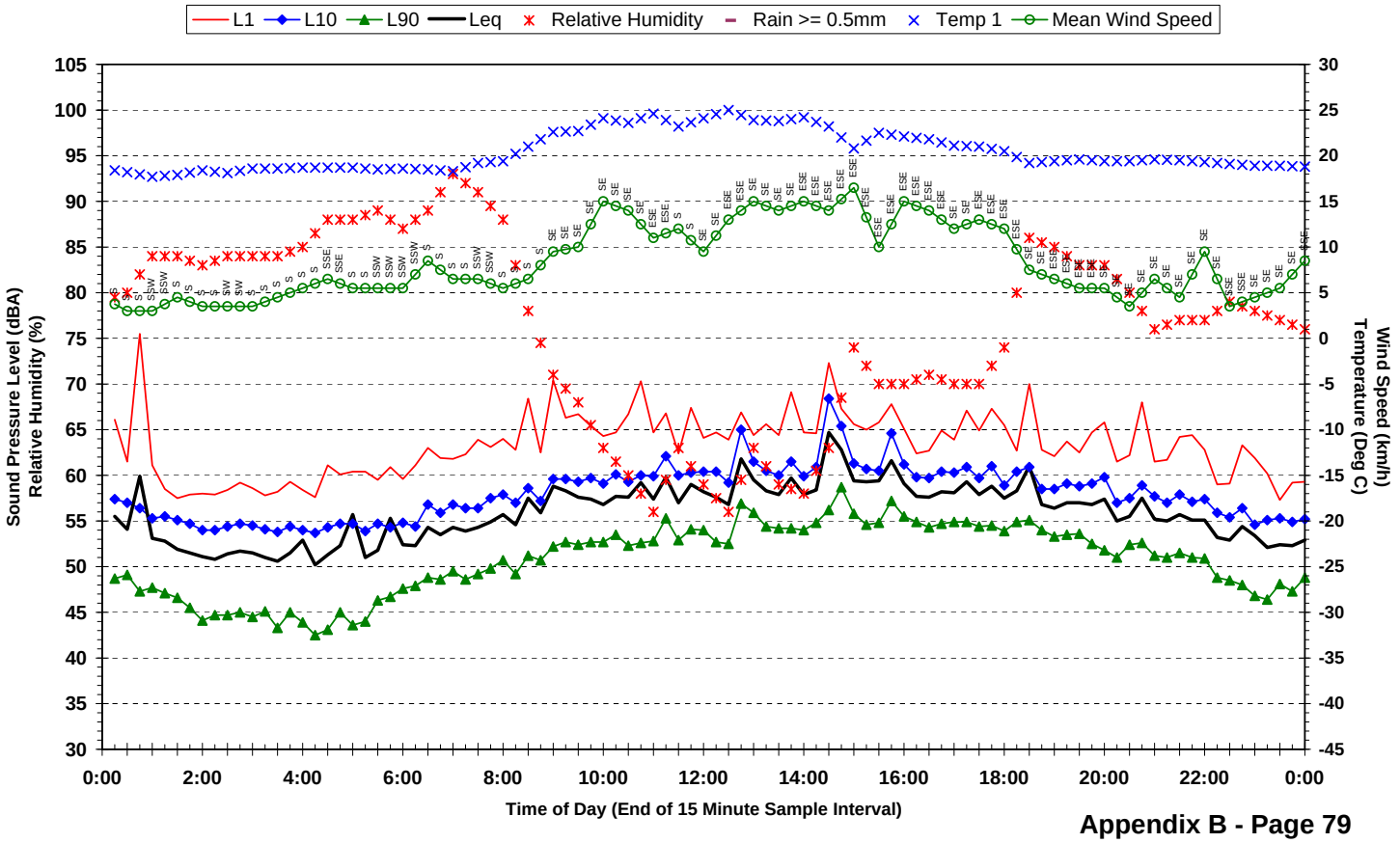
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Friday 9 November 2007



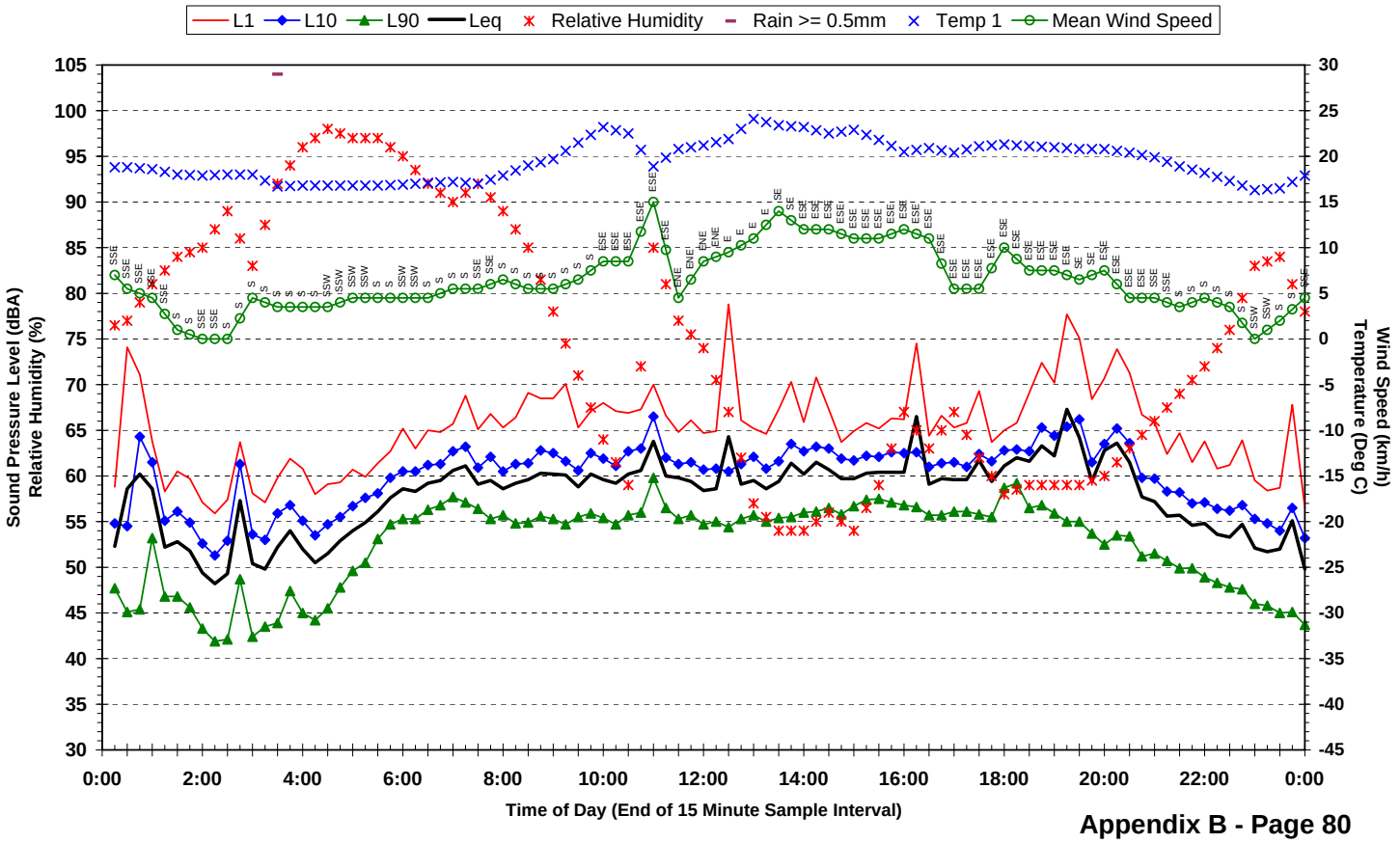
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Saturday 10 November 2007



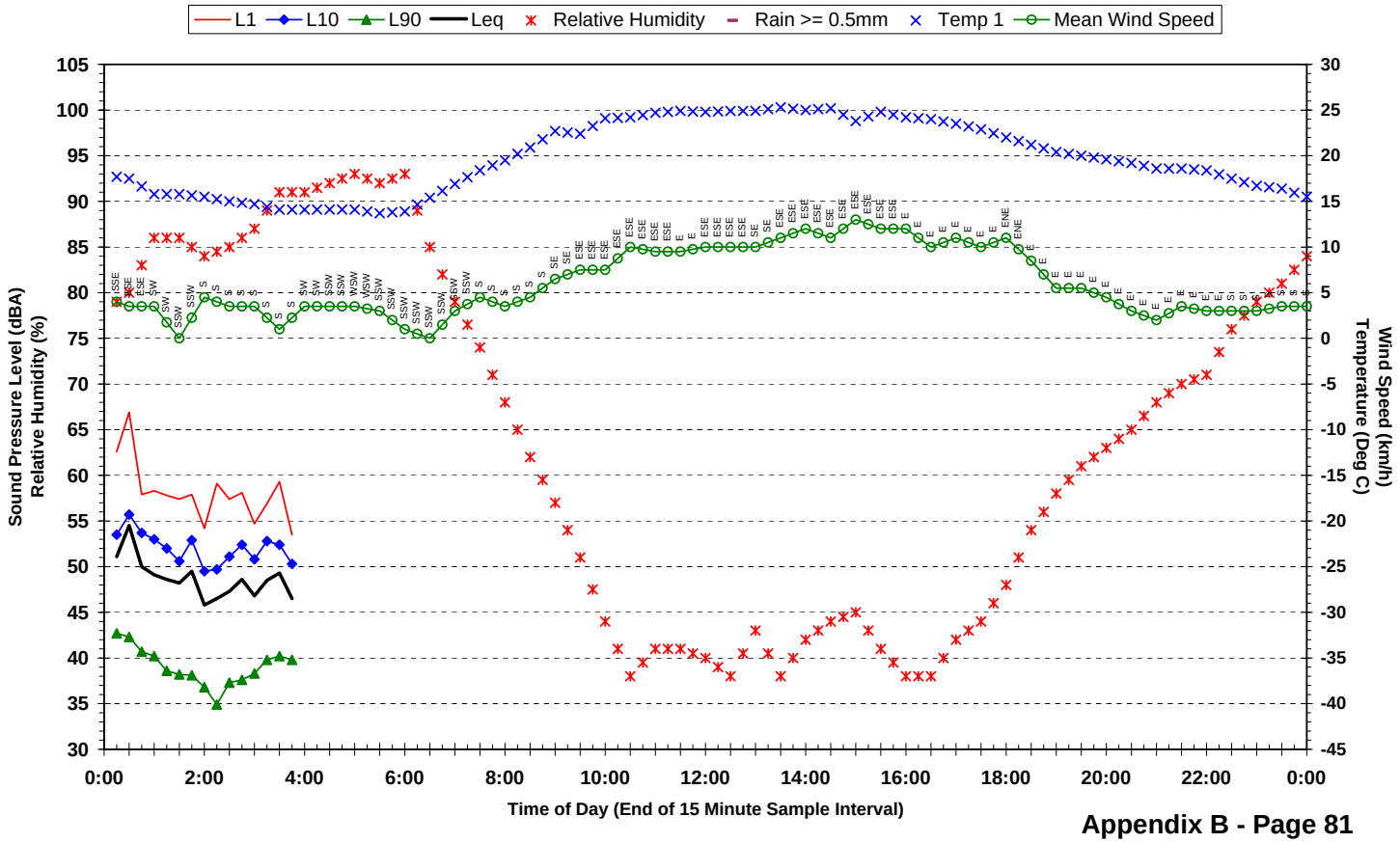
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Sunday 11 November 2007



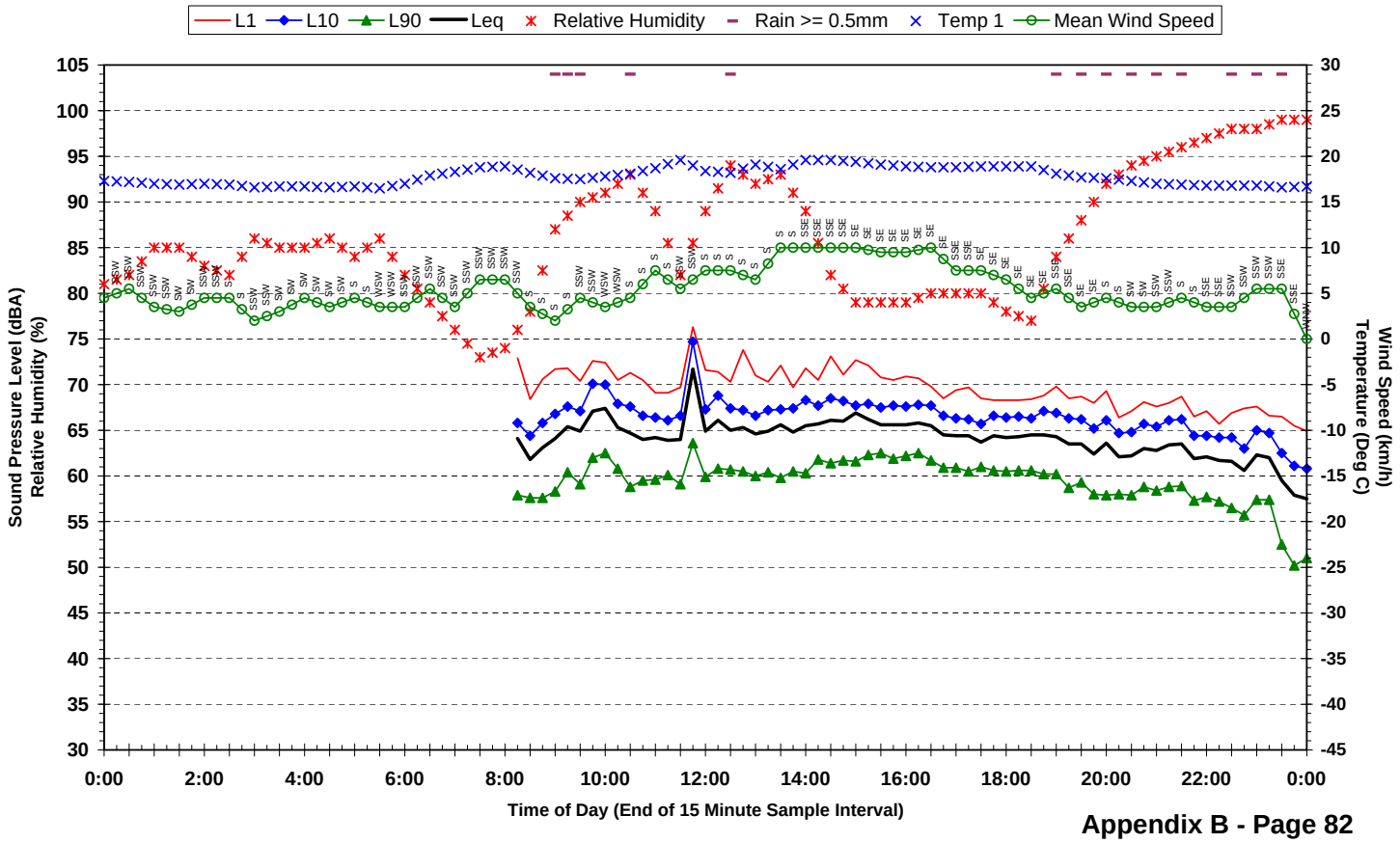
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Monday 12 November 2007



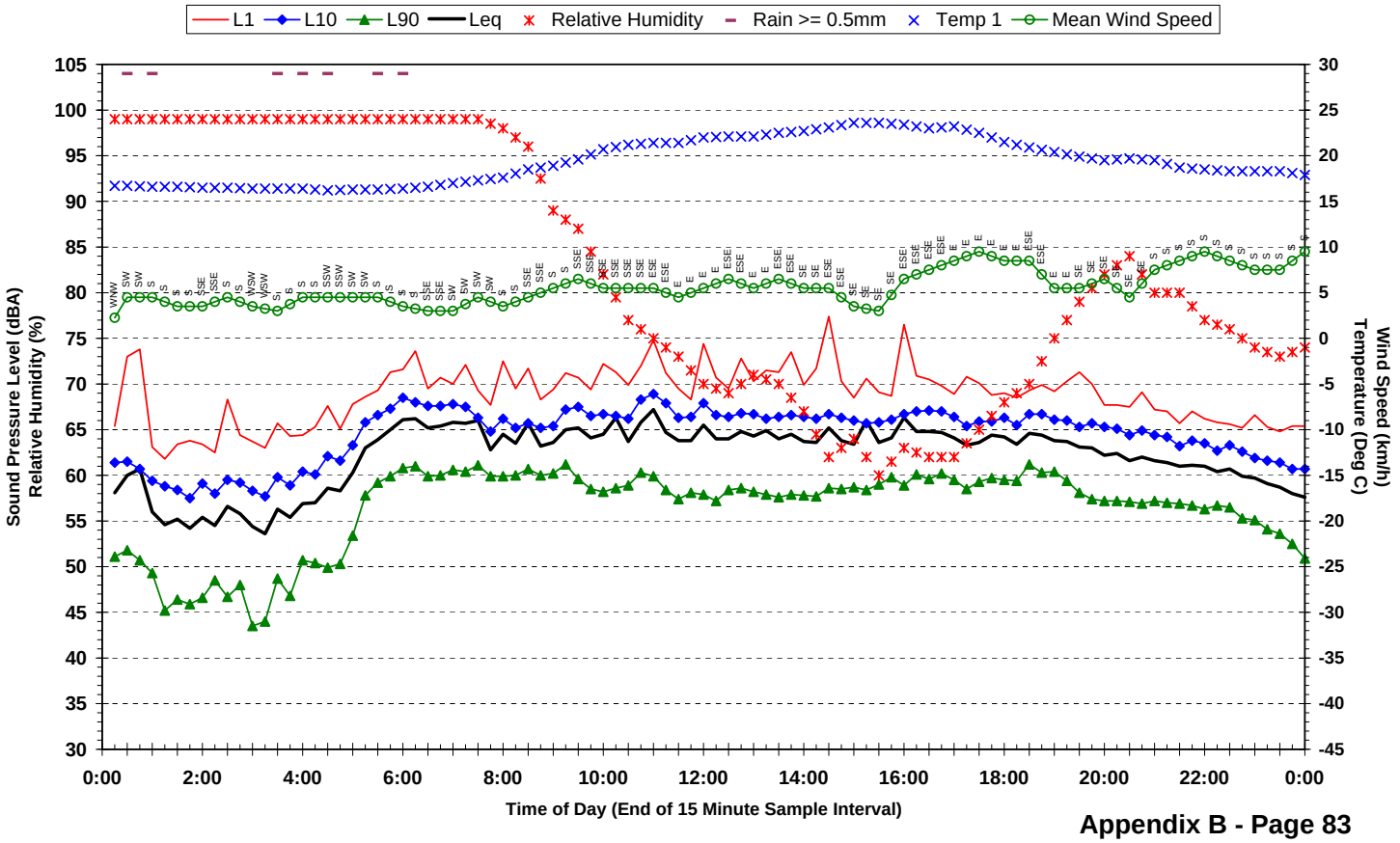
Statistical Ambient Noise Levels
Location 8 - 5 Clyde Street, Brisbane City - Tuesday 13 November 2007



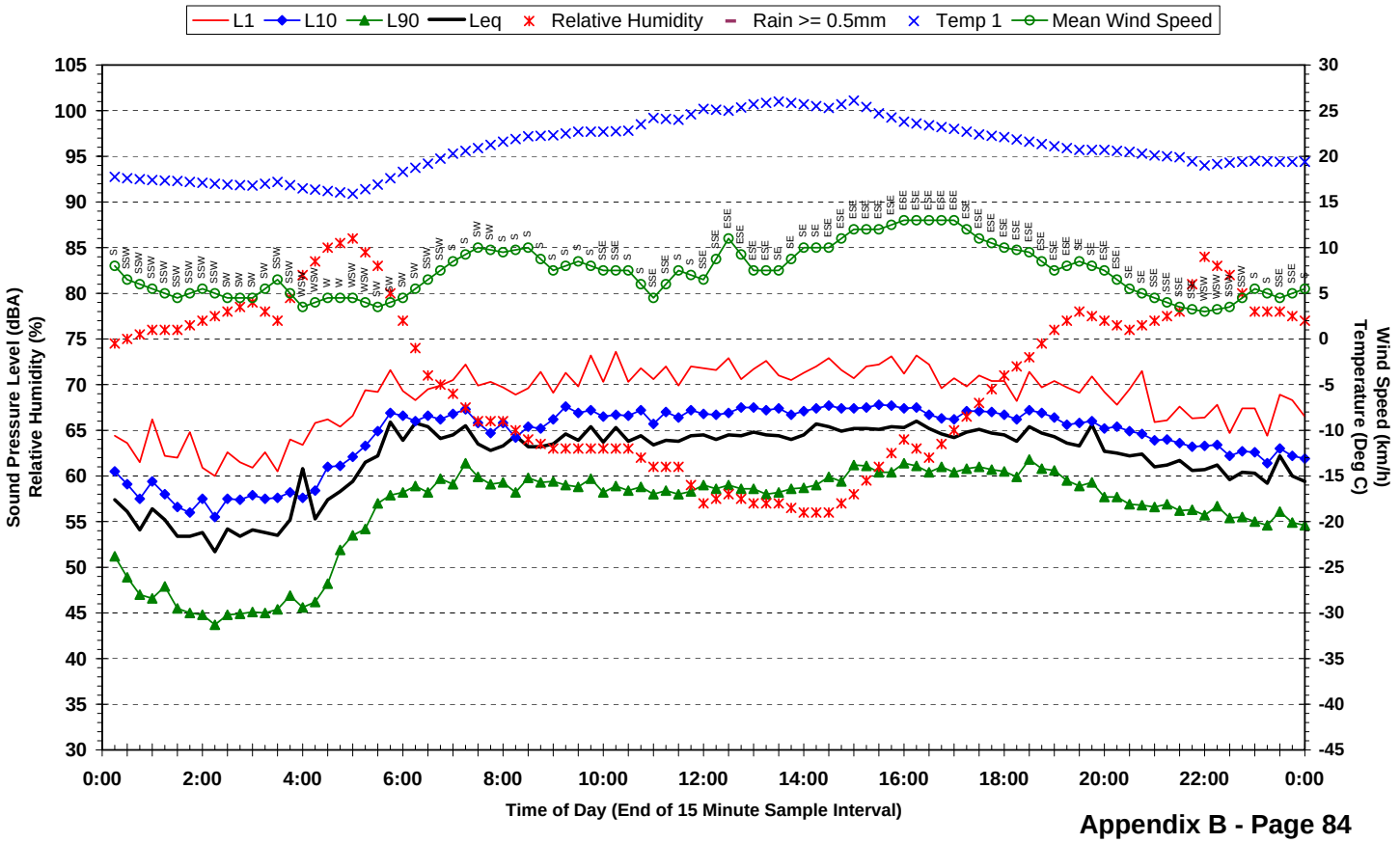
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Wednesday 7 November 2007



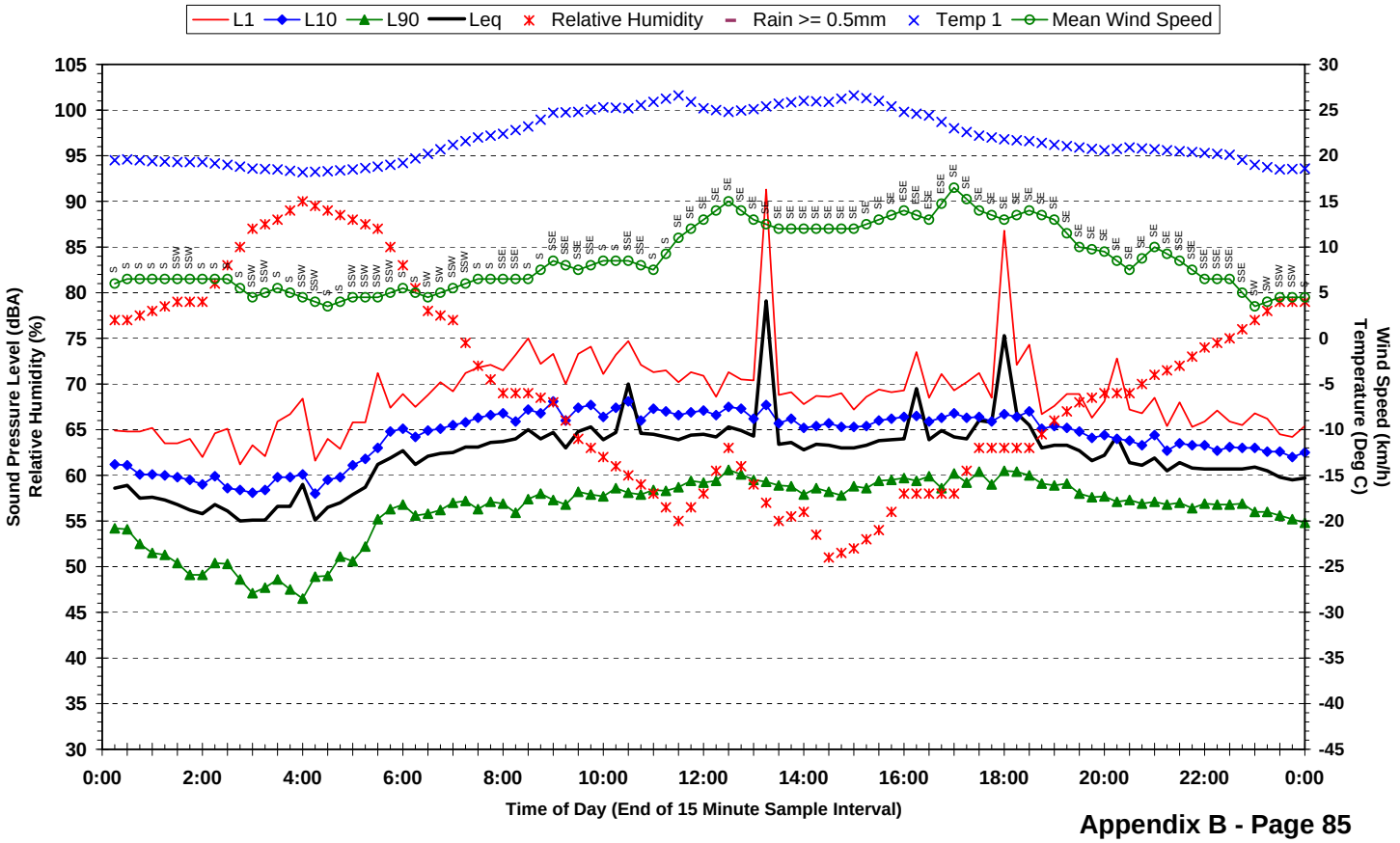
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Thursday 8 November 2007



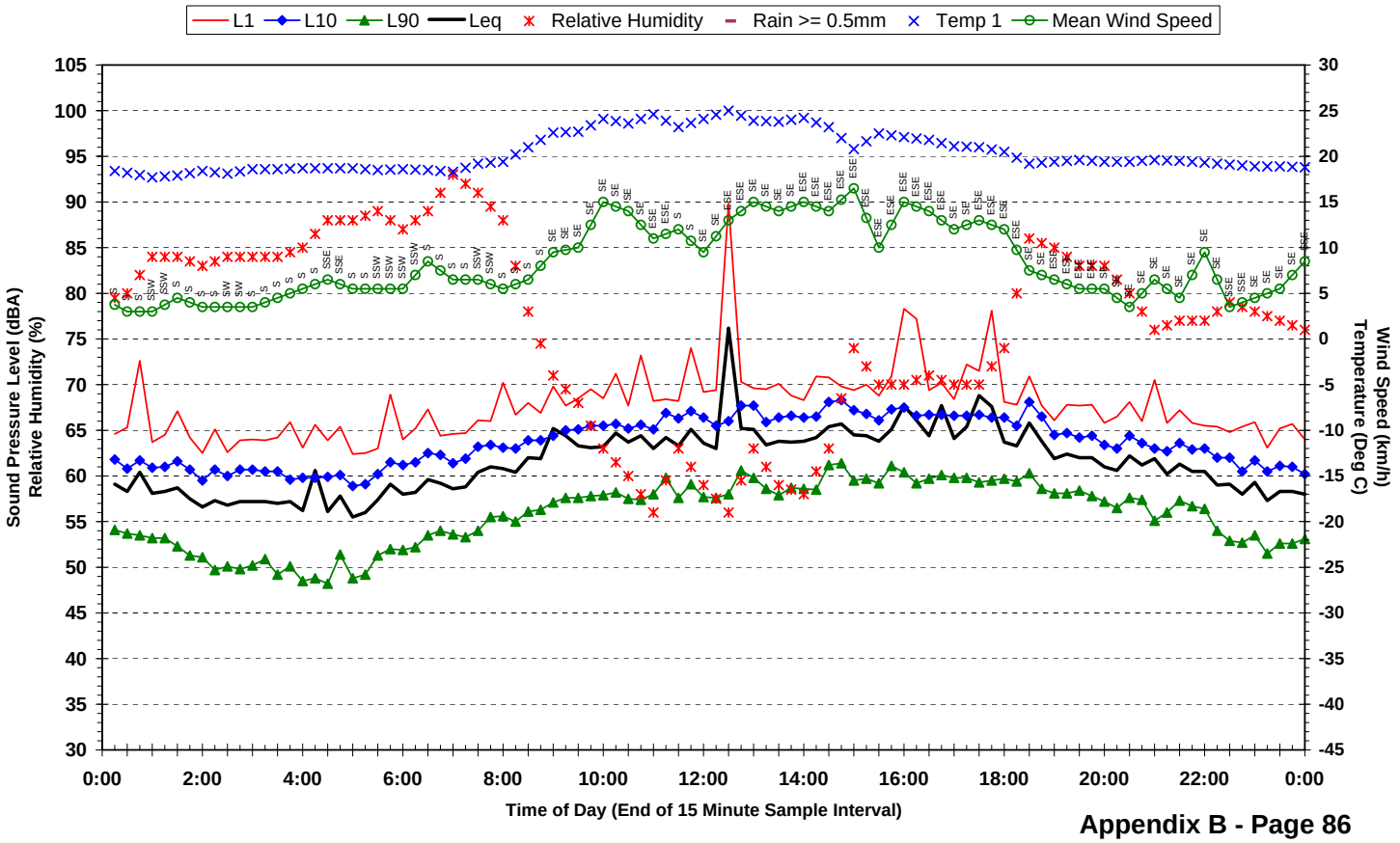
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Friday 9 November 2007



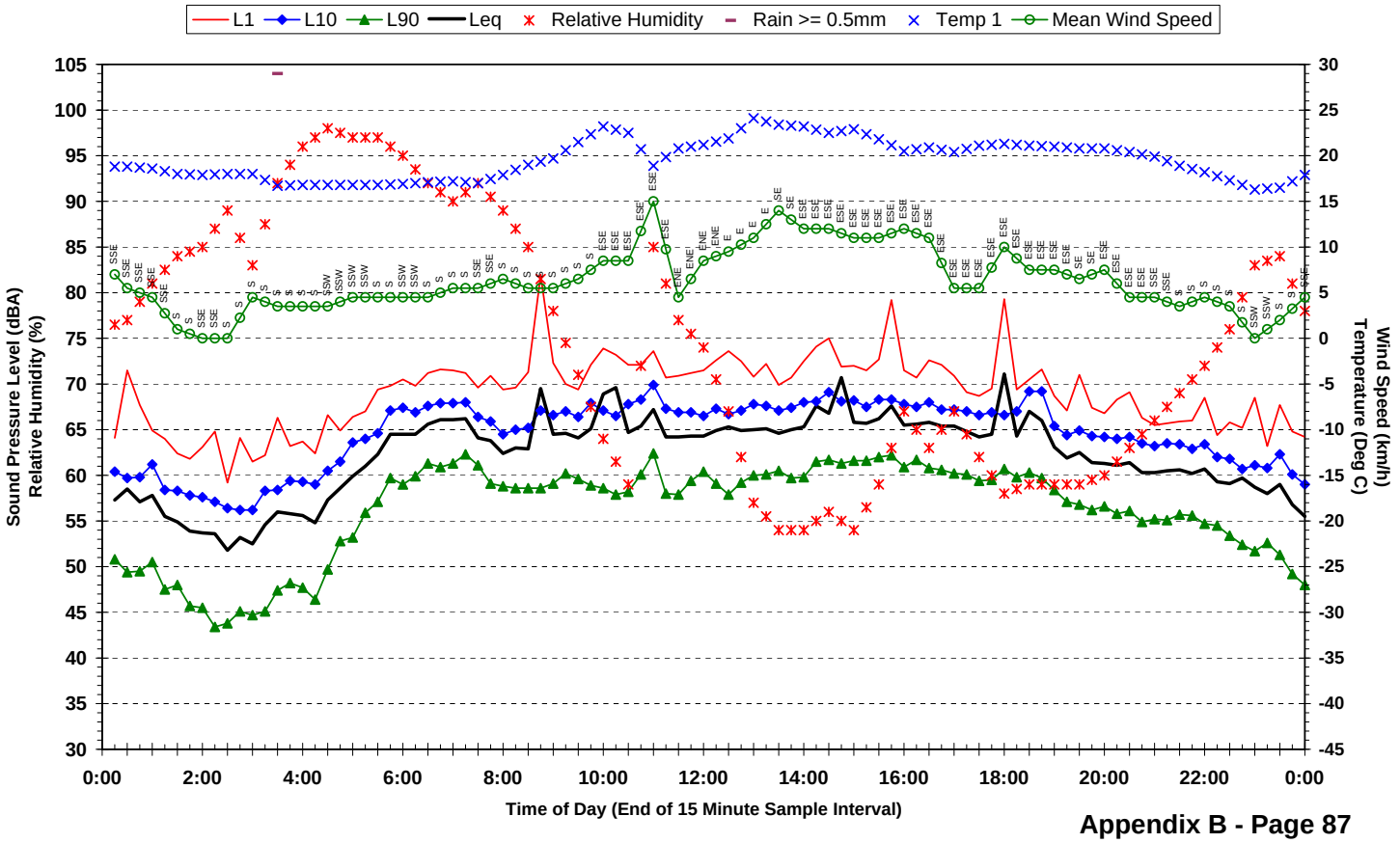
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Saturday 10 November 2007



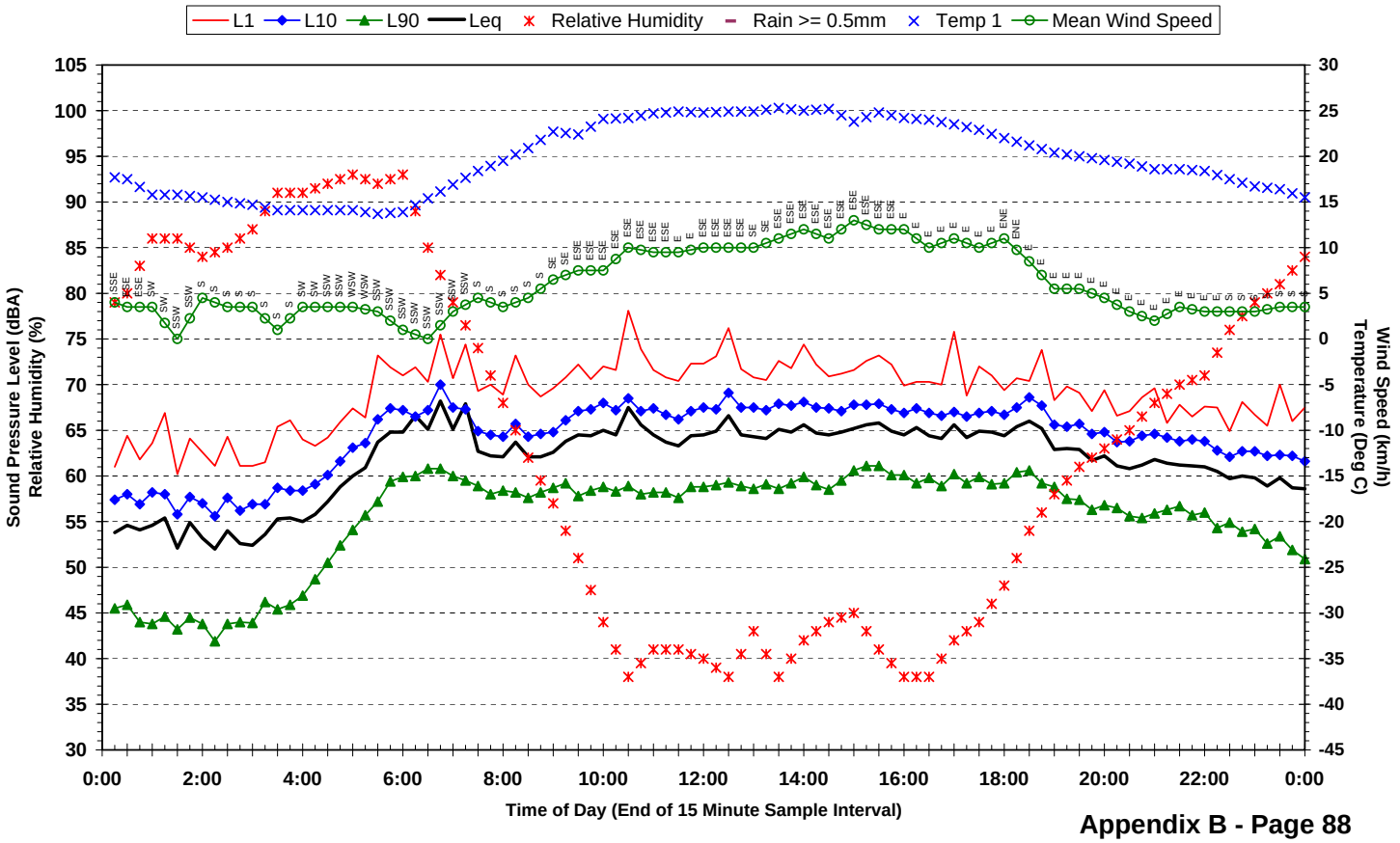
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Sunday 11 November 2007



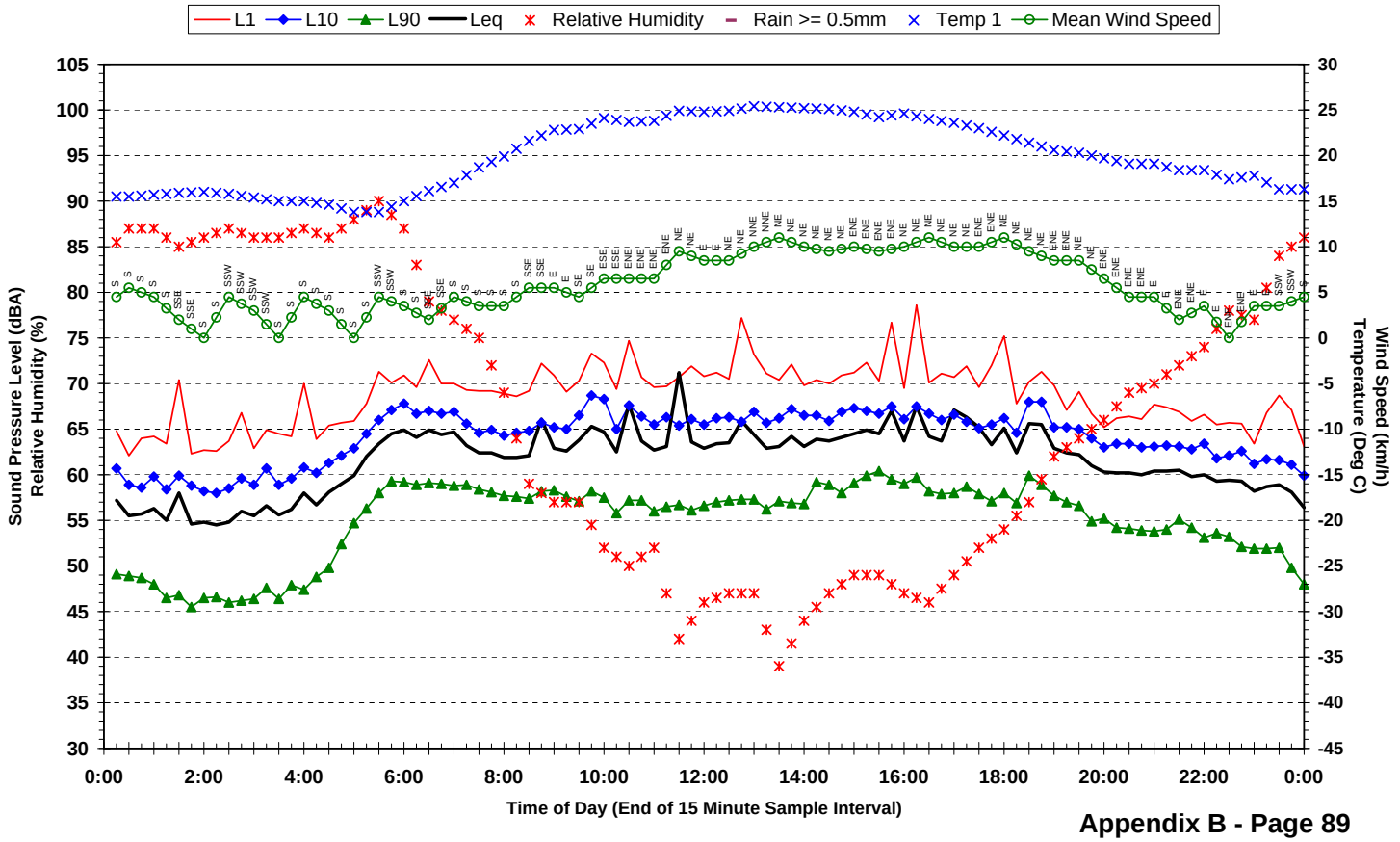
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Monday 12 November 2007



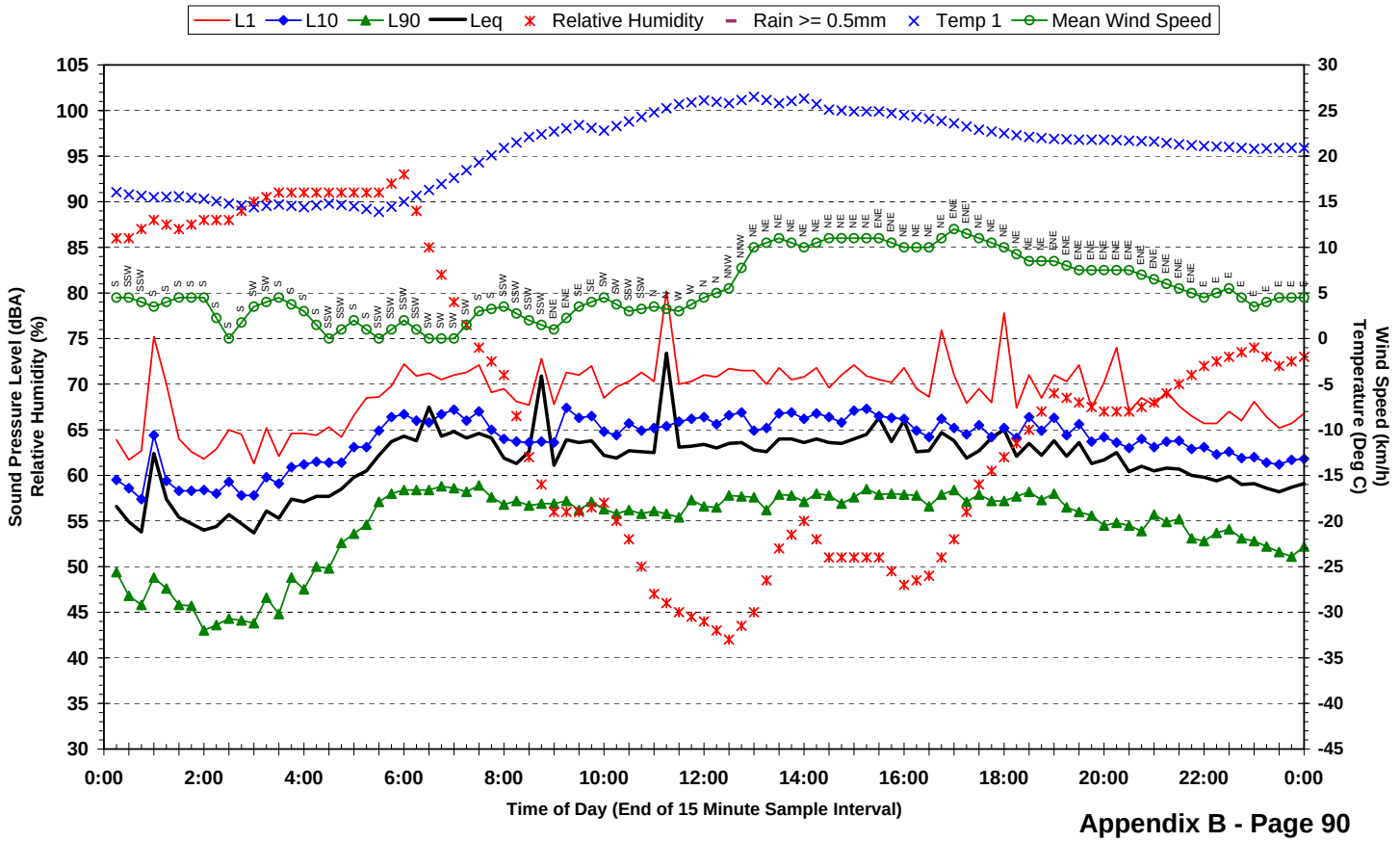
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Tuesday 13 November 2007



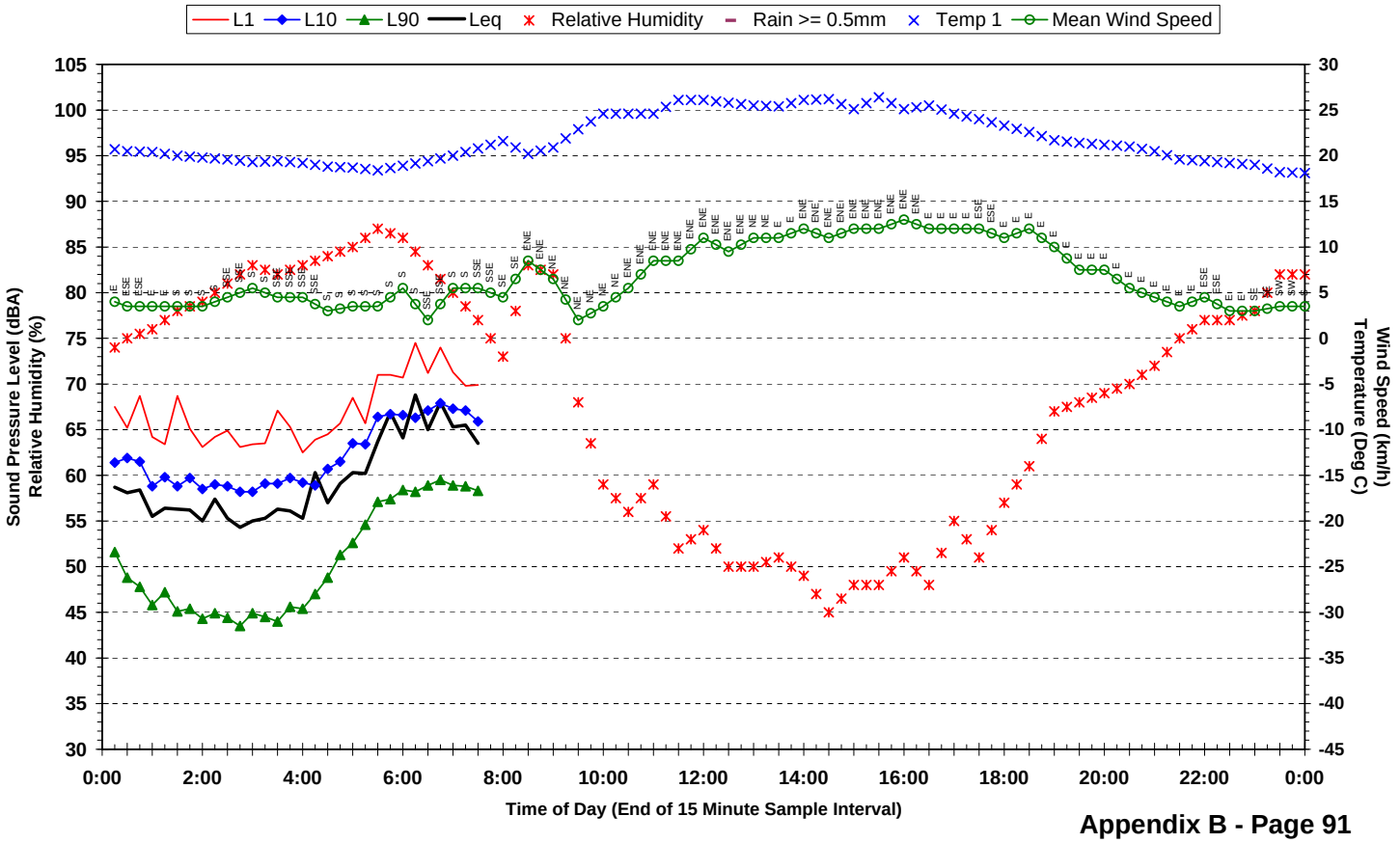
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Wednesday 14 November 2007



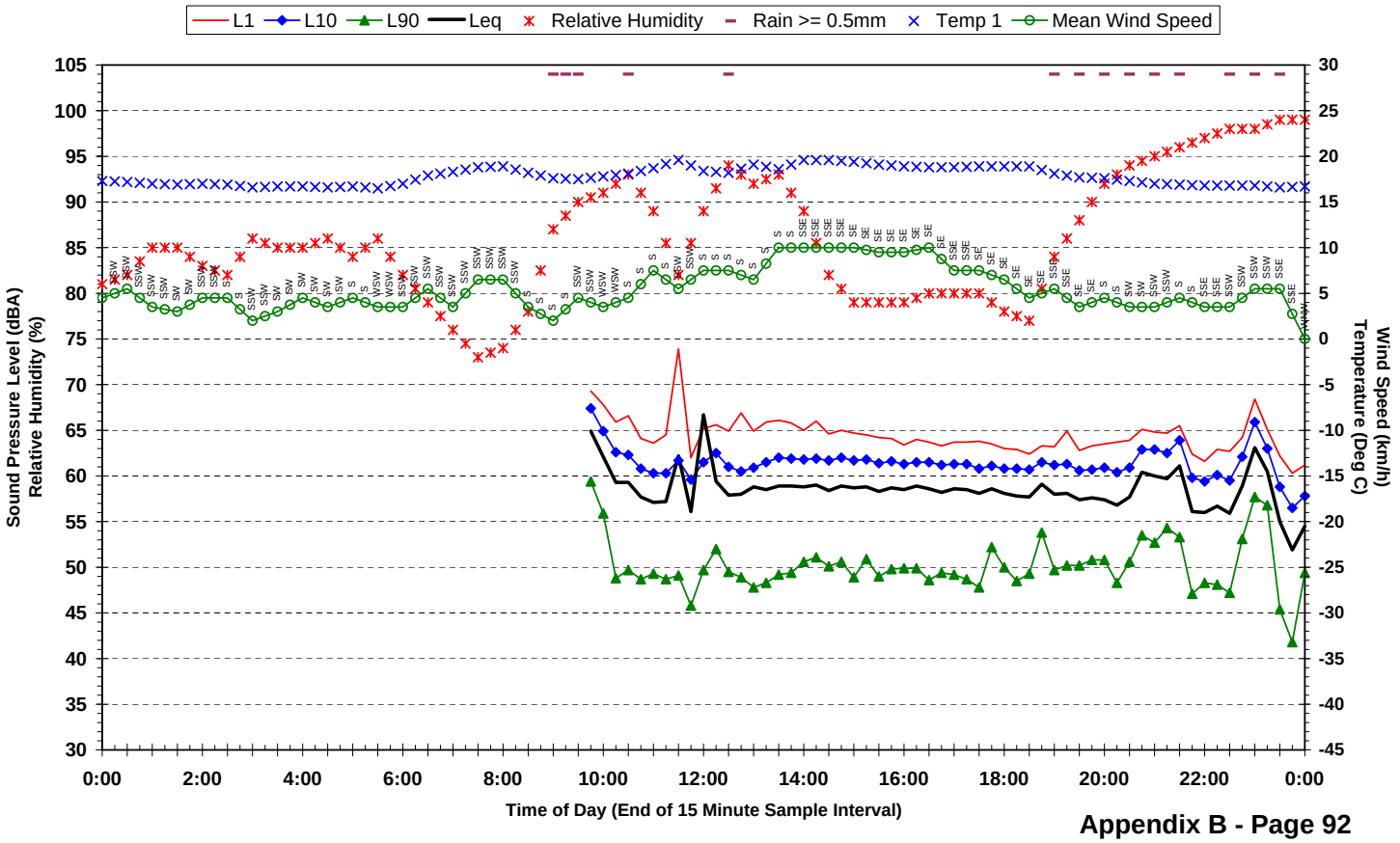
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Thursday 15 November 2007



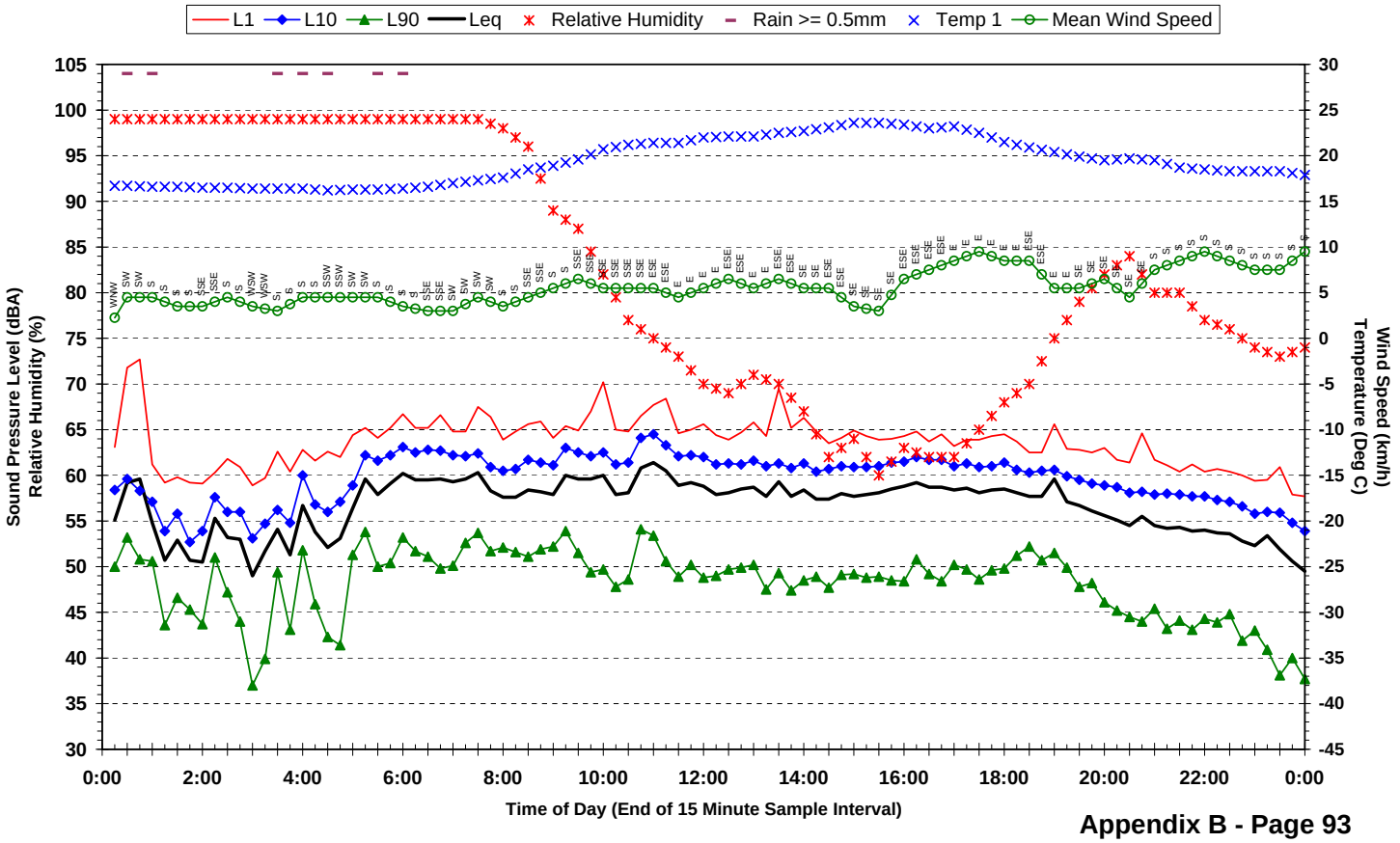
Statistical Ambient Noise Levels
Location 9 - 26 Lower Clifton Terrace, Red Hill - Friday 16 November 2007



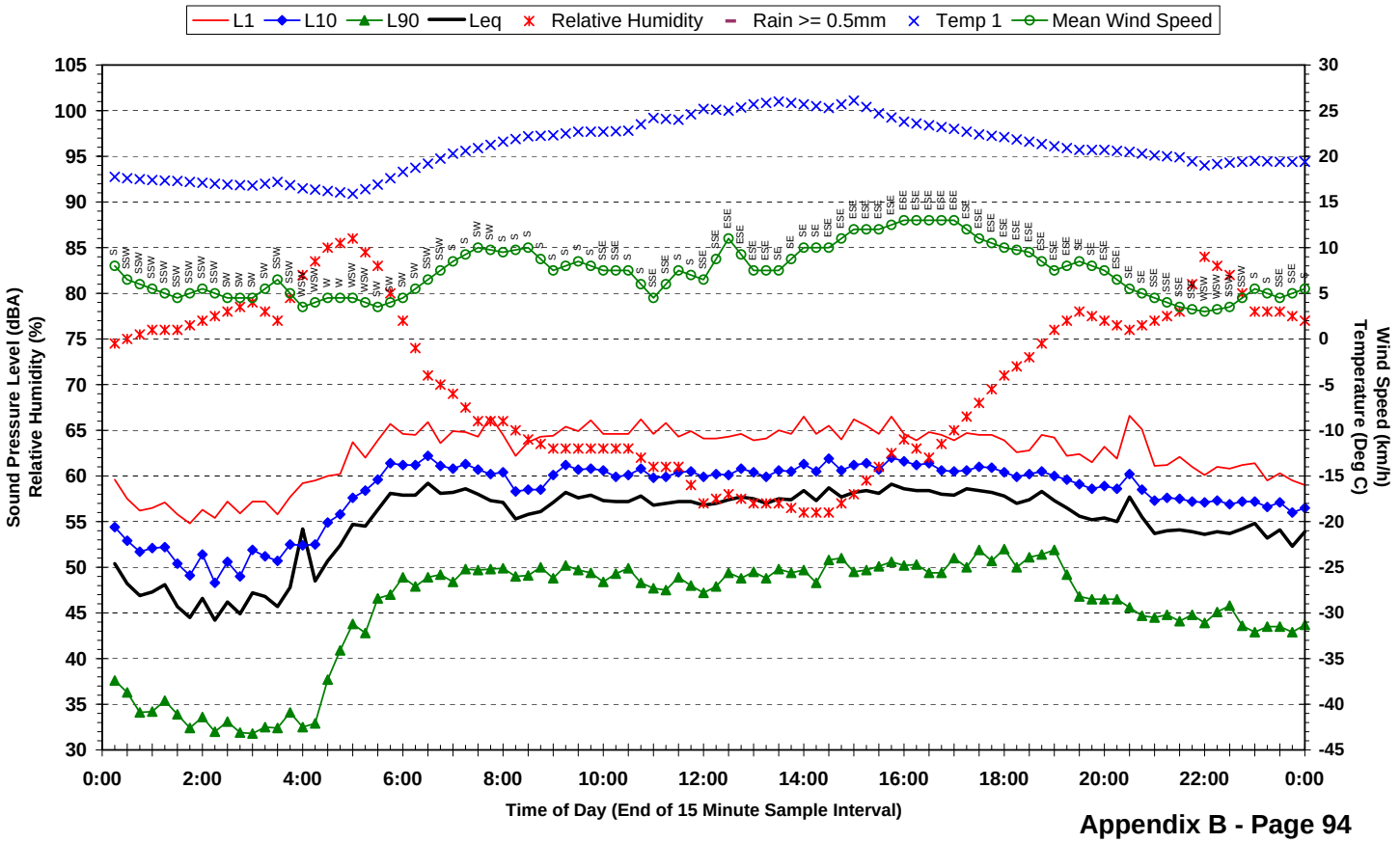
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Wednesday 7 November 2007



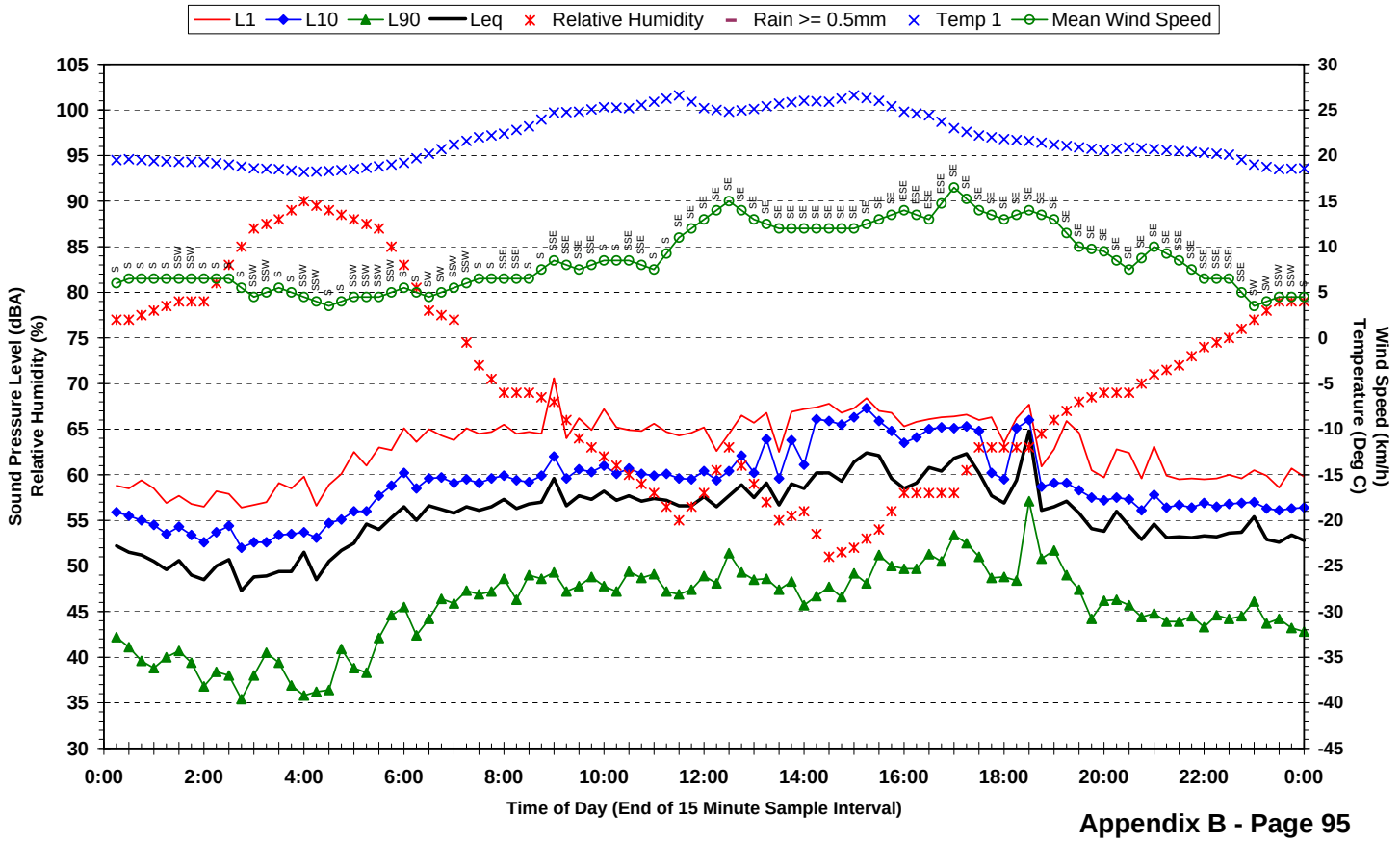
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Thursday 8 November 2007



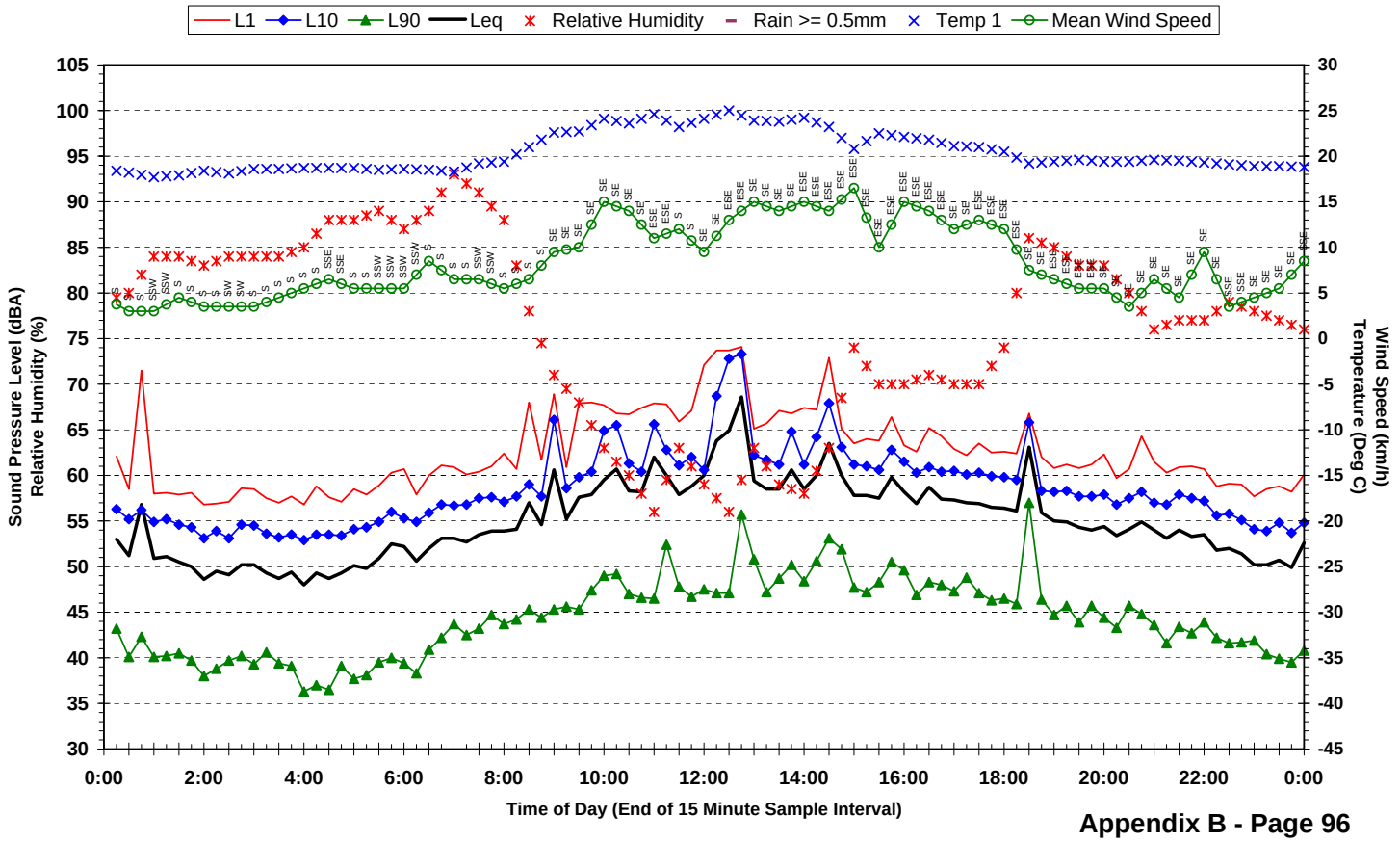
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Friday 9 November 2007



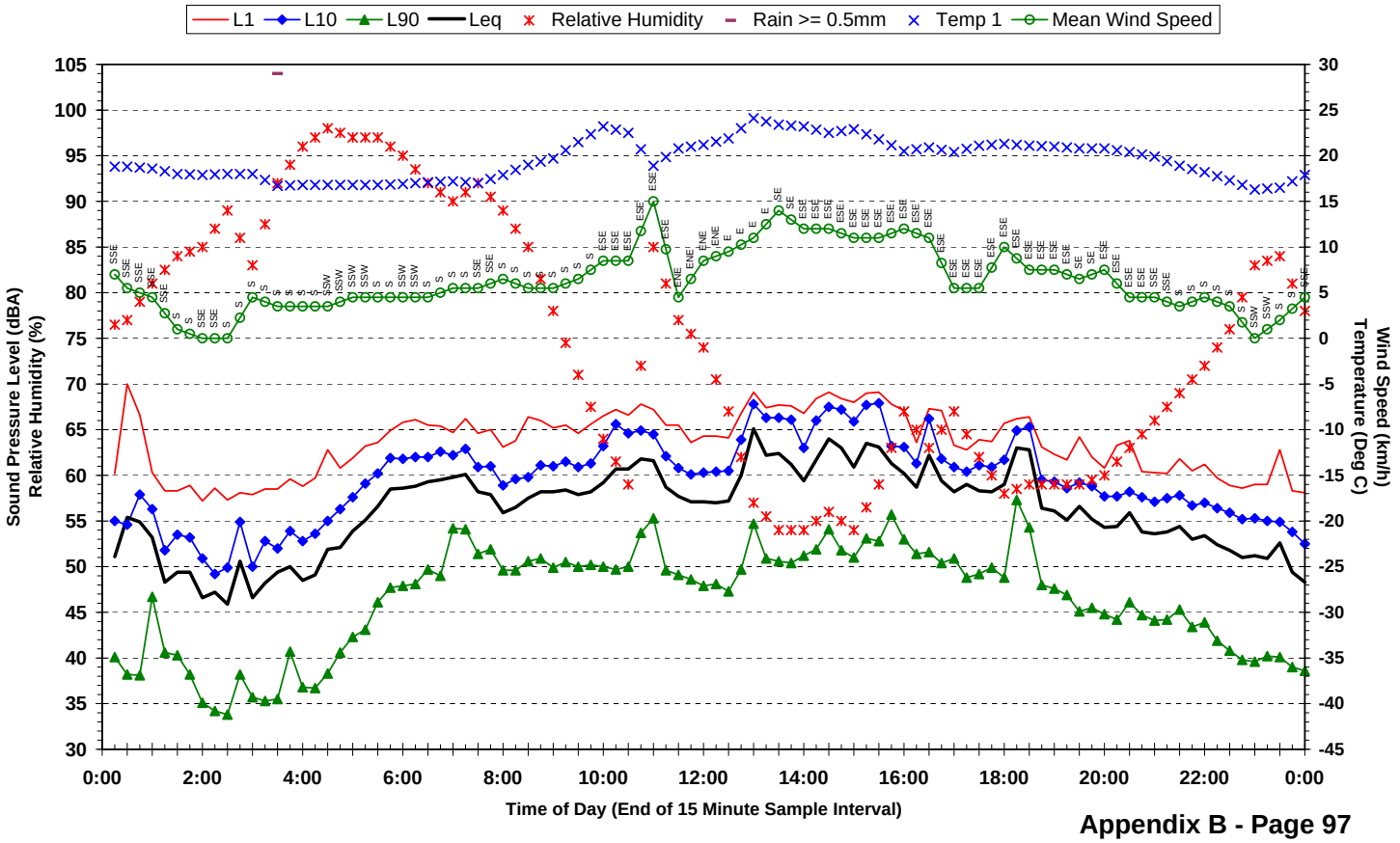
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Saturday 10 November 2007



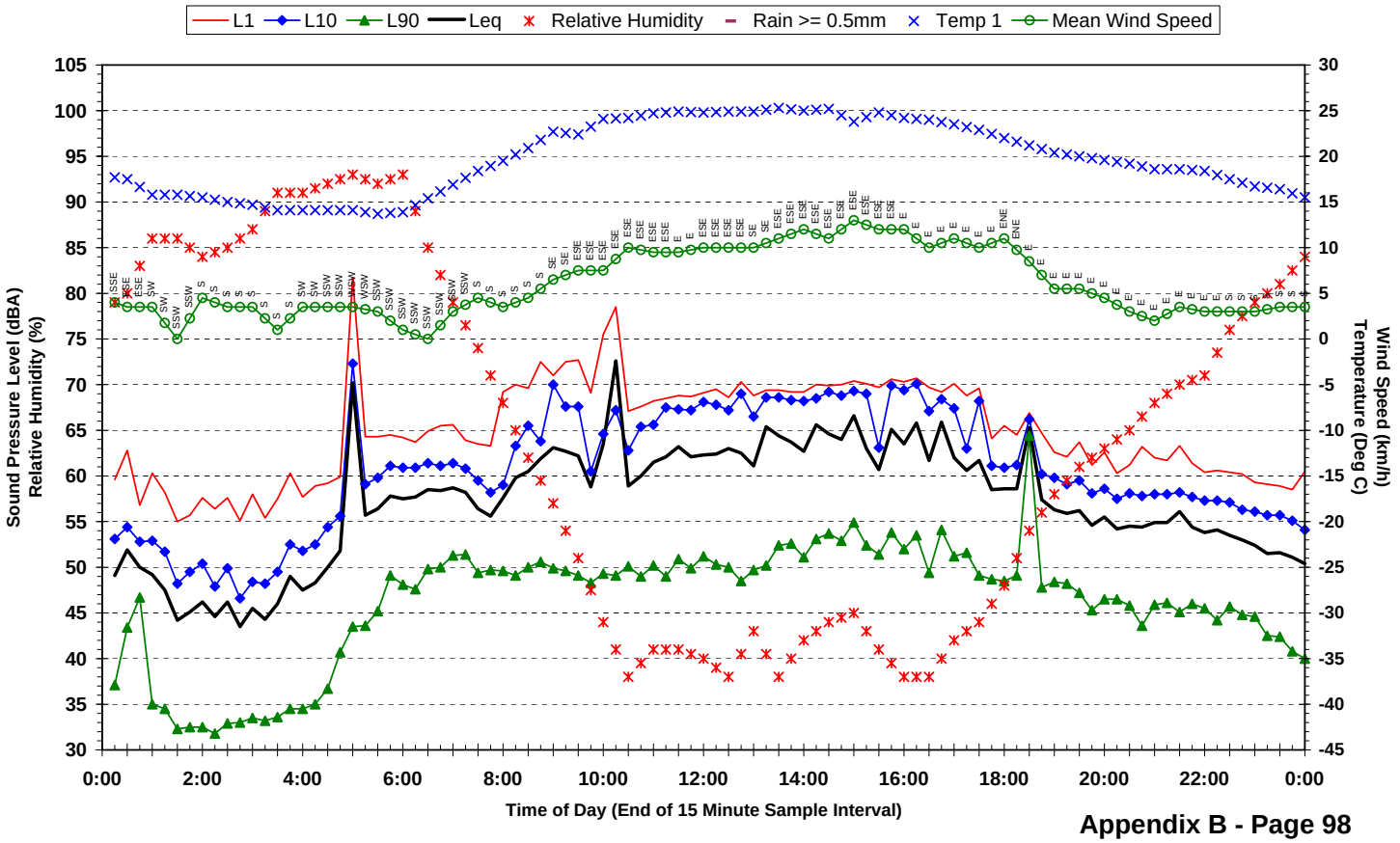
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Sunday 11 November 2007



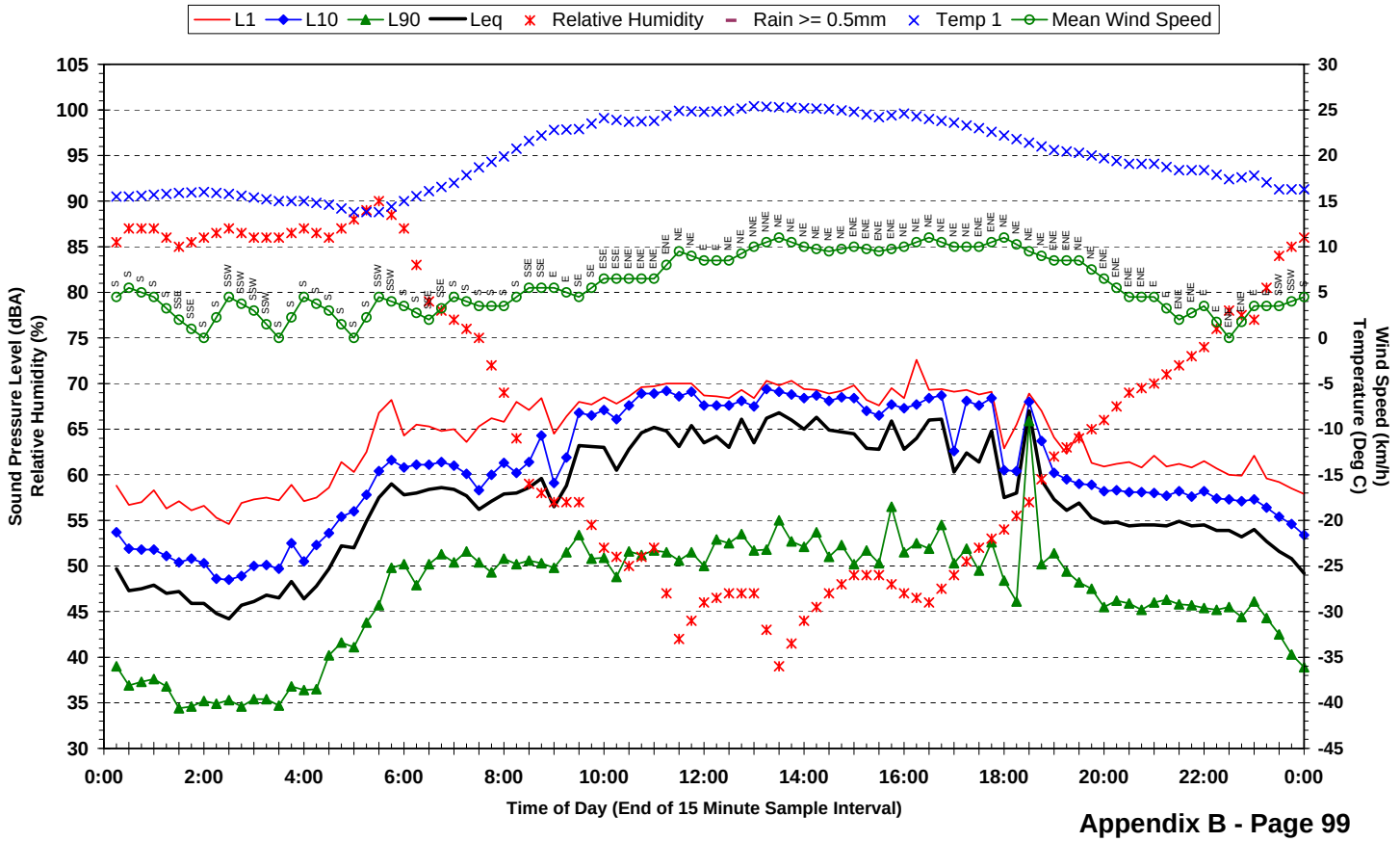
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Monday 12 November 2007



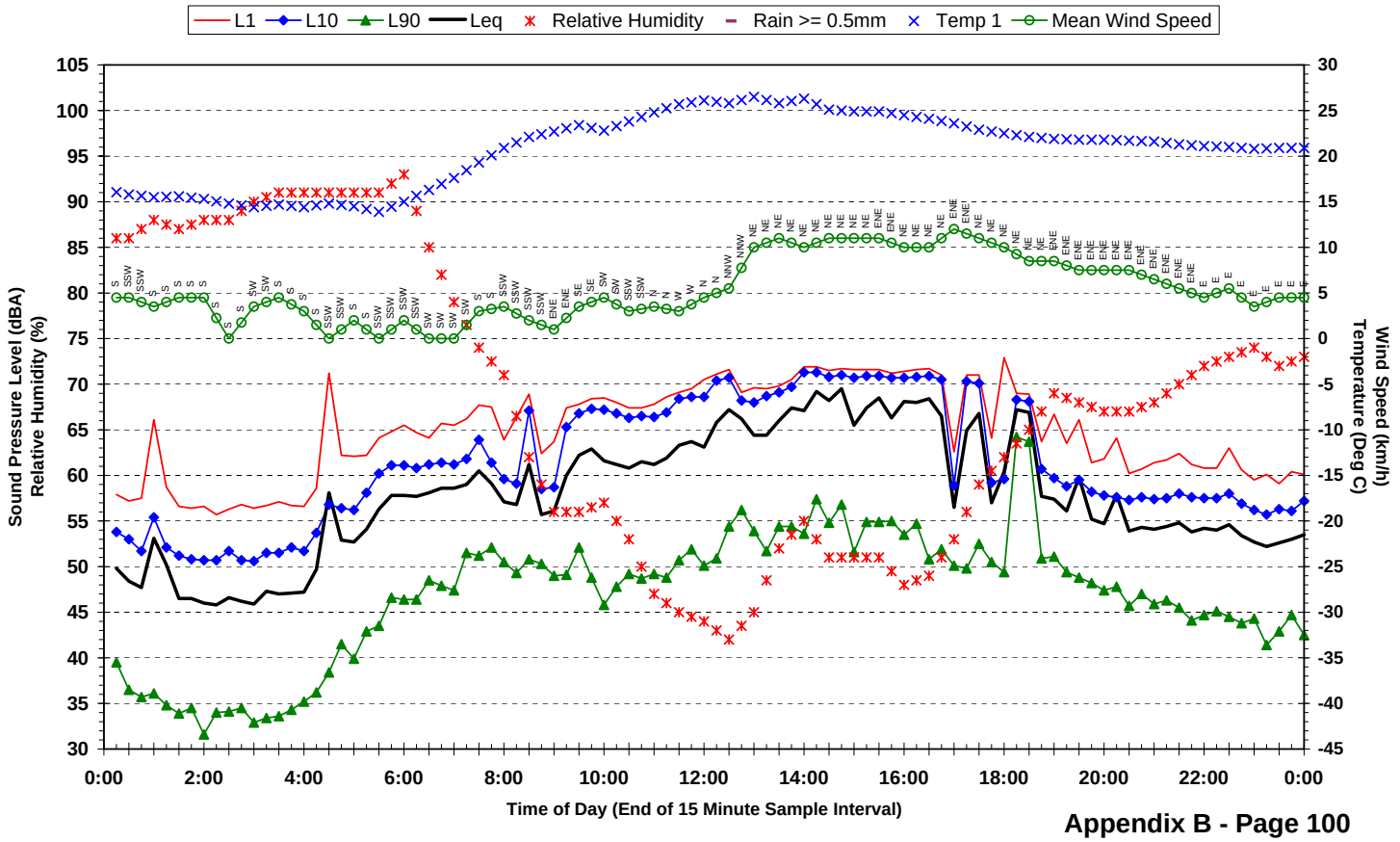
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Tuesday 13 November 2007



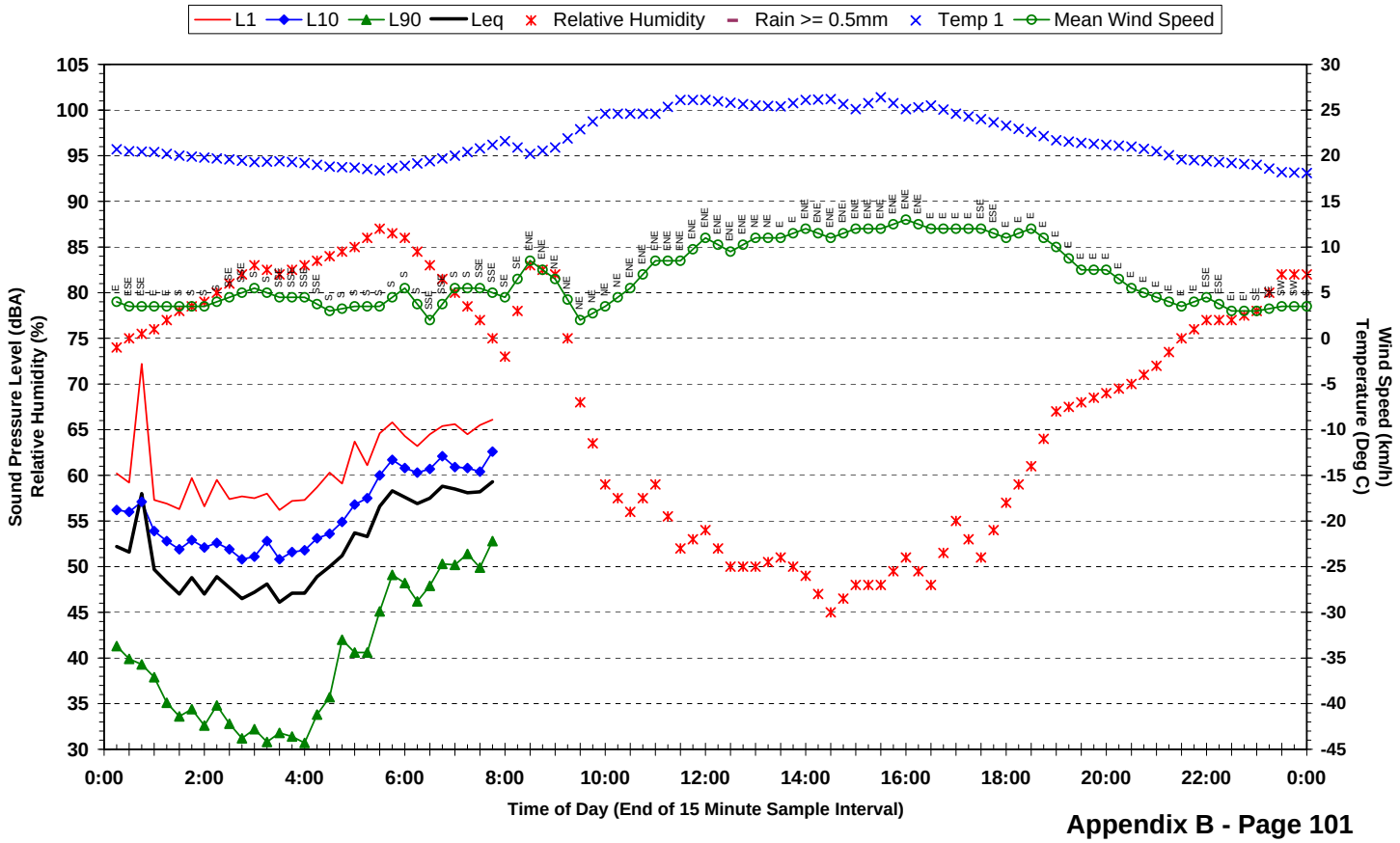
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Wednesday 14 November 2007



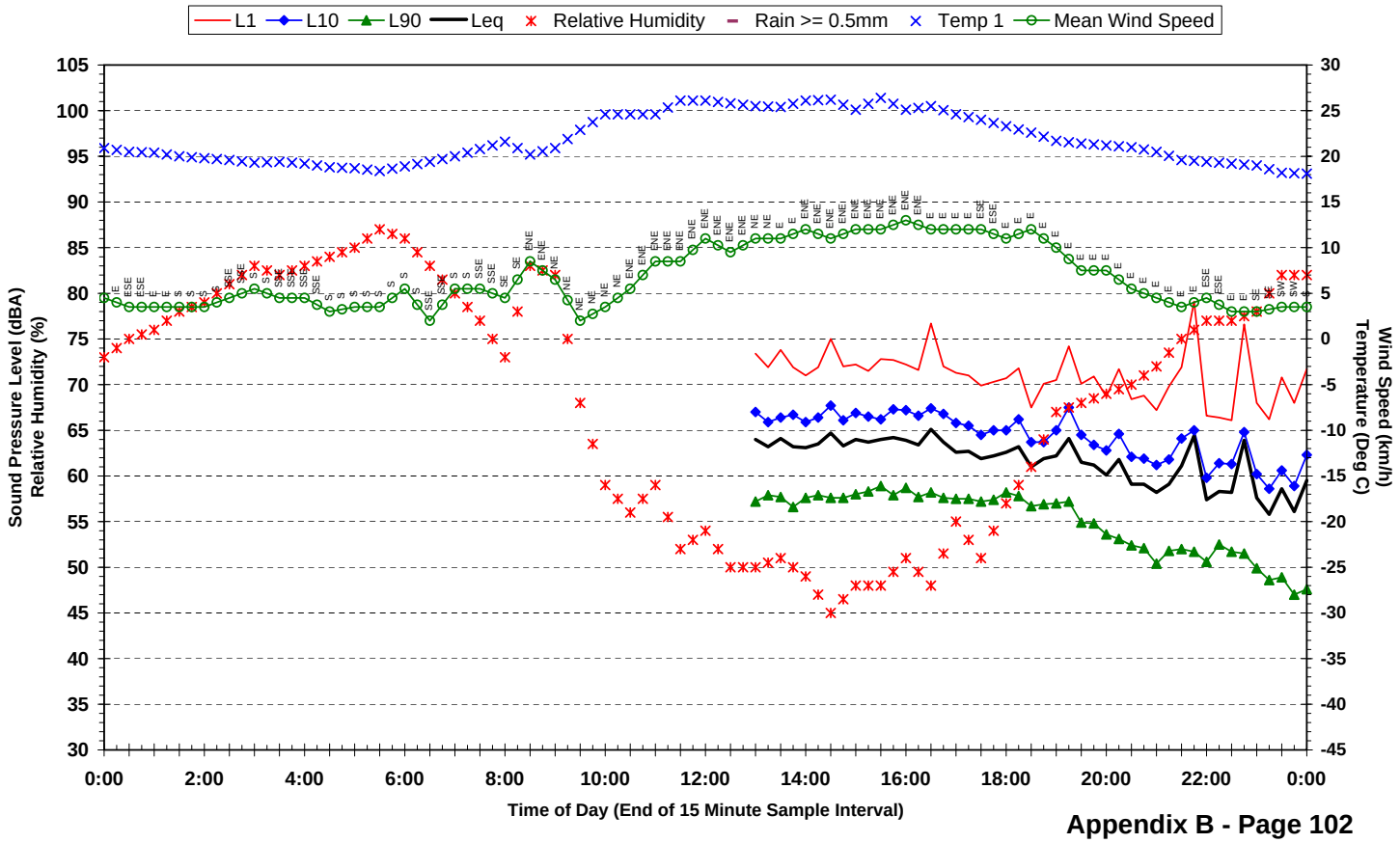
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Thursday 15 November 2007



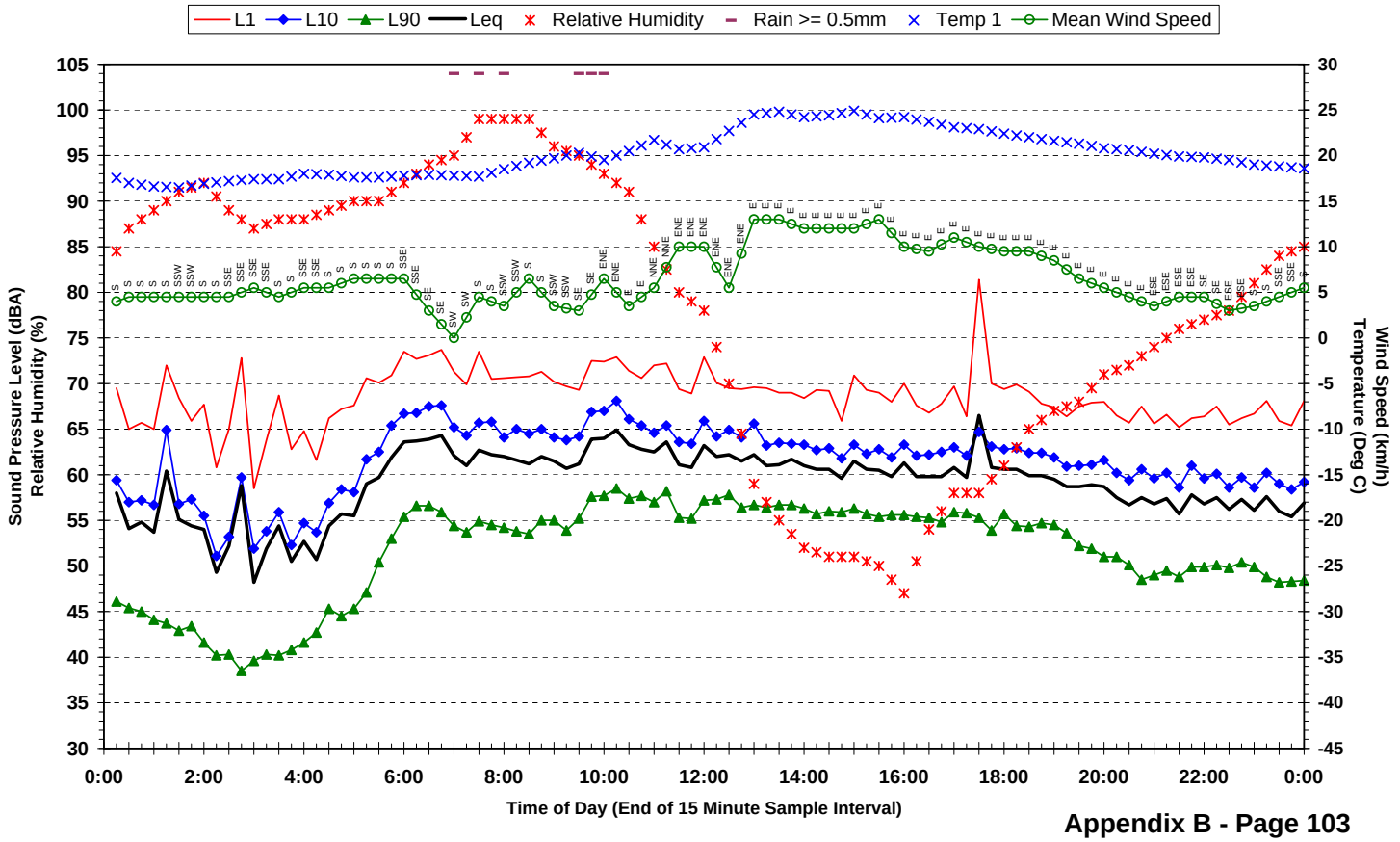
Statistical Ambient Noise Levels
Location 10 - 7 Westbury Street, Red Hill - Friday 16 November 2007



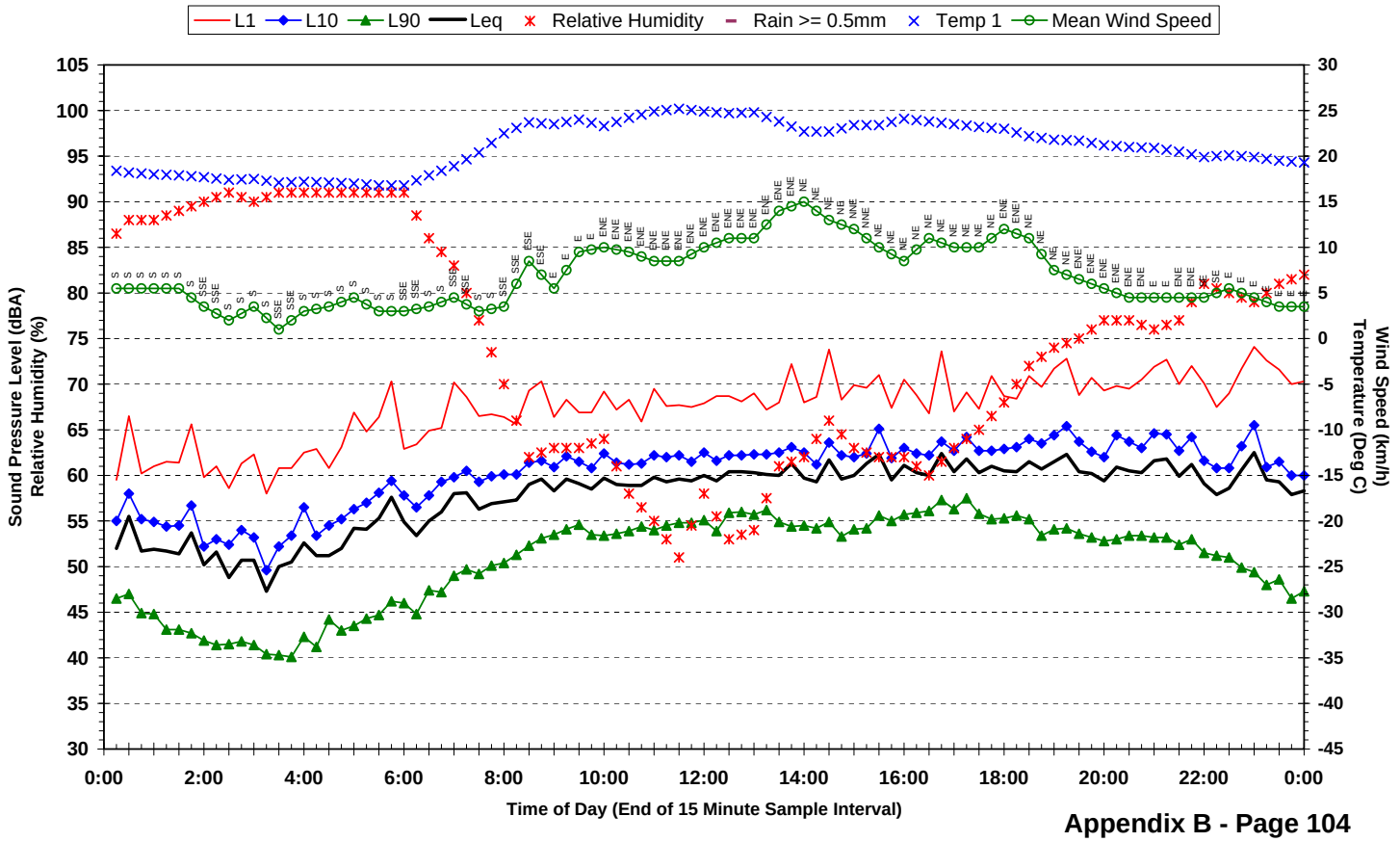
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Friday 16 November 2007



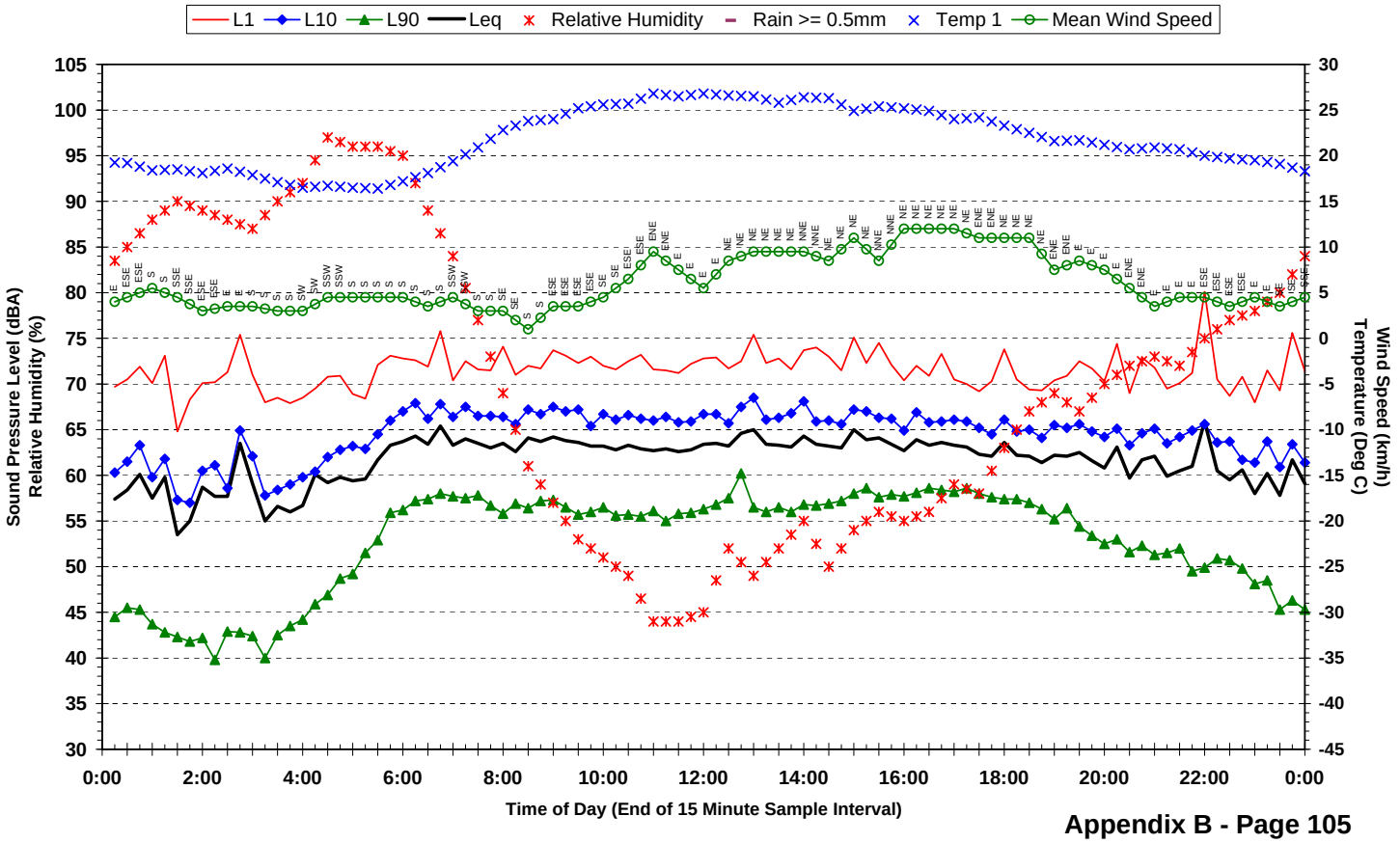
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Saturday 17 November 2007



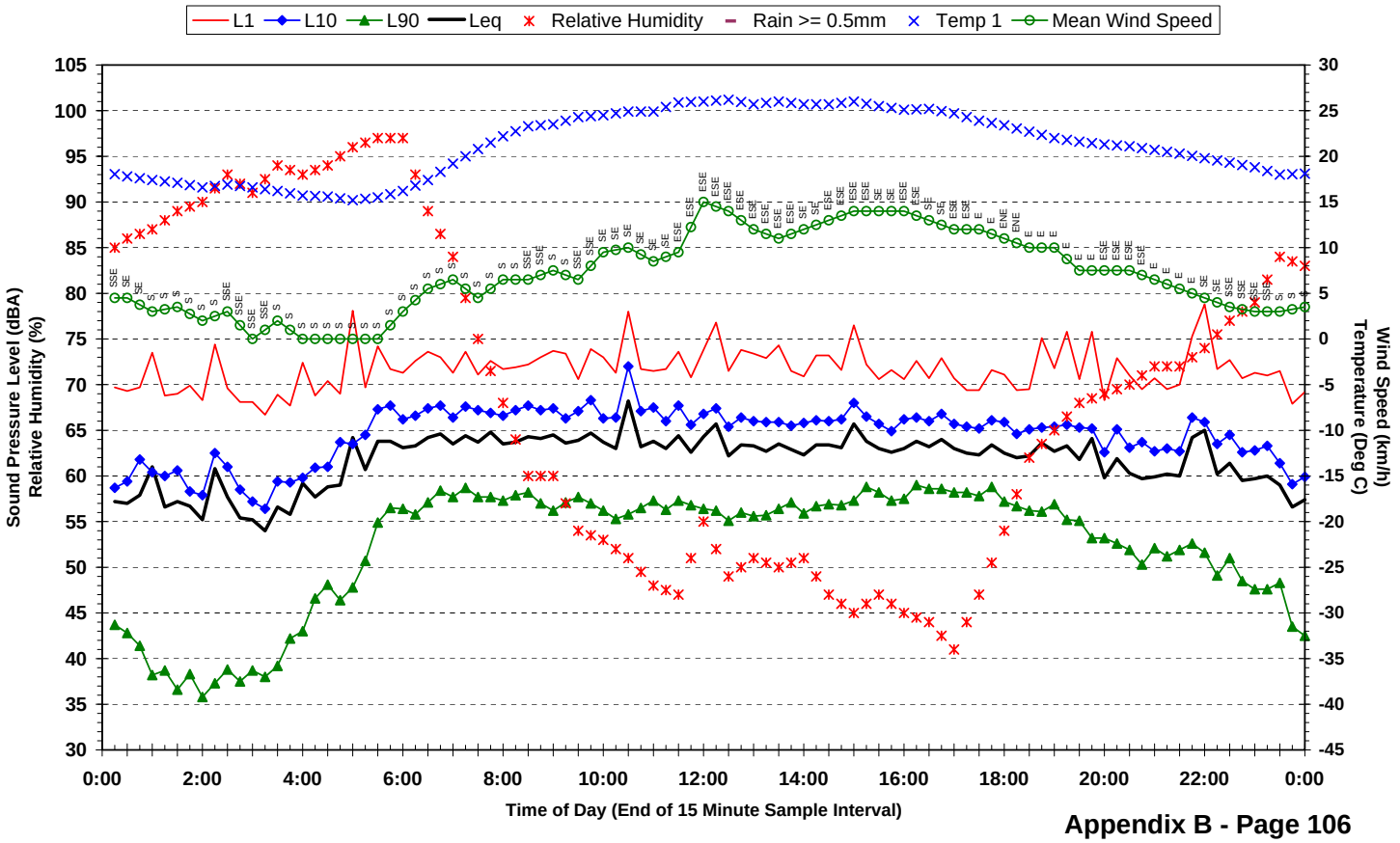
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Sunday 18 November 2007



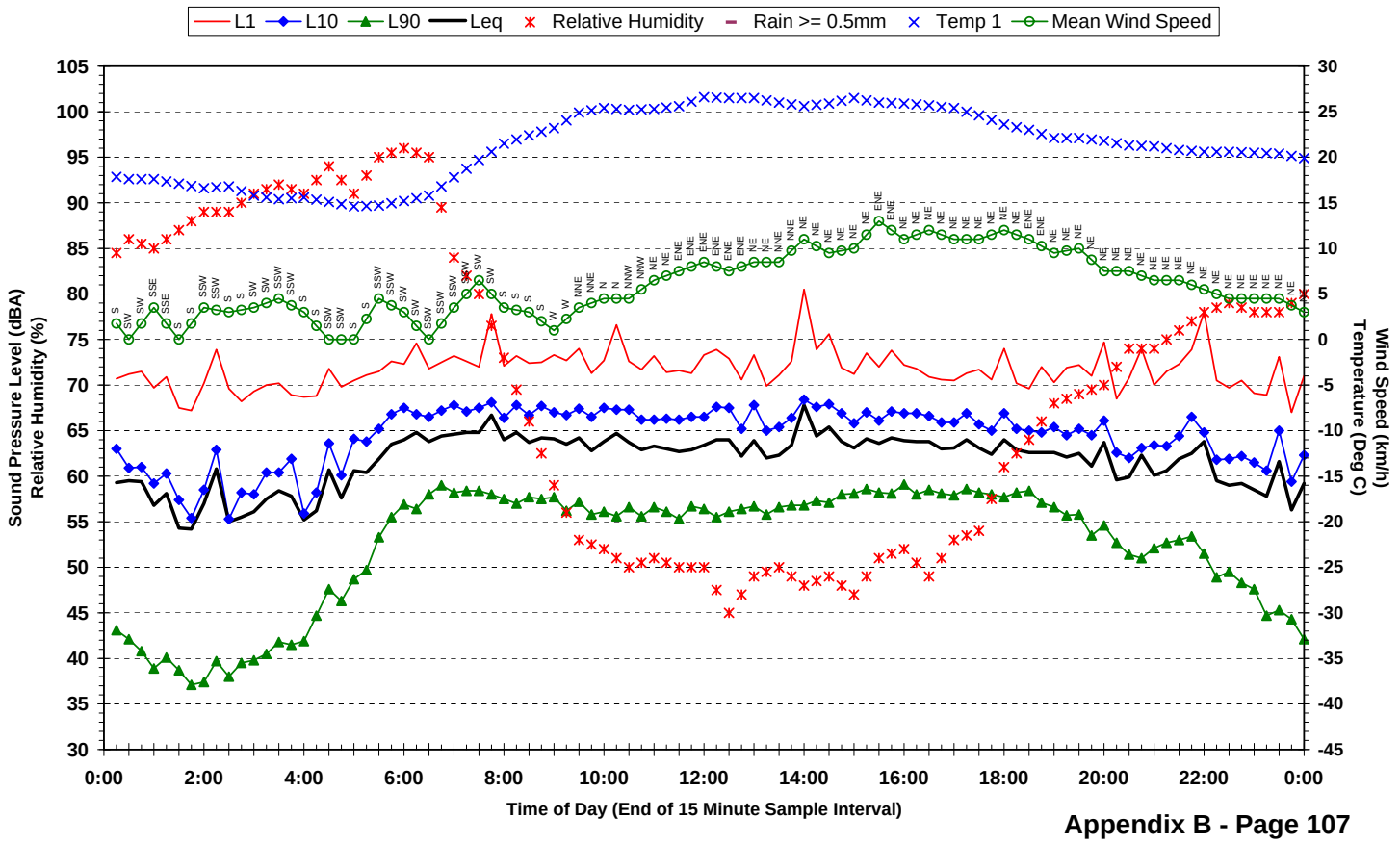
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Monday 19 November 2007



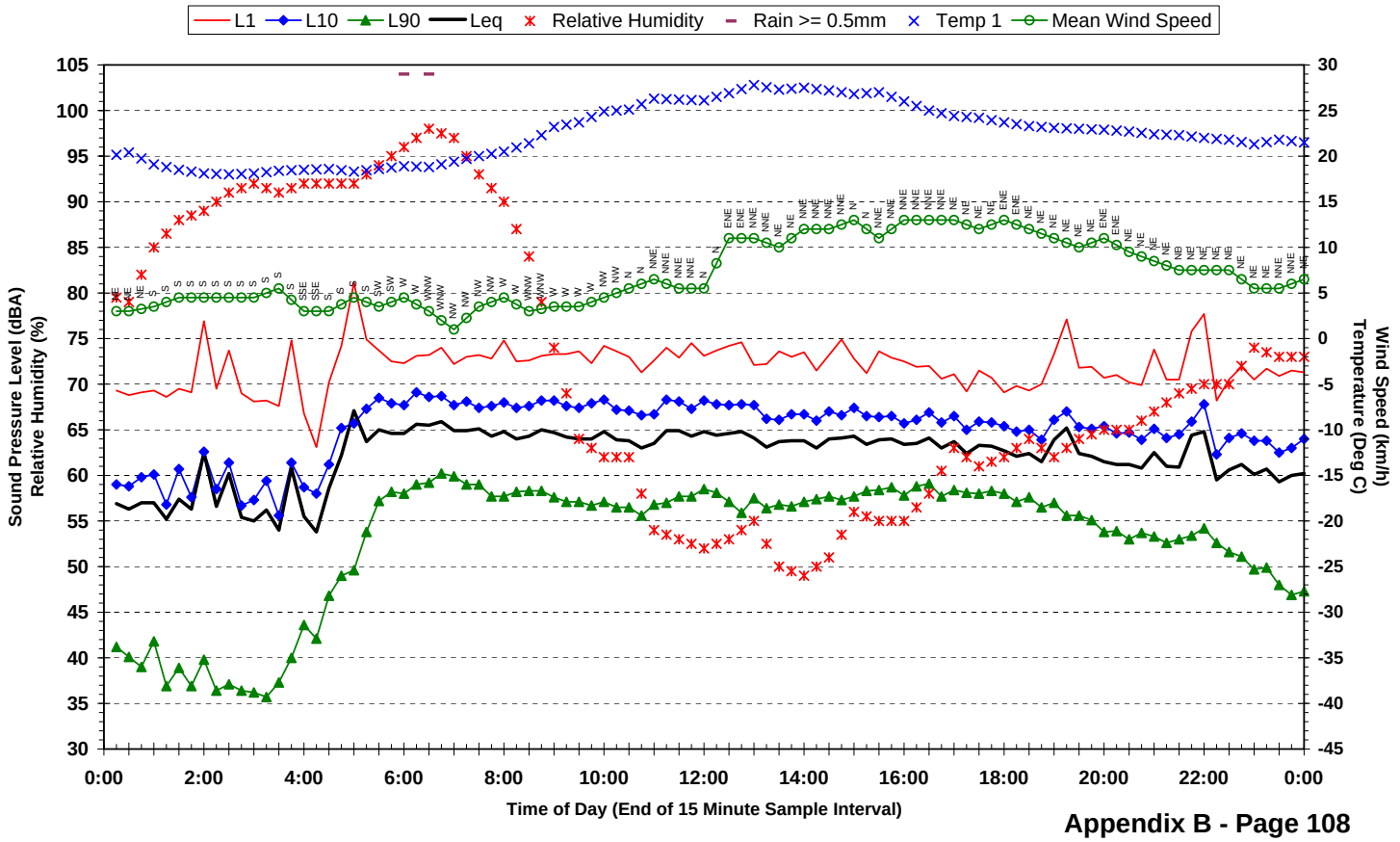
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Tuesday 20 November 2007



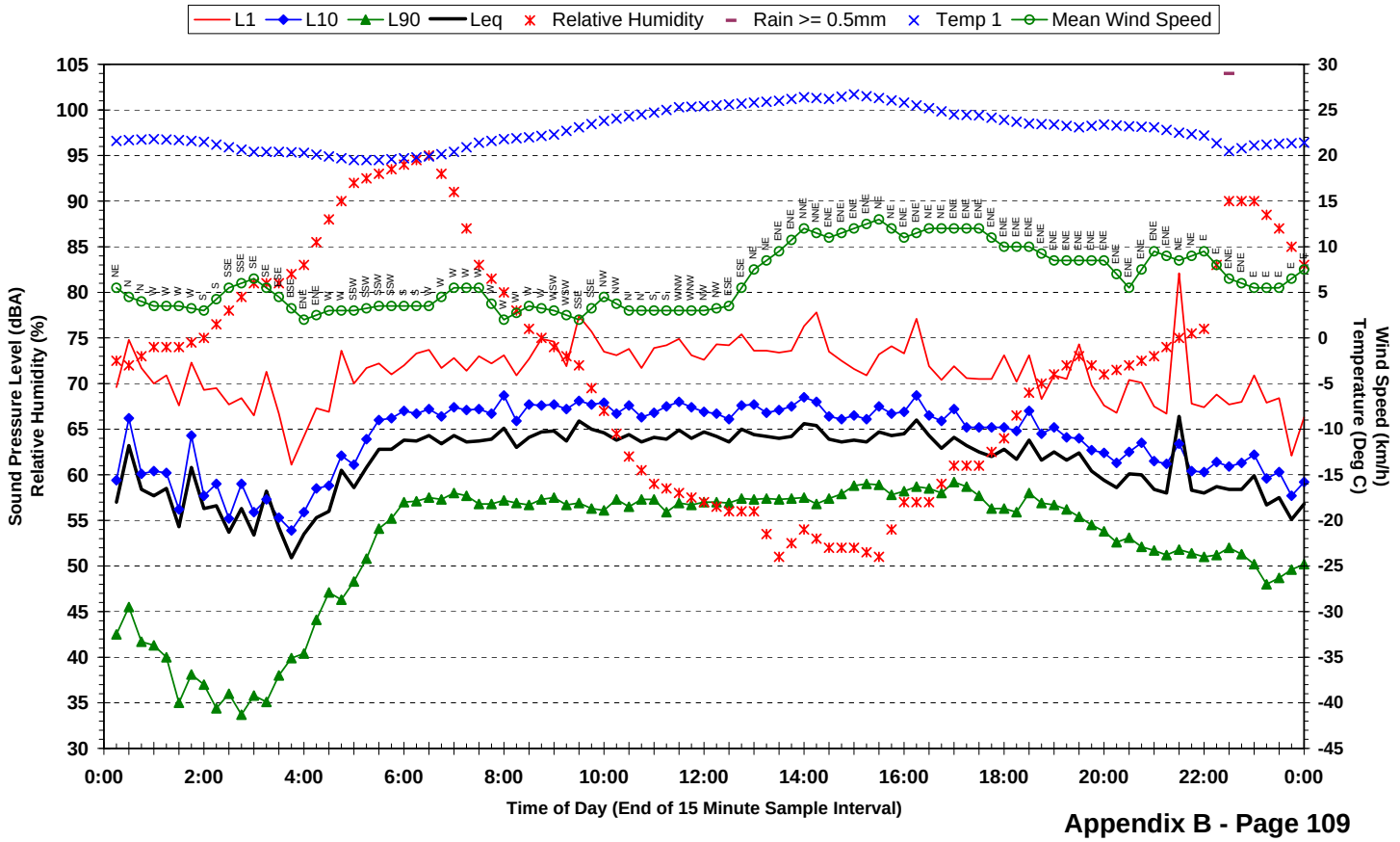
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Wednesday 21 November 2007



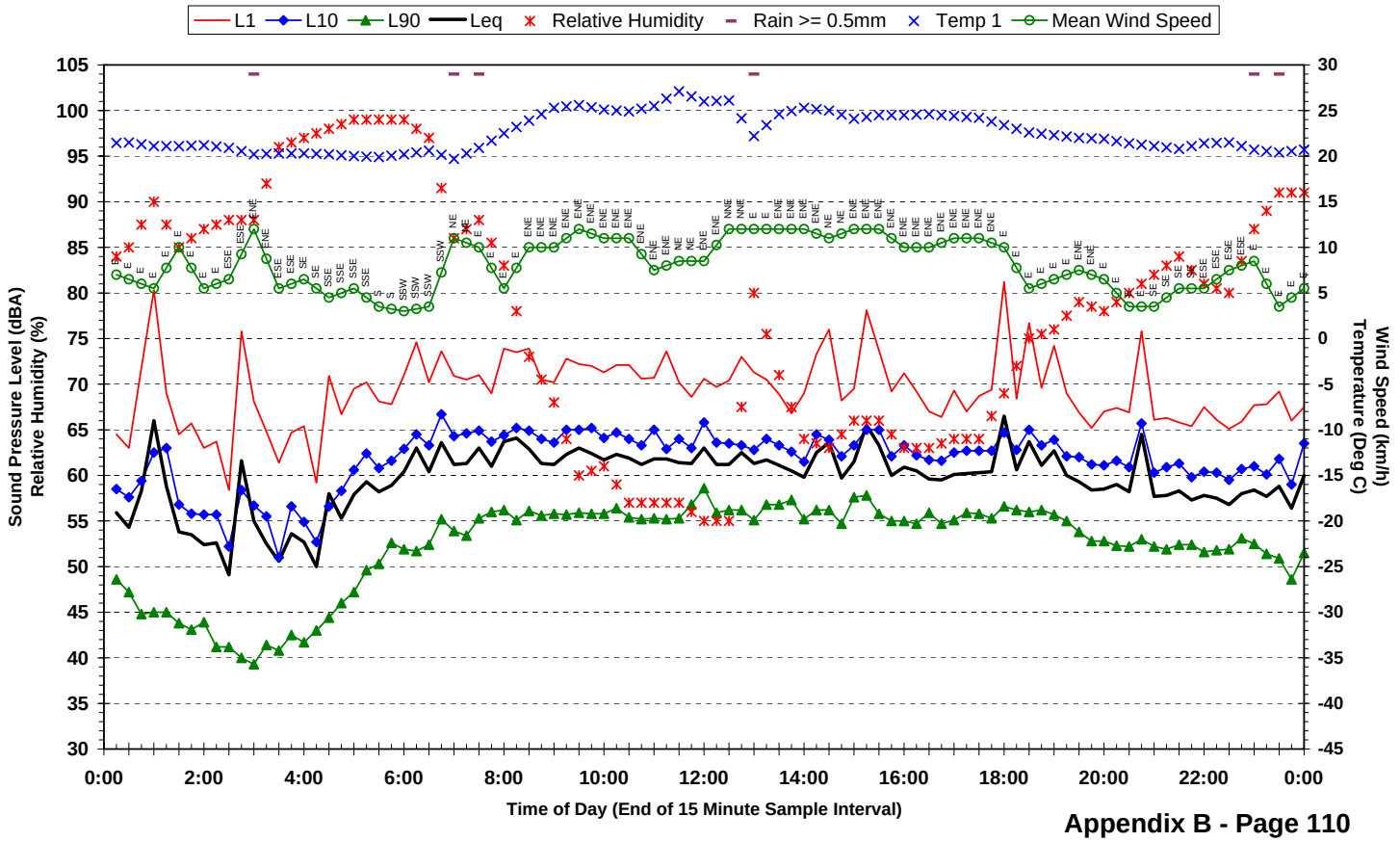
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Thursday 22 November 2007



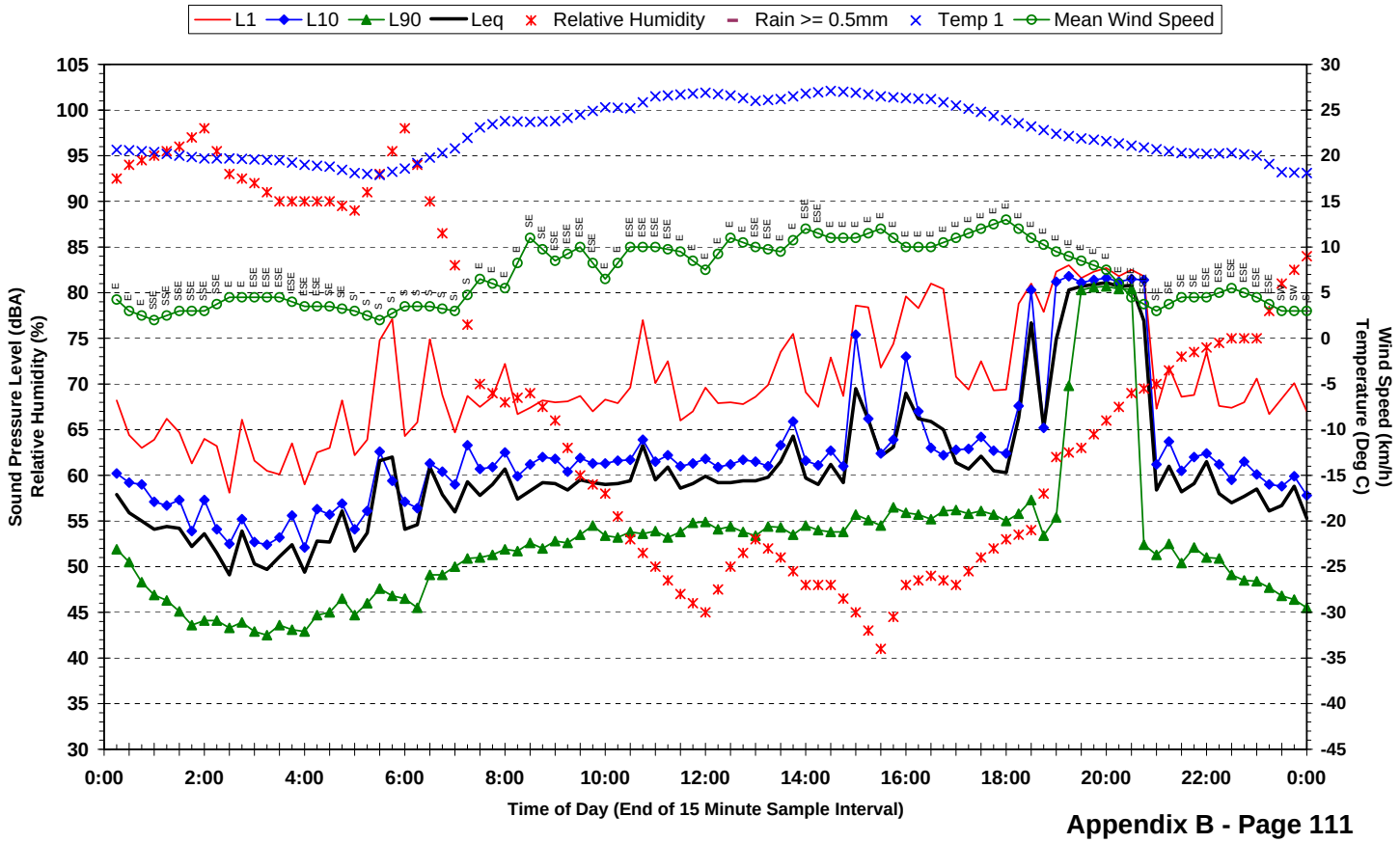
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Friday 23 November 2007



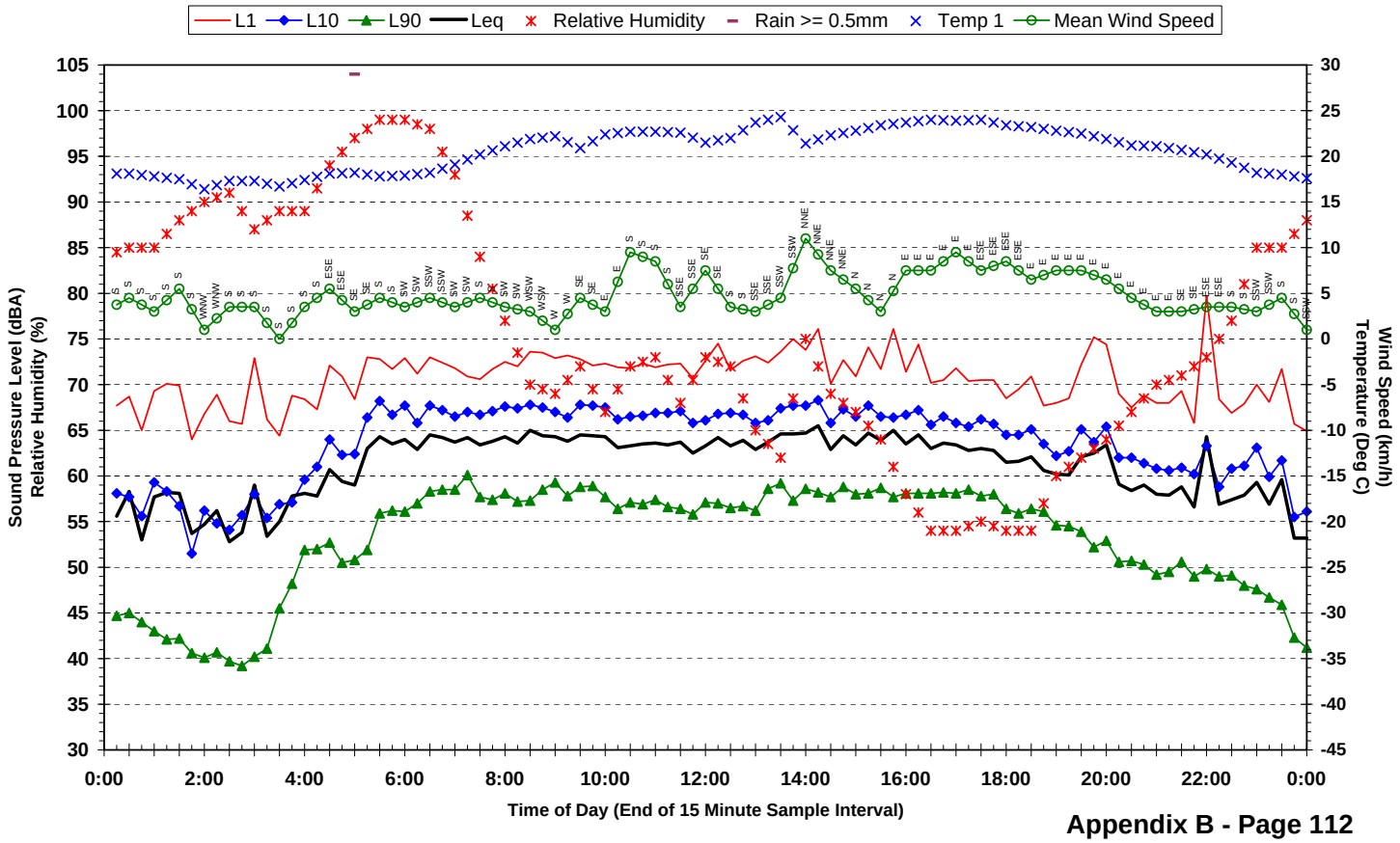
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Saturday 24 November 2007



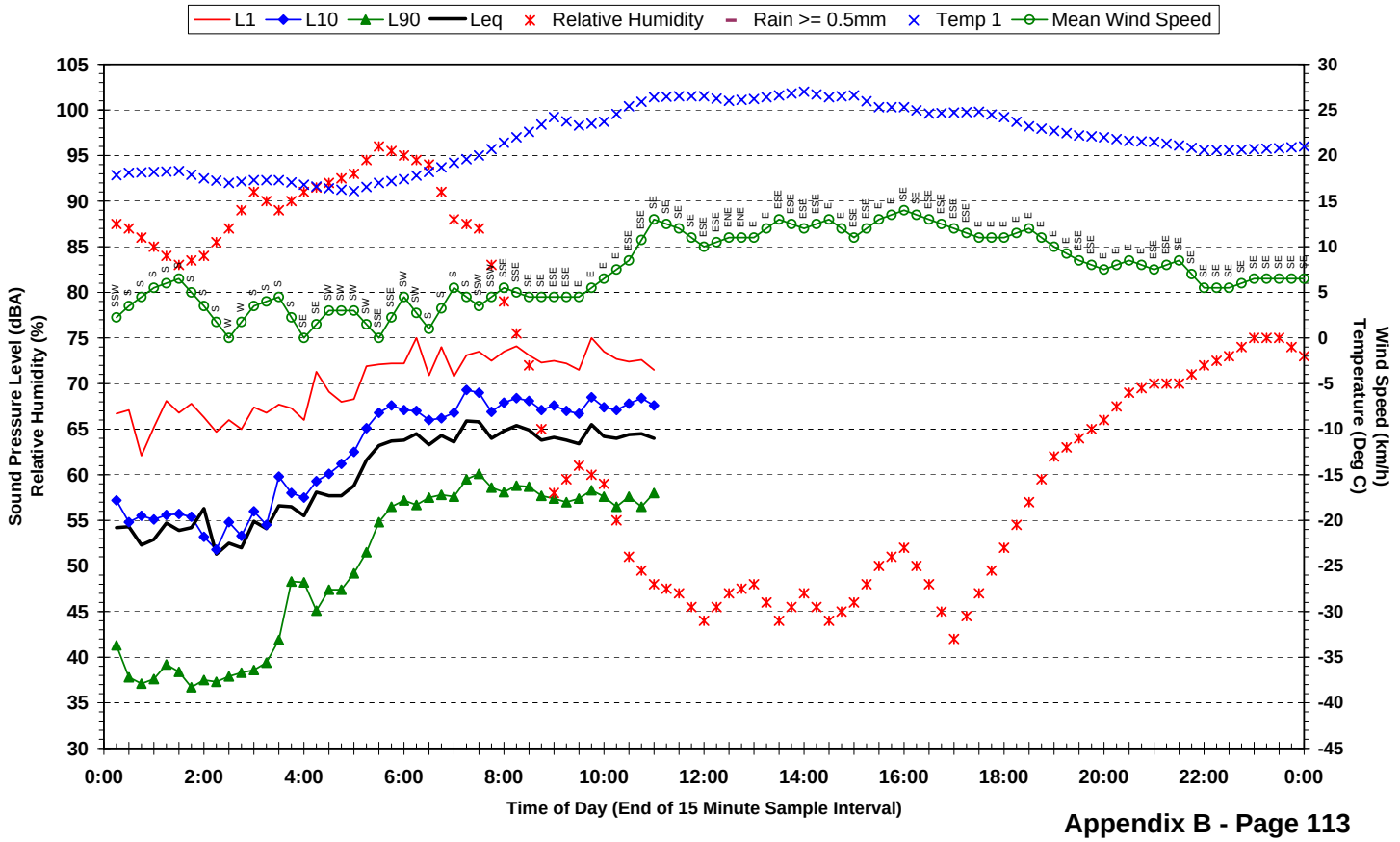
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Sunday 25 November 2007



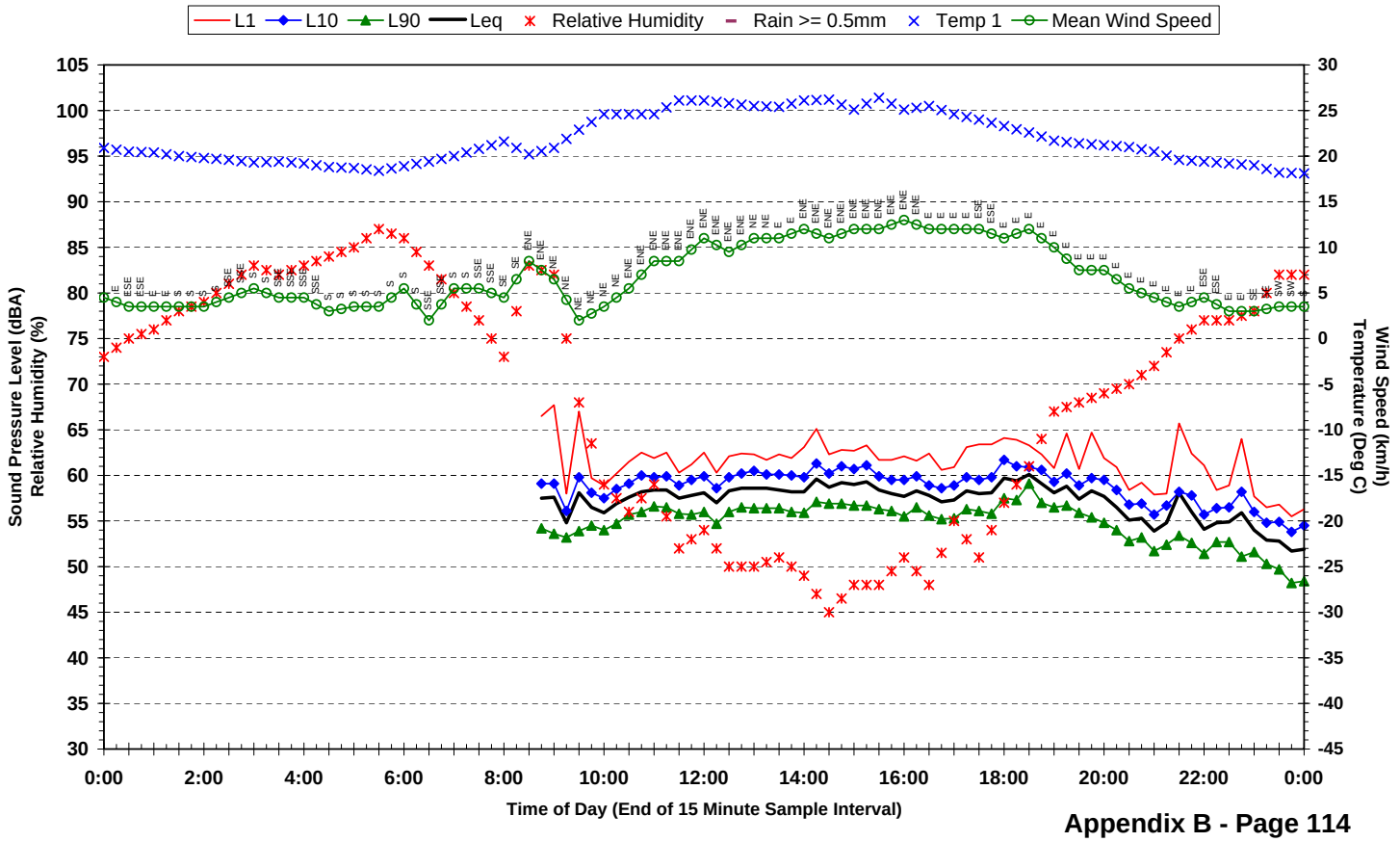
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Monday 26 November 2007



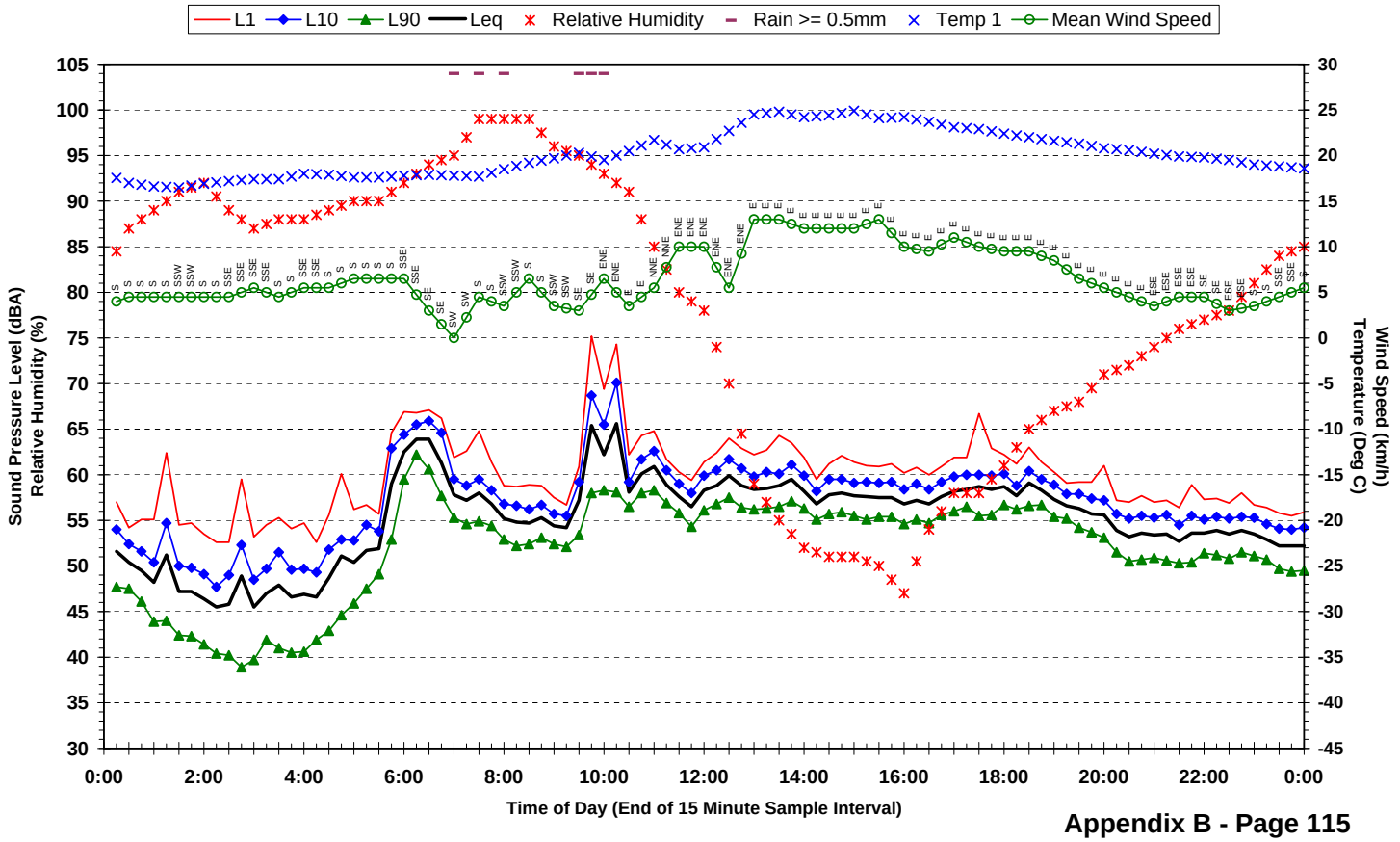
Statistical Ambient Noise Levels
Location 11 - INB Normanby Station - Tuesday 27 November 2007



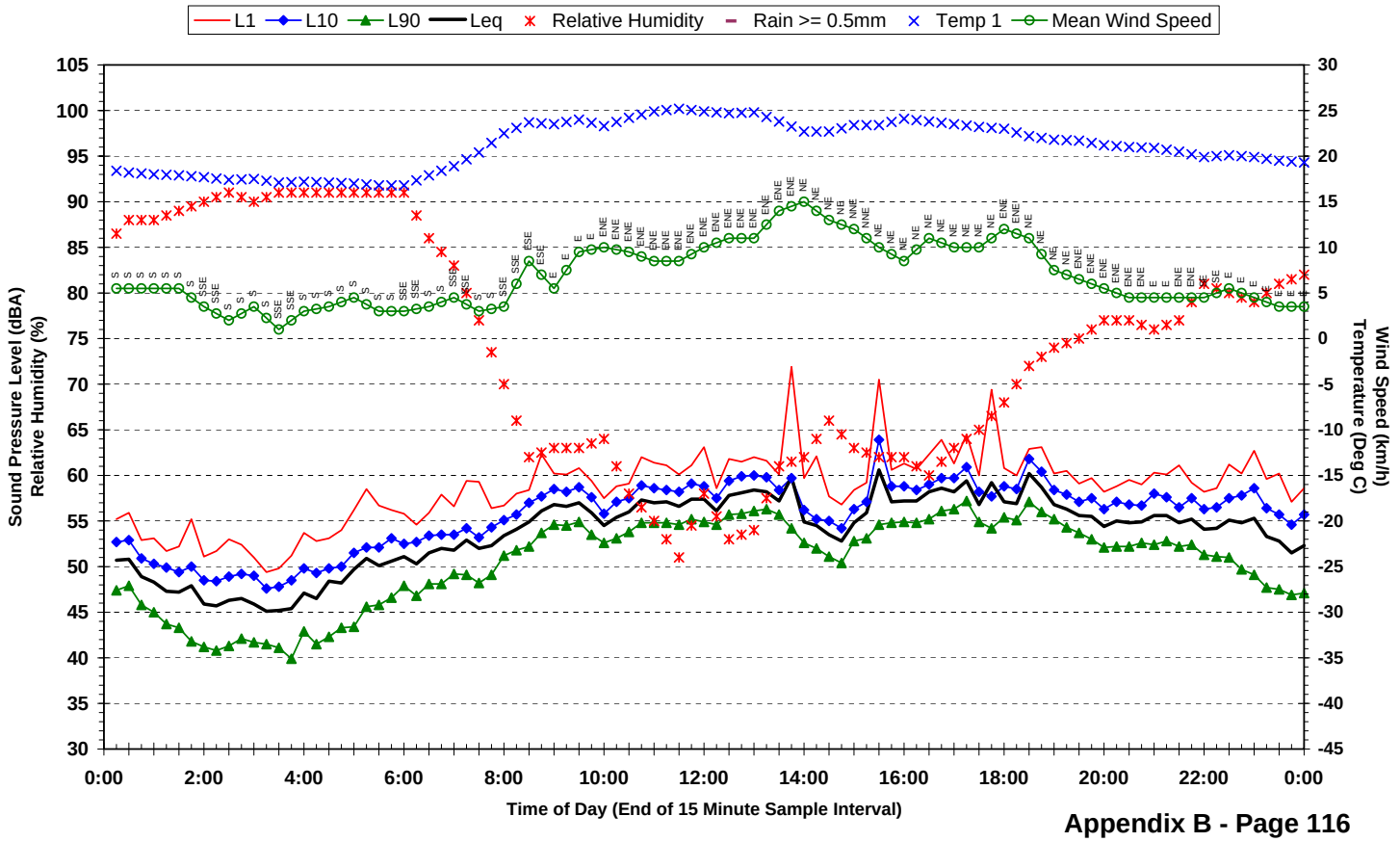
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Friday 16 November 2007



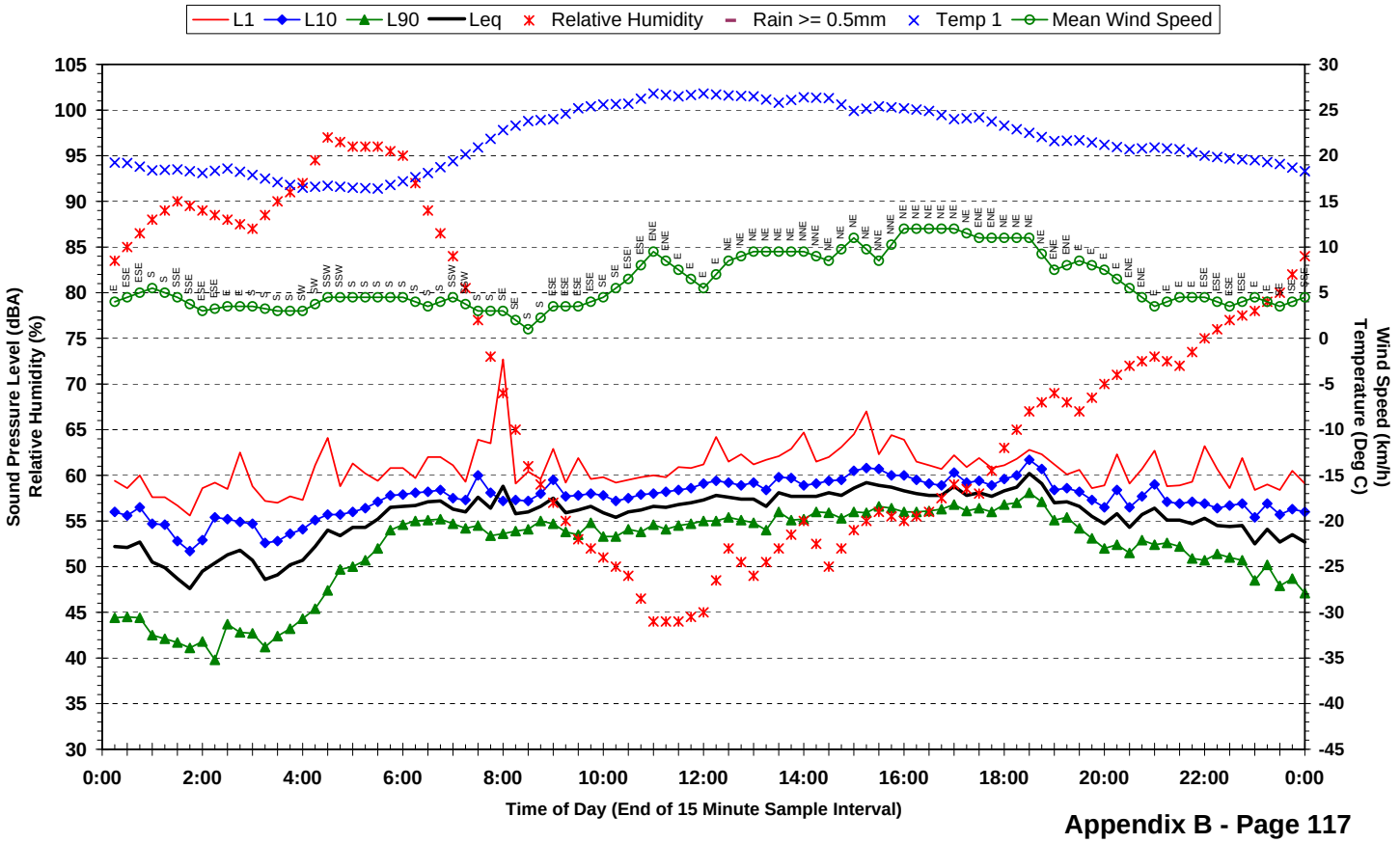
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Saturday 17 November 2007



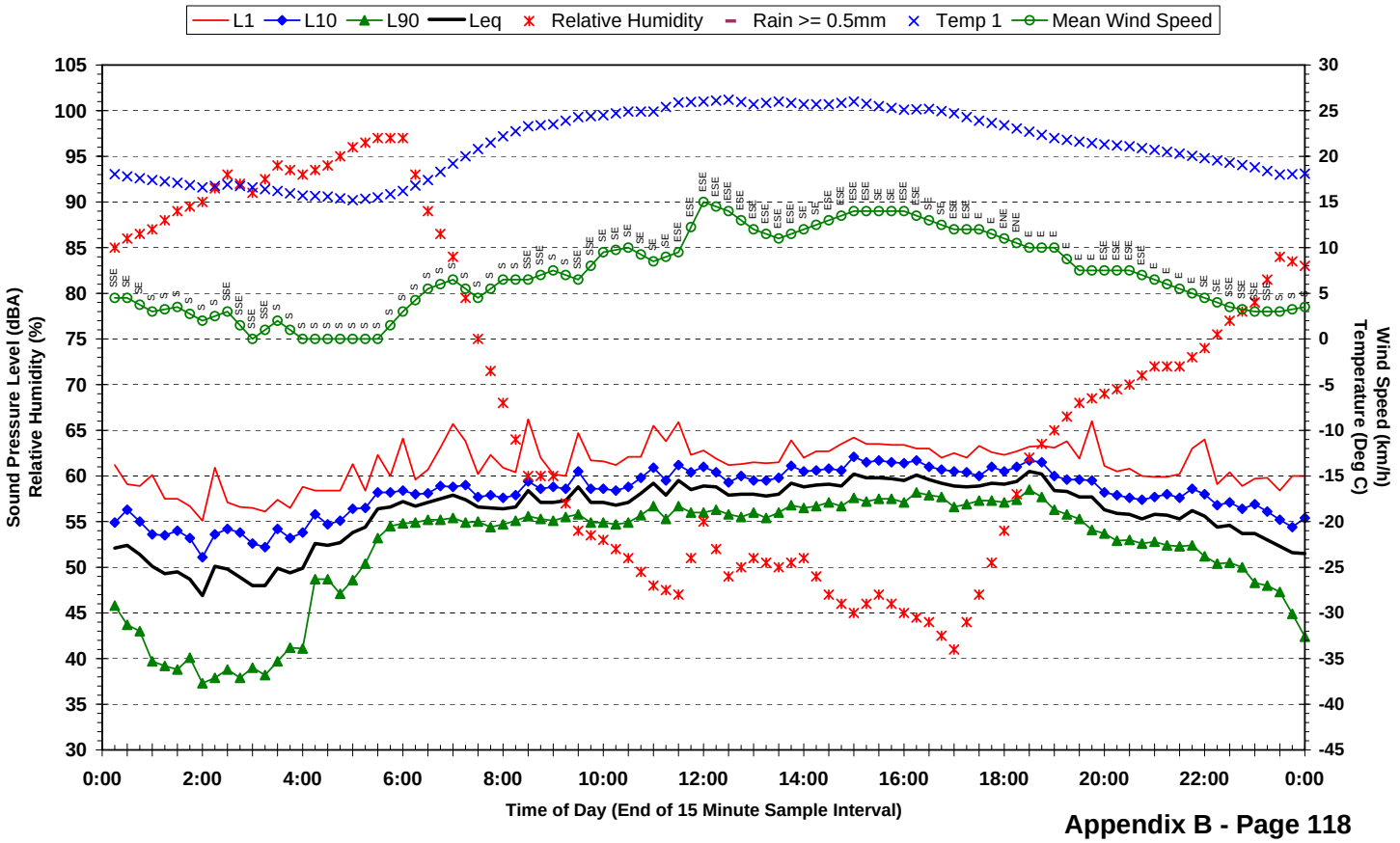
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Sunday 18 November 2007



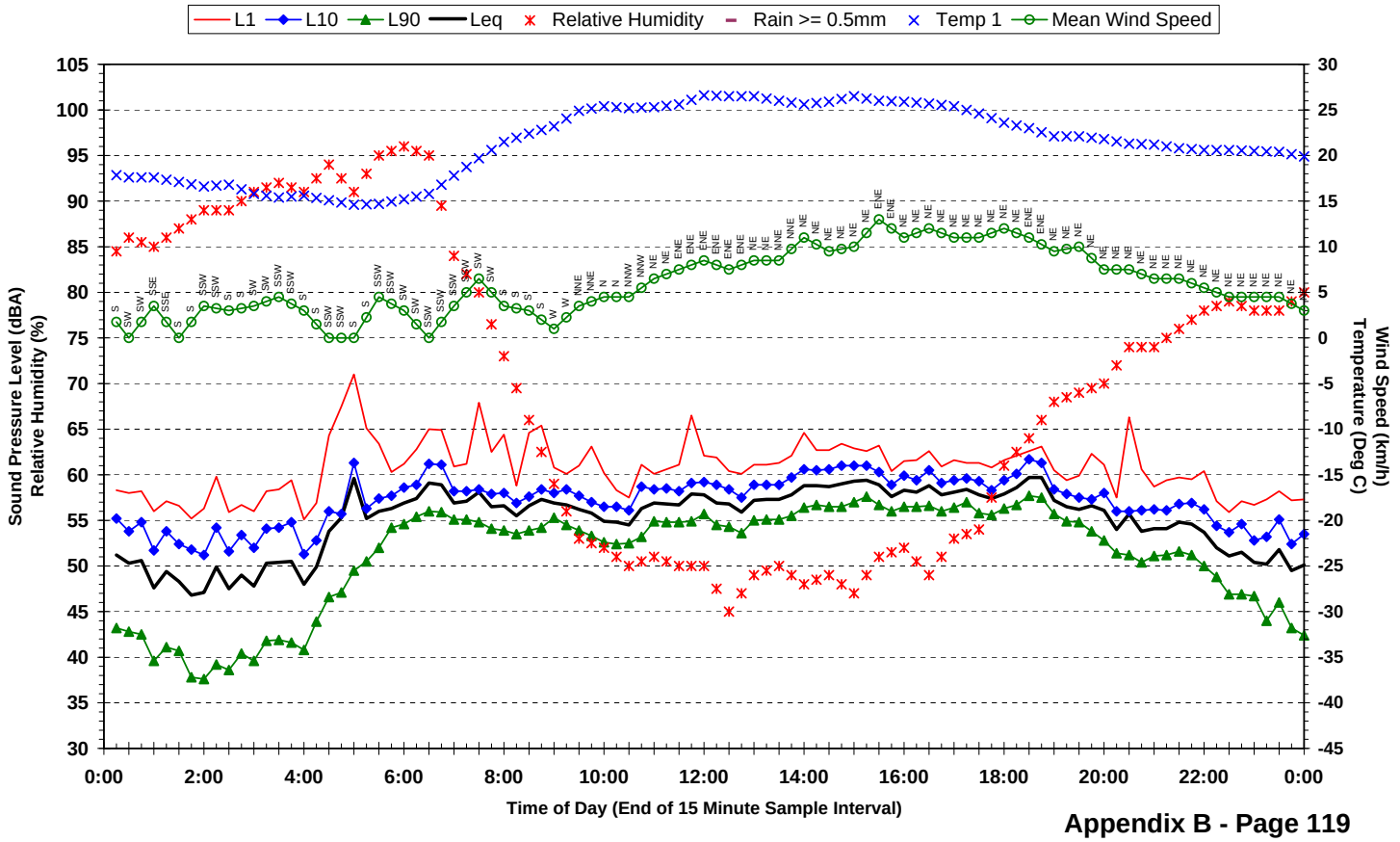
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Monday 19 November 2007



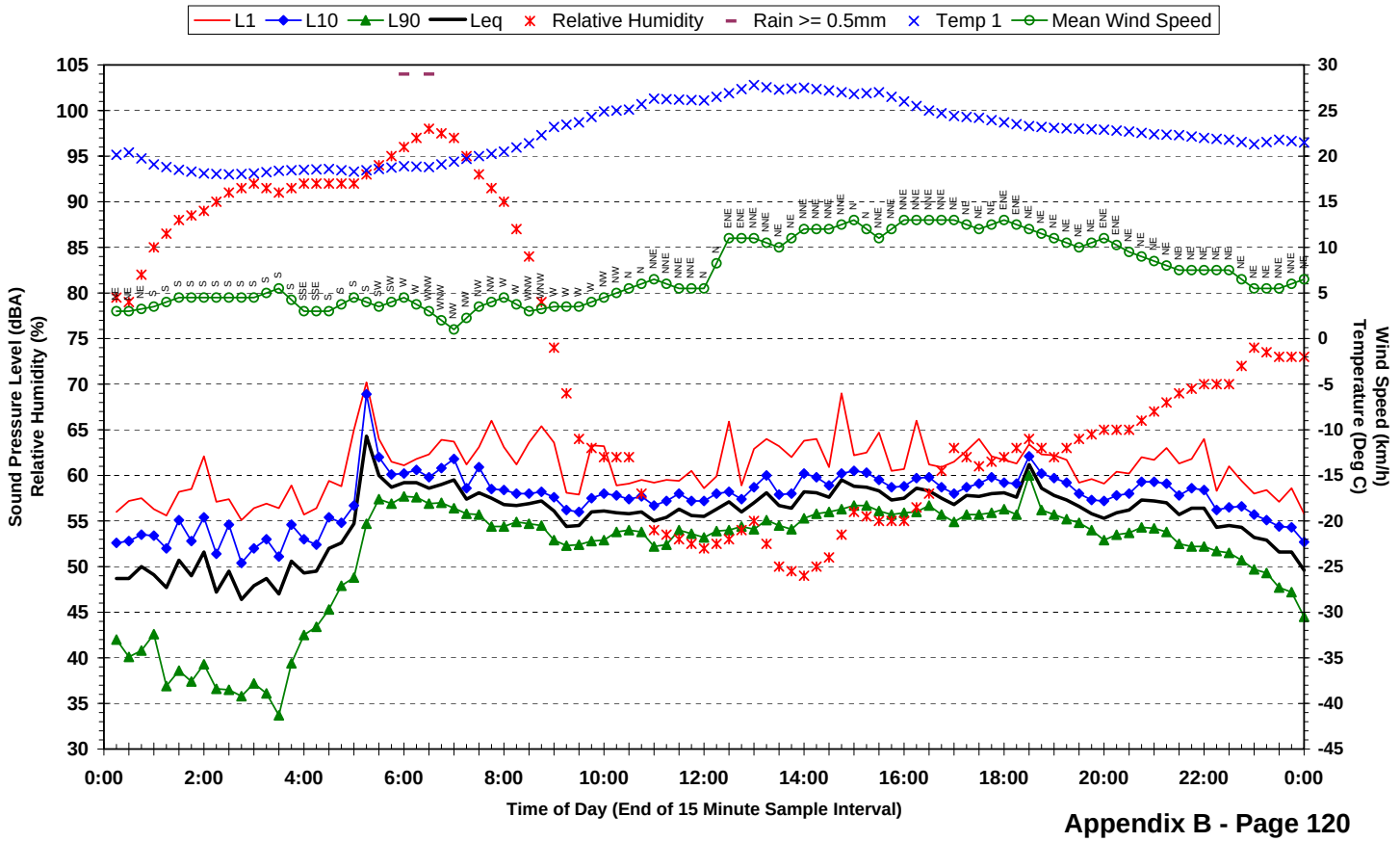
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Tuesday 20 November 2007



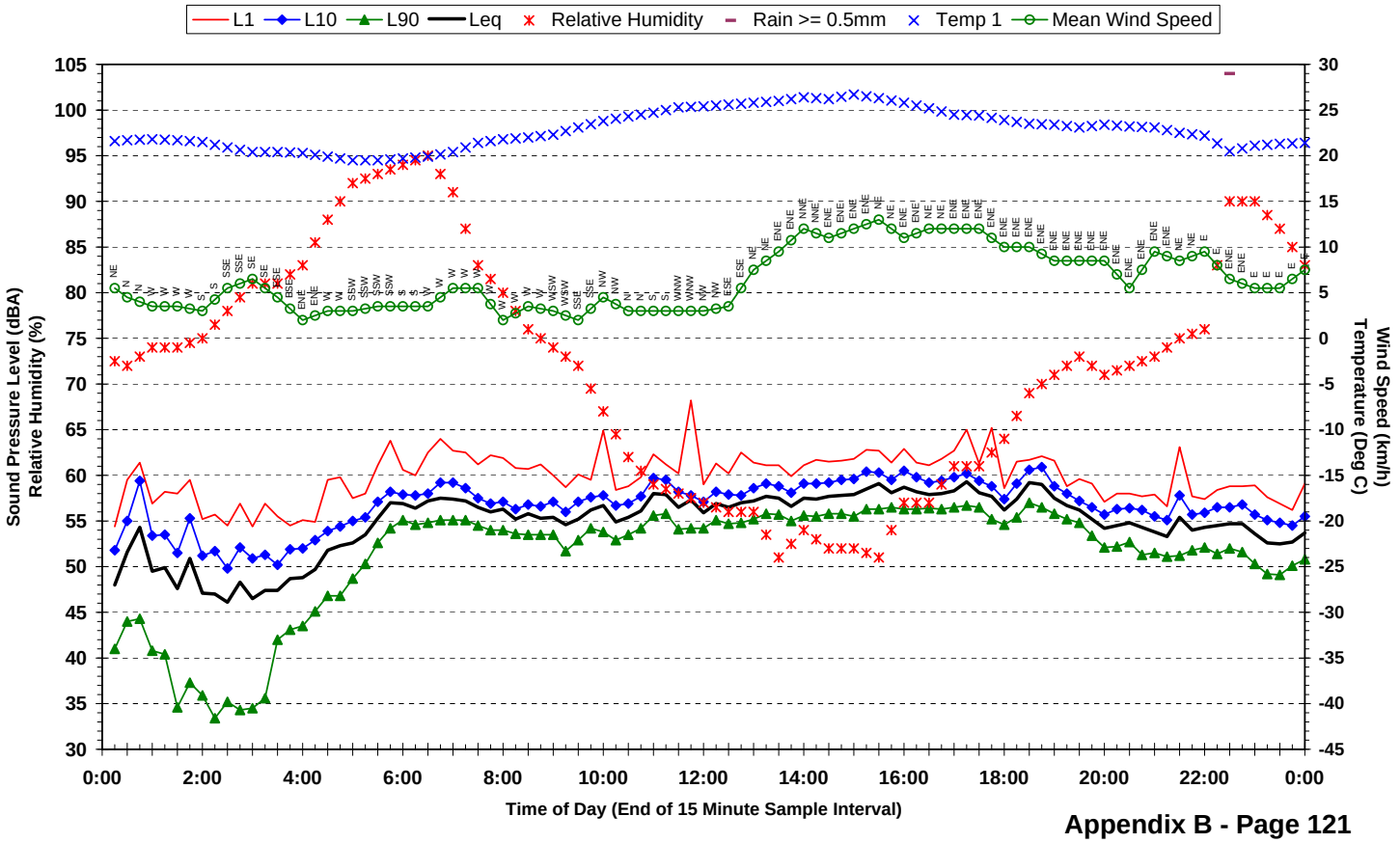
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Wednesday 21 November 2007



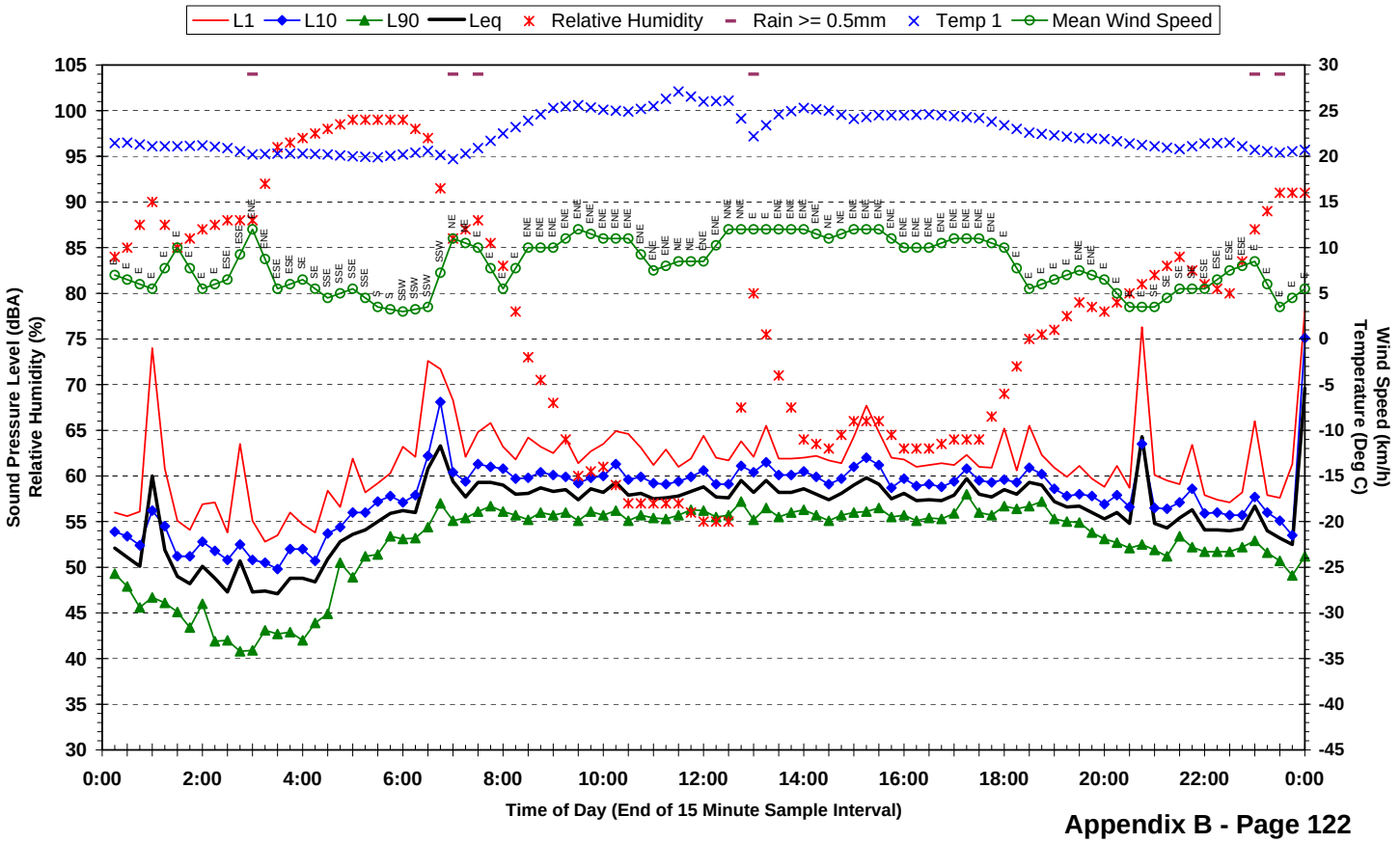
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Thursday 22 November 2007



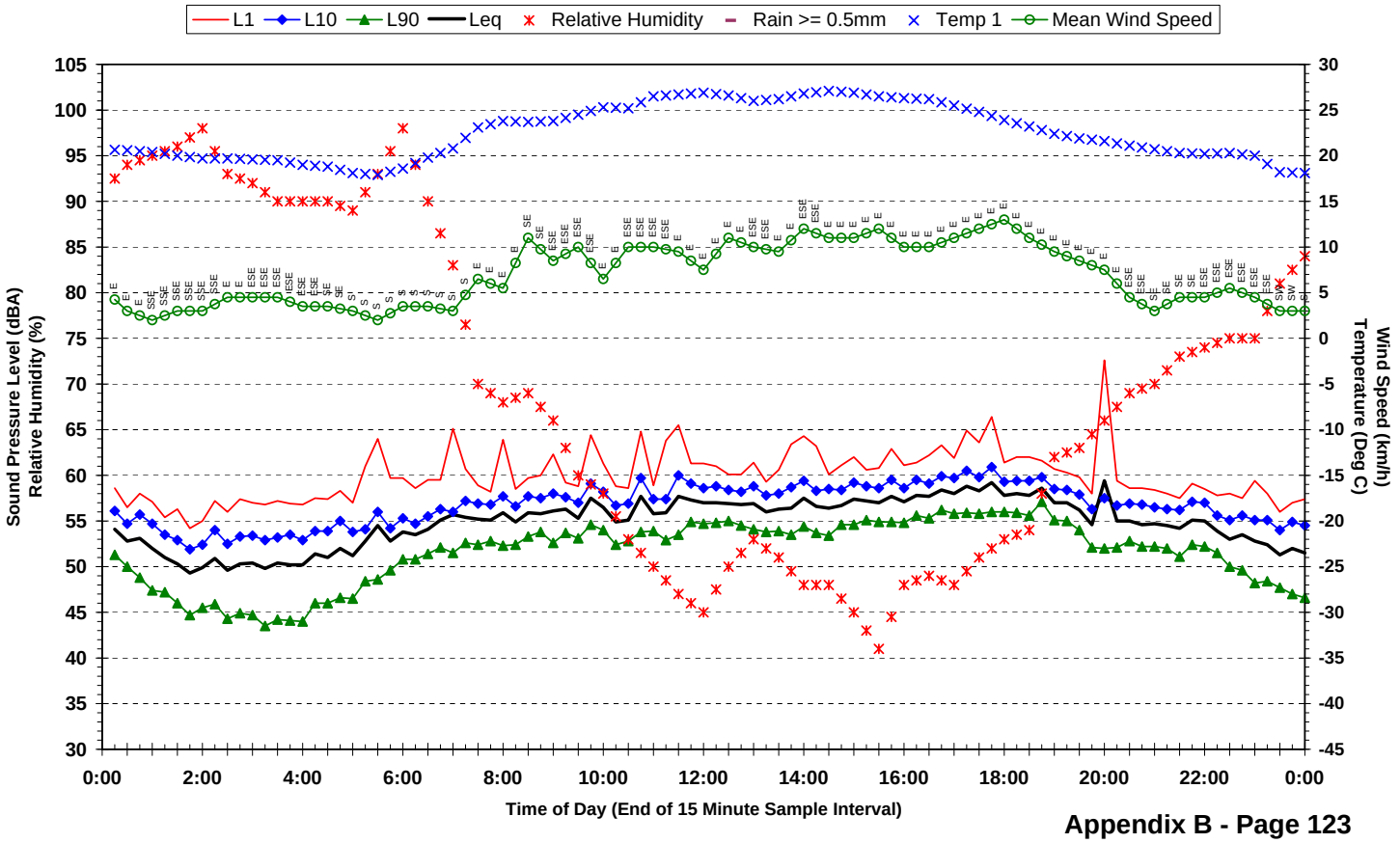
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Friday 23 November 2007



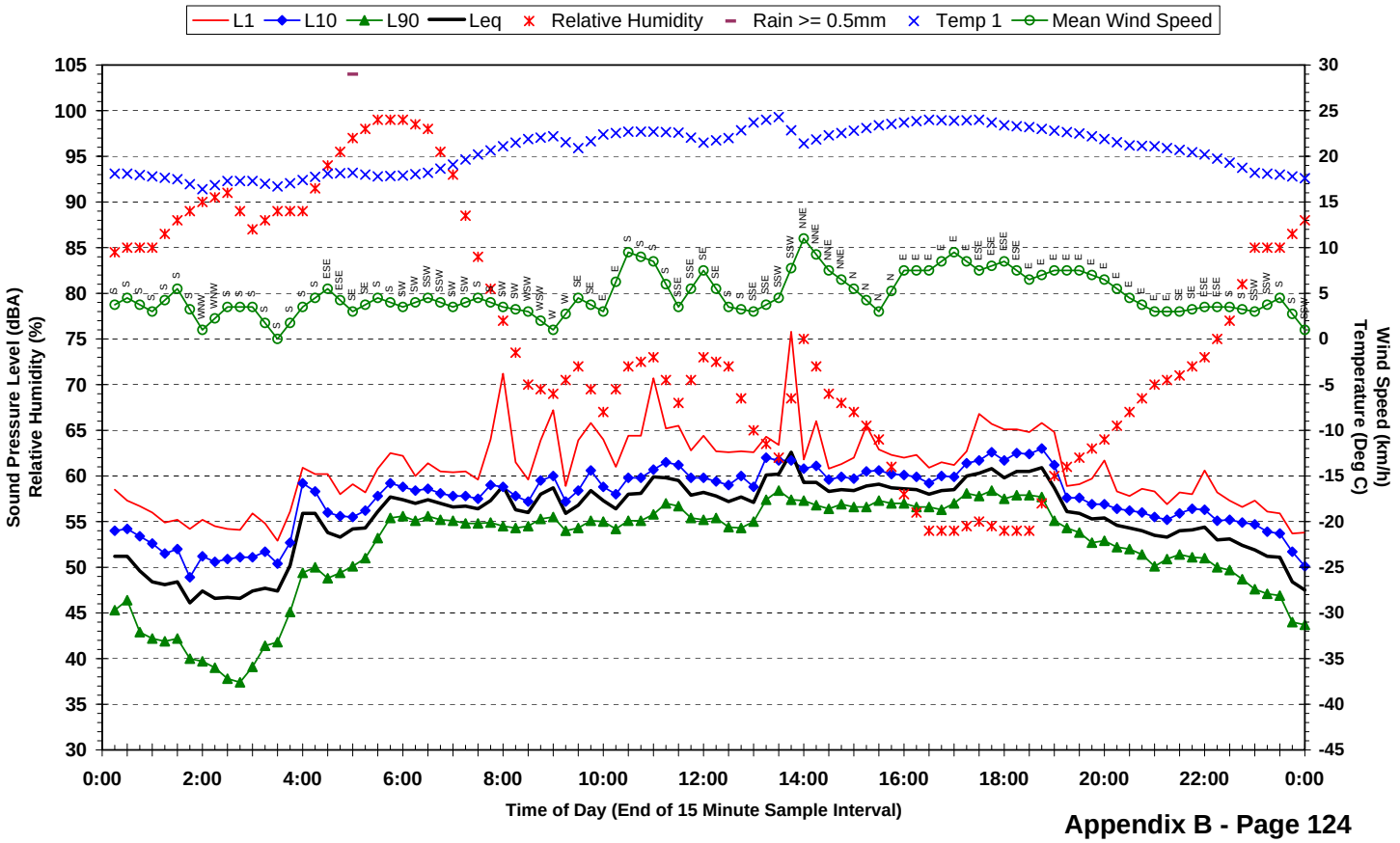
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Saturday 24 November 2007



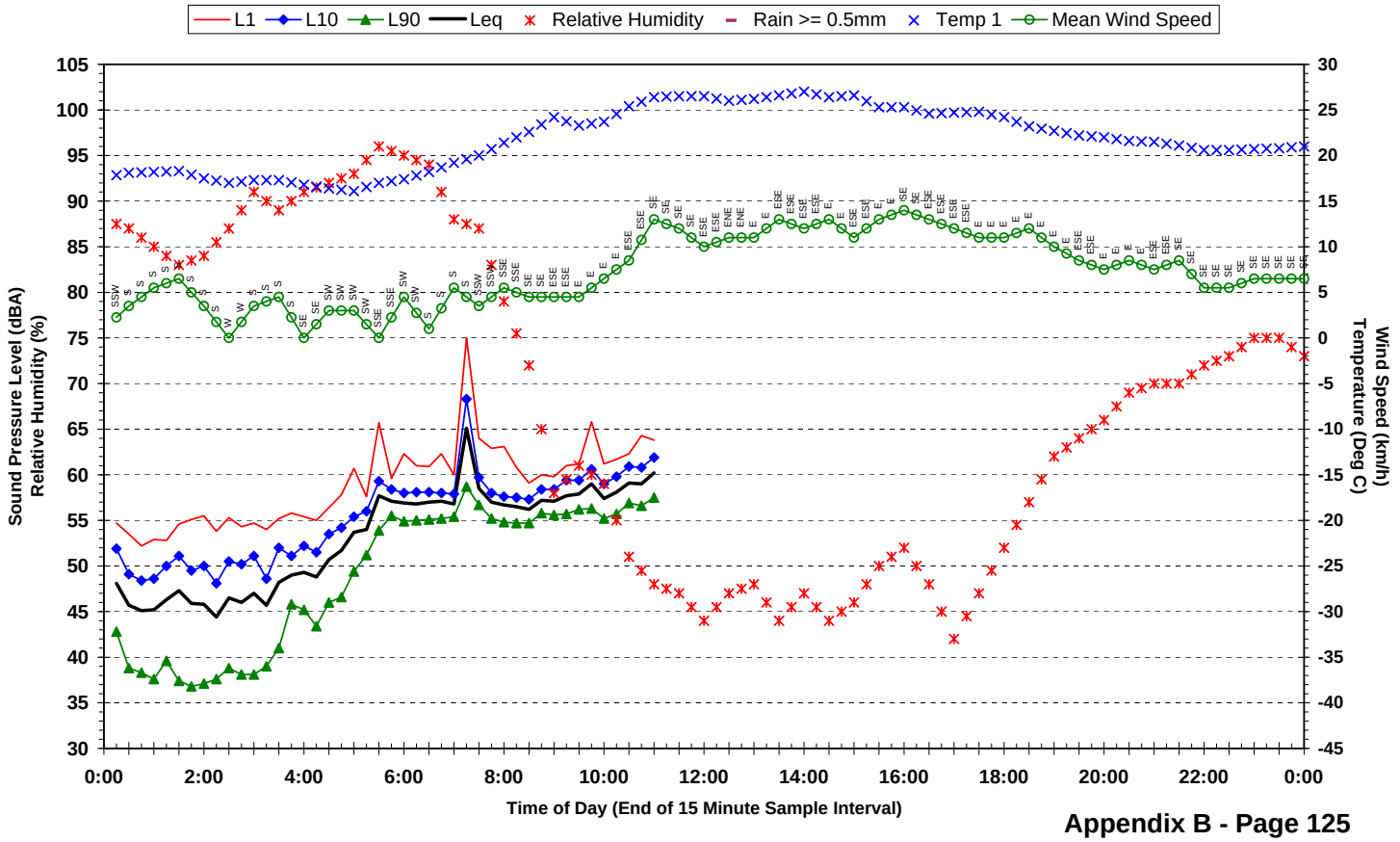
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Sunday 25 November 2007



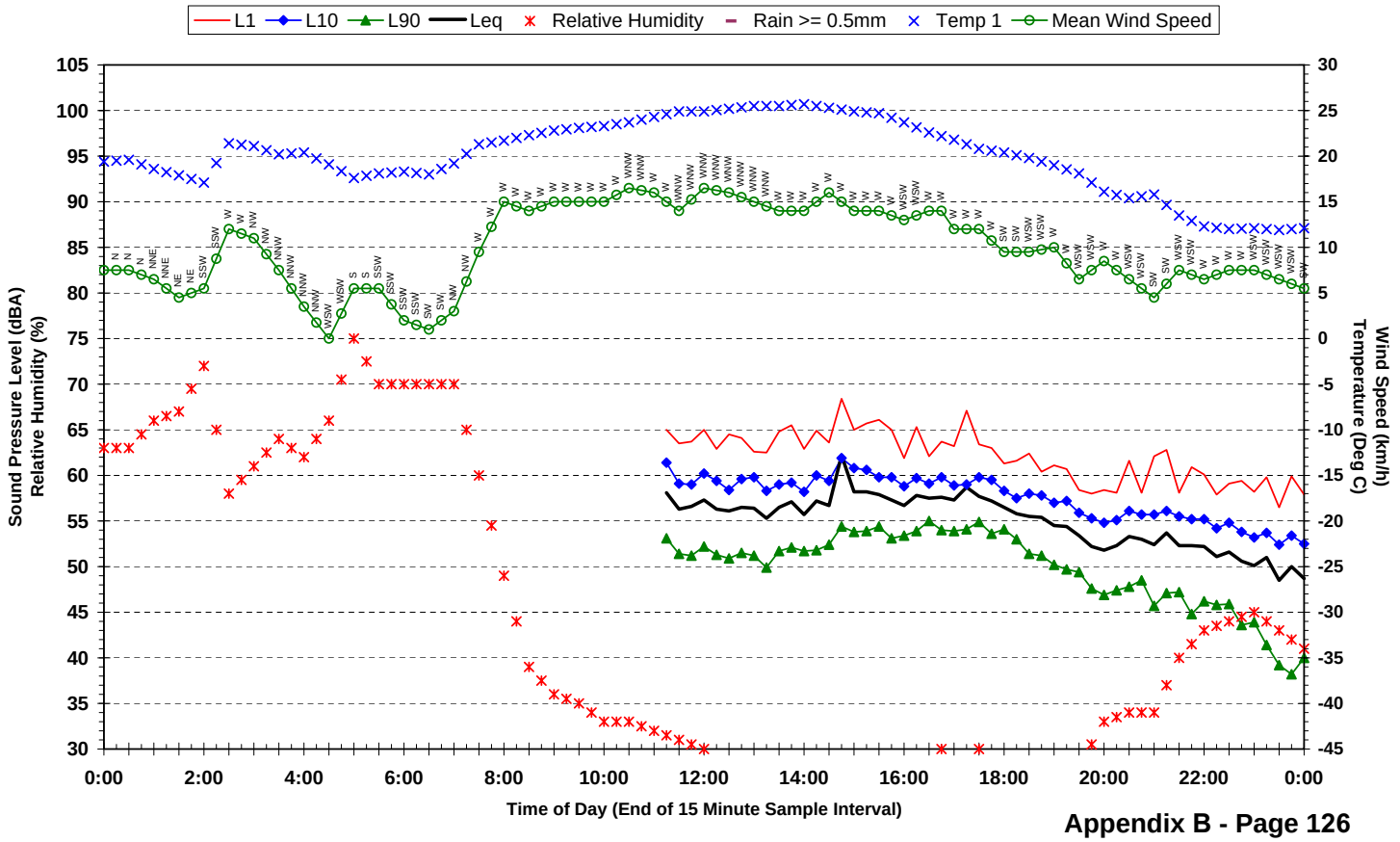
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Monday 26 November 2007



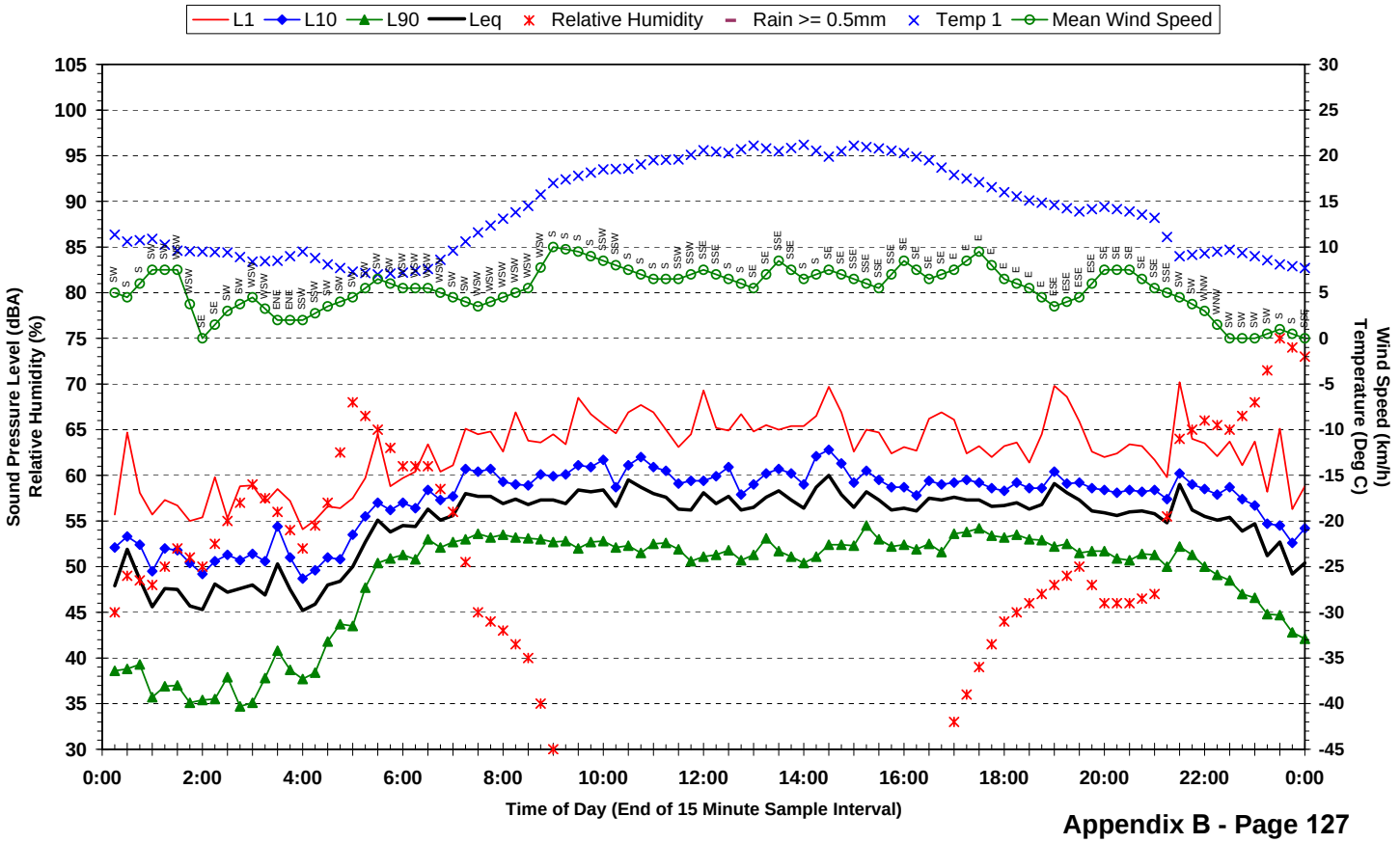
Statistical Ambient Noise Levels
Location 12 - 43 Normanby Terrace, Kelvin Grove - Tuesday 27 November 2007



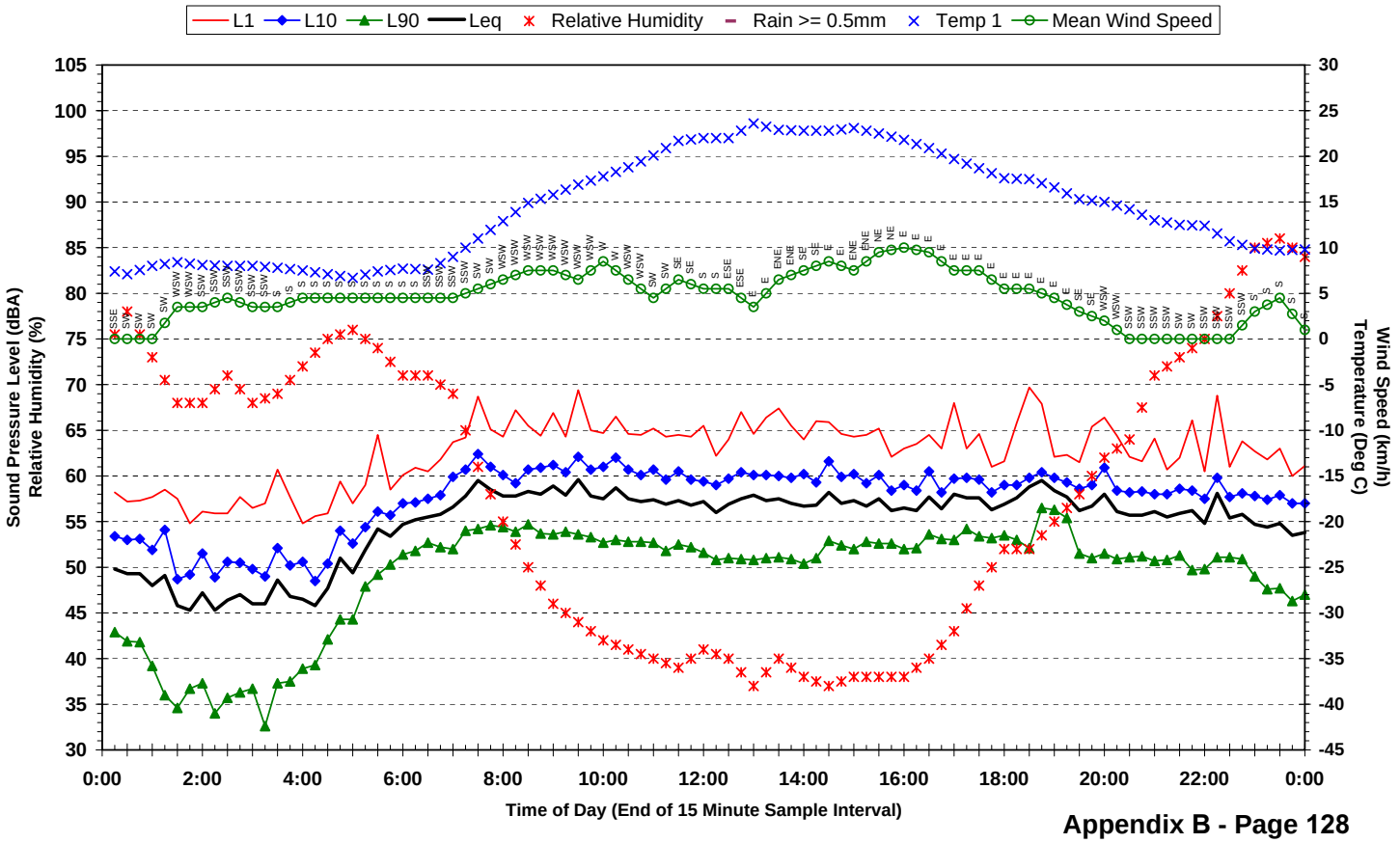
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Monday 28 April 2008



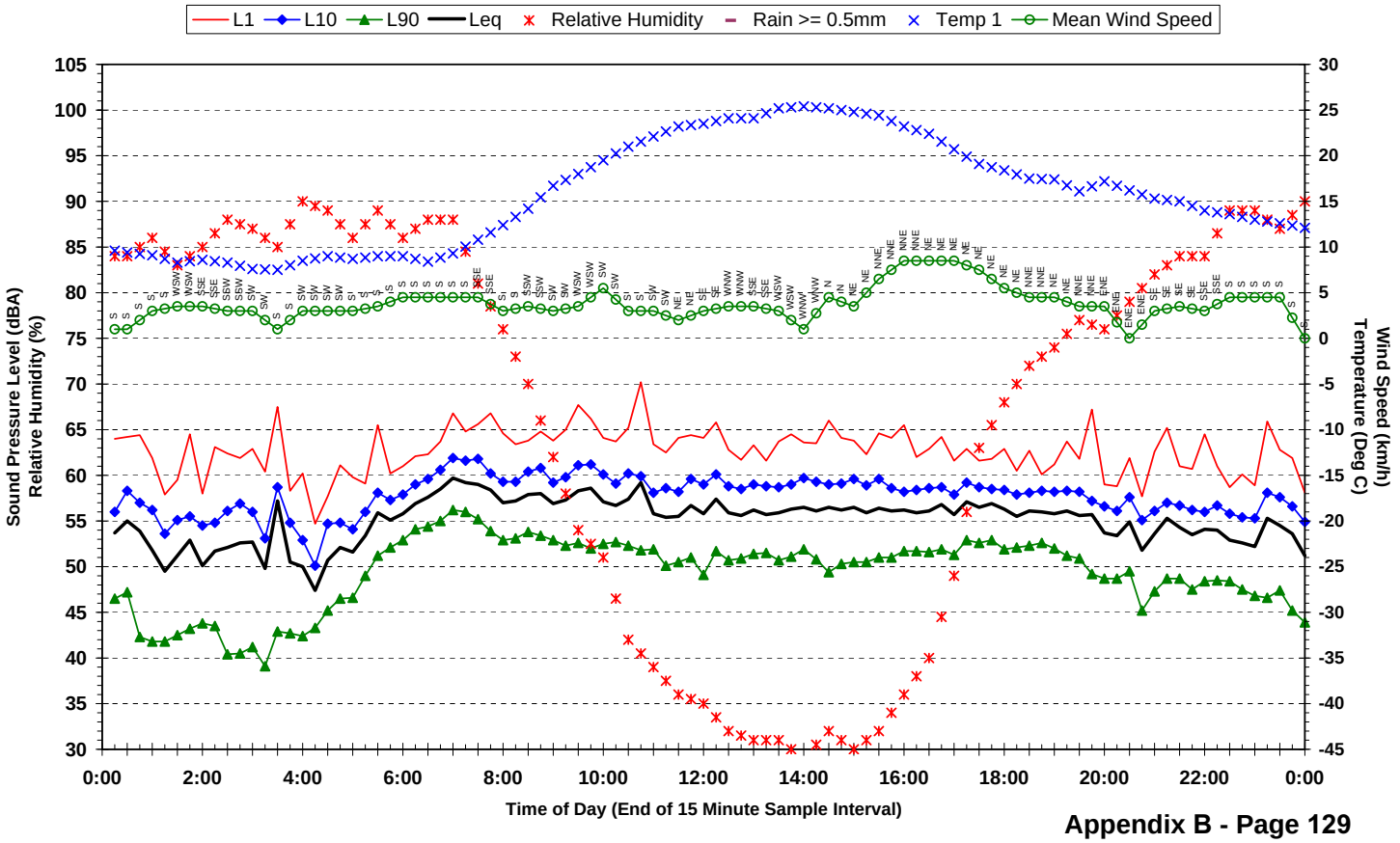
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Tuesday 29 April 2008



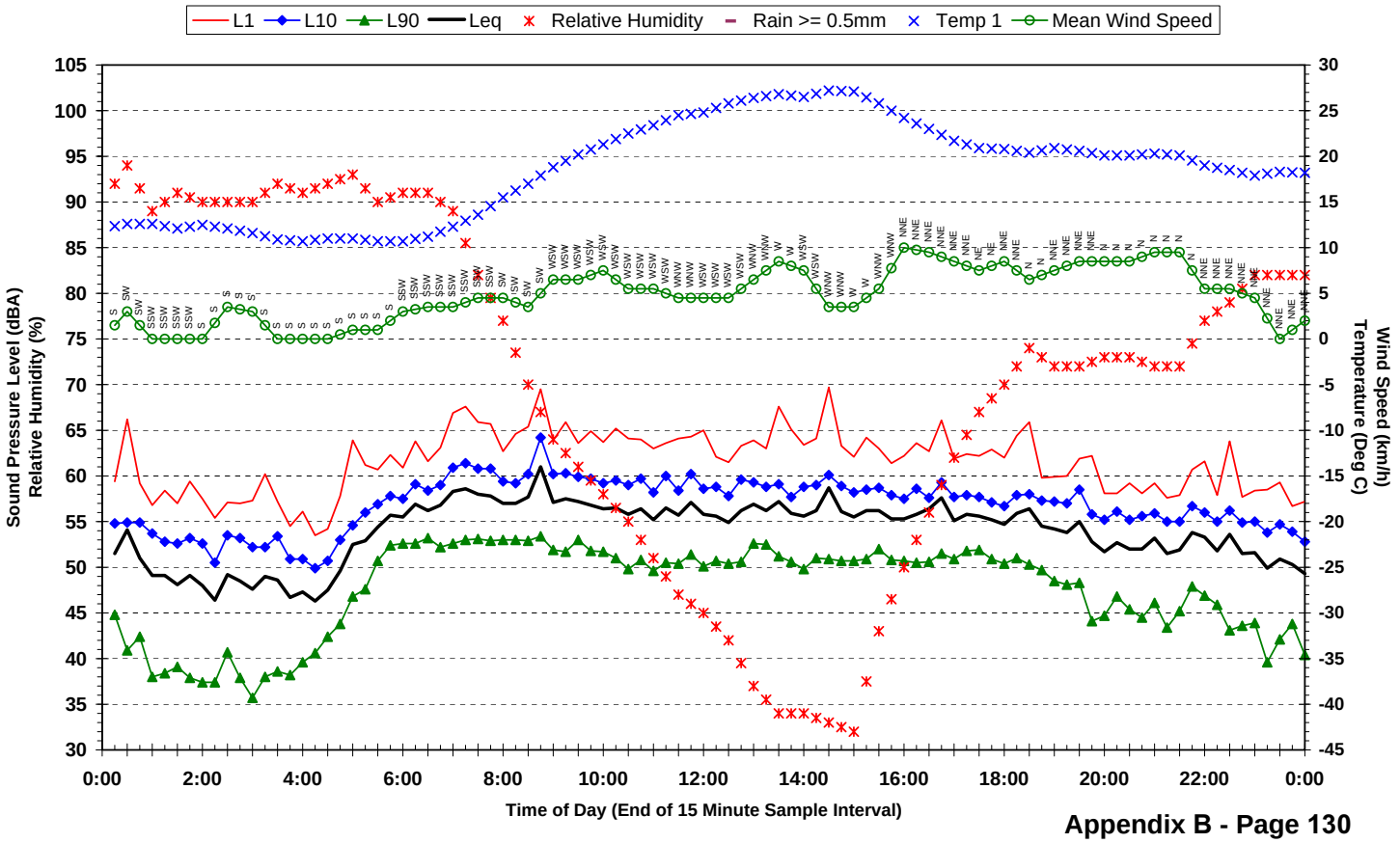
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Wednesday 30 April 2008



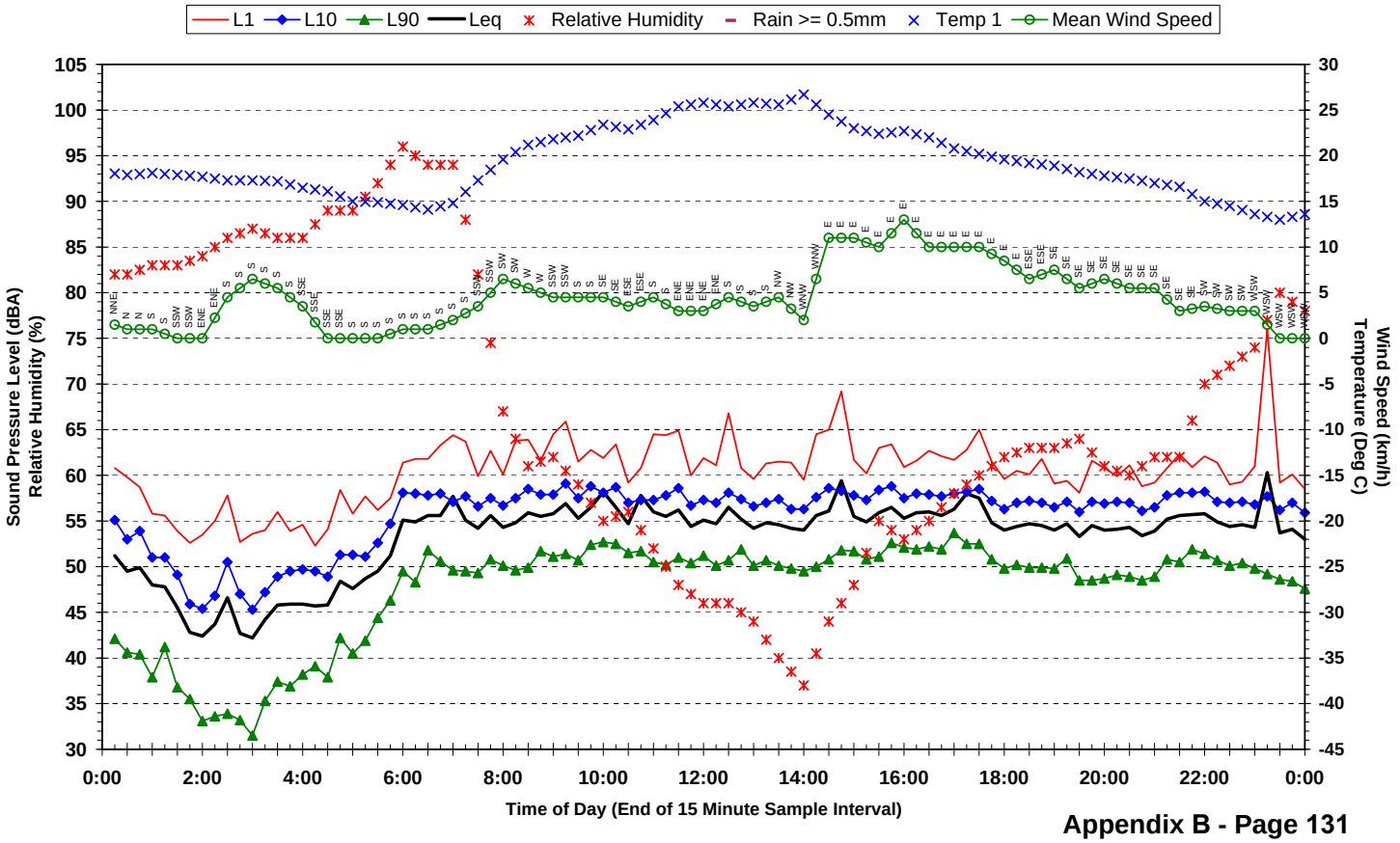
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Thursday 1 May 2008



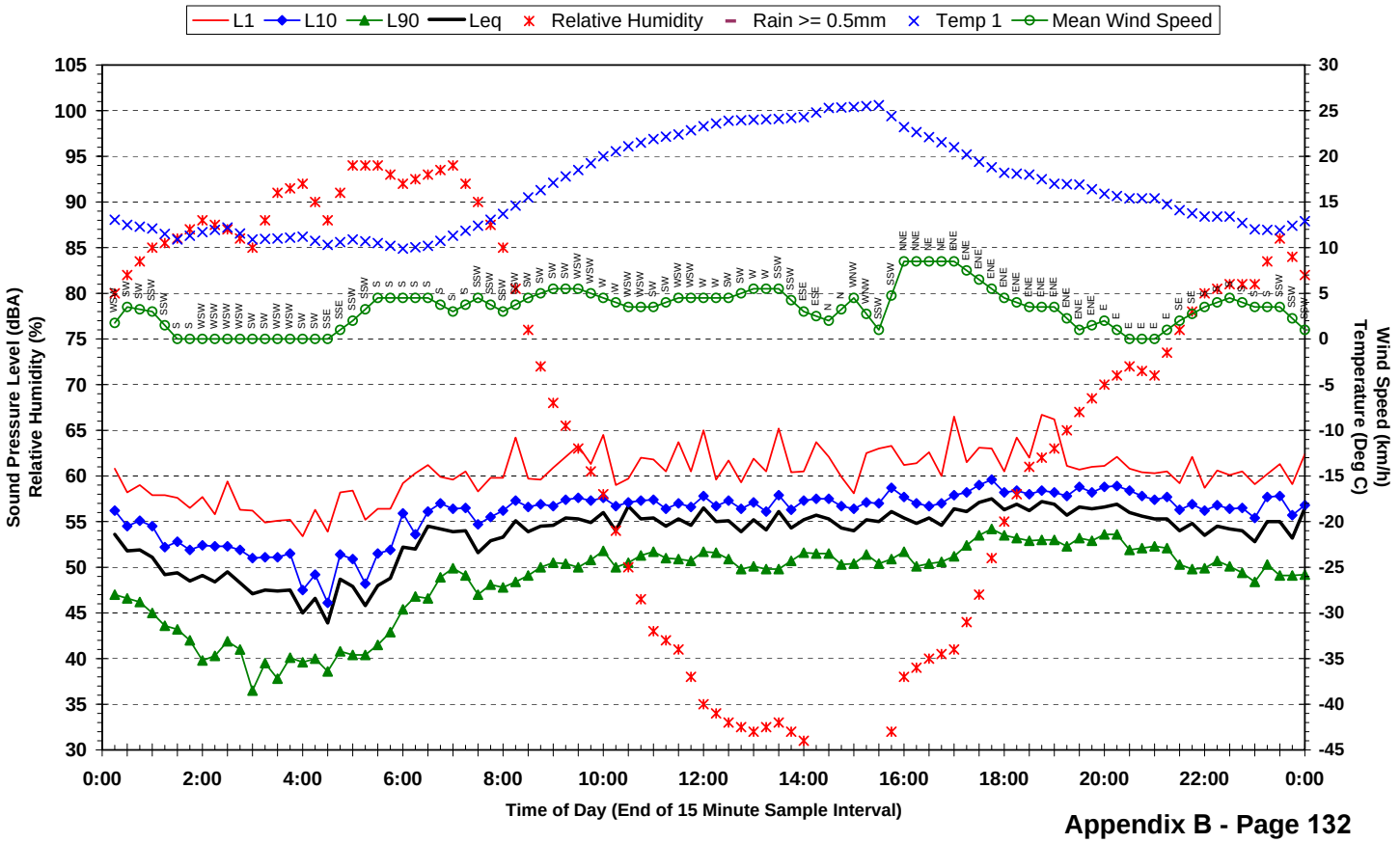
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Friday 2 May 2008



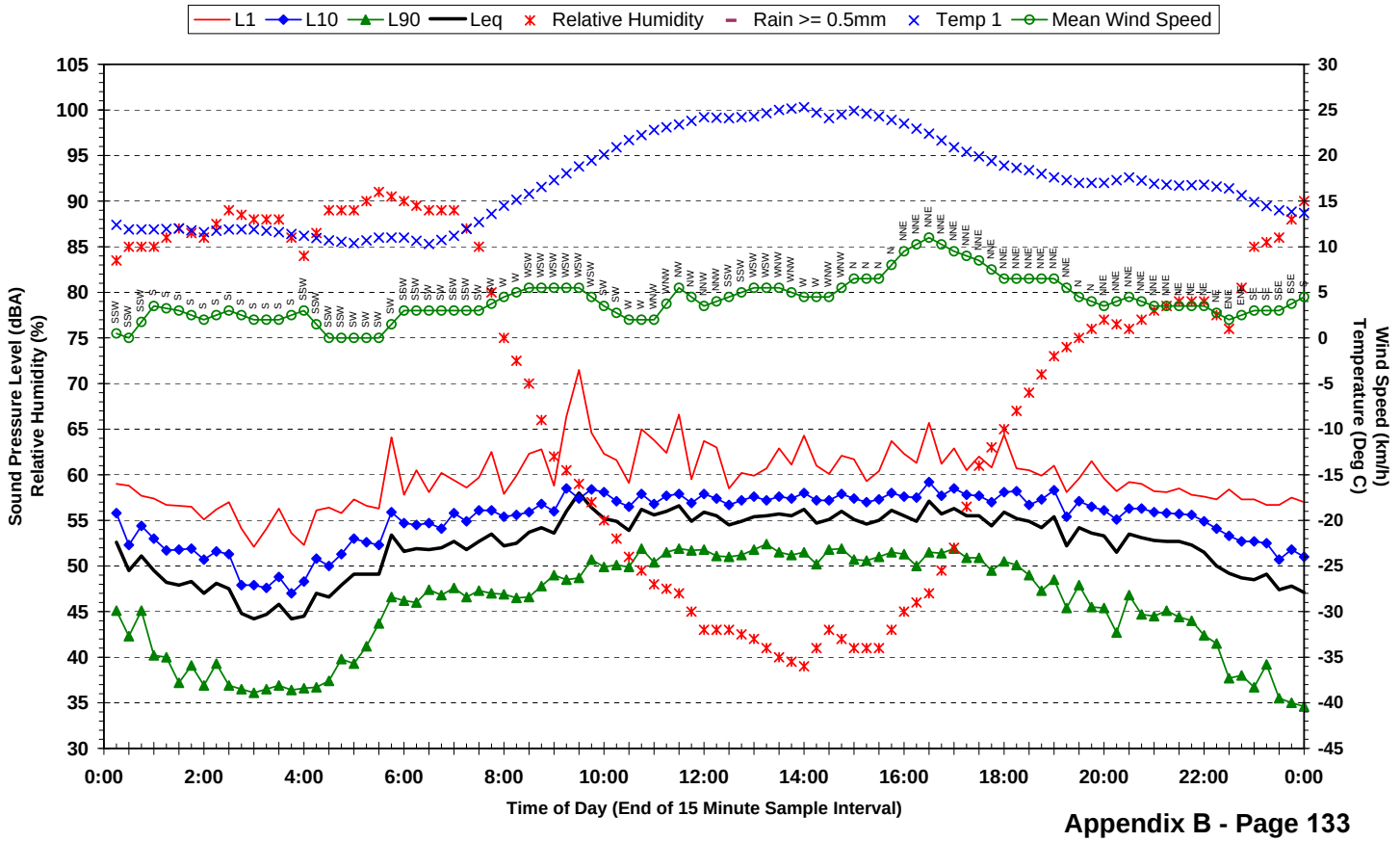
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Saturday 3 May 2008



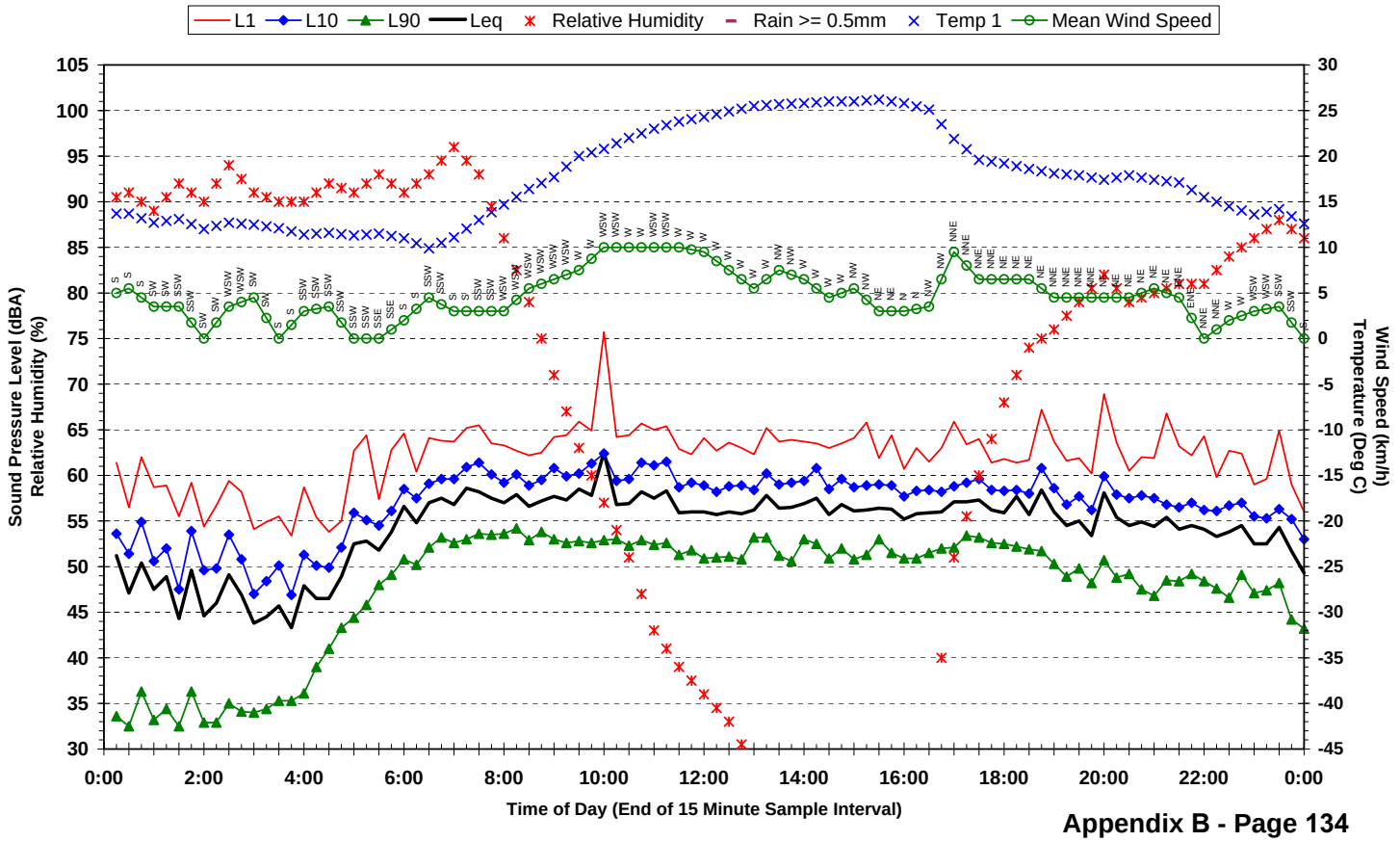
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Sunday 4 May 2008



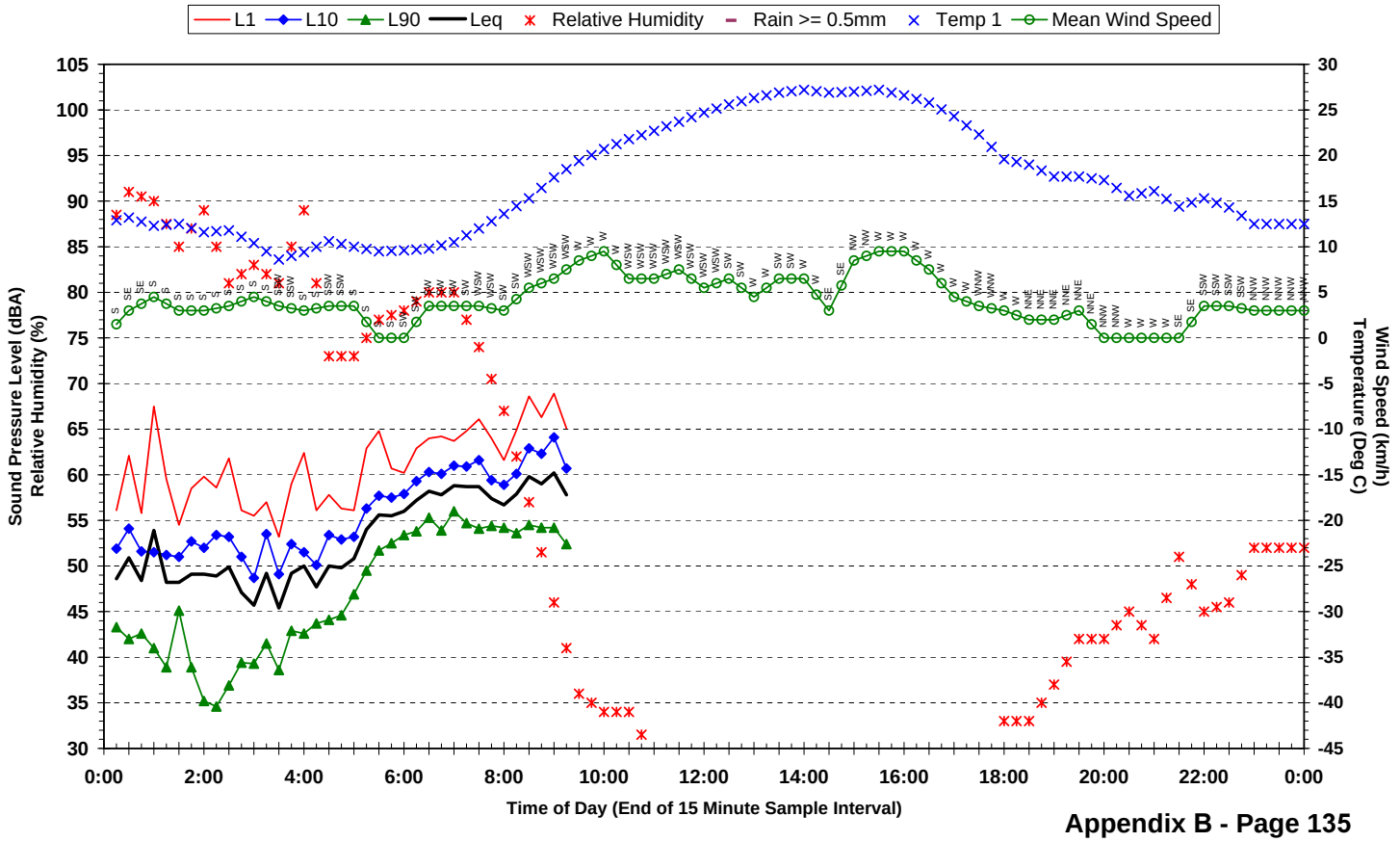
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Monday 5 May 2008



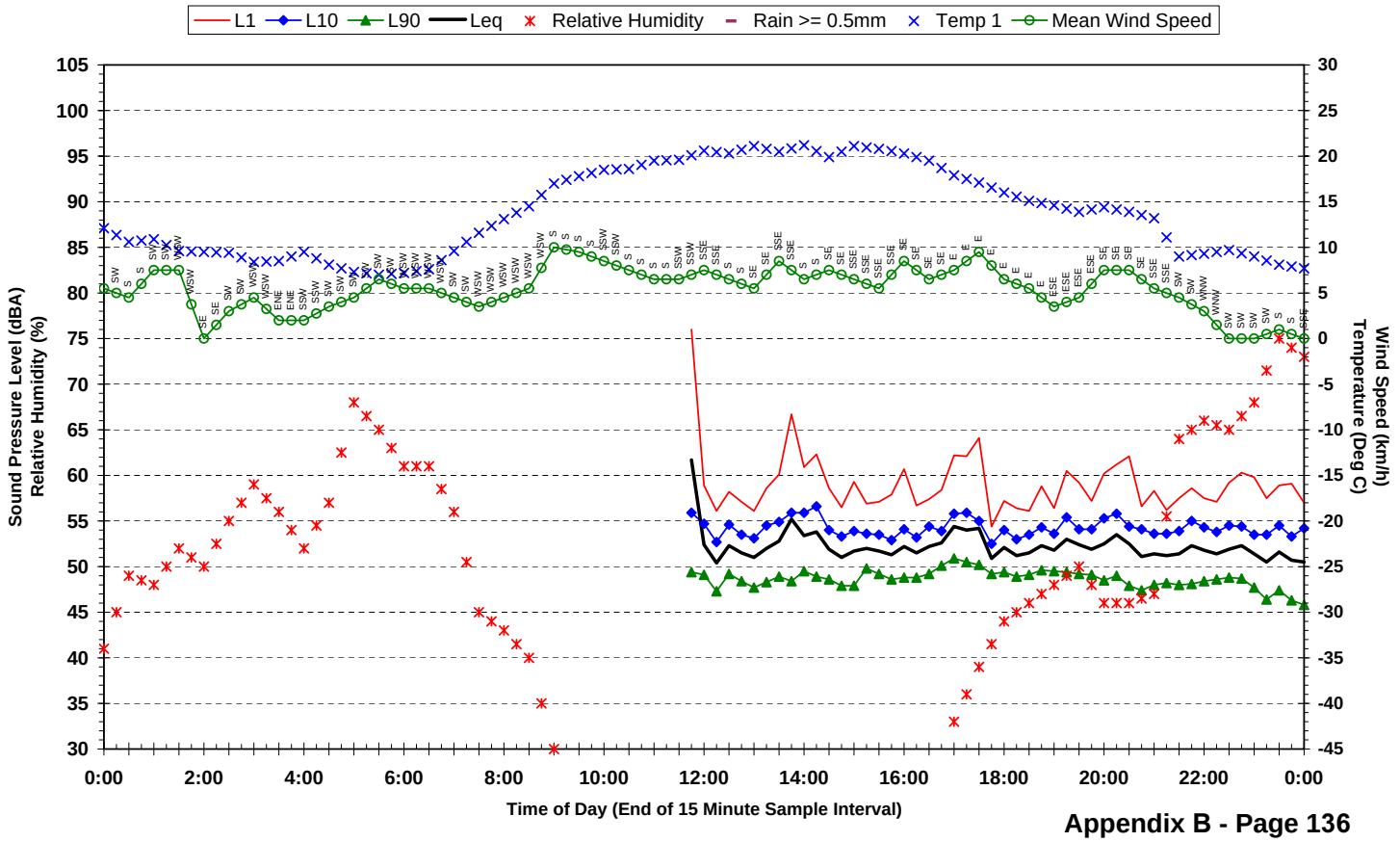
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Tuesday 6 May 2008



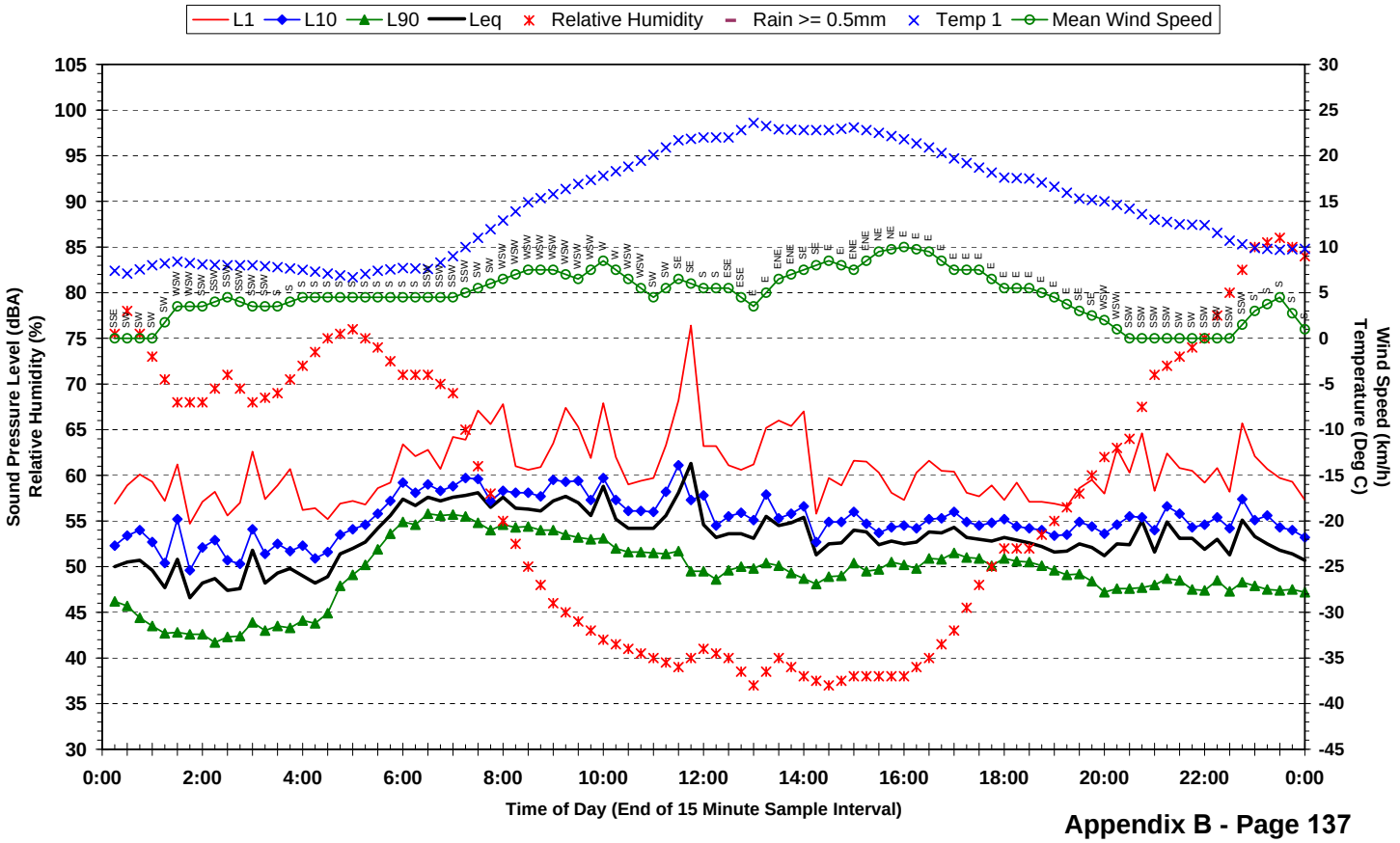
Statistical Ambient Noise Levels
Location 13 - 9 Horrocks Street, Toowong - Wednesday 7 May 2008



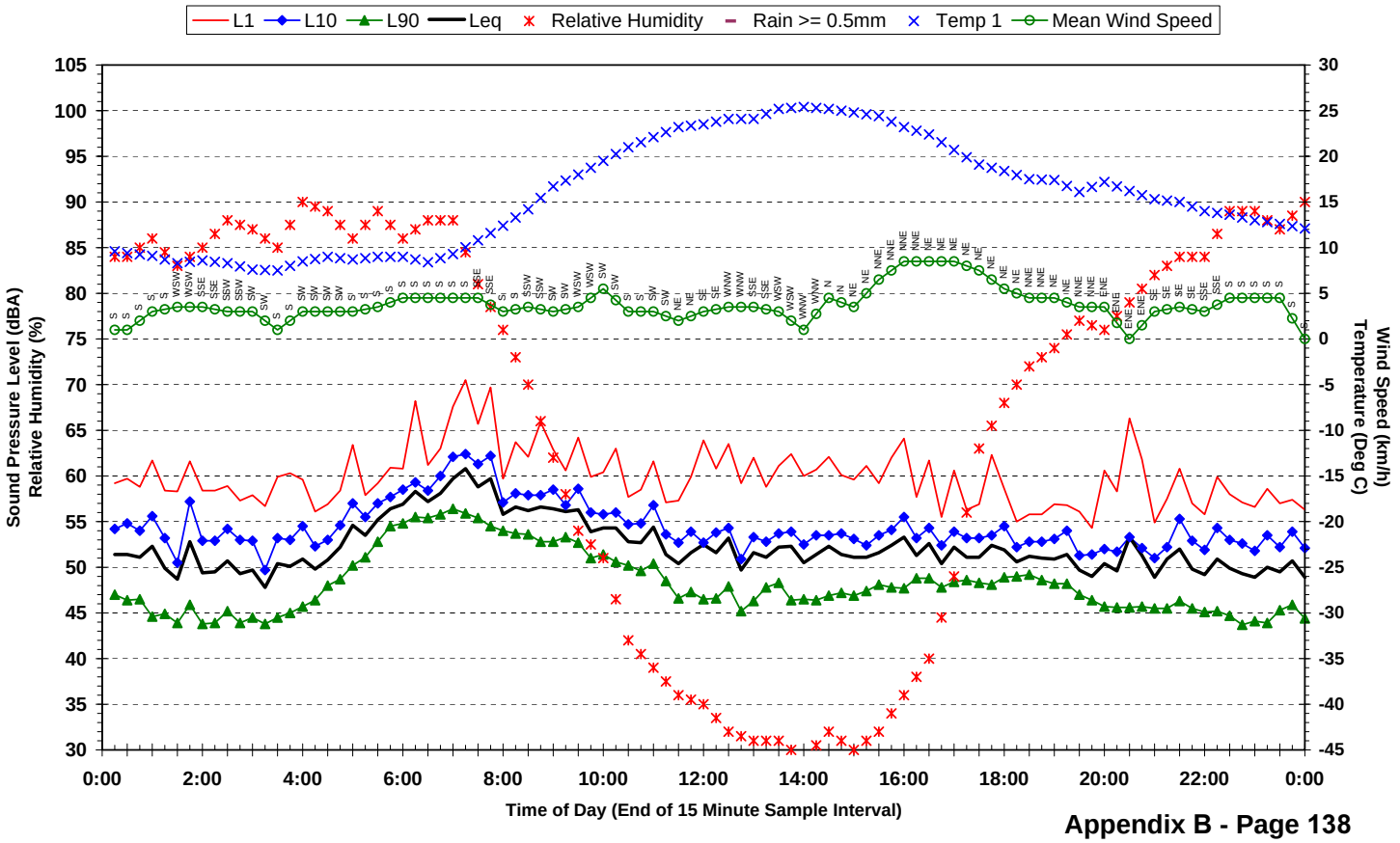
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Tuesday 29 April 2008



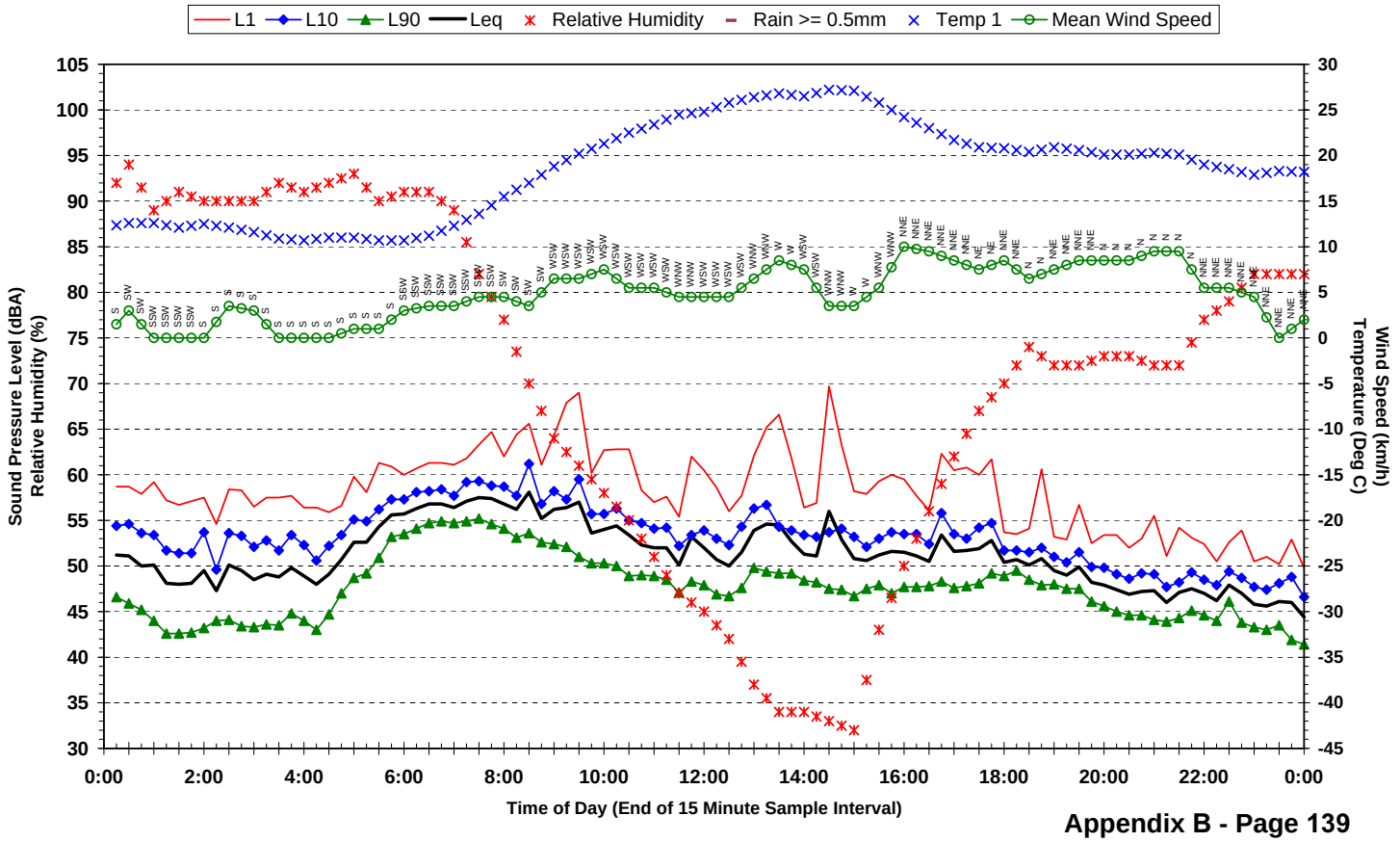
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Wednesday 30 April 2008



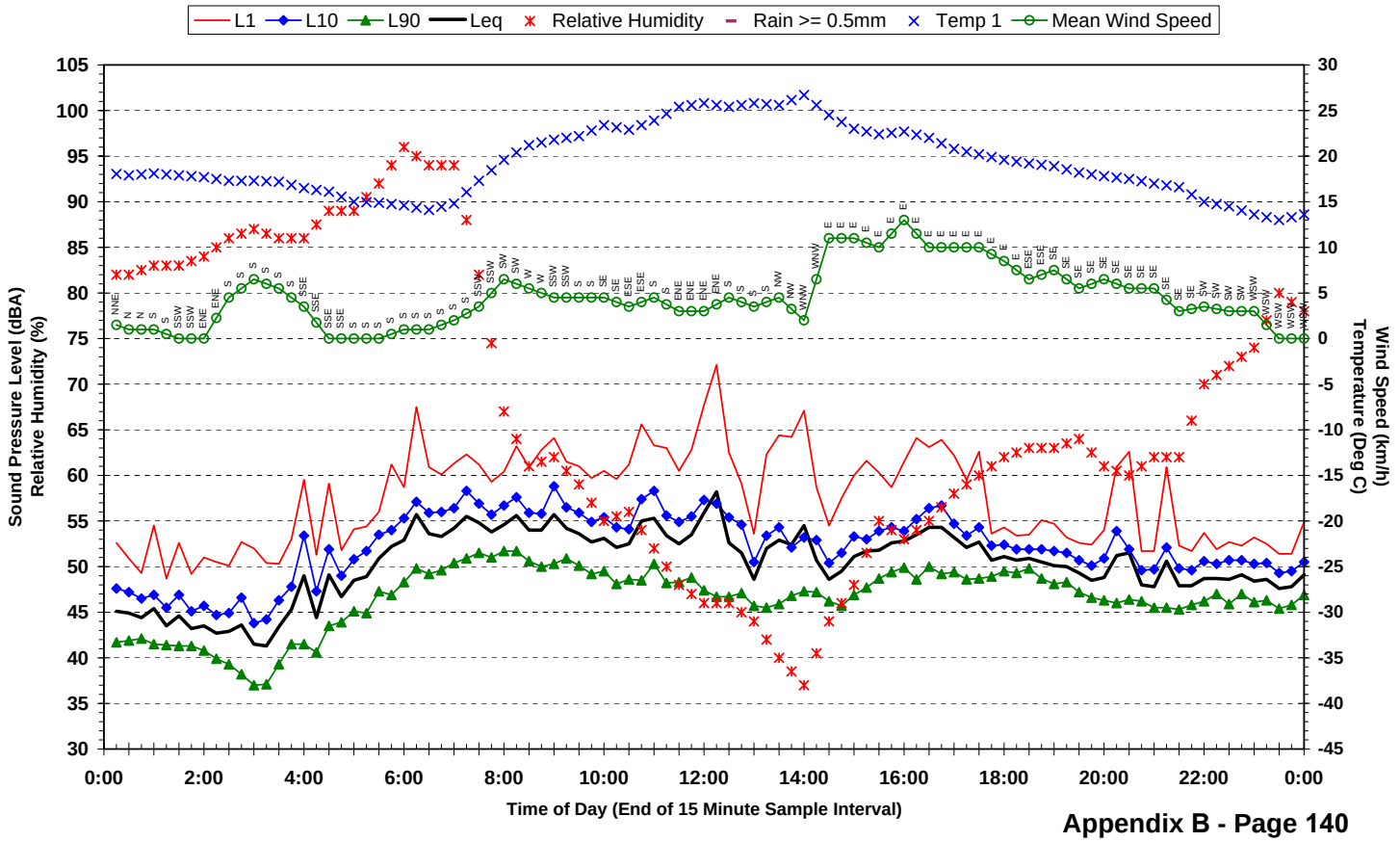
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Thursday 1 May 2008



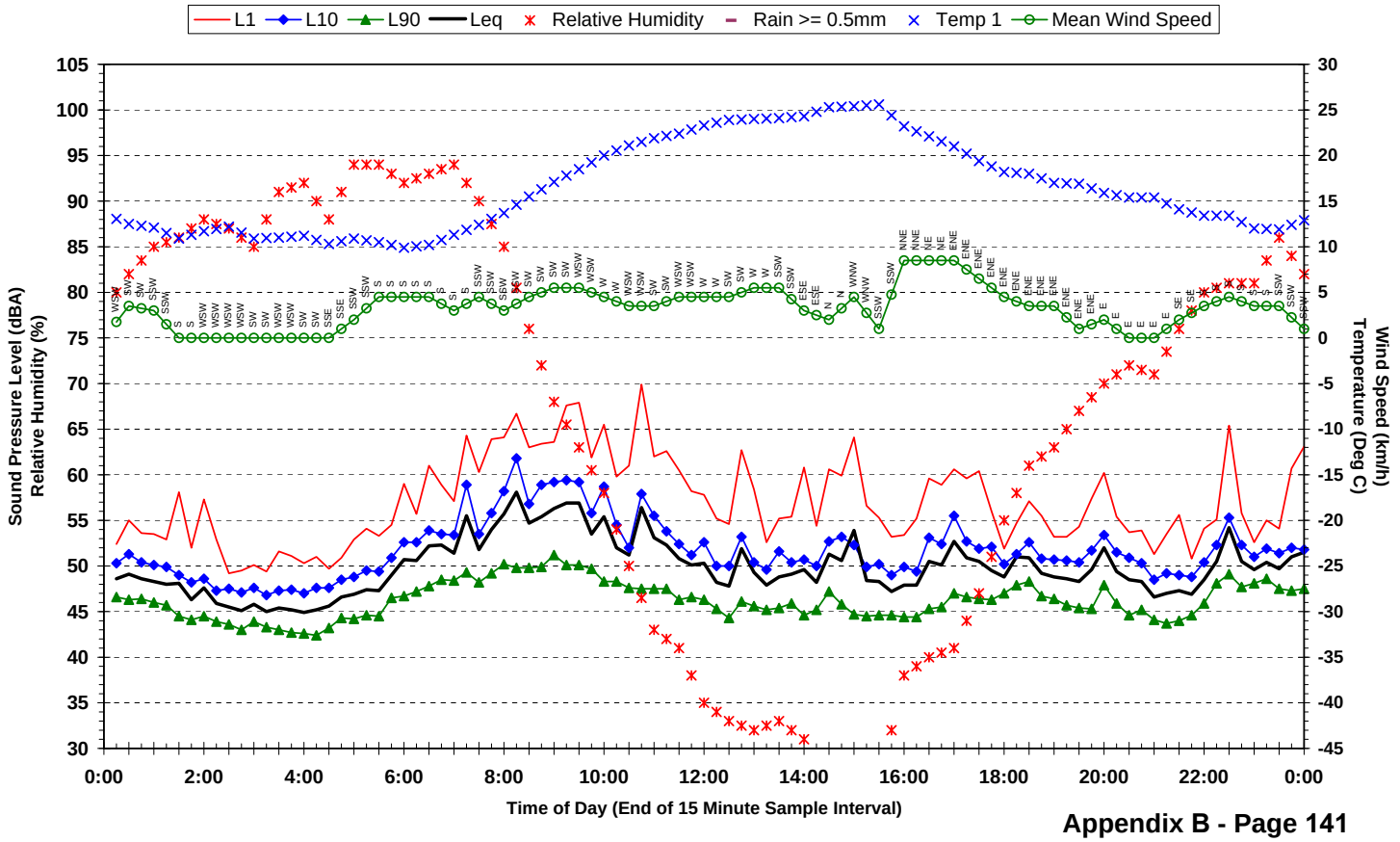
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Friday 2 May 2008



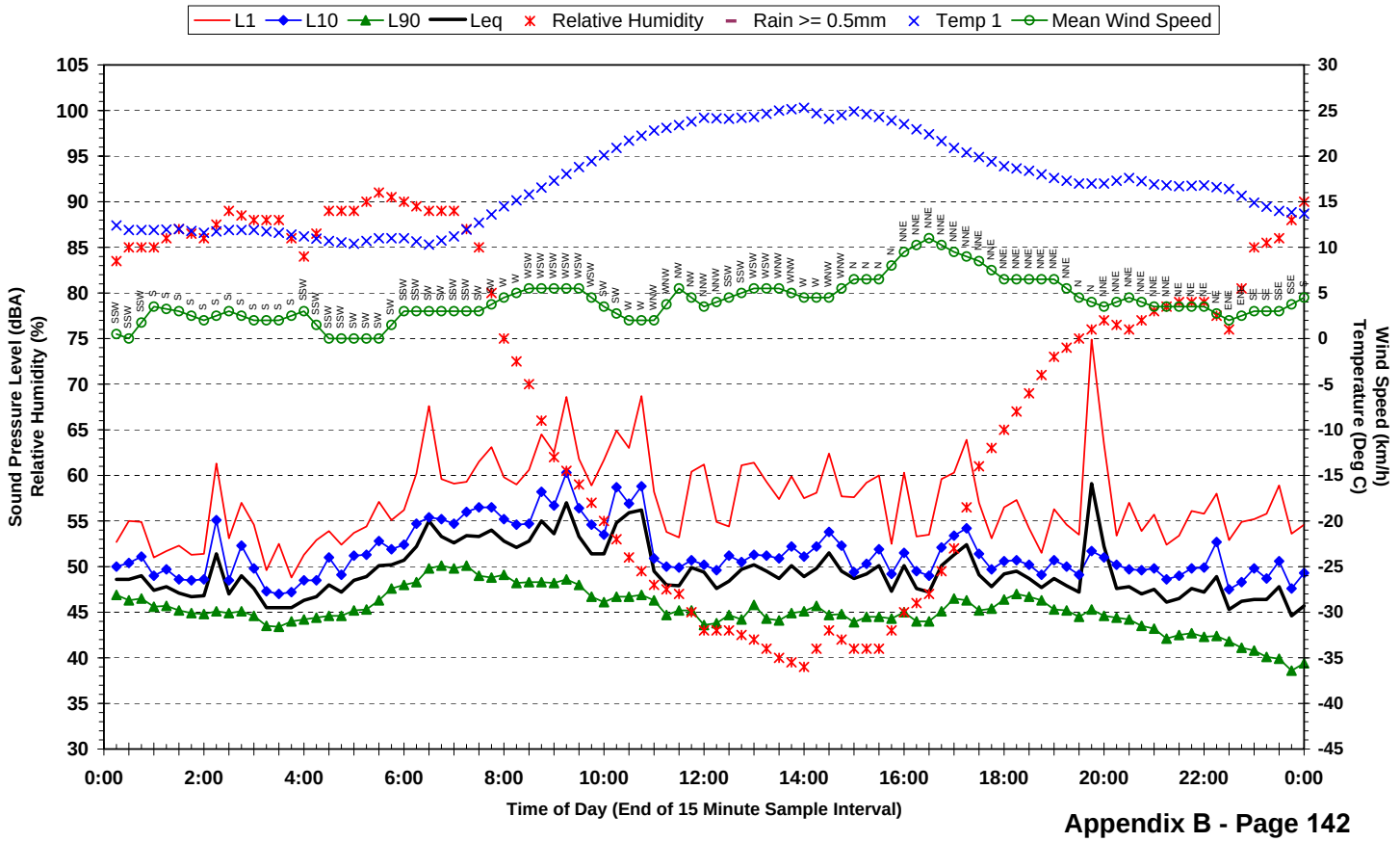
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Saturday 3 May 2008



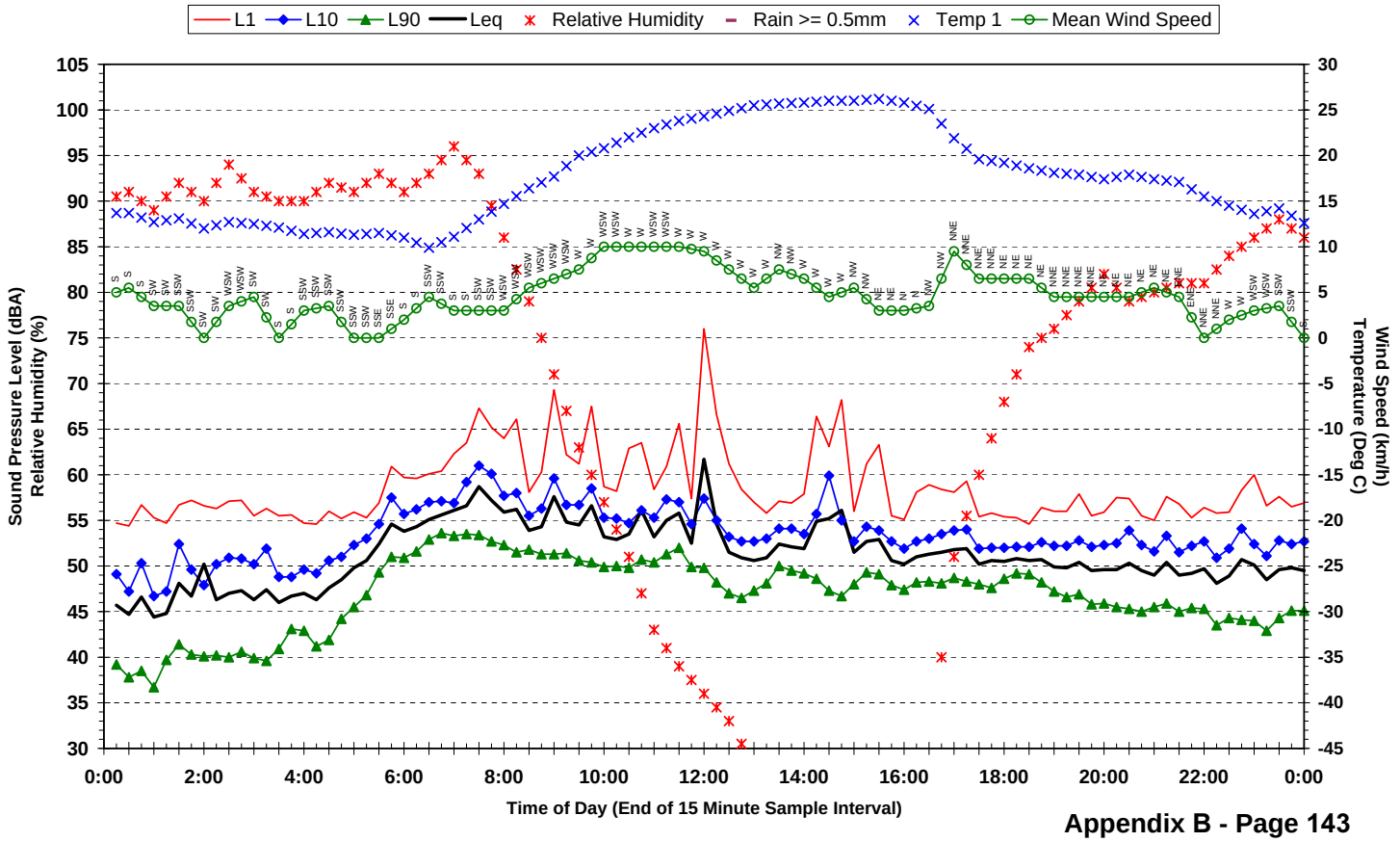
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Sunday 4 May 2008



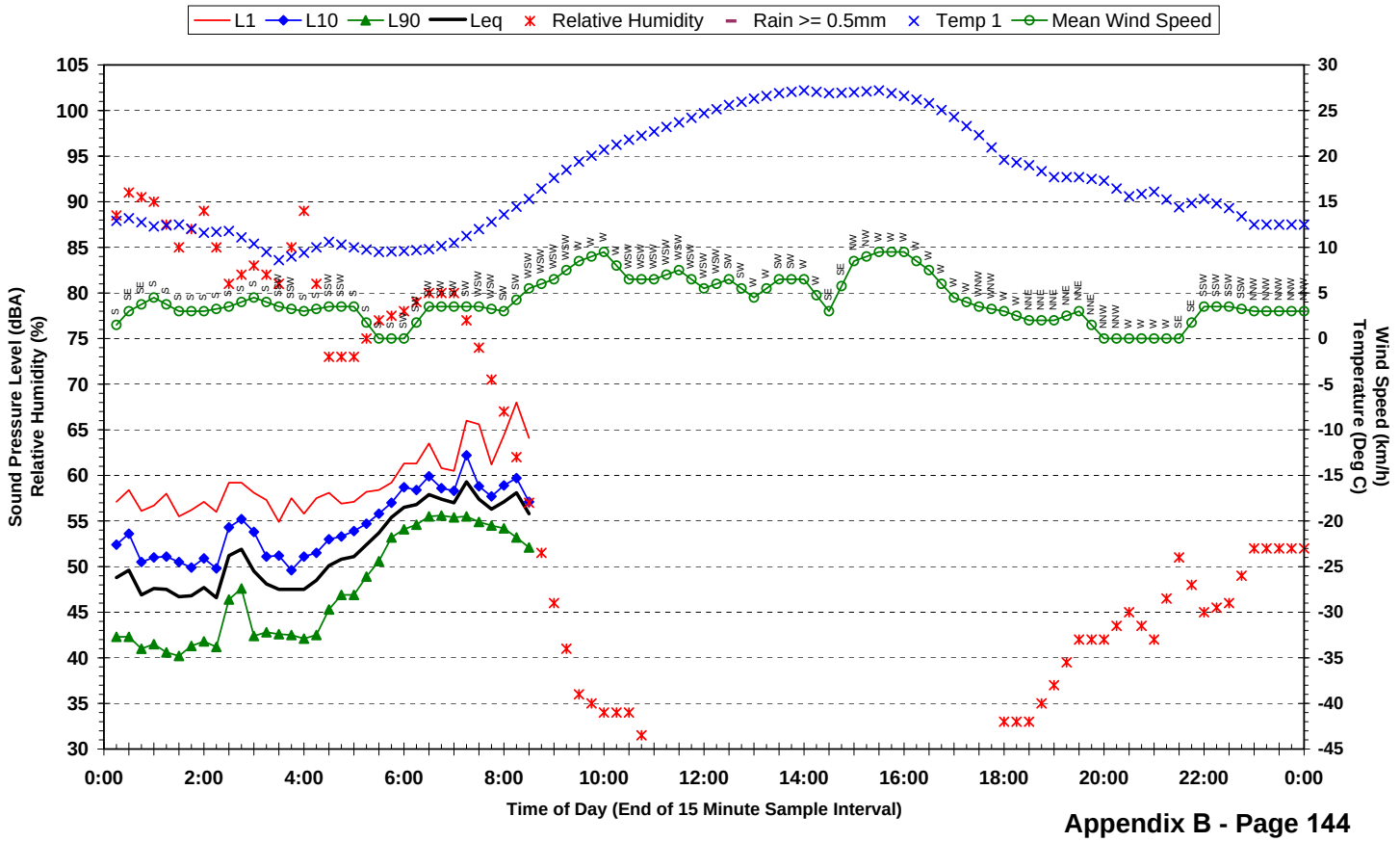
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Monday 5 May 2008



Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Tuesday 6 May 2008



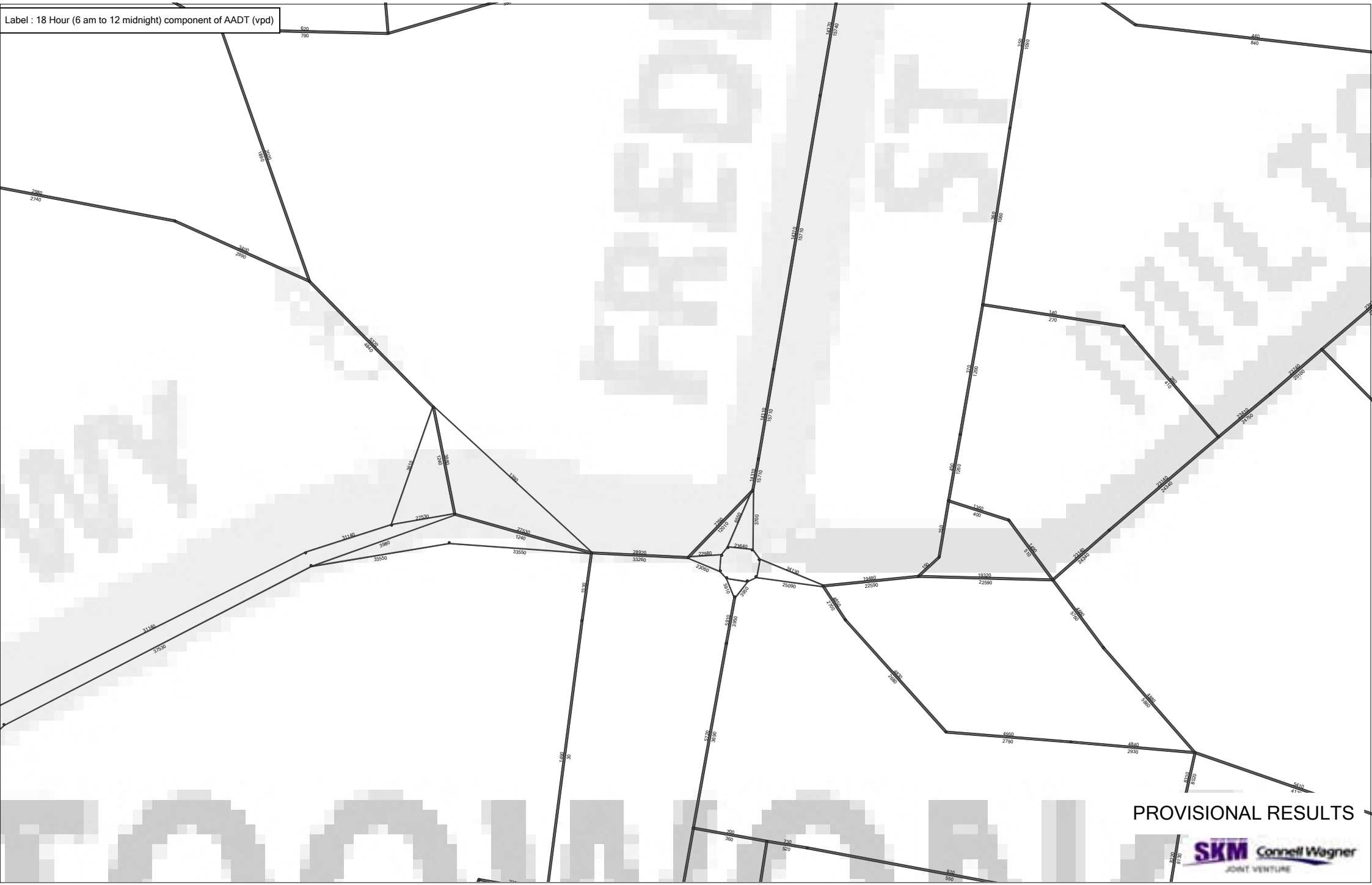
Statistical Ambient Noise Levels
Location 14 - QUT Kelvin Grove Campus - Wednesday 7 May 2008



Appendix C

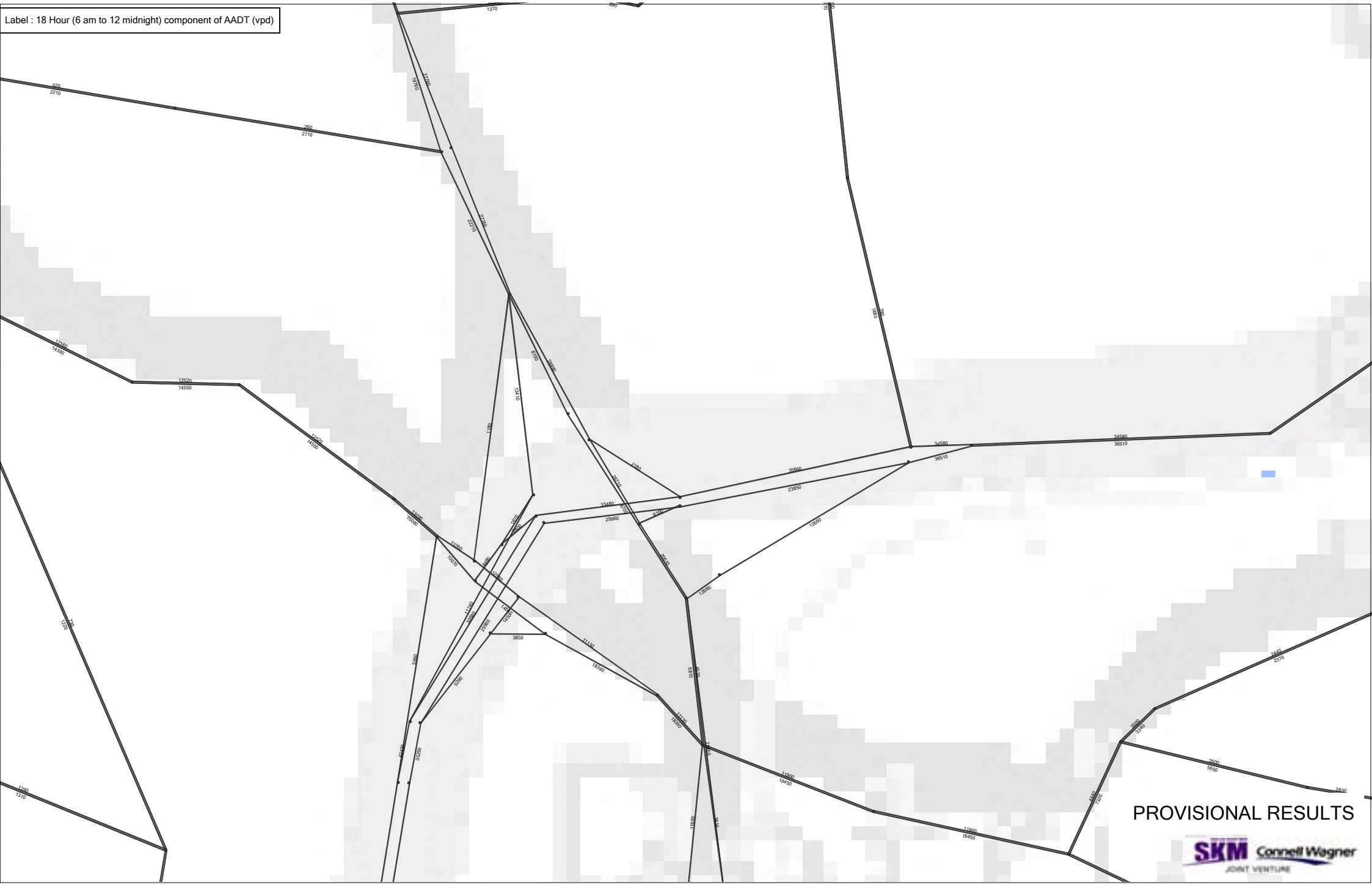
Report 20-1854R3

NL EIS : 2007 18 Hour component of AADT, Base Year (TR_2007_003)



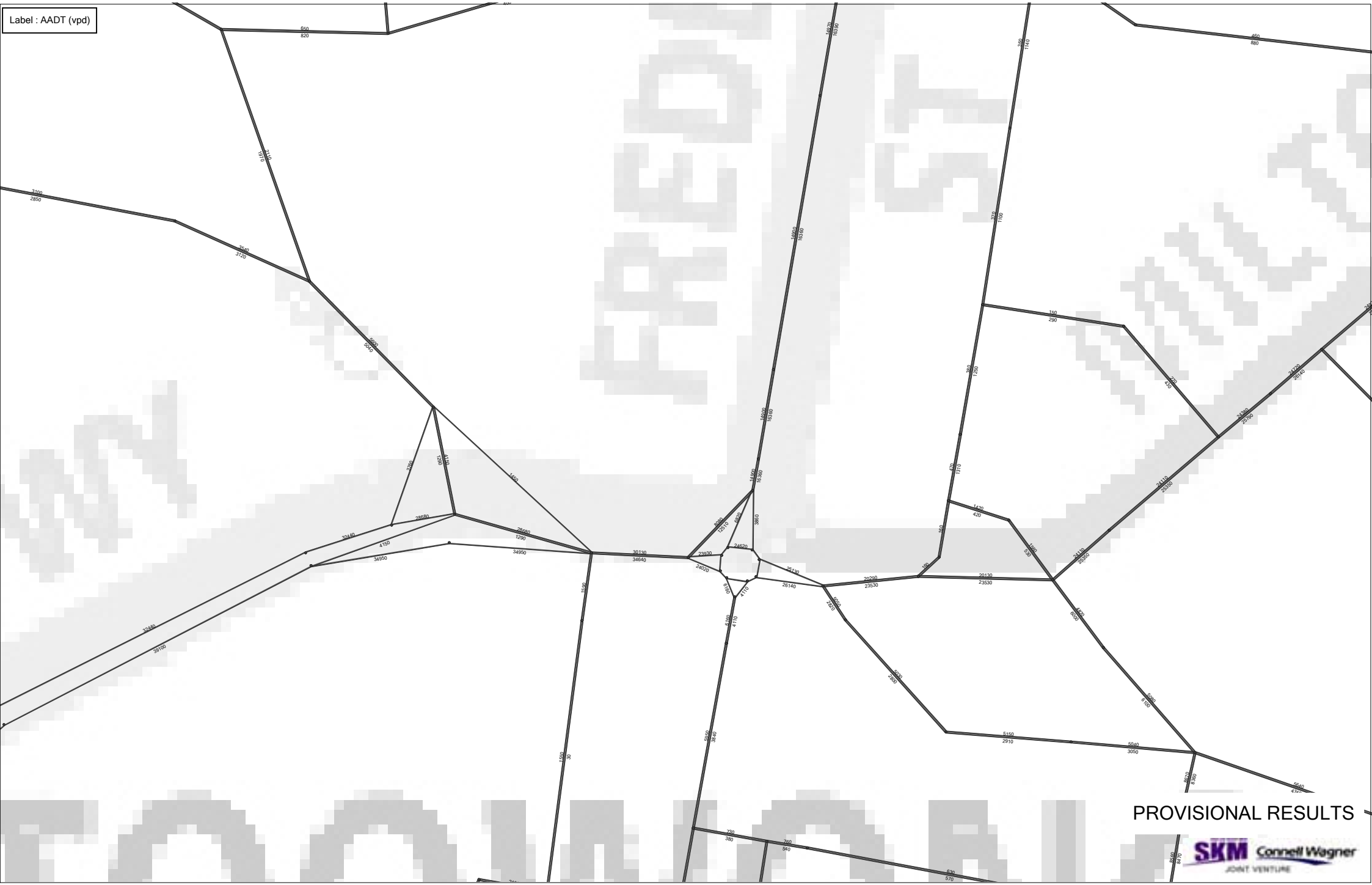
TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:37 (MIPOC12)

NL EIS : 2007 18 Hour component of AADT, Base Year (TR_2007_003)



TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:37 (MIPOC12)

NL EIS : 2007 AADT Daily Traffic Volumes, Base Year (TR_2007_003)

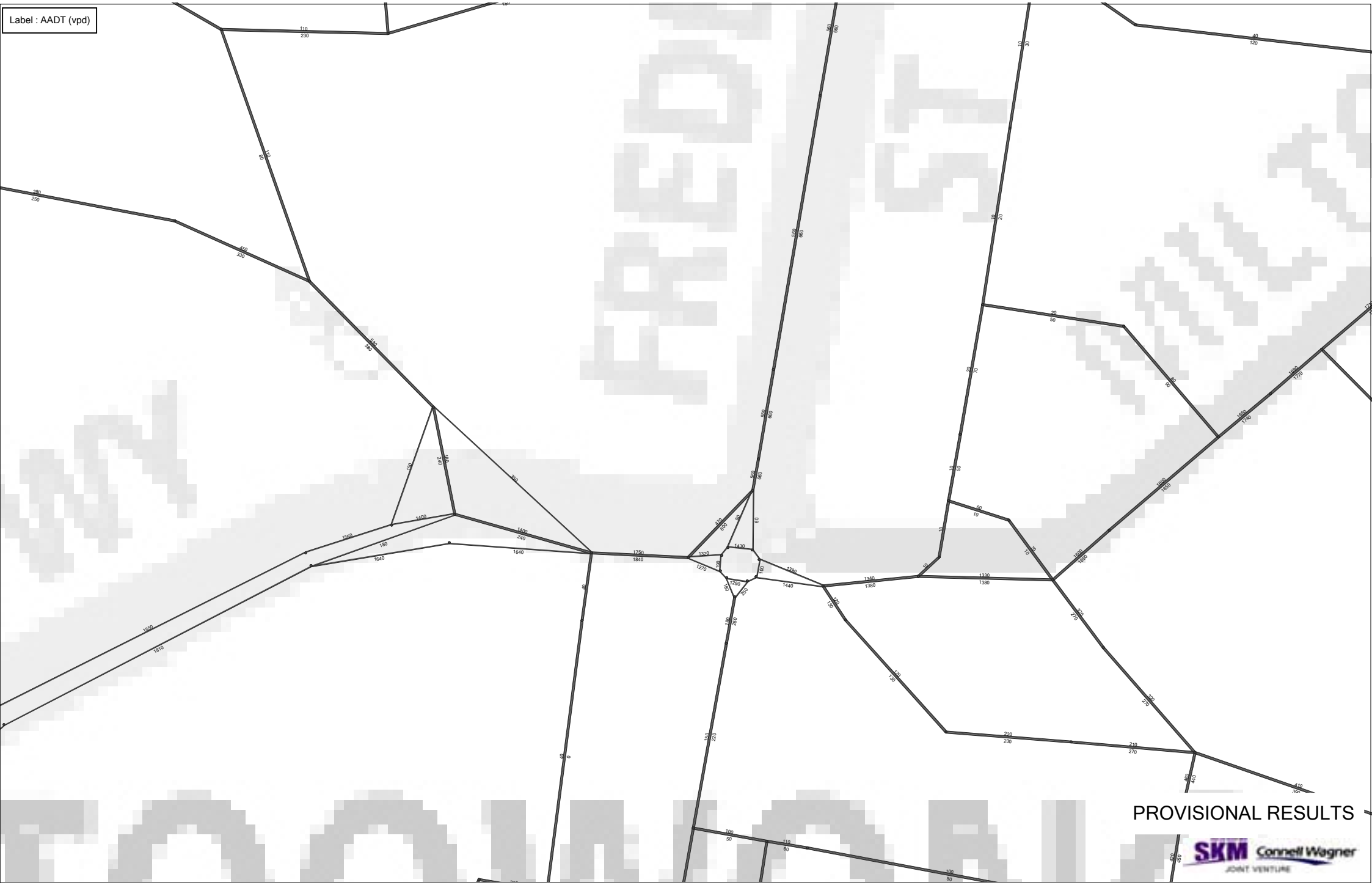


TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:44 (MIPOC12)

NL EIS : 2007 AADT Daily Traffic Volumes, Base Year (TR_2007_003)

TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:44 (MIPOC12)

NL EIS : 2007 AADT Daily Heavy Vehicle Traffic Volumes, Base Year (TR_2007_003)



TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:43 (MIPOC12)

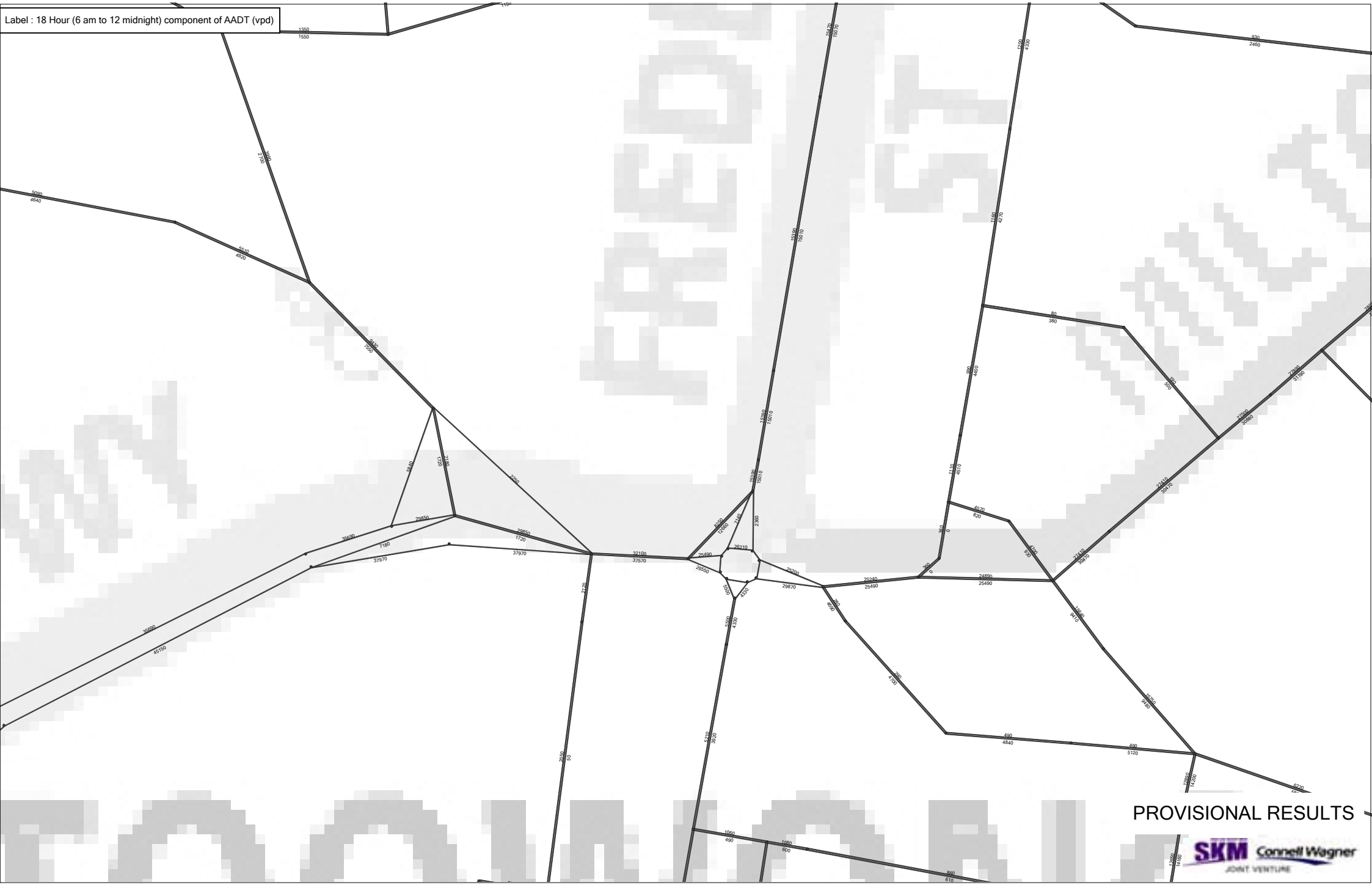
NL EIS : 2007 AADT Daily Heavy Vehicle Traffic Volumes, Base Year (TR_2007_003)

TR_2007_003 NORTHERN LINK MODEL
Scenario 5000: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-24 14:43 (MIPOC12)

Appendix D

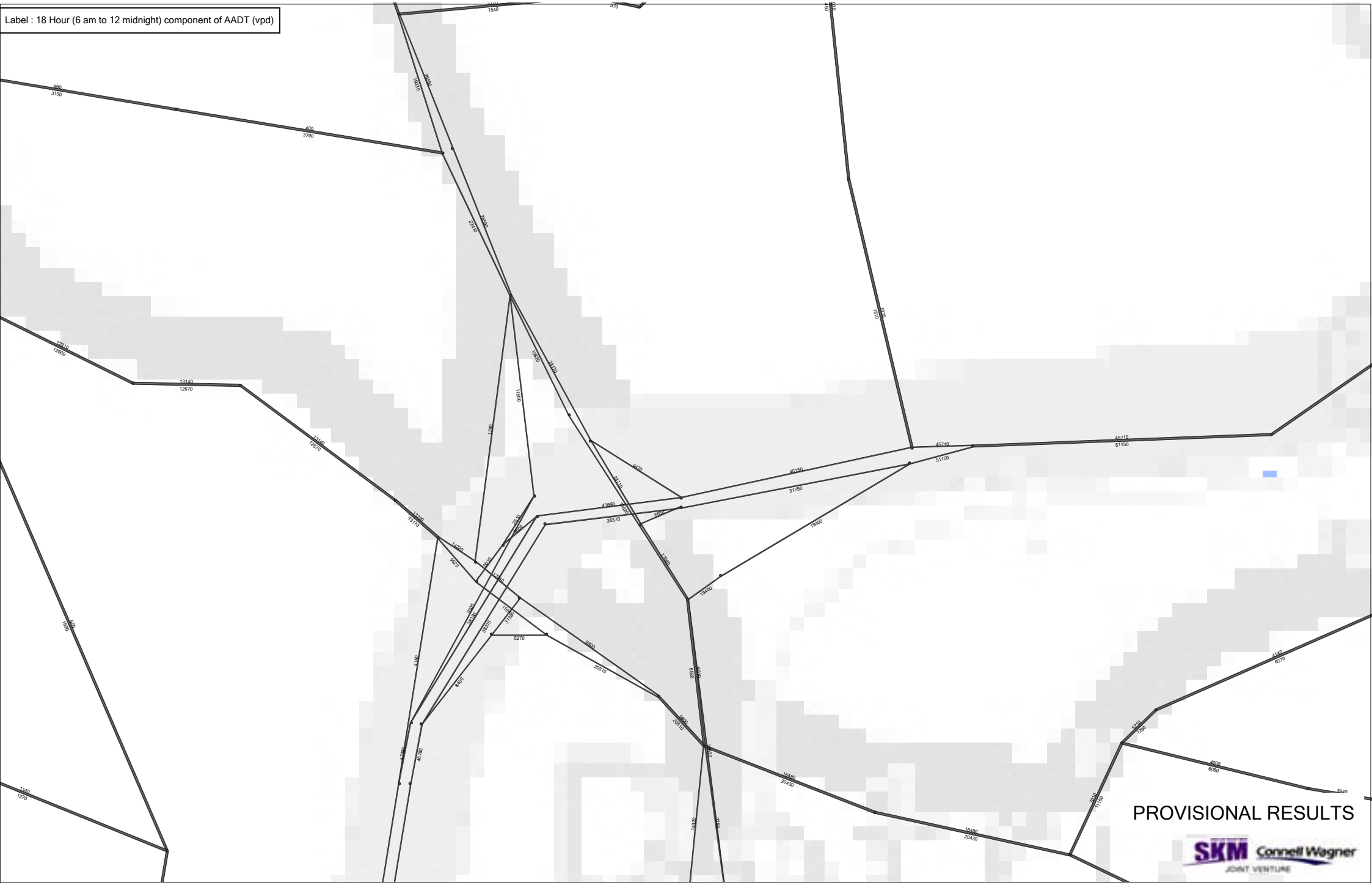
Report 20-1854R3

NL EIS : 2014 18 Hour component of AADT, Without Northern Link (TR_2014_135)



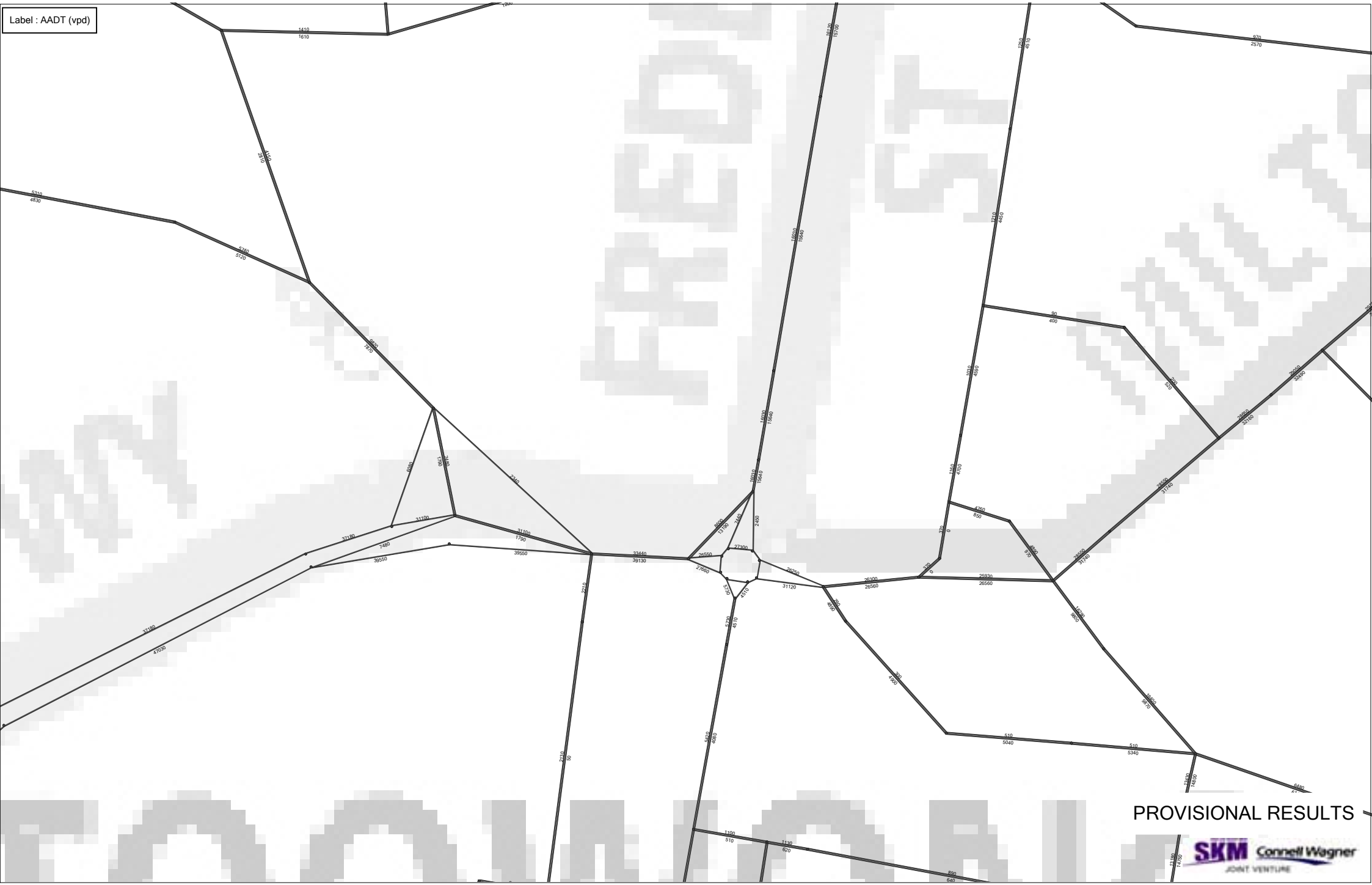
NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 13:50 (082249)

NL EIS : 2014 18 Hour component of AADT, Without Northern Link (TR_2014_135)



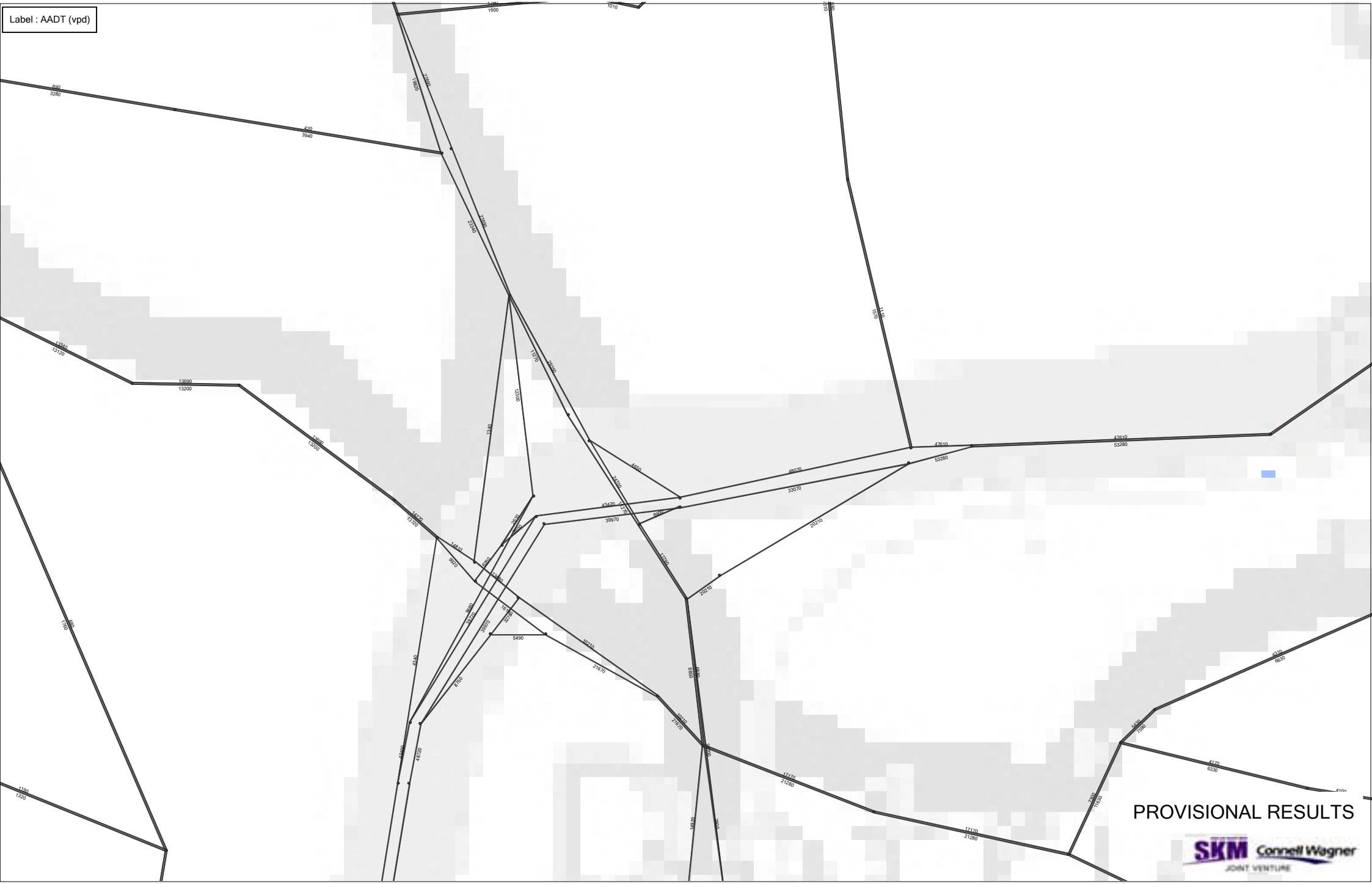
NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 13:50 (082249)

NL EIS : 2014 AADT Daily Traffic Volumes, Without Northern Link (TR_2014_ 135)



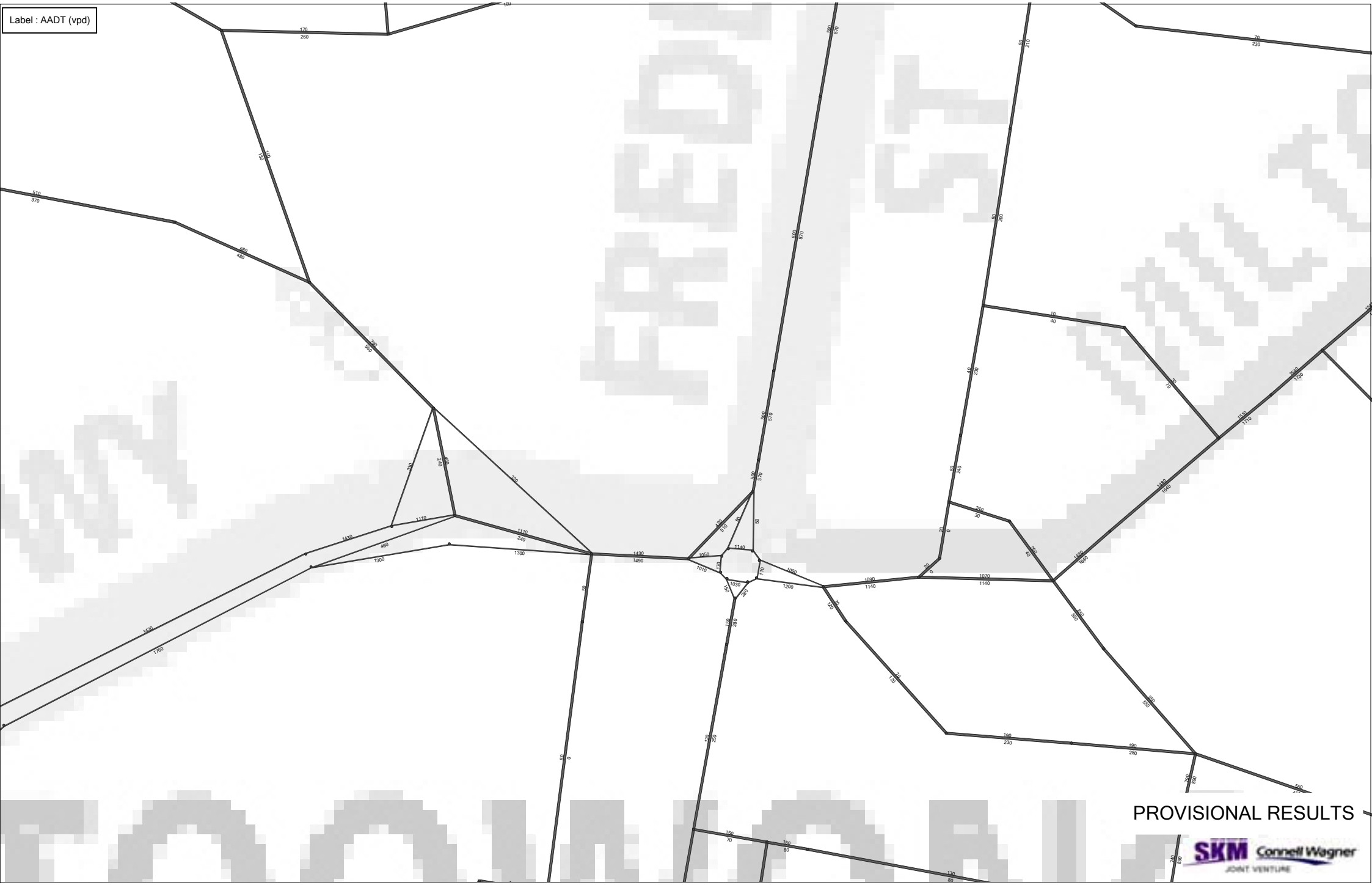
NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 09:51 (082249)

NL EIS : 2014 AADT Daily Traffic Volumes, Without Northern Link (TR_2014_ 135)



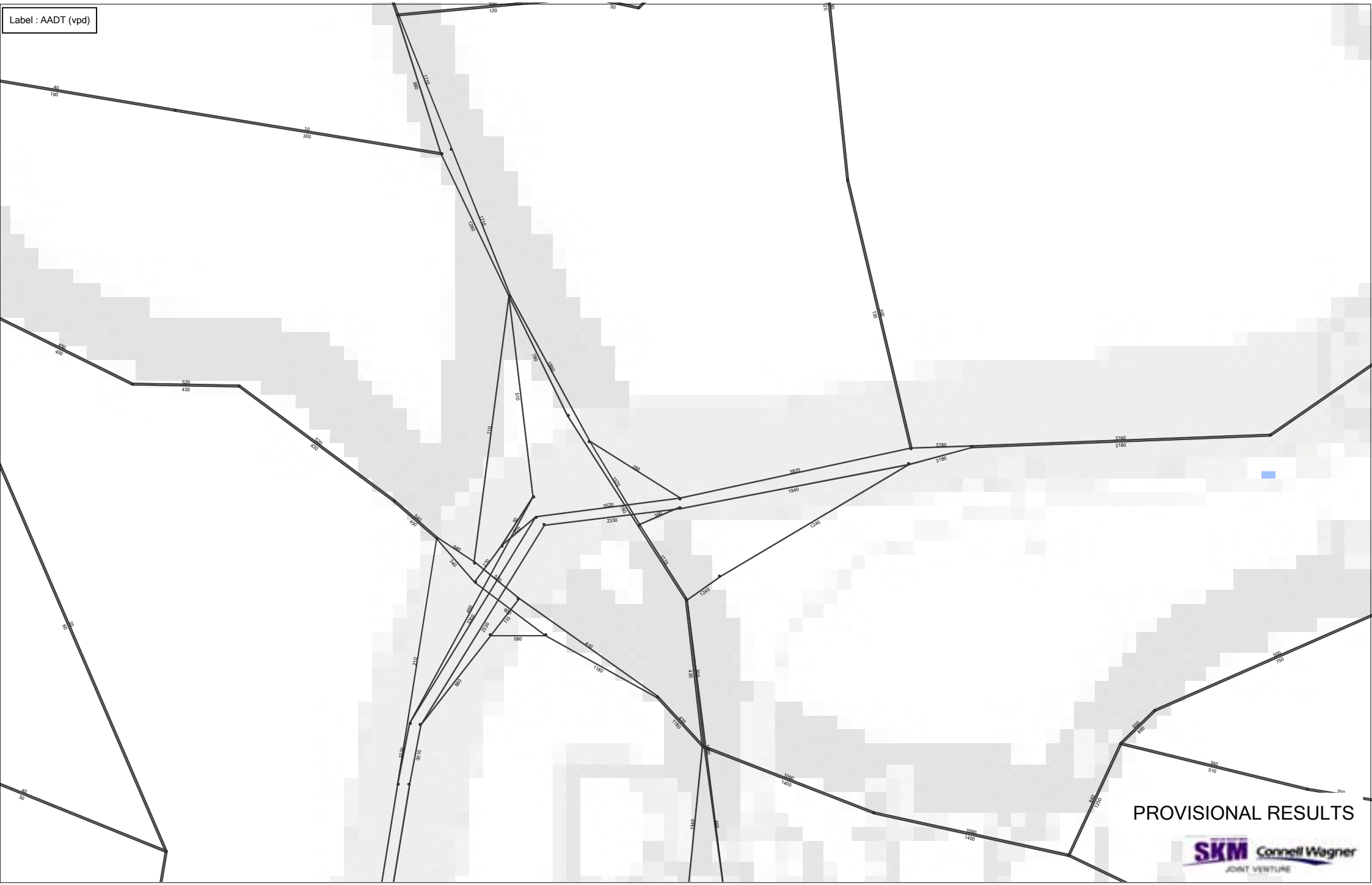
NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 09:51 (082249)

NL EIS : 2014 AADT Daily Heavy Vehicle Traffic Volumes, Without Northern Link (TR_2014_135)



NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 09:49 (082249)

NL EIS : 2014 AADT Daily Heavy Vehicle Traffic Volumes, Without Northern Link (TR_2014_135)

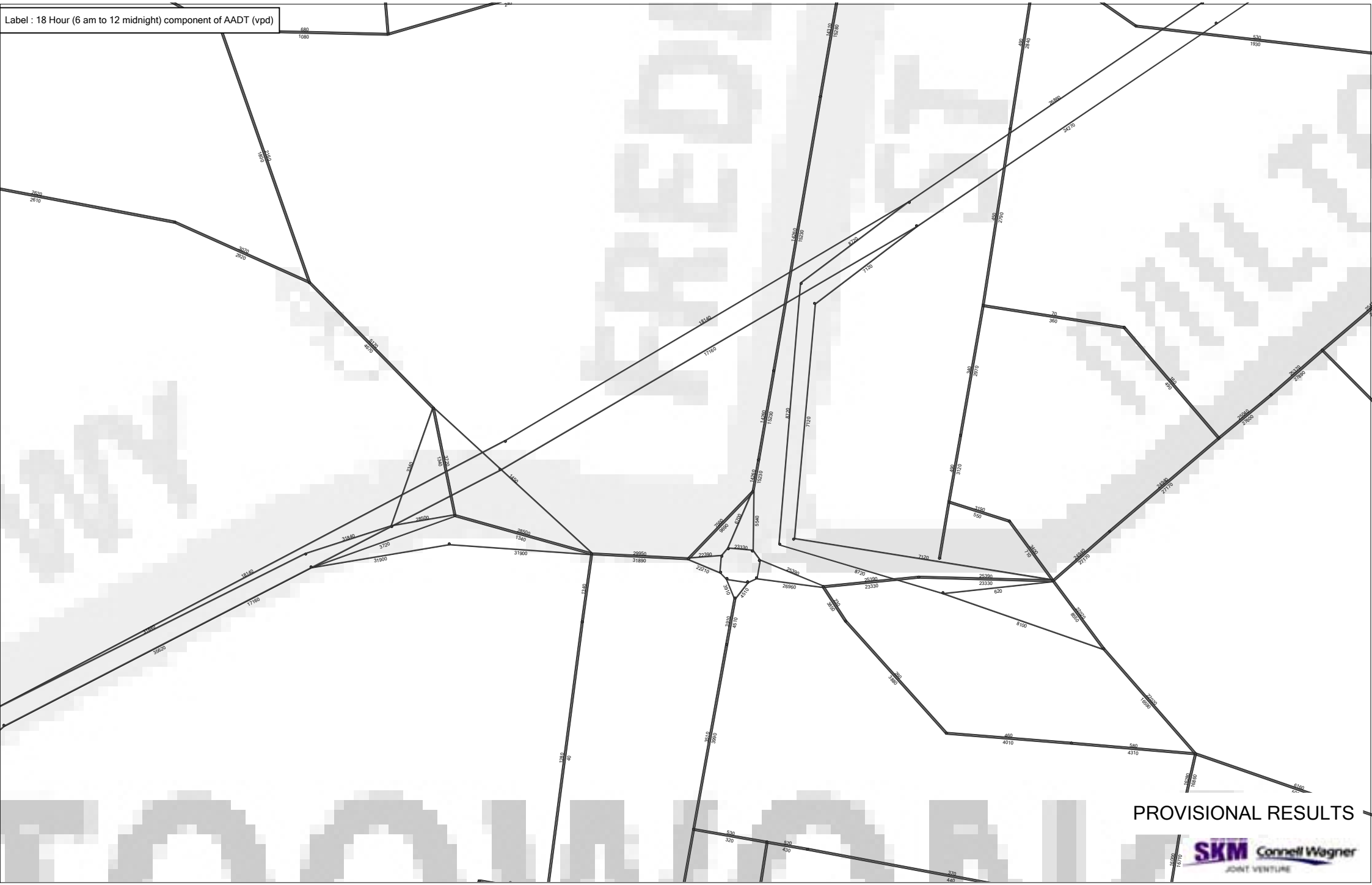


NORTHERN LINK MODEL
Scenario 51435: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 09:49 (082249)

Appendix E

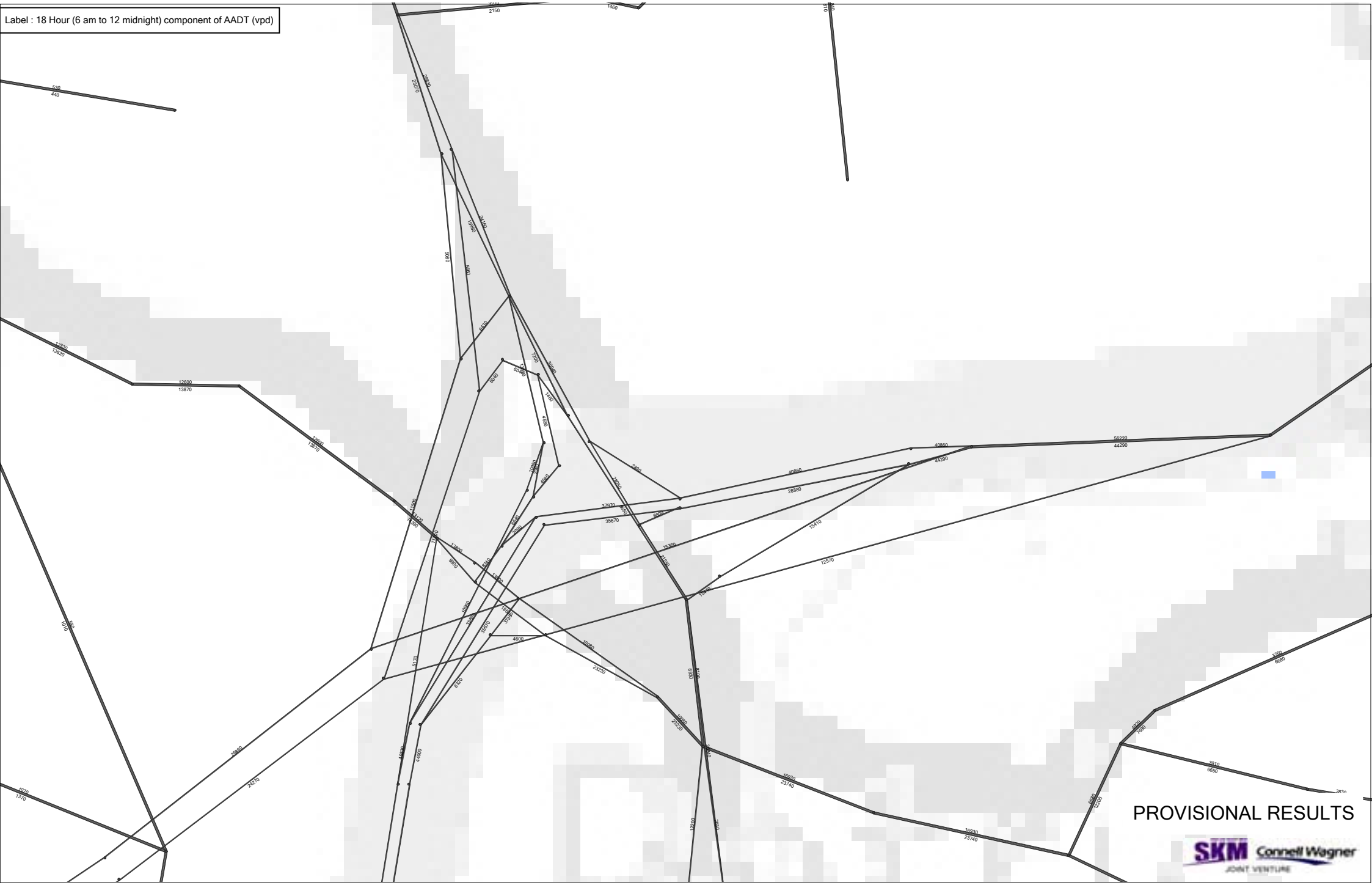
Report 20-1854R3

NL EIS : 2014 18 Hour component of AADT, With Northern Link (TR_2014_136)



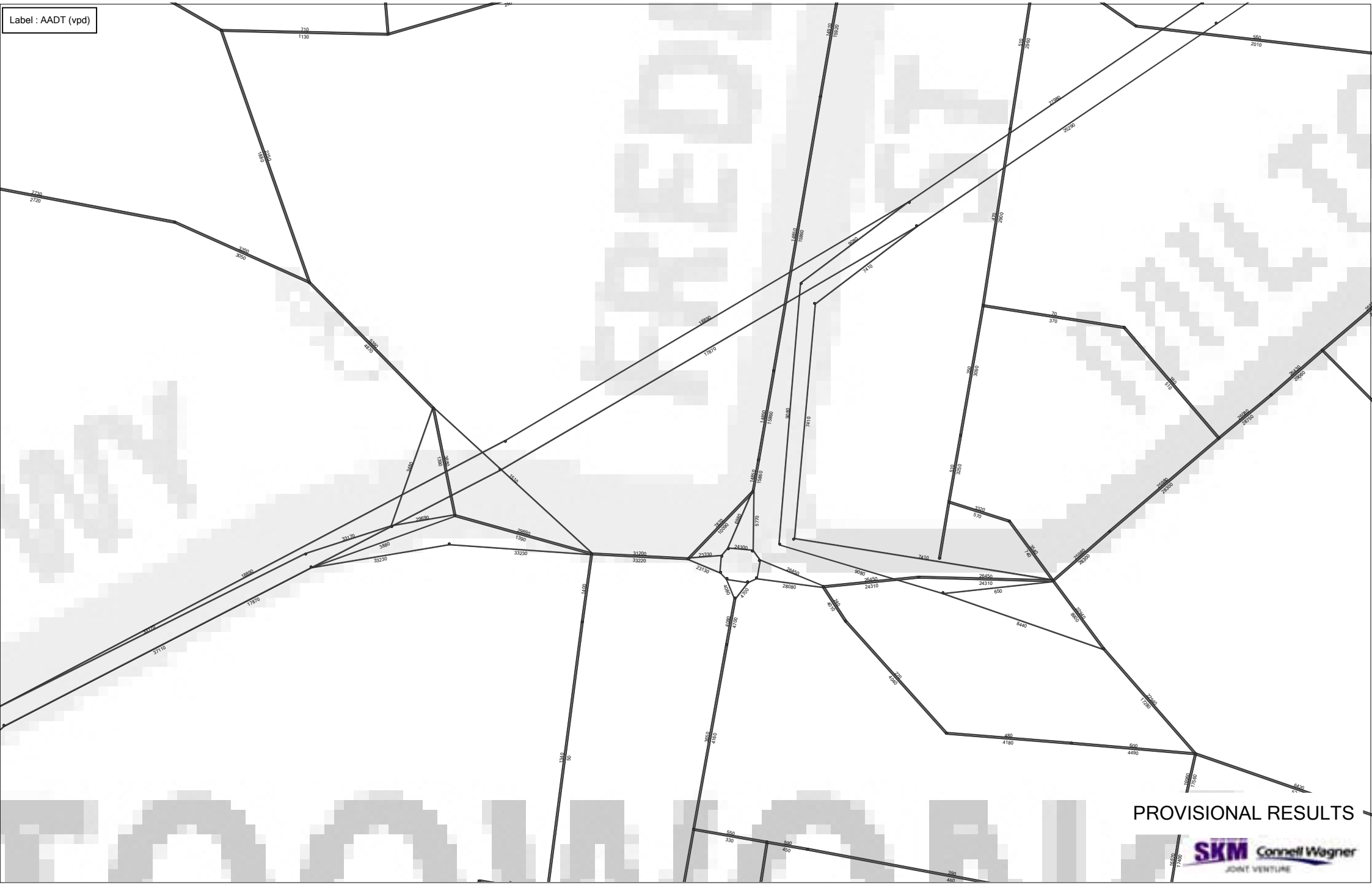
NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:18 (082249)

NL EIS : 2014 18 Hour component of AADT, With Northern Link (TR_2014_136)



NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:18 (082249)

NL EIS : 2014 AADT Daily Traffic Volumes, With Northern Link (TR_2014_136)

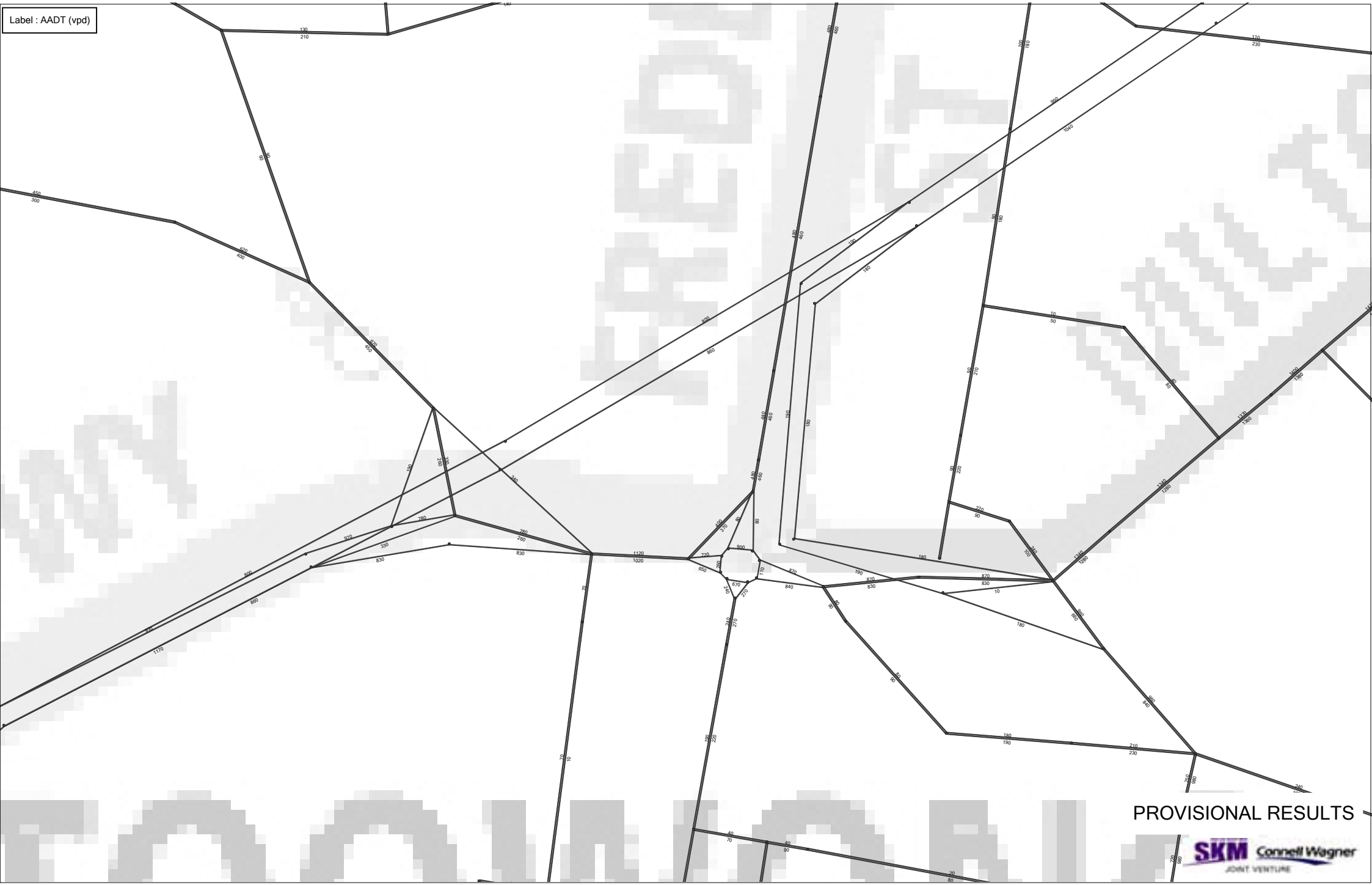


NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:20 (082249)

NL EIS : 2014 AADT Daily Traffic Volumes, With Northern Link (TR_2014_136)

NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:20 (082249)

NL EIS : 2014 AADT Daily Heavy Vehicle Traffic Volumes, With Northern Link (TR_2014_136)



NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:19 (082249)

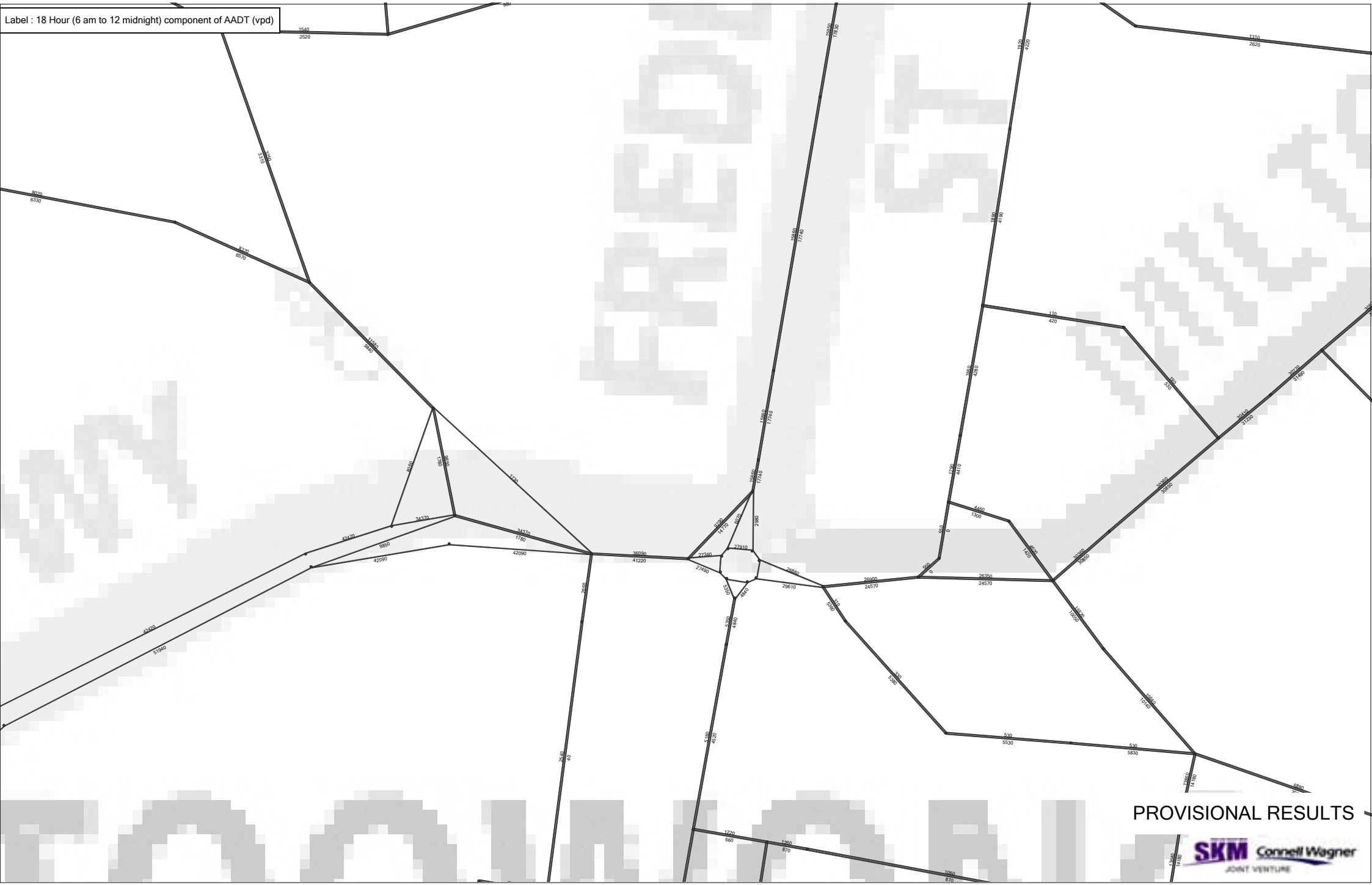
NL EIS : 2014 AADT Daily Heavy Vehicle Traffic Volumes, With Northern Link (TR_2014_136)

NORTHERN LINK MODEL
Scenario 51436: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-05-01 10:20 (082249)

Appendix F

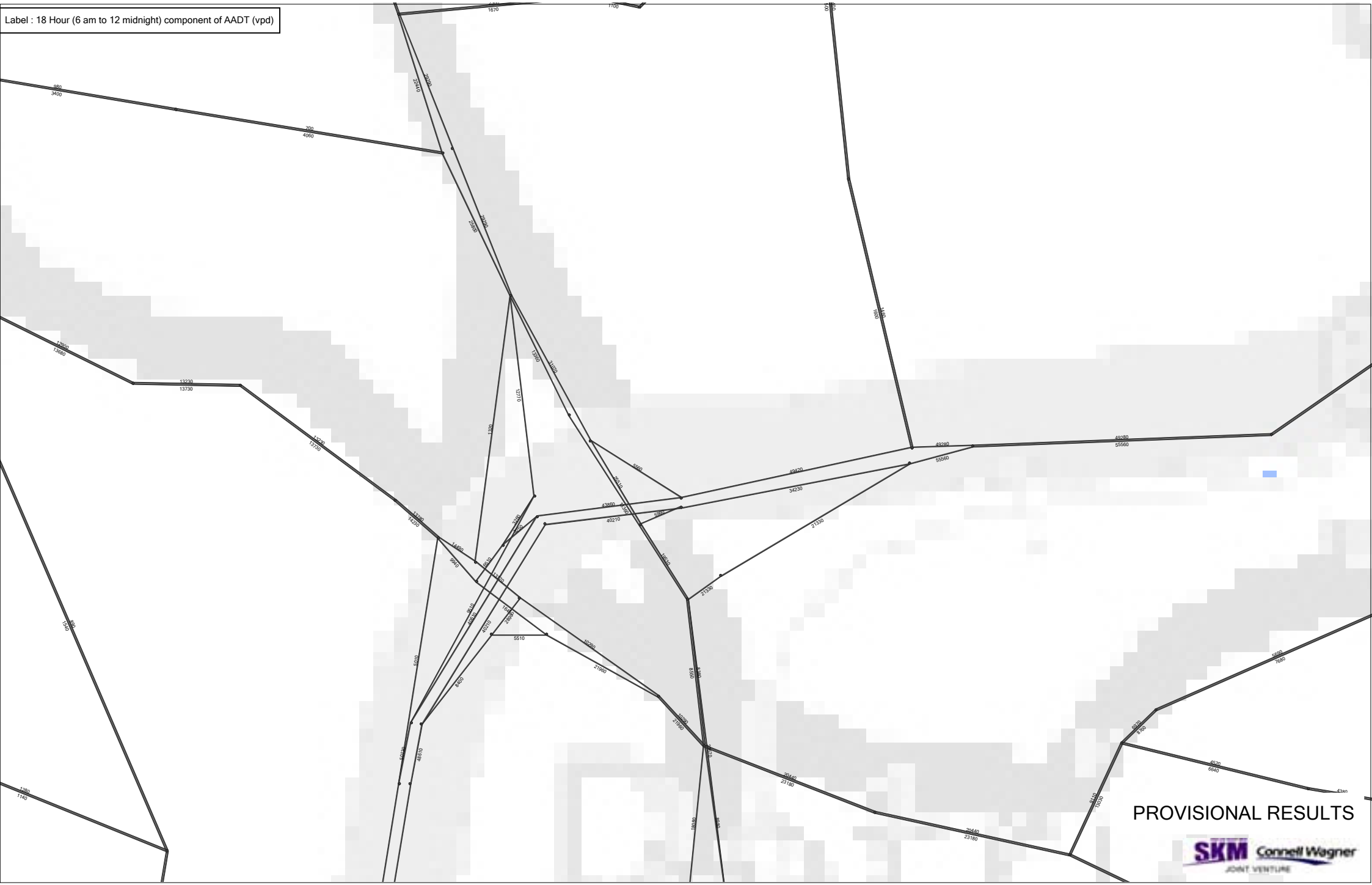
Report 20-1854R3

NL EIS : 2026 18 Hour component of AADT, Without Northern Link (TR_2026_135)



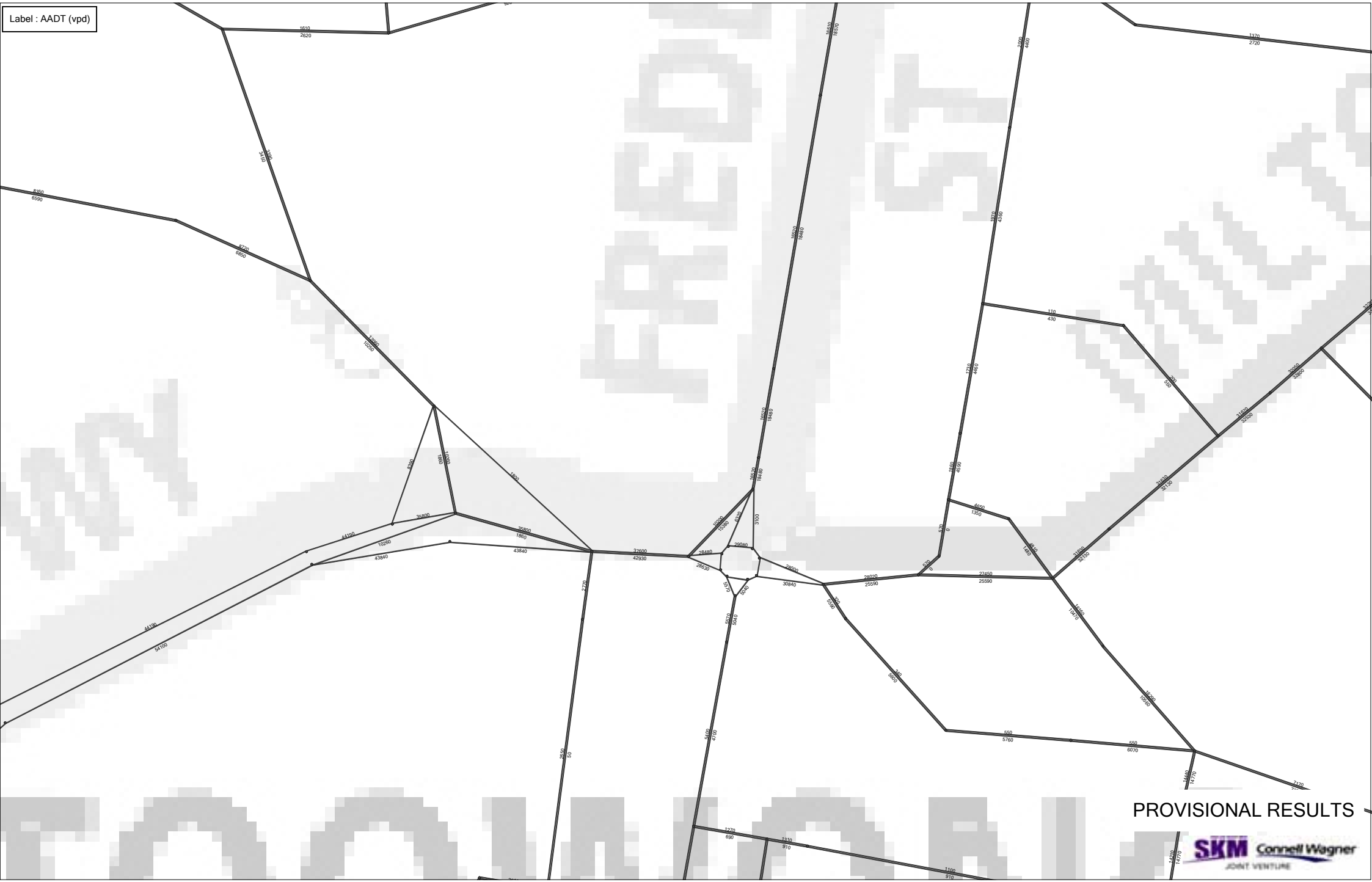
NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:28 (MIPOC12)

NL EIS : 2026 18 Hour component of AADT, Without Northern Link (TR_2026_135)



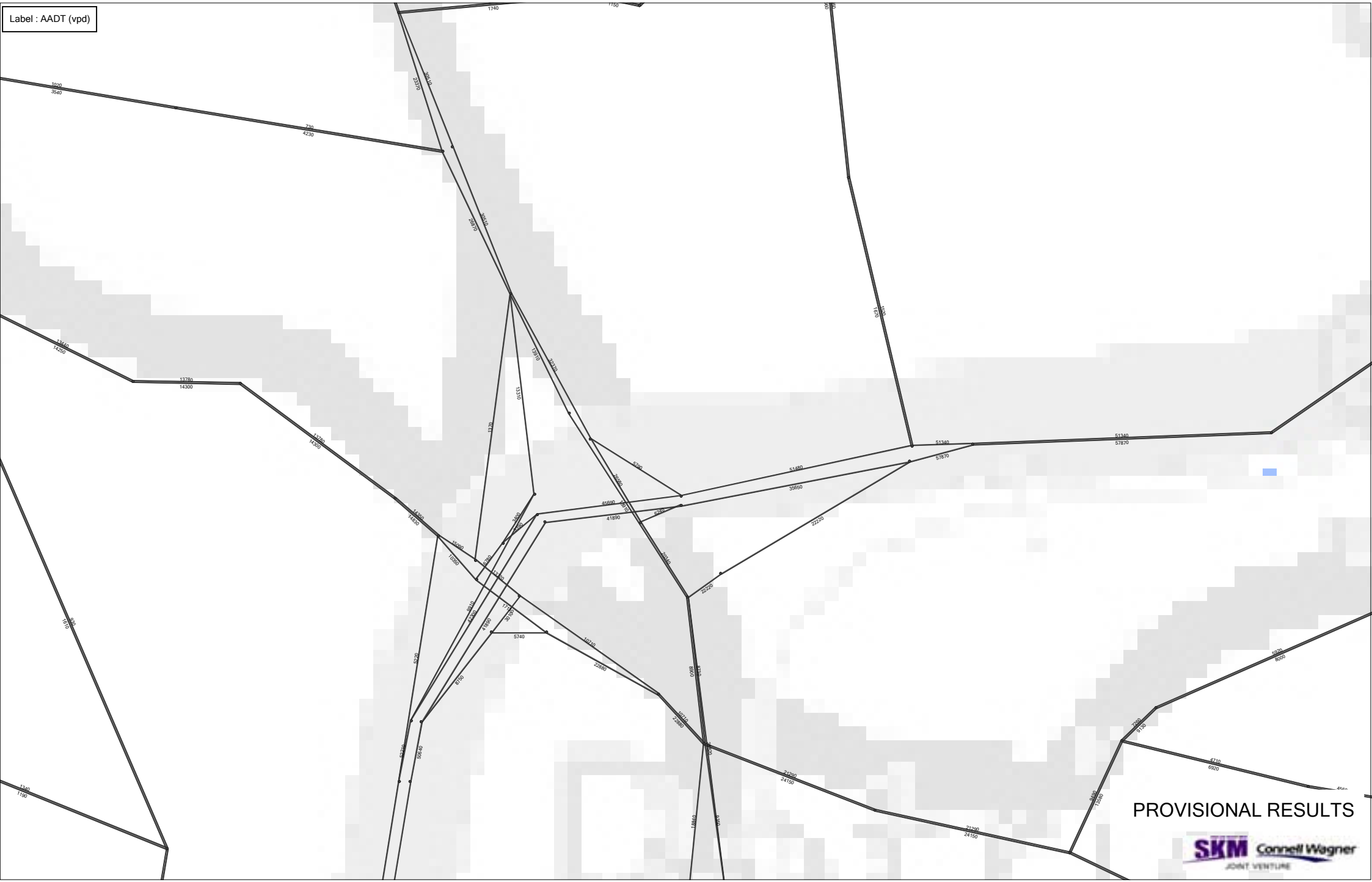
NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:28 (MIPOC12)

NL EIS : 2026 AADT Daily Traffic Volumes, Without Northern Link (TR_2026_135)



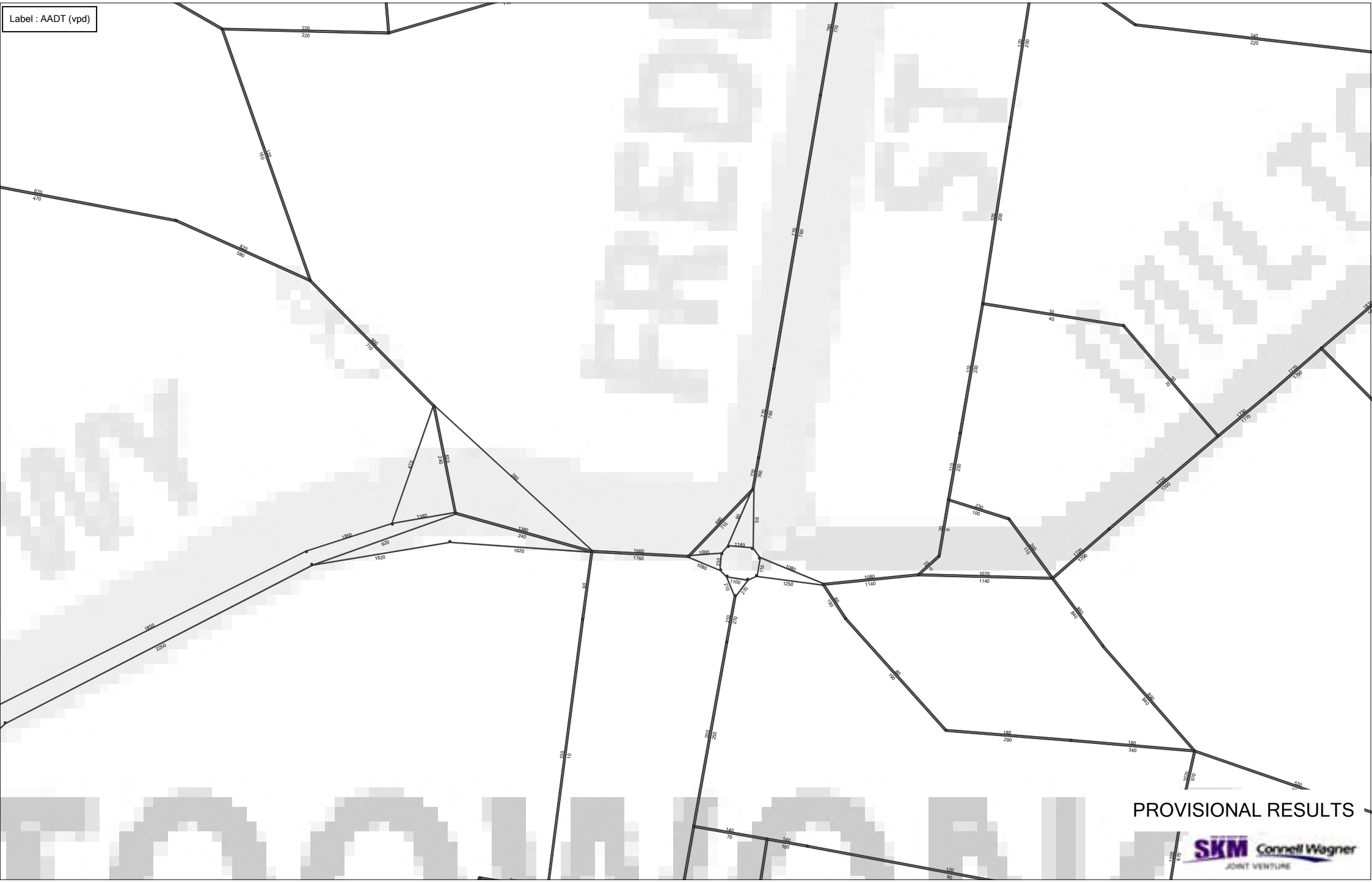
NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:32 (MIPOC12)

NL EIS : 2026 AADT Daily Traffic Volumes, Without Northern Link (TR_2026_ 135)



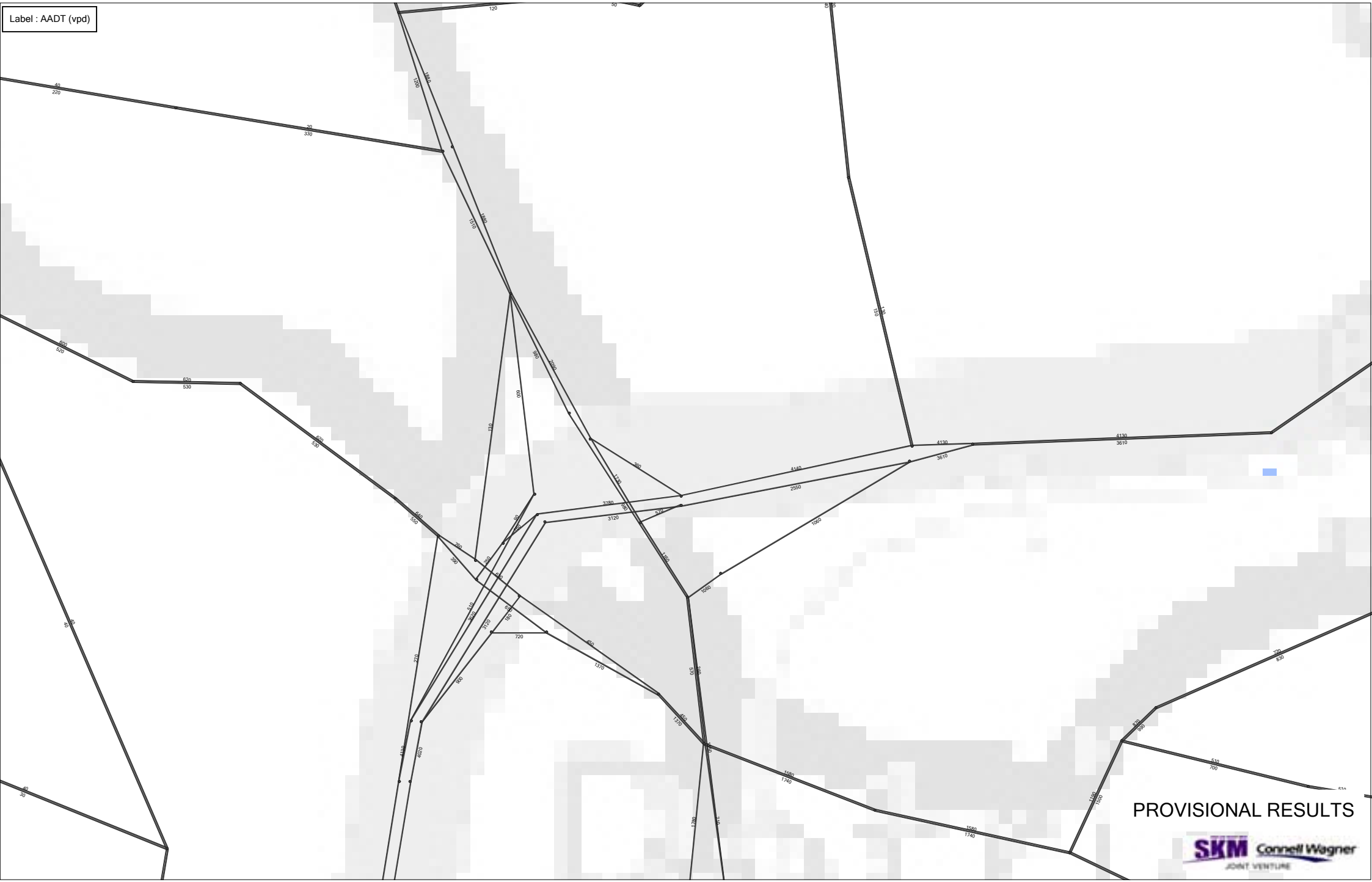
NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:32 (MIPOC12)

NL EIS : 2026 AADT Daily Heavy Vehicle Traffic Volumes, Without Northern Link (TR_2026_135)



NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:29 (MIPOC12)

NL EIS : 2026 AADT Daily Heavy Vehicle Traffic Volumes, Without Northern Link (TR_2026_135)

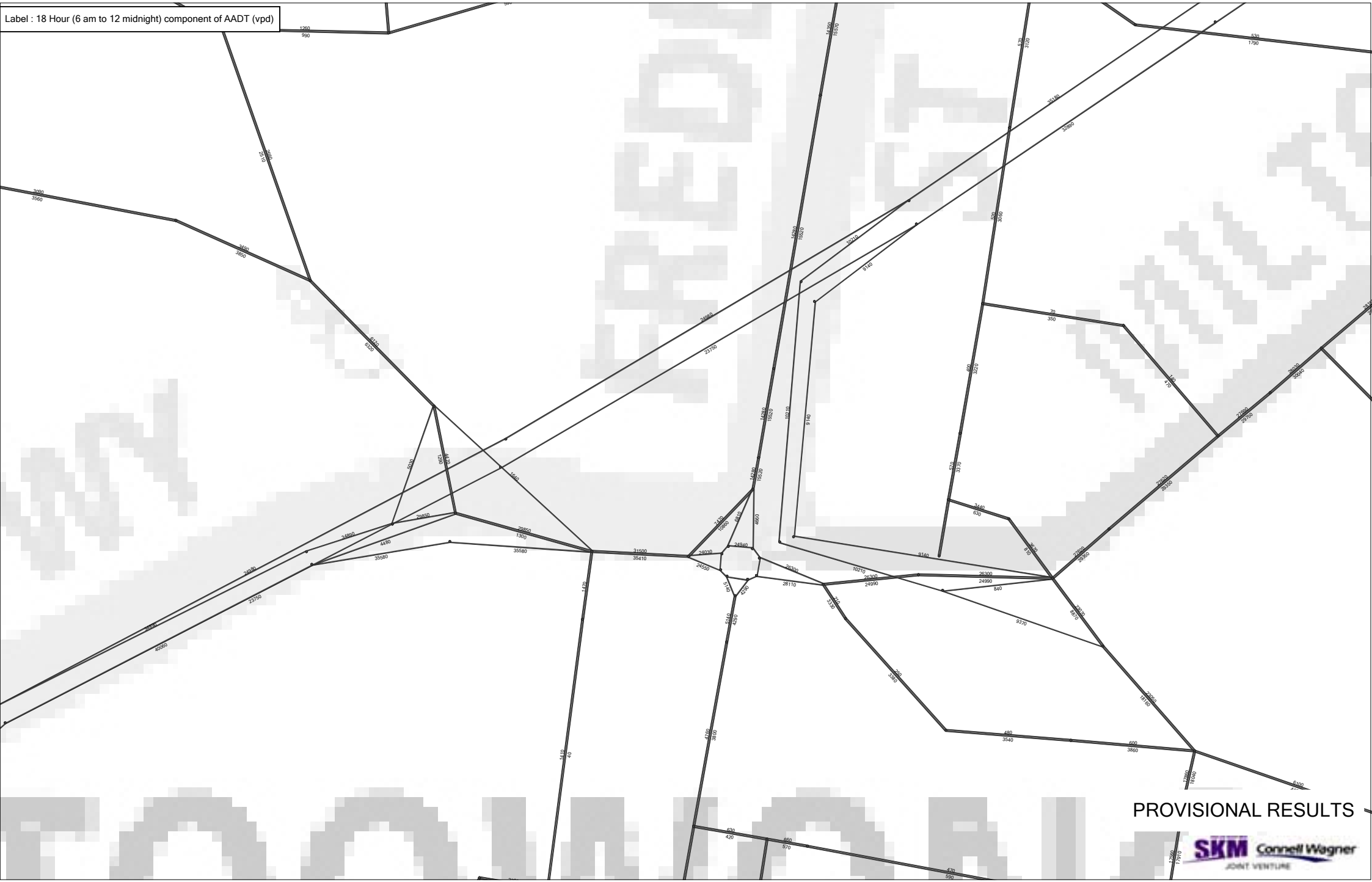


NORTHERN LINK MODEL
Scenario 52635: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 10:29 (MIPOC12)

Appendix G

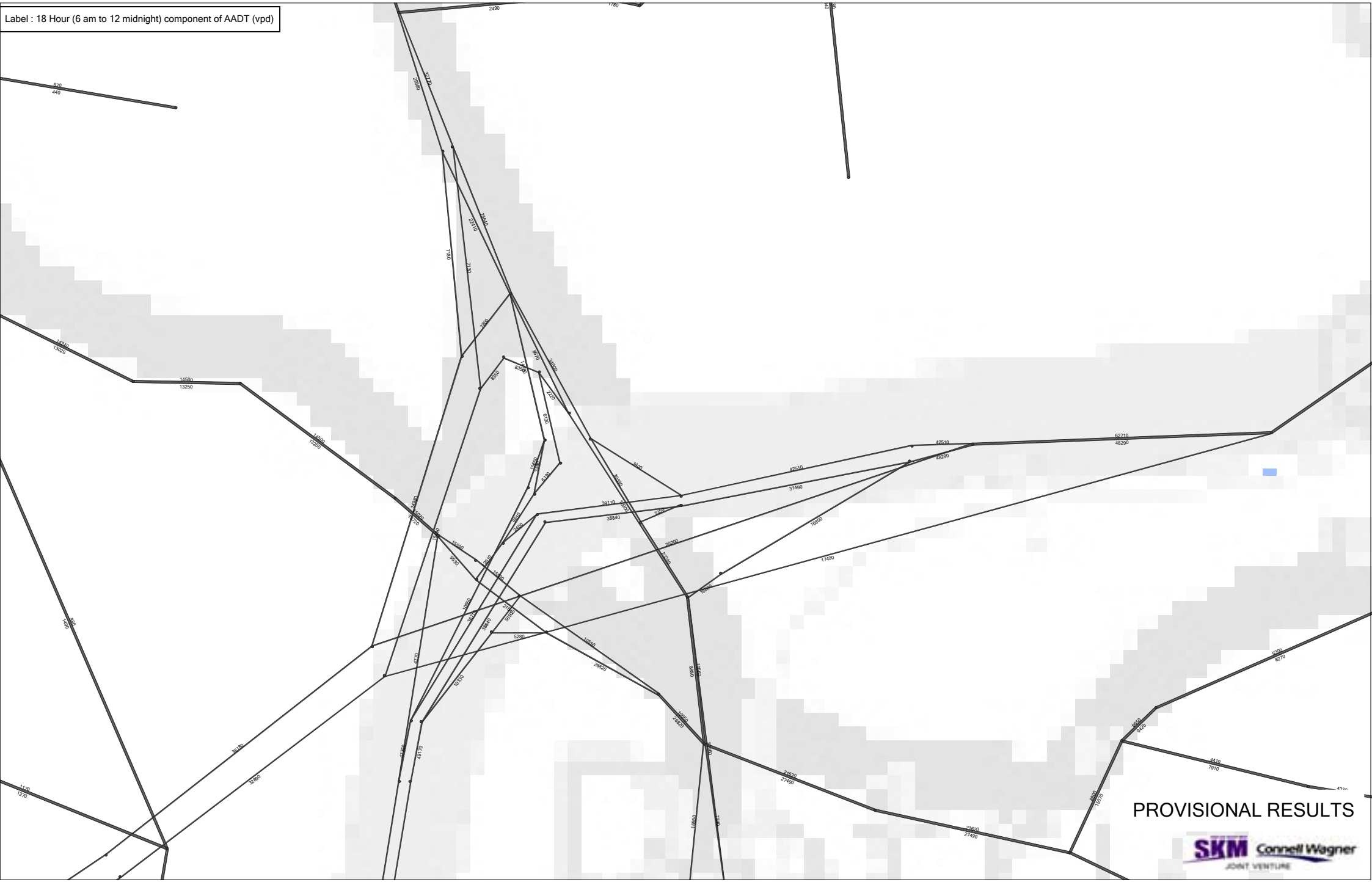
Report 20-1854R3

NL EIS : 2026 18 Hour component of AADT, With Northern Link (TR_2026_136)



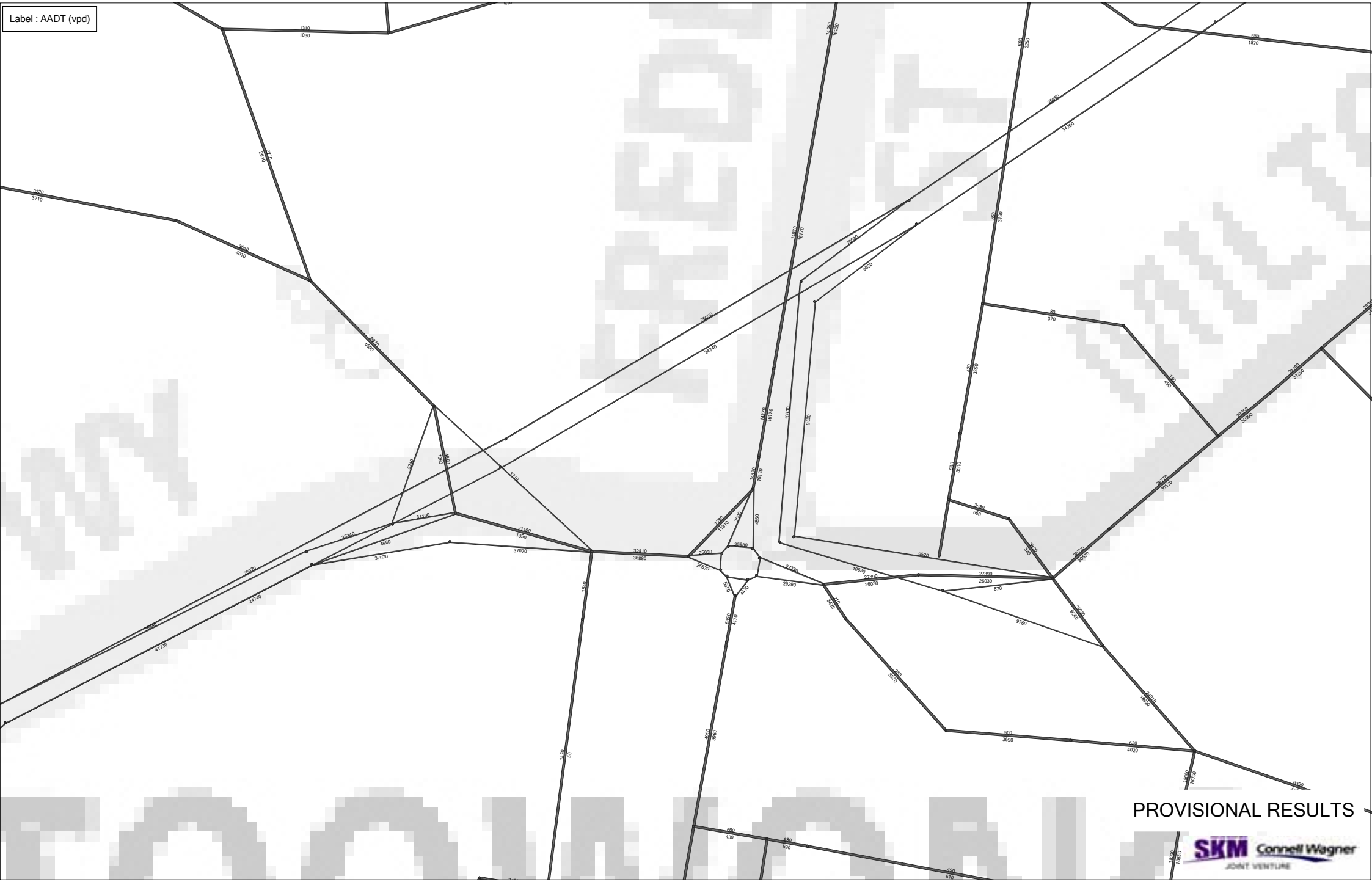
NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:54 (MIPOC12)

NL EIS : 2026 18 Hour component of AADT, With Northern Link (TR_2026_136)



NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:54 (MIPOC12)

NL EIS : 2026 AADT Daily Traffic Volumes, With Northern Link (TR_2026_136)

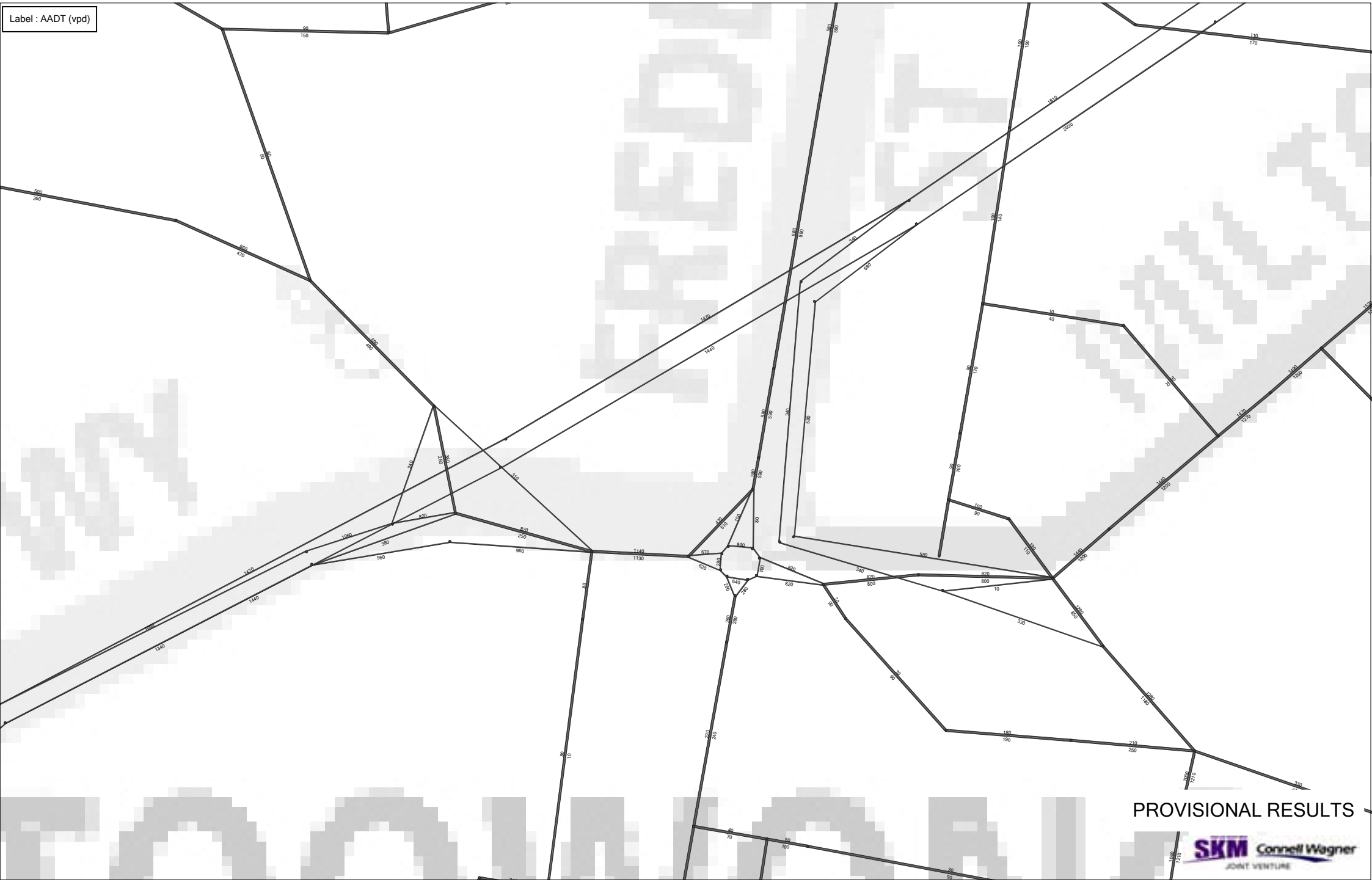


NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:56 (MIPOC12)

NL EIS : 2026 AADT Daily Traffic Volumes, With Northern Link (TR_2026_136)

NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:56 (MIPOC12)

NL EIS : 2026 AADT Daily Heavy Vehicle Traffic Volumes, With Northern Link (TR_2026_136)



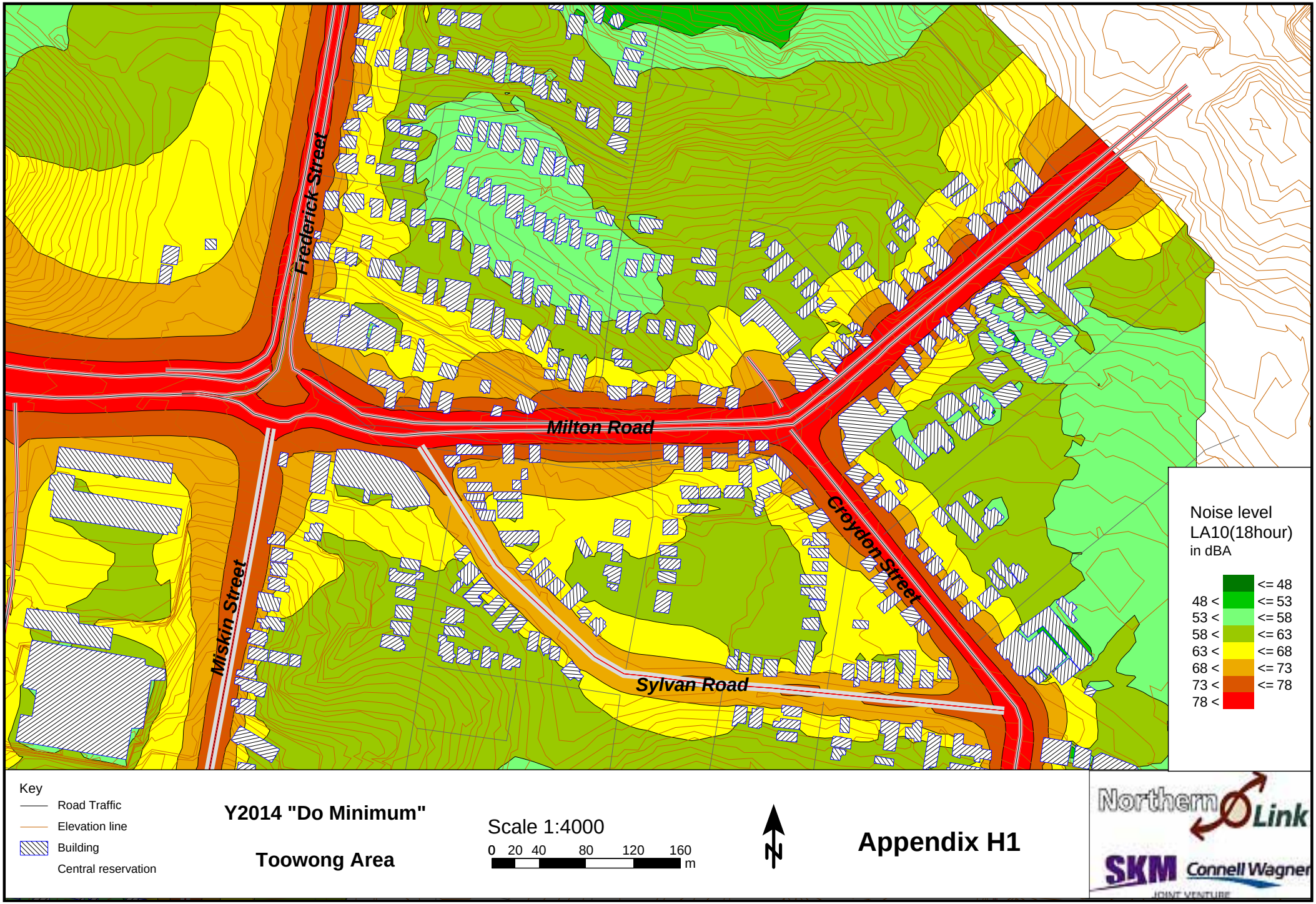
NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:55 (MIPOC12)

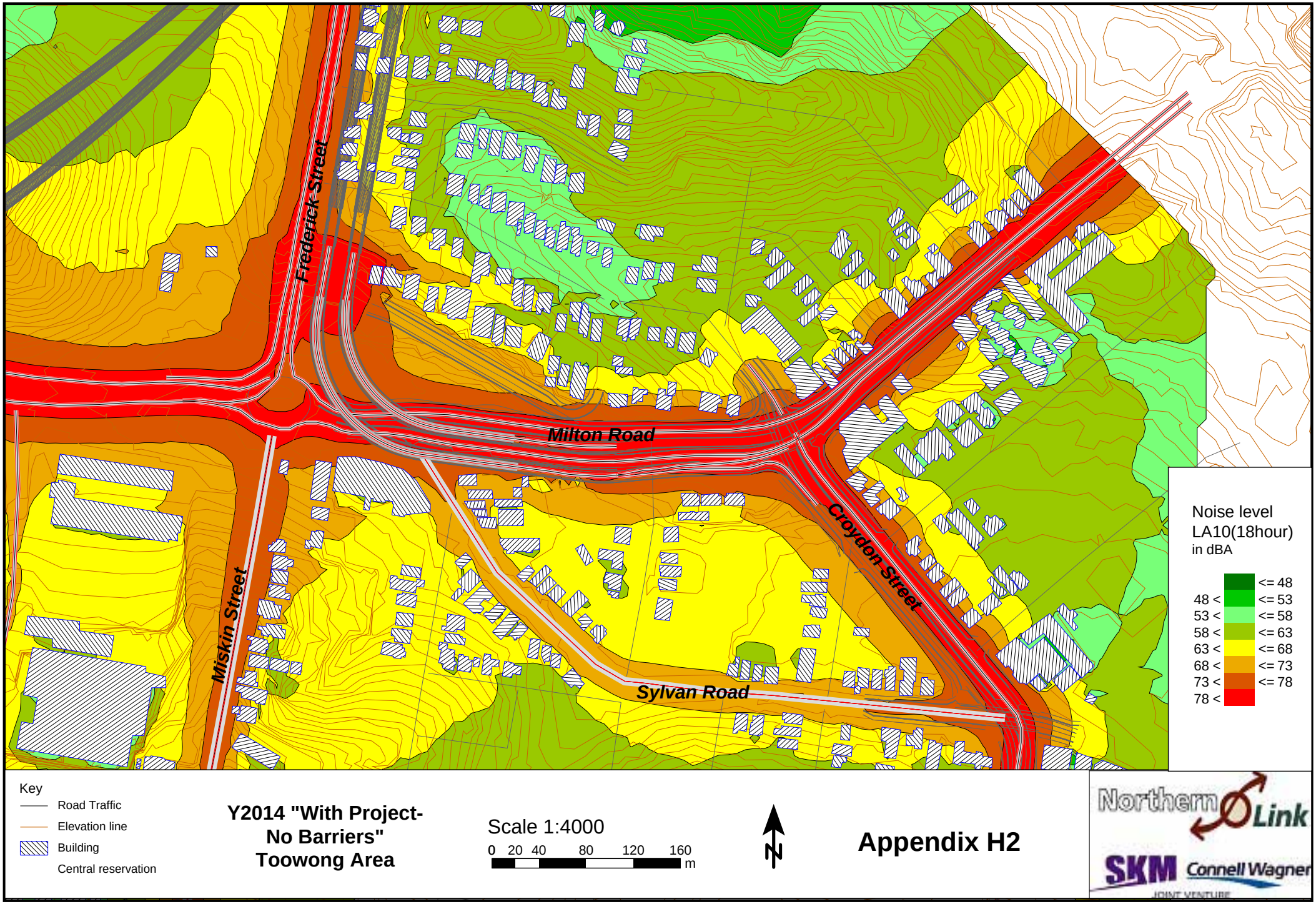
NL EIS : 2026 AADT Daily Heavy Vehicle Traffic Volumes, With Northern Link (TR_2026_136)

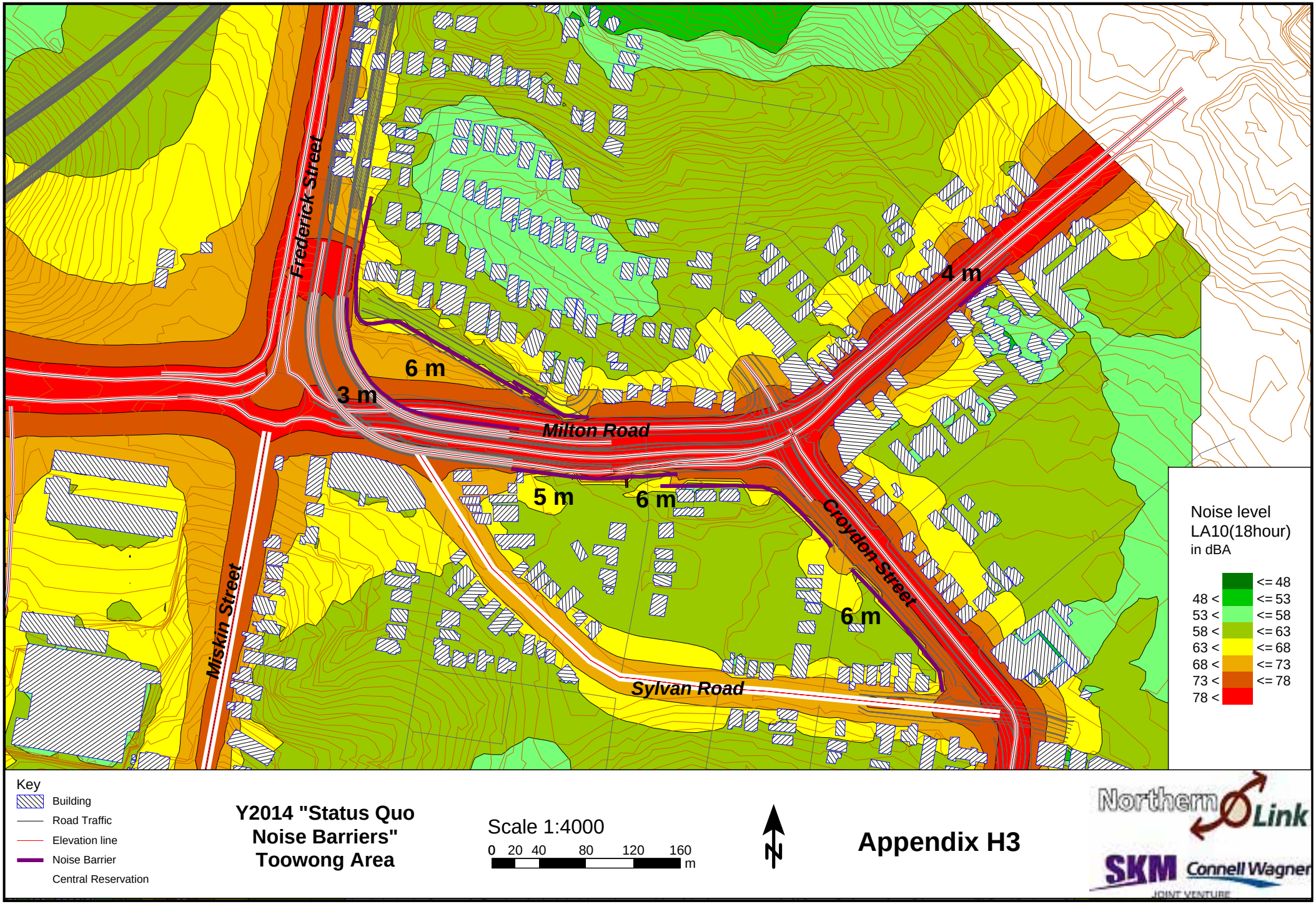
NORTHERN LINK MODEL
Scenario 52636: Derived Scenario - Total Daily (24hr) Traffic Volumes
2008-04-23 11:55 (MIPOC12)

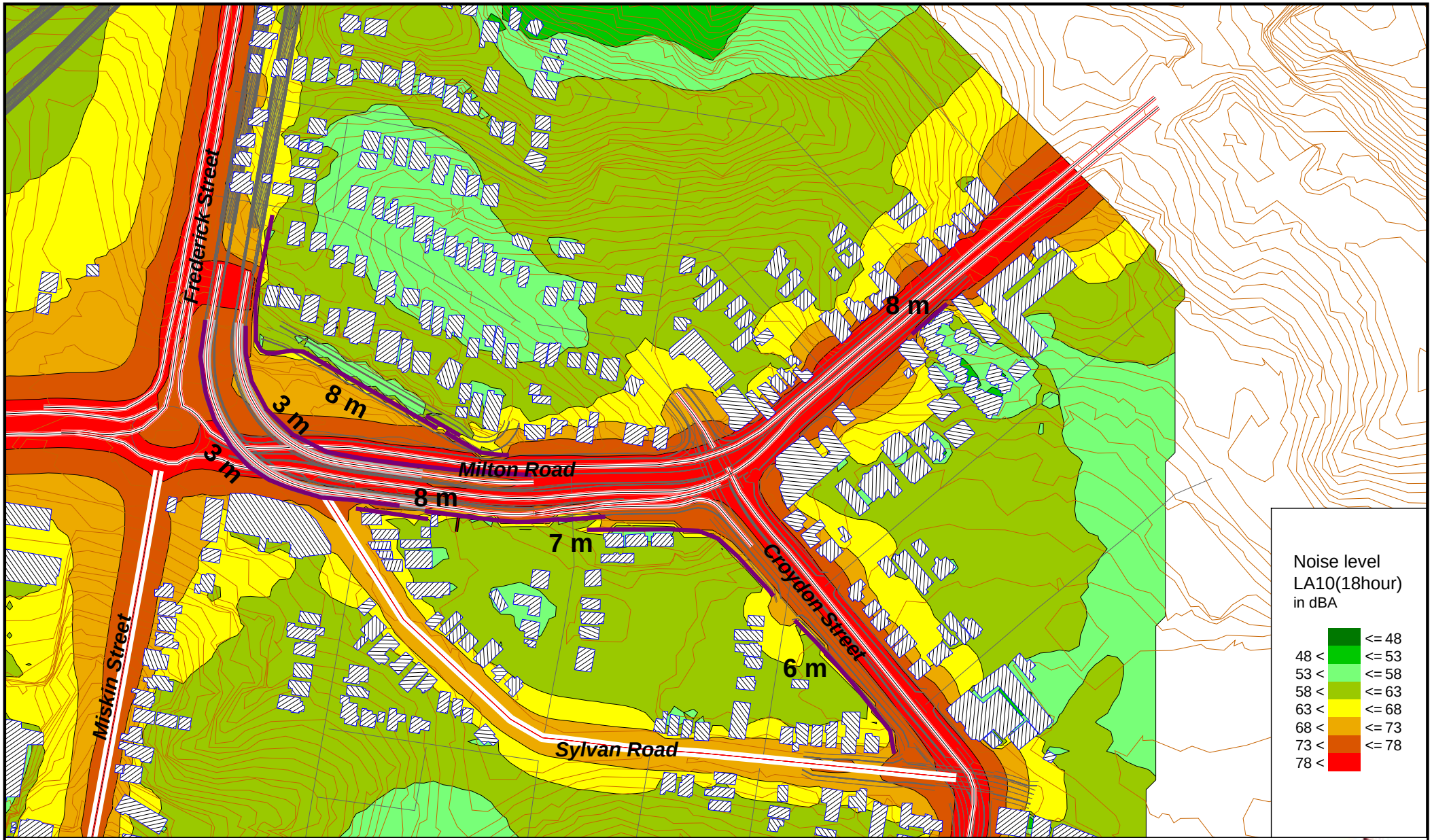
Appendix H

Report 20-1854R3


Frederick Street
Milton Road
Croydon Street
Miskin Street
Sylvan Road
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2014 "Do Minimum"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H1
Northern Link
SKM Connell Wagner
JOINT VENTURE


Frederick Street
Milton Road
Croydon Street
Miskin Street
Sylvan Road
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2014 "With Project-
No Barriers"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H2
Northern Link
SKM Connell Wagner
JOINT VENTURE


Frederick Street
Milton Road
Miskin Street
Croydon Street
Sylvan Road
6 m
3 m
4 m
5 m
6 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2014 "Status Quo
Noise Barriers"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H3
Northern Link
SKM Connell Wagner
JOINT VENTURE



Key

- Building
- Road Traffic
- Elevation line
- Noise Barrier
- Central Reservation

Y2014 "Planning Level Noise Barriers" Toowong Area

Scale 1:4000

0 20 40 80 120 160 m

N

Appendix H4

Northern Link

SKM Connell Wagner JOINT VENTURE


Frederick Street
Milton Road
Croydon Street
Miskin Street
Sylvan Road
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2026 "Do Minimum"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H5
Northern Link
SKM Connell Wagner
JOINT VENTURE

Key

- Road Traffic
- Elevation line
- Building
- Central reservation

Y2026 "With Project- No Barriers" Toowong Area

Scale 1:4000

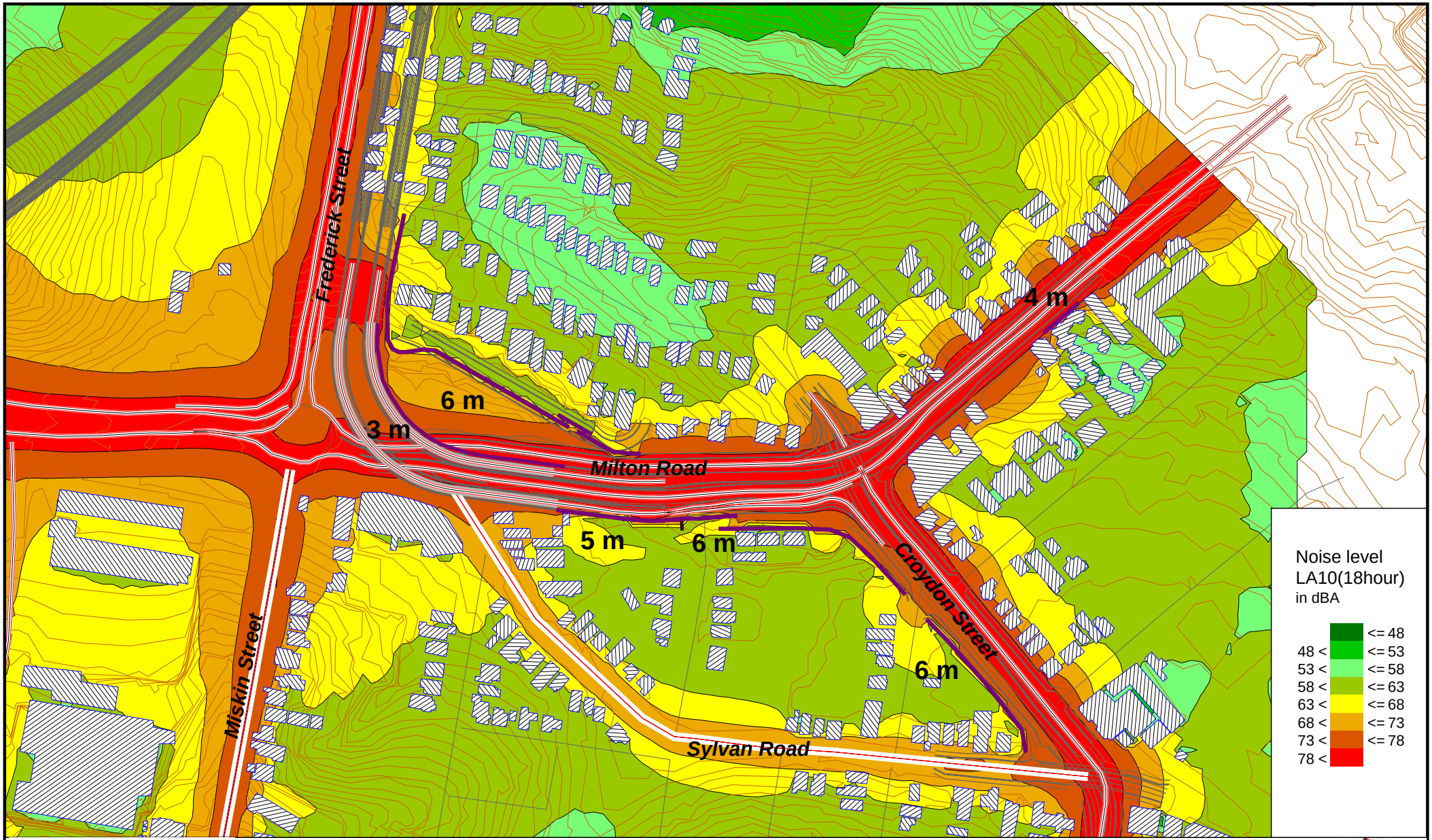
0 20 40 80 120 160 m

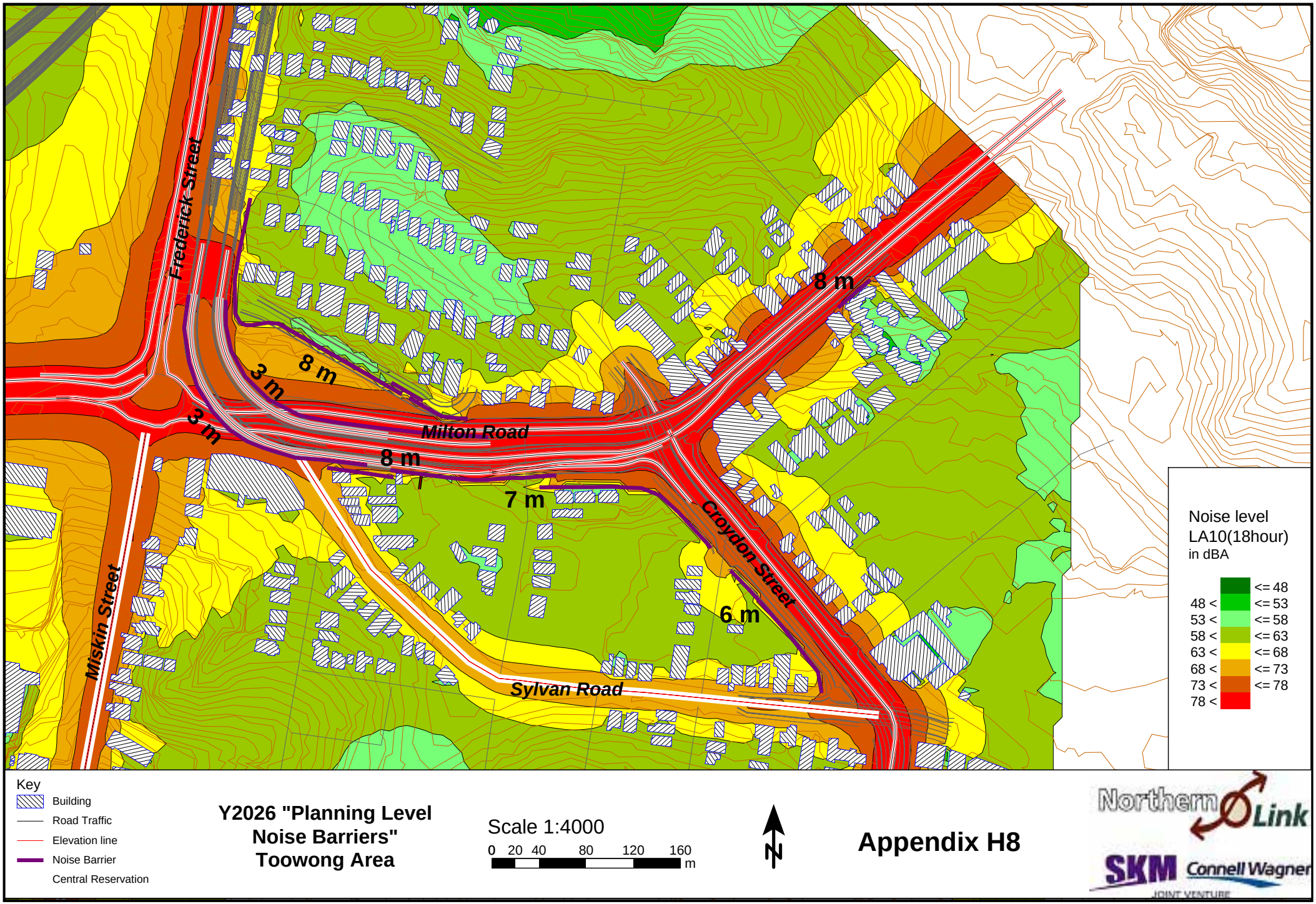
N

Appendix H6

Northern Link

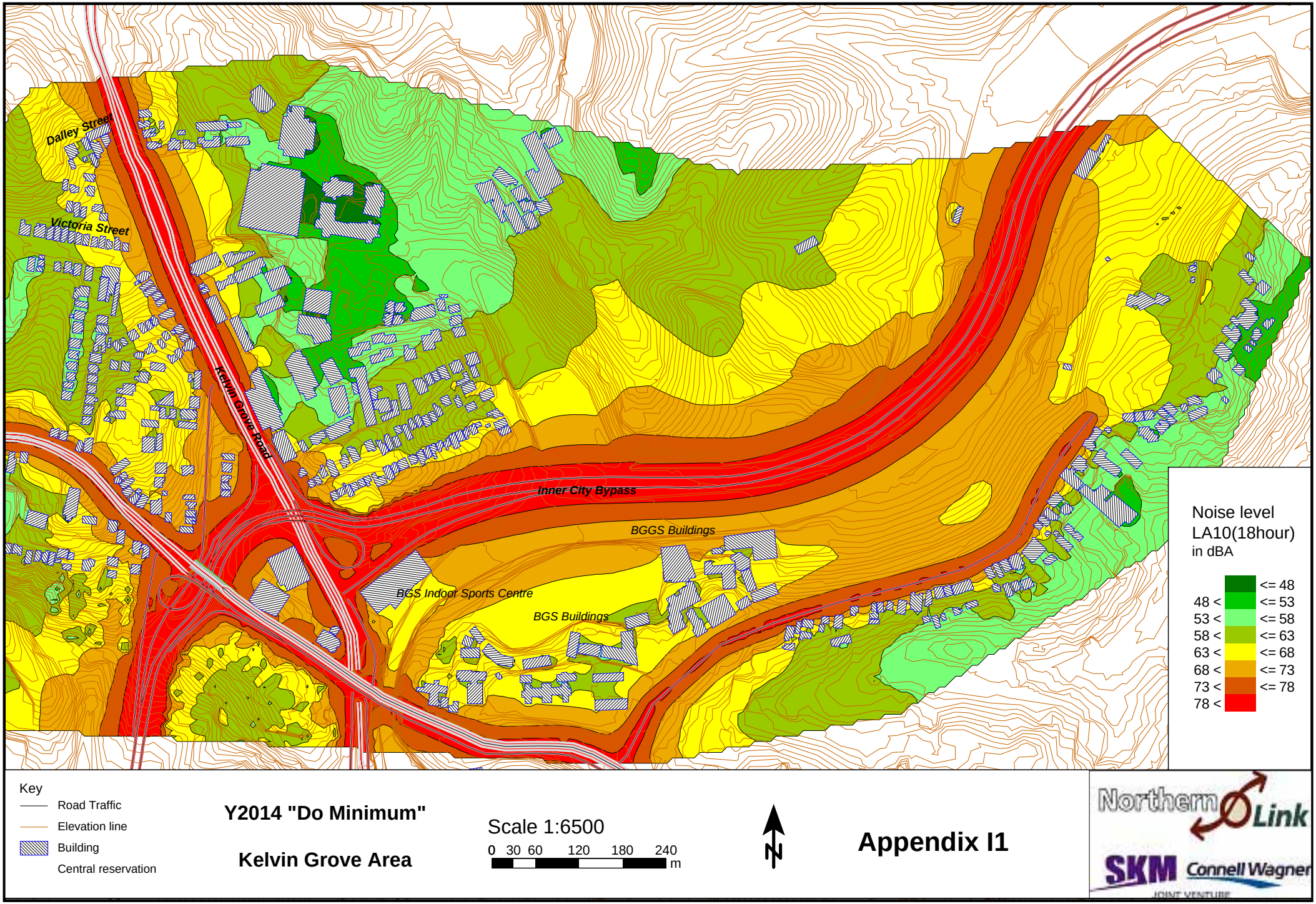
SKM Connell Wagner JOINT VENTURE

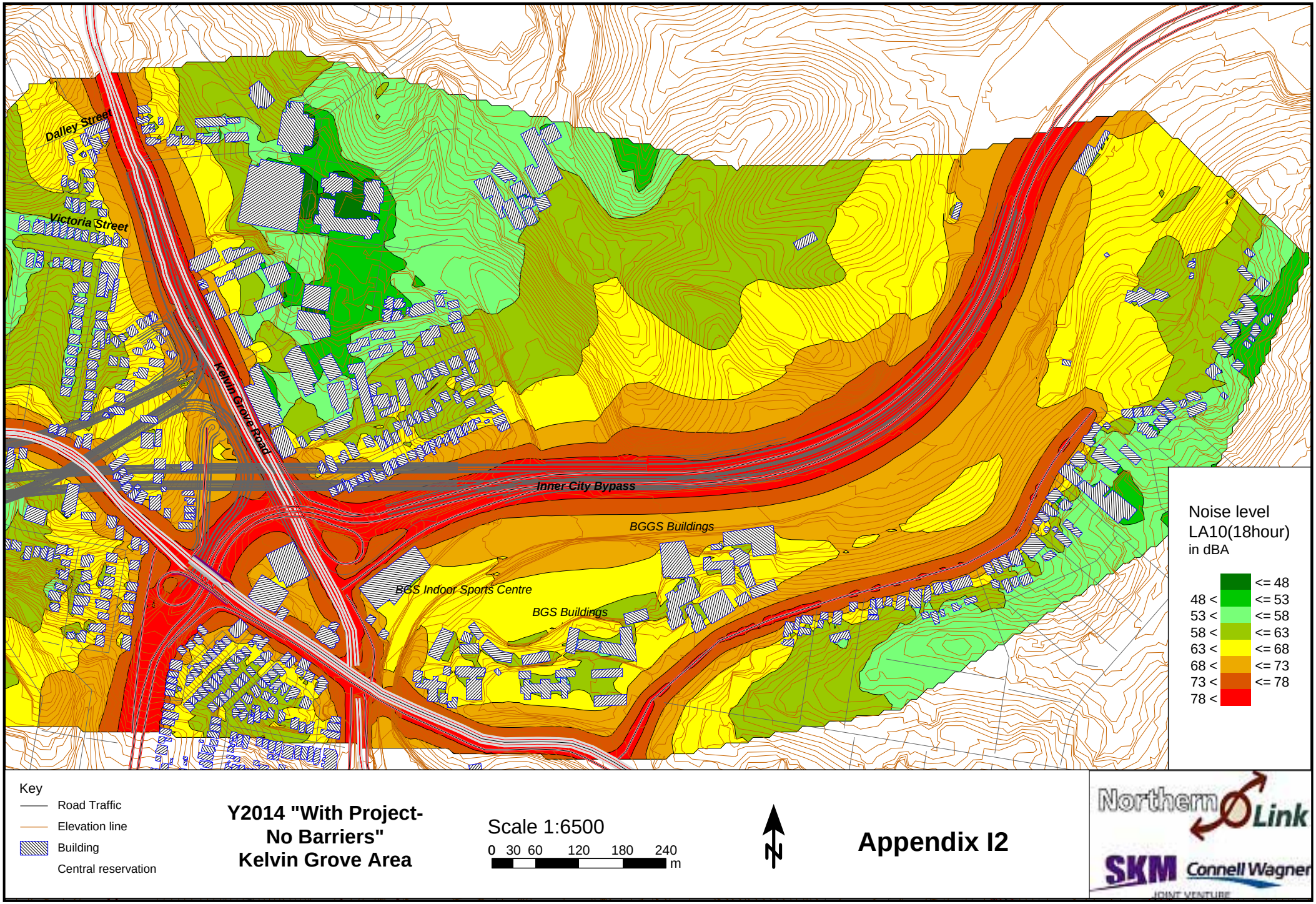

Frederick Street
Milton Road
Miskin Street
Croydon Street
Sylvan Road
3 m
6 m
4 m
5 m
6 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Noise Barrier
Central Reservation
Y2026 "Status Quo
Noise Barriers"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H7
Northern Link
SKM Connell Wagner
JOINT VENTURE

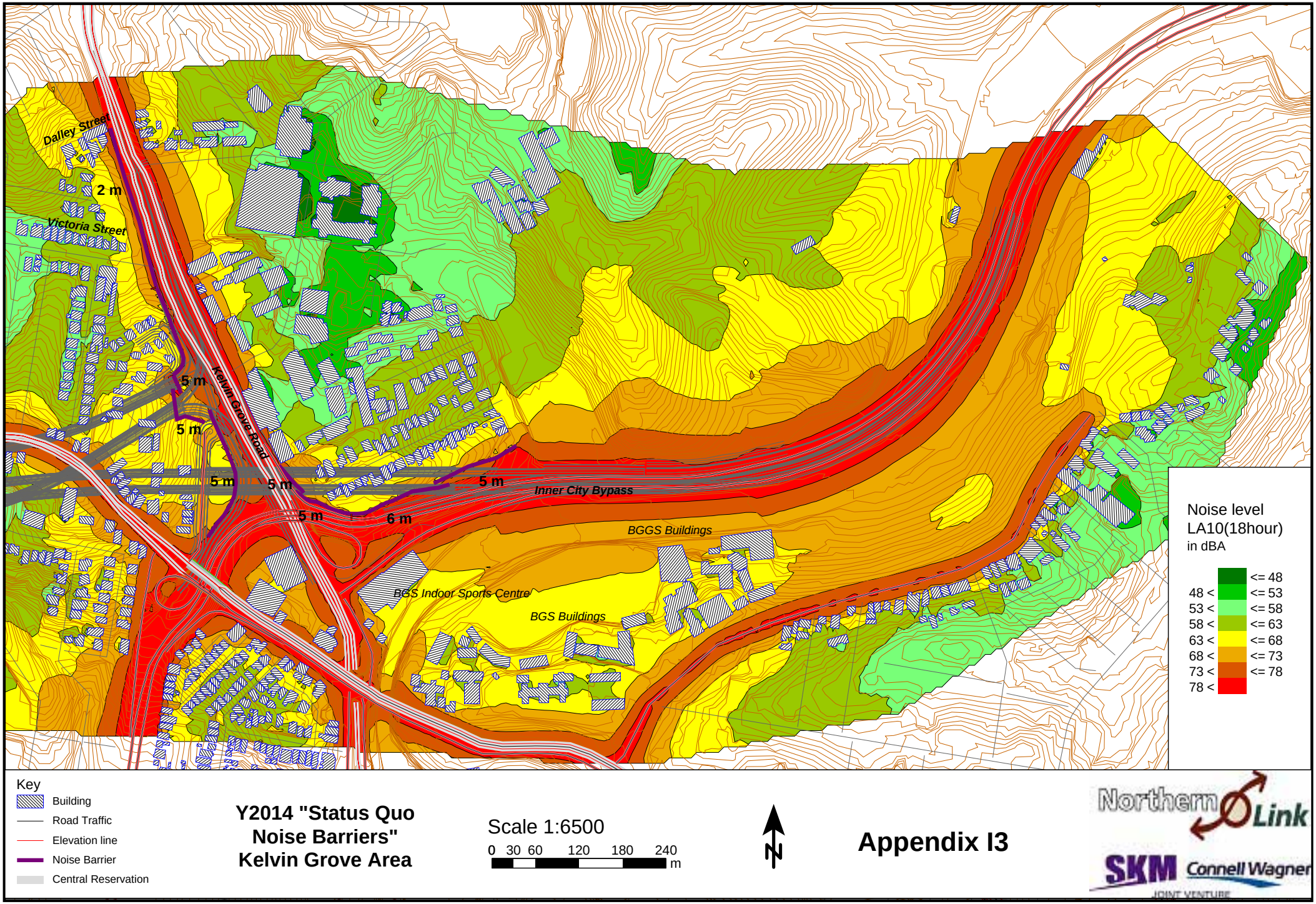

Frederick Street
Milton Road
Miskin Street
Croydon Street
Sylvan Road
8 m
3 m
8 m
3 m
8 m
7 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2026 "Planning Level
Noise Barriers"
Toowong Area
Scale 1:4000
0 20 40 80 120 160
m
N
Appendix H8
Northern Link
SKM Connell Wagner
JOINT VENTURE

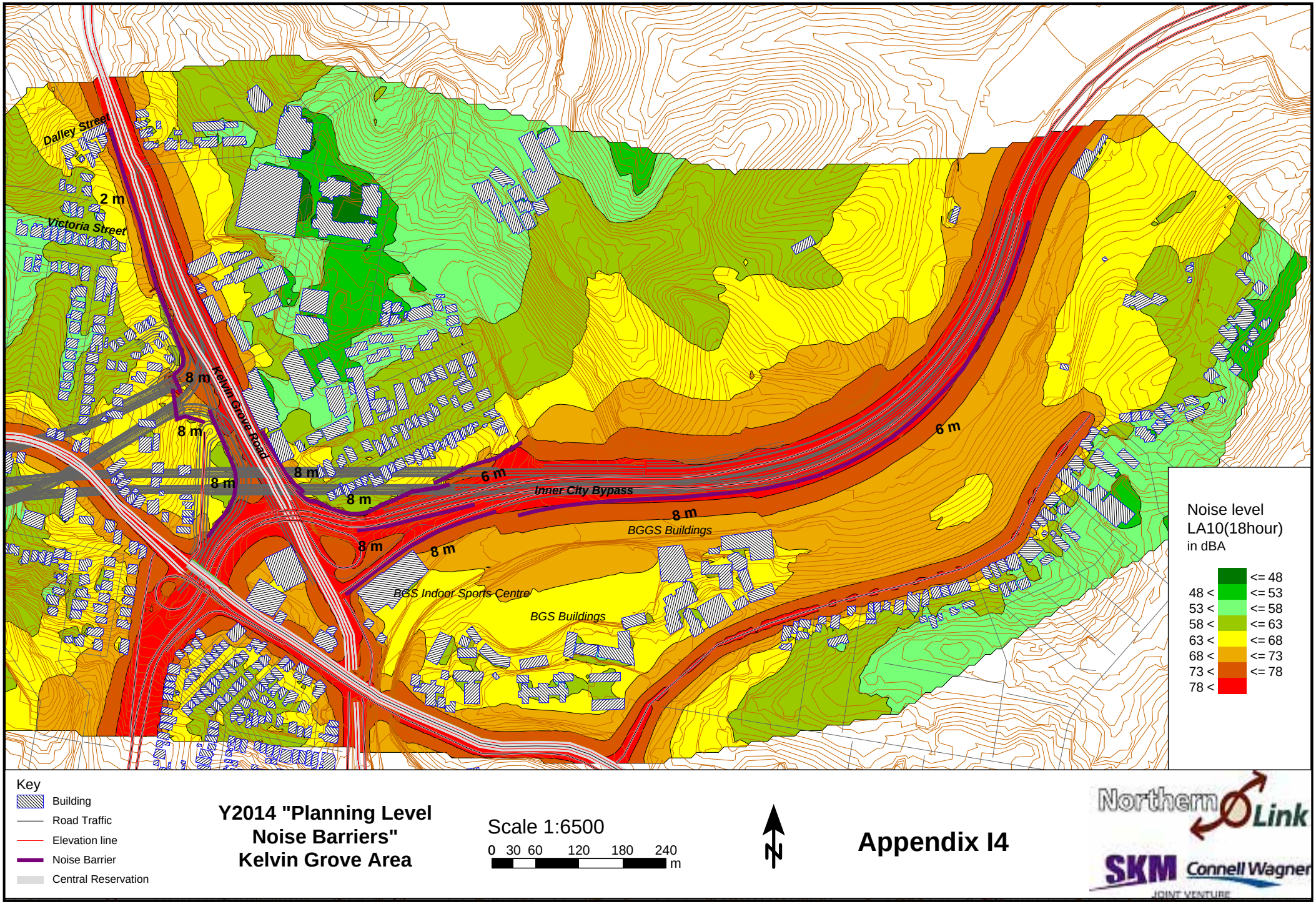
Appendix I

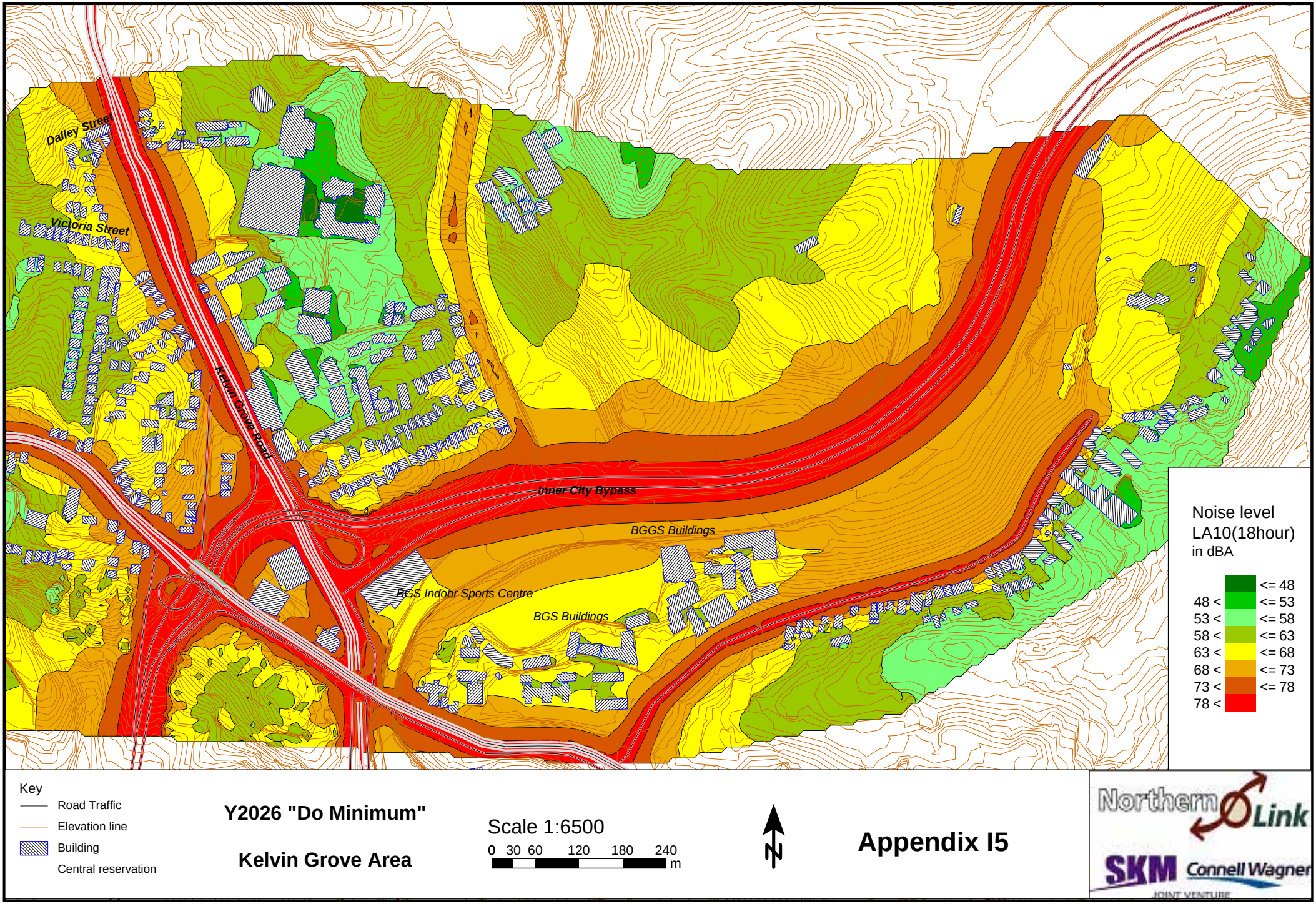
Report 20-1854R3

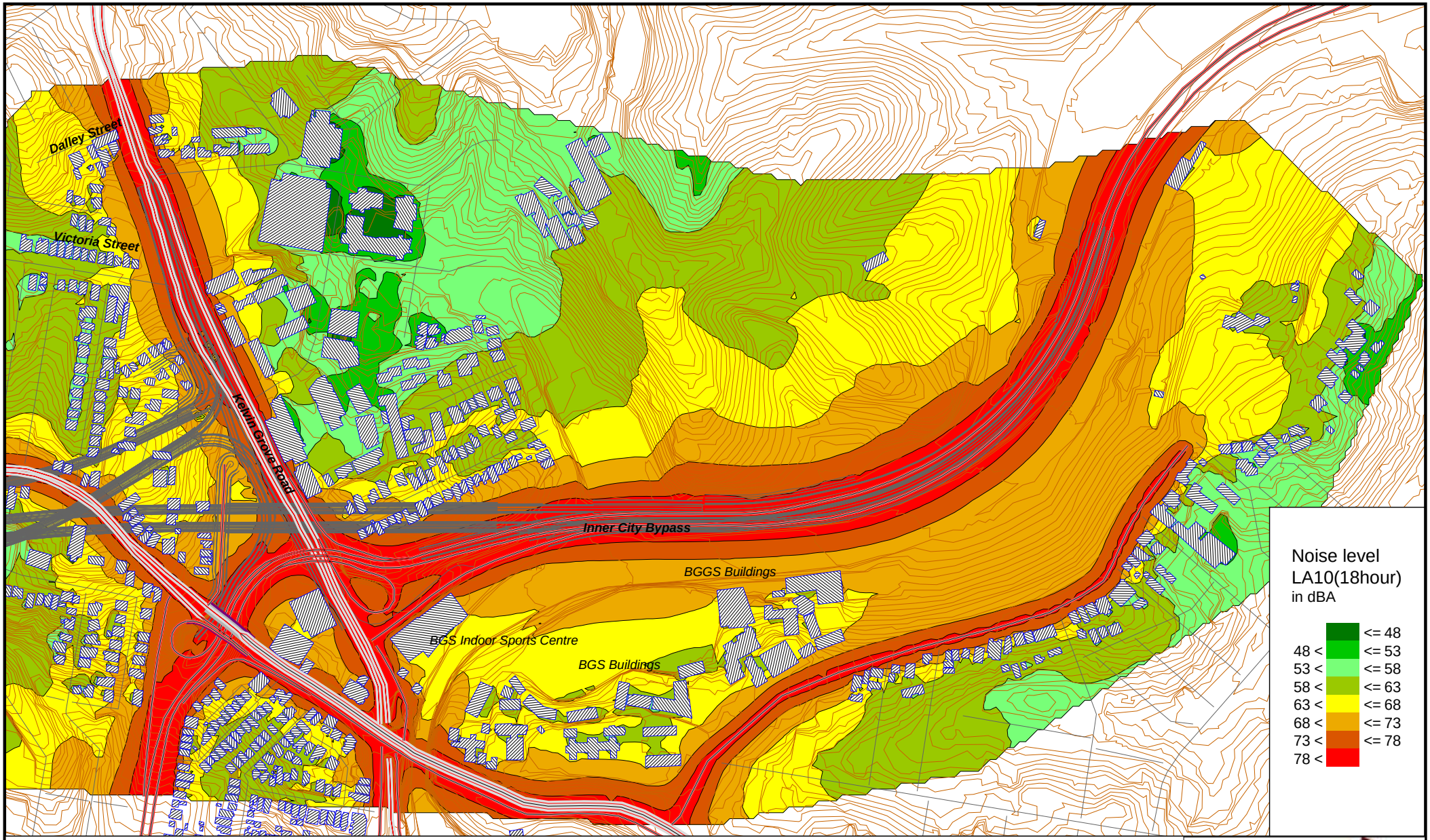

Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2014 "Do Minimum"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I1
Northern Link
SKM Connell Wagner
JOINT VENTURE

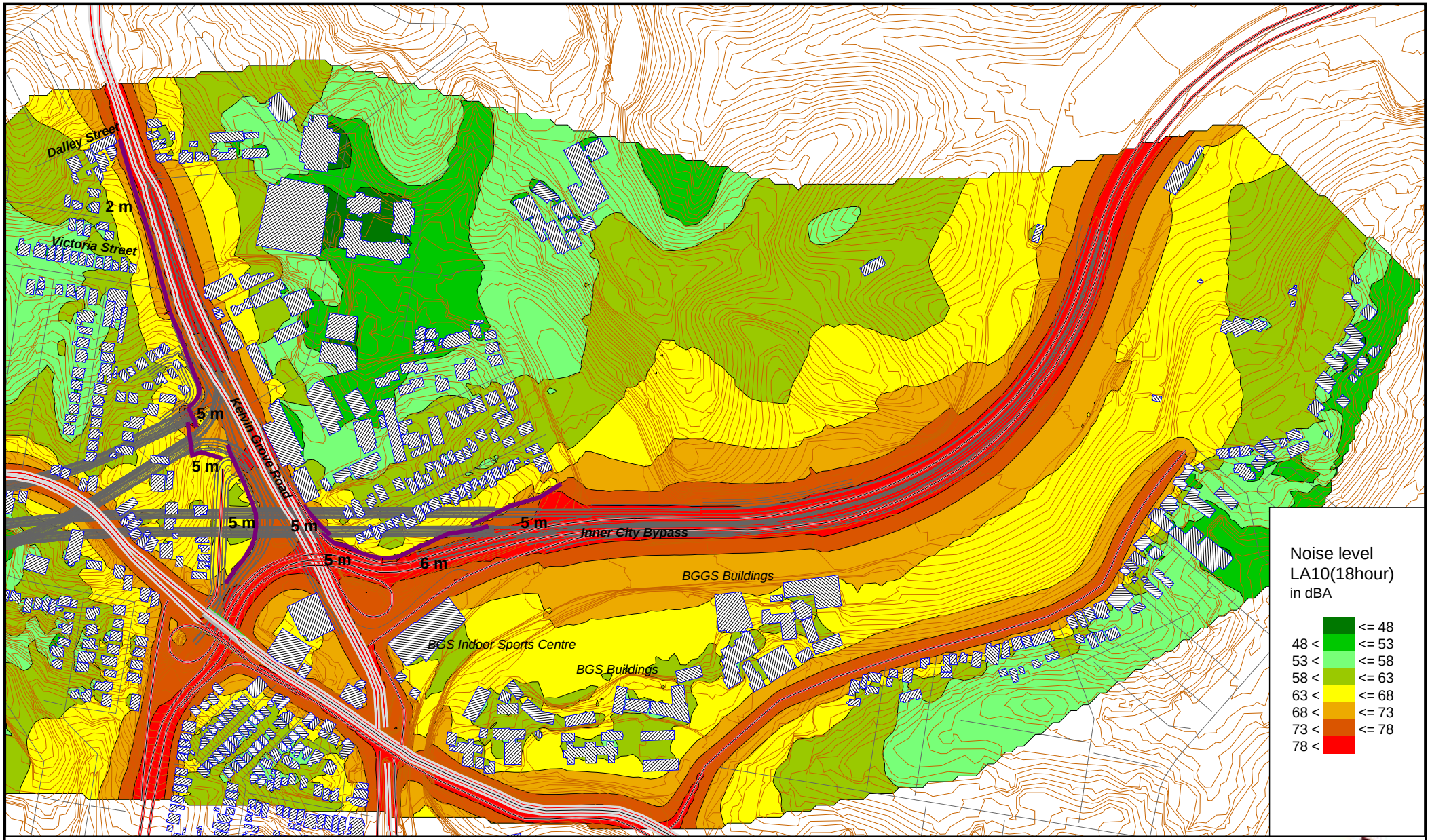

Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2014 "With Project-
No Barriers"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I2
Northern Link
SKM Connell Wagner
JOINT VENTURE

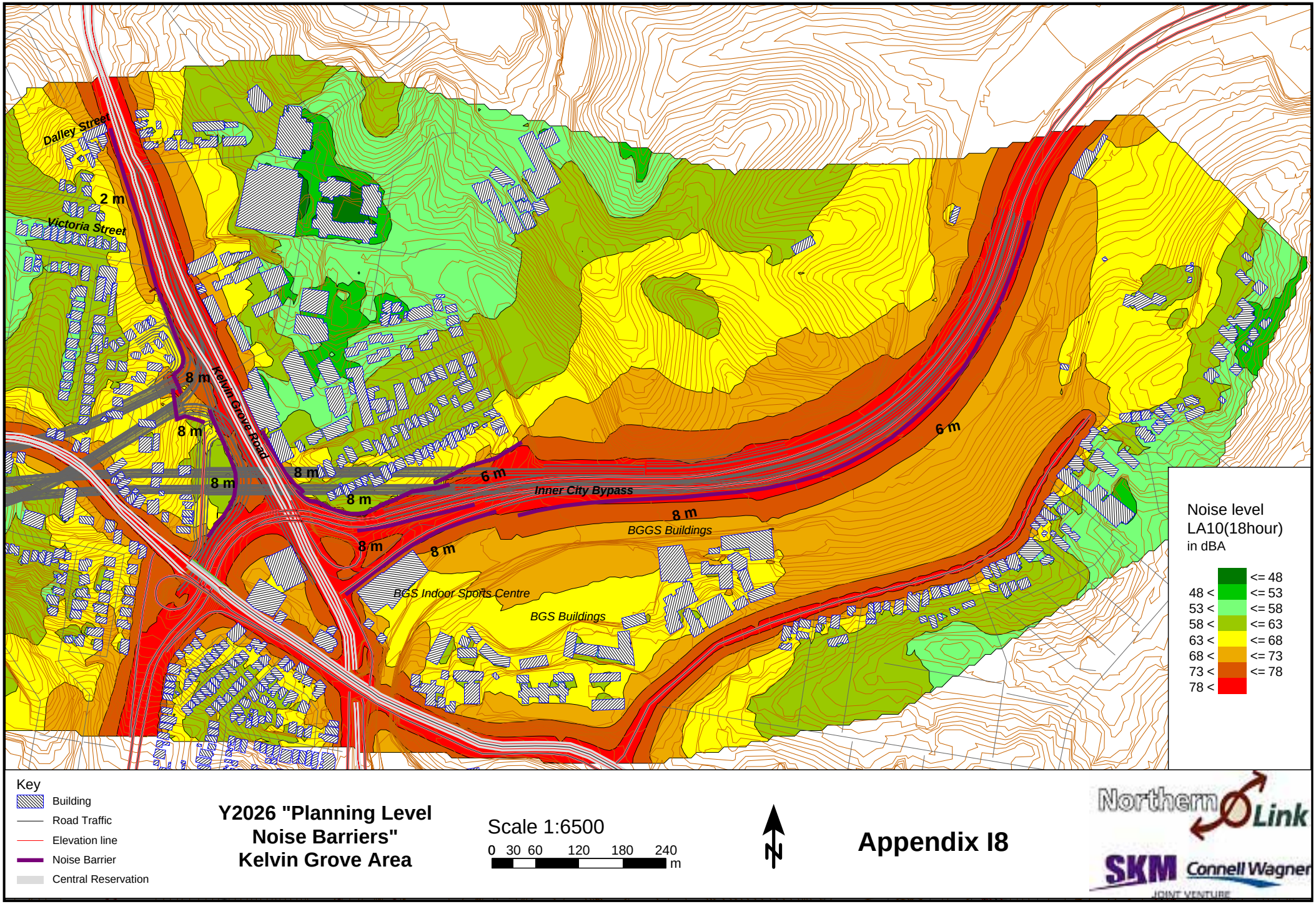

Dalley Street
2 m
Victoria Street
Kelvin Grove Road
5 m
5 m
5 m
5 m
5 m
6 m
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2014 "Status Quo
Noise Barriers"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I3
Northern Link
SKM Connell Wagner
JOINT VENTURE


Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
2 m
8 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2014 "Planning Level Noise Barriers" Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240 m
N
Appendix I4
Northern Link
SKM Connell Wagner
JOINT VENTURE


Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2026 "Do Minimum"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I5
Northern Link
SKM Connell Wagner
JOINT VENTURE


Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Road Traffic
Elevation line
Building
Central reservation
Y2026 "With Project-
No Barriers"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I6
Northern Link
SKM Connell Wagner
JOINT VENTURE


Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
2 m
5 m
5 m
5 m
5 m
5 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2026 "Status Quo
Noise Barriers"
Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240
m
N
Appendix I7
Northern Link
SKM Connell Wagner
JOINT VENTURE


Dalley Street
Victoria Street
Kelvin Grove Road
Inner City Bypass
BGGS Buildings
BGS Indoor Sports Centre
BGS Buildings
2 m
8 m
6 m
Noise level
LA10(18hour)
in dBA
<= 48
48 < <= 53
53 < <= 58
58 < <= 63
63 < <= 68
68 < <= 73
73 < <= 78
78 <
Key
Building
Road Traffic
Elevation line
Noise Barrier
Central Reservation
Y2026 "Planning Level Noise Barriers" Kelvin Grove Area
Scale 1:6500
0 30 60 120 180 240 m
N
Appendix I8
Northern Link
SKM Connell Wagner
JOINT VENTURE