Appendix H Noise and Vibration Assessment

ATKINS ACOUSTICS

Postal Address
P.O. Box 432
Gladesville
N.S.W. 1675
AUSTRALIA
A.C.N. 068 727 195
A.B.N. 19 068 727 195
Telephone: 02 9879 4544
Fax: 02 9879 4810
Email: AtkinsAcoustics@bigpond.com.au

Atkins Acoustics and Associates Pty Ltd.
Consulting Acoustical & Vibration Engineers

OPERATION AND CONSTRUCTION NOISE & VIBRATION ASSESSMENT GLOUCESTER GAS PROJECT

38.6354.R1:GA/DESKTOP/2009

Prepared for: AECOM
P.O. Box 726
PYMBLE NSW 2073

Prepared by: Atkins Acoustics & Associates Pty Ltd
8-10 Wharf Road
GLADESVILLE NSW 2111

October 2009

CONTENTS

	Page No.
EXECUTIVE SUMMARY	
1.0 INTRODUCTION	4
2.0 PROJECT DESCRIPTION	6
2.1 Overview	6
2.2 Gas Field Development Area	6
2.2.1 Production Well Construction	8
2.2.2 Production Well Construction Program	8
2.2.3 GFD Operation Noise Sources	9
2.3 Central Processing Facility	10
2.3.1 Central Processing Facility Construction	11
2.3.2 Central Processing Facility Construction Program	12
2.3.3 Central Processing Facility Operation Noise Sources	12
2.3.4 Potentially Affected Receivers	12
2.4 Gas Transmission Pipeline.	13
2.4.1 Gas Transmission Pipeline Construction	15
2.4.2 Gas Transmission Pipeline Construction Program	15
2.4.3 Potentially Affected Receivers	15
2.5 Hexham Delivery Station	16
2.5.1 Delivery Station Construction	16
2.5.2 Delivery Station Construction Program	16
2.5.3 Delivery Station Operational Noise Sources	18
2.5.4 Potentially Affected Receivers	18
2.6 Operational Traffic	18
2.7 Intermittent Operational Noise (Sleep Disturbance)	19
2.8 Operational Ground Vibration	19
3.0 EXISTING AMBIENT NOISE ENVIRONMENT	20
3.1 Monitoring Equipment and Procedures	20
3.2 Acoustic Parameters	20
3.3 Unattended Noise Monitoring	20
3.4 Meteorological Conditions during Monitoring	21
3.5 Measurement Results	21
3.6 Industrial Noise Policy Assessment Procedures	22
3.7 Ambient Noise Assessment for Pipeline Corridor	23
4.0 TARGET NOISE ASSESSMENT GOALS	24
4.1 Operational Target Noise Goals	24
4.2 Sleep Disturbance Assessment Goals	26
4.3 Road Traffic Noise	26

CONTENTS

Page No.

5.0 METEOROLOGICAL CONDITIONS 28
5.1 Gloucester Area 28
5.1.1 Wind 28
5.1.2 Atmospheric Stability 29
5.2 Hexham/Kooragang Island 30
5.2.1 Wind 30
5.2.2 Atmospheric Stability 30

6.0 OPERATIONAL NOISE AND VIBRATION 31
6.1 Noise and Vibration Sources 31
6.1.1 CPF Plant 31
6.1.2 HDS Equipment 32
6.2 Noise Modelling Procedure 33
6.3 CPF Noise Predictions 33
6.4 HDS Noise Predictions 34
6.5 Assessment 35
6.5.1 CPF Sites 35
6.5.2 HDS 36
6.5.3 Comments 36

7.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT GOALS 37
7.1 DECCW, Interim Construction Noise Guideline 37
7.1.1 Construction Hours 38
7.1.2 Quantitative Assessment Method 38
7.1.2(a) Sleep Disturbance at Residences 40
7.1.3 Qualitative Assessment Method 40
7.1.4 Project Construction Noise Goals 40
7.2 Ground Vibration 42
7.2.1 Annoyance 42
7.2.2 Perception 43
7.2.3 Structural Damage 44
7.3 Blast Assessment Goals 45
7.3.1 Air-blast Overpressure 45
7.3.2 Ground Vibration 45
7.3.3 Blast Project Assessment Goals 45

8.0 CONSTRUCTION PLANT NOISE and VIBRATION SOURCES 46
8.1 Overview of Construction Activities 46
8.1.1 Gas Field Development Area 46
8.1.2 Central Processing Facility 46
8.1.3 Gas Transmission Pipeline Construction 47
8.1.4 Hexham Delivery Station 47
8.2 Construction Equipment Noise Emission Levels 48
8.3 Construction Equipment Vibration Emission Levels 50

CONTENTS

Page No.

9.0 CONSTRUCTION NOISE and VIBRATION IMPACT ASSESSMENT 52
9.1 Construction Noise Predictions 52
9.1.1 Gas Field Development Area 52
9.1.1(a) Sleep Disturbance Noise Predictions 54
9.1.2 Central Processing Facility Construction 54
9.1.3 Gas Transmission Line Construction 55
9.1.4 Hexham Delivery Station Construction 56
9.2 Overview 57
9.3 Traffic Generation 57
9.3.1 GFDA Traffic 57
9.3.2 CPF Traffic 58
9.3.3 GTL Traffic 50
9.3.4 HDS Traffic 60
9.3.5 Traffic Noise Assessment 60
9.4 Vibration Levels from Construction Activities 61
9.5 Blast Assessment 61
9.5.1 Air-blast Overpressure Prediction Model 62
9.5.2 Ground Vibration Prediction Model 62

10.0 MANAGEMENT OF NOISE and VIBRATION IMPACTS 64

11.0 CONCLUSION 67

LIST OF FIGURES

FIGURE 1: Gas Field Area 7
FIGURE 2: Conceptual CPF Layout (Rail Loop South (Site 7)) 10
FIGURE 3: Conceptual CPF Layout (Tiedeman (Site 1)) 11
FIGURE 4: Gas Transmission Pipeline Corridor 14
FIGURE 5: Hexham Delivery Station 17
FIGURE 6: Human Response to Vibration 44
FIGURE 7: LAmax Passby Traffic Noise Levels 61
FIGURE 8: Air-Blast Overpressure v Distance 62
FIGURE 9: Ground Vibration v Distance 63

CONTENTS

Page No.

LIST OF TABLES

Table 1:	Residential Receptor Locations	13
Table 2.	Residential Receptor Locations	18
Table 3:	Operational Traffic Projections	19
Table 4:	RBL's and Ambient Noise Levels (CPF Site 1 and 7)	21
Table 5:	RBL's and Ambient Noise Levels (HDS)	22
Table 6:	INP Noise Policy Amenity Goals	23
Table 7:	Operational Project Noise Goals (CPF Sites 1 and 7)	25
Table 8:	Operational Project Noise Goals (HDS)	26
Table 9:	Sleep Disturbance Assessment Goals	26
Table 10:	Road Traffic Noise Goals	27
Table 11:	Summary of Wind Direction and Percentage Occurrence	29
Table 12:	Atmospheric Stability Frequency and ELR - Winter Nights	29
Table 13:	Summary of Wind Direction and Percentage Occurrence	30
Table 14:	Atmospheric Stability Frequency and ELR - Winter Nights	30
Table 15:	Plant Sound Power Levels (CPF)	32
Table 16:	Plant Sound Power Levels (HDS)	32
Table 17:	Predicted Sound Pressure Level Contributions (CPF Site 7)	34
Table 18:	Predicted Sound Pressure Level Contributions (CPF Site 1)	34
Table 19:	Predicted Sound Pressure Level Contributions (HDS)	35
Table 20:	Recommended Standard Construction Hours	38
Table 21:	Noise at Residences (Quantitative Assessment)	39
Table 22:	Noise at Other Sensitive Receptors (Quantitative Assessment)	40
Table 23:	Construction Noise Target Goals	41
Table 24:	Vibration Levels for Assessment of Human Comfort	43
Table 25:	Human Perception of Vibration	43
Table 26:	Safety Limits for Structural Damage	44
Table 27:	Assessment Goals for Blasting	45
Table 28:	Plant Schedules and Sound Power Levels	48
Table 29:	Plant Vibration Levels	51
Table 30:	Predicted Construction Noise Levels (GFDA)	52
Table 31.	Predicted Construction LA1 Noise Levels (GFDA)	54
Table 32:	Predicted Construction Noise Levels (CPF)	55
Table 33:	Predicted Construction Noise Levels (Pipeline)	56
Table 34:	Predicted Construction Noise Levels (HDS)	57
Table 35:	Range of Typical Noise Sources	57
Table 36:	Vehicle Movements during GFDA Construction	58
Table 37:	Vehicle Movements - CPF Plant and Equipment	59
Table 38:	Pipeline Construction Material Delivery	60
Table 39:	Vehicle Movements - HDS	60

ATTACHMENTS

ATTACHMENT 1. AMBIENT SOUND PRESSURE LEVEL MEASUREMENTS

ATTACHMENT 2. WIND ROSES

ATTACHMENT 3. STABILITY CLASS DATA

ATTACHMENT 4. CPF (Sites 1 and 7) NOISE CONTOUR PLOT (CALM)

ATTACHMENT 5. HDS NOISE CONTOUR PLOT (CALM)

ATTACHMENT 6: TERMS AND DEFINITIONS

REFERENCES

Reference 1: Department of Environment and Climate Change, *Environmental Noise Control Manual* (ENCM)

Reference 2: Department of Environment and Climate Change, *Assessing Vibration: a technical guideline*

Reference 3: Australian and New Zealand Environment and Conservation Council (ANZECC), *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*

Reference 4: German Standard DIN4150 -1986 - Part 3

Reference 5: British Standard BS7385 -1993 - Part 2

Reference 6: Department of Environment, Climate Change and Water, *Interim Construction Noise Guideline*,

EXECUTIVE SUMMARY

The Gloucester gas project is a venture of AGL Gloucester Pty Ltd *(AGL)*. The project consists of four (4) key components to produce, compress and transport coal seam gas from the Gloucester region to a delivery station in Hexham, Newcastle.

Atkins Acoustics was commissioned by *AECOM* on behalf of *AGL* to conduct an operation and construction noise and vibration impact assessment of the proposal.

The main study area is centered around the township of Stratford. The Petroleum Exploration Licence 285 *(PEL 285)* area extends approximately sixty (60) kilometres north to south and approximately twenty (20) kilometres east to west. The preferred pipeline corridor is approximately one hundred (100) metres wide and ninety-five (95) kilometres long. The corridor would extend from the selected central processing facility to the proposed gas delivery station at Hexham.

The main components of the project include the:

- Gas Field Development Area *(GFDA);* the gas production development within the *PEL285*;
- Central Processing Facility *(CPF);* the facility compresses and dehydrates the gas;
- Gas Transmission Pipeline*;* the high-pressure gas transmission pipeline from Stratford to Hexham; and
- Hexham Delivery Station *(HDS)* - Hexham pressure reduction and distribution station.

As part of the study the envisaged operation and construction activities have been assessed in accordance with the following guidelines:

- Department of Environment, Climate Change and Water's *(DECCW)* Industrial Noise Policy *(INP),*
- *DECCW* Interim Construction Noise Guideline *(ICNG),*
- *DECCW* guideline, Assessing Vibration: a technical guideline, and

- Australian and New Zealand Environment and Conservation Council (ANZECC), *Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*.

The main operational noise sources associated with the *CPF* would include gas generators, compressors, compressor cooler fans, pumps, fans and valves. The generators and compressors would be housed in individual acoustic enclosures and the compressor fin cooling fans selected on acoustic performance. The results of noise modelling show that with additional secondary engineering controls the project noise goals are predicted to be satisfied.

From investigations undertaken, it is not envisaged that there would be any significant operational noise sources or noise impacts arising from the gas transfer pipeline.

Noise modelling for the *HDS* has shown that the project noise goals are predicted to be exceeded without the inclusion of secondary noise controls at the closest residential property on Old Maitland Road and the shared industrial and commercial boundaries. As part of the detailed design (when final details of the plant and equipment will be determined) a more detailed assessment of the noise would be undertaken to confirm the extent of noise mitigation required to satisfy the project noise goals.

It is not expected that operational $L_{A1,\ 1\ mim}$ noise levels emitted from the *GFDA, CPF, gas transmission pipeline* and *HDS* would be greater than 5-10dBA above the operational L_{Aeq} levels or the *DECCW* sleep disturbance assessment goals.

No operational vibration sources have been identified that are likely to generate ground vibration at exposed receptors.

The main construction activities envisaged for the project include access track construction, vegetation clearing, drilling, fraccing, trenching, concreting, structure erection, pipe preparation, pipe installation and plant installation. It is proposed that construction activities would generally be restricted to daytime hours. Some well construction works in the *GFDA* including drilling and preparation for fraccing would occur twenty-four (24) hours a day where noise impacts on residential dwellings can be managed.

The assessment findings have shown there would be situations where construction noise levels exceed the target assessment goals during construction. When assessing noise from construction activities it is recognised that the procedures and recommendations published by the *DECCW* are regarded as planning tools. The recommendations are not mandatory, and their application for assessing construction noise is not determined purely on the basis of compliance or otherwise with numerical noise levels.

The assessment has shown that ground vibration from construction activities can be controlled to levels that would satisfy the recommended project goals and expected to be acceptable from both human disturbance and structural damage points of view. With respect to potential blasting activities and airblast/ground vibration impacts, the assessment has shown that maximum instantaneous charges *(MIC's)* can be controlled to ensure that blasting activities (if required) can be controlled to comply with goals recommended by the Australian and New Zealand Environmental Control Committee (A*NZECC)* and accepted by the *DECCW.*

Overall the traffic volumes generated during the operational and construction phases of the project are considered as minimal when compared to the reported Annual Average Daily Traffic *(AADT)* road traffic volumes for The Bucketts Way of between 1555 and 4095 vehicles per day, and 9343 vehicles per day for the Pacific Highway, Hexham and predicted to satisfy the daytime target noise assessment goals for local and collector roads, respectively.

To manage environmental noise impacts during construction, it is recommended that a Noise Management Plan *(NMP)* be prepared. As part of the *NMP*, it is recommended that a public relations program be developed and implemented to inform residents and the community of the progress of the activities, and potential noise and vibration impacts during each phase of the construction.

1.0 INTRODUCTION

The Gloucester Gas Project is a venture of AGL Gloucester L E Pty Ltd *(AGL)*. The project consists of four (4) key components to produce, compress and transport coal seam gas from the Gloucester region to Hexham, Newcastle.

- Gas Field Development Area (GFDA); the gas production development within the PEL285;
- Central Processing Facility (CPF); the facility compresses and dehydrates the gas;
- Gas Transmission Pipeline; the high-pressure gas transmission pipeline from Stratford to Hexham; and
- Hexham Delivery Station (HDS) - Hexham pressure reduction and distribution station.

Atkins Acoustics was commissioned by *AECOM* on behalf of *AGL* to conduct an operation and construction noise and vibration impact assessment of the proposal. Due to the relatively short construction period for the gas transmission pipeline, the physical area of the pipeline corridor and the temporary transient nature of the pipeline construction works a *'Qualitative'* assessment was undertaken for this part of the assessment.

The main aims of the investigations and assessment were to:

- identify potential noise and vibration impacts from the proposal;
- measure, review and comment on the ambient background noise levels in the vicinity of the Gloucester and Hexham infrastructure works ;
- establish project noise goals in accordance with procedures documented in the Department of Environment, Climate Change *and Water (DECCW),* Industrial Noise Policy *(INP)*, the *DECCW* Interim Construction Noise Guideline *(ICNG),* and the *DECCW* Assessing Vibration: a technical guideline;

- predict and evaluate operational noise from the proposal;
- predict and evaluate noise and vibration impacts from the envisaged construction activities; and
- where noise and vibration assessment goals are predicted to be exceeded, recommend ameliorative control options.

The information presented in the report has been prepared for the investigation described herein, and should not be used in any other context or for any other purpose without written approval from *Atkins Acoustics, AECOM* and *AGL.*

2.0 PROJECT DESCRIPTION

2.1 Overview

The main study area is centered around the township of Stratford. The Stratford Petroleum Exploration Licence 285 *(PEL 285)* area extends approximately sixty (60) kilometres north to south and approximately twenty (20) kilometres east to west.

The preferred pipeline corridor is approximately one hundred (100) metres wide and ninety-five (95) kilometres long. The corridor would extend from the selected central processing facility to the proposed gas delivery station at Hexham.

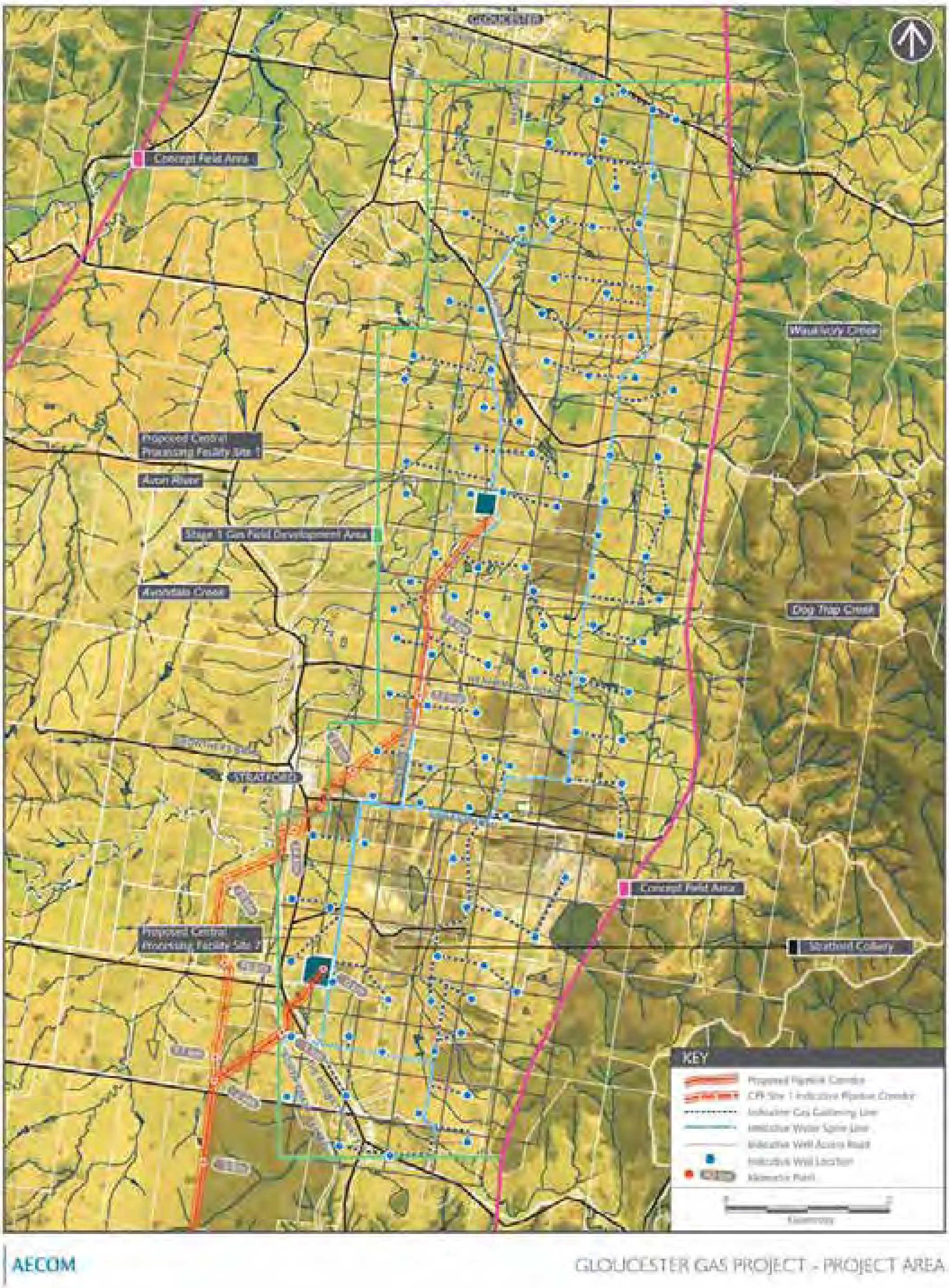
The main components of the project include the:

- Gas Field Development Area *(GFDA)* – the gas production development area within *PEL 285*;
- Central Processing Facility *(CPF)* – the facility compresses and dehydrates the gas;
- Gas Transmission Pipeline –the high-pressure gas transmission pipeline from Stratford to Hexham; and
- the Hexham Delivery Station *(HDS)* - the pressure reduction and distribution station.

2.2 Gas Field Development Area

The principal activities that would be undertaken to develop the gas field include the drilling, completion and connection of production wells. Within the *GFDA* there would be up to one hundred and ten (110) vertical wells spaced at approximately six hundred (600) metres apart. The wells would be interconnected by polyurethane pipe for the purpose of gas and water gathering. Water produced as a by-product would be captured separately for on-site treatment and disposal. *Figure 1* illustrates the layout of the *GFDA*.

Figure 1. Gas Field Area



2.2.1 Production Well Construction

At each well head a single vertical well is anticipated, although in some circumstances, as part of the development of future stages there may be more than one well. Wells would be drilled using conventional drilling rigs and completed with required down hole and surface equipment after being "fracced" to stimulate gas and water flow. The process would comprise the following activities:

- site preparation,
- production well drilling,
- production well geophysical logging,
- production casing running and cementing,
- completion which may include perforating and fracture stimulation, or an alternative completion,
- installation of pumps and surface facilities, and
- cleanup and rehabilitation.

2.2.2 Production Well Construction Program

The envisaged construction program for the *GFDA* would be scheduled over a period of twelve (12) to eighteen (18) months. This represents the shortest (i.e., most intensive) construction schedule as a worse case scenario. This may be extended, however this would reduce the intensity of activities (and potentially reduce the intensity of noise generation). The shortest timeframe therefore has been assumed for this assessment. Initial site establishment, access road, pad preparation, decommissioning and rehabilitation would be conducted during daytime hours (nominally 7.00am to 6.00pm). The development of each well and its infrastructure would occur over a period of about six to eight (6-8) weeks. This would include site preparation, drilling, well completion and installation of surface infrastructure at the well head. Should drilling take place during normal daytime hours, a period of two (2) weeks of drilling is anticipated per well. If twenty-four (24) hour drilling occurred the period would be reduced to approximately one (1) week. It is the intention of *AGL*, where feasible, to conduct drilling operations twenty-four (24) hours a day to reduce the duration of the activities and limit noise exposure for residential properties. Albeit it is acknowledged that a number of residential dwellings are located in relative close proximity and could be exposed to construction noise. Drilling hours would be considered on a site by site basis subject to meeting relevant project noise goals or as otherwise agreed with affected landowners.

Access to well site locations within the *GFDA* would be provided via existing roads and tracks, where possible. Where access tracks are required to be constructed alignments would be determined in consultation with landowners to determine the most beneficial location.

Traffic associated with each well site could generate up to sixty-two (62) vehicle trips for the mobilisation of equipment in addition to vehicle movements required for the transport of gravel. The movement of site personnel may generate six (6) to eight (8) vehicle trips per day.

2.2.3 GFDA Operational Noise Sources

Field audits undertaken at existing pilot well sites identified that the main operational noise sources would be associated with valves and the vacuum pump-motor. Electricity supply to each well head could be via a network of under ground cables or from individual gas powered generators. The results of field noise measurements confirmed that the equivalent sound power level for the well head plant was 70dBA 10^{-12} Watts. The sound power level for the generator if installed would be in the order of 75-80dBA 10^{-12} Watts. At fifty (50) metres from the well head the predicted equivalent sound pressure level is in the order of 35-38dBA.

At some well heads where up to four (4) wells could be co-located, the equivalent operational noise level at one hundred (100) metres is predicted to be in the order of 29-32dBA. With a nominal six hundred (600) metres spacing between well heads, it is not anticipated that there would be any measurable cumulative noise effects from the well network. Considering the distance separation to existing residential dwellings, noise from the *GFDA* well network would be described as minimal and low risk in terms of potential impacts. Noise modelling would be undertaken during the detailed design phase to ensure that project noise goals are satisfied. On this understanding operational noise from the well network has not been considered any further in the report.

2.3 Central Processing Facility

Two (2) preferred sites *(Figure 1)* have been selected and assessed for potential noise impacts from the *CPF*. The sites are identified as *CPF Site 7* and *CPF Site 1*. The gas and water collected at each well head would be transported via a network of pipes to the *CPF*. Gas produced by the wells would be treated at the *CPF* and pressurised for transport to Hexham via the gas transmission pipeline. Water collected from the wells would be transported for treatment at the *CPF*.

The *CPF* would consist primarily of gas-powered generators and reciprocating compressors, which would, in stages, compress the gas. Conceptual layouts of both *CPF* sites are provided in *Figures 2 and 3*

Figure 2. Conceptual Layout - CPF Site 7

Figure 3. Conceptual Layout - CPF Site 1

2.3.1 Central Processing Facility Construction

The *CPF* site works would include clearing, civil, construction and plant installation. The components for the *CPF* would be transported to the site by road. Road transportation would include articulated vehicles with extended trailers where required. Vehicle movements associated with the delivery of plant and equipment are expected to comprise initially up to forty-six (46) heavy vehicle trips and some thirty-six (36) light vehicle trips per day.

2.3.2 Central Processing Facility Construction Program

Construction of the *CPF* would be undertaken over a period of approximately twelve (12) months, and typically between 7.00am to 6.00pm Monday to Friday, and 8.00am to 1.00pm Saturday. Where it is demonstrated that construction noise can be controlled and/or managed, construction works would be undertaken outside the above daytime hours.

2.3.3 Central Processing Facility Operational Noise Sources

The main operation noise sources associated with the *CPF* include generators, compressors, compressor cooler fans, pumps, fans and valves. To ameliorate operational noise, the following strategies have been considered and incorporated into the concept design.

- generator and compressor acoustic enclosures;
- low noise rated valves; and
- low noise rated compressors, fans and pumps.

2.3.4 Potentially Affected Receivers

The *CPF* sites are located in rural areas and generally separated from residential dwellings. *CPF Site 7* is located in the vicinity of the Gloucester Coal open cut coal mine and coal processing facilities. *CPF Site 1* is in an area described as predominantly rural. *Table 1* presents a summary of nearby residential dwellings and typical offset distances to the *CPF's.* Receptor assessment locations are shown in Attachment 4 and 5.

Table 1. Residential Assessment Locations

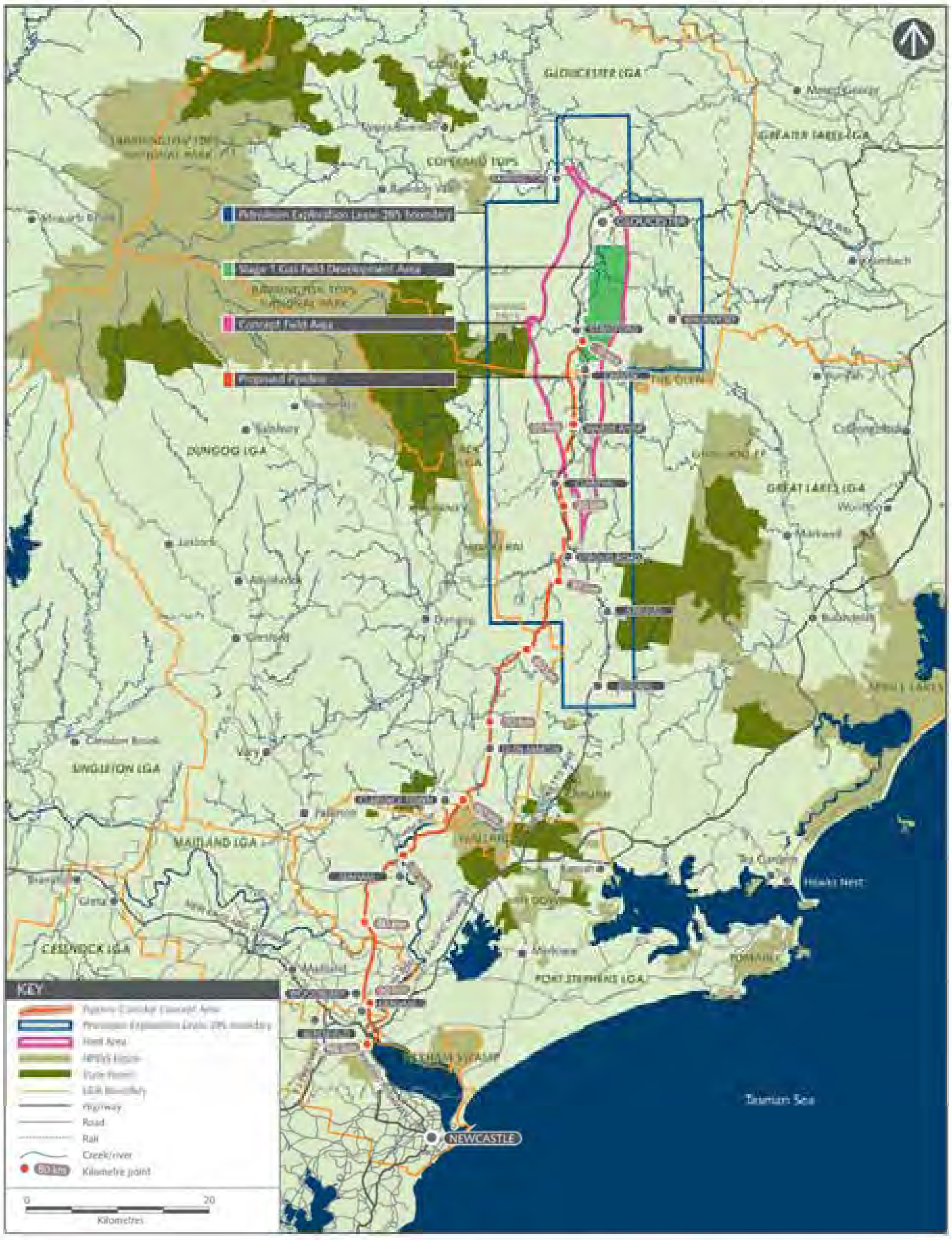
Reference Assessment Locations	Reference Measurement Location *	Distance from CPF (metres)
CPF Site 7		
P1	R2	1100
P2	R1	520
P3	R8	460
P4	-	1700
P5	-	1600
P6	-	1300
CPF Site 1		
P7	-	1900
P8	R5	1500
P9	-	1800
P10	R4	1400
P11	-	480
P12	-	1600
P13	R7	1300
P14	-	1500

***R** - Reference Measurement Locations where background noise monitoring has been undertaken to establish RBL's (refer Table 4)*

2.4 Gas Transmission Pipeline.

The gas transmission pipeline would commence at the selected *CPF* and connect to *HDS* at Hexham *(Figure 4)*. Preliminary investigations determined the preferred pipeline corridor and likely constraints relating to existing land use, environmentally sensitive areas and constructability.

Figure 4. Gas Transmission Pipeline Corridor



GLOUCESTER COAL SEAM METHANE GAS PROJECT LOCATION
AND PEL 285 BOUNDARY

2.4.1 Gas Transmission Pipeline Construction

The envisaged pipeline construction activities include:

- clearing – removal of vegetation,
- civil – site leveling using graders, excavators and bulldozers,
- trenching – either a specialist trencher or an excavator to dig the trench for pipe-laying,
- pipe stringing – delivery of pipes adjacent to the trench,
- welding – welding of continuous strings of pipe up to 1 km in length,
- lowering-in and backfill – the pipe would be lowered into the trench and backfill with screened trench spoil,
- hydrostatic testing –testing with water and pressurised above the maximum allowable operation pressure to ensure the integrity,
- temporary work areas – during construction a number of temporary work areas would be required for the storage of pipe and facilities, and
- rehabilitation of the pipeline construction area.

Vehicle movements associated with the delivery of pipe, plant and equipment for this phase of the project is expected to comprise five-ten (5-10) trucks and in the order of fifteen -thirty (15-30) light vehicles per day.

2.4.2 Gas Transmission Pipeline Construction Program

Construction would be undertaken in teams on a scrolling basis along the pipeline route. It is anticipated that the total duration of the works would be approximately twelve (12) months. The envisaged duration at any one (1) specific location is expected to be in the order of three (3) weeks.

2.4.3 Potentially Affected Receivers

Built up areas along the pipeline corridor include Nelson, Duckenfield, Woodberry and Tarro. Some residences are in the order of 30-100m (estimated from aerial photography) from the corridor centre-line. Typically residences are located in excess of 200m from the corridor. Accordingly, the assessment has considered anticipated construction activities and predicted noise and vibration levels at various offset distances to represent potential receiver locations. A detailed noise and vibration management plan would be prepared to address potential impacts in more detail when the actual pipeline location is confirmed and approved.

2.5 Hexham Delivery Station

The gas transmission pipeline would terminate at the proposed *HDS* on the southern side of the Hunter River *(Figure 5)*. The *HDS* would principally involve above ground pipe work including dry gas filtration, water bath heaters, metering, flow control valves and a noise attenuated pipeline blowdown stack.

2.5.1 Delivery Station Construction

The envisaged construction activities would include:

- civil – site leveling using graders and excavators,
- welding – welding of pipes, and
- hydrostatic testing –testing with water and pressurised above the maximum allowable operation pressure to ensure the integrity.

Vehicle movements associated with the construction of the *HDS* is expected to generate five (5) to ten (10) truck movements and eighteen (18) light vehicles per day.

2.5.2 Delivery Station Construction Program

Construction of the *HDS* would be undertaken over a period of up to six (6) months and typically between 7.00am to 6.00pm Monday to Friday, and 8.00am to 1.00pm Saturday. Where it is demonstrated that construction noise can be controlled and/or managed, construction works would be undertaken outside the above daytime hours.

Figure 5. Hexham Delivery Station

2.5.3 Delivery Station Operational Noise Sources

The main operation noise sources associated with the *HDS* includes valves/fittings and pipe radiated noise. To ameliorate operational noise, the following strategies have been incorporated into the concept design.

- pipe sizing to reduce passage velocities;
- low noise rated valves; and
- pipework design to minimise turbulent flow conditions.

2.5.4 Potentially Affected Receivers

The *HDS* is located in an area zoned and developed with a mixture of industrial and residential uses. The closest residential dwellings *(Table 2)* are located 150m to the north-west on the corner of Old Punt Road and Old Maitland Road, and 330m to the north-east on Old Maitland Road. The area is subjected to noise from road traffic and local industrial activities.

Table 2. Residential Assessment Locations - HDS

Reference Assessment Locations	Reference Measurement Locations	Distance from HDS (metres)
P15	R9*	1300
P16	-	150
P17	R10*	330

**R - Reference Measurement Locations to establish RBL's (Table 4)*

2.6 Operational Traffic

Reported *AADT* road traffic volumes for The Bucketts Way range between 1555 vehicles per day and 4095 vehicles per day. For the Pacific Highway at Hexham the reported *AADT* is in the order of 9343 vehicles per day. Likely traffic volumes generated during the operational phase of the project are summarised in *Table 3* and considered as insignificant in terms of increased traffic noise.

Table 3: Operational Traffic Projections

Personnel	Anticipated vehicle numbers	Usage information
Stage 1 GFDA		
6 field operators for field monitoring	Up to six light vehicles	Daily usage to check the wells. Movements internal to Stage 1 GFDA.
6 workover crew operating the workover rig and support vehicles	One workover rig, one truck and two light vehicles	Monthly usage for work-over operations internal to the Stage 1 GFDA.
CPF		
Field Operations management and administration	Ten light vehicles	20 external movements per day.
2 x Plant Operators (one per day and night shift)	Two light vehicles	4 external movements per day.
1 x Plant Supervisor		
1 x Electrical & Instrumentation technician	One light vehicle	2 external movements per day.
4 Workshop and maintenance staff	Four light vehicles	8 external movements per day.
6 CPF contractors (compression, E&I and environmental license compliance)	Four light vehicles	8 external movements per day. Anticipated onsite every 3 months.
Pipeline		
1 x Pipeline technicians	One light vehicle.	Routine inspections of the pipeline route requiring movements on the external road network along the pipeline route. Additional support from plant operators where required

2.7 Intermittent Operational Noise (Sleep Disturbance)

It is understood that noise from the operational plant would be continuous and intermittent sources would not be greater than 5-10dBA above the L_{Aeq} levels. Hence intermittent noise has not been assessed in terms of sleep disturbance.

2.8 Operational Ground Vibration

No operational ground vibration sources have been identified that would be likely to generate ground vibration at exposed residential receptors.

3.0 EXISTING AMBIENT NOISE ENVIRONMENT

An assessment of the existing ambient noise was undertaken to establish project noise assessment goals for the project. The measurements included both attended audits to identify sources contributing to the ambient noise and unattended monitoring.

3.1 Monitoring Equipment and Procedures

The measurement instrumentation comprised a Bruel & Kjaer Precision Sound Level Meter Type 2215, a Svantek SVAN 949 Sound Level Analyser and RTA Environmental Noise Loggers. The reference calibration level for each instrument was checked prior to and after the measurements with a Bruel & Kjaer Sound Level Calibrator Type 4230 and remained within ± 1.

3.2 Acoustic Parameters

The ambient noise levels were measured and recorded as percentile and energy averaged A-weighted levels. The percentile A-weighted sound levels are the levels exceeded for the relevant percentage of the measurement period *(Attachment 1)*. The parameters regarded as being the most common to describe ambient noise levels are the "L_{A90}" or the A-weight sound pressure level exceeded for 90% of the sampling period and is referred to as the background noise level; and, the "L_{Aeq}" or the A-weighted equivalent continuous sound pressure level for the sampling period which if maintained for the duration of the measurement period would be equal to the same energy as the actual time varying levels.

3.3 Unattended Noise Monitoring

Unattended noise monitoring was undertaken between October 2008 and June 2009. The reference measurement locations *(Tables 4 and 5)* were selected to provide information on the existing noise levels for areas considered to be potentially exposed to operational noise from the *GFDA, CPF* and *HDS*. The measurements locations selected include rural areas with limited traffic flows, areas exposed to road traffic noise and areas exposed to mining and industrial activities.

The measurement results were evaluated in accordance with *INP* procedures to confirm the *RBL's* and ambient levels *(Tables 4 and 5)*.

3.4 Meteorological Conditions during Monitoring

In accordance with Section 3.4 of the *INP*, noise data was excluded from the monitoring results when average wind speeds were greater than 5m/s and/or rain occurred.

3.5 Measurement Results

Attachment 1 presents a graphic presentation of the noise measurement results. *Tables 4 and 5* presents a summary of the measurement data collected. The measurement results show that the evening *RBL's* are marginally higher than the daytime levels. This finding is not uncommon for rural areas where the ambient noise can be influenced by wind direction changes and distant noise sources.

Table 4. Rating Background Levels and Ambient Noise Levels (CPF Sites 1 and 7)
dBA re: 20×10^{-6} Pa

Date	Assessment Background Noise Levels					
	RBL (dB)			Ambient $L_{Aeq, period}$		
	Day	Evening	Night	Day	Evening	Night
Ambient Noise Measurement Results (September 2008)						
Reference Measurement Location R1/P2.						
RBL	37.6	40.0	37.2			
Logarithmic Average L_{Aeq}				63.4	56.8	61.6
Reference Measurement Location R2/P1.						
RBL	32.1	35.3	31.4			
Logarithmic Average L_{Aeq}				49.6	48.6	46.8
Reference Measurement Location R3.						
RBL	32.5	34.1	29.9			
Logarithmic Average L_{Aeq}				58.8	45.5	46.0
Reference Measurement Location R4/P10.						
RBL	30.4	32.2	31.3			
Logarithmic Average L_{Aeq}				49.7	39.8	43.4
Reference Measurement Location R5/P5.						
RBL	30.6	31.5	31.1			
Logarithmic Average L_{Aeq}				56.1	52.7	49.9
Reference Measurement Location R6.						
RBL	29.7	33.2	32.2			
Logarithmic Average L_{Aeq}				53.3	51.3	47.4
Reference Measurement Location R7/P13.						
RBL	31.6	32.8	31.3			
Logarithmic Average L_{Aeq}				57.1	45.4	46.4

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays.

Table 4. Rating Background Levels and Ambient Noise Levels. Cont'd (CPF Sites 1 and 7)
dBA re: 20 $\times 10^{-6}$ Pa

Date	Assessment Background Noise Levels					
	RBL (dB)			Ambient $L_{Aeq, period}$		
	Day	Evening	Night	Day	Evening	Night
Ambient Noise Measurement Results (April 2009)						
Reference Measurement Location R2A.						
RBL	35.0	34.0	31.2			
Logarithmic Average L_{Aeq}				47.4	46.2	44.8
Reference Measurement Location R8/P3.						
RBL	34.5	35.2	34.5			
Logarithmic Average L_{Aeq}				57.1	52.2	47.4

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays.

Table 5. Rating Background Levels and Ambient Noise Levels (HDS)
dBA re: 20 $\times 10^{-6}$ Pa

Ambient Noise Measurement Results (June 2009*)						
Reference Measurement Location R9/P15.						
RBL	49.9	47.5	45.7			
Logarithmic Average L_{Aeq}				55.4	55.2	55.1
Reference Measurement Location R10/P17.						
RBL	43.7	45.3	39.7			
Logarithmic Average L_{Aeq}				56.0	51.8	52.9

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays.

Residential properties identified as being exposed to existing industrial/mining noise sources include (R1), (R2), (R8) and (R10). The noise monitoring results for (R3) and (R6) were considered as part of the assessment of the ambient background noise. As the locations were outside the *CPF* 30dBA predicted operational noise contour plot they were not considered as the most exposed and not identified in *Tables 17* and *18.*

3.6 Industrial Noise Policy Assessment Procedures

For preservation of acoustic amenity, the *INP* requires industrial noise in residential areas be within the acceptable levels for the locality and land-use. The *INP* would define the subject receivers as *Rural* or *Suburban* and *Urban*. *Table 6* presents a summary of the *INP* acceptable and recommended maximum amenity noise goals for residential development in different noise catchments.

Table 6: INP Noise Policy Amenity Goals

Receiver Description	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level	
			Acceptable	Recommended Maximum
Residence	Rural	Day Evening Night	50 45 40	55 50 45
	Suburban (1)	Day Evening Night	55 45 40	60 50 45
	Urban (2)	Day Evening Night	60 50 45	65 55 50
Passive recreation areas	All	When in use	50	55
Active recreation areas	All	When in use	55	60
Commercial	All	When in use	65	70
Industrial	All	When in use	70	75

NOTES: Daytime: (7.00am to 6.00pm)
Evening: (6.00pm to 10.00pm)
Nighttime: (10.00pm to 7.00am)

(1) Suburban
– an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristics:
- decreasing noise levels in the evening period (1800-2200); and/or
- evening ambient noise levels defined by the natural environment and infrequent human activity.

This area may be located in either a rural, rural-residential or residential zone, as defined or other planning instrument.

(2) Urban
- an area with an acoustical environment that:
- is dominated by 'urban hum' or industrial source noise
- has through traffic with characteristically heavy and continuous traffic flows during peak periods
- is near commercial districts or industrial districts
- has any combination of the above
- where 'urban hum' means the aggregate sound of many unidentifiable, mostly traffic related sound sources.

This area may be located in either a rural, rural-residential or residential zone, as defined or other planning instrument, and also includes mixed land-use zones such as mixed commercial and residential uses.

3.7 Ambient Noise Assessment for Pipeline Corridor

Given the short-term nature of the pipeline construction works at any particular receptor location, background noise measurements were not measured along the corridor. With respect to this component of the project, a 'qualitative assessment' has been undertaken *(Section 9)* to identify the cause of potential noise impacts and methods to manage noise.

4.0 TARGET NOISE ASSESSMENT GOALS

4.1 Operational Target Noise Goals

With respect to what is considered to represent the current best practice for assessing environmental noise, the main aims are to control intrusive noise and manage increases in ambient noise *(noise creep)* from industrial sources.

The intrusiveness of a noise is considered to be acceptable if the $L_{Aeq,\ 15\ min}$ level does not exceed the *RBL* by more than 5dBA. In order to preserve noise amenity, the *INP* recommends that L_{Aeq} level from industrial sources should not normally exceed the recommended acceptable noise level (*Table 7*) assessed over the relevant assessment period, i.e. day, evening and night. Where existing L_{Aeq} levels are controlled by industrial noise, and the level approaches or exceeds the recommended acceptable level, noise assessment goals for new sources are normally set below the existing L_{Aeq} level in order to limit any further increase or noise "creep". Meeting the *INP* acceptable levels *(Table 6)* would normally *(DECCW, INP)* protect the community from annoyance.

For the purpose of controlling and assessing environmental noise impacts, the *INP* recommends that the acceptable levels *(INP. Tables 2.1 and 2.2)* shown in *Table 6* represent the ideal total level of noise from industrial sources that should be met by any further development of the area.

The *DECCW* recognise (*INP. Section 1.4.1)* that in setting assessment goals, the levels established in accordance with the *INP* procedures are best regarded as planning tools. The levels determined in accordance with the recommended procedures are not mandatory, and an application for a noise producing development is not determined purely on the basis of compliance or otherwise of noise goals. Other factors that need to be taken into account in the determination include economic consequences, other environmental effects and the social worth of the proposal. In determining project-specific noise levels from *RBL's,* the *DECCW* recommend that the intrusive noise level for evening be set no greater than the daytime intrusive noise level and the nighttime intrusive level should be no greater than the day or evening levels.
For the purpose of establishing project noise goals, the existing *RBL's* and the

"Rural/Suburban/Urban" INP amenity goals form the basis of the evaluation and determining the noise goals summarised in *Tables 7 and 8.*

For assessment purposes the noise goals are assessed at residential boundaries or thirty (30) metres from a residential dwelling on the property, if the boundary is more than thirty (30) metres from the dwelling.

Table 7: Operational Project Noise Goals - CPF Sites 1 and 7
dBA re: 20 x 10^{-6} Pa

Period	**Sound Pressure Levels**				
	Existing RBL	**Existing Amenity Level L_{Aeq}**	**Recommended Amenity Goal L_{Aeq}**	**Intrusive Goal L_{Aeq}**	**Project Noise Goals L_{Aeq}**
Reference Measurement Location R1/P2.					
Day	37.6	63.4	55	43	43
Evening	40.0	56.8	45	43	43
Night	37.2	61.6	40	42	42
Reference Measurement Location R2/P1.					
Day	32.1	49.6	55	37	37
Evening	35.3	48.6	45	37	37
Night	31.4	46.8	40	36	36
Reference Measurement Location R3.					
Day	32.5	58.8	55	37	37
Evening	34.1	45.5	45	37	37
Night	29.9	46.0	40	35	35
Reference Measurement Location R4/P10.					
Day	30.4	49.7	50	35	35
Evening	32.2	39.8	45	35	35
Night	31.3	43.4	40	35	35
Reference Measurement Location R5.					
Day	30.6	56.1	50	36	36
Evening	31.5	52.7	45	36	36
Night	31.1	49.8	40	36	36
Reference Measurement Location R6.					
Day	29.7	53.3	50	35	35
Evening	33.2	51.3	45	35	35
Night	32.2	47.4	40	35	35
Reference Measurement Location R7/P13.					
Day	31.6	57.1	50	37	37
Evening	32.8	45.4	45	37	37
Night	31.3	46.4	40	36	36
Reference Measurement Location R8/P3.					
Day	34.5	57.1	55	40	40
Evening	35.2	52.2	45	40	40
Night	34.5	47.4	40	40	37

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays

Table 8: Operational Project Noise Goals - HDS

dBA re: 20 x 10^{-6} Pa

Period	Sound Pressure Levels				
	Existing RBL	Existing Amenity Level L_{Aeq}	Recommended Amenity Goal L_{Aeq}	Intrusive Goal L_{Aeq}	Project Noise Goals L_{Aeq}
Reference Measurement Location R9/P15. Tomago Village Caravan Park					
Day	49.9	55.4	60	55	55
Evening	47.5	55.2	50	53	45
Night	45.7	55.1	45	51	45
Reference Measurement Location R10/P17. Old Maitland Road					
Day	43.7	56.0	60	49	49
Evening	45.3	51.8	50	50	42
Night	39.7	52.9	45	45	43

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays

4.2 Sleep Disturbance Assessment Goals

The *DECCW*, Environmental Noise Control Manual *(ENCM)* provides guidelines for assessing sleep disturbance from short-term noise events. Referenced to the *ENCM (Section 19.3)* the $L_{A1,\ 1min}$ noise level measured or assessed over a one (1) minute period outside a residential bedroom window should not exceed the L_{A90} background level by more than 15dBA. The *DECCW* accept that the $L_{A1,\ 1min}$ above the *RBL* is appropriate for assessing sleep disturbance during nighttime hours (2200-0700). *Table 9* presents the sleep disturbance assessment goals developed from *RBL* levels in *Table 4*.

Table 9: Sleep Disturbance Assessment Goals CPF and HDS

dBA re: 20 x 10^{-6} Pa

Referenced Assessment Location	Existing RBL	Sleep Disturbance Assessment Goals $L_{A1,\ 1\ min}$
CPF Sites 1 and 7 and GFDA		
Rural (R2-R7)	30-32	45-47
Rural exposed to Gloucester Colliery (R1, R8)	34-37	49-52
HDS		
Hexham	40-46	55-61

4.3 Road Traffic Noise

Procedures for assessing road traffic noise from new land use developments are documented in the *DECCW (*EPA), *Environmental Criteria for Road Traffic Noise (ECRTN)* and summarised in *Table 10*

Table 10. Road Traffic Noise Goals

dBA re: 20 x 10^{-6} Pa

Land Use Development	Traffic Noise Assessment Goals		Where Goals are already Exceeded
	Daytime (7.00am to 10.00pm)	Nighttime (10.00pm to 7.00am)	
Land use developments with potential to create additional traffic on local roads	$L_{Aeq,\ 1\ hour}$ 55	$L_{Aeq,\ 1\ hour}$ 50	In all cases, the redevelopment should not increase existing noise levels by more than 2dBA. Where feasible and reasonable noise levels from existing roads should be reduced to meet the noise criteria. In many instances this may be achievable only through long-term strategies.
Land use developments with potential to create additional traffic on collector roads	$L_{Aeq,\ 1\ hour}$ 60	$L_{Aeq,\ 1\ hour}$ 55	
Land use developments with potential to create additional road traffic on existing freeways/arterial roads	$L_{Aeq,\ 15\ hour}$ 60	$L_{Aeq,\ 9\ hour}$ 55	

For the purpose of assessing likely future road traffic noise from the proposal the $L_{Aeq,\ 1\ hour}$ 55/60dBA (daytime) and $L_{Aeq,\ 1\ hour}$ 50/55dBA (nighttime) assessment goals have been considered.

5.0 METEOROLOGICAL CONDITIONS

Site investigations confirmed that the study areas are subject to seasonal prevailing winds and temperature inversions. It is recognised that the effects of meteorological conditions enhance or reduce noise propagation and noise at distant receptors. In the near field wind has minor influence on measured down wind sound levels. Wind effects become more important as distances increase. Depending on wind speed and distance from a noise source, up wind noise measurement levels compared to down wind conditions can vary by over ±10dBA. Temperature gradients create similar enhancement effects to wind, however the effects are generally less than wind effects and uniform in all directions.

In accordance with *INP* procedures meteorological conditions have been assessed from data provided by *AECOM*.

5.1 Gloucester Area

The meteorological data reported for Gloucester included seasonal day, evening and night data for wind and stability classes *(Attachments 2 and 3)*.

5.1.1 Wind

Table 11 presents a summary of the dominant wind data and the frequency of occurrences.

Table 11: Summary of Wind Direction and Percentage Occurrence

Season	Winds ± ≤ 3m/s with Frequency of Occurrence's ≥ 30%	
	Direction	<3m/sec
Day		
Summer	ENE (± 45º)	27%
Autumn	SSW (± 45º)	24%
Winter	SW (± 45º)	10%
Spring	SE (± 45º)	20%
Evening		
Summer	NE (± 45º)	49%
Autumn	NNW (± 45º)	26%
Winter	WNW (± 45º)	13%
Spring	NW (± 45º)	21%
Night		
Summer	N (± 45º)	41%
Autumn	NW (± 45º)	38%
Winter	WNW (± 45º)	12%
Spring	NW (± 45º)	29%

Referenced to *INP* assessment procedures for seasonal frequency of wind velocities up to 3m/sec. north-east, north and north-west winds require assessment in the noise modelling.

5.1.2 Atmospheric Stability

Table 12 presents summaries of the atmospheric stability class data and frequency of occurrences.

Table 12: Atmospheric Stability Frequency and ELR - Winter Nights

Stability Class	Occurrence Percentage	Estimate ELR °C/100m	Qualitative Description
A	0	<-1.9	Lapse
B	0	-1.9 to -1.7	Lapse
C	0	-1.7 to -1.5	Lapse
D	48.1%	-1.5 to -0.5	Neutral
E	45.7%	-0.5 to 1.5	Weak Inversion
F	6.3%	1.5 to 4.0	Moderate Inversion
G	-	> 4.0	Strong Inversion

From the *INP* assessment procedures referenced to the frequency of occurrence of moderate to strong (1.5 °C/100m to >4.0 °C/100m) inversions is less than 30%. With respect to Class E (weak inversions) the frequency of occurrence is greater than 30% and requires assessment in the noise modelling.

5.2 Hexham/Kooragang Island

Site investigations revealed that the Hexham/Kooragang Island areas are subject to seasonal prevailing winds and temperature inversions. In accordance with *INP* procedures meteorological conditions have been assessed from data collected at the Port Waratah Coal Services *(PWCS)* Kooragang Coal Loader (Kooragang Island).

5.2.1 Wind

The meteorological data reported includes annual and seasonal data for wind and stability classes *(Attachments 3 and 4)*. *Tables 13 and 14* present summaries of the wind data and percentage occurrences of stability classes.

Table 13: Summary of Wind Direction and Percentage Occurrence

Season	Winds ± ≤ 3m/s with Frequency of Occurrence's ≥ 30%		
	Day	Evening	Night-time
Summer	Nil	NE	Nil
Autumn	Nil	Nil	Nil
Winter	Nil	Nil	WNW
Spring	Nil	NNE	Nil

Referenced to *INP* north-east, north-north-east and west-north-west wind effects would be considered as dominant conditions and require assessment.

5.2.2 Atmospheric Stability

Table 14 present summaries of the atmospheric stability class data and frequency of occurrences.

Table 14: Atmospheric Stability Frequency of Occurrence - Winter/Night

Stability Class	Occurrence Percentage	Estimate ELR[1] °C/100m	Qualitative Description
A	0%	<-1.9	Lapse
B	0%	-1.9 to -1.7	Lapse
C	0%	-1.7 to -1.5	Lapse
D	31.4%	-1.5 to -0.5	Neutral
E	17.9%	-0.5 to 1.5	Weak Inversion
F	50.8%	1.5 to 4.0	Moderate Inversion
G	-	> 4.0	Strong Inversion

The *INP* assessment procedures and data assessed moderate (1.5 to 4.0 °C/100m) inversions occur more than 30% and require assessment.

6.0 OPERATIONAL NOISE AND VIBRATION

6.1 Noise and Vibration Sources

The main operational noise sources associated with the project include the *CPF* and *HDS.* The noise from both facilities is expected to be continuous and free from significant tonal and impulsive sources.

It is not expected that operational $L_{A1,\ 1\ mim}$ noise levels emitted from the *GFDA, CPF, GTP* and *HDS* would be greater than 5-10dBA above the operational L_{Aeq} levels or exceed the *DECCW* sleep disturbance assessment goals.

No operational vibration sources have been identified that are likely to generate ground vibration at exposed receptors.

6.1.1 CPF Plant

The *CPF* plant would include five (5) three (3) MW gas powered generators, eight (8) compressors, eight (8) compressor cooling fan systems, pumps and valves. *Table 15* presents a summary of plant and measured sound power data provided by the manufacturer, which have been adopted for noise modelling and assessing compliance with the project noise goals. The data summarised in *Table 15* assumes that the generators and compressors are installed in individual acoustic enclosures and the fin cooling fans selected on noise performance and that there would be no significant tonal or low frequency noise characteristics. No allowance for low frequency noise has been assumed in the noise modelling. When the final operational specifications for the *CPF* are determined, the acoustic parameters would be reviewed and noise control requirements determined.

Table 15. Plant Sound Power Levels (CPF)
dB 10^{-12} Watts

Plant Description	Sound Power Levels 10^{-12} Watts									Lw
	31	62	125	250	500	1K	2K	4K	8K	dBA
Central Processing Facility										
Compressor	116	104	98	92	85	77	72	64	53	89
Compressor Fin Fan Cooler	-	100	99	96	91	89	82	77	71	94
Compressor Exhaust	-	88	72	65	69	72	68	63	61	75
Power Generator	117	111	115	109	95	92	92	94	94	105
Power Generator Exhaust	105	99	103	97	83	80	80	82	82	93

6.1.2 HDS Equipment

Operational noise from the *HDS* would be dependent on design factors including the number of process trains, gas flow pressure and velocities, valve types, pipe sizes and the location of bends and valves. *Table 16* presents a summary of manufactures and measured sound power data adopted for noise modelling and assessing compliance with the project noise goals. As the distribution station design would be site specific and dependent on final operational specifications the design and noise control requirements would be determined during the detail design phase.

Table 16. Plant Sound Power Levels (HDS)
dB 10^{-12} Watts

Plant Description	Sound Power Levels 10^{-12} Watts									Lw
	31	62	125	250	500	1K	2K	4K	8K	dBA
Hexham Delivery Station										
High Flow Rate										
Water bath heater 1	92	102	108	111	114	114	113	113	111	120
Water bath heater 2	92	102	108	111	114	114	113	113	111	120
Dry Gas Filters	94	104	110	113	116	116	115	115	113	122
Meters	92	102	108	111	114	114	113	113	111	120
Flow Control Stage 1	74	84	90	93	96	96	95	95	93	102
Flow Control Stage 2	82	92	98	101	104	104	103	103	101	110
Low Flow Rate										
Water bath heater 1	65	75	81	84	87	87	86	86	84	93
Water bath heater 2	65	75	81	84	87	87	86	86	84	93
Dry Gas Filters	44	54	60	63	66	66	65	65	63	72
Meters	65	75	81	84	87	87	86	86	84	93
Flow Control Stage 1	69	79	85	88	91	91	90	90	88	97
Flow Control Stage 2	77	87	93	96	99	99	98	98	86	105

6.2 Noise Modelling Procedure

Noise from the two *CPF* sites was modelled with the *DECCW* approved Environmental Noise Model *(ENM)* computer model. The model considers attenuation factors including distance, ground absorption, atmospheric absorption, topographical features of the area and normal operating conditions.

Section 5.3.1 of the *INP* guidelines recommends that atmospheric stability and wind effects be assessed when they occur for 30% of the time or more in any assessment period or season. Considering the meteorological and seasonal wind data *(Section 5)*, calm conditions and north, northeast and northwest winds have been assessed together with temperature gradients of 2°C/100m. The meteorological scenarios modelled are outlined below:

- Condition 1: Calm (day/evening): RH 60%, and 20°C;
- Condition 2: Northeast wind (summer/evening): 2m/sec, RH 60%, and 20°C;
- Condition 3: North wind (summer/night): 2m/sec, RH of 60%, and 15°C;
- Condition 4: Northwest wind (autumn/night): 2m/sec, RH 60%, and 15°C;
- Condition 5: Northwest wind (spring/night): 2m/sec, RH 60%, and 15°C;
- Condition 6: Temperature gradient 2°C/100m, RH 60%, and 15°C, and
- Condition 7: Temperature gradient of 2°C/100m, 2m/sec northwest wind, RH 60%, and 15°C.

6.3 CPF Noise Predictions

Noise contours plots produced from the ENM modelling are presented in *Attachment 4 CPF Site 7 and CPF Site 1* for calm wind conditions. The contours are presented for descriptive and visual purpose only. For assessment purposes the closest residential dwellings were evaluated and reference locations *(Attachments 4)* selected to model and assess operational noise contributions *(Tables 17 and 18)*.

Table 17: Predicted Sound Pressure Level Contributions CPF Site 7
L_{Aeq} re: 20 x 10^{-6} Pa

Reference Location	Predicted Sound Pressure Level Contributions							Project Noise Goal
	Meteorological Conditions							
	1	2	3	4	5	6	7	
R2/P1	28	25	23	24	24	29	25	**36**
R1/P2	38	42	41	36	36	41	37	**42**
R8/P3	**40**	**46**	**44**	**39**	**39**	**43**	**42**	**37**
P4	26	32	32	30	30	30	31	**35**
P5	26	32	33	32	32	30	32	**35**
P6	31	35	**36**	35	35	34	**36**	**35**

1. Calm: relative humidity of 60%, and air temperature of 20°C;
2. Northeast wind (summer/evening): 2m/sec, relative humidity of 60%, and air temperature of 20°C;
3. North wind (summer/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
4. Northwest wind (autumn/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
5. Northwest wind (spring/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
6. Temperature gradient 2°C/100m elevation, relative humidity of 60%, and air temperature of 15°C, and
7. Temperature gradient of 2°C/100m elevation, 2m/sec northwest wind, relative humidity of 60%, and air temperature of 15°C.

Table 18: Predicted Sound Pressure Level Contributions CPF Site 1
L_{Aeq} re: 20 x 10^{-6} Pa

Reference Location	Predicted Sound Pressure Level Contributions							Project Noise Goal
	Meteorological Conditions							
	1	2	3	4	5	6	7	
P7	29	31	30	27	27	30	29	**36**
R5/P8	34	34	32	30	30	34	32	**36**
P9	30	32	32	31	31	31	31	**35**
R4/P10	**44**	**45**	**46**	**45**	**45**	**45**	**46**	**36**
P11	24	21	24	27	27	26	29	**36**
P12	31	27	29	34	34	35	**37**	**36**
R7/P13	28	24	26	30	30	30	31	**36**

1. Calm : relative humidity of 60%, and air temperature of 20°C;
2. Northeast wind (summer/evening): 2m/sec, relative humidity of 60%, and air temperature of 20°C;
3. North wind (summer/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
4. Northwest wind (autumn/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
5. Northwest wind (spring/night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
6. Temperature gradient 2°C/100m, relative humidity of 60%, and air temperature of 15°C, and
7. Temperature gradient of 2°C/100m, 2m/sec northwest wind, relative humidity of 60%, and air temperature of 15°C.

6.4 HDS Noise Predictions

Noise contour plots produced from the ENM modelling are presented in *Attachment 5* for calm wind conditions. The contours are presented for descriptive and visual purpose only. For assessment purposes the closest residential dwellings were evaluated and reference locations selected to model and assess operational noise contributions *(Table 19).* The meteorological scenarios modelled are outlined below:

- Condition 1: Calm: RH 60%, and 20°C;
- Condition 2: Northeast wind (evening): 2m/sec, RH 60%, and 20°C;
- Condition 3: North-north-east wind (evening): 2m/sec, RH of 60%, and 20°C;
- Condition 4: West-north-west wind (night): 2m/sec, RH 60%, and 15°C;
- Condition 5: Temperature gradient 4°C/100m, RH 60%, and 15°C, and
- Condition 6: Temperature gradient of 4°C/100m, 2m/sec west-north-west wind, RH 60%, and 15°C.

Table 19: Predicted Sound Pressure Level Contributions (HDS)

L_{Aeq} re: 20 x 10^{-6} Pa

Reference Location	Description	Predicted Sound Pressure Level Contributions						Project Noise Goals
		Meteorological Conditions						
		1	**2**	**3**	**4**	**5**	**6**	
High Volume Flow								
R9/P15	Caravan Park	34	30	30	44	38	**49**	45
P16	Punt Road	**68**	**65**	**66**	**70**	**69**	**70**	43
R10/P17	Old Maitland Road	**59**	**59**	**60**	**63**	**60**	**65**	43
Low Pressure Flow								
R9/P15	Caravan Park	14	9	10	24	19	30	45
P16	Punt Road	**46**	41	42	**47**	**47**	**48**	43
R10/P17	Old Maitland Road	35	34	36	41	36	43	43

1. Calm : relative humidity of 60%, and air temperature of 20°C;
2. Northeast wind (evening): 2m/sec, relative humidity of 60%, and air temperature of 20°C;
3. North North East wind (evening): 2m/sec, relative humidity of 60%, and air temperature of 20°C;
4. West North West (night): 2m/sec, relative humidity of 60%, and air temperature of 15°C;
5. Temperature gradient 4°C/100m elevation, relative humidity of 60%, and air temperature of 15°C, and
6. Temperature gradient of 4°C/100m elevation, 2m/sec northwest wind, relative humidity of 60%, and air temperature of 15°C.

6.5 Assessment

6.5.1 CPF Sites

The noise modelling summarised in *Table 17* for *CPF Site 7* show that the recommended project noise goals are exceeded at P3. A marginal (1dBA) noise exceedance is predicted at P6 when the effects of prevailing north winds and temperature inversions are considered. The noise modelling results identified that the generators, compressors and compressor cooling fin fans contribute to the predicted noise exceedances. To achieve an additional 9-10dBA cumulative noise reduction, the generator and compressor noise controls require upgrading. Management options that could be considered to reduce the site noise emissions include upgraded acoustic treatments, and built structures around the generators and compressors.

The noise modelling summarised in *Table 18* for *CPF Site 1 show* that the project noise goals are exceeded at P11 for calm and adverse meteorological conditions. The plant contributing to the predicted noise exceedances include the generators, compressors and compressor cooling fin fans. To achieve the 10dBA site noise reduction, the generator and compressor enclosures and compressor cooling fin fan noise controls would require upgrading and/or secondary noise control structures.

6.5.2 HDS

The noise predictions summarised in *Table 19* show that the project noise goals are exceeded at the closest residential properties for calm and adverse meteorological conditions. With respect to the site boundaries that are shared with industrial and commercial properties the project noise goals *(65-75dBA)* are exceeded without the inclusion of secondary noise controls. The main sources contributing to the predicted noise exceedances include the valves, fittings and radiated noise from pipe trains. As the distribution station design would be site specific and dependent on final operational specifications the design and noise control requirements would be determined during the detail design phase. Secondary controls could include the reselection of valves and fittings, design of pipe trains to reduce velocities and turbulence, lagging pipes and acoustic rated compound walls/mounds.

6.5.3 Comments

As part of the project design, development and assessment when final details of the plant and equipment are specified and the project noise goals confirmed, a more detailed noise assessment would be undertaken to establish and confirm the extent of noise mitigation required for the *CPF* and *HDS* . During the detailed project design phase, the acoustic investigations would assess for the need to adjust the source noise to account for tonality, impulsiveness, intermittency, irregularity or low-frequency content.

7.0 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT GOALS

For major construction projects undertaken in New South Wales the *DECCW* recommend procedures for assessing noise and vibration impacts. Publications released and referred to by the *DECCW* with reference to the assessment of construction noise and vibration impacts include the *Interim Construction Noise Guideline (2009)* and *Assessing Vibration: a technical guideline.*

7.1 DECCW, Interim Construction Noise Guideline

The Interim Construction Noise Guideline *(ICNG)* was developed by the *DECCW* in response to concerns raised with respect to construction noise impacts. The primary objective of the *ICNG* is aimed at managing noise from construction works regulated by the *DECCW.* The guideline deals with procedures to:

- promote a clear understanding of ways to identify and minimise noise from construction works;
- focus on applying all 'feasible and reasonable' work practices to minimise construction noise impacts;
- encourage construction to be undertaken during recommended hours;
- streamline the assessment and approval stages
- reduce time spent dealing with complaints at the project implementation stage; and
- provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

The *DECCW* recognise that feasible work practices are practical to implement, while reasonable work practices take into account the balance of costs and benefits and community views. Work practices recommended by the *DECCW* can include notifying the community of expected noise impacts and when they are expected to occur.

The procedures and recommendations published in the *ICNG* for assessing noise from construction activities are best regarded as planning tools. They are not mandatory, and their application for assessing construction noise is not determined purely on the basis of compliance or otherwise with numerical noise levels.

For the purpose of assessing and managing noise impact the *ICNG* procedures refer to the proposed construction hours and the duration of the works. For construction works extending more than three (3) weeks a 'quantitative assessment method' is recommended. For construction works that are unlikely to affect an individual or sensitive land use for more than three (3) weeks in total, the *ICNG* refers to a 'qualitative assessment method'.

7.1.1 Construction Hours

The recommended standard hours for construction are summarised in *Table 20.* Albeit the *DECCW* recognise that the recommended hours are not mandatory and that there would be situations, where construction works are undertaken outside of these hours.

Table 20. Recommended Standard Construction Hours

Work Type	Recommended Standard Hours of Work*
Normal Construction	Monday to Friday 7.00am to 6.00pm Saturday 8.00am to 1.00pm No works on Sundays or public holidays
Blasting	Monday to Friday 9.00am to 5.00pm Saturday 9.00am to 1.00pm No blasting on Sundays or public holidays

* The relevant authority (consent, determination or regulatory) may impose more or less stringent construction hours

7.1.2 Quantitative Assessment Method

The *ICNG* *(Chapter 4)* refers to quantitative assessment methods involving predicted noise levels and comparing them with levels developed from Chapter 4 of the Guideline. For assessment purposes the Rating Background Level *(RBL)* is used when determining the management assessment level. *Table 21* sets out noise management levels at residences and how they are applied. Restrictions to construction hours may apply to activities that generate noise at residences above the 'highly noise affected ' noise management level.

Table 21. Noise at Residences (Quantitative Assessment)

<table>
<tr><th>Time of Day</th><th>Management Level LAeq (15 min)</th><th>How to Apply</th></tr>
<tr><td rowspan="2">Recommended standard hours:
Monday to Friday 7.00am to 6.00pm
Saturday 8.00am to 1.00pm
No works on Sundays or public holidays</td><td>Noise affected RBL+10dB</td><td>The noise affected level represents the point above which there may be some community reaction to noise.
• Where the predicted or measured LAeq 15min is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.
• The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details</td></tr>
<tr><td>Highly noise affected 75</td><td>The highly noise affected level represents the point above which there may be strong community reaction to noise.
• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:
1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences.
2. If the community is prepared to accept longer period of construction in exchange for restrictions on construction times</td></tr>
<tr><td>Outside recommended standard hours</td><td>Noise affected RBL+5</td><td>• A strong justification would typically be required for works outside the recommended standard hours
• The proponent should apply all feasible and reasonable work practices to meet the noise affected level
• Where feasible and reasonable practices have been applied and noise is more than 5 above the noise affected level, the proponent should negotiate with the community</td></tr>
</table>

* Noise levels apply at the residential property boundary that is most exposed to construction noise. If the property boundary is more than 30m from the residence the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence.

For other noise sensitive land uses, such as schools, hospitals, etc *Table 22* presents management levels based on the principle that the characteristic activity for each of these land uses should not be unduly disturbed. Internal levels referenced in *Table 22* are to be assessed at the centre of the occupied room. External levels are to be assessed at the most affected point within 50m of the area boundary. Where internal noise levels cannot be measured adjusted external levels are recommended.

Table 22. Noise at Other Sensitive Receptors (Quantitative Assessment)

Land Use	**Management Level LAeq (15 min)**	
	Internal	**External**
Classrooms at schools and other educational institutes	45	55
Hospital wards and operating theatres	45	55
Places of worship	45	55
Active recreation areas	-	65
Passive recreation areas	-	60
Industrial premises	-	75
Office, retail outlets		70
Community centres	Refer to AS2107**	

* External levels measured within 50m of property boundary.
** Refer to recommended 'maximum' internal levels in AS2107 for specific uses.

7.1.2(a) Sleep Disturbance at Residences

Where construction works are planned to extend over more than two consecutive nights, and a quantitative assessment method is used, the *ICNG* recommends that the analysis include the assessment of maximum noise levels, and the extent and number of time that the maximum noise level are likely to exceed the *RBL*.

7.1.3 Qualitative Assessment Method

The qualitative method for assessing noise is used for construction sites that are not likely to affect an individual or sensitive land use for more than three (3) weeks. Where residences may be affected by noise, work practice methods should be considered and a community notification program be implemented together with a Noise Management Plan.

7.1.4 Project Construction Noise Goals

Considering the *ICNG* and the measured *RBLs,* the target assessment goals recommended for evaluating construction noise from the *GFDA, CPF's and HDS* are summarised in *Table 23*.

For assessment purposes construction noise is assessed at a height of 1.5m above ground level at a residential property boundary or thirty (30) metres from a residential dwelling, if the boundary is more than thirty (30) metres from the dwelling.

Table 23: Construction Noise Target Goals – dBA 20×10^{-6} Pa

Period	Sound Pressure Levels				
	Existing RBL	Existing Amenity Level L_{Aeq}	Daytime Noise Goal L_{Aeq}	Evening Noise Goal L_{Aeq}	Night Noise Goal L_{Aeq}
STAGE 1- GAS FIELD DEVELOPMENT AREA					
GFDA					
Reference Measurement Location R1/P2.					
Day	37.6	57.1	48		
Evening	40.0	52.2		45	
Night	37.2	47.4			42
Reference Measurement Location R2/P1.					
Day	32.1	49.6	42		
Evening	35.3	48.6		40	
Night	31.4	46.8			36
Reference Measurement Location R3.					
Day	32.5	58.8	43		
Evening	34.1	45.5		37	
Night	29.9	46.0			35
Reference Measurement Location R4/P10.					
Day	30.4	49.7	40		
Evening	32.2	39.8		35	
Night	31.3	43.4			35
Reference Measurement Location R5/P8.					
Day	30.6	56.1	41		
Evening	31.5	52.7		36	
Night	31.1	49.9			36
Reference Measurement Location R6.					
Day	29.7	53.3	40		
Evening	33.2	51.3		35	
Night	32.2	47.4			35
Reference Measurement Location R7/P13.					
Day	31.6	57.1	42		
Evening	32.8	45.4		37	
Night	31.3	46.4			36

CPS Site 1					
Reference Measurement Location R4/P10.					
Day	30.4	49.7	40		
Evening	32.2	39.8		35	
Night	31.3	43.4			35
Reference Measurement Location R5/P8.					
Day	30.6	56.1	41		
Evening	31.5	52.7		36	
Night	31.1	49.9			36
Reference Measurement Location R7/P13.					
Day	31.6	57.1	42		
Evening	32.8	45.4		37	
Night	31.3	46.4			36

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays

Table 23: Construction Noise Target Goals
dBA 20 × 10^{-6} Pa

Period	Sound Pressure Levels				
	Existing RBL	Existing Amenity Level L_{Aeq}	Daytime Noise Goal L_{Aeq}	Evening Noise Goal L_{Aeq}	Night Noise Goal L_{Aeq}
CPS Site 7					
Reference Measurement Location R1/P2.					
Day	37.6	57.1	48		
Evening	40.0	52.2		45	
Night	37.2	47.4			42
Reference Measurement Location R2/P1.					
Day	32.1	49.6	42		
Evening	35.3	48.6		40	
Night	31.4	46.8			36
Reference Measurement Location R8/P3.					
Day	34.5	57.1	45		
Evening	35.2	52.2		40	
Night	34.5	47.4			40
HEXHAM DELIVERY STATION					
Reference Measurement Location R9/P15.					
Day	49.9	55.4	60		
Evening	47.5	55.2		53	
Night	45.7	55.1			53
Reference Measurement Location R10/P17.					
Day	43.7	56.0	54		
Evening	45.3	51.8		50	
Night	39.7	52.9			45

Notes: Daytime: 7.00am to 6.00pm Monday to Saturday, 8.00am to 6.00pm Sunday and Public Holidays.
Evening: 6.00pm to 10.00pm.
Night: 10.00pm to 7.00am Monday to Saturday, 10.00pm to 8.00am Sunday and Public Holidays

7.2 Ground Vibration

As part of the site preparation rock may be encountered and accordingly rock hammers and or small explosive charges may be required. The effect of vibration on humans and structures is normally considered and evaluated in terms of annoyance and structural damage.

7.2.1 Annoyance

The *DECCW*, *Assessing Vibration: a technical guideline* recommends goals for assessing human response and potential disturbance to the occupants of buildings. *Table 24* presents a summary of velocity levels (rms) referenced to specific frequency bands adjusted by multiplying factors for residential receptors referenced to human response *(BS 6472-1992. Figure B1.4).*

Table 24: Vibration Levels for Assessment of Human Comfort

Frequency (Hz)	Vibration Level (mm/s)			
	Continuous Vibration		Intermittent Vibration	
	Day (2)	Night (1.4)	Day (60)	Night (90)
1	3.2	2.2	95	31
1.25	2.3	1.6	68	22
1.6	1.6	1.1	47	15
2	1.1	0.8	33	11
2.5	0.8	0.6	24	8.0
3.15	0.6	0.4	17	5.8
4	0.4	0.3	19	4.0
5	0.3	0.2	9.5	3.2
6.3	0.3	0.2	7.6	2.5
8	0.2	0.1	6.0	2.0
10	0.2	0.1	6.0	2.0
12.5	0.2	0.1	6.0	2.0
16	0.2	0.1	6.0	2.0
20	0.2	0.1	6.0	2.0
25	0.2	0.1	6.0	2.0
31.5	0.2	0.1	5.4	1.8
40	0.2	0.1	6.0	2.0
50	0.2	0.1	6.0	2.0
63	0.2	0.1	6.0	2.0
80	0.2	0.1	6.0	2.0

7.2.2 Perception

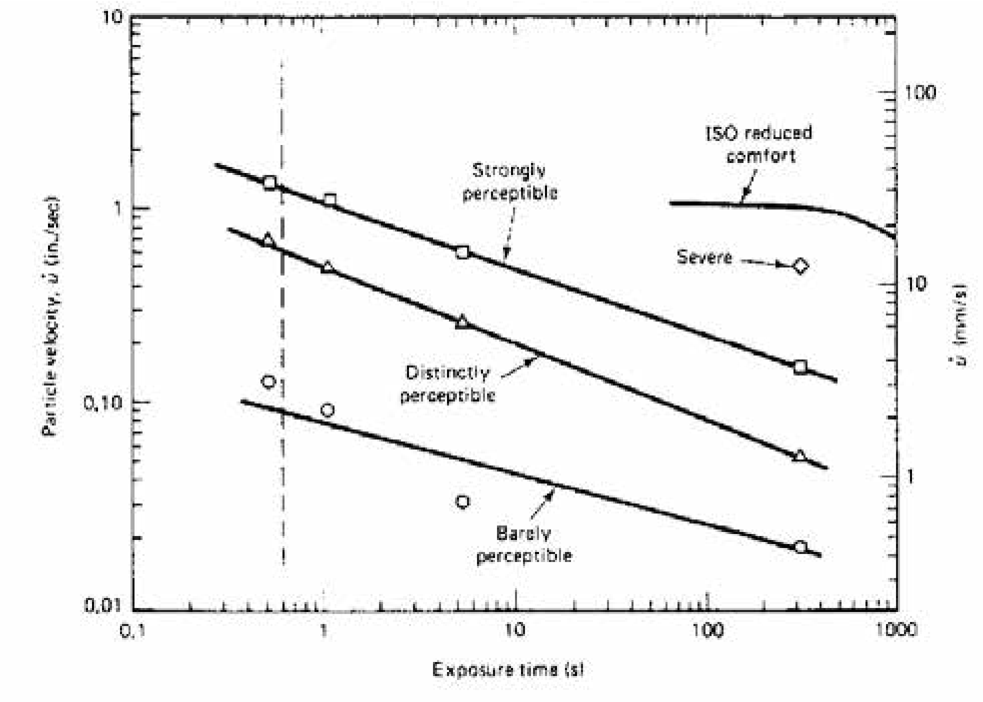
For comparison of vibration in terms of human response, *Table 25* presents a summary of levels referenced to likely perception.

Table 25: Human Perception of Vibration
Ref: German Standard DIN 4150 (1986)

Vibration Levels mm/sec	Likely Perception
0.15	Perception Threshold
0.35	Barely Noticeable
1.0	Noticeable
2.2	Easily Noticeable
6.0	Strongly Noticeable
14.0	Very Strongly Noticeable

Figure 6 compares human response to vibration levels and exposure. The data in *Figure 6* demonstrates that short duration vibration exposure levels are less perceptible than longer continuous levels.

Figure 6: Human Response to Vibration



7.2.3 Structural Damage

German Standard DIN4150 Part 3 (1986) provides guidelines for evaluating the effects of vibration on structures. The values recommended in the standard are summarised in *Table 26*. The values are the maximum levels measured in any direction at the building foundation.

Table 26: Safety Limits for Structural Damage

Type of Structure	**Vibration Level (mm/s)**		
	< 10Hz	**10Hz to 50Hz**	**50Hz to 100Hz**
Commercial/industrial buildings or buildings with similar design	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20
Structures of great intrinsic value (eg. buildings under preservation)	3	3 to 8	8 to 10

Ref: German Standard DIN4150

7.3 Blast Assessment Goals

Guidelines documented in the *ANZECC "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration*" and *ENCM* [Chapter 154] are normally used to establish goals for assessing blast air-blast overpressure and ground vibration.

7.3.1 Air-blast Overpressure

The *DECCW/ANZECC* recommends a level 115dBLin for the assessment of air-blast overpressure at residential dwellings and commercial premises. The *DECCW* allows this level to be exceeded by up to 5% of the total blasts over a period of 12 months, with a maximum limit of 120dBLin.

7.3.2 Ground Vibration

The *DECCW/ANZECC* ground vibration goal for residential is 5mm/sec (peak particle velocity). The *DECCW* normally allow this level to be exceeded by up to 5% of the total number of blasts over a period of 12 months with a maximum limit of 10mm/s.

7.3.3 Blast Project Assessment Goals

From the *DECCW/ANZECC* recommendations, *Table 27* provides a summary of the recommended blast assessment goals.

Table 27: Assessment Goals for Blasting

Assessment Location	Air-blast Overpressure dBLin		Ground Vibration PPV mm/s	
	Recommended	**Maximum Allowable**	**Recommended**	**Maximum Allowable**
Residential/Commercial Buildings	115	120	5	10

For assessment of air-blast overpressure the *DECCW/ANZECC* recommends measurement at any sensitive receiver be at least three point five (3.5) metres from a building or structure, and ground vibration measured at any point at least the longest dimension of the foundations of a building or structure away from the building or structure.

8.0 CONSTRUCTION PLANT NOISE and VIBRATION SOURCES

The main construction activities envisaged include: access track construction, vegetation clearing, drilling, fraccing, trenching, concreting, structure erection, pipe preparation, pipe installation and plant installation.

8.1 Overview of Construction Activities

The construction sequence would generally be conducted as follows, however subject to the work program some activities may be conducted concurrently at multiple locations.

8.1.1 Gas Field Development Area Construction

At wellhead locations in the *GFDA* single and multiple vertical wells are anticipated *(Figure 1)*. Wells would be drilled using conventional truck mounts drilling rigs and completed with required down hole and surface equipment after being "fracced" to stimulate gas and water flow. The process would comprise the following activities:

- site preparation;
- production well drilling;
- production casing running and cementing;
- fraccing;
- installation of pumps and surface facilities, and
- site cleanup and rehabilitation.

8.1.2 Central Processing Facility

The *CPF* site would require an access road to be constructed, site establishment, preparation for foundations, the erection of structures and the installation of the support plant and equipment. The process would comprise the following activities:

- site preparation;
- foundation preparation;
- concrete pours;
- erection of structures; and
- installation of plant and surface facilities, and site cleanup.

8.1.3 Gas Transmission Pipeline Construction

Much of the route is located on cleared rural land and would not require further clearing, however where the route deviates over timbered land, clearing would be required. Clearing would be conducted in small teams utilising hand tools such as chain saws and the like where appropriate. Where large trees are identified, graders and bulldozers may be utilised to remove entire trees including stumps. Where possible, all vegetation would be mulched.

The envisaged sequence of construction activities for the pipeline include:

- site access and clearing;
- site leveling using graders, excavators and bulldozers;
- trenching with a specialist trencher or excavator;
- pipe stringing – delivery of pipes adjacent to the trench;
- welding – welding of continuous strings up to 1 km in length;
- lowering-in and backfill.

Where required, preparation of the working areas would utilise a front-end loader and/or dozer. Should rock be encountered use of rock hammers or small explosive blast may be required.

8.1.4 Hexham Delivery Station

The *HDS* site would require minor site preparation works, foundations, the erection of structures, pipe work and valves. The process would comprise the following activities:

- site preparation;
- foundation preparation;
- erection of structures;
- welding, installation of plant and surface facilities, and
- site cleanup.

8.2 Construction Equipment Noise Emission Levels

For the assessment of noise from the envisaged construction activities, the following plant noise levels (*Table 28*) have been considered.

Table 28: Plant Schedules and Sound Power Levels
dBA re: 10^{-12} Watts

Item	Type	Number of Items	Sound Power Level L_{Aeq}
GFDA			
Access Track Construction			
Dozer	Tracked	1	109
Grader		1	103
Dump Truck		1	105
Vibrating Roller		1	106
Water Cart		1	103
		Total	**114**
Vegetation Clearing			
Timber Shredder	Truck mounted	1	118
Excavator	Tracked	1	106
Dozer	Tracked	1	109
Chainsaw		1	110
		Total	**119**
Site Preparation/Clean Up			
Excavator	Tracked	1	106
Water Cart		1	103
Grader		1	103
Dozer	Tracked	1	109
Truck		1	105
		Total	**113**
Production Well Construction			
Generator	Diesel	1	103
Forklift		1	105
Drill Rig		1	112
Crane		1	104
Concrete Vibrator		1	105
Concrete Truck/Pump		1	106
		Total	**115**
Fraccing			
Generator	Diesel	1	103
Reticulating Pumps		4	124
Mountain Mover		1	123
V12 Pump		4	117
		Total	**127**
Gas Gathering Line Installation			
Trenching machine		1	105
Excavator	Tracked	1	106
Grader		1	103
		Total	**109**

Table 28: Plant Schedules and Sound Power Levels. Cont'd.
dBA re: 10^{-12} Watts

Item	Type	Number of Items	Sound Power Level L_{Aeq}
Central Processing Facility			
Access Track Construction			
Dozer	Tracked	1	109
Water Cart		1	103
Vibrating Roller		1	106
Grader		1	103
		Total	**112**
Earthworks (Site Preparation/Clean Up)			
Excavator	Tracked	2	109
Water Cart		1	103
Truck		2	108
Vibrating Rollers		2	109
Grader		1	103
Dozer	Tracked	2	112
		Total	**116**
Civil and Construction			
Grader		1	103
Excavator		2	109
Bobcats		2	105
Forklift		1	103
Piling Rig		1	116
Water Cart		1	103
Concrete Vibrator		1	105
Concrete Truck/Pump		1	106
Crane		2	107
Generator		1	103
		Total	**119**
Gas Transmission Pipeline			
Access Track Construction			
Grader		1	103
Water Cart		1	103
		Total	**108**
Vegetation Clearing			
Timber Shredder		1	118
Grader		1	103
Dozer	Tracked	2	109
Chainsaw		1	110
		Total	**119**
Earthworks (Site Preparation/Clean Up)			
Grader		1	103
Dozer	Tracked	1	109
Water Cart		1	103
Truck		1	105
		Total	**112**

Table 28: Plant Schedules and Sound Power Levels. Cont'd.
dBA re: 10^{-12} Watts

Item	Type	Number of Items	Sound Power Level L_{Aeq}
Pipeline Installation			
Trenching Machine		1	105
Excavator		1	106
Rock Saw		1	102
Side booms		3	104
Padding Machine		1	104
Grader		1	103
Water Cart		1	103
Truck		1	105
Diesel Generator		1	103
		Total	**113**
Hexham Delivery Station			
Access Construction			
Grader		1	103
Water Cart		1	103
		Total	**106**
Earthworks (Site Preparation/Clean Up)			
Dozer	Tracked	1	109
Grader		1	103
Vibrating Roller		1	106
Water Cart		1	103
Truck		1	105
		Total	**113**
Civil and Construction			
Piling Rig		1	116
Water Cart		1	103
Bobcat		1	102
Concrete Truck/Pump		1	106
Crane		2	107
Truck		1	105
		Total	**117**

8.3 Construction Equipment Vibration Emission Levels

During the excavation and construction activities associated with access tracks and preparation of trenches, it may be necessary to use plant and equipment that would generate ground vibration. To evaluate the likely effects of the construction activities, the following vibration levels (*Table 29*) have been considered.

Table 29: Typical Plant Vibration Levels mm/sec

Plant Description	Vibration Levels mm/sec		
	@ 5m	@ 20m	@ 40m
Rock-breaker (large)	5	0.5	0.3
Rock breaker (light)	1	0.3	0.1
Dozer	2	0.2	0.02
Truck	1	0.05	0.02

9.0 CONSTRUCTION NOISE and VIBRATION IMPACT ASSESSMENT

9.1 Construction Noise Predictions

A summary of predicted noise levels for typical construction activities at reference distances is presented in *Tables 30-31*. The modelling assumed the plant schedules referenced in *Table 28* with no account of additional attenuation from topography or ground absorption. To assist with the identification of typical residential receptors potentially exposed to noise from the well construction sites and the noise levels summarised in *Tables 30, 32-43, Figure 1* identifies the extent of the *CFDA* and well locations.

9.1.1 Gas Field Development Area

Construction stages across the *GFDA* for each well site would include site preparation, drilling, fraccing, installation of plant and site cleaning up. The construction noise target goals *(Table 23)* established for these works are 40/43dBA (day), 35/37dBA (evening) and 35/36dBA (night). *Table 30* presents the calculated noise levels from each phase.

Table 30: Predicted Construction Noise Levels (GFDA)
L_{Aeq} re: 20×10^{-6} Pa

Construction Activity	Distance from Construction Activity (m)						
	25m	100m	250m	500m	1000m	2000m	3000m
Access Track Construction	78	66	58	52	46	40	36
Vegetation Clearing	83	71	63	57	51	45	41
Site Preparation/Clean Up	77	65	57	51	45	39	35
Production Well Construction	79	67	59	53	47	41	37
Fraccing	91	79	71	65	59	53	49
Gas Gathering Line Installation	73	61	53	47	41	35	31

Noise controls and mitigation requirements during the *GFDA* construction would be considered on a site-specific basis and managed in accordance with a Noise Management Plan. As part of the NMP additional ambient background noise monitoring would be undertaken to confirm site specific target assessment goals. For the purpose of this assessment the range of ambient background noise levels presented in *Table 23* have been adopted to develop target noise assessment goals

Modelling has shown that noise levels from access track construction and vegetation clearing could exceed the daytime target assessment goal (40/43dBA) at a number of residential properties. The access track establishment activities for each site would be short term (1-3 days) and restricted to daytime hours.

During site preparation, including drilling and well construction noise levels are predicted to exceed the daytime target assessment goal (40/43dBA) at exposed properties. Noise from the drilling operations during evening and nighttime hours is predicted to exceed the target assessment goals (35/37dBA (evening) and 35/36dBA (night) at the closest exposed residential properties without additional noise controls. With respect to noise from drill rigs, investigations and audit measurements have shown that noise typically exhibits directional characteristics. Particularly noticeable is that the noise at the 'rear' or the drive side of rigs is 8-10dBA higher than at the 'front'. Noise measurements 40-50 metres back from drilling rigs have shown that the 'front' to the 'rear' directional characteristics reduce to 6-8dBA. With consideration to site establishment and rig orientation for sensitive receiver locations, effective noise reductions are readily available. General principles available to reduce noise from drilling activities involve maximising benefits from directivity characteristics of drilling rig, location of site offices, control rooms and other ancillary buildings to provide shielding, 'cut & fill' operations in the formation of the work pad to maximise shielding effects and the location of excavated fill material and/or installation of temporary noise walls. Where practical and feasible, plant selections, temporary noise controls and work practices would be considered to minimise noise exposure and impacts. With the adoption of acoustic screens, work practices and plant with acoustic enclosures significant noise reductions can be readily achieved.

Noise modelling for fraccing activities has shown that the daytime (40/43dBA) and evening (35/37dBA) target noise goals are likely to be exceeded at exposed residential properties. Noise from the fraccing process can be reduced with secondary noise controls including orientation of equipment, portable acoustic screens, work practices and barriers. With respect to the fraccing activities for each well site, the fraccing itself would be limited to three-four (3-4) hours. To further manage noise exposure during the fraccing operation, it is recommended that consultation be undertaken with affected landowners.

The *GFDA* noise controls and mitigation requirements would be considered on a site-specific basis and managed in accordance with a Noise Management Plan. Well site construction would be undertaken with the goal of achieving compliance with relevant criteria. Where compliance cannot be achieved with all feasible and reasonable mitigation in place, consultation would be undertaken with the affected receptor to manage noise impacts during construction. Options such as restricting the use of plant/equipment and timing of activities likely to generate significant noise impacts would also be considered to minimise noise exposure.

9.1.1(a) Sleep Disturbance Noise Predictions

Noise from possible intermittent activities include metal/metal contact, hammering, etc associated with nighttime drilling was modelled with a source sound power level of 110-115dBA. The predicted levels in *Table 31* are presented and for assessment can be compared to the target noise goals 45/47dBA. Noise from these activities would be controlled and mitigation requirements considered and managed on a site-specific basis in accordance with a Noise Management Plan.

Table 31: Predicted Construction LA1 Noise Levels (GFDA)
L_{A1} re: 20×10^{-6} Pa

Construction Activity	Distance from Construction Activity (m)			
	250m	500m	1000m	2000m
Intermittent Noise	54-59	48-53	42-47	36-41

9.1.2 Central Processing Facility Construction

The envisaged *CPF* construction stages include site preparation, concrete pours, installation of plant and site cleaning up. The daytime construction noise target goals *(Table 23)* for *CPF Site 1* and *CPF Site 7* are 40/43dBA, 45/48dBA, respectively.

For assessment purposes *Table 32* presents calculated noise levels from each stage of the *CPF* site works.

Table 32: Predicted Construction Noise Levels (CPF)
L_{Aeq} re: 20 × 10 $^{-6}$ Pa

Construction Activity	Distance from Construction Activity (m)						
	25m	100m	250m	500m	1000m	2000m	3000m
Access Track Construction	76	64	56	50	44	38	34
Site Preparation/Clean Up	80	68	60	54	48	42	38
Civil and Construction	83	71	63	57	51	45	41

Noise controls and mitigation requirements would be considered on a site-specific basis and managed in accordance with a Noise Management Plan. Where compliance cannot be achieved at a receptor with all feasible and reasonable mitigation in place, consultation would be undertaken with the affected receptor to manage noise impacts during construction. Options such as restricting the use of certain plant/equipment and timing of activities likely to generate significant noise impacts would also be considered to minimise noise exposure.

9.1.3 Gas Transmission Pipeline Construction

Table 33 presents the calculated noise levels from each phase of the pipeline construction works. Construction would be undertaken in teams on a scrolling basis along the pipeline route. The envisaged duration at any one (1) specific location is expected to be less than three (3) weeks.

Table 33: Predicted Construction Noise Levels (Pipeline)
L_{Aeq} re: 20 × 10 $^{-6}$ Pa

Construction Activity	Distance from Construction Activity (m)						
	25m	100m	250m	500m	1000m	2000m	3000m
Access Track Construction	72	60	52	46	40	34	30
Vegetation Clearing	83	71	63	57	51	45	41
Site Preparation/Clearing	76	64	56	50	44	38	34
Pipe Installation	77	65	57	51	45	39	35

Where practical and feasible, plant selections, temporary noise controls and work practices would be considered to minimise noise impacts. This would typically involve orientation of equipment, staging of activities, shielding and minimisation of simultaneous operations. To ensure noise levels are controlled and impacts managed during construction a Construction Environmental Management Plan *(CEMP)* would be prepared and implemented by the contractors engaged.

Construction of the gas transmission pipeline would also include crossing a number of watercourses and road/rail infrastructure which would require horizontal directional drilling (HDD) and thrust boring techniques. These activities would require twenty four (24) hour construction to maintain the integrity of the borehole. Construction periods of up to two (2) months may also be required. Sufficient detailed design and planning has not yet been undertaken to determine the exact locations of these locations, and would be dependent on factors including crossing depth, pipe diameter, setback distances from the crossing location as well as other design factors.

A noise impact assessment for would be undertaken for HDD and thrust boring activities prior to construction as part of a Noise Management Plan, which would be included within the Construction Environmental Management Plan (CEMP). This would include identification of sensitive receptors, background noise monitoring (if required), prediction of noise levels and design of mitigation measures to manage noise impacts from these construction activities.

9.1.4 Hexham Delivery Station Construction

The construction stages for the Hexham site would include minor site preparation, concrete pours, installation of pipework and site cleaning up. *Table 34* presents the calculated noise levels for each phase of the site works.

Table 34: Predicted Construction Noise Levels (HDS)
L_{Aeq} re: 20 × 10 $^{-6}$ Pa

Construction Activity	Distance from Construction Activity (m)		
	100m	**250m**	**500m**
Access Construction	58	50	44
Site Preparation/Clean Up	65	57	51
Civil and Construction	69	61	55

Noise from the envisaged civil and construction works is predicted to satisfy the target daytime noise goal (54dBA) at the closest residential dwellings on Old Maitland Road (P17) and exceed the goal at P16. With the adoption of acoustic screens, work practices and plant with acoustic enclosures the envisaged civil and construction noise levels are expected to satisfy the target daytime noise goal (54dBA) at P16. Where practical and feasible, plant selections, temporary noise controls and work practices would be considered to minimise noise impacts.

9.2 Overview

To assist providing and understanding of noise impacts and the levels presented above, a summary of typical noise source levels is presented in *Table 35*.

Table 35: Range of Typical Noise Sources.
re: 20×10^{-6} Pa

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

9.3 Traffic Generation

Traffic generated during construction would be associated with construction plant and equipment deliveries and construction workers. Where possible, construction traffic would be restricted to internal road networks created for the project and the pipeline right of way, reducing potential impacts upon the surrounding road network and public roads.

9.3.1 GFDA Traffic

Vehicle movements associated with the initial delivery of plant and equipment for the drilling phase of the development are shown in *Table 36* and expected to comprise up to sixty-two (62) initial heavy vehicle movements to the site over a period of several days. Vehicle movements beyond the initial delivery of drill plant and equipment would largely occur within the *GFDA* with drill rigs and associated plant moving between well sites. Each mobilisation of drilling plant would require some sixty-two (62) heavy vehicle movements. There may be a need for this equipment to travel off-site onto the surrounding local road network in order to access other well sites within the *GFDA*, however this is expected to occur infrequently. Mobilisation of drilling equipment would predominantly occur on the internal *GFDA* road network.

Upon completion of drilling, plant and equipment would be removed from the site involving a further sixty-two (62) movements. Removal of plant and equipment from the site is expected to take several days with vehicle movements being spread over this period. Where possible, deliveries would be made outside of peak transport times, and within the internal road network for the project to minimise potential disturbances to local traffic.

Table 36: Vehicle Movements During GFDA Construction

Item Description	Vehicle/s	Movements
Drilling rigs	Trucks	8-12
Frac equipment	Trucks	14
Frac tanks	Trucks	14
Production equipment	Trucks	4
Cementing equipment	Trucks	8
Water Tankers	8-10 tankers.	10
Total Heavy Vehicle Movements*		**62**
Personnel Transport	6 – 8 per well location	6-8

9.3.2 CPF Traffic

The *CPF* construction would require delivery of construction plant and materials to the site prior to construction and represent the main traffic volumes in respect of the *CPF* facility. The *CPF* construction would also generate some thirty-six (36) light vehicle movements per day over the anticipated construction period of twelve (12) months

Delivery of construction plant and equipment would be staggered to reflect the construction program with the earthmoving equipment delivered to the *CPF* site first. Concrete would then be delivered, followed by the generators, compressor units and other plant. Vehicle movements associated with the delivery of materials to the *CPF* are summarised in the *Table 37*.

Table 37: Vehicle Movements - CPF Plant and Materials

Description	Delivery Vehicle	Movements to Site	Movements from Site
Compressor Skids (8 Units)	1 low loader per unit with escorts	8	8
	2 low loaders with escorts	16	16
	One Truck	8	8
	One Truck	8	8
Dehydration Skids	One Truck	2	2
	One Truck	2	2
	One Truck	2	2
Miscellaneous containers and Equipment	One Truck per delivery	3 per week	3 per week
Concrete Delivery	275 Truck deliveries	9 per day	9 per day
Equipment transport	2 trucks	2 per day	2 per day
Personnel transport	18 light vehicles	18 per day	18 per day

9.3.3 GTL Traffic

Vehicle movements on public roads associated with the construction of the pipeline would be largely generated through the initial delivery of plant, equipment and materials. In relation to the pipeline construction, there is expected to be three laydown areas along the pipeline route, spaced at roughly equal intervals. Construction materials, including the pipeline itself would be delivered to these laydown areas and stored until required for use. The laydown areas would be located on private land in consultation with relevant landowners. Materials (including sections of pipe) would be transported along the appropriate major route dependent upon the section of the pipeline under construction, with local and private roads utilised to gain access to the laydown area. The use/construction upgrade of private access roads would be subject to agreement with relevant landowners. Where possible, delivery of materials, plant and equipment for pipeline construction would be made outside of peak transport times to minimise potential disturbances to local traffic. Vehicle movements associated with the initial delivery of materials to laydown areas are summarised in the *Table 38*.

Table 38: Pipeline Construction Material Delivery

Description	Item Information	Delivery Vehicle
Pipe Delivery	Approximately 10 movements per day	5 trucks per day over a stringing period of 70 days delivering to two of three laydown areas.
Equipment transport	Approximately 4 movements per day	2 low loaders per day transporting equipment from one work front to the next.
Water	2 trucks continuously during construction	2 water trucks per day travelling along the ROW.

9.3.4 HDS Traffic

The *HDS* construction would require delivery of construction equipment and various plant and construction materials to the site. Deliveries would be staggered to reflect the construction program with the site preparation equipment delivered first. Concrete would then be delivered, followed by the pipe work and other auxiliary fittings/valves etc. Vehicle movements associated with the delivery of materials to the *HDS* are summarised in the *Table 39*.

Table 39: Vehicle Movements - HDS

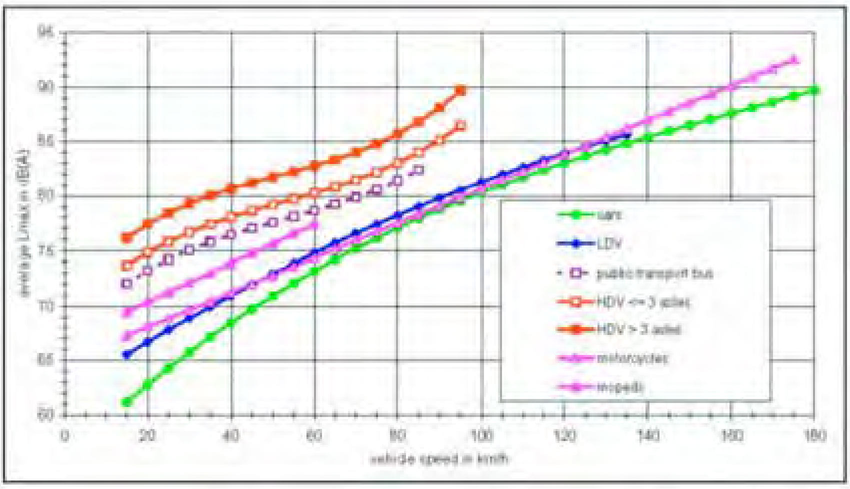
Description	Movements
Miscellaneous site preparation	4-5 per day
Concrete Delivery	4-5 per day
Equipment transport	Total 8
Personnel transport	18 per day
Pipework/valves/etc	Total 9-12

9.3.5 Traffic Noise Assessment

For the traffic noise modelling it was assumed that construction activities could generate up to 30-40 car movements per hour with 10% heavy vehicles. With an average pass-by traffic speed of 50kph, the predicted $L_{Aeq\ 1\ hour}$ at thirty (30) metres of 51dBA satisfies the daytime 55/60dBA target noise assessment goals for local and collector roads, respectively. Passby L_{Amax} noise levels *(Figure 7)* from cars and trucks at thirty (30) metres are predicted to range between 56-72dBA.

Overall the traffic volumes generated during construction are considered as minimal when compared to the reported *AADT* road traffic volumes for The Bucketts Way, Stratford of between 1555 and 4095, and 9343 for the Pacific Highway, Hexham.

Figure 7. LAmax Passby Traffic Noise Levels @ 10 metres
(Reference: Steven, 2005)



9.4 Vibration Levels from Construction Activities

The main source of ground vibration that has been identified and assessed is associated with rock hammers. Ground vibration level predicted from rock hammers could range up to 0.5mm/sec at a distance of twenty (20) metres, and are below 0.3mm/sec at forty (40) metres. Vibration levels at these distances satisfy the structural damage assessment goals *(Table 24*), and expected to be acceptable from a human disturbance point of view.

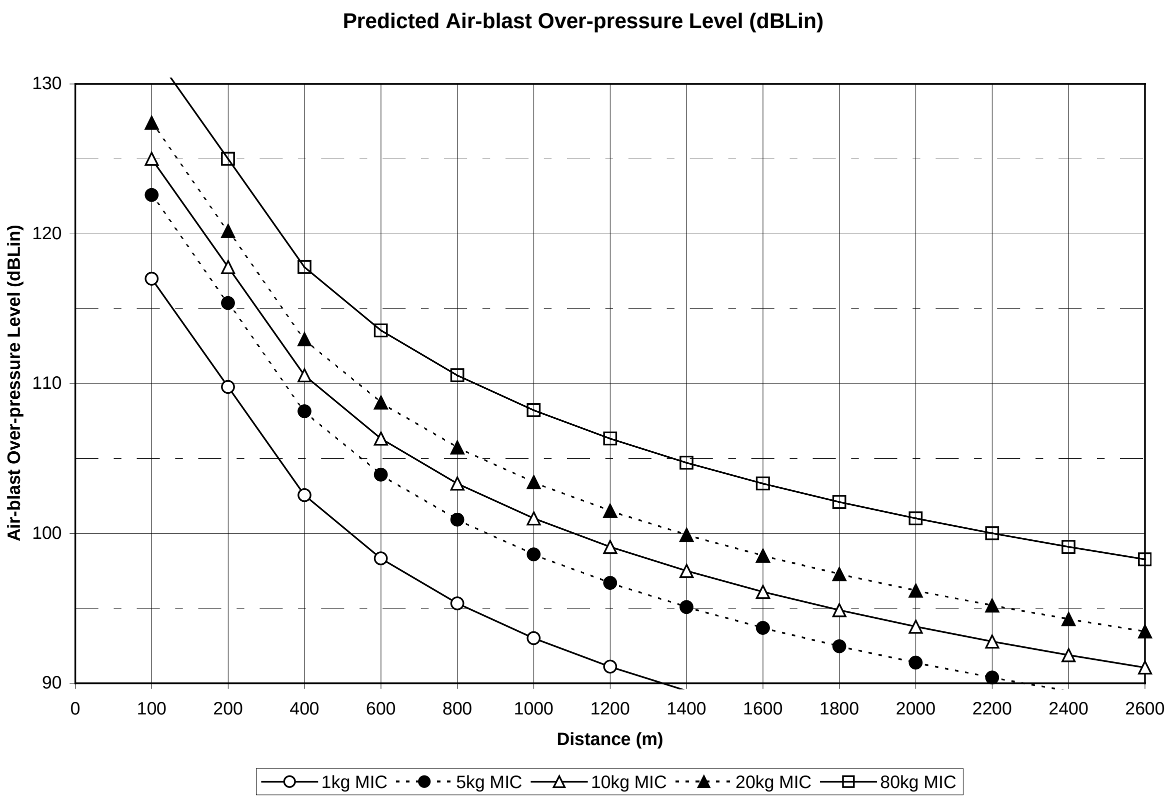
9.5 Blast Assessment

Confined blasting may be required to remove rock outcrops. Blast holes would be drilled and filled with an explosive charge and detonated with the aid of primers and detonators. Impacts associated with blasting normally relate to air blast overpressure and ground vibration.

9.5.1 Air-blast Overpressure Prediction Model

Air-blast overpressure is a function of maximum instantaneous explosive charge and the distance between the receiver and blast location. *Figure 8* presents a summary of the maximum instantaneous charge *(MIC)* blast design data used to predict air-blast overpressure.

Figure 8: Air-blast Overpressure v Distance

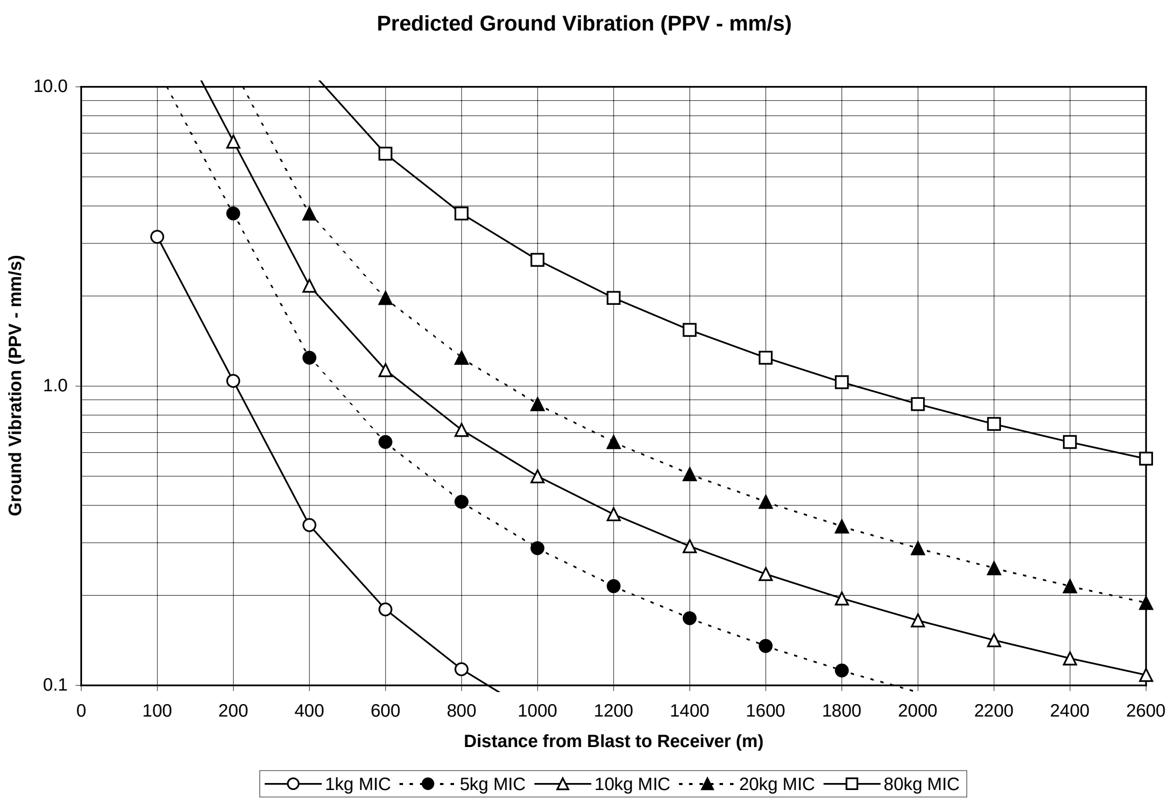


The results in *Figure 8* show that the *DECCW/ANZECC* air-blast overpressure goal (115dBLin) can be satisfied with the employment of controlled MIC's (1-3kg) at a distance of two hundred (200) metres.

9.5.2 Ground Vibration Prediction Model

Ground vibration is a function of maximum instantaneous charge, the distance between receiver and blast location and ground condition. The predictive formula adopted for peak particle velocity (PPV) assessment is based on the site law data provided in Australian Standard AS2187: Part 2 (1993). *Figure 9* provides the predicted PPV v distance vibration levels for confined blast conditions.

Figure 9: Ground Vibration v Distance



The results summarised in *Figure 9* show that the *DECCW/ANZECC* ground vibration goal (5mm/sec) is satisfied with the employment of controlled MIC's (1-3kg) at a distance of two hundred (200) metres.

10.0 MANAGEMENT OF NOISE AND VIBRATION IMPACTS

As part of the project management it is recommended that a Noise Management Plan (*NMP)* be prepared to address and manage construction and operational noise and vibration, and identify methods to manage impacts. The *NMP* would be prepared in consultation with relevant authorities including *DECCW* and construction contractors. As part of the NMP, the following would be addressed:

- selection of plant and equipment where practical on acoustic performance;
- noise certification of all site plant and equipment prior to commencing site work and regular monitoring and maintenance to ensure equipment noise emission levels do not deteriorate due to poor maintenance or damage;
- work practices to minimise potential noise and vibration impacts;
- a monitoring program to ensure that construction noise and vibration emissions are controlled and that the best possible practices are implemented;
- noise and vibration monitoring shall be conducted in response to community complaints and at the request of the *DECCW.* Reports of investigations shall be provided to the *DECCW* upon request;
- development and implementation of a public relations program to inform residents and the community of the progress of activities and potential noise and vibration impacts of each phase of the project; and
- the establishment of procedures to address noise and vibration complaints received from the public during the construction period
- The Proponent shall implement all practicable measures to undertake the development in a way that minimises the noise generated.

Concept Area

The Proponent shall undertake further detailed noise assessment in respect of proposed works within the Concept Area once further details of well site locations and associated infrastructure are confirmed. Details of this assessment shall form part of subsequent project application/s required to be submitted in respect of the proposed works.

As a guide, the following general principles would be considered when identifying potential well site locations for the Concept Field Area:

- Well site locations would be chosen in consideration of the proximity to nearest sensitive receivers and would take account of local topography and meteorological conditions which may affect the extent of noise impacts;
- The potential for noise impact would be considered in the preliminary planning phase of the project such that noise minimisation would be built into the inherent project design;
- The full range of available mitigation measures would be considered and applied where necessary to ensure that noise impacts can be maintained at an acceptable level, and managed as part of a Noise Management Plan.

Stage 1 GFDA

- Fraccing would be undertaken during daytime hours. Finishing works associated with fraccing could extend into evening hours where project noise goals can be achieved or as otherwise agreed with affected landowners. Secondary noise controls such as portable acoustic screens would be installed.
- Drilling activities would be undertaken during daytime hours. Drilling activities are to be undertaken during evening and night time hours only where project noise goals can be achieved or as otherwise agreed with affected landowners.
- Activities associated with the construction of access tracks and the clearing of vegetation to be undertaken during daytime hours only.

CPF

- The Proponent shall undertake a detailed assessment for the acoustic design measures required for the *CPF* plant to ensure that operational noise levels are maintained within the relevant project noise goals:
- Following final plant selection and detailed design, the Proponent shall commission a further detailed operational noise assessment of the *CPF* plant to establish and confirm expected operational noise levels and inform detailed design of noise mitigation for the plant.
- The Proponent shall undertake a program of noise monitoring once the *CPF* is operational in order to validate the design and mitigation measures applied to the facility. If required, further mitigation may be recommended following the

monitoring program to ensure that operational noise is maintained at an acceptable level.

Gas Transmission Pipeline

- The Proponent shall ensure that advanced notification of commencement of construction works is provided to potentially affected landowners (generally those within two (2) kilometres of the pipeline construction works) indicating the length of time during which impacts may be experienced, the nature of potential impacts and a contact number for complaints to be recorded and responded to.
- The Proponent shall ensure that works requiring the use of rock hammers do not occur within twenty (20) metres of a residence.
- The Proponent shall ensure that works requiring blasting do not occur within two hundred (200) metres of a residence.

Hexham Delivery Station

- The Proponent shall undertake a detailed assessment for the acoustic design measures required for the *HDS* plant to ensure that operational noise levels are maintained within the relevant project noise goals:
- Following final plant selection and detailed design, the Proponent shall commission a further detailed operational noise assessment of the *HDS* plant to establish and confirm expected operational noise levels and inform detailed design of noise mitigation for the plant.
- The Proponent shall undertake a program of noise monitoring once the *HDS* is operational in order to validate the design and mitigation measures applied to the facility. If required, further mitigation may be recommended following the monitoring program to ensure that operational noise is maintained at an acceptable level.

11.0 CONCLUSION

The Gloucester gas project is a venture of AGL Gloucester Pty Ltd *(AGL)*. The project consists of four (4) key components to produce, compress and transport coal seam gas from the Gloucester region to a delivery station in Hexham, Newcastle.

The main study area is centered around the township of Stratford. The Exploration Licence 285 area extends approximately sixty (60) kilometres north to south and approximately twenty (20) kilometres east to west. The preferred pipeline corridor is approximately one hundred (100) metres wide and ninety-five (95) kilometres long. The corridor would extend from the selected central processing facility to the proposed gas delivery station at Hexham.

The main operational noise sources associated with the *CPF* would include gas generators, compressors, compressor cooler fans, pumps, fans and valves. The generators and compressors would be housed in individual acoustic enclosures and the compressor fin cooling fans selected on acoustic performance. The results of noise modelling show that with additional secondary engineering controls the project noise goals are predicted to be satisfied.

From investigations undertaken, it is not envisaged that there would be any significant operational noise sources or noise impacts arising from the gas transfer pipeline.

Modelling for the *HDS* has shown that the project noise goals are predicted to be exceeded at the closest residential properties on Punt Road, Old Maitland Road and the shared industrial and commercial boundaries without the inclusion of secondary controls. As part of the detailed design (when final details of the plant and equipment will be determined) a more detailed assessment of the noise would be undertaken to confirm the extent of noise mitigation required to satisfy the project noise goals.

It is not expected that operational $L_{A1,\ 1\ mim}$ noise levels emitted from the *GFDA*, *CPF*, *gas transmission pipeline* and *HDS* would be greater than 5-10dBA above the operational L_{Aeq} levels or the *DECCW* sleep disturbance assessment goals.

No operational vibration sources have been identified that are likely to generate ground vibration at exposed receptors.

The main construction activities envisaged for the project include access track construction, vegetation clearing, drilling, fraccing, trenching, concreting, structure erection, pipe preparation, pipe installation and plant installation. It is proposed that construction activities would generally be restricted to daytime hours. Some well construction works in the *GFDA* including drilling and preparation for fraccing would occur twenty-four (24) hours a day where noise impacts on residential dwellings can be managed.

Noise modeling has shown there would be situations where construction noise levels exceed the target assessment goals during construction.

Ground vibration from construction activities can be controlled to levels that would satisfy the recommended project goals and expected to be acceptable from both human disturbance and structural damage points of view.

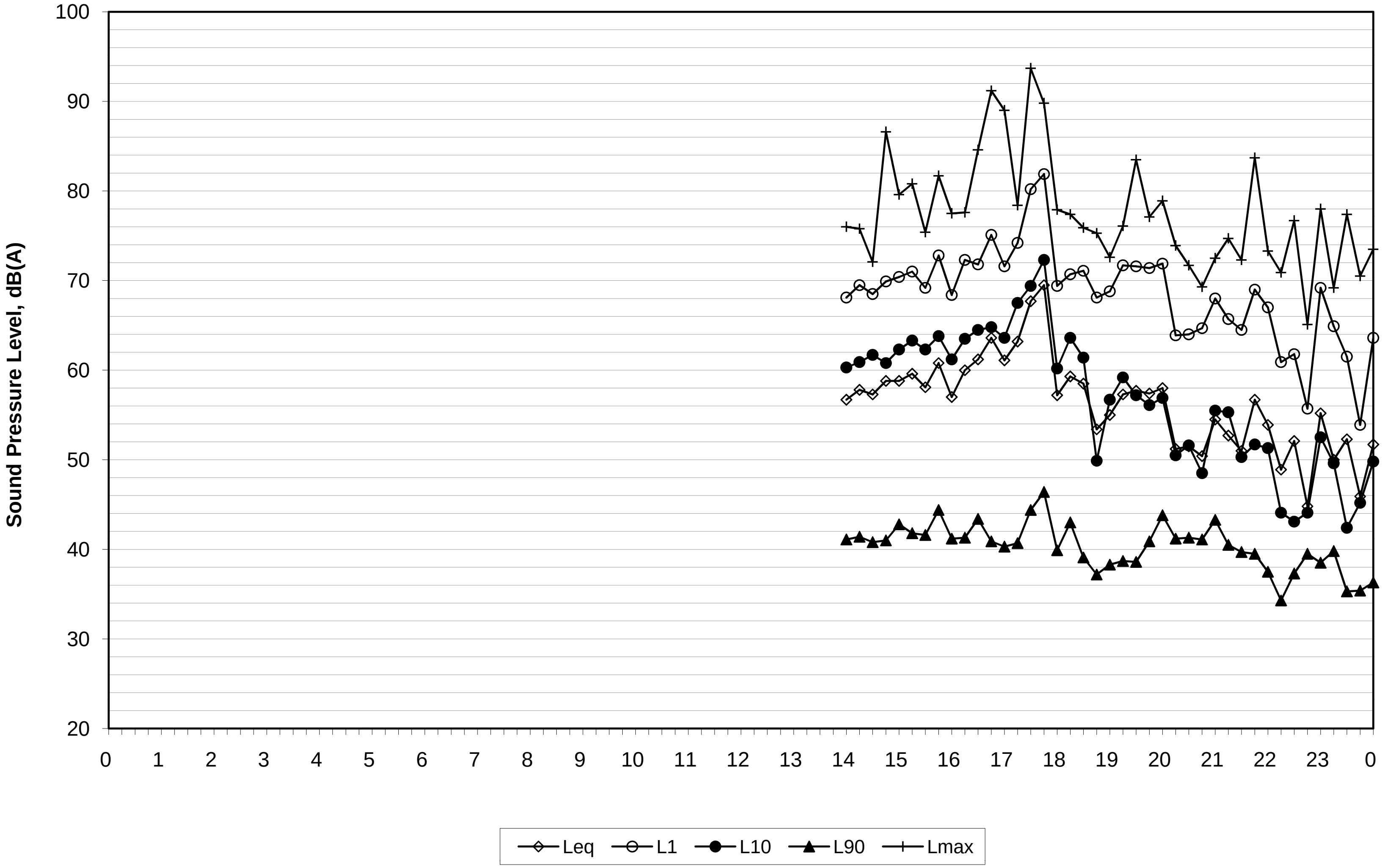
Traffic volumes generated during the operational and construction phases of the project are considered as minimal when compared to the reported Annual Average Daily Traffic *(AADT)* road traffic volumes for The Bucketts Way of between 1555 and 4095 vehicles per day, and 9343 vehicles per day for the Pacific Highway, Hexham and predicted to satisfy the daytime target noise assessment goals for local and collector roads, respectively.

To manage environmental noise and vibration impacts during construction, it is recommended that a Noise Management Plan *(NMP)* be prepared. As part of the *NMP*, it is recommended that a public relations program be developed and implemented to inform residents and the community of the progress of the activities, and potential noise and vibration impacts during each phase of the construction.

ATTACHMENT 1: AMBIENT SOUND PRESSURE LEVEL MEASUREMENTS

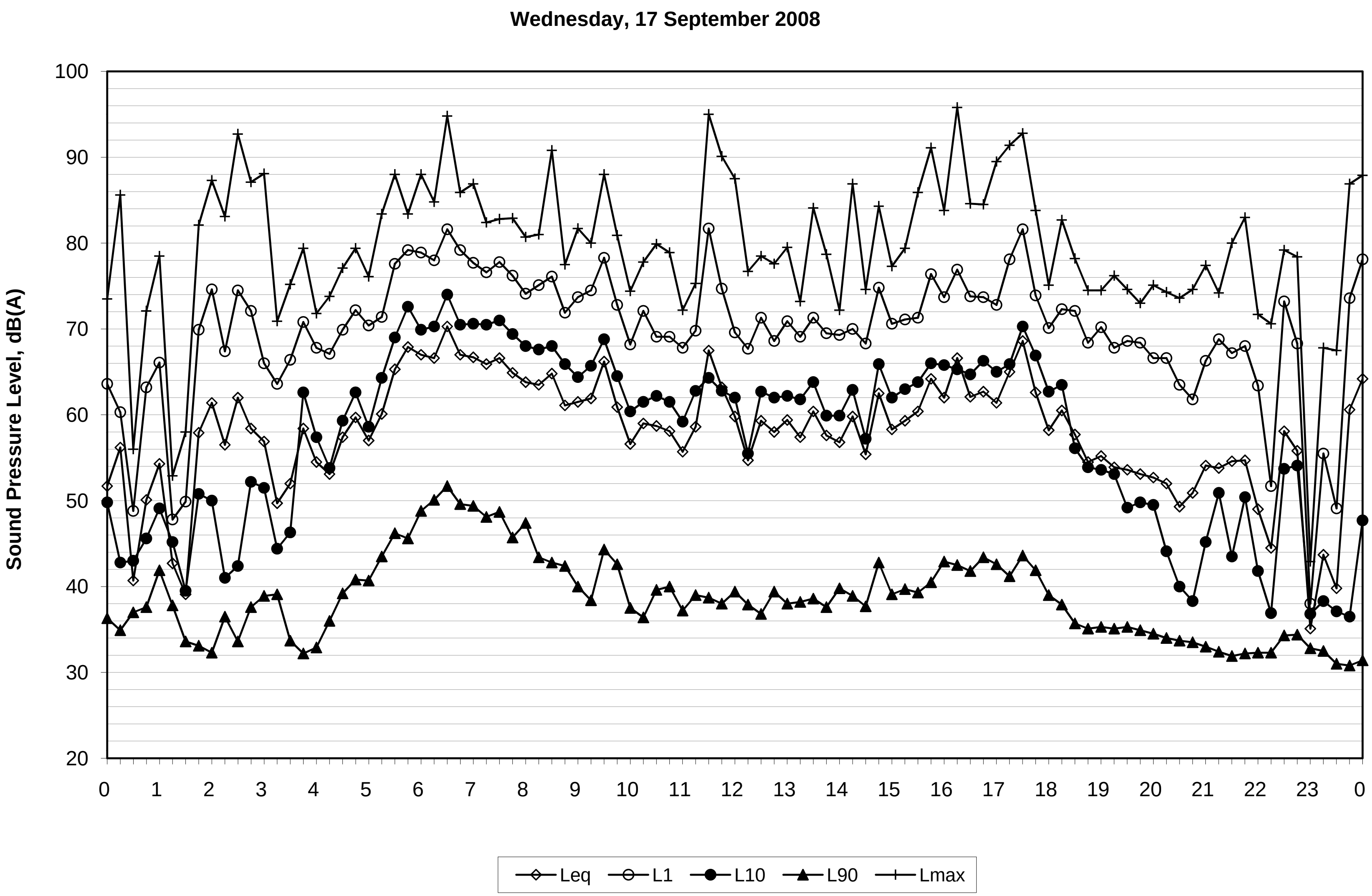
Ambient Sound Pressure Levels

Tuesday, 16 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

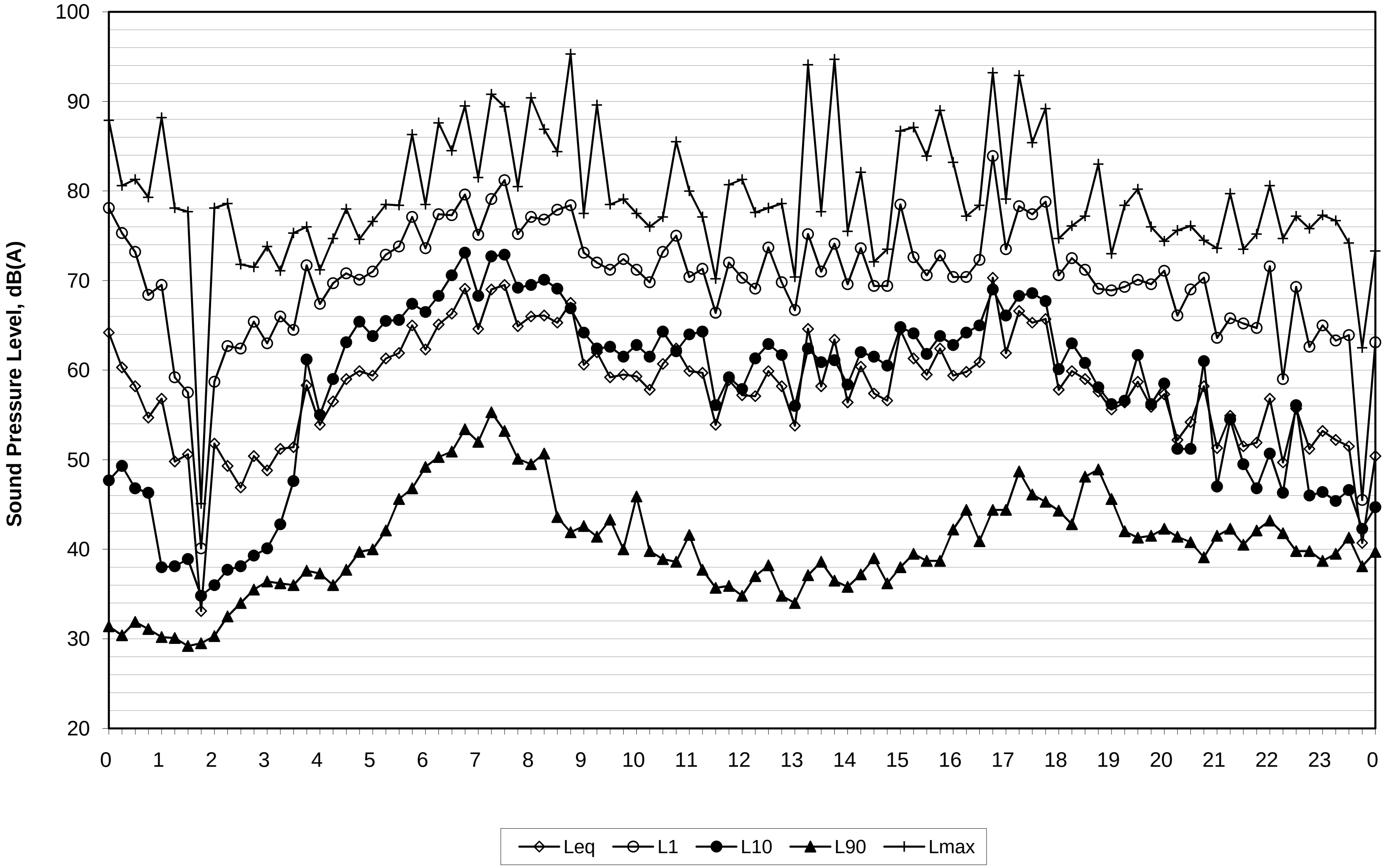


Reference Measurement Location
R1

6354R1_t.xls

Ambient Sound Pressure Levels

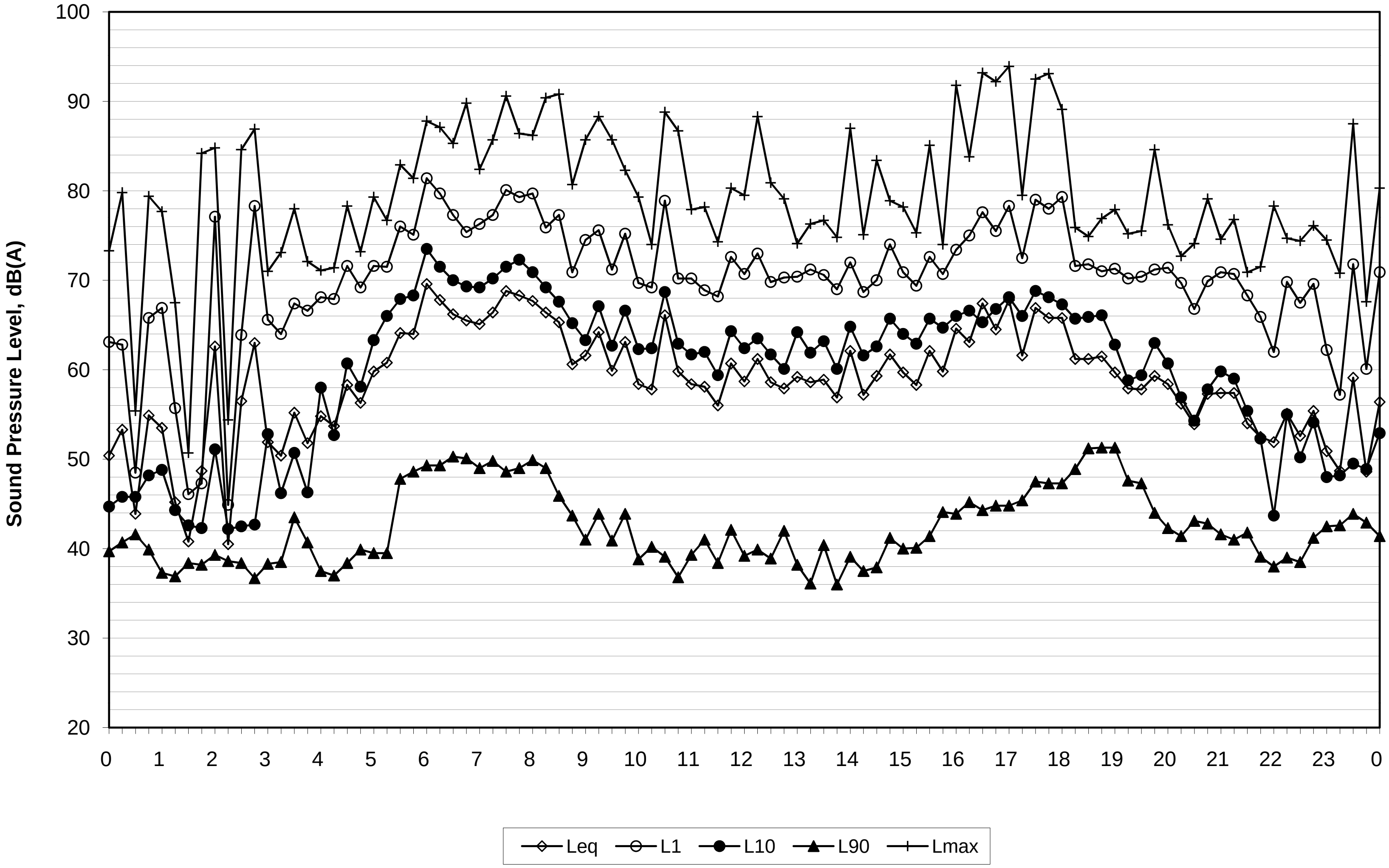
Thursday, 18 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

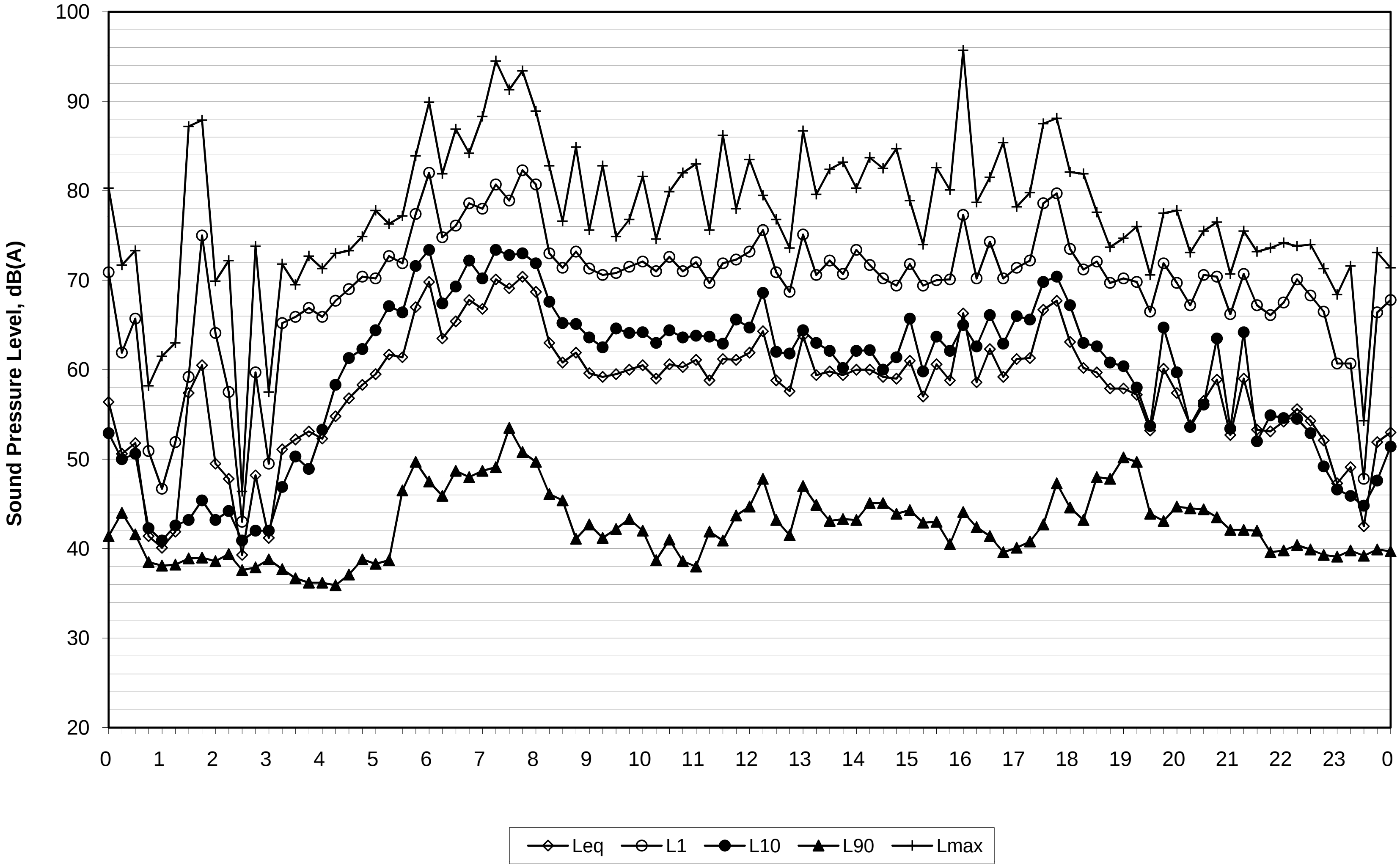
Friday, 19 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

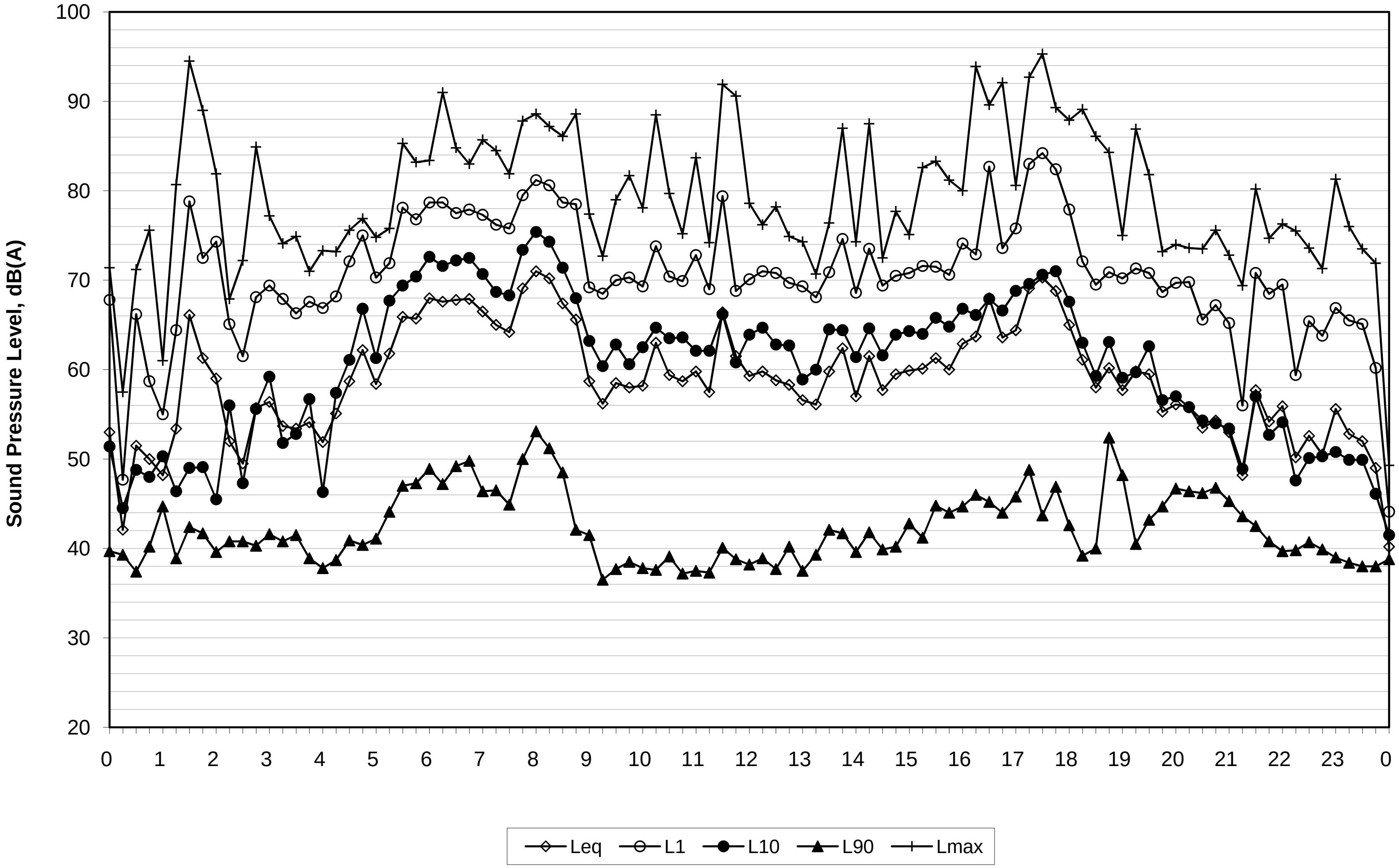
Saturday, 20 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

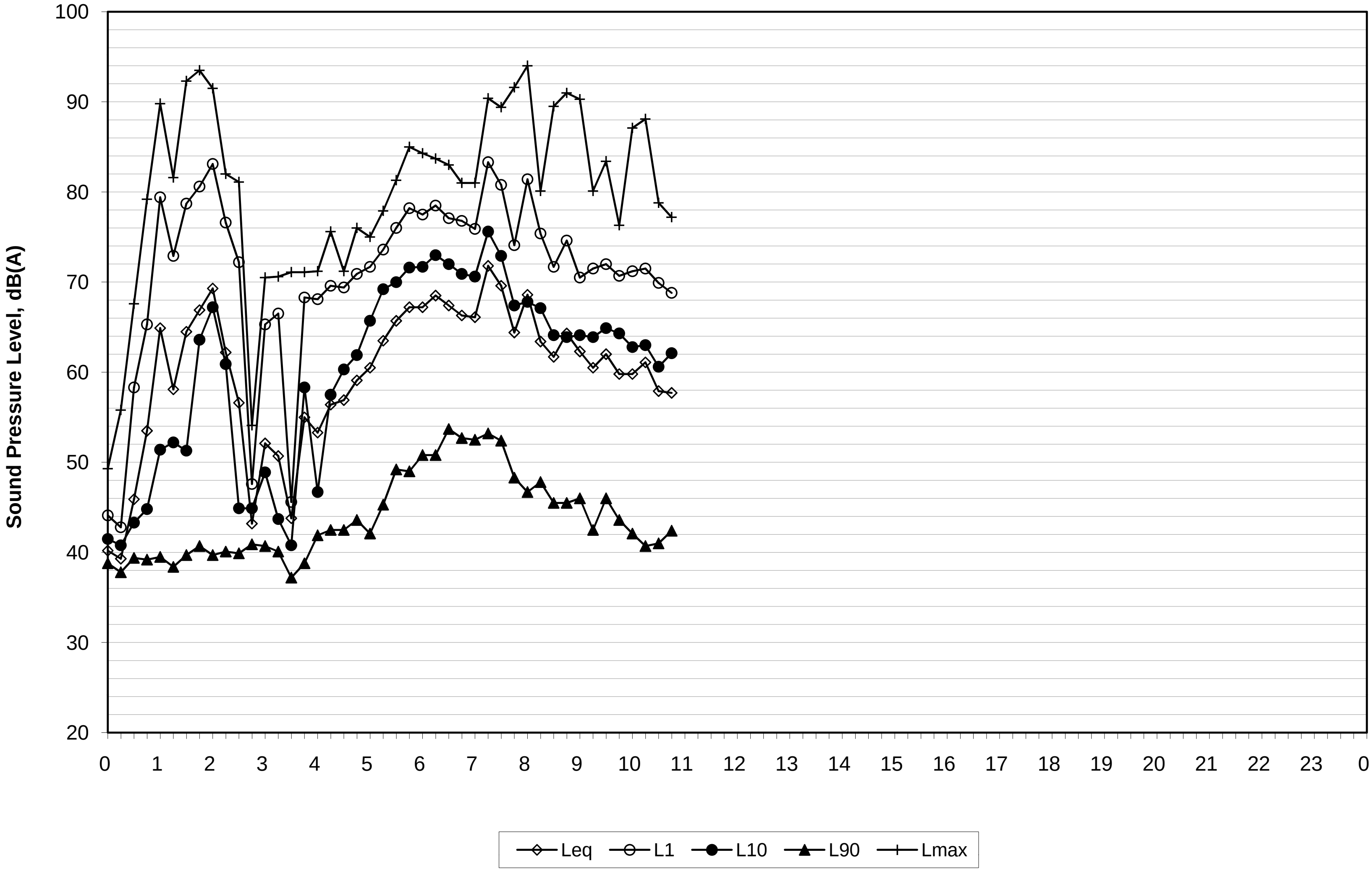
Sunday, 21 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

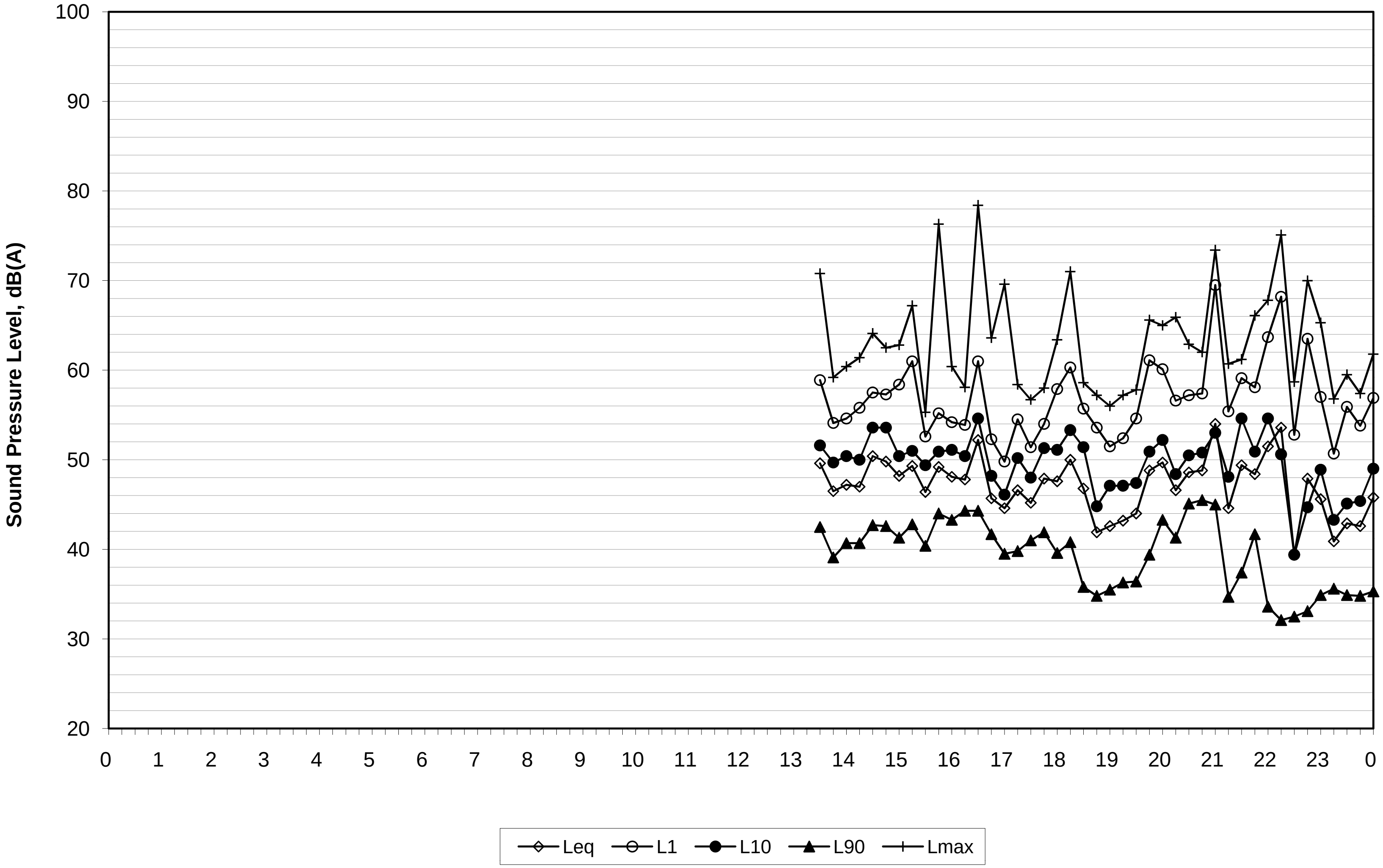
Monday, 22 September 2008



Reference Measurement Location
R1

Ambient Sound Pressure Levels

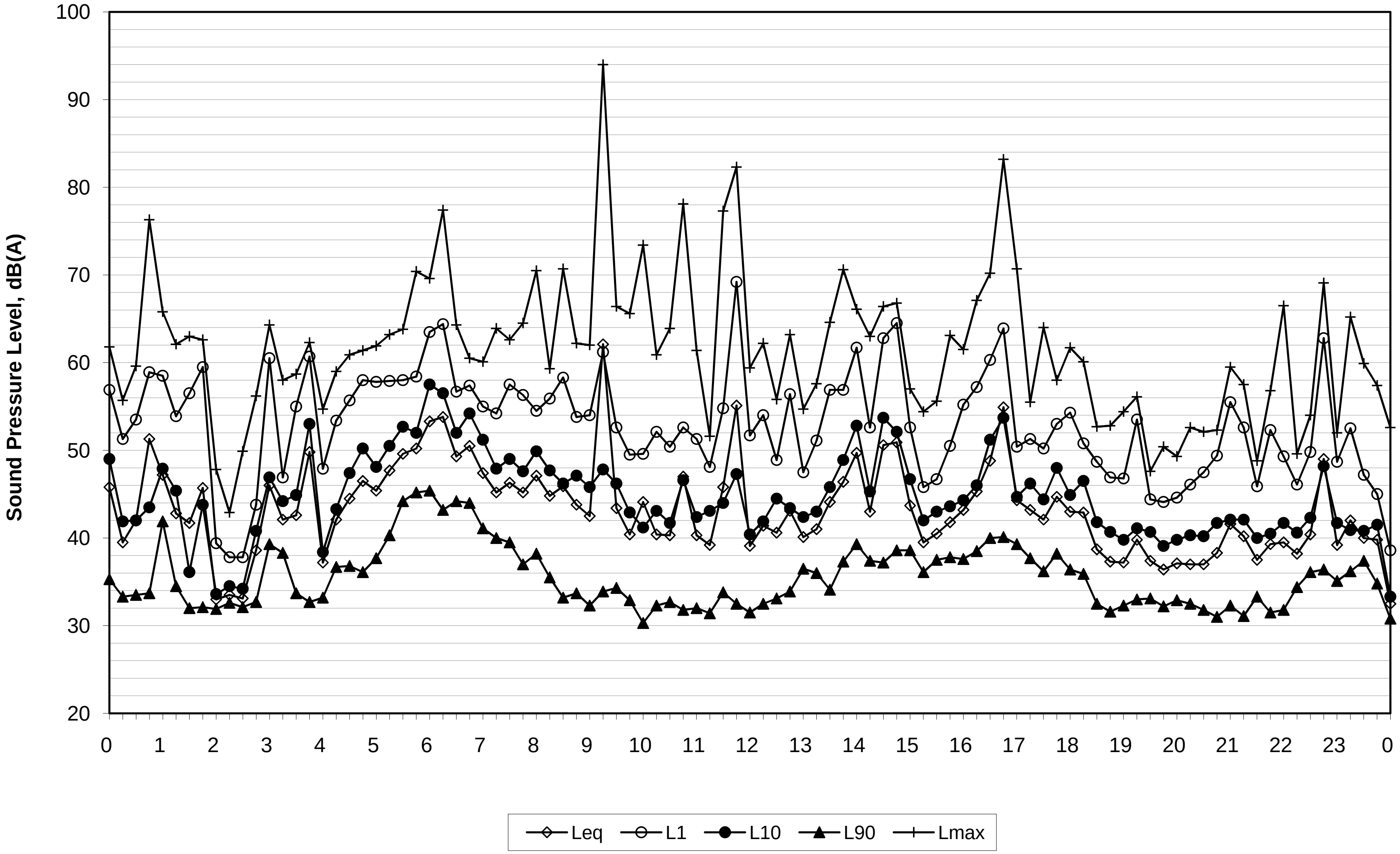
Tuesday, 16 September 2008



Reference Measurement Location
R2

Ambient Sound Pressure Levels

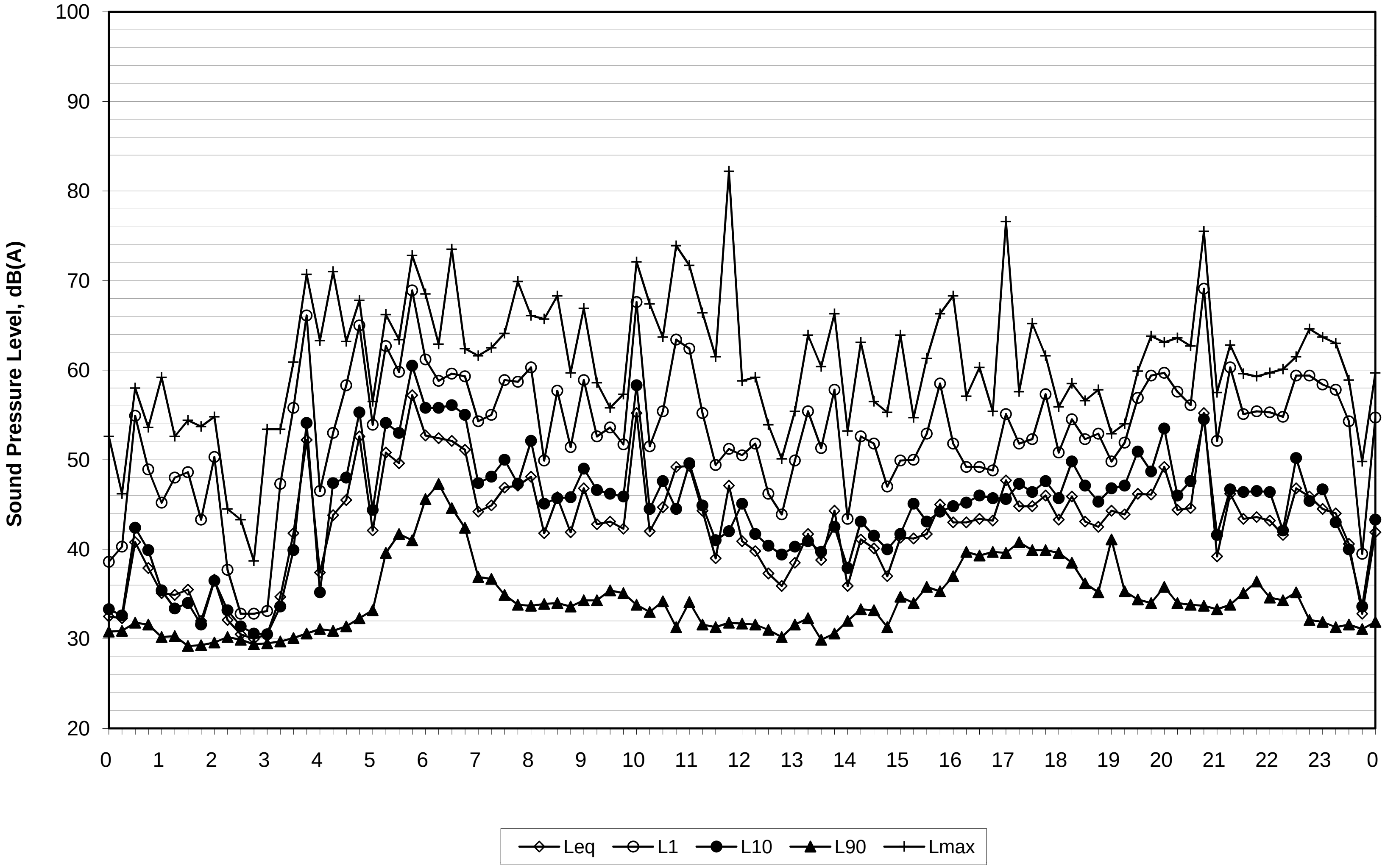
Wednesday, 17 September 2008



Reference Measurement Location
R2

Ambient Sound Pressure Levels

Thursday, 18 September 2008

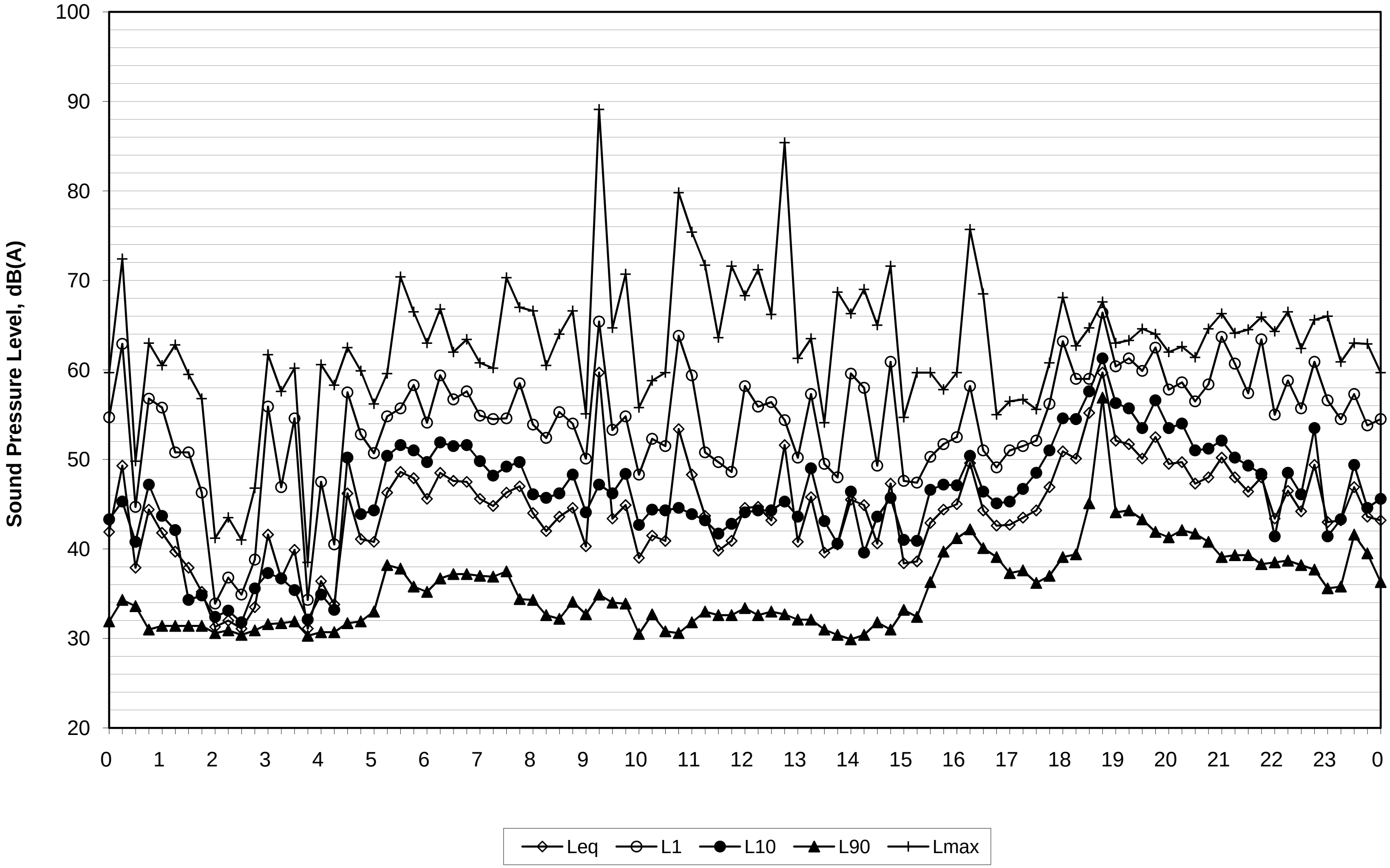


Reference Measurement Location
R2

6354R2_t.xls

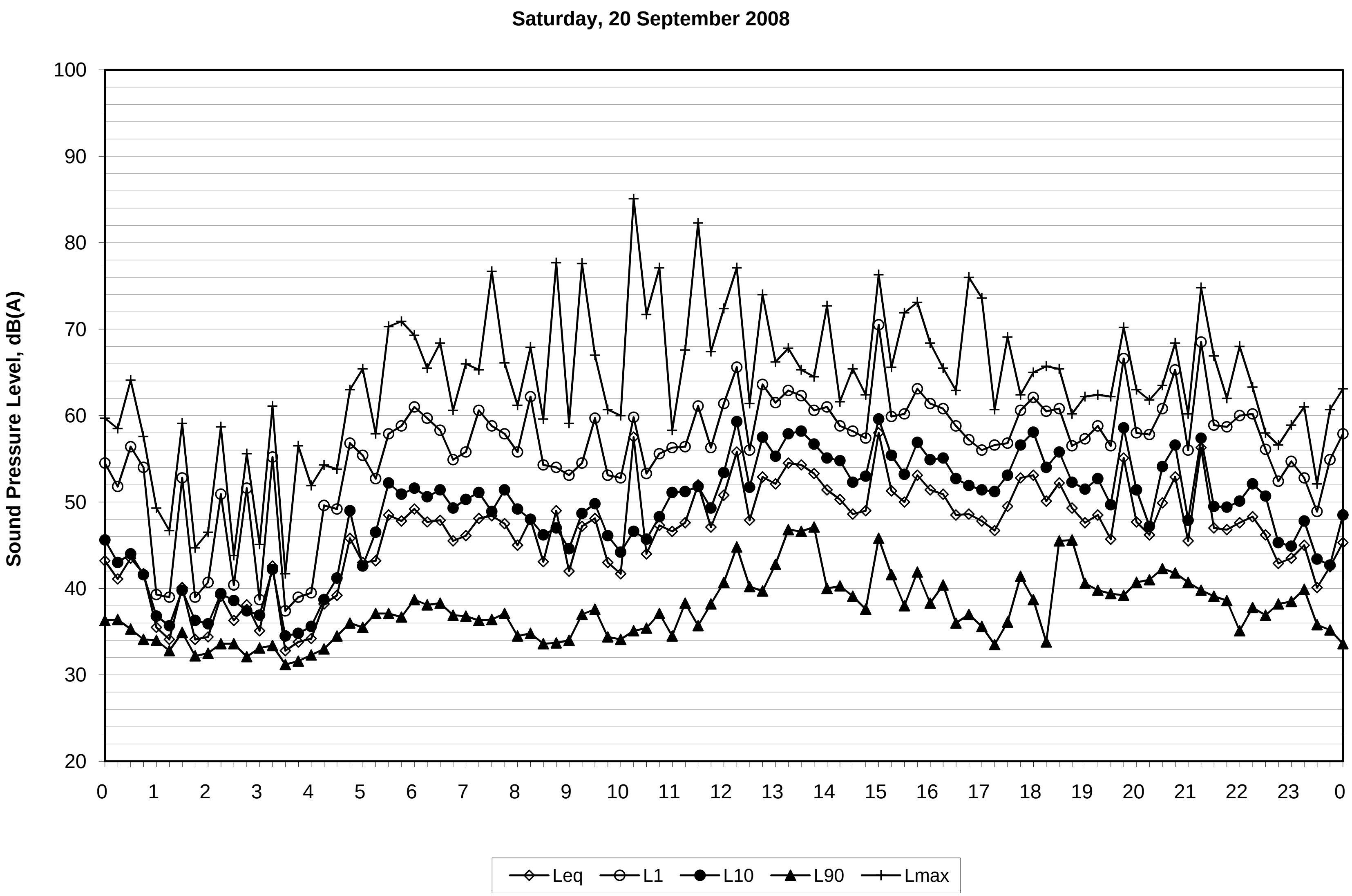
Ambient Sound Pressure Levels

Friday, 19 September 2008



Reference Measurement Location
R2

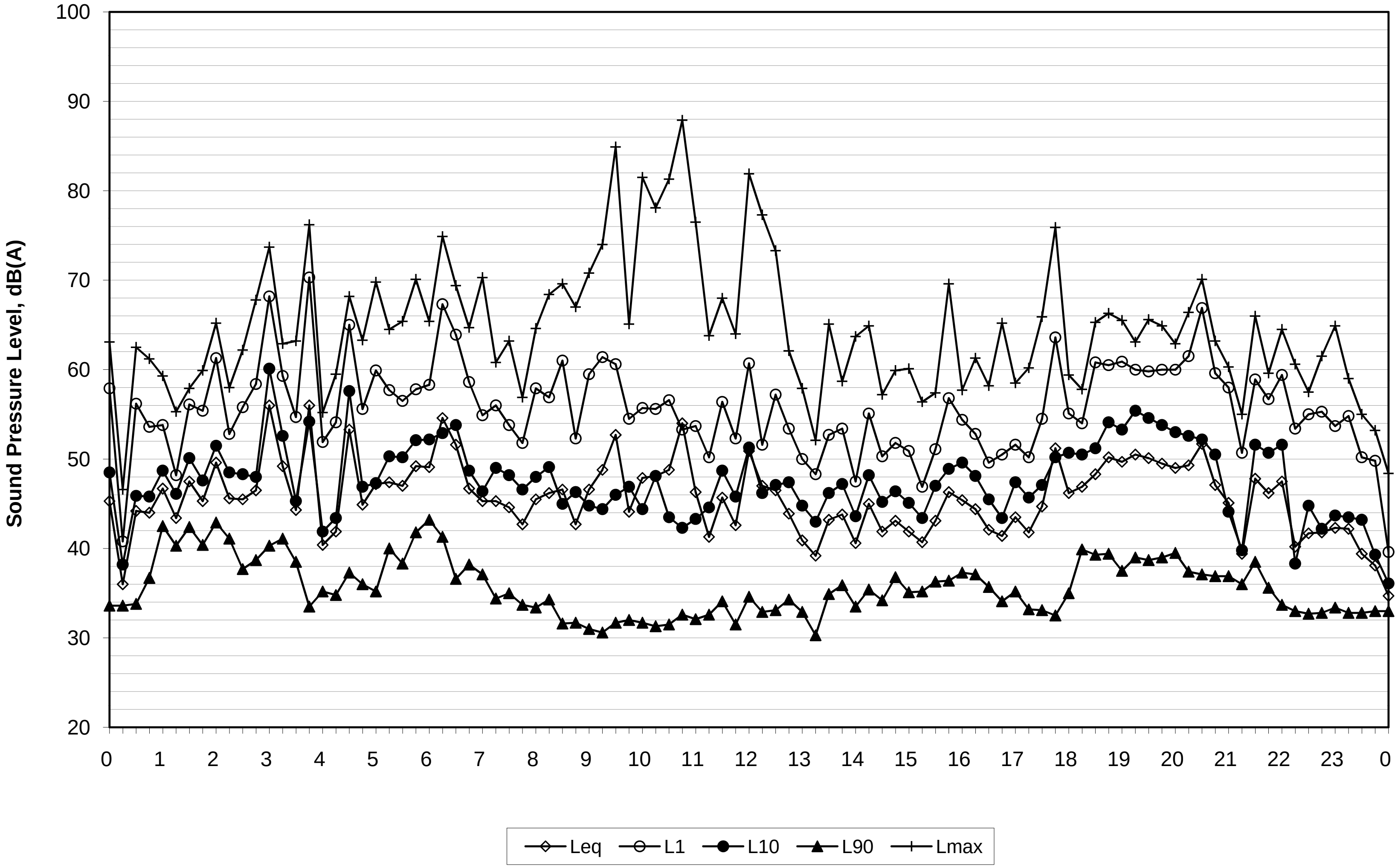
Ambient Sound Pressure Levels



Reference Measurement Location
R2

Ambient Sound Pressure Levels

Sunday, 21 September 2008

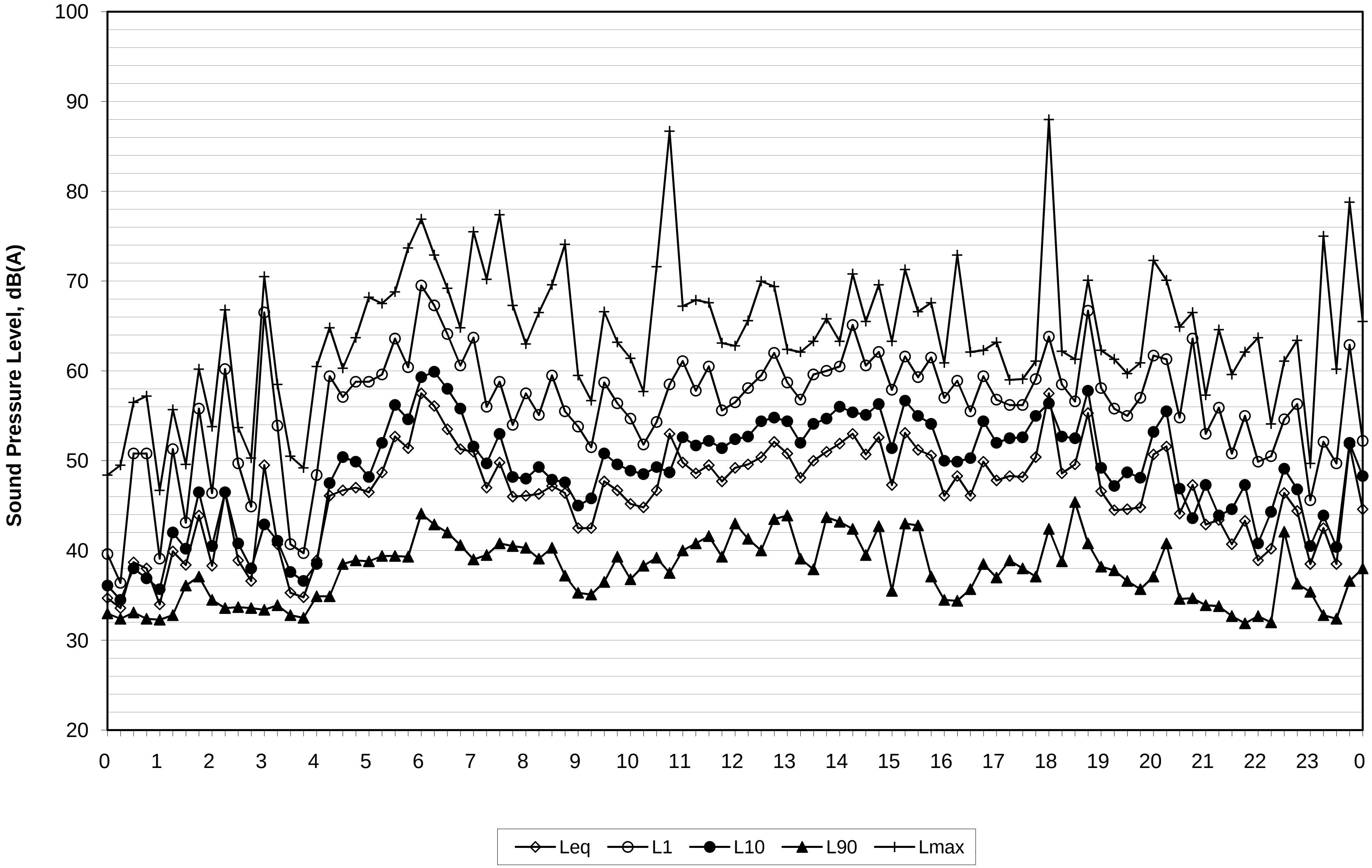


Reference Measurement Location
R2

6354R2_t.xls

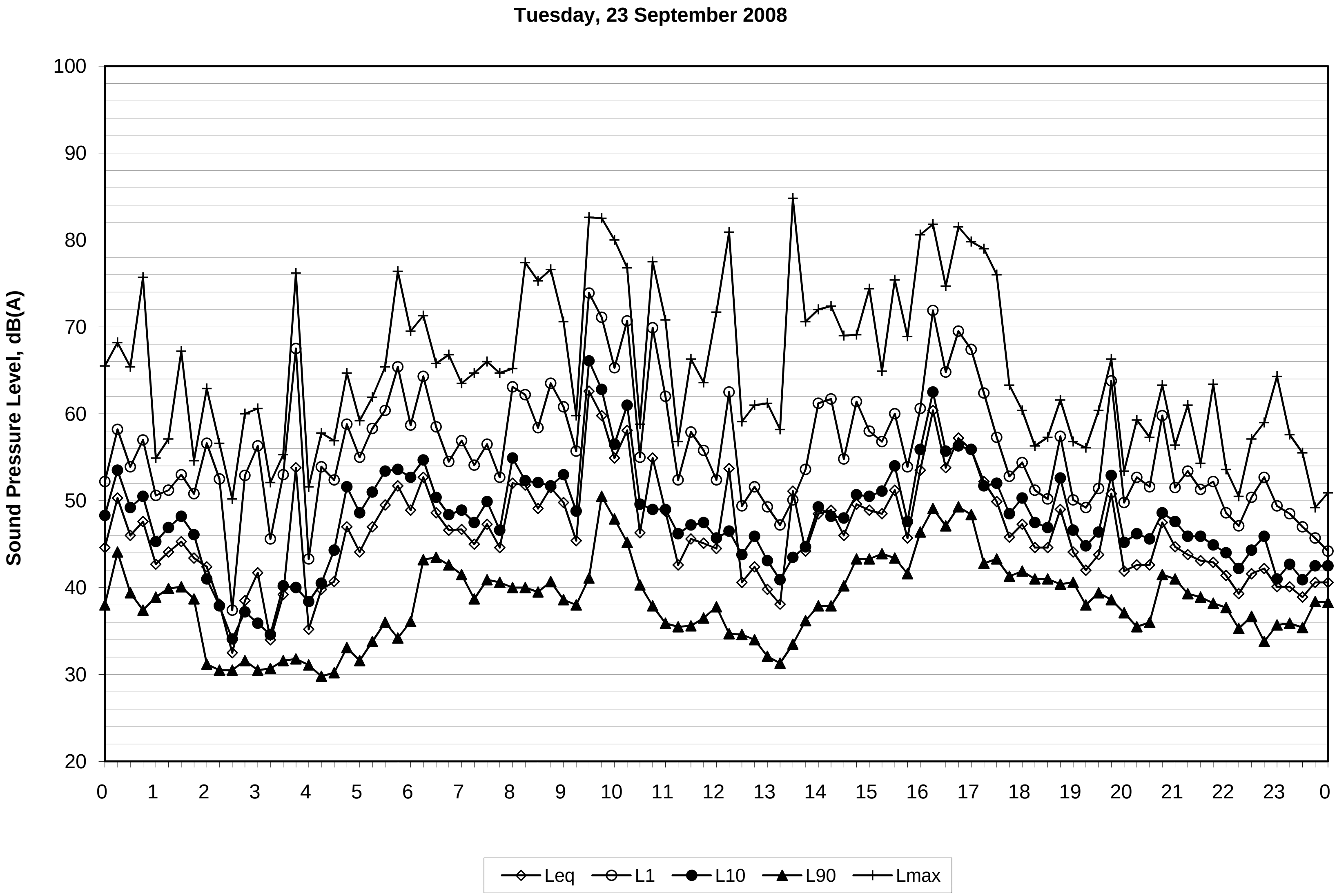
Ambient Sound Pressure Levels

Monday, 22 September 2008



Reference Measurement Location
R2

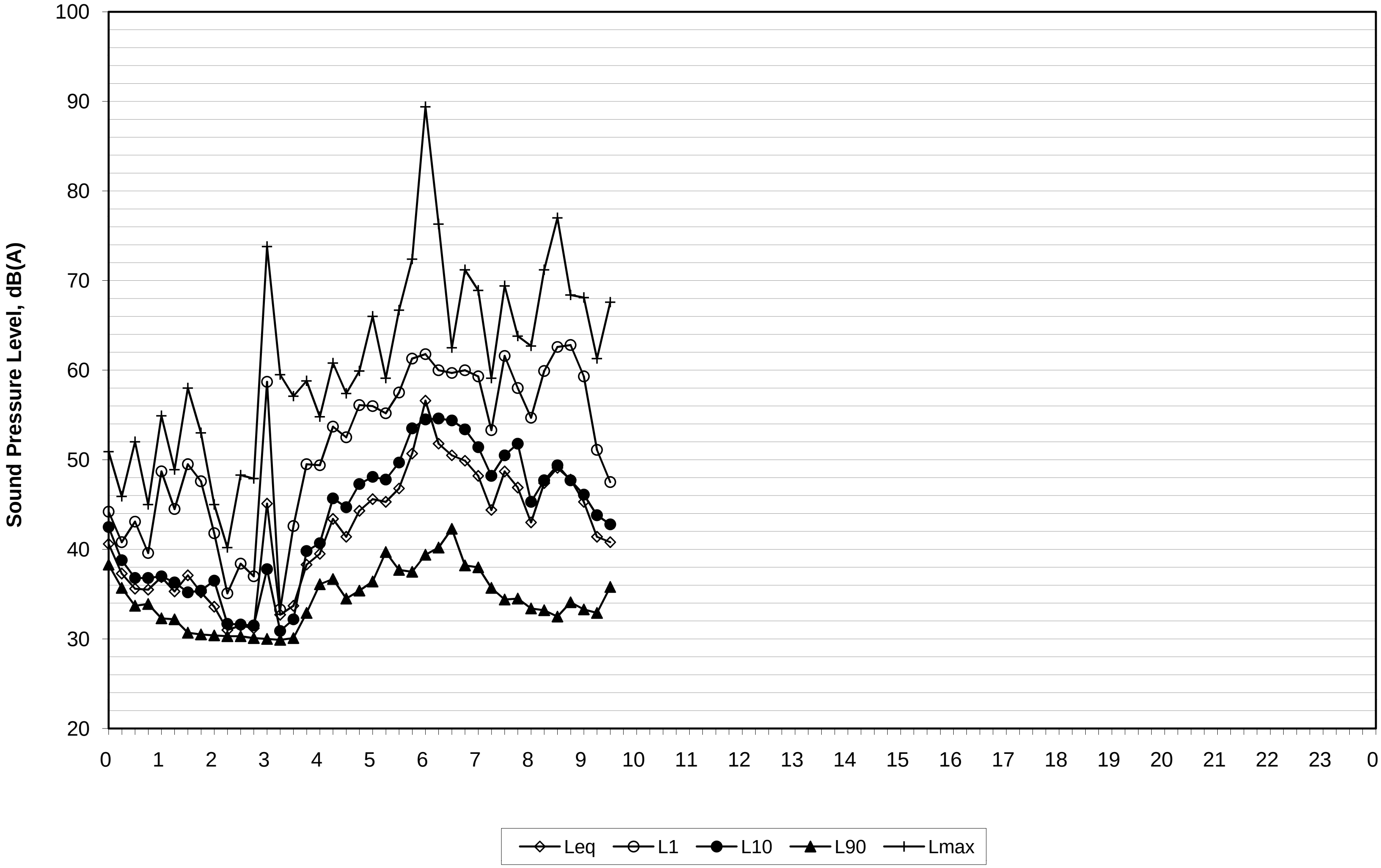
Ambient Sound Pressure Levels



Reference Measurement Location
R2

Ambient Sound Pressure Levels

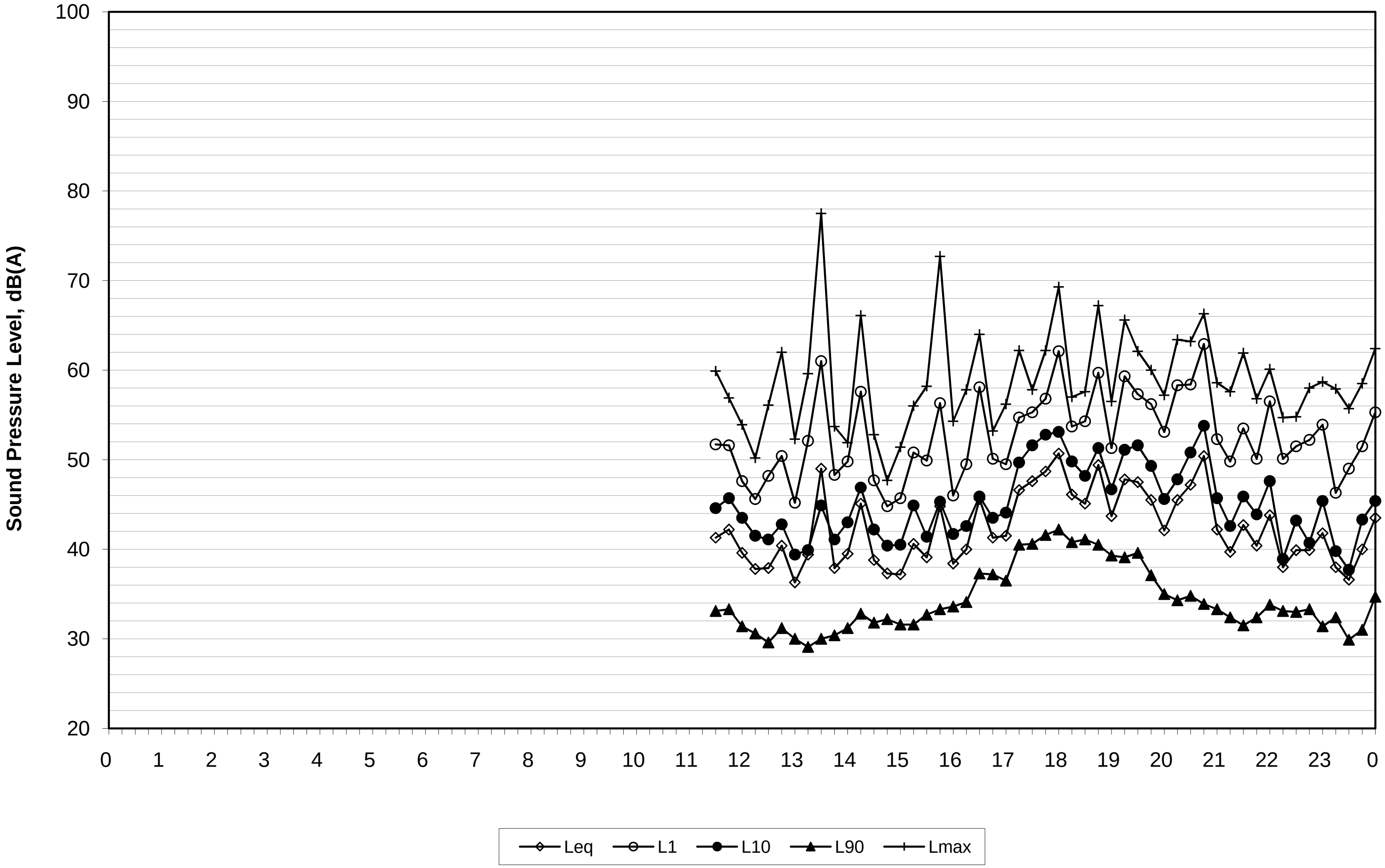
Wednesday, 24 September 2008



Reference Measurement Location
R2

Ambient Sound Pressure Levels

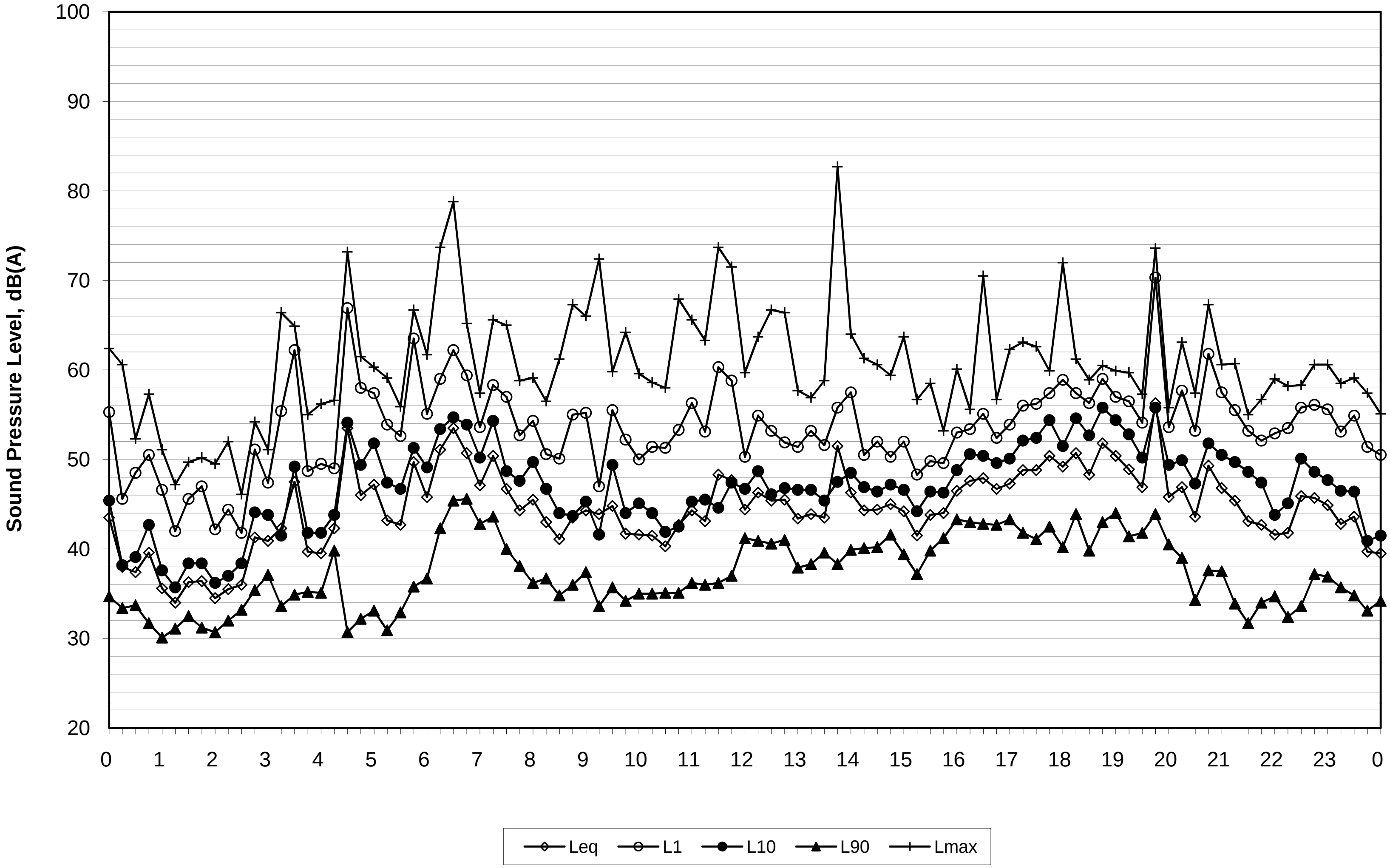
Thursday, 16 April 2009



Reference Measurement Location
R2a

Ambient Sound Pressure Levels

Friday, 17 April 2009

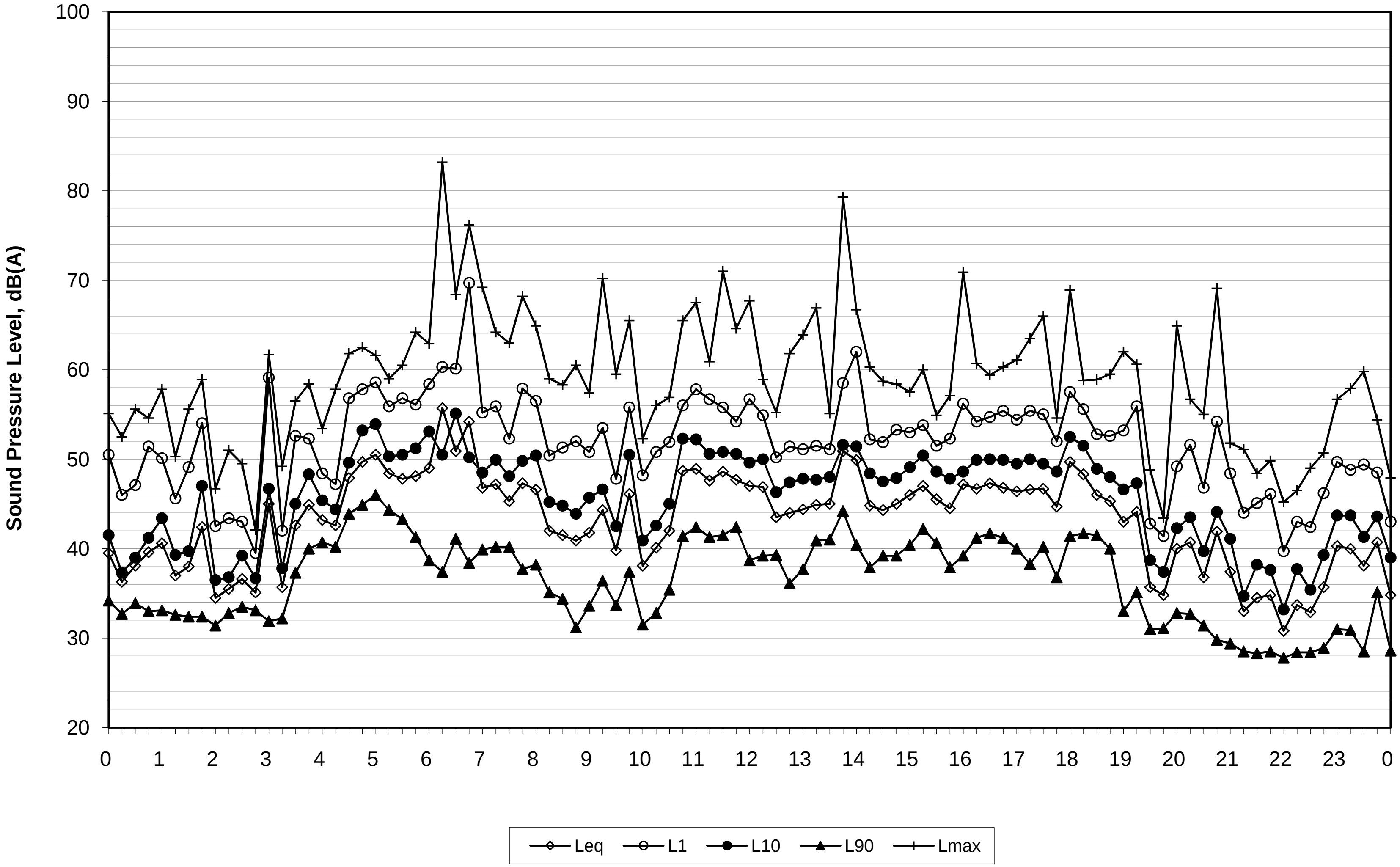


Reference Measurement Location
R2a

6354r2a_t.xls

Ambient Sound Pressure Levels

Saturday, 18 April 2009

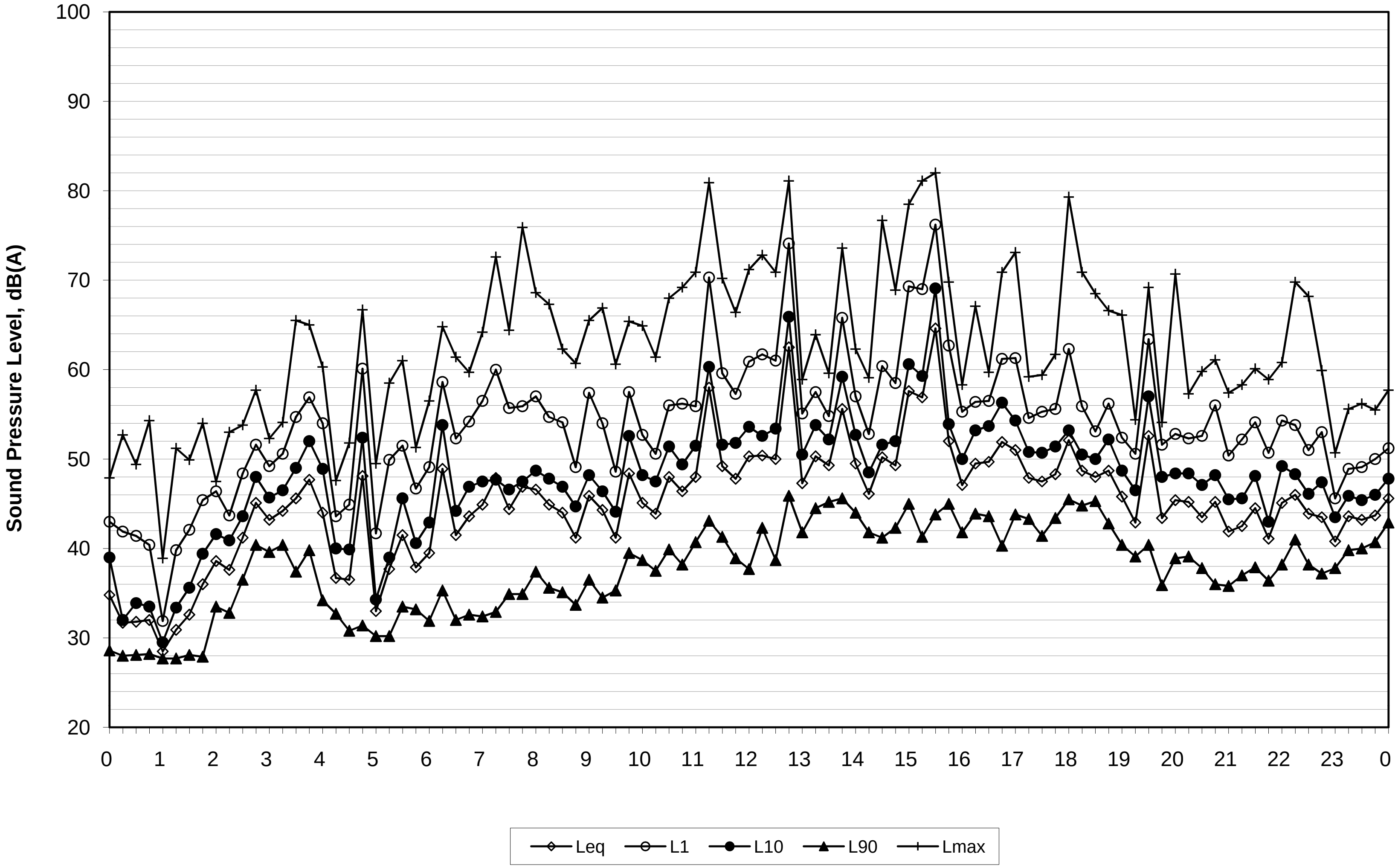


Reference Measurement Location
R2a

6354r2a_t.xls

Ambient Sound Pressure Levels

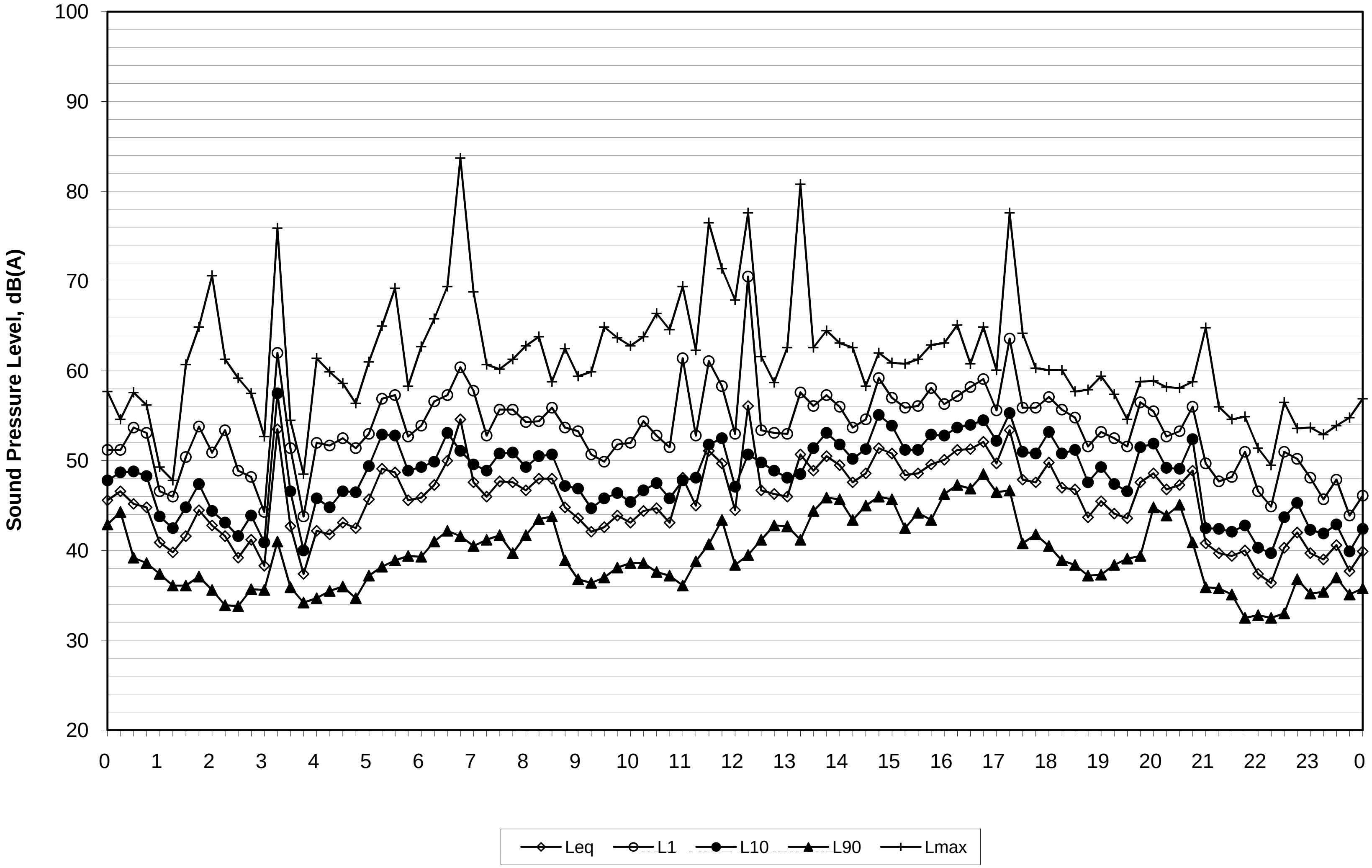
Sunday, 19 April 2009



Reference Measurement Location
R2a

Ambient Sound Pressure Levels

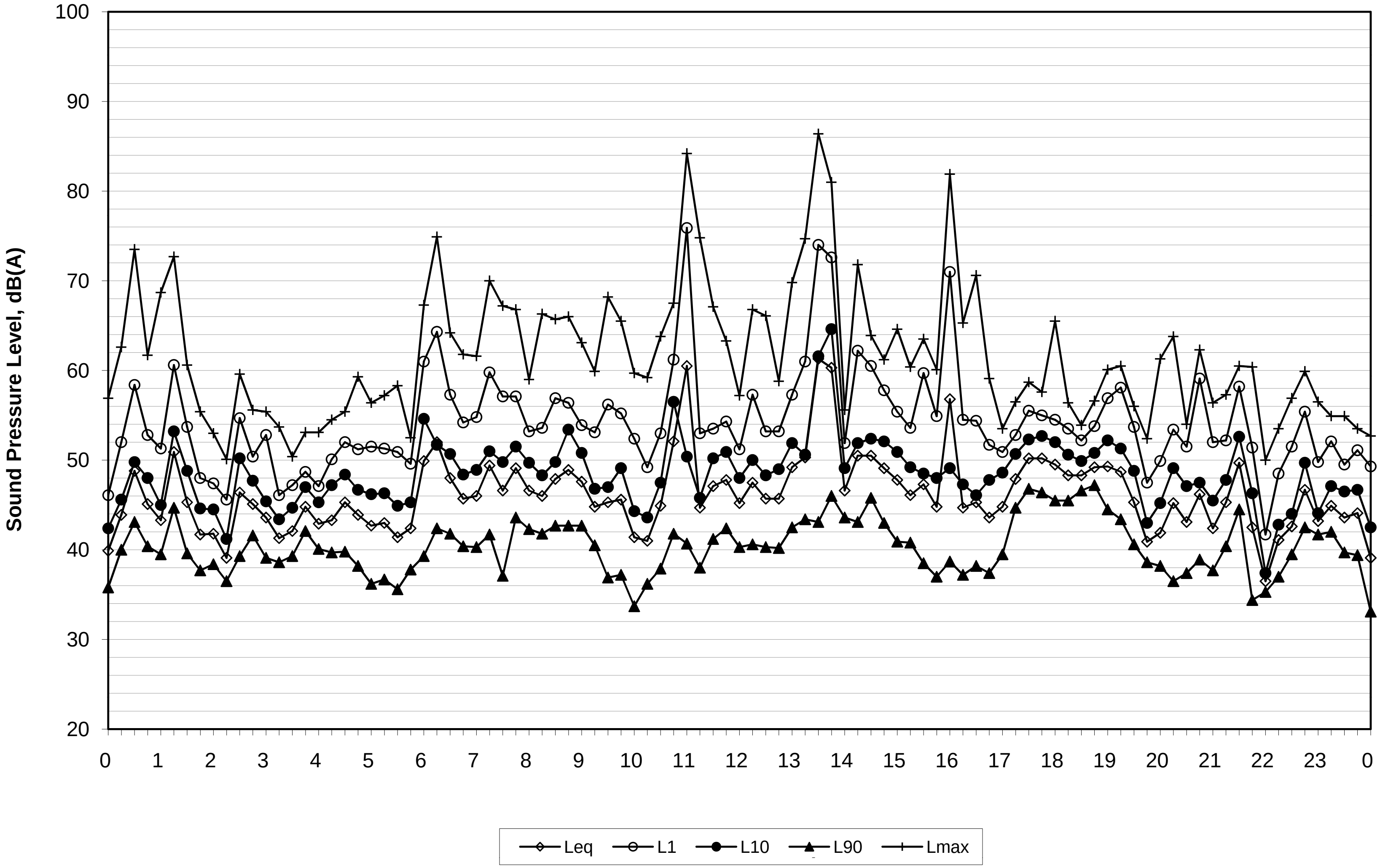
Monday, 20 April 2009



Reference Measurement Location
R2a

Ambient Sound Pressure Levels

Tuesday, 21 April 2009

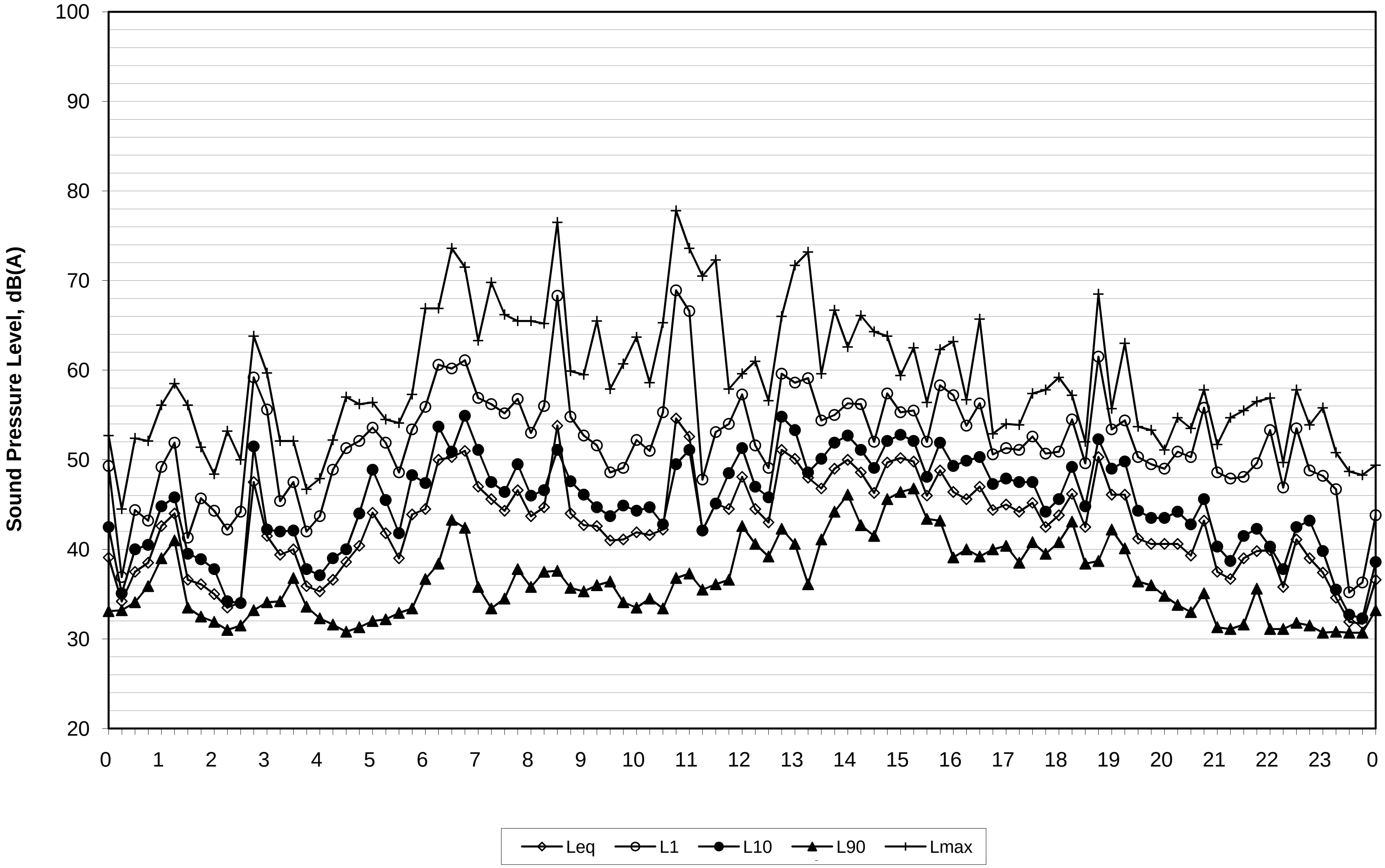


Reference Measurement Location
R2a

6354r2a_t.xls

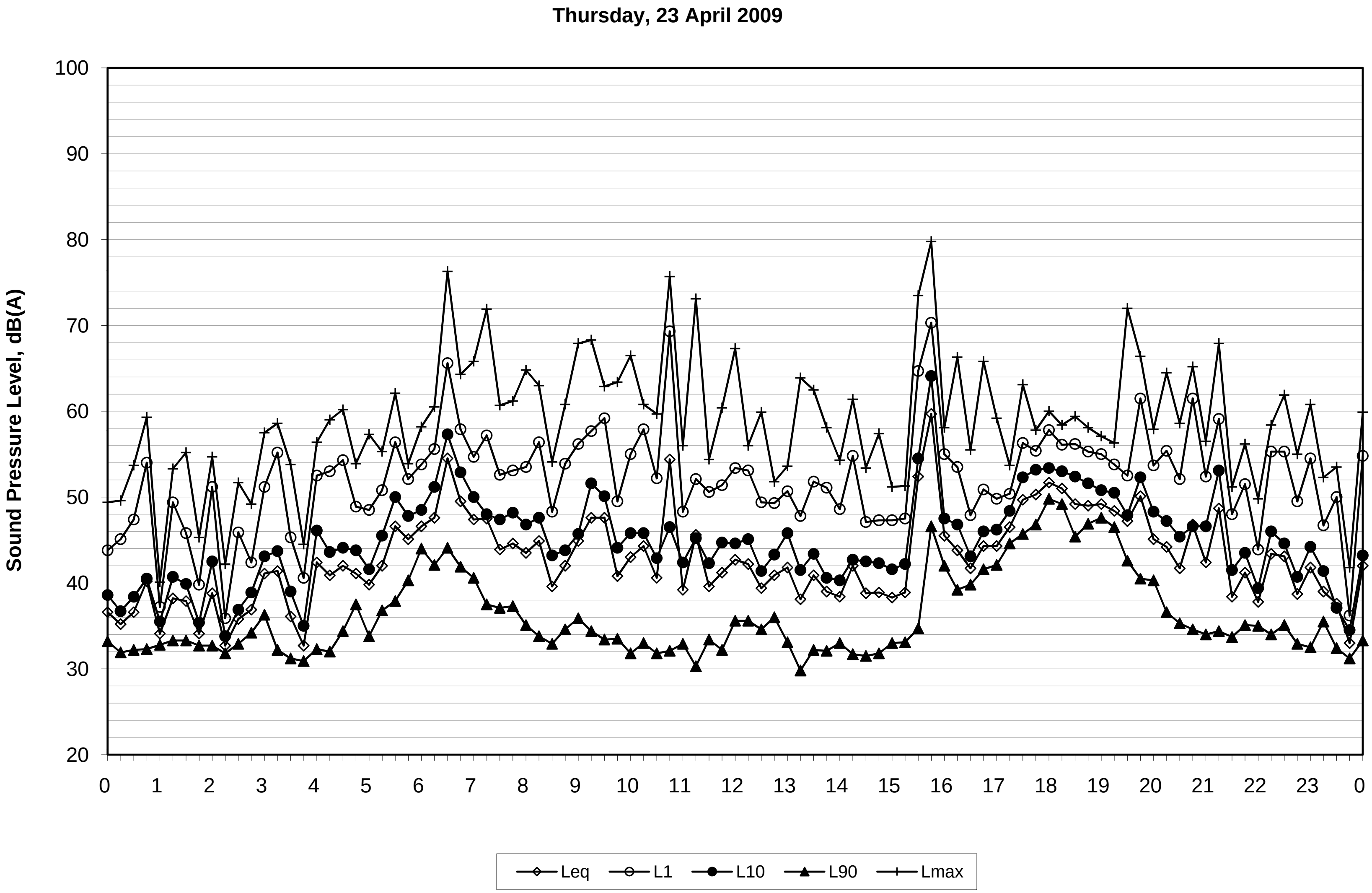
Ambient Sound Pressure Levels

Wednesday, 22 April 2009



Reference Measurement Location
R2a

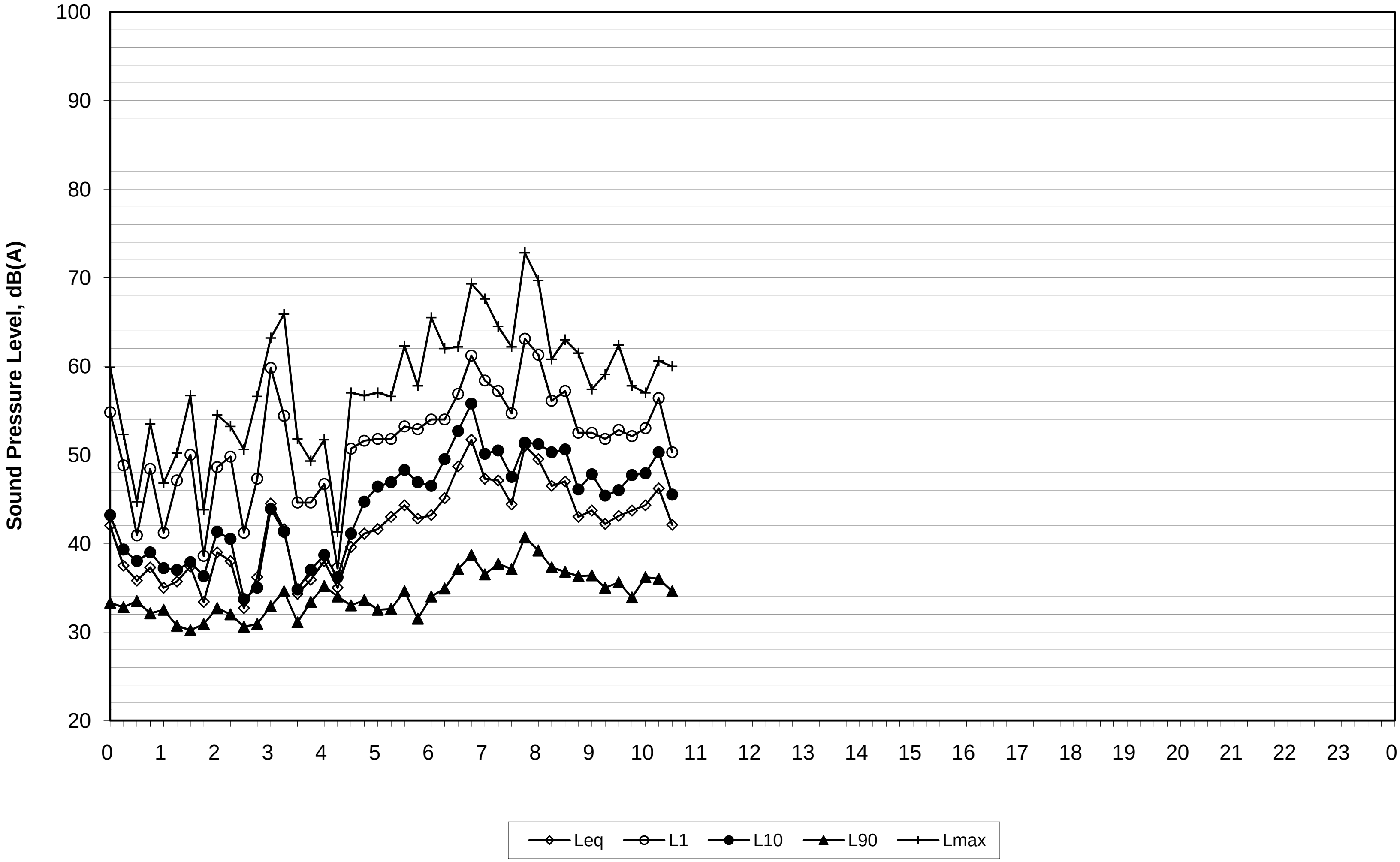
Ambient Sound Pressure Levels



Reference Measurement Location
R2a

Ambient Sound Pressure Levels

Friday, 24 April 2009

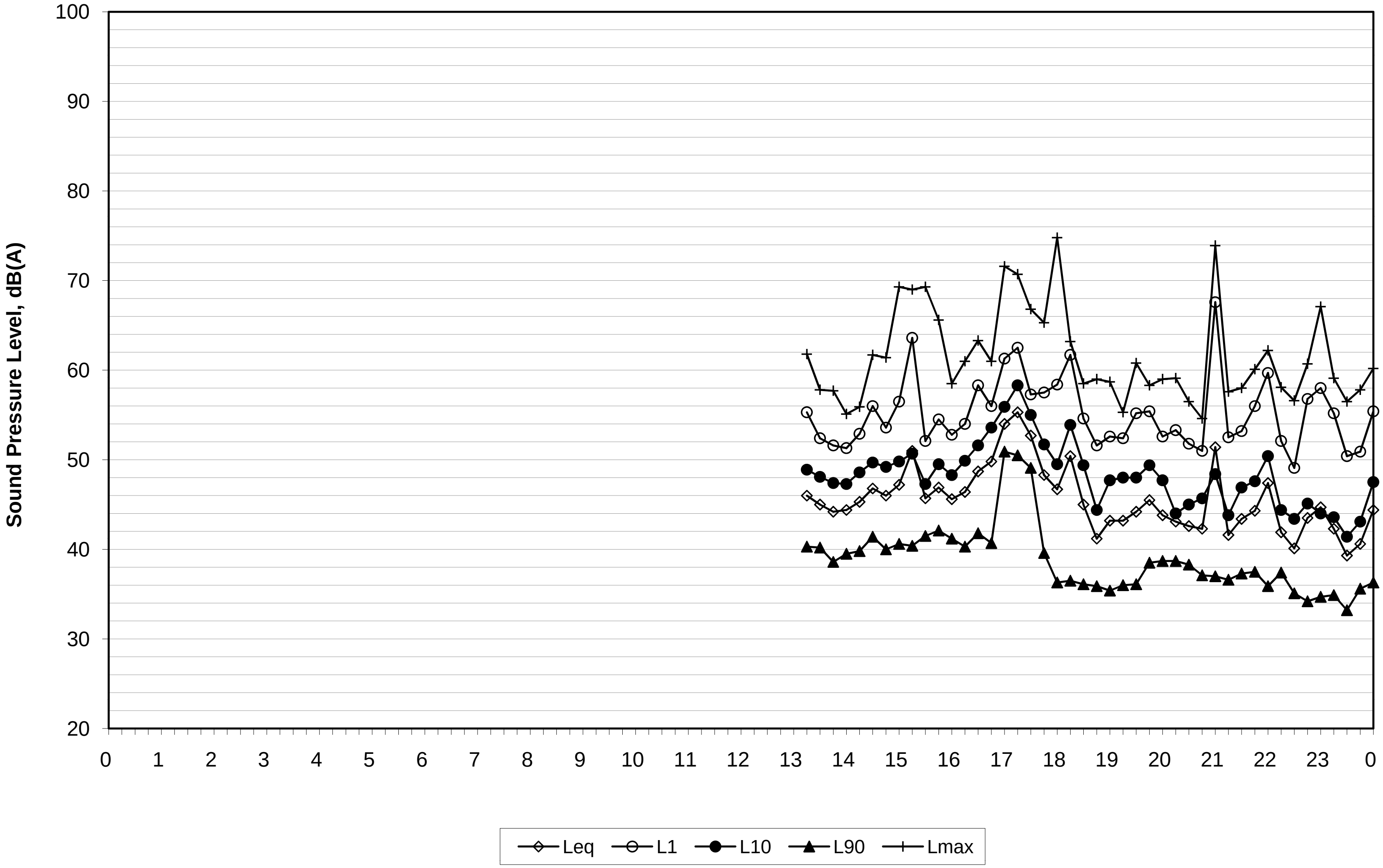


Reference Measurement Location
R2a

6354r2a_t.xls

Ambient Sound Pressure Levels

Tuesday, 16 September 2008

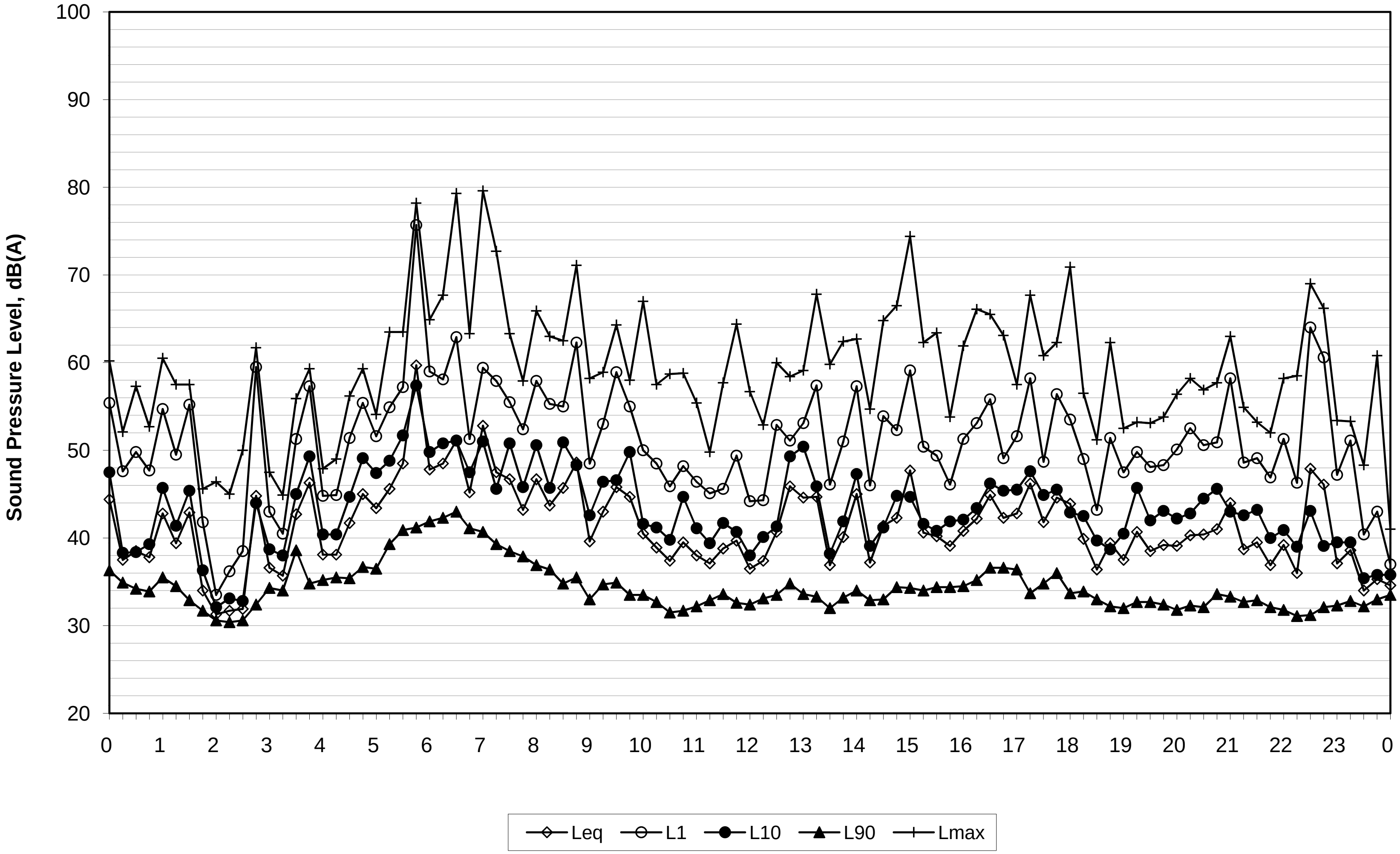


Reference Measurement Location
R3

6354R3_t.xls

Ambient Sound Pressure Levels

Wednesday, 17 September 2008

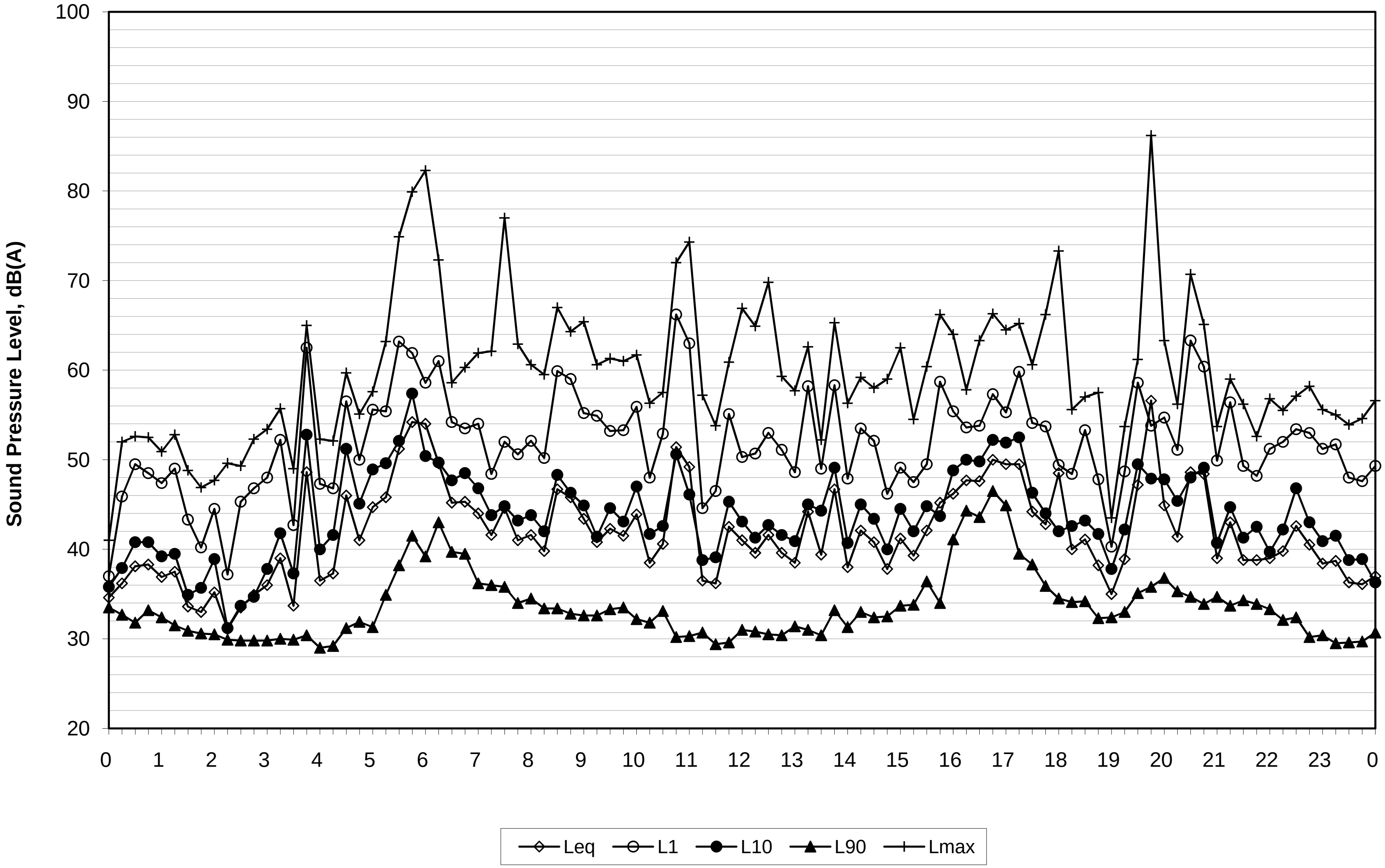


Reference Measurement Location
R3

6354R3_t.xls

Ambient Sound Pressure Levels

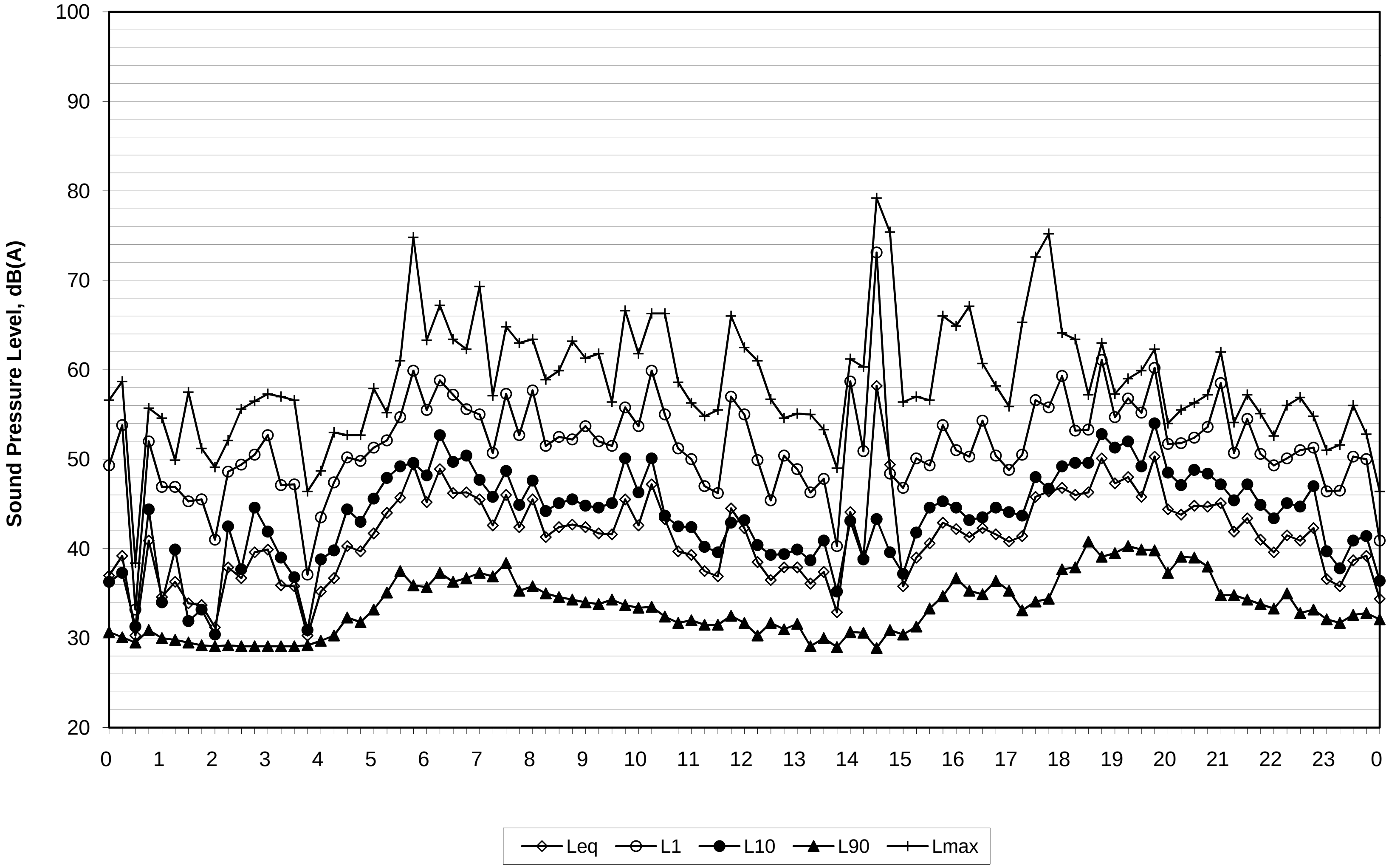
Thursday, 18 September 2008



Reference Measurement Location
R3

Ambient Sound Pressure Levels

Friday, 19 September 2008

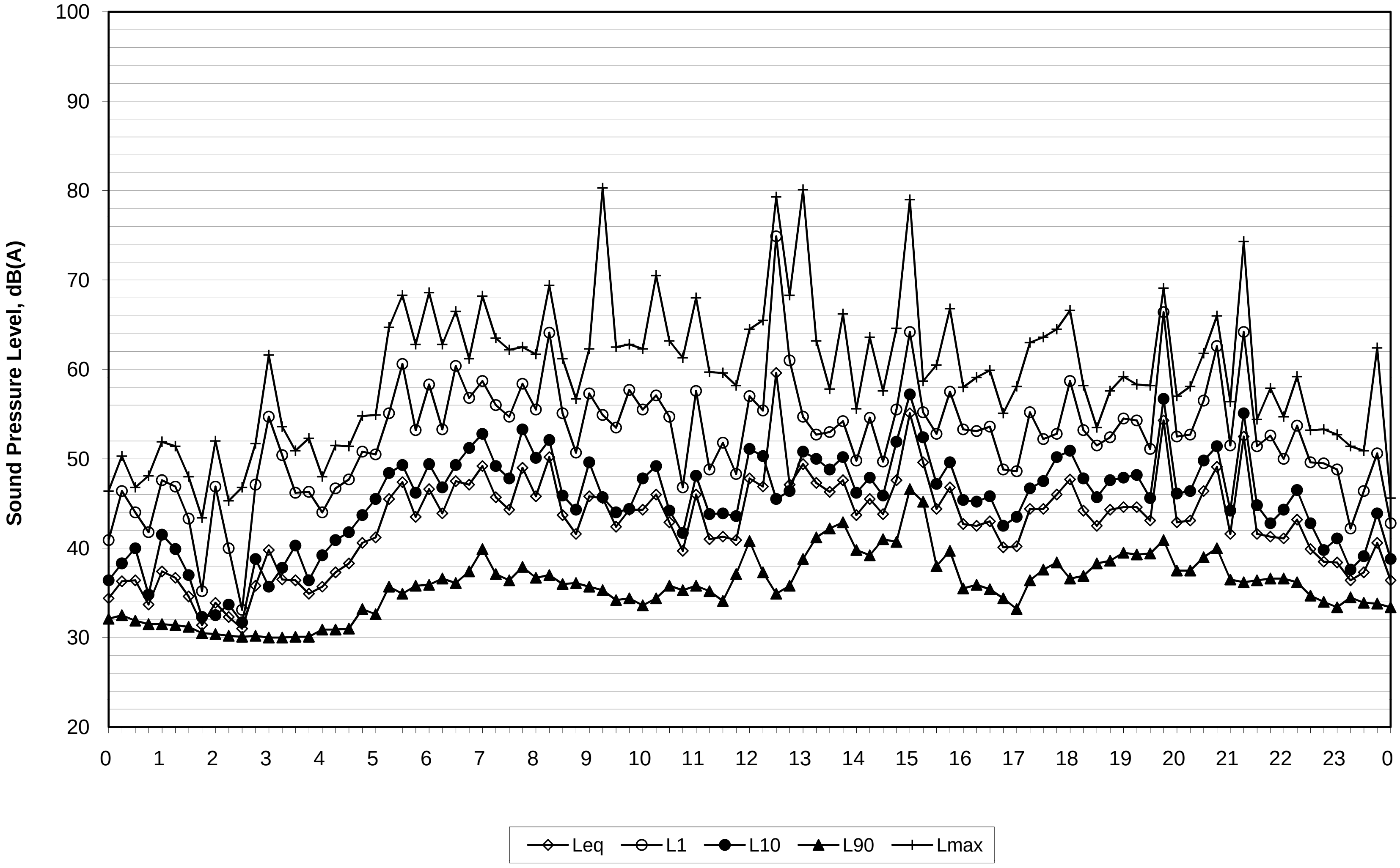


Reference Measurement Location
R3

6354R3_t.xls

Ambient Sound Pressure Levels

Saturday, 20 September 2008

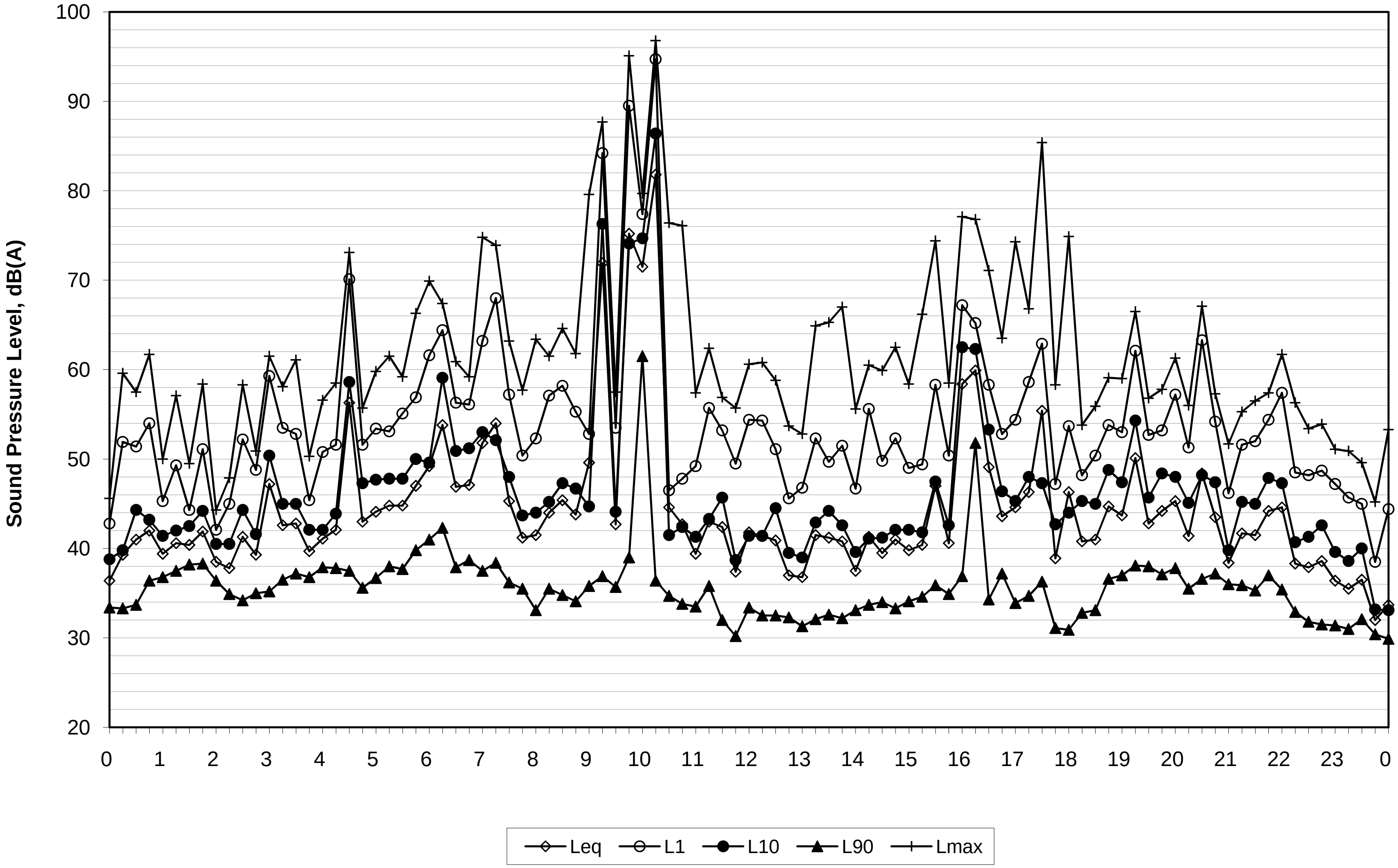


Reference Measurement Location
R3

6354R3_t.xls

Ambient Sound Pressure Levels

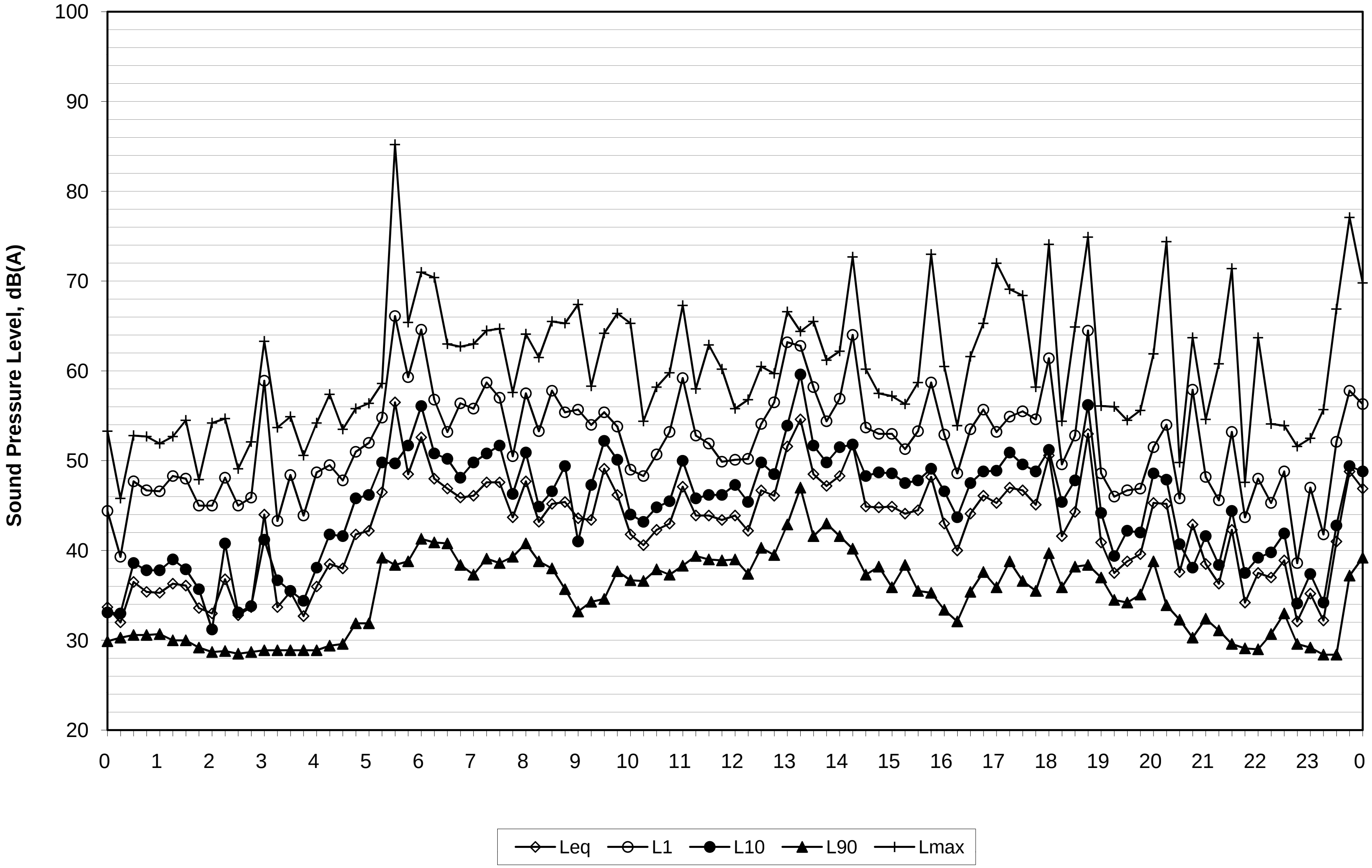
Sunday, 21 September 2008



Reference Measurement Location
R3

Ambient Sound Pressure Levels

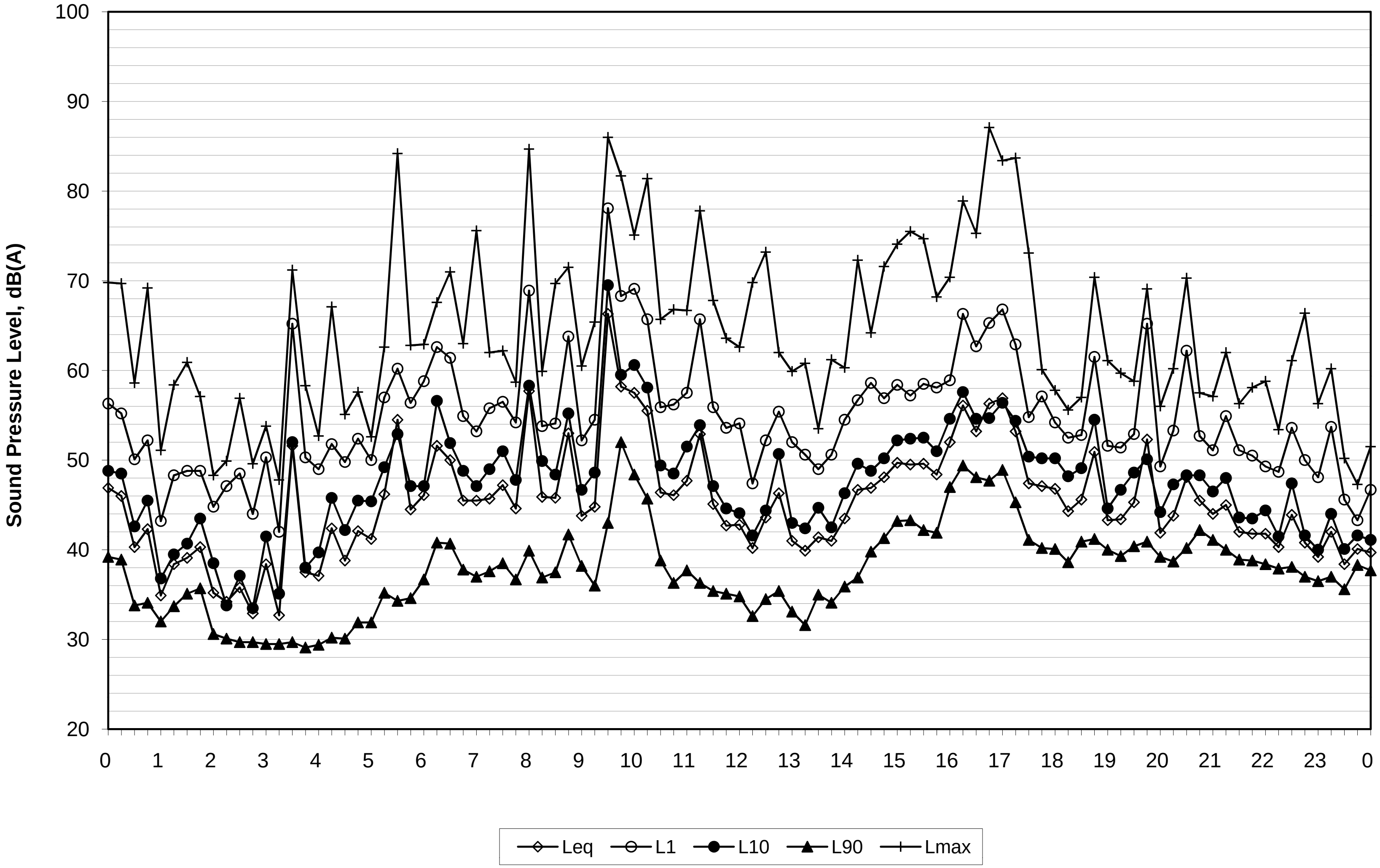
Monday, 22 September 2008



Reference Measurement Location
R3

Ambient Sound Pressure Levels

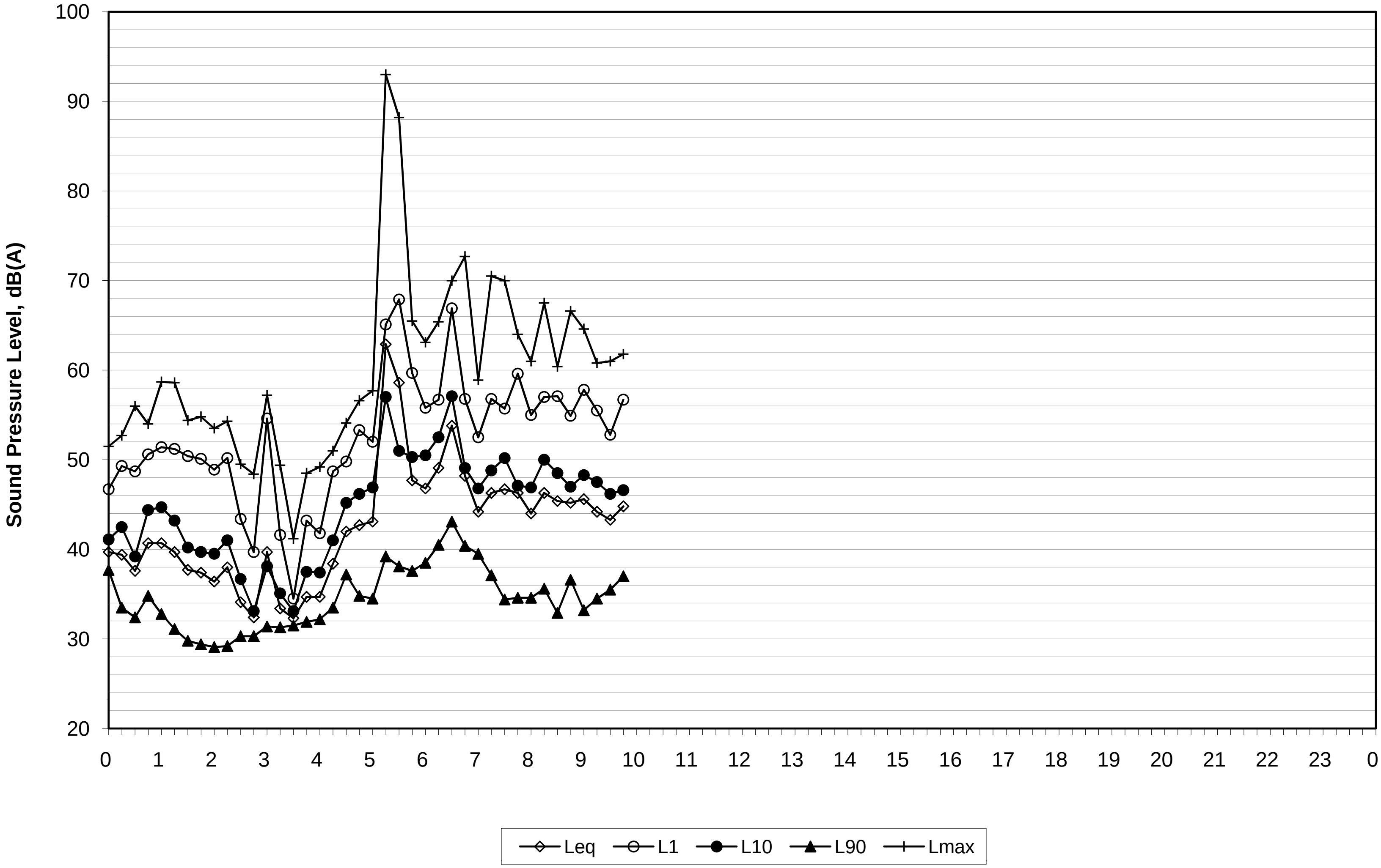
Tuesday, 23 September 2008



Reference Measurement Location
R3

Ambient Sound Pressure Levels

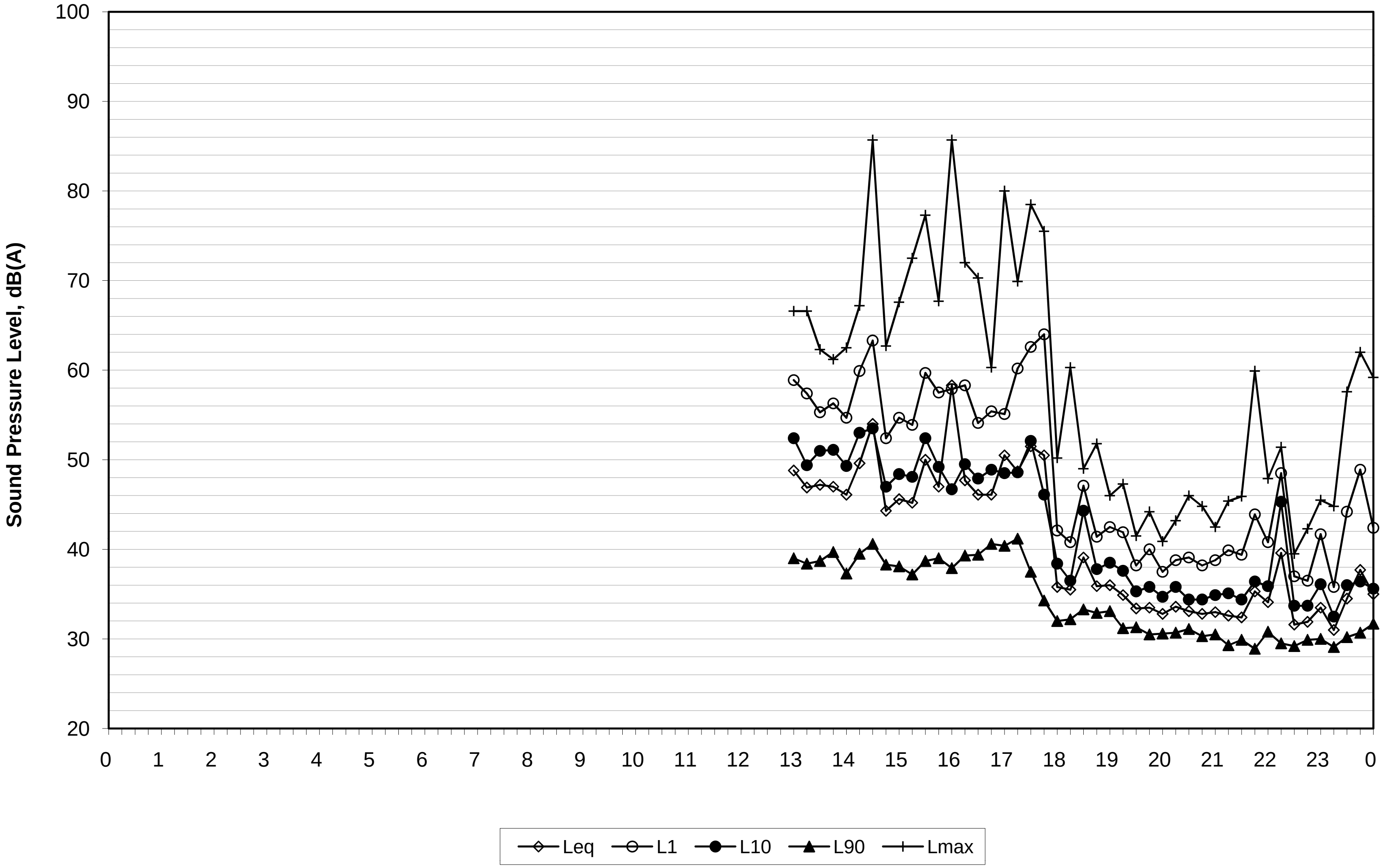
Wednesday, 24 September 2008



Reference Measurement Location
R3

Ambient Sound Pressure Levels

Tuesday, 16 September 2008

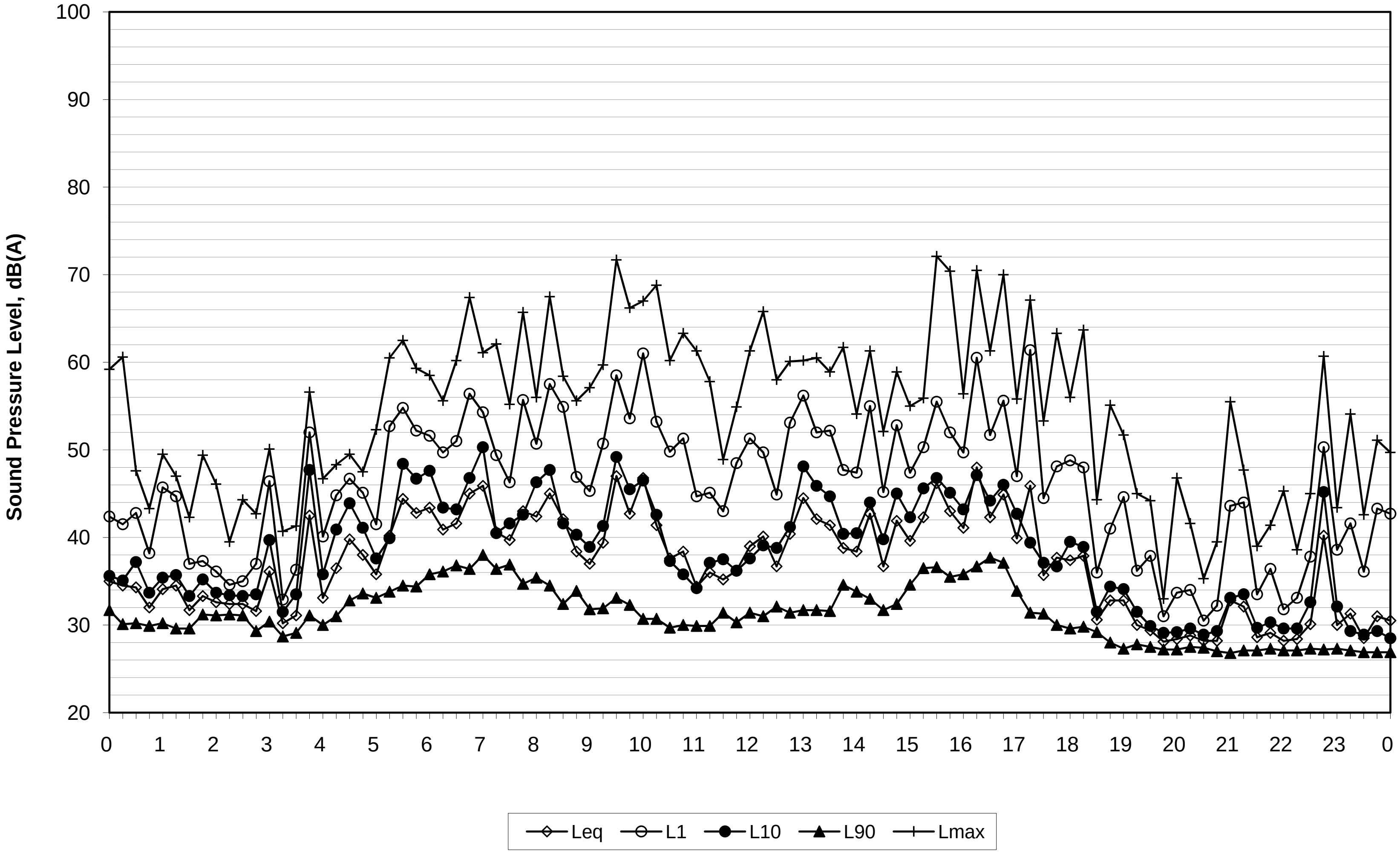


Reference Measurement Location
R4

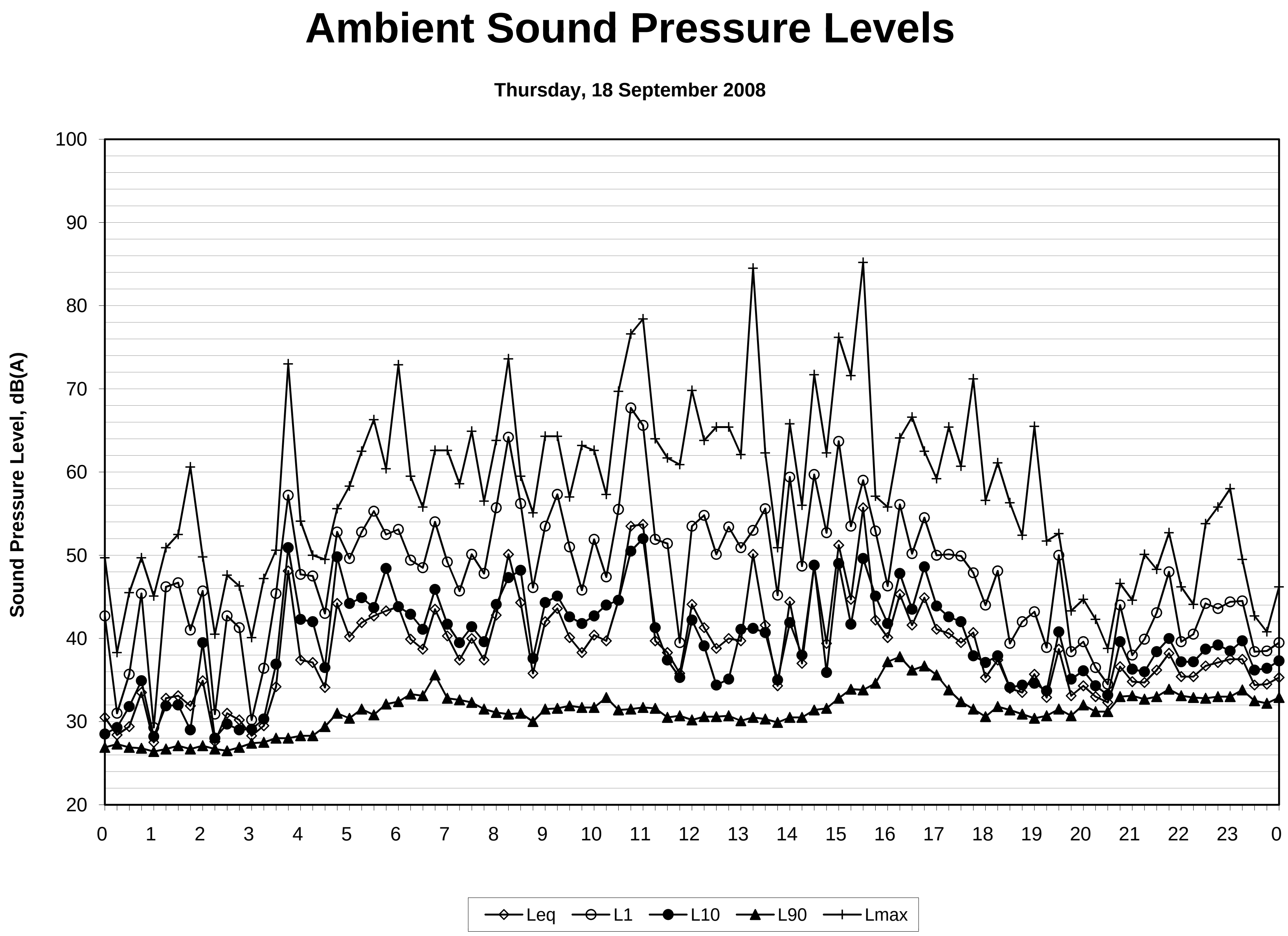
6354R4_t.xls

Ambient Sound Pressure Levels

Wednesday, 17 September 2008

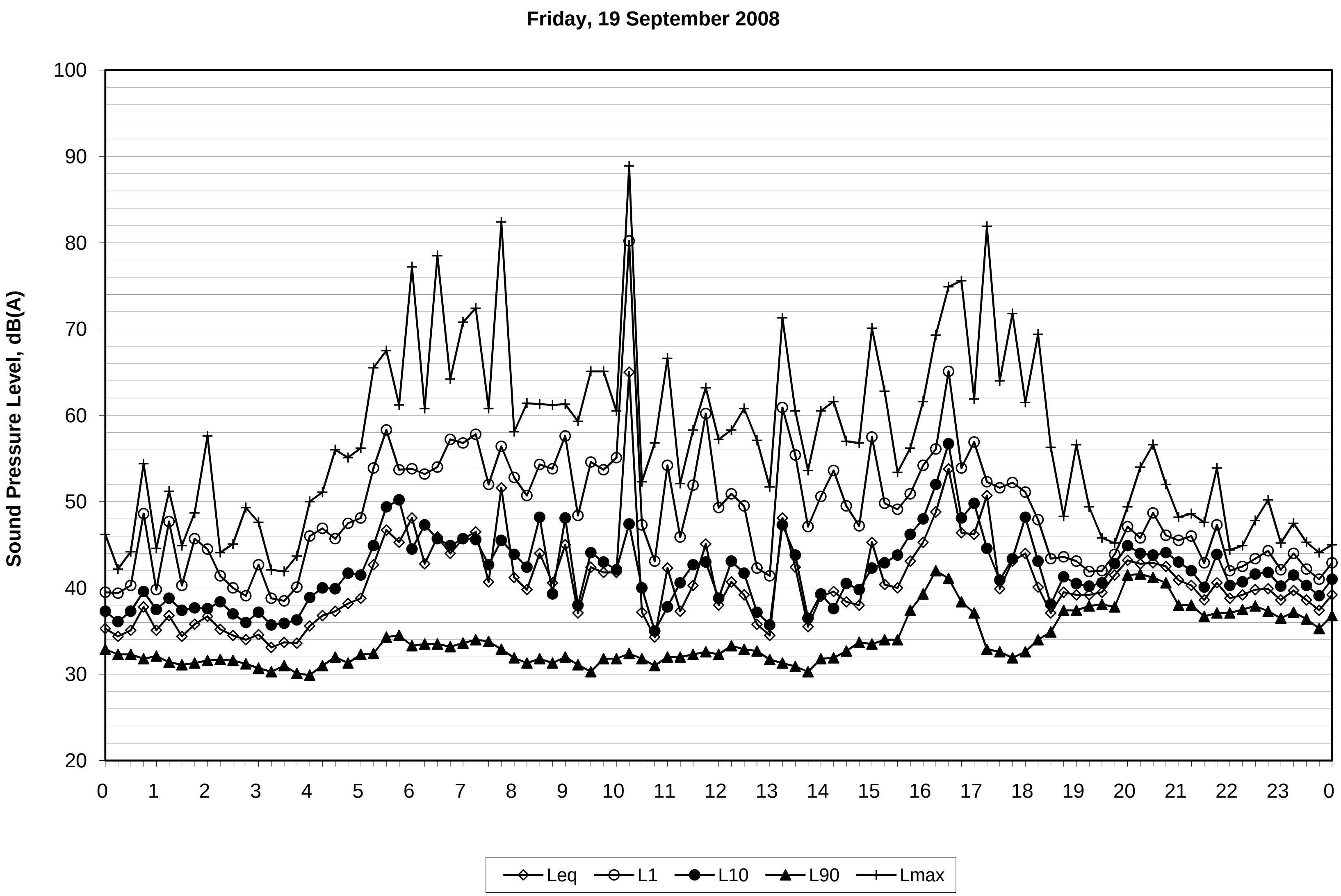


Reference Measurement Location
R4



Reference Measurement Location
R4

Ambient Sound Pressure Levels

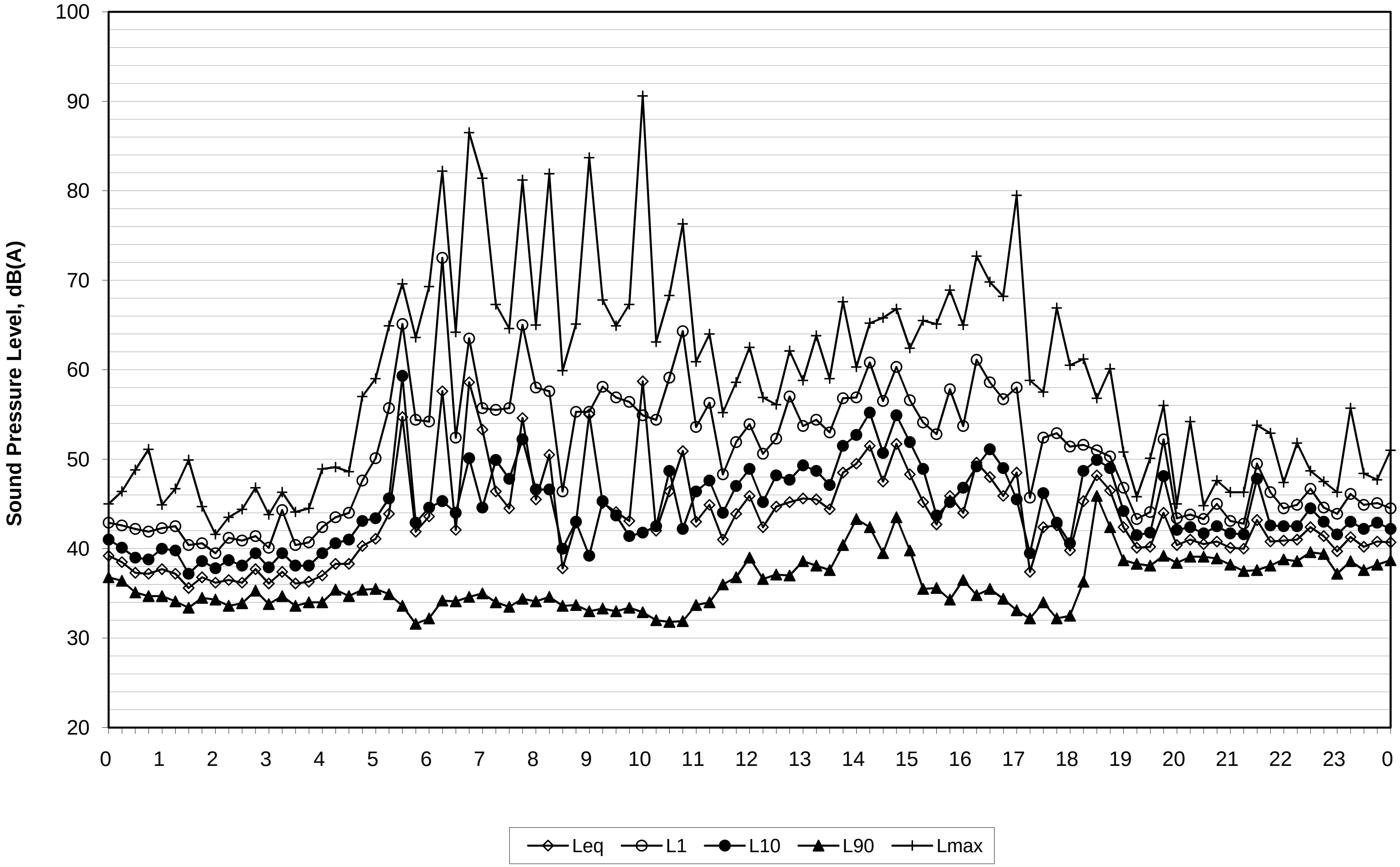


Reference Measurement Location
R4

6354R4_t.xls

Ambient Sound Pressure Levels

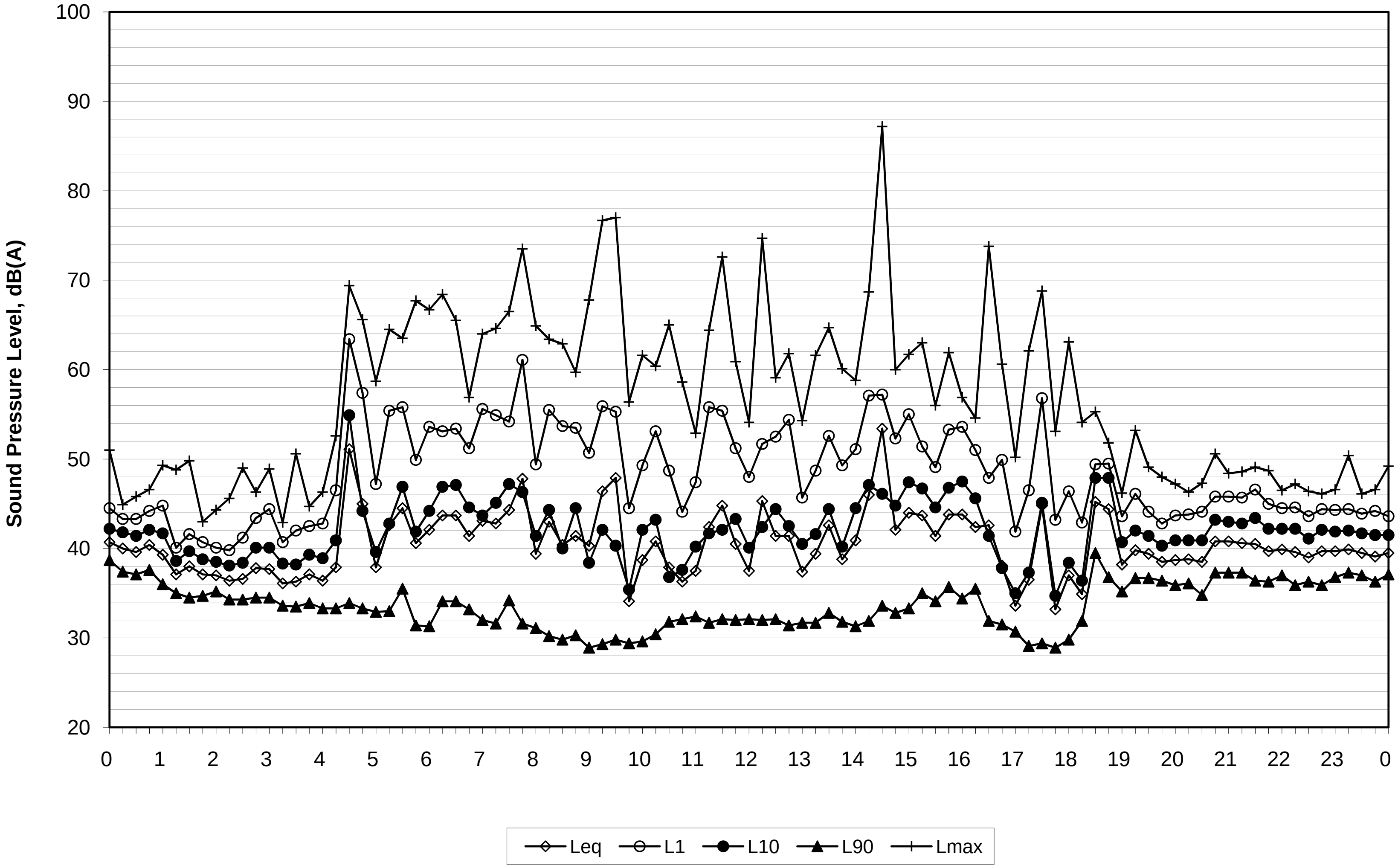
Saturday, 20 September 2008



Reference Measurement Location
R4

Ambient Sound Pressure Levels

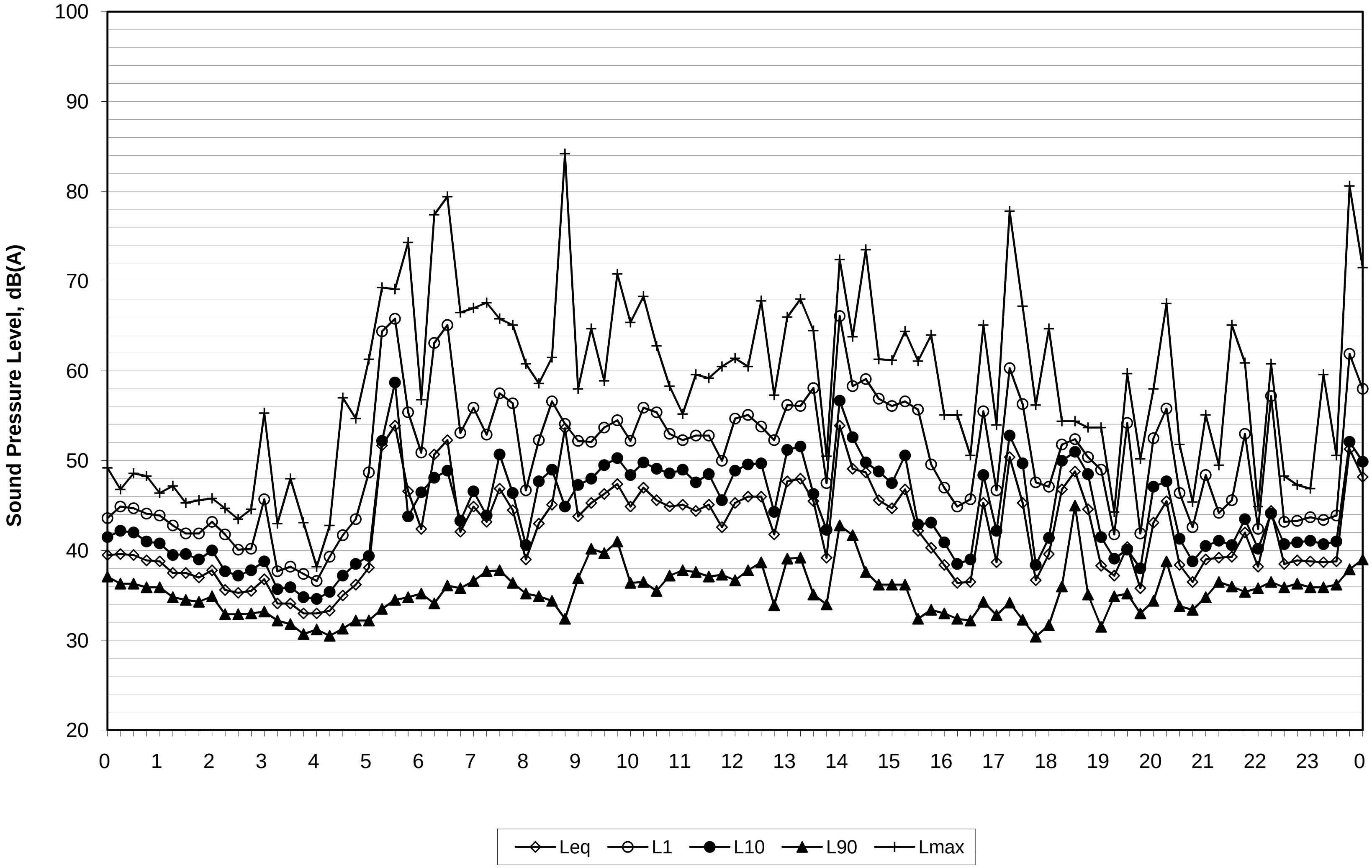
Sunday, 21 September 2008



Reference Measurement Location
R4

Ambient Sound Pressure Levels

Monday, 22 September 2008

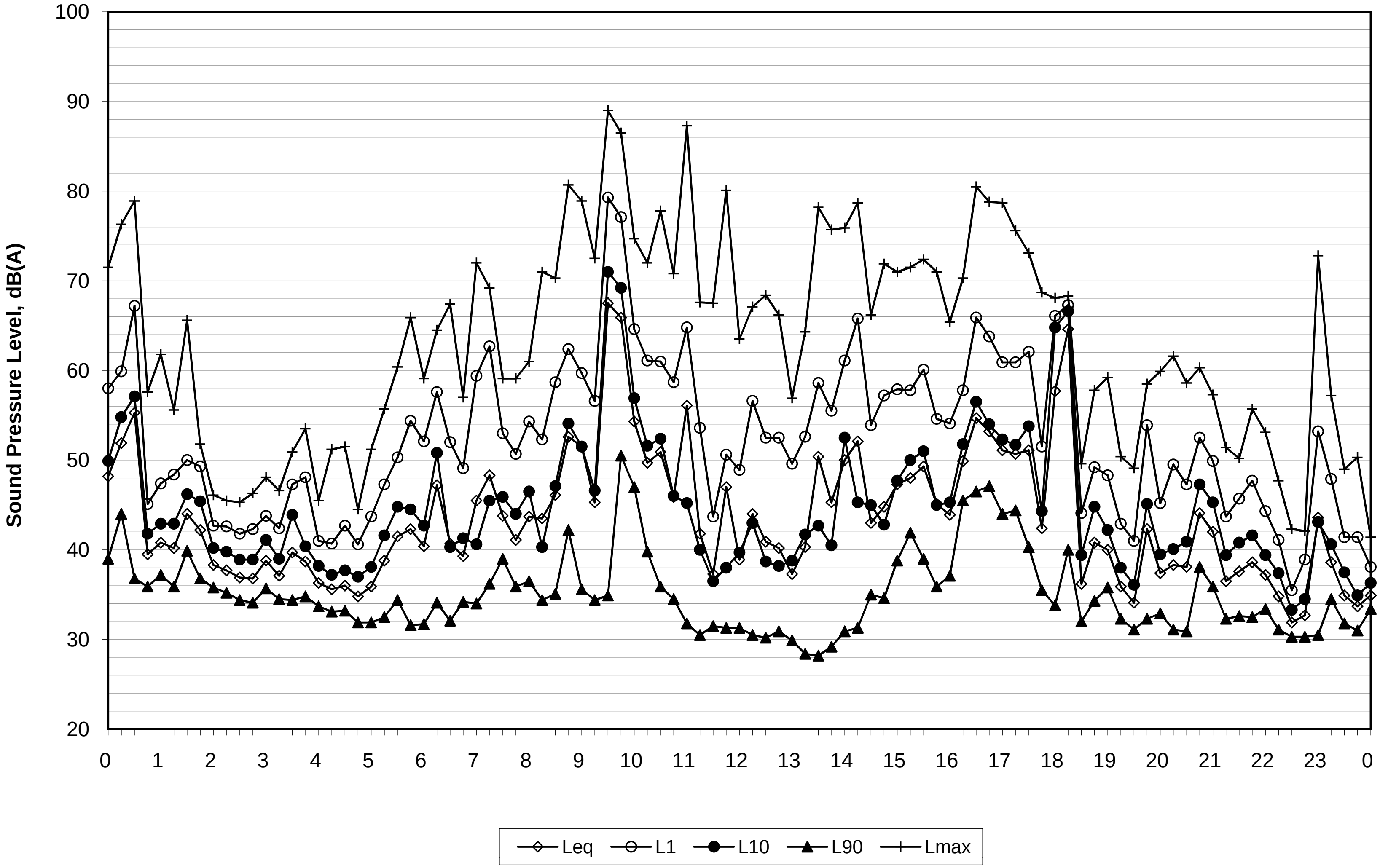


Reference Measurement Location
R4

6354R4_t.xls

Ambient Sound Pressure Levels

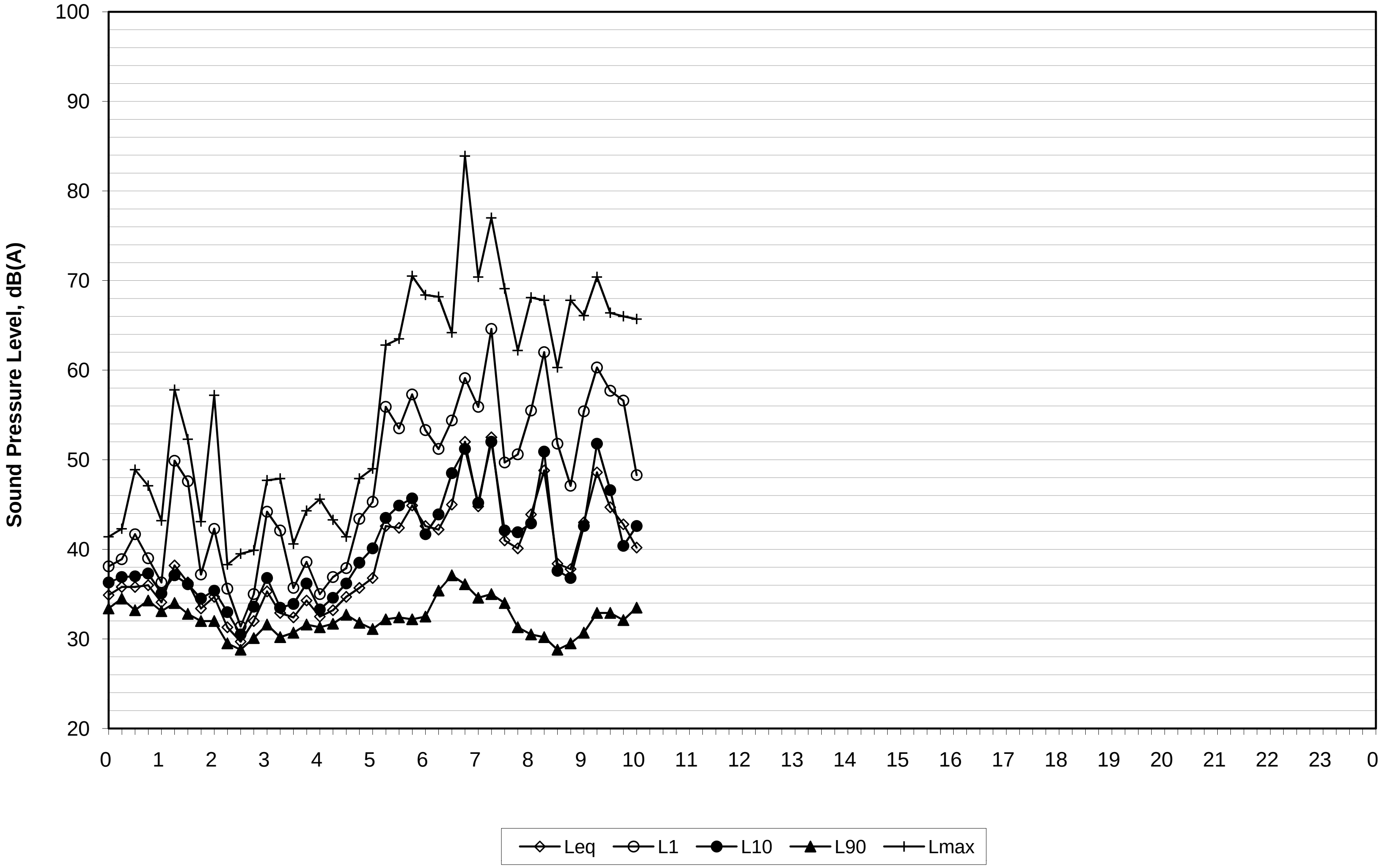
Tuesday, 23 September 2008



Reference Measurement Location
R4

Ambient Sound Pressure Levels

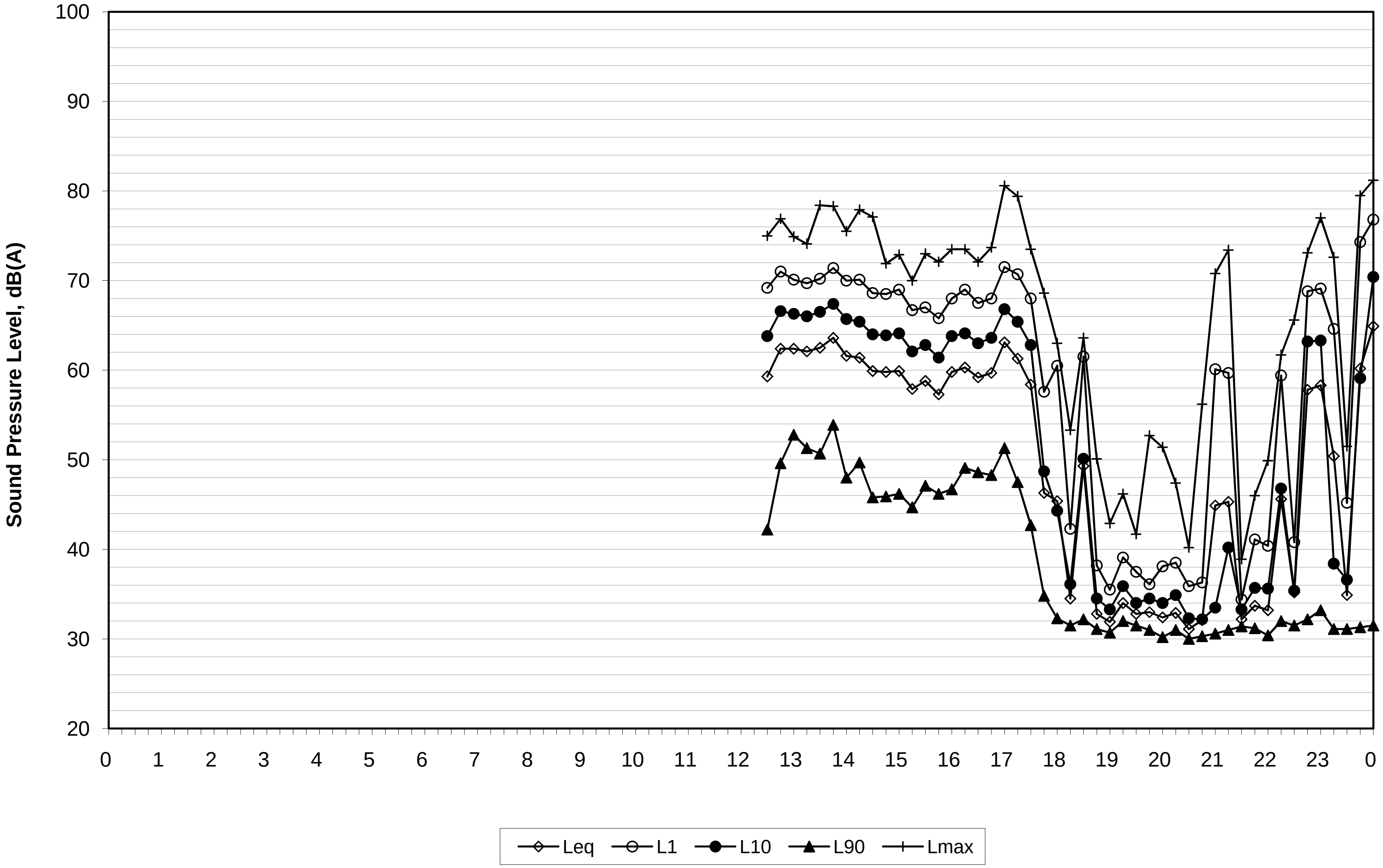
Wednesday, 24 September 2008



Reference Measurement Location
R4

Ambient Sound Pressure Levels

Tuesday, 16 September 2008

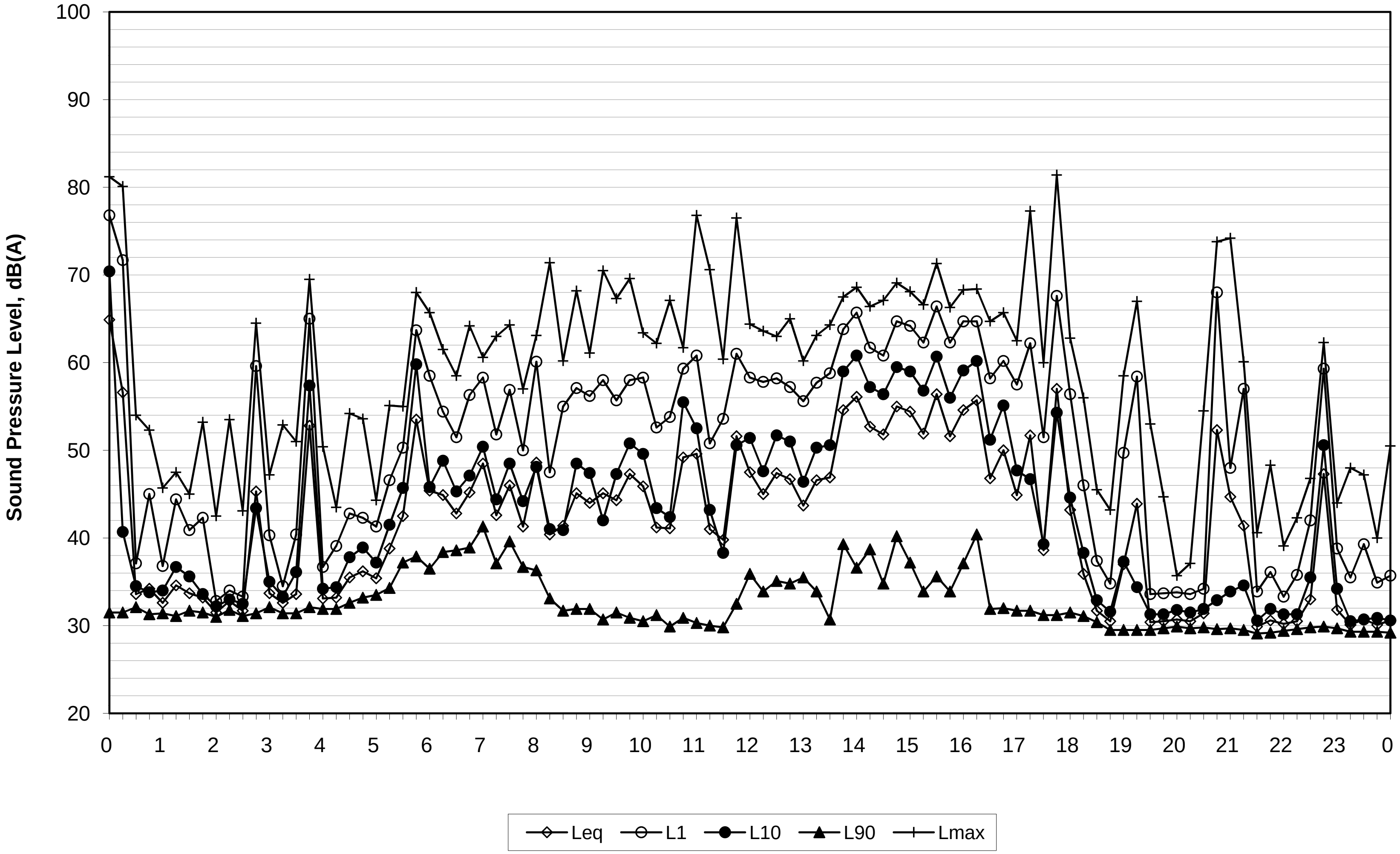


Reference Measurement Location
R5

6354R5_t.xls

Ambient Sound Pressure Levels

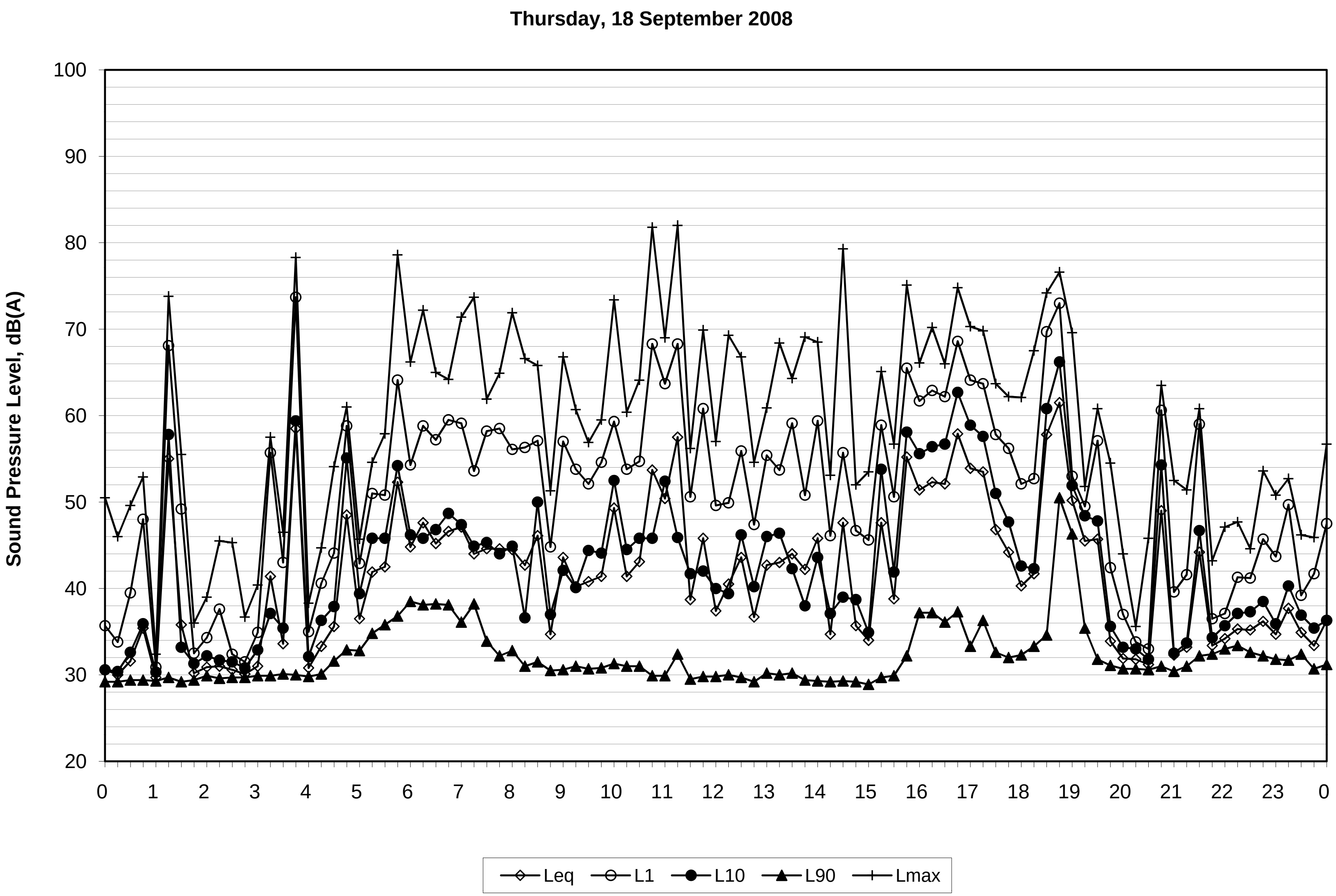
Wednesday, 17 September 2008



Reference Measurement Location
R5

6354R5_t.xls

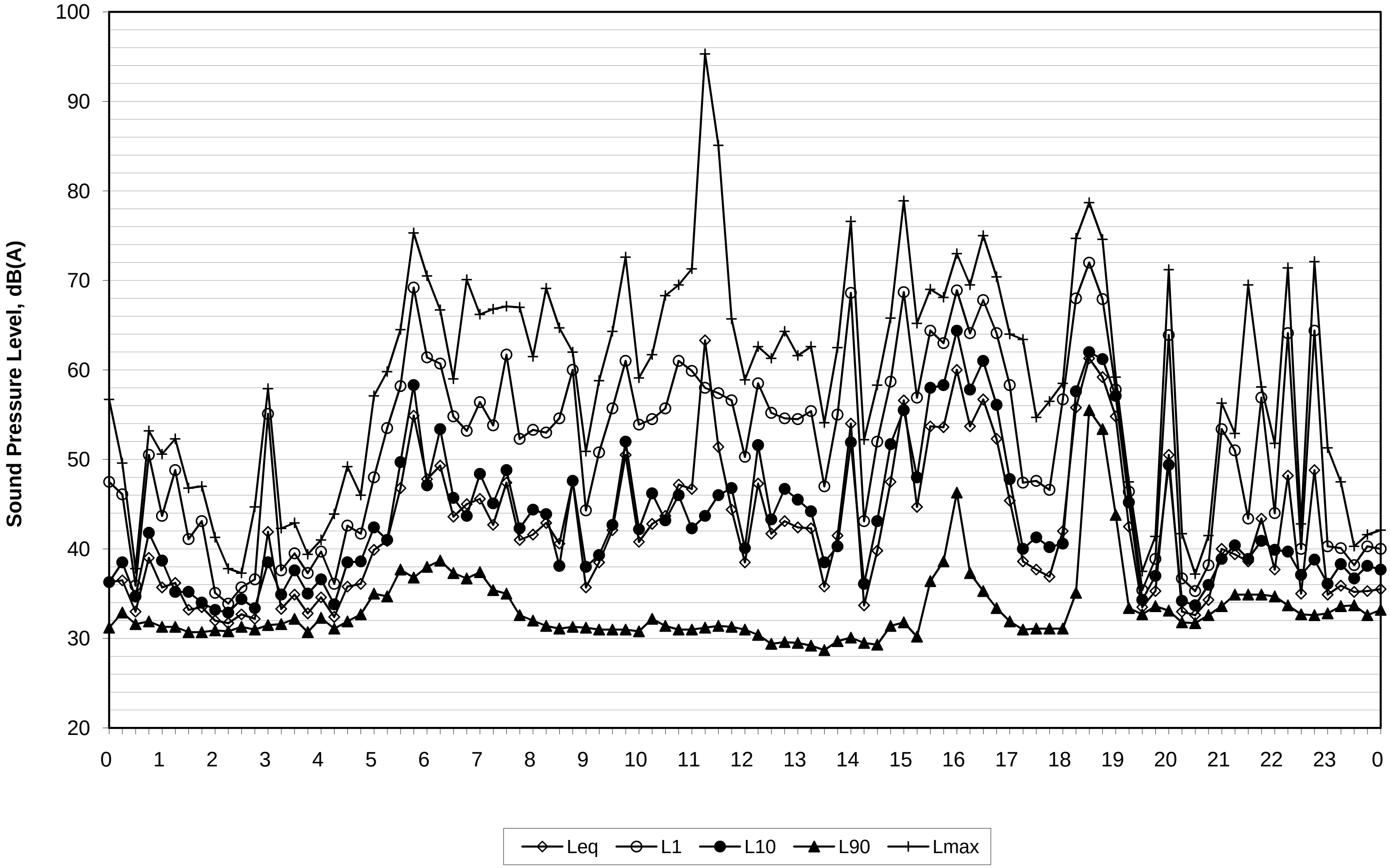
Ambient Sound Pressure Levels



Reference Measurement Location
R5

Ambient Sound Pressure Levels

Friday, 19 September 2008

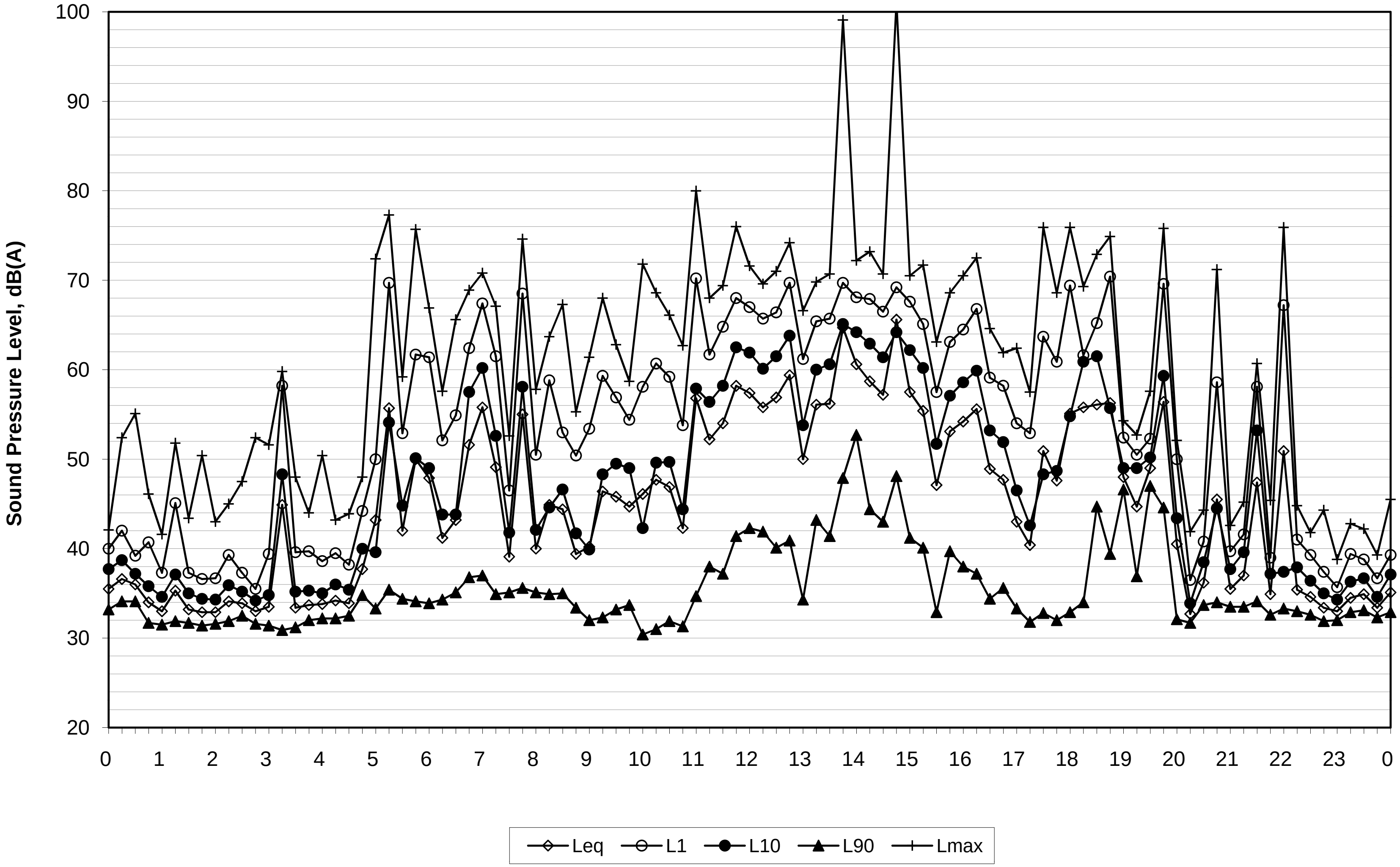


Reference Measurement Location
R5

6354R5_t.xls

Ambient Sound Pressure Levels

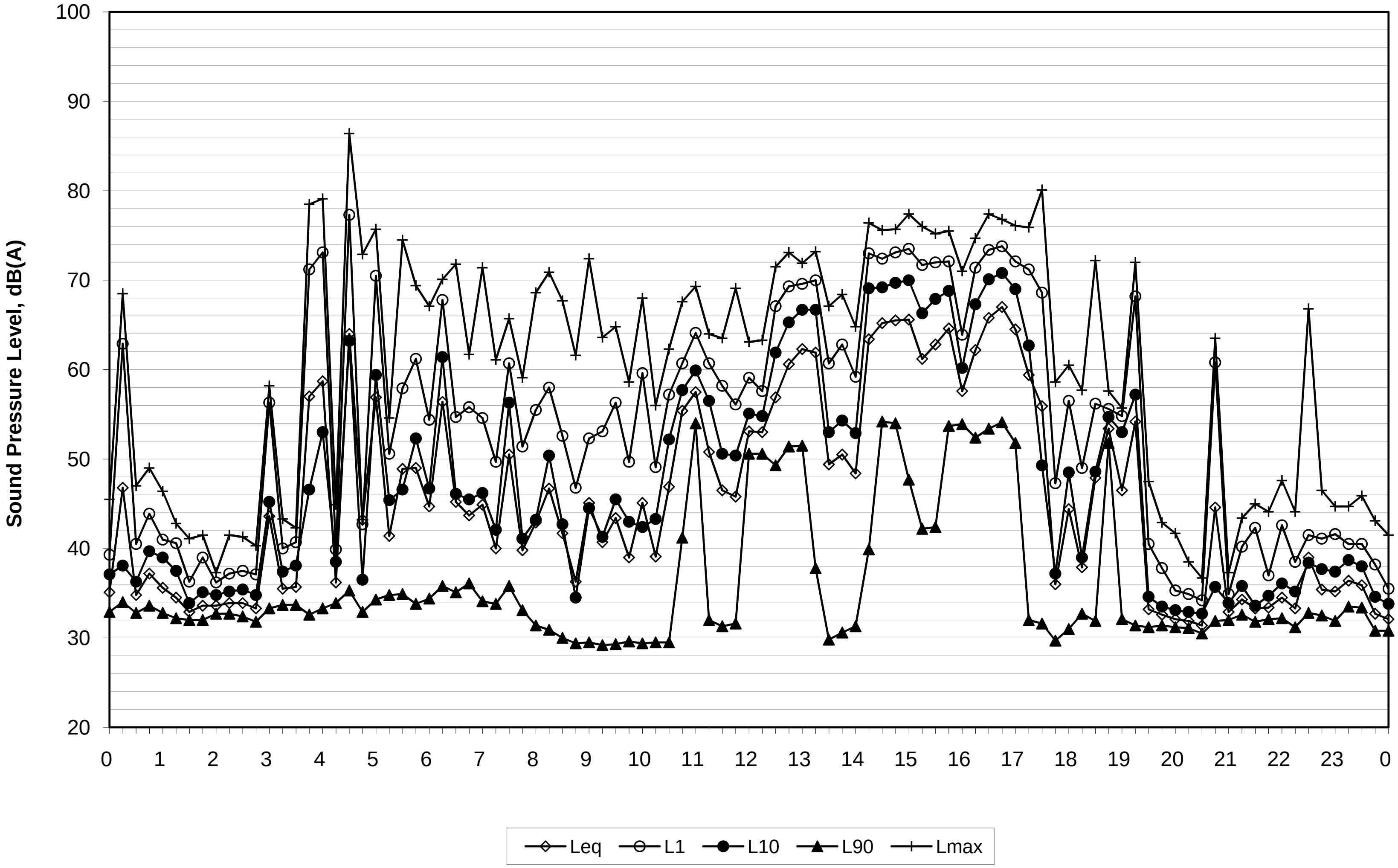
Saturday, 20 September 2008



Reference Measurement Location
R5

Ambient Sound Pressure Levels

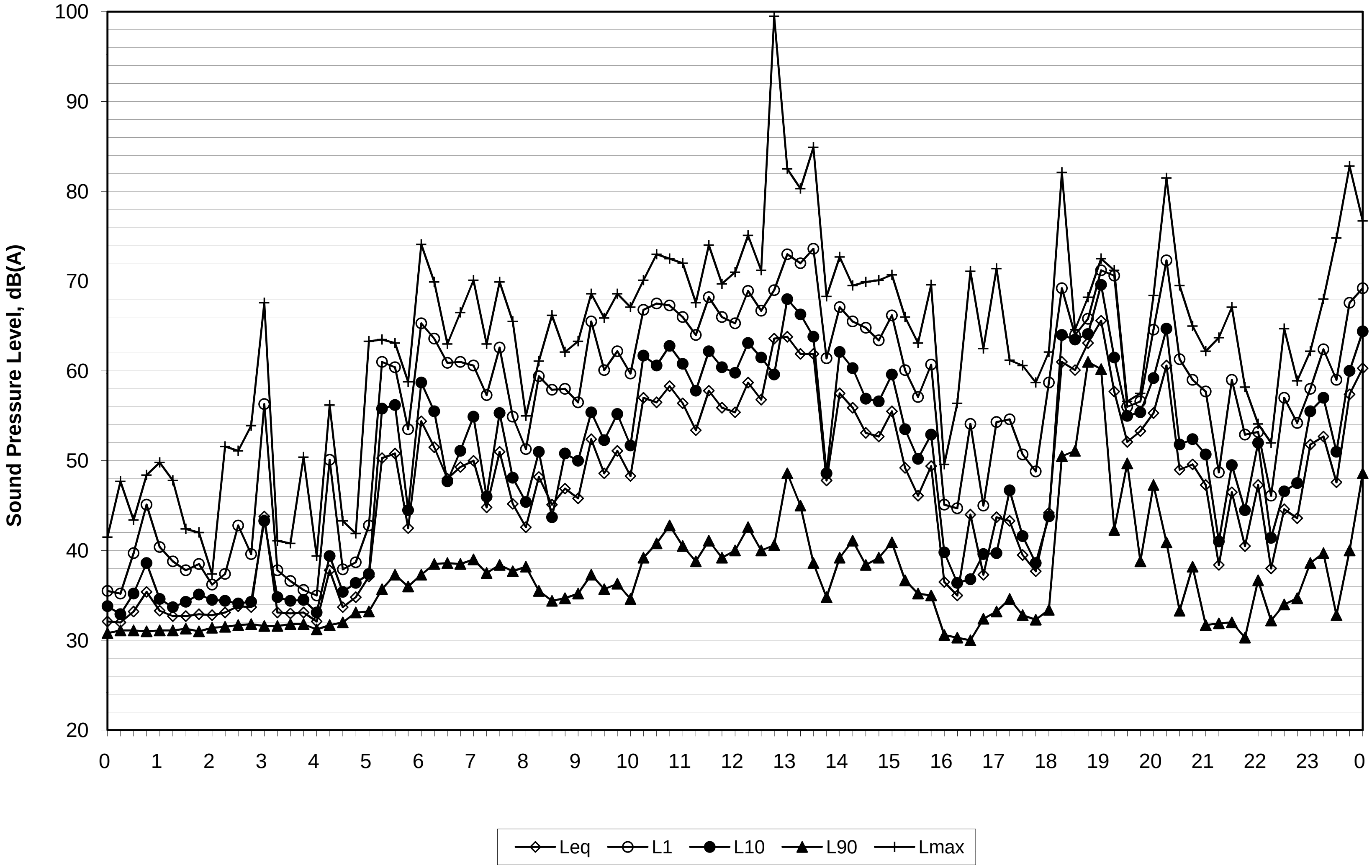
Sunday, 21 September 2008



Reference Measurement Location
R5

Ambient Sound Pressure Levels

Monday, 22 September 2008

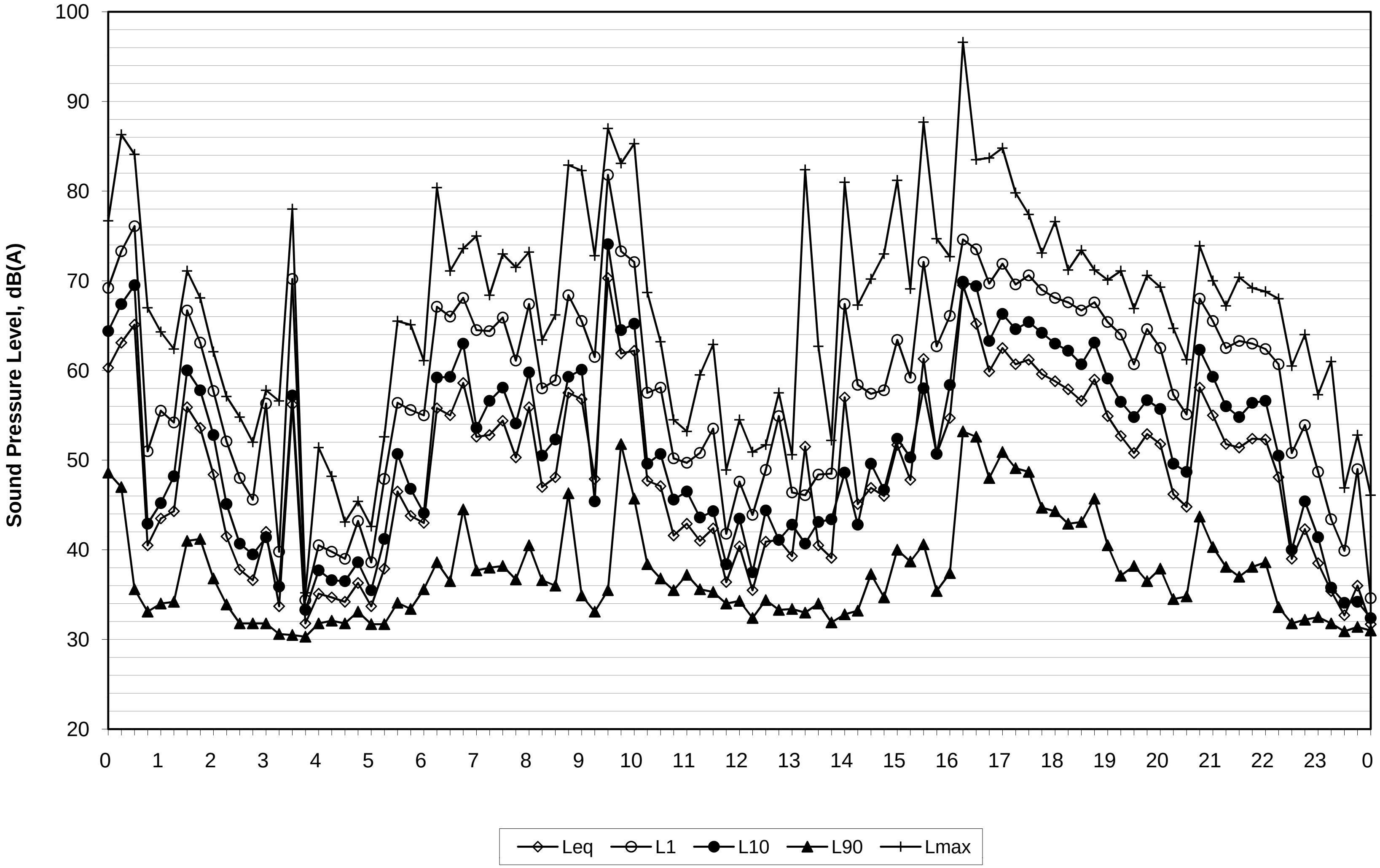


Reference Measurement Location
R5

6354R5_t.xls

Ambient Sound Pressure Levels

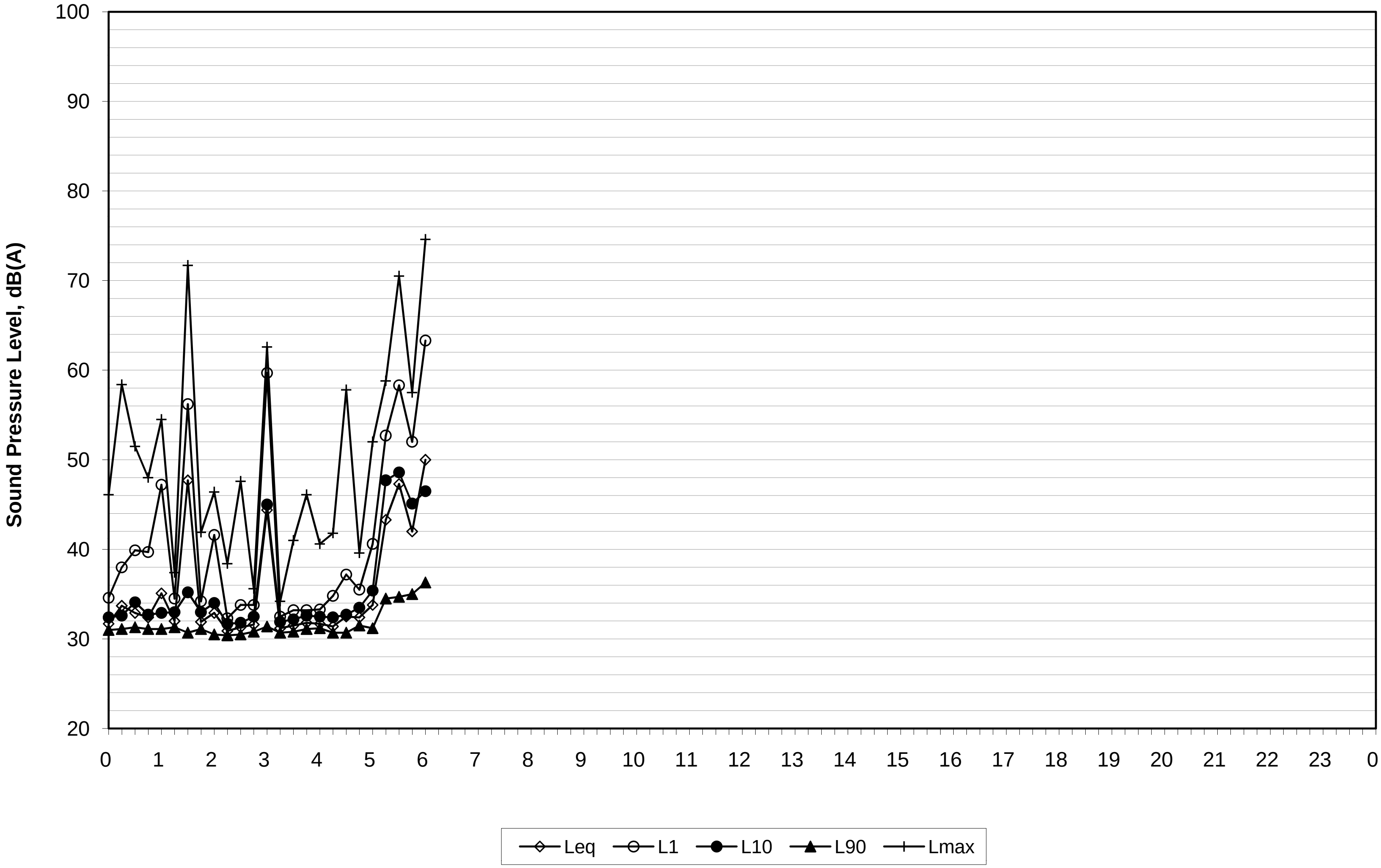
Tuesday, 23 September 2008



Reference Measurement Location
R5

Ambient Sound Pressure Levels

Wednesday, 24 September 2008

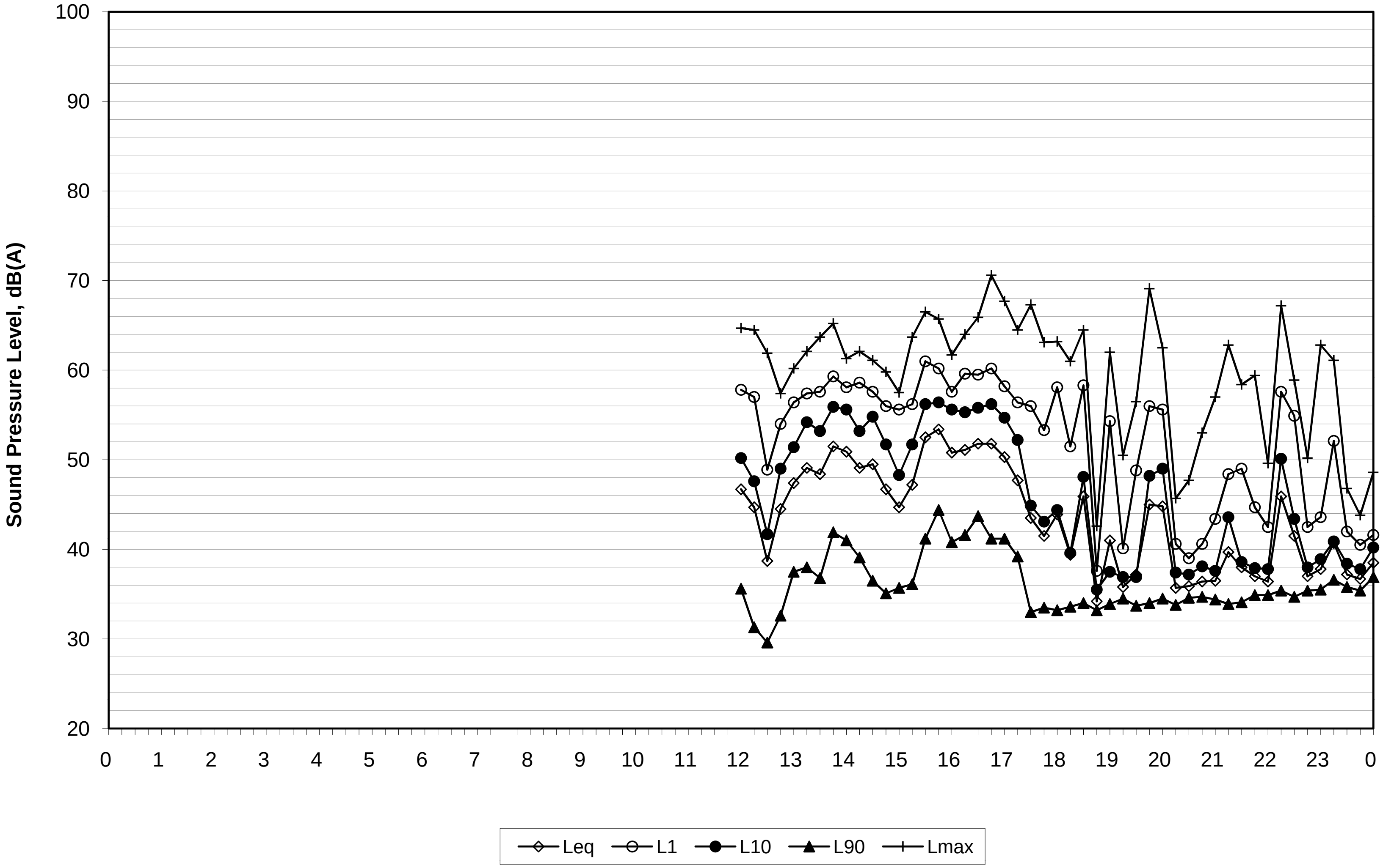


Reference Measurement Location
R5

6354R5_t.xls

Ambient Sound Pressure Levels

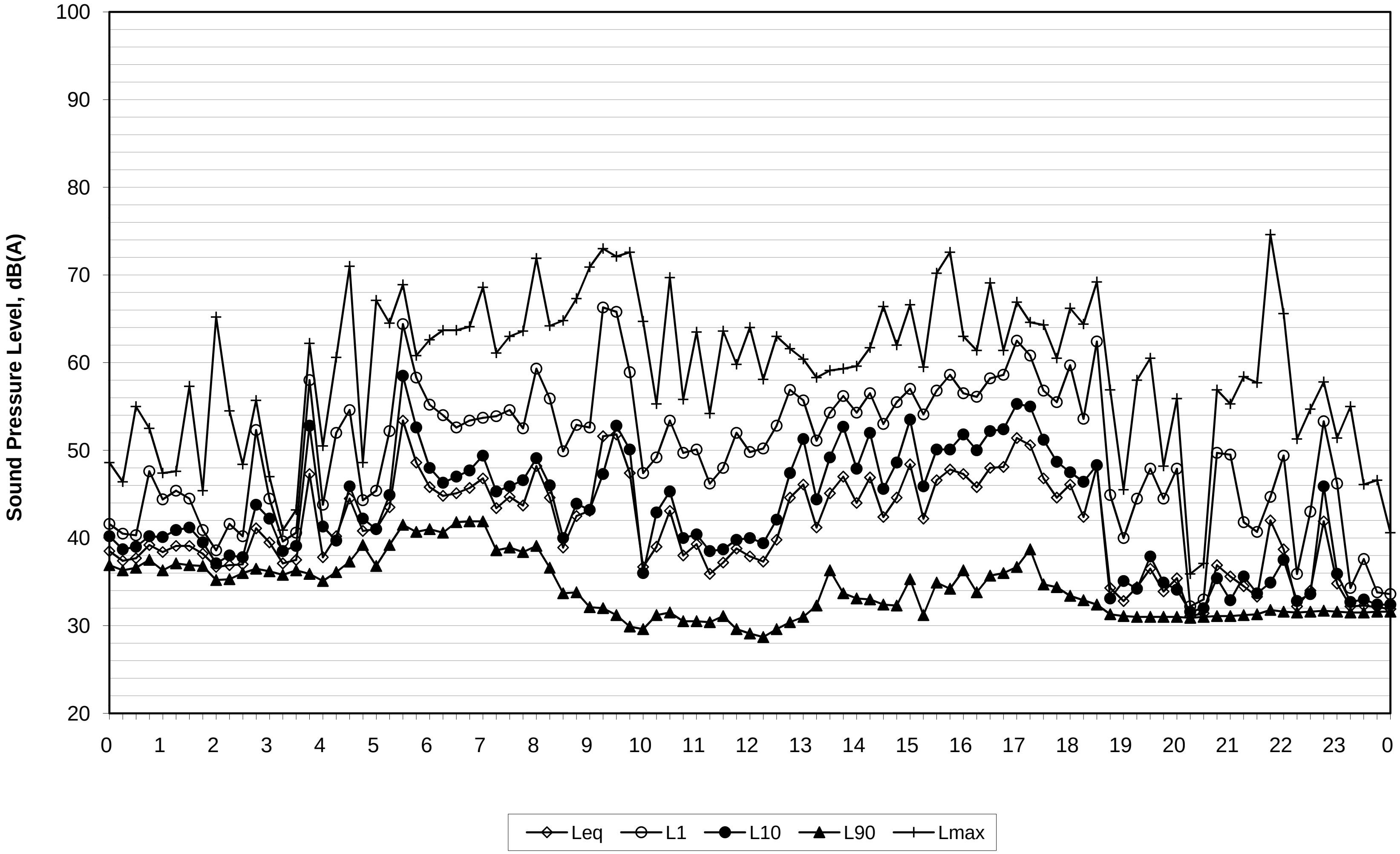
Tuesday, 16 September 2008



Reference Measurement Location
R6

Ambient Sound Pressure Levels

Wednesday, 17 September 2008

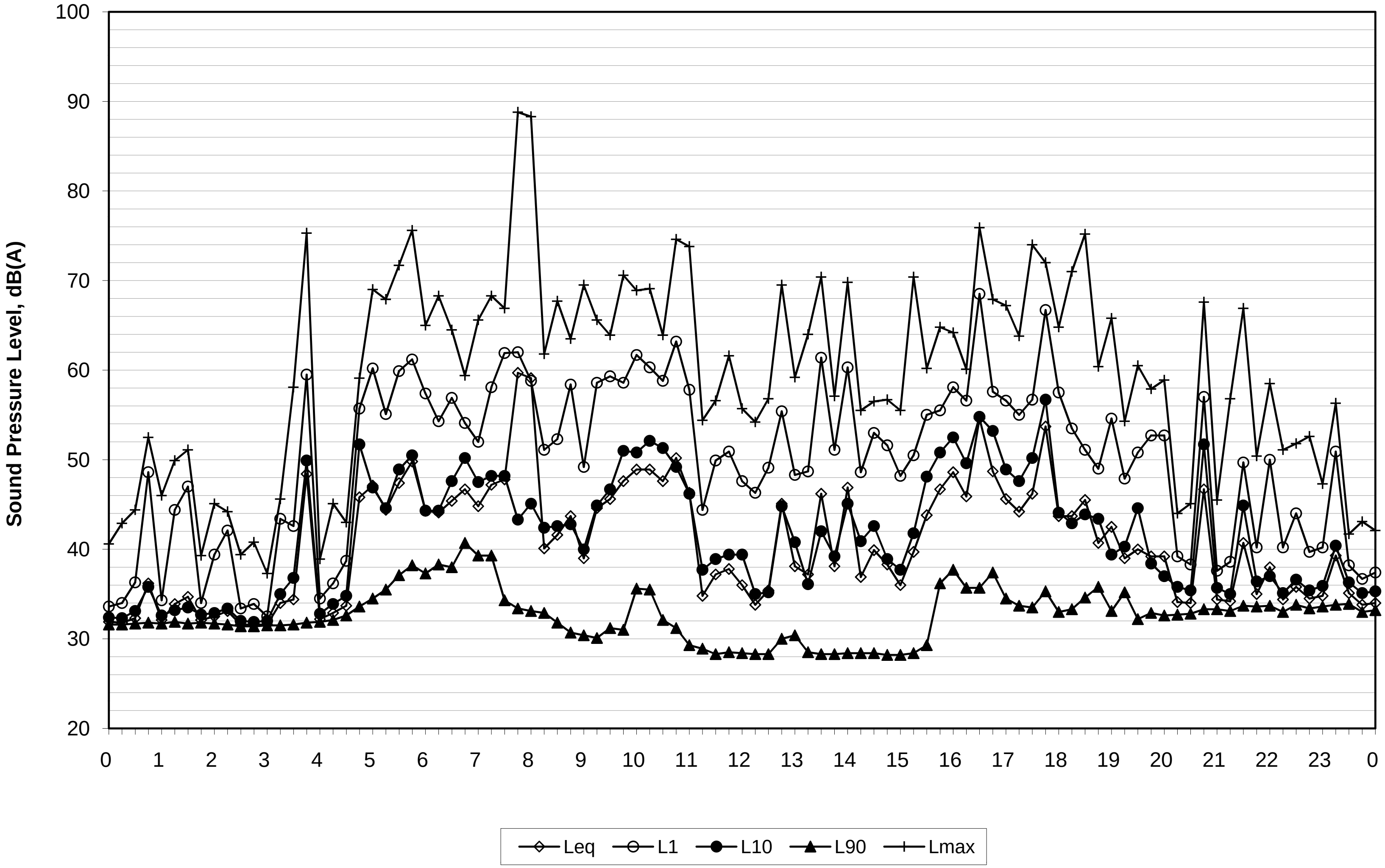


Reference Measurement Location
R6

6354R6_t.xls

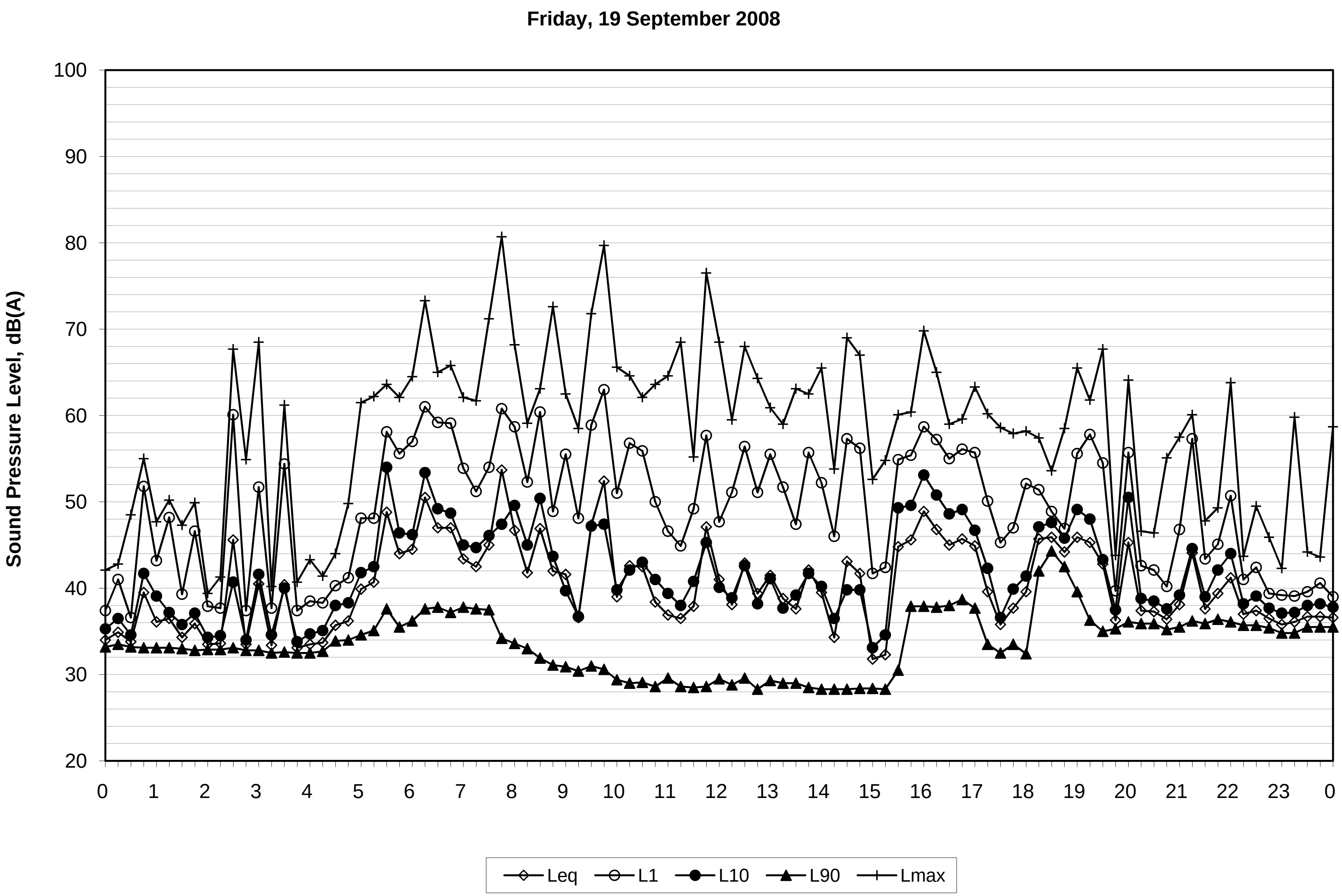
Ambient Sound Pressure Levels

Thursday, 18 September 2008



Reference Measurement Location
R6

Ambient Sound Pressure Levels

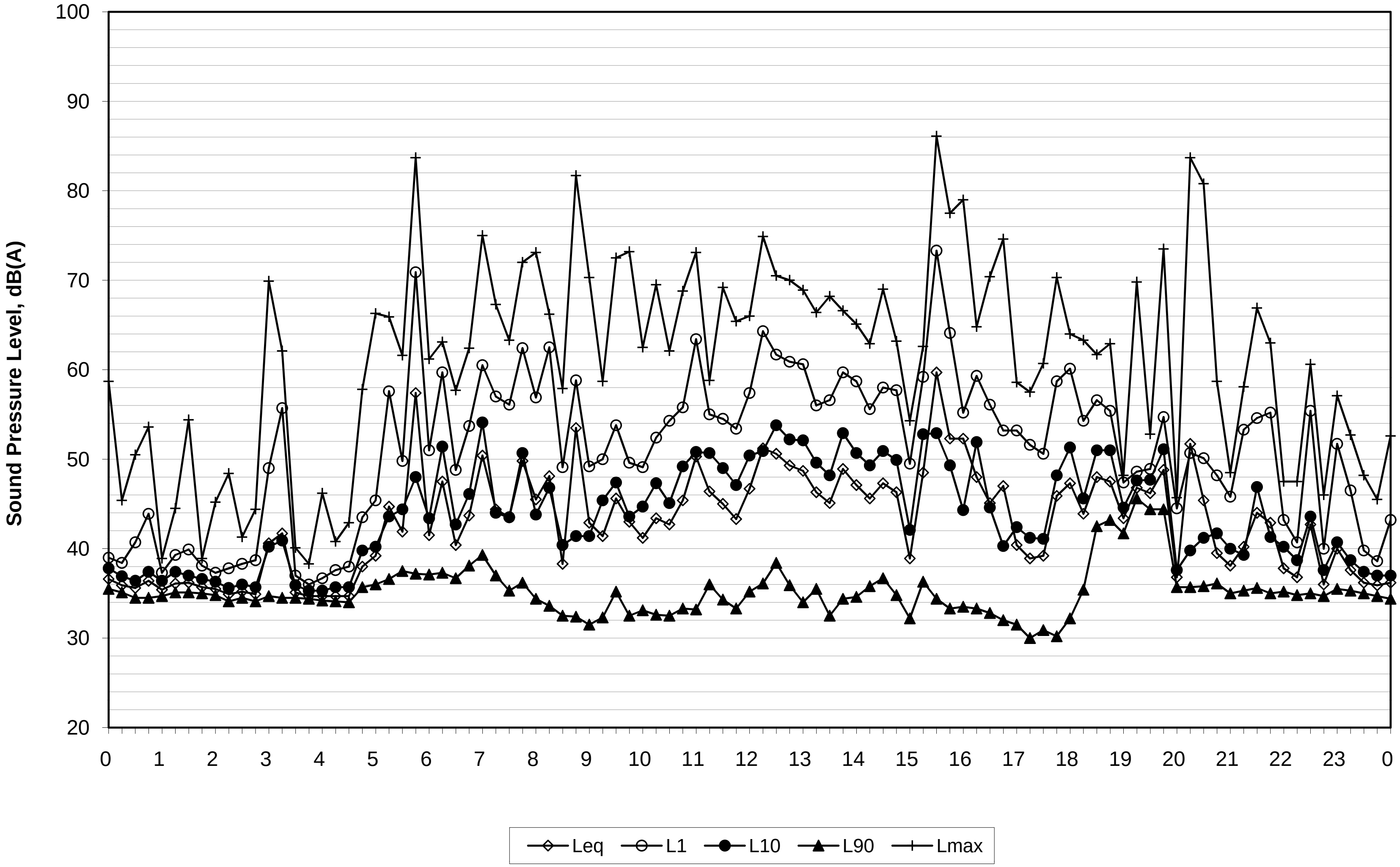


Reference Measurement Location
R6

6354R6_t.xls

Ambient Sound Pressure Levels

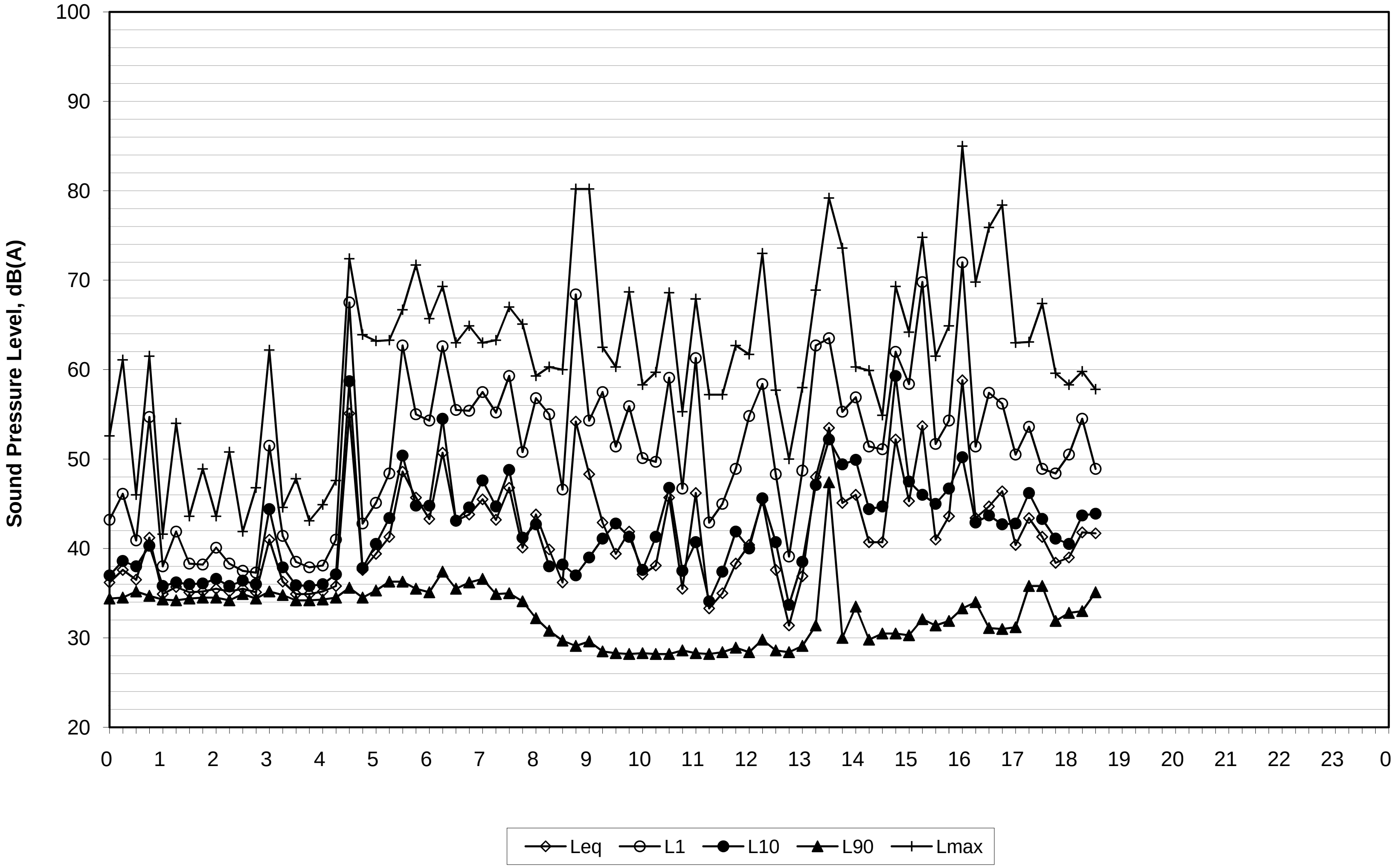
Saturday, 20 September 2008



Reference Measurement Location
R6

Ambient Sound Pressure Levels

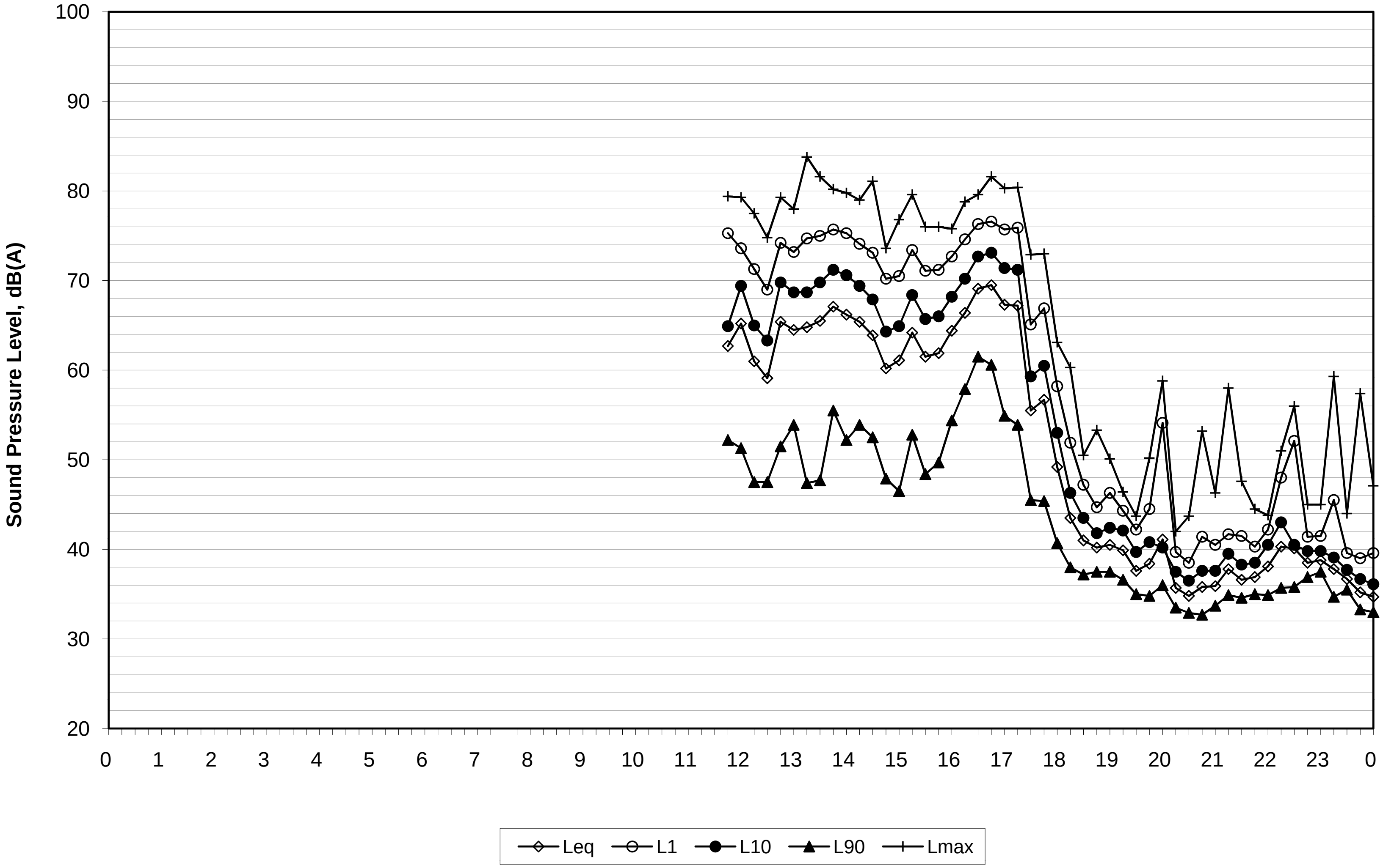
Sunday, 21 September 2008



Reference Measurement Location
R6

Ambient Sound Pressure Levels

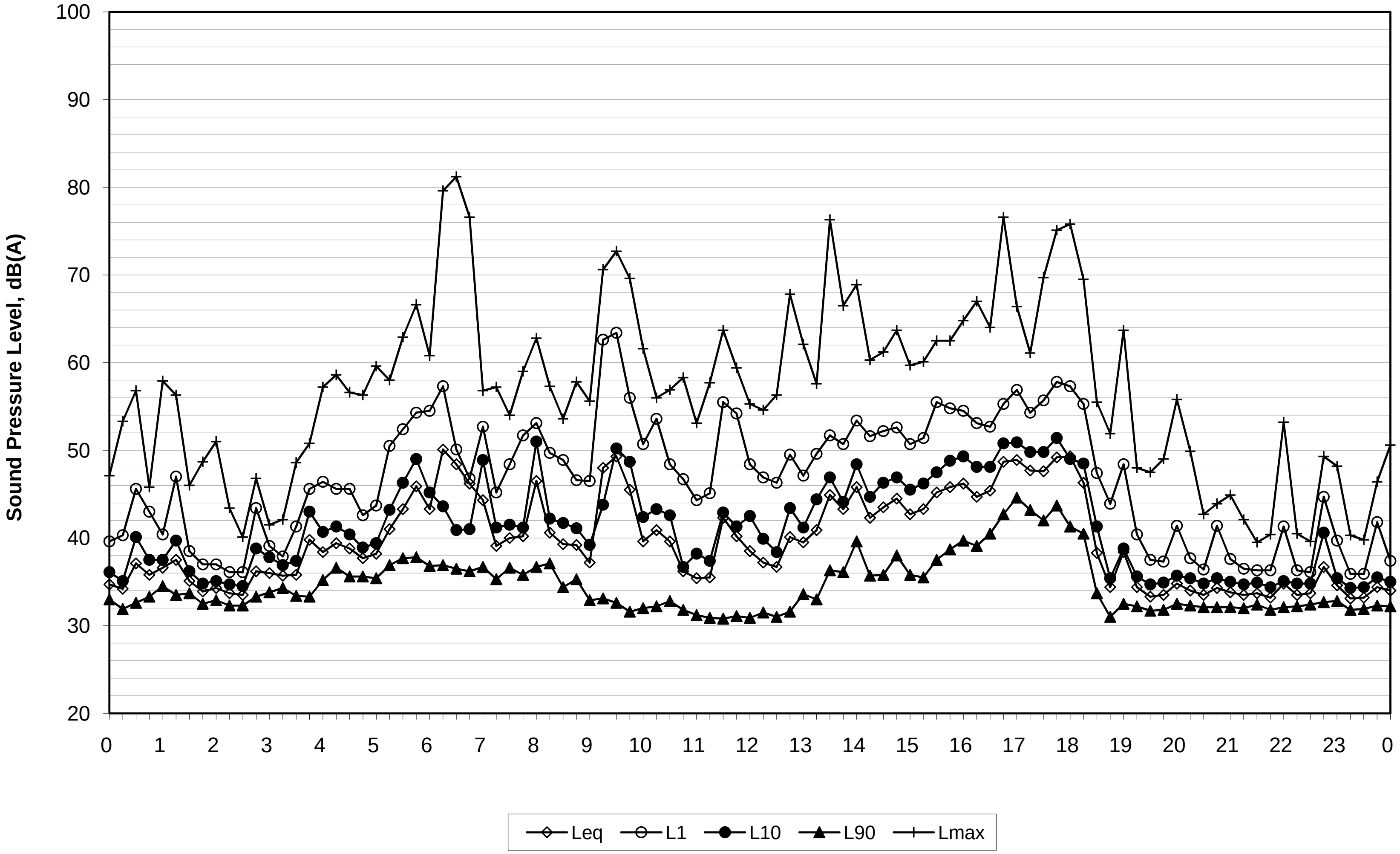
Tuesday, 16 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

Wednesday, 17 September 2008

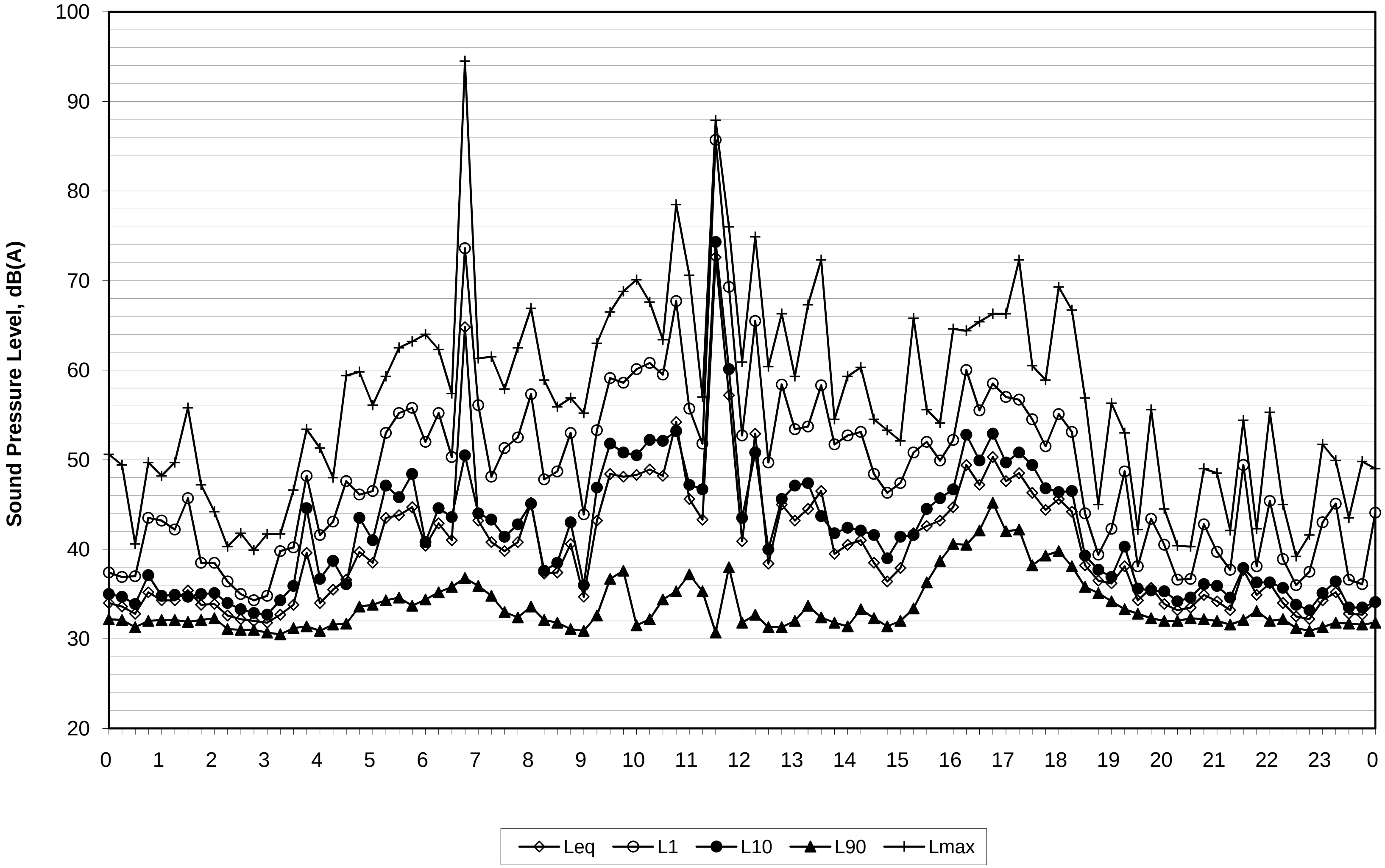


Reference Measurement Location
R7

6354R7_t.xls

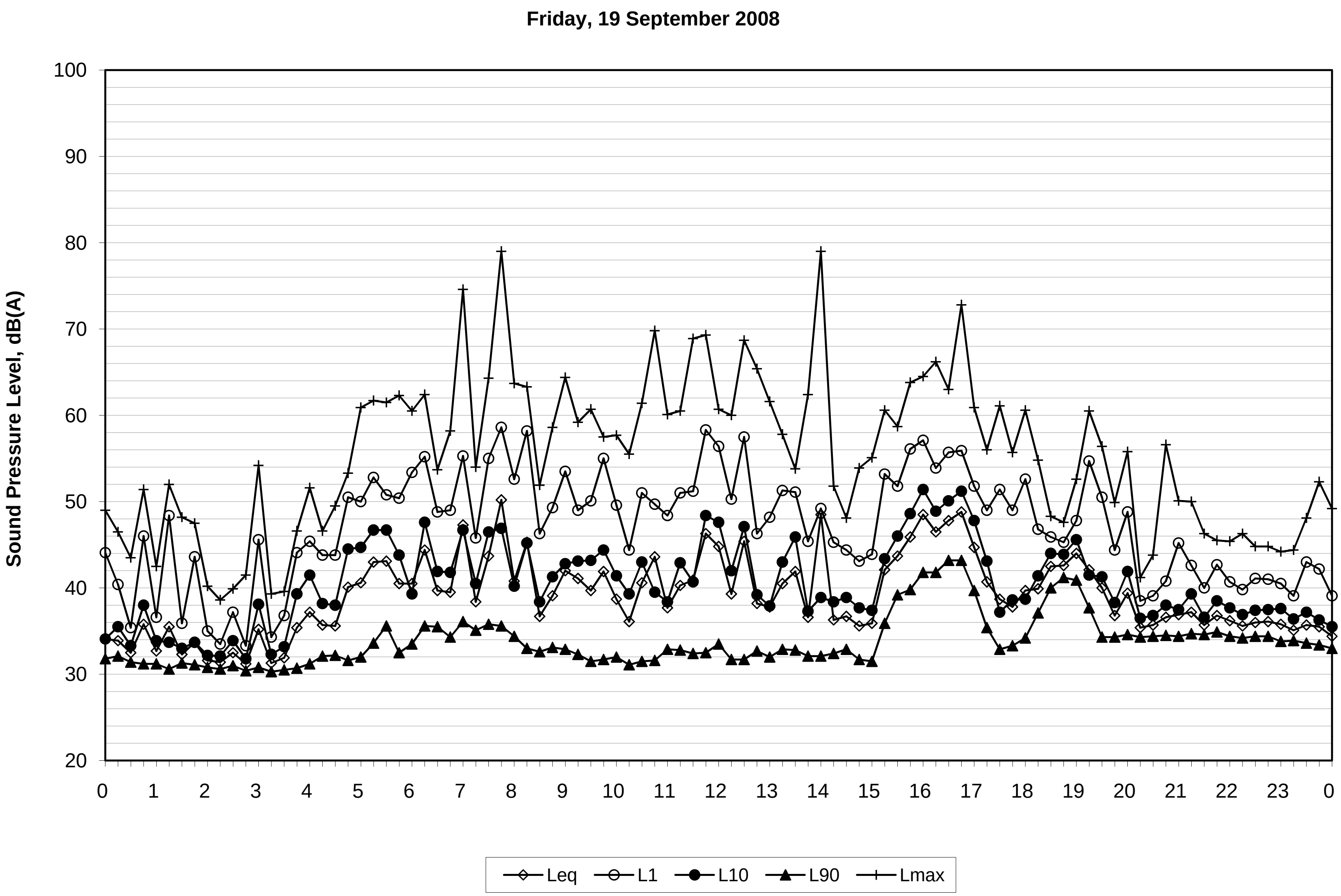
Ambient Sound Pressure Levels

Thursday, 18 September 2008



Reference Measurement Location
R7

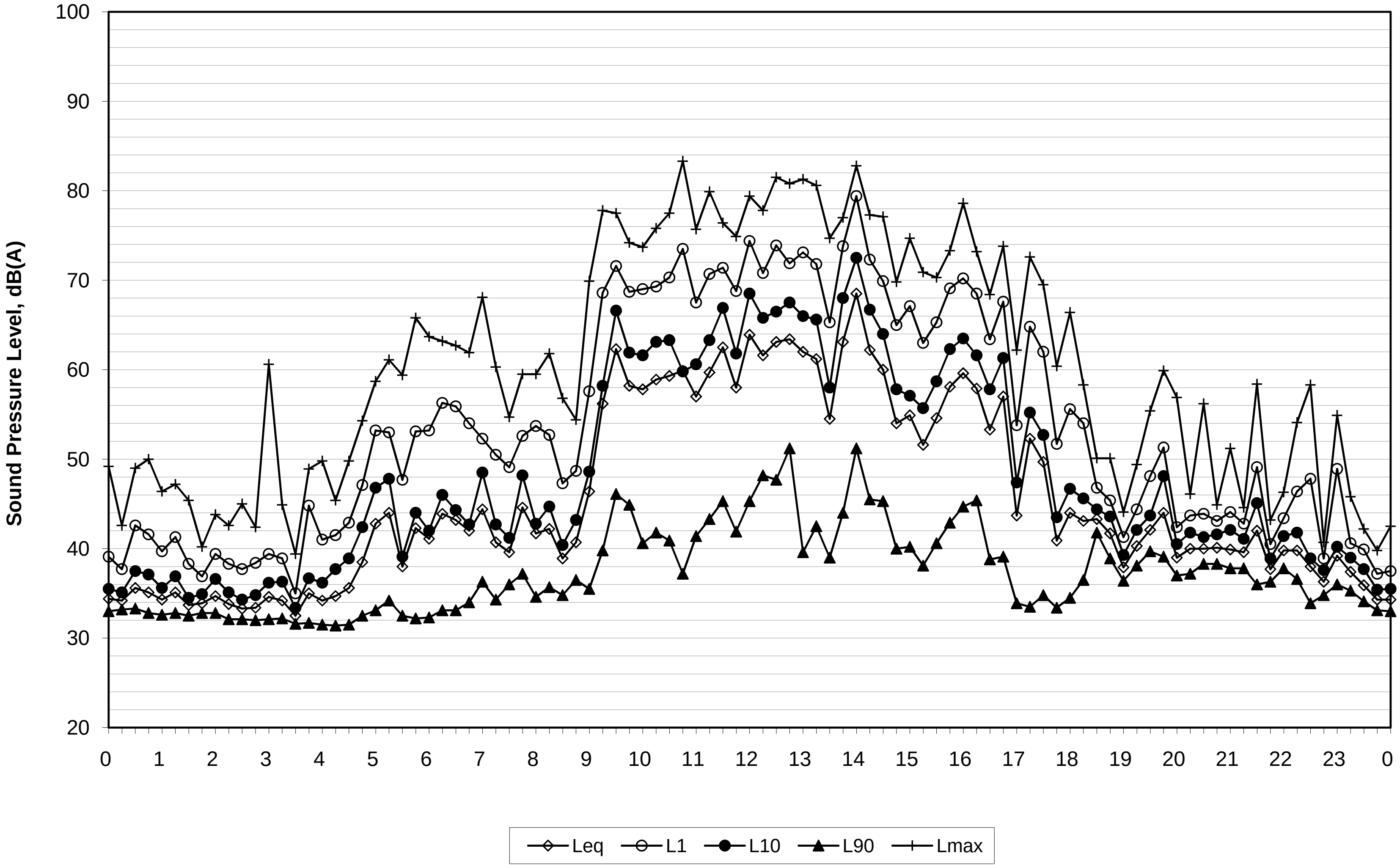
Ambient Sound Pressure Levels



Reference Measurement Location
R7

Ambient Sound Pressure Levels

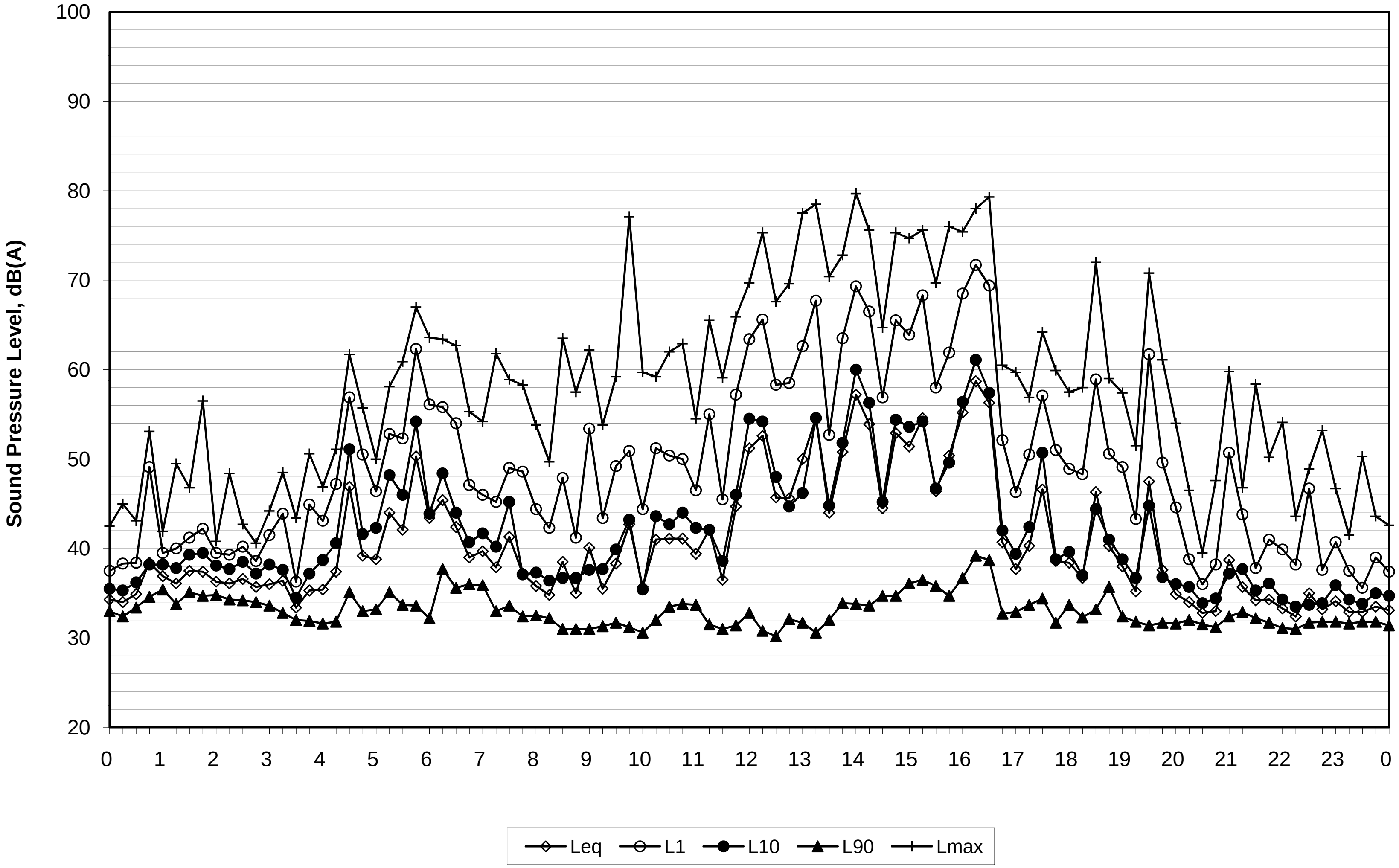
Saturday, 20 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

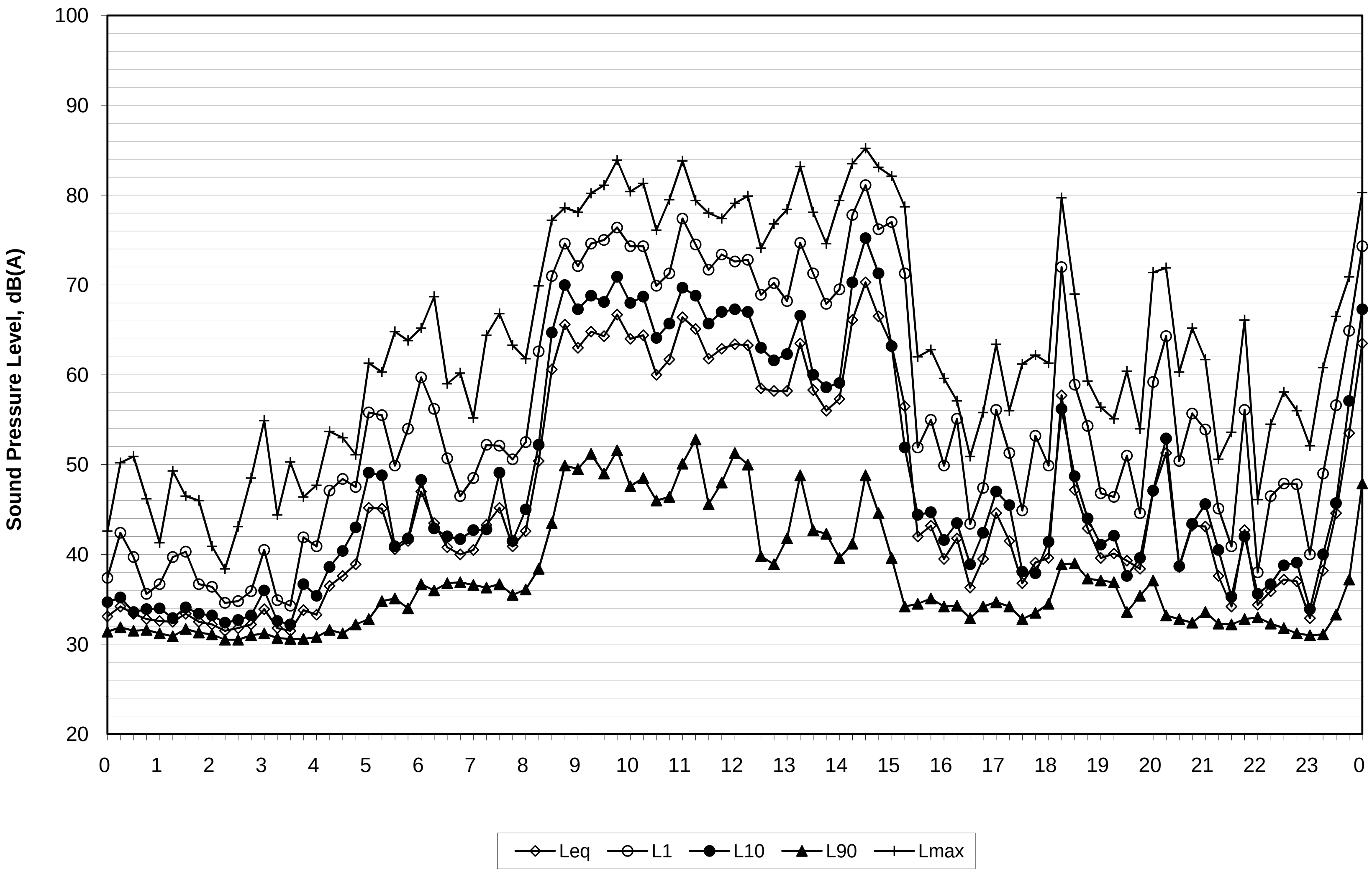
Sunday, 21 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

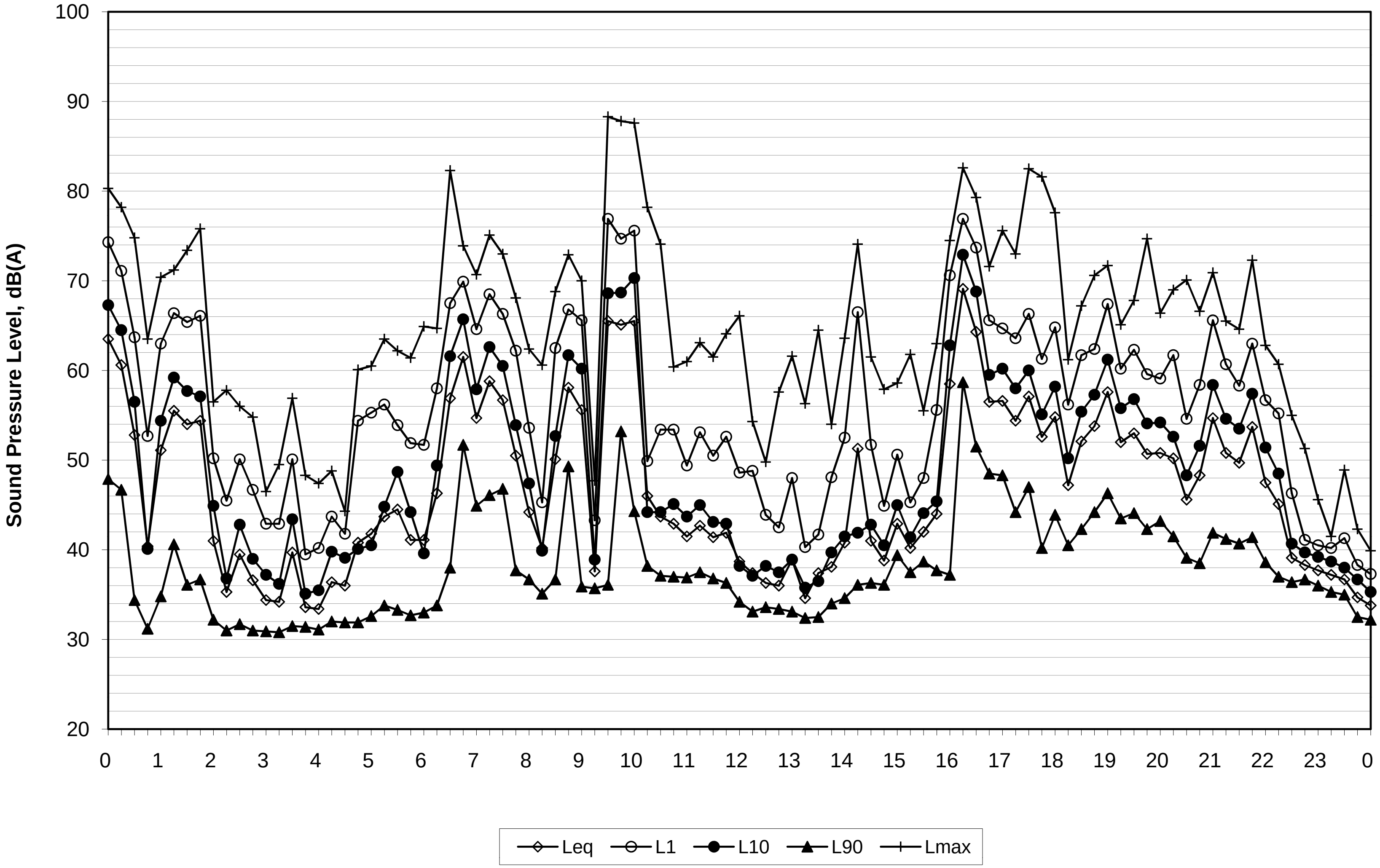
Monday, 22 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

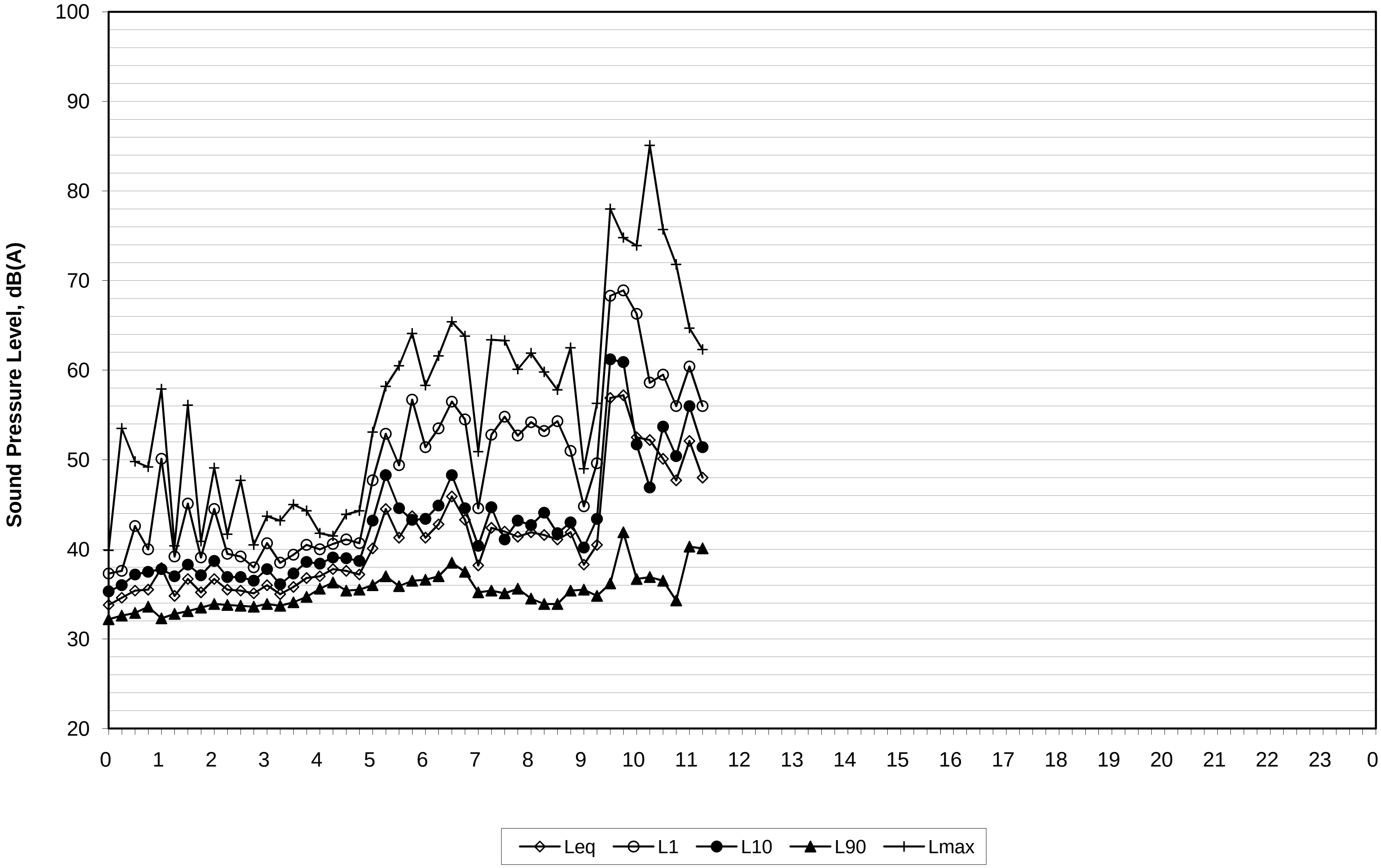
Tuesday, 23 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

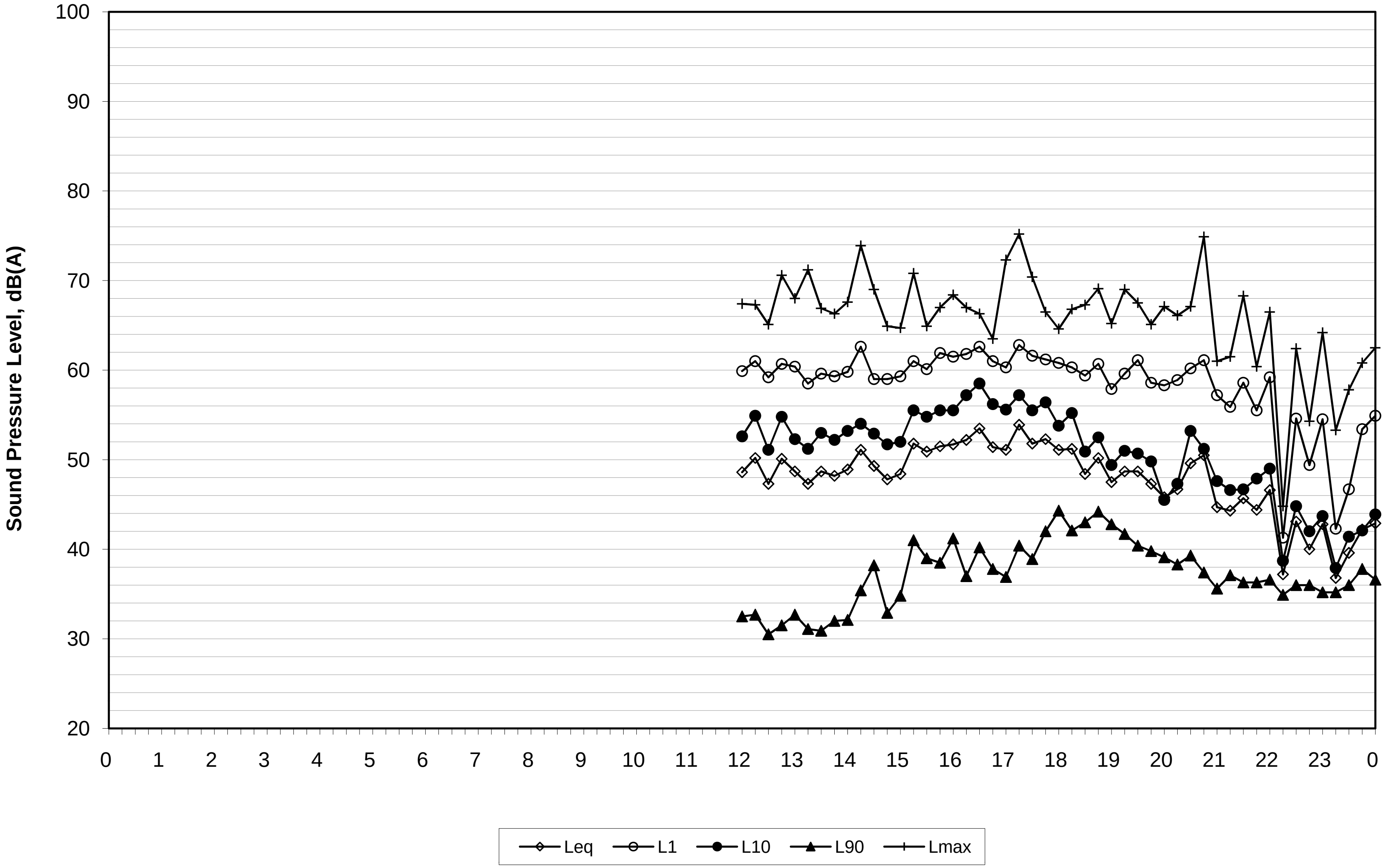
Wednesday, 24 September 2008



Reference Measurement Location
R7

Ambient Sound Pressure Levels

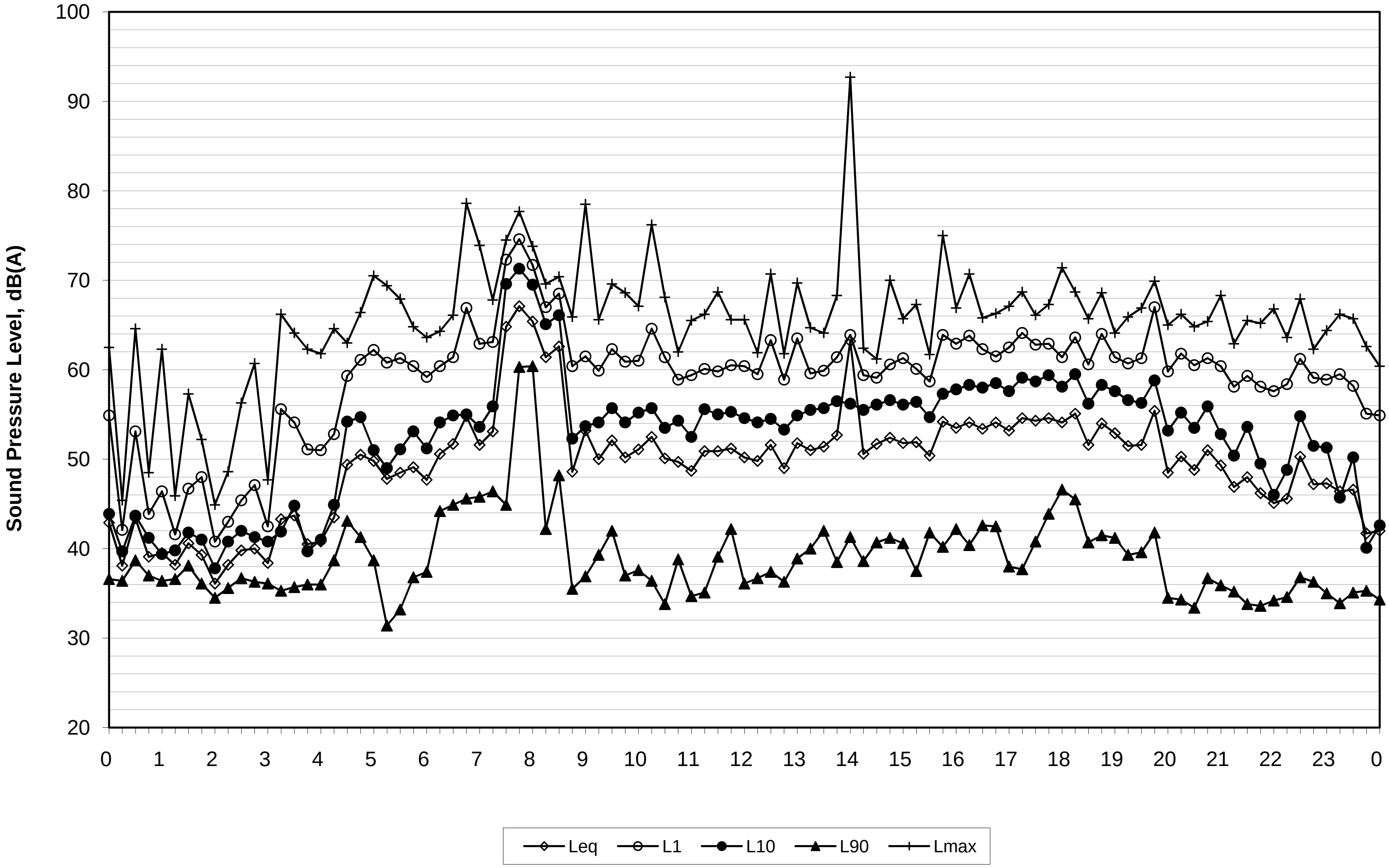
Thursday, 16 April 2009



Reference Measurement Location
R8

Ambient Sound Pressure Levels

Friday, 17 April 2009

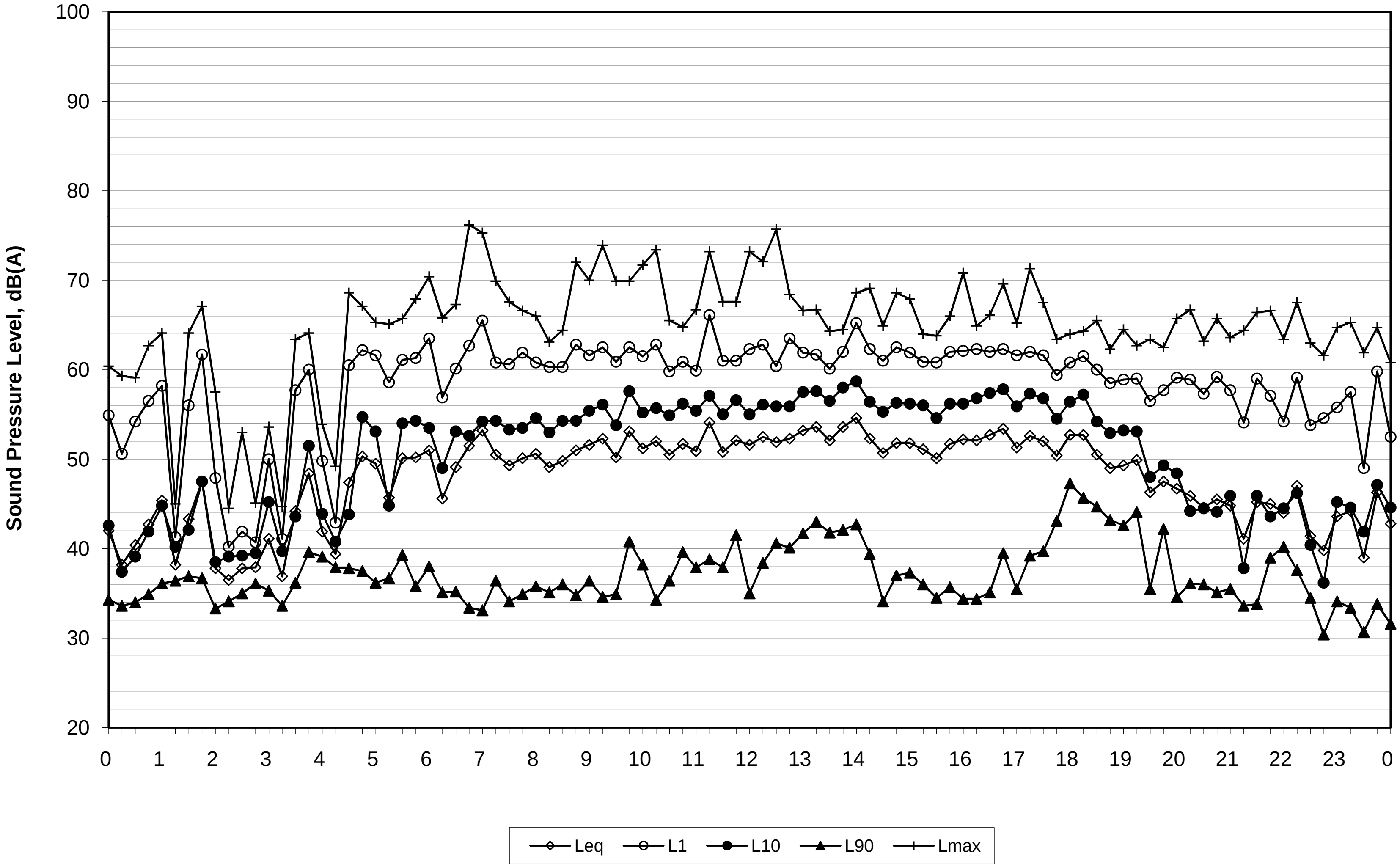


Reference Measurement Location
R8

6354r8_t.xls

Ambient Sound Pressure Levels

Saturday, 18 April 2009

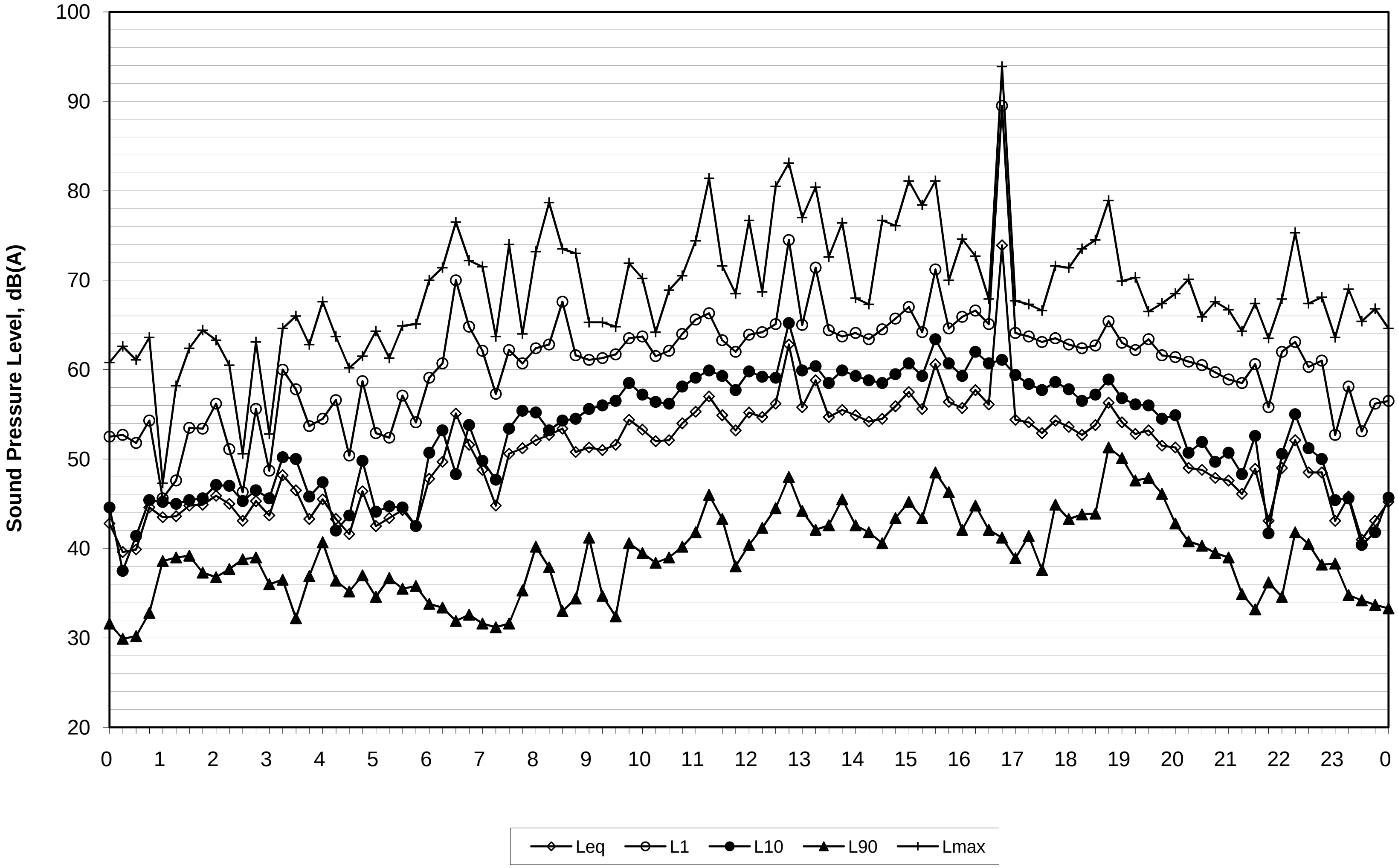


Reference Measurement Location
R8

6354r8_t.xls

Ambient Sound Pressure Levels

Sunday, 19 April 2009

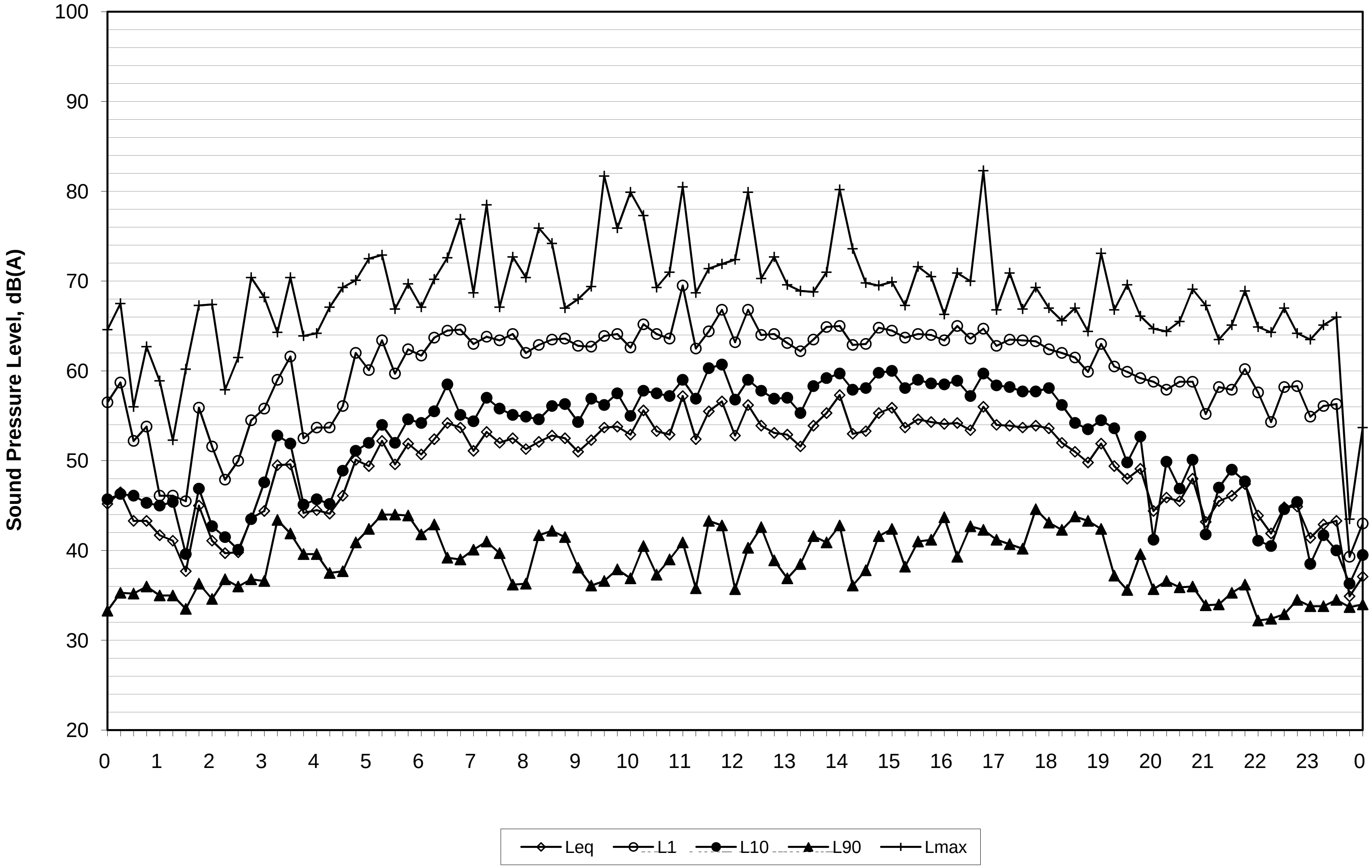


Reference Measurement Location
R8

6354r8_t.xls

Ambient Sound Pressure Levels

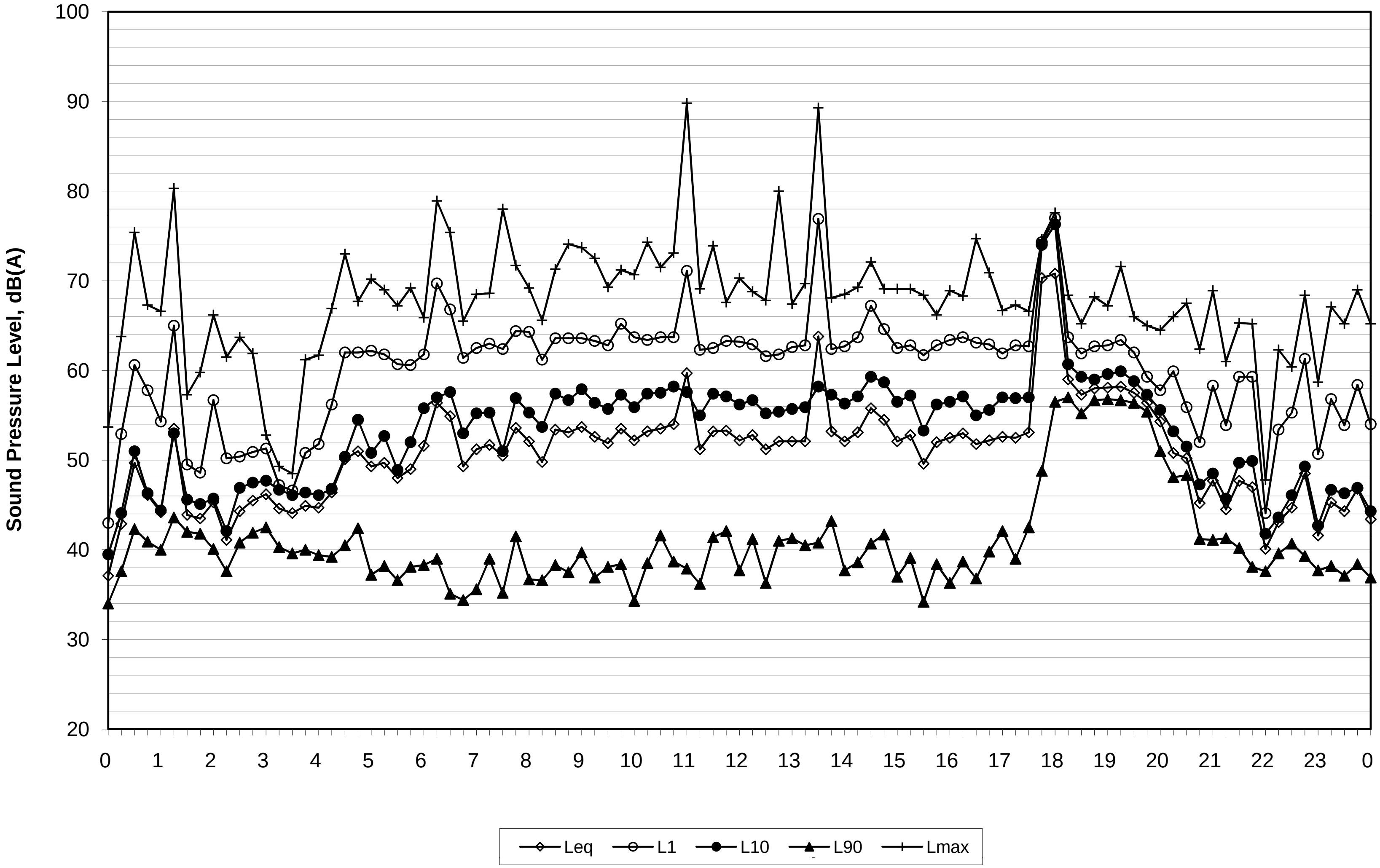
Monday, 20 April 2009



Reference Measurement Location
R8

Ambient Sound Pressure Levels

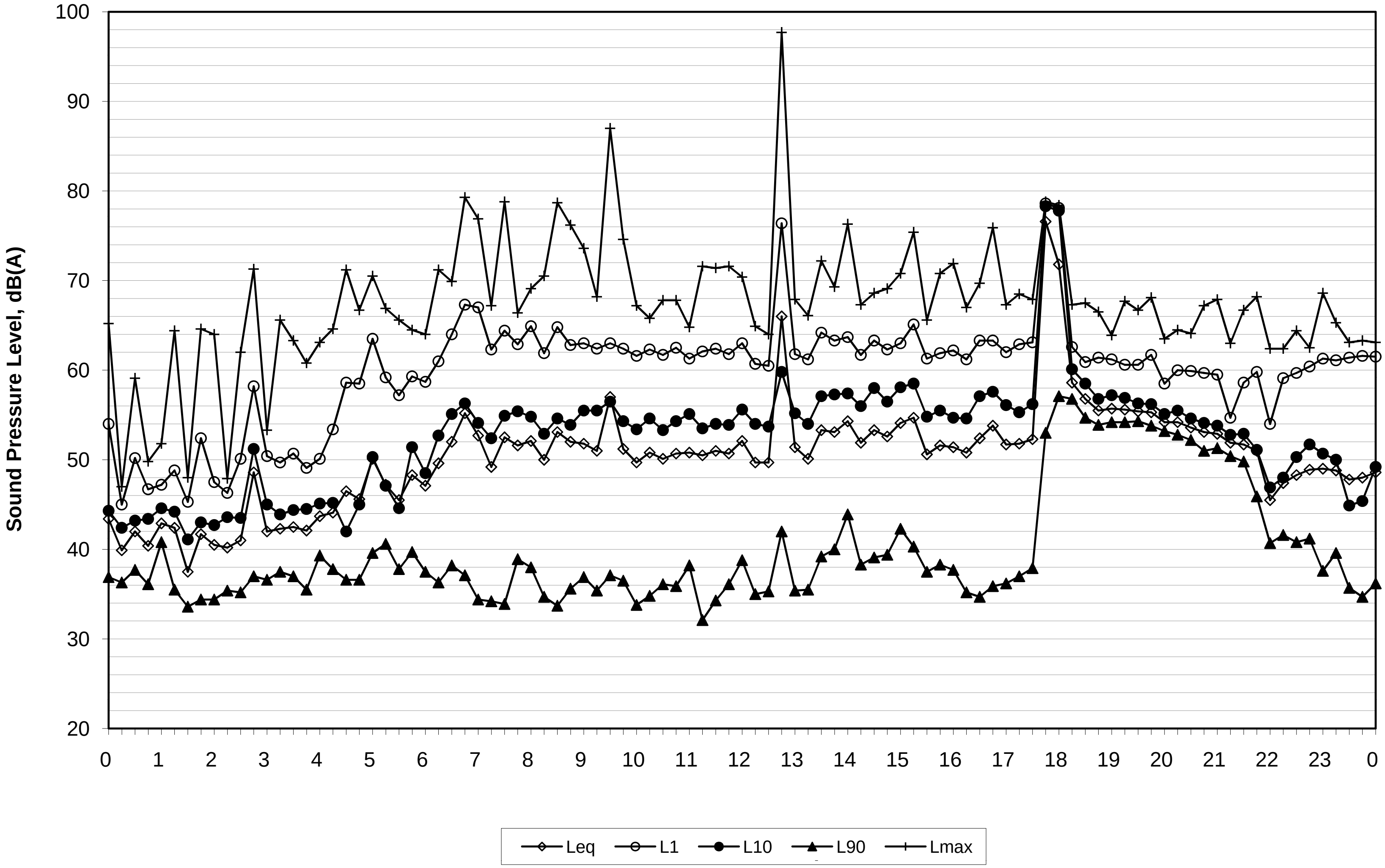
Tuesday, 21 April 2009



Reference Measurement Location
R8

Ambient Sound Pressure Levels

Wednesday, 22 April 2009

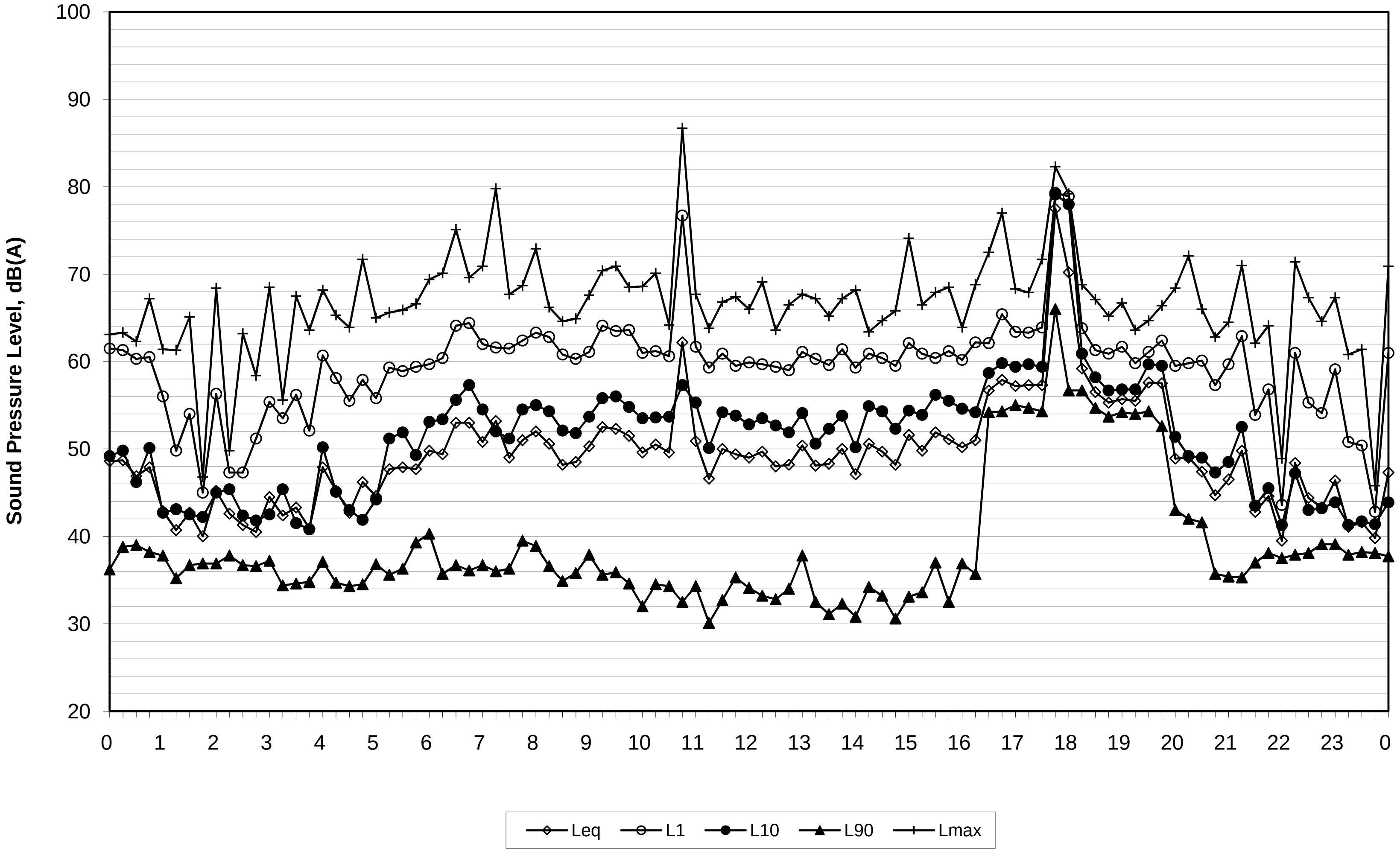


Reference Measurement Location
R8

6354r8_t.xls

Ambient Sound Pressure Levels

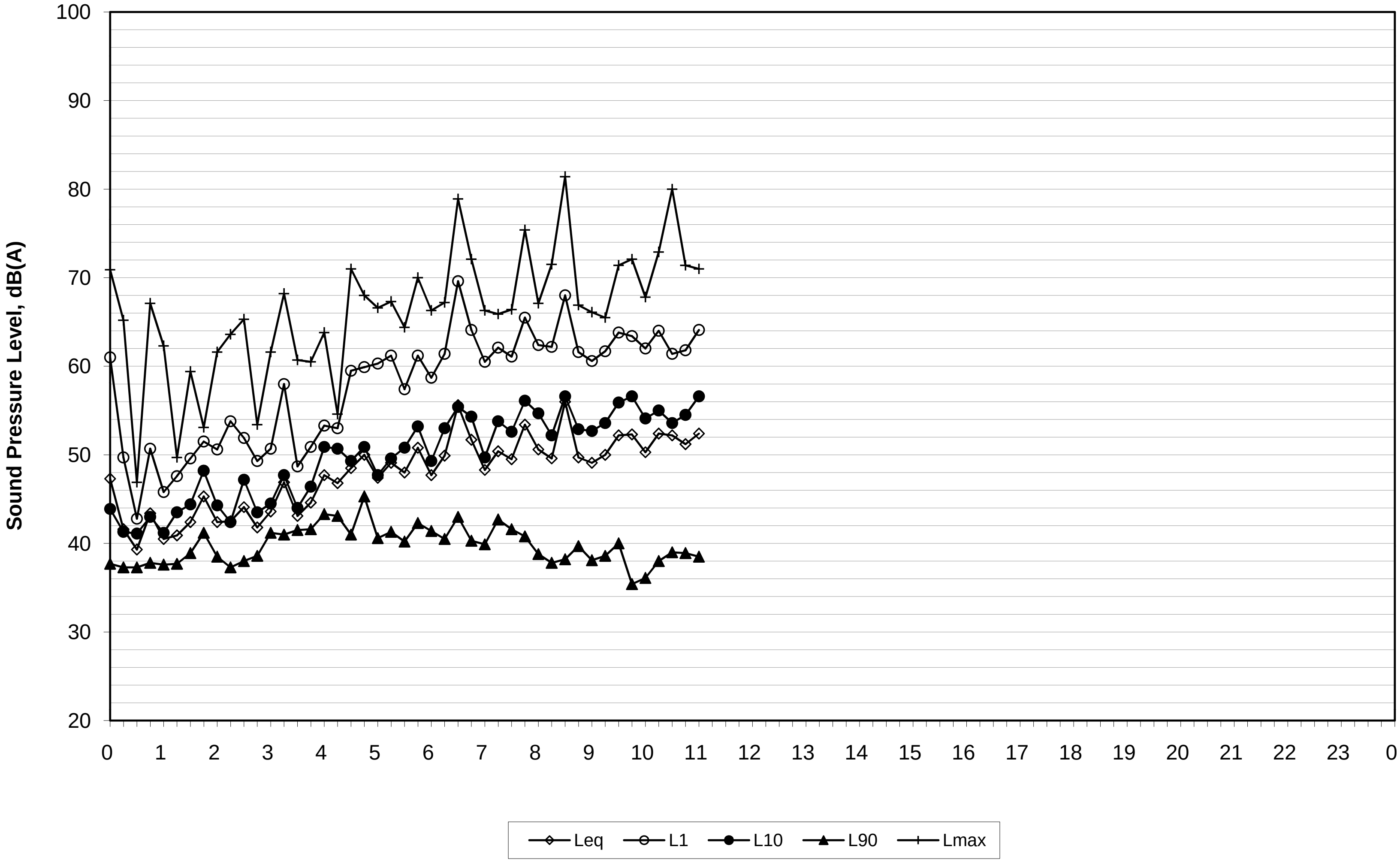
Thursday, 23 April 2009



Reference Measurement Location
R8

Ambient Sound Pressure Levels

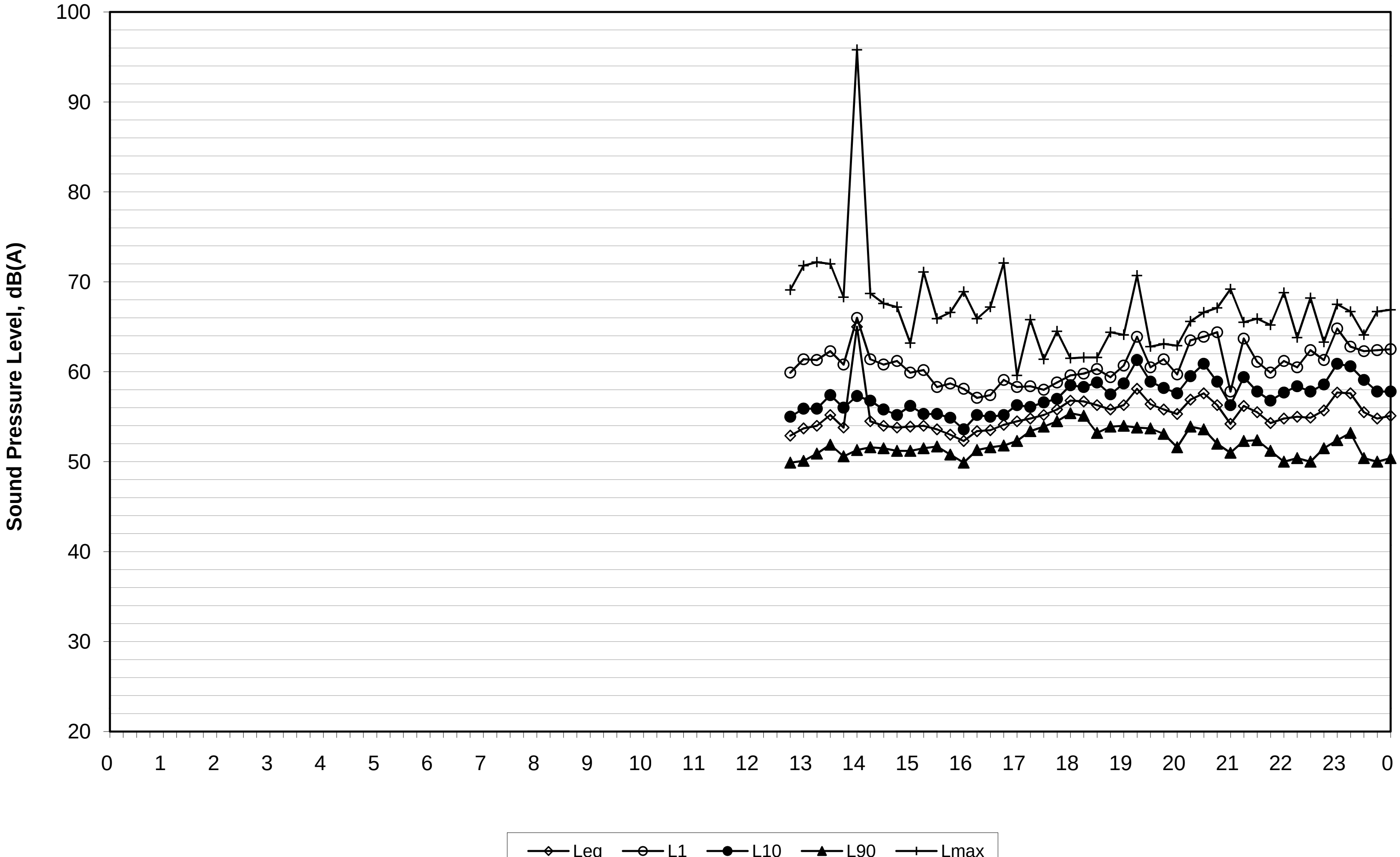
Friday, 24 April 2009



Reference Measurement Location
R8

Ambient Sound Pressure Levels

Friday, 12 June 2009

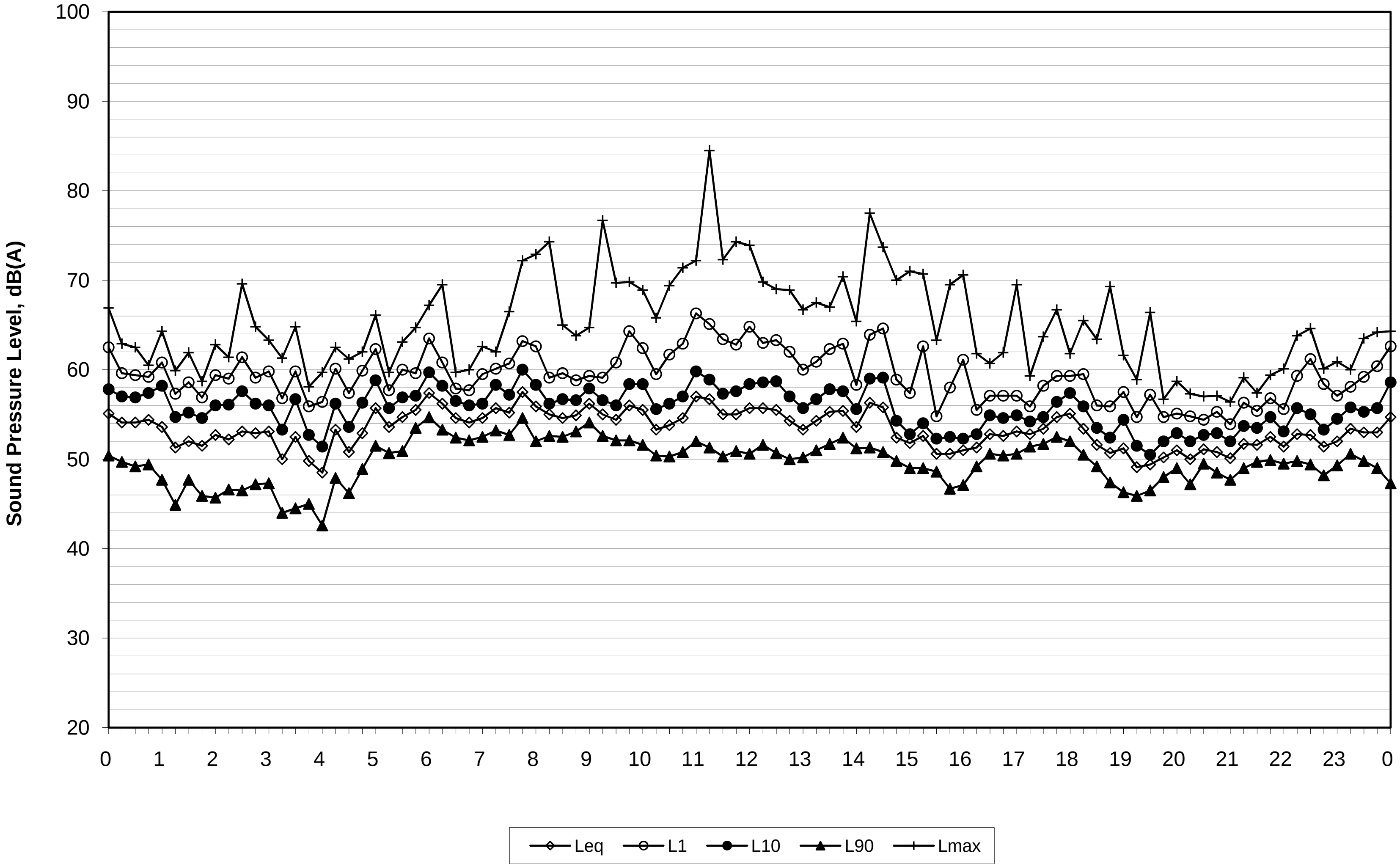


Reference Measurement Location
R9

6354r9_t.xls

Ambient Sound Pressure Levels

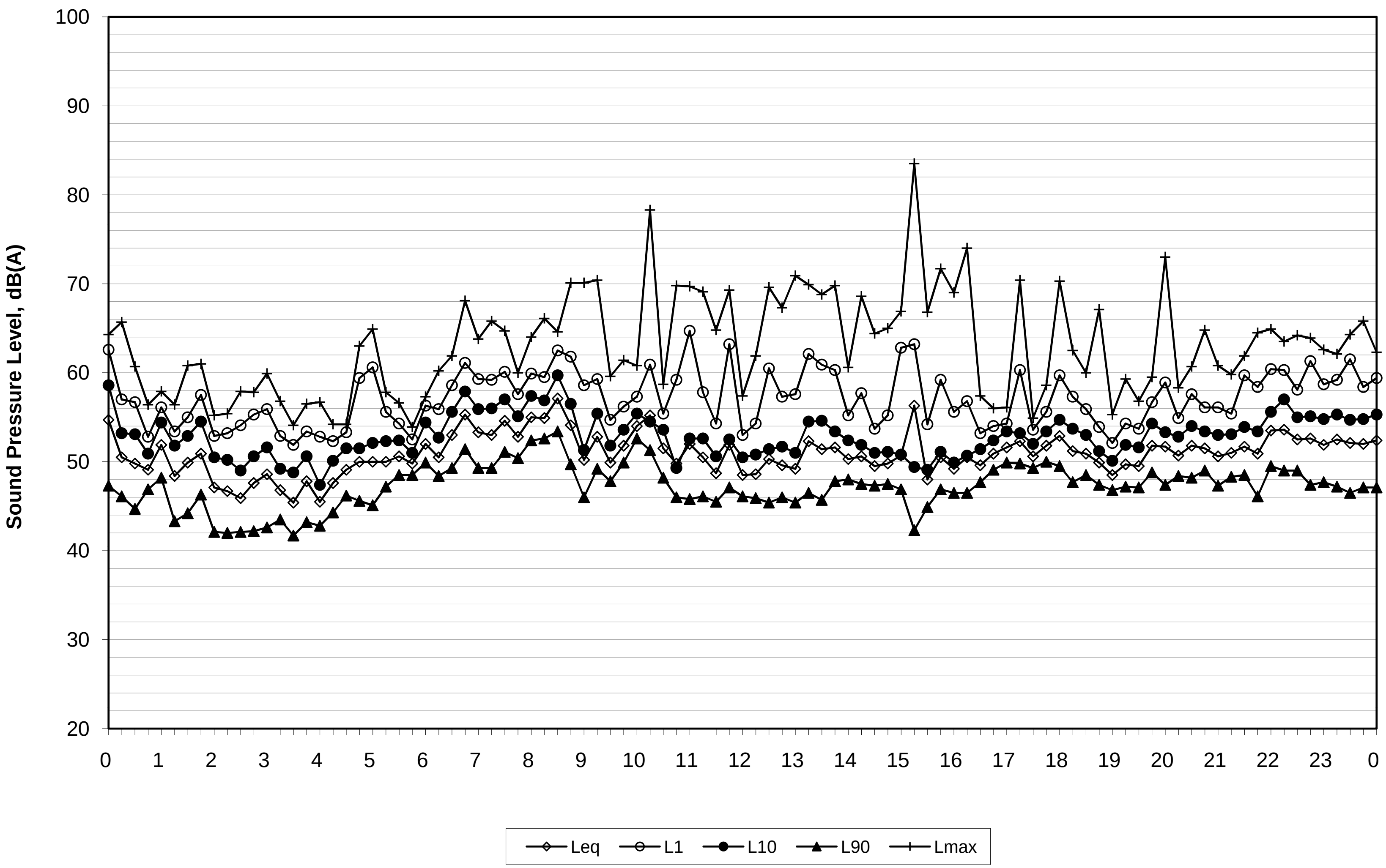
Saturday, 13 June 2009



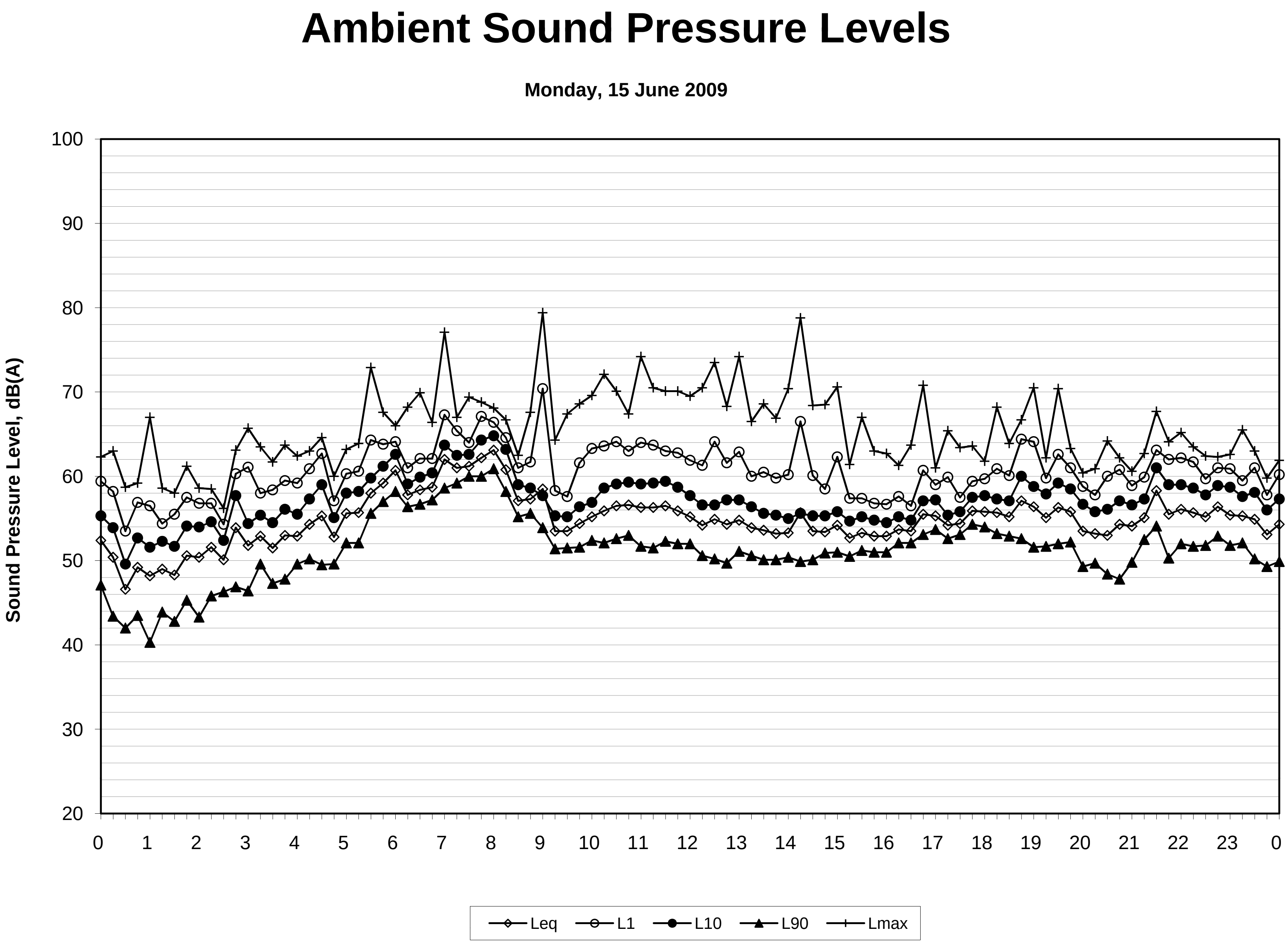
Reference Measurement Location
R9

Ambient Sound Pressure Levels

Sunday, 14 June 2009



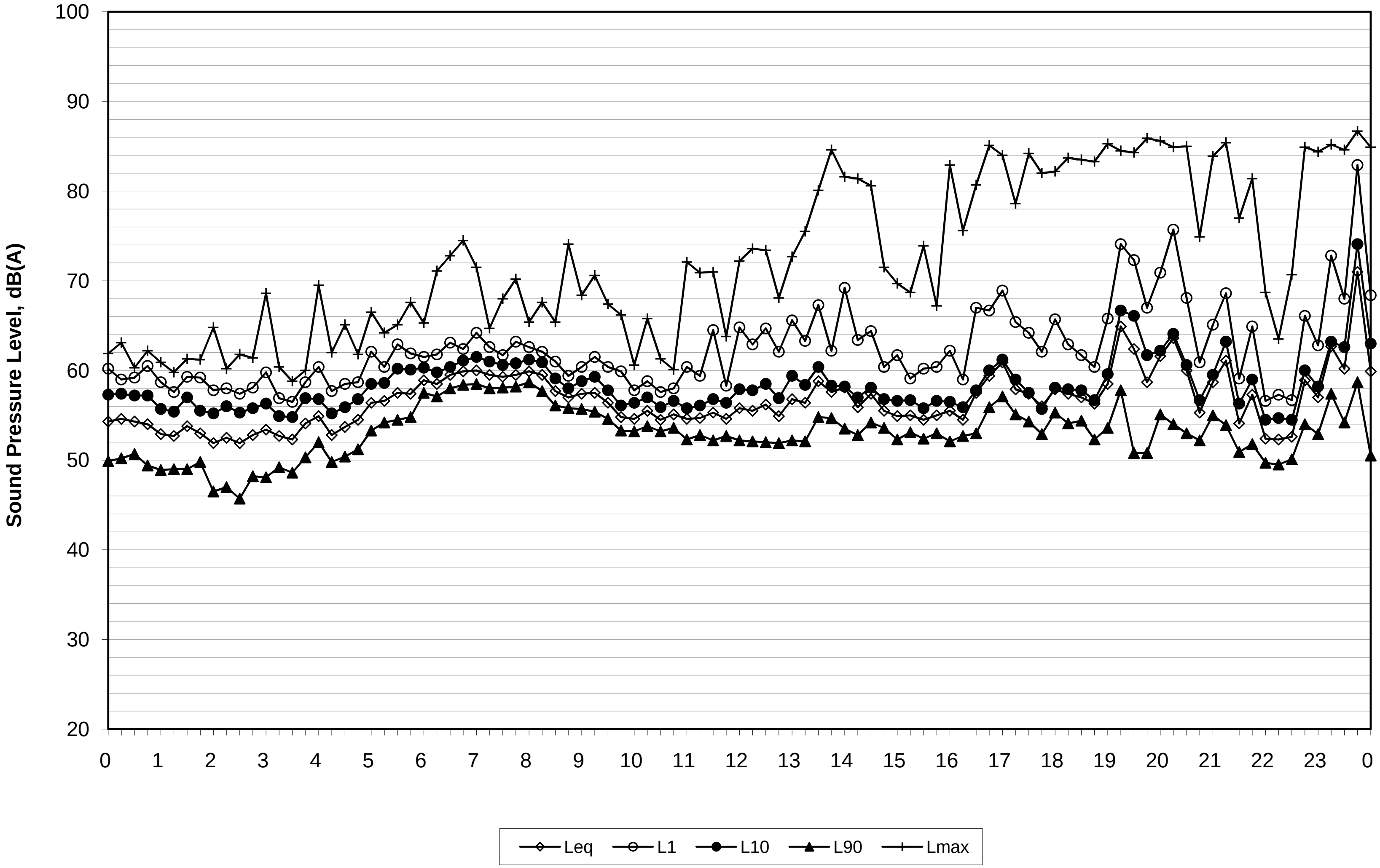
Reference Measurement Location
R9



Reference Measurement Location
R9

Ambient Sound Pressure Levels

Tuesday, 16 June 2009

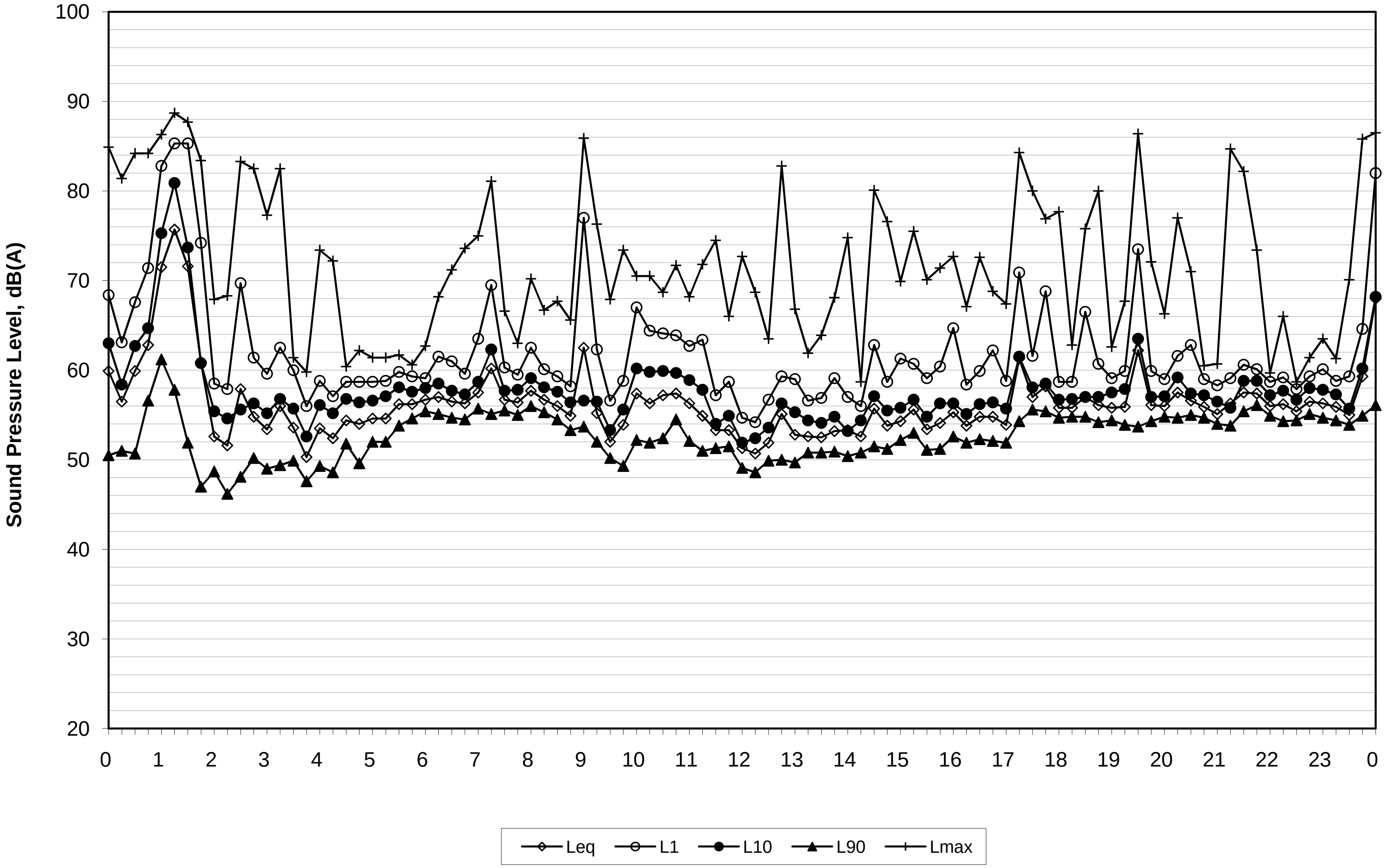


Reference Measurement Location
R9

6354r9_t.xls

Ambient Sound Pressure Levels

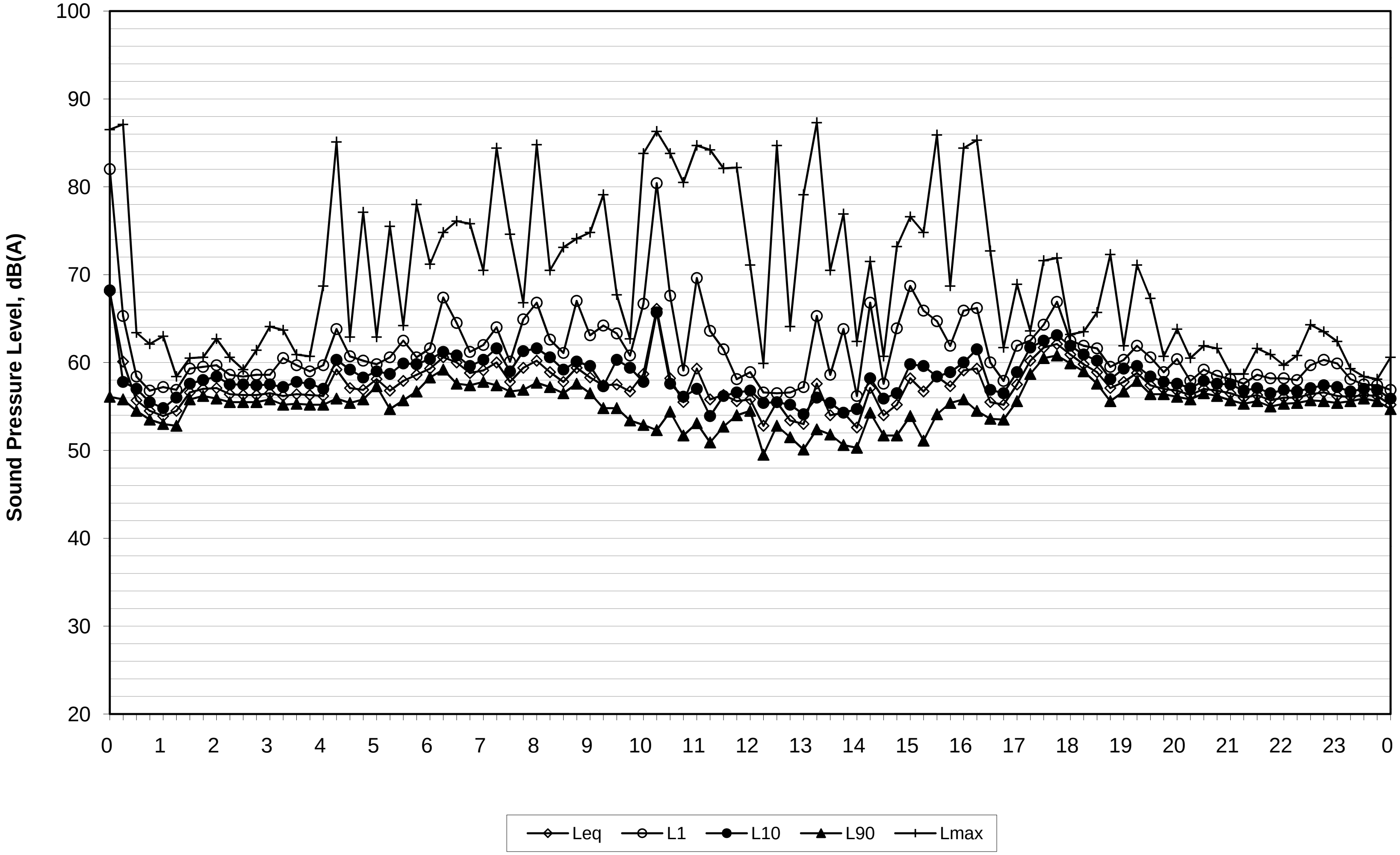
Wednesday, 17 June 2009



Reference Measurement Location
R9

Ambient Sound Pressure Levels

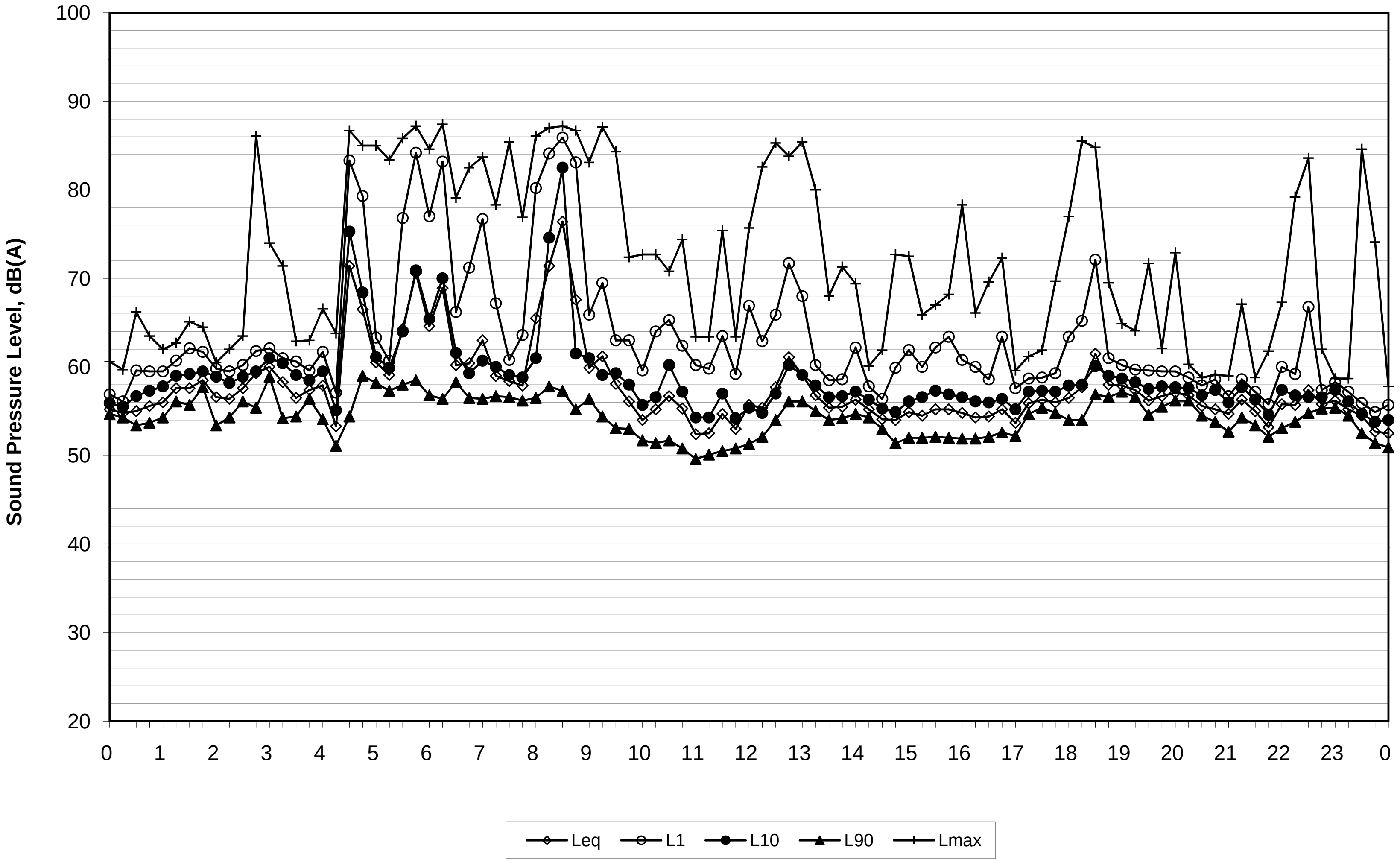
Thursday, 18 June 2009



Reference Measurement Location
R9

Ambient Sound Pressure Levels

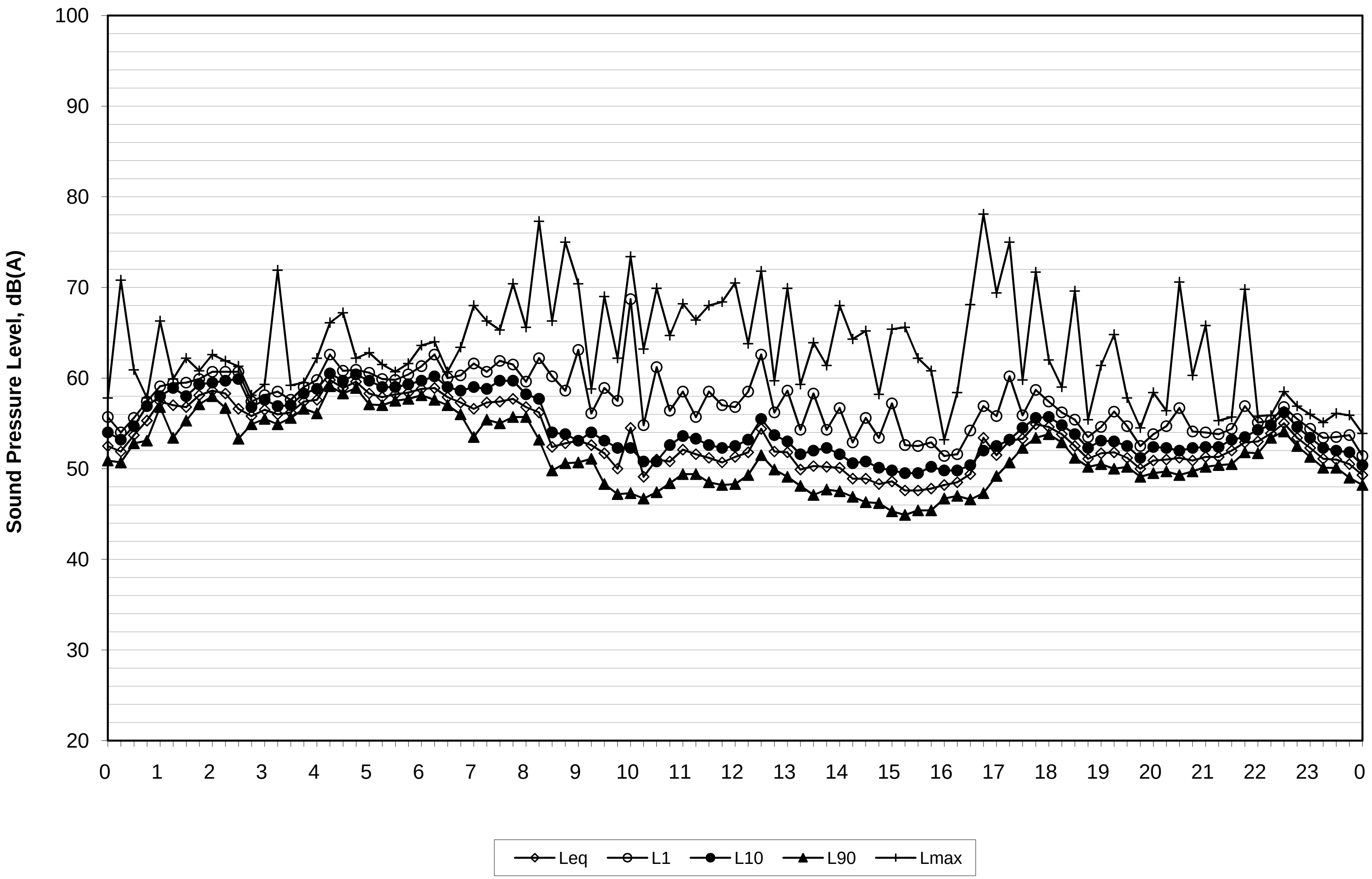
Friday, 19 June 2009



Reference Measurement Location
R9

Ambient Sound Pressure Levels

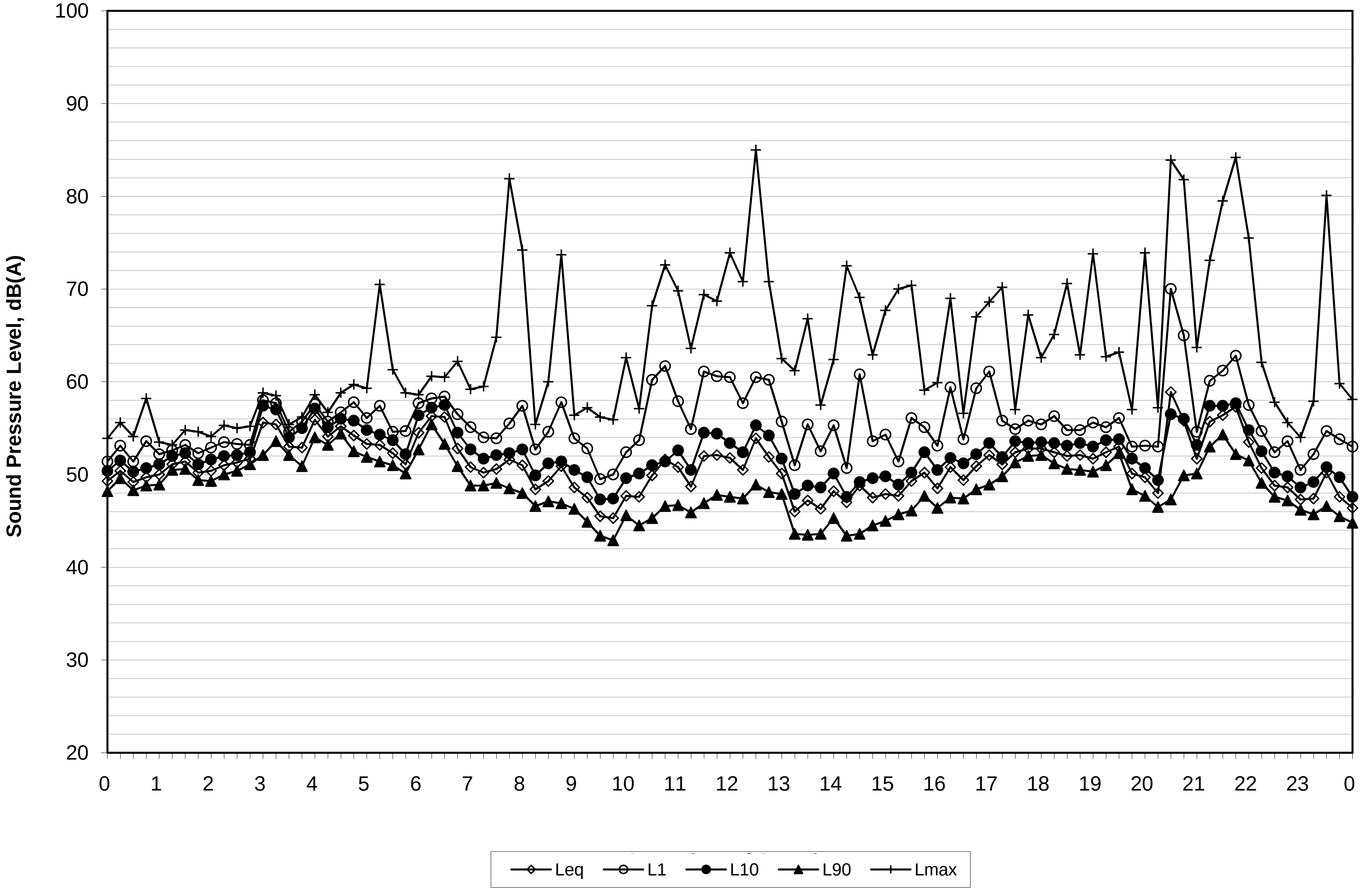
Saturday, 20 June 2009



Reference Measurement Location
R9

Ambient Sound Pressure Levels

Sunday, 21 June 2009

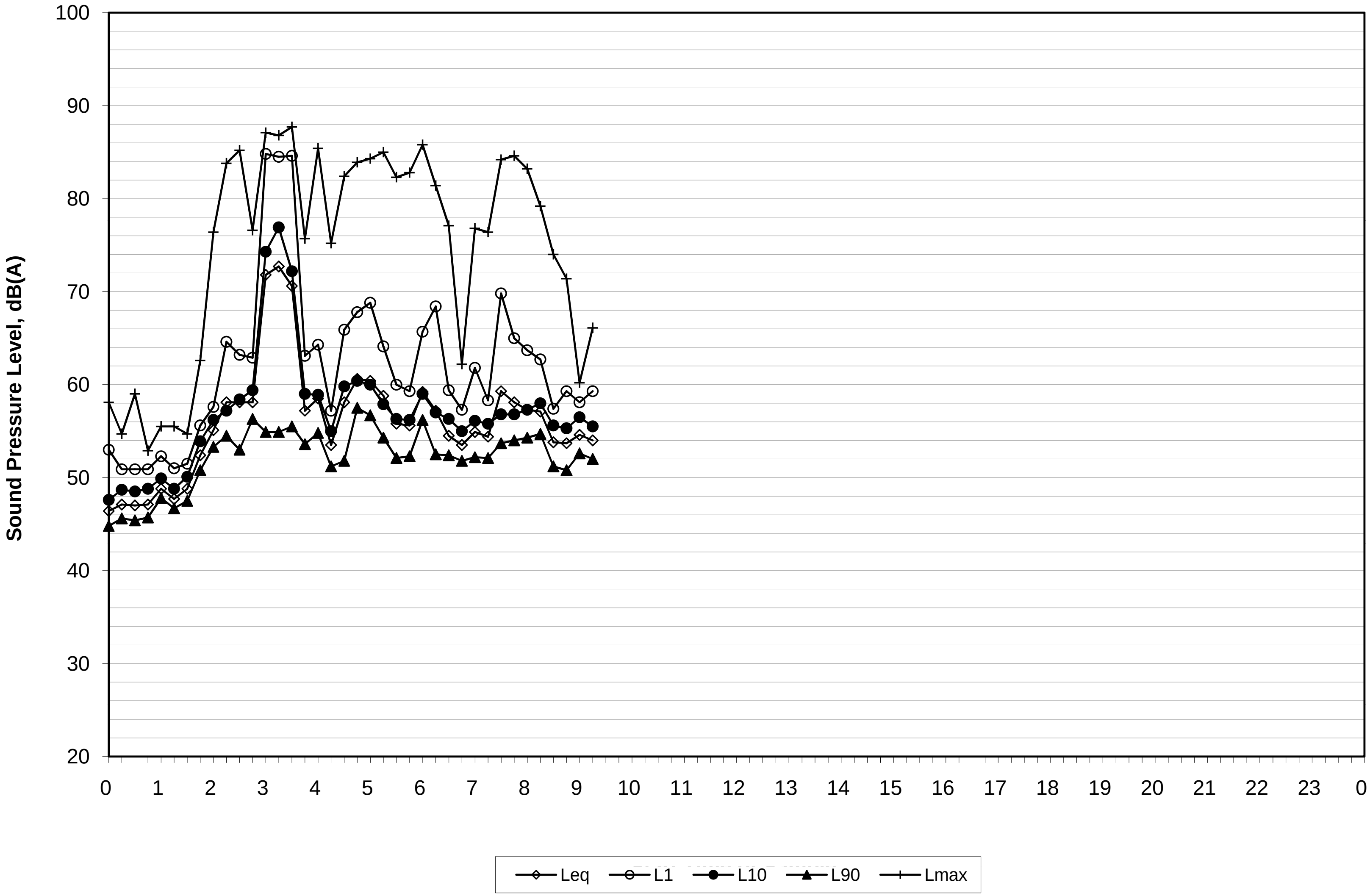


Reference Measurement Location
R9

6354r9_t.xls

Ambient Sound Pressure Levels

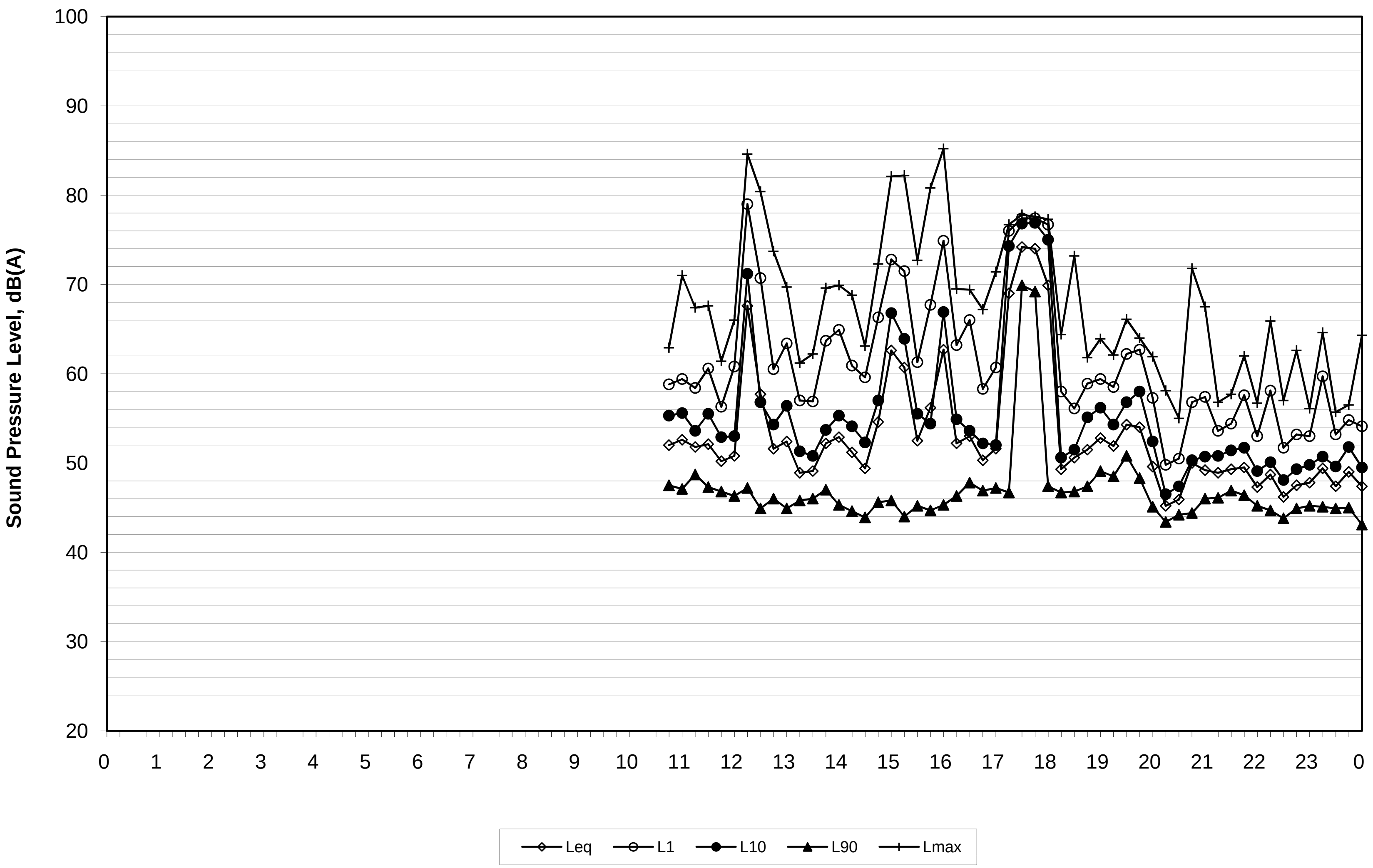
Monday, 22 June 2009



Reference Measurement Location
R9

Ambient Sound Pressure Levels

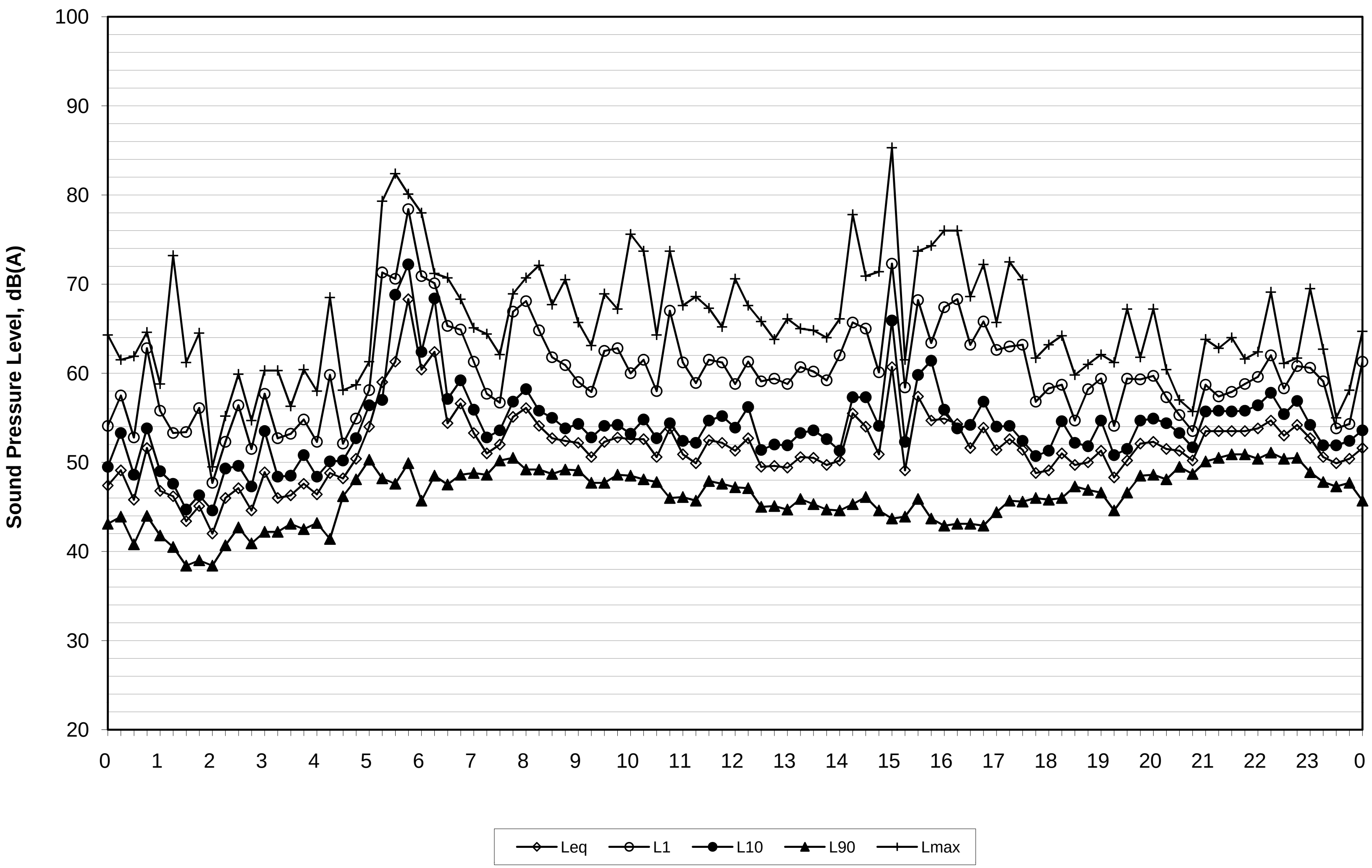
Monday, 22 June 2009



Reference Measurement Location
R10

Ambient Sound Pressure Levels

Tuesday, 23 June 2009

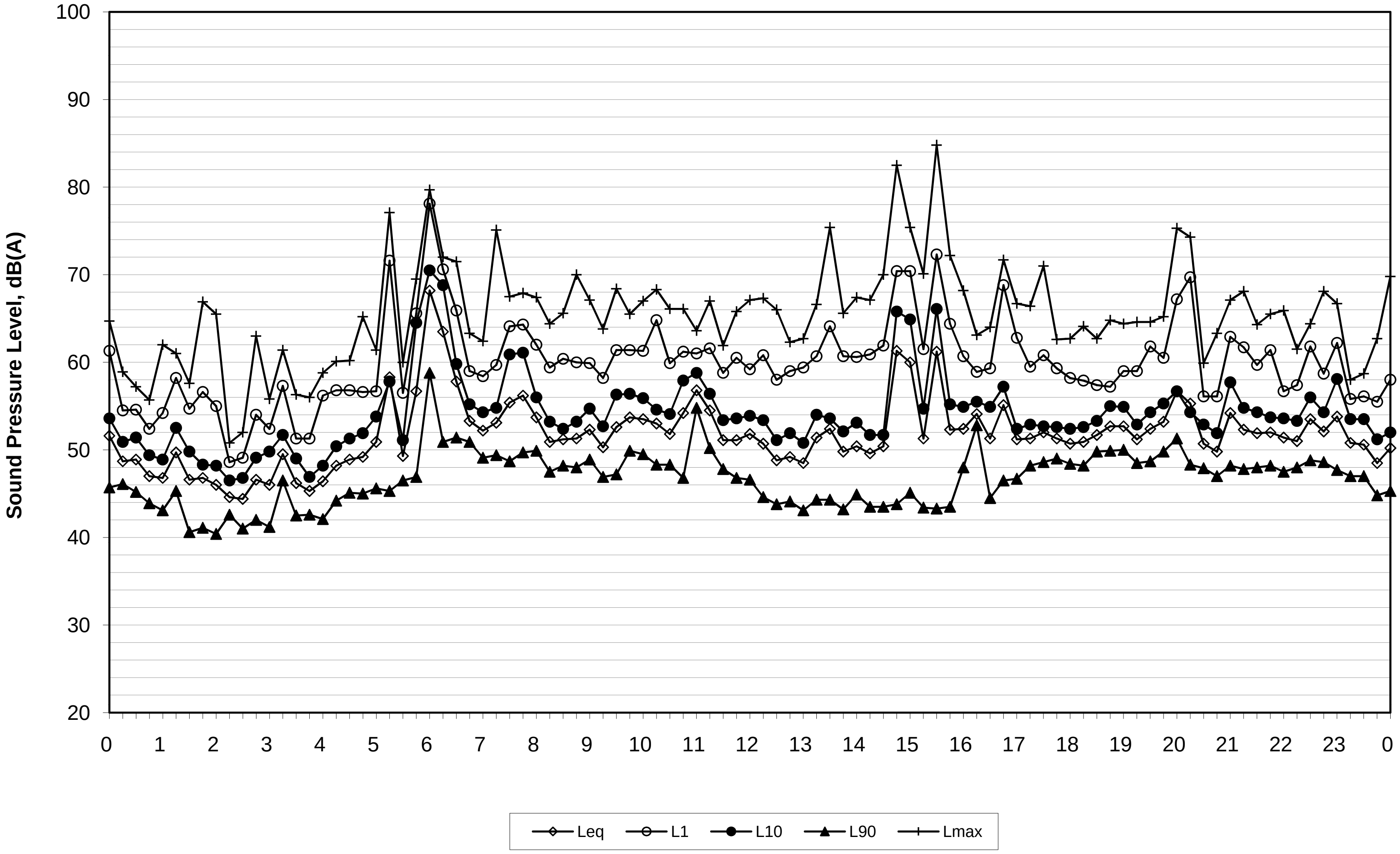


Reference Measurement Location
R10

6354r10_t.xls

Ambient Sound Pressure Levels

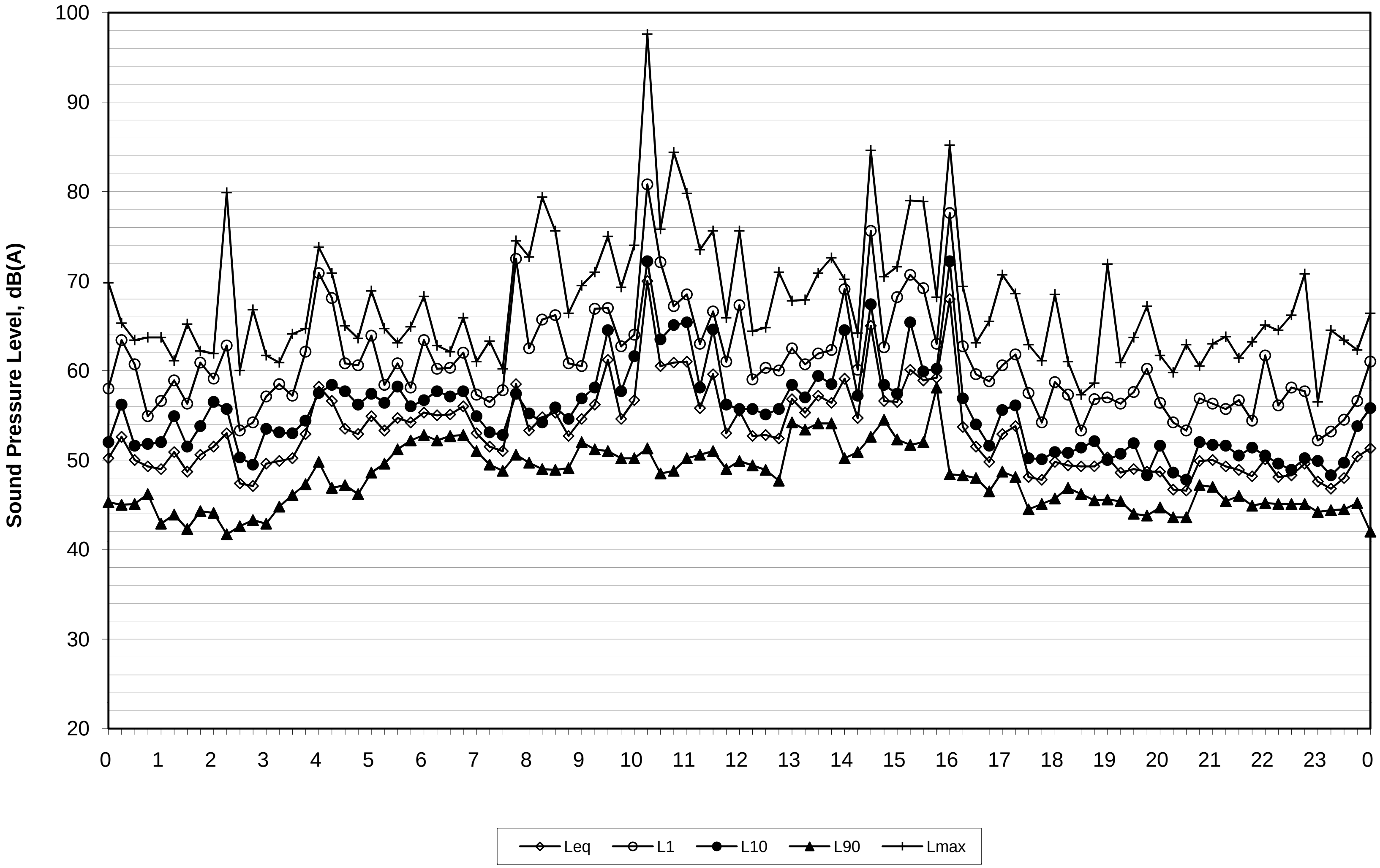
Wednesday, 24 June 2009



Reference Measurement Location
R10

Ambient Sound Pressure Levels

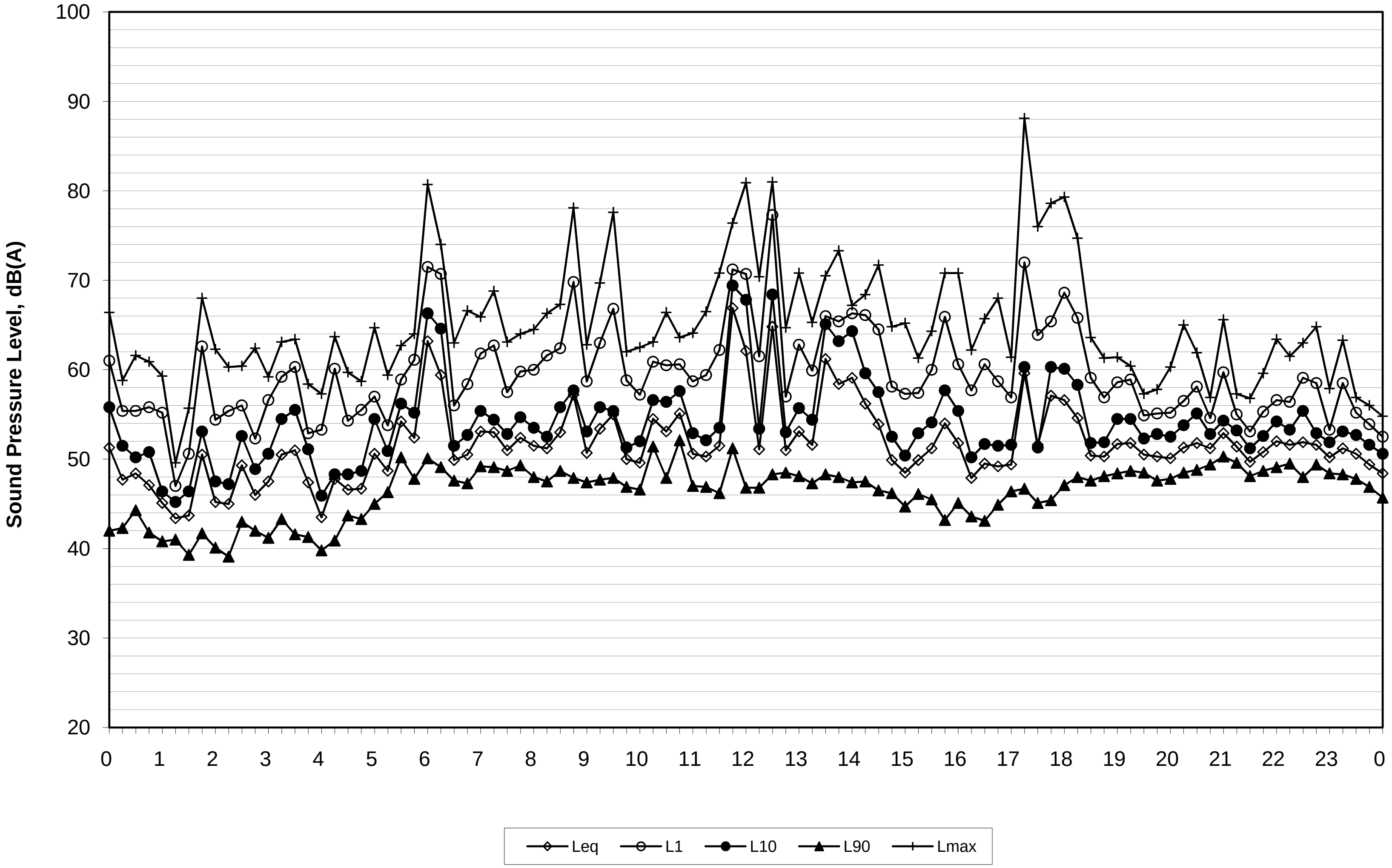
Thursday, 25 June 2009



Reference Measurement Location
R10

Ambient Sound Pressure Levels

Friday, 26 June 2009

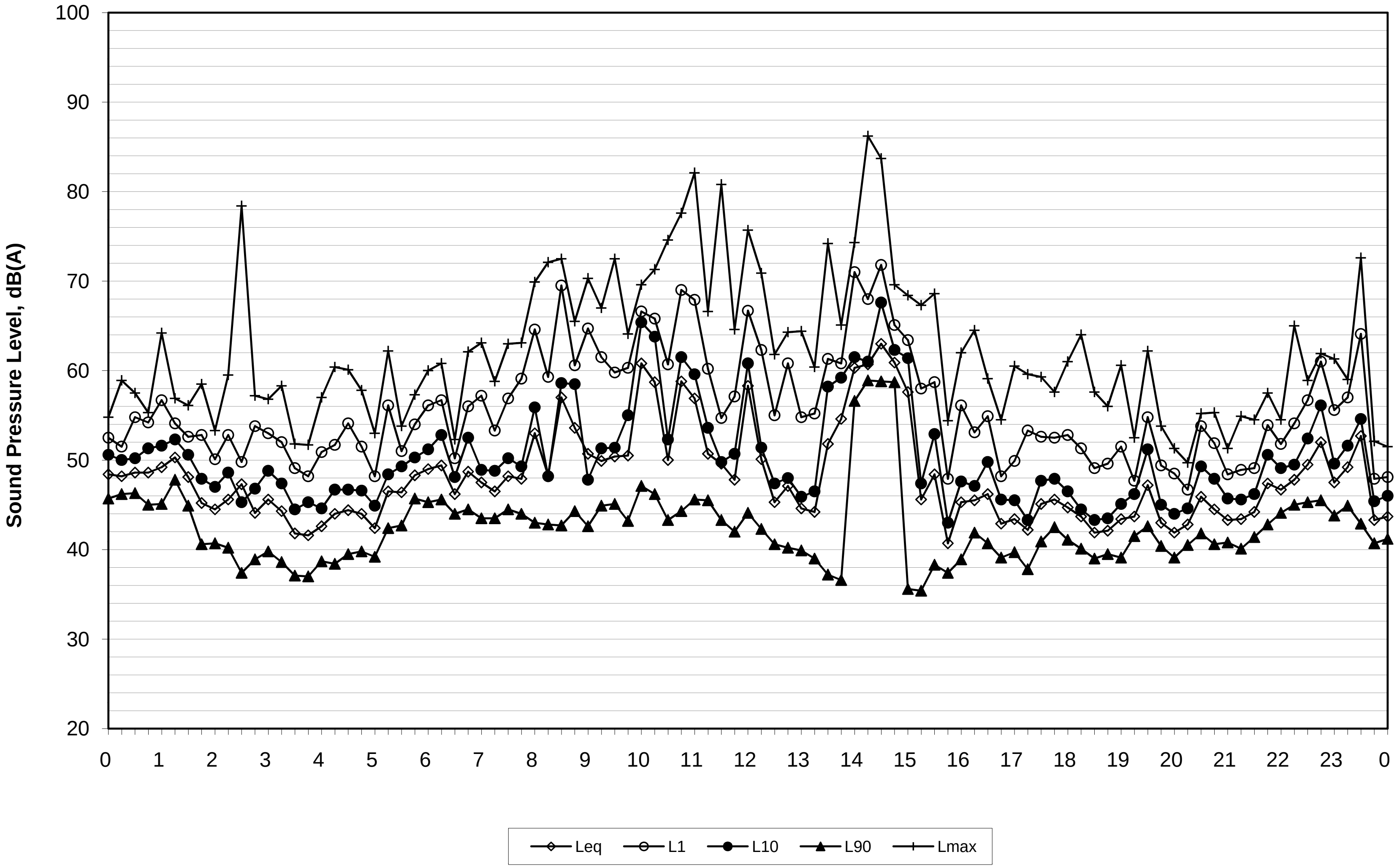


Reference Measurement Location
R10

6354r10_t.xls

Ambient Sound Pressure Levels

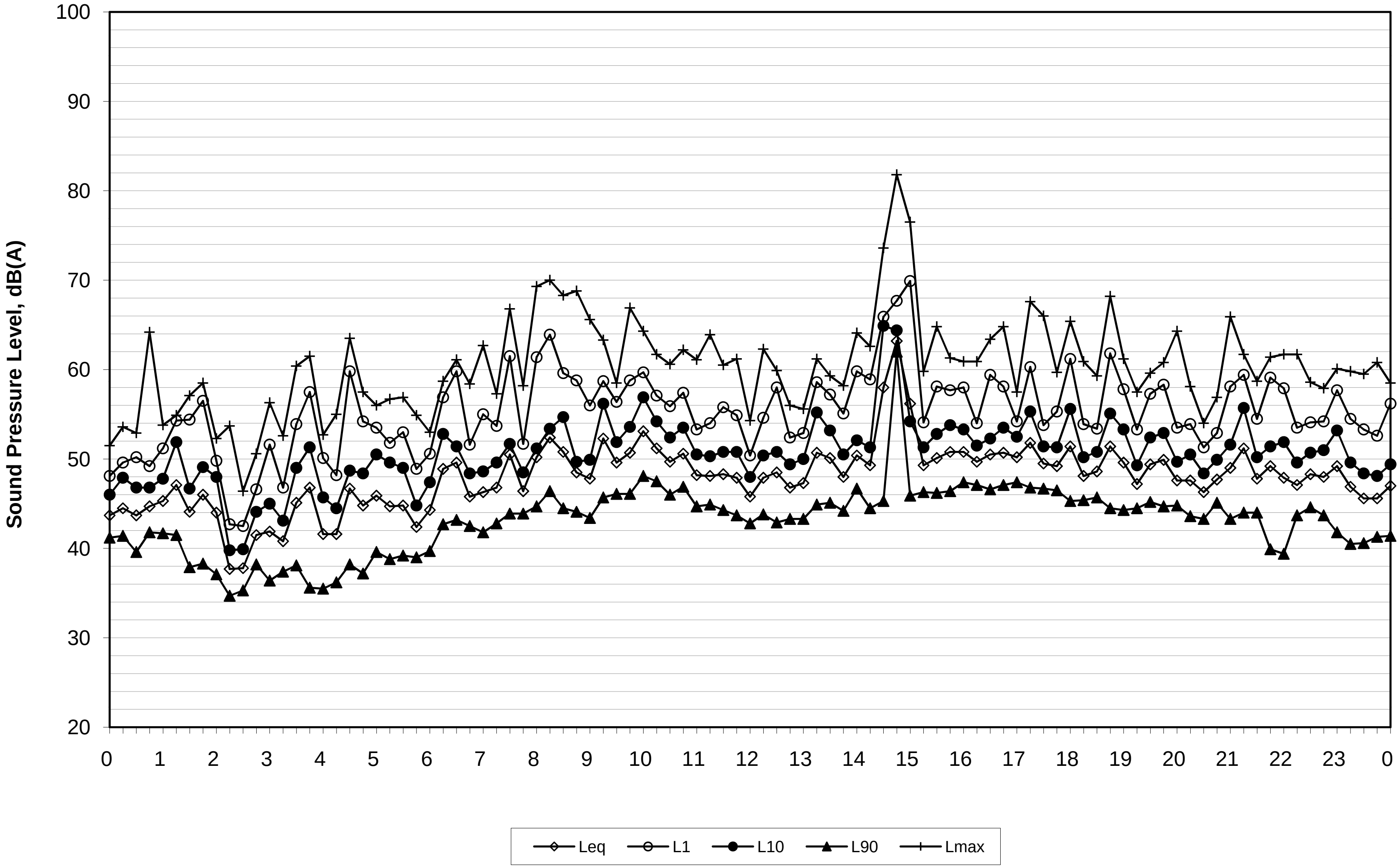
Saturday, 27 June 2009



Reference Measurement Location
R10

Ambient Sound Pressure Levels

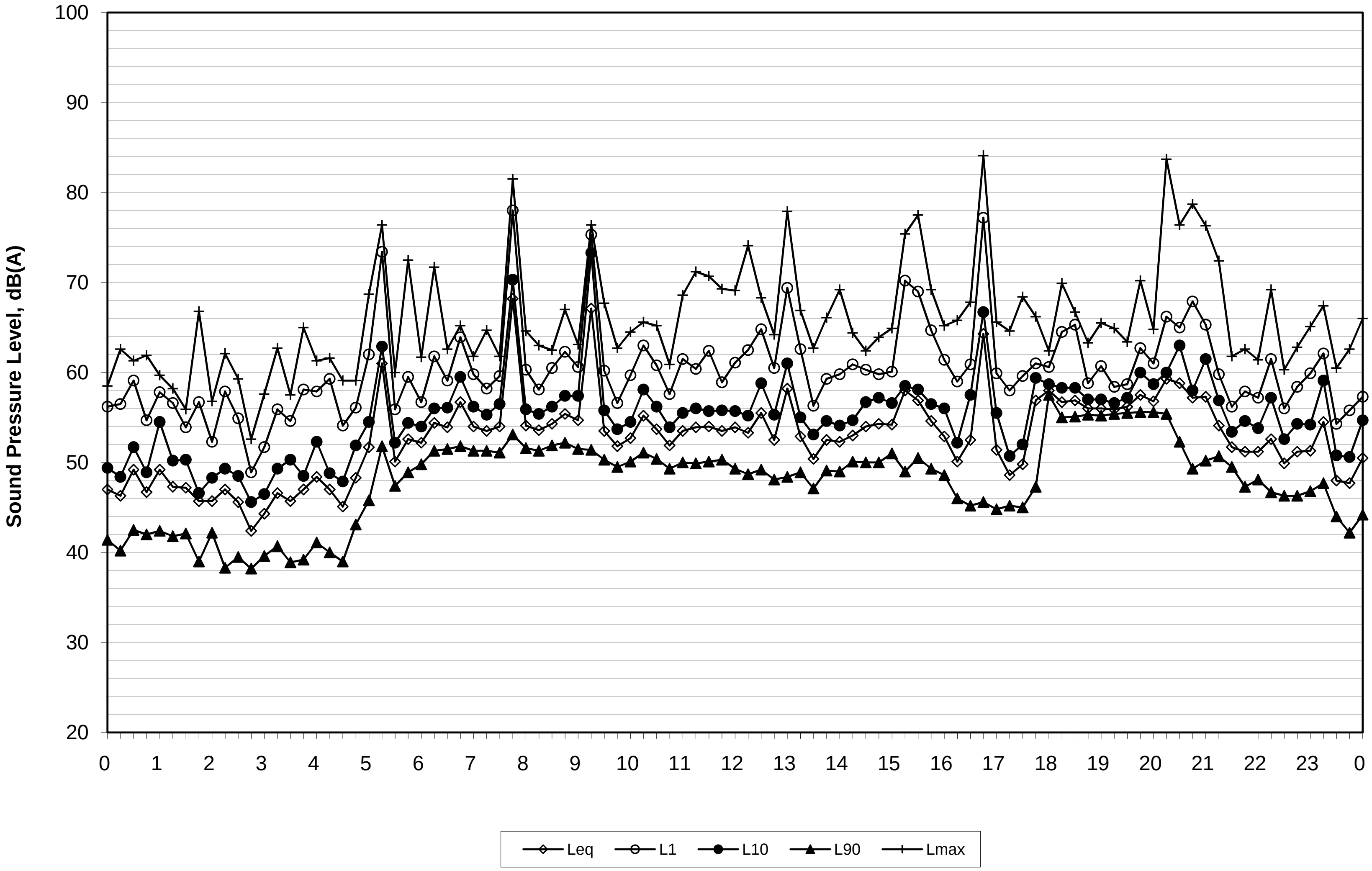
Sunday, 28 June 2009



Reference Measurement Location
R10

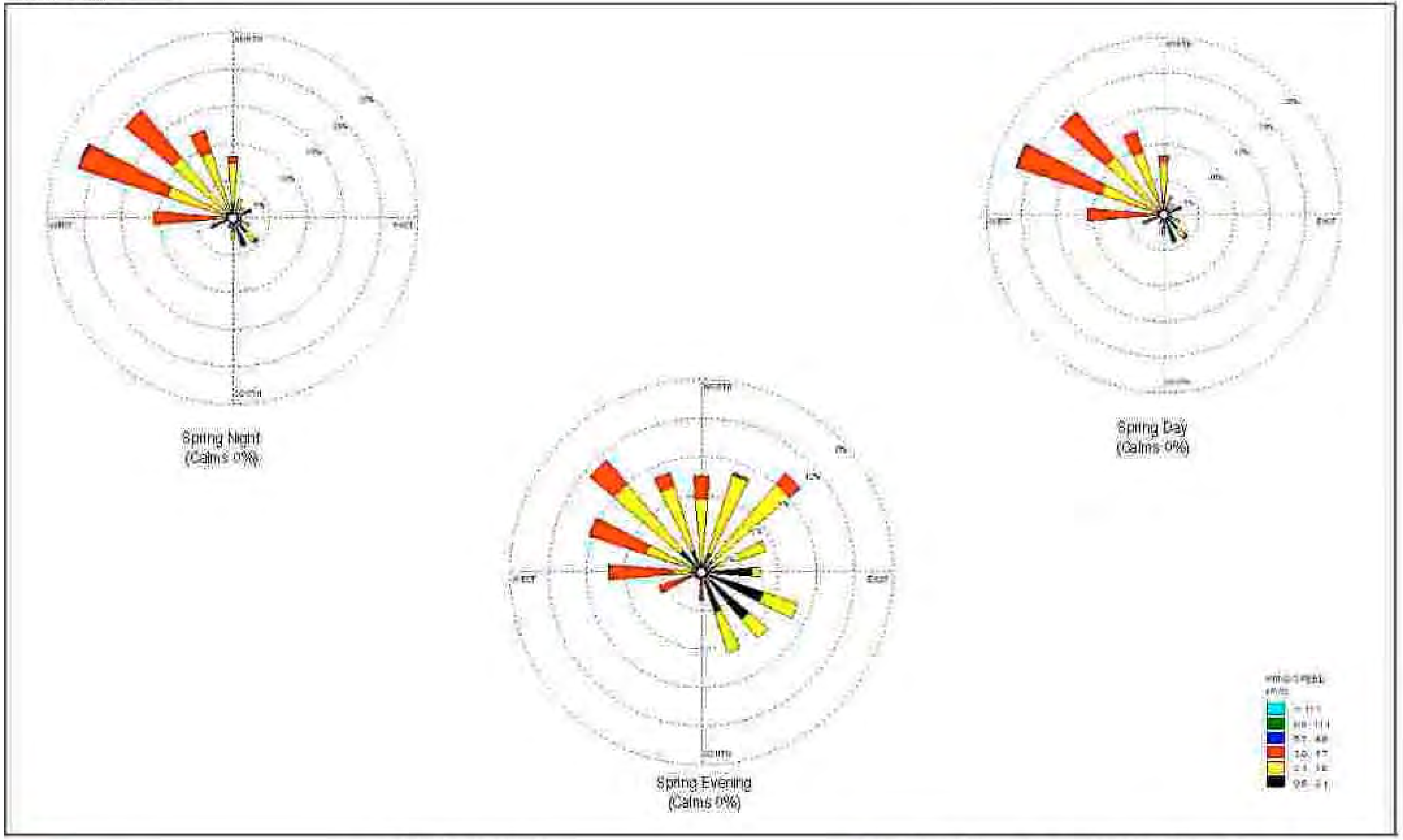
Ambient Sound Pressure Levels

Monday, 29 June 2009



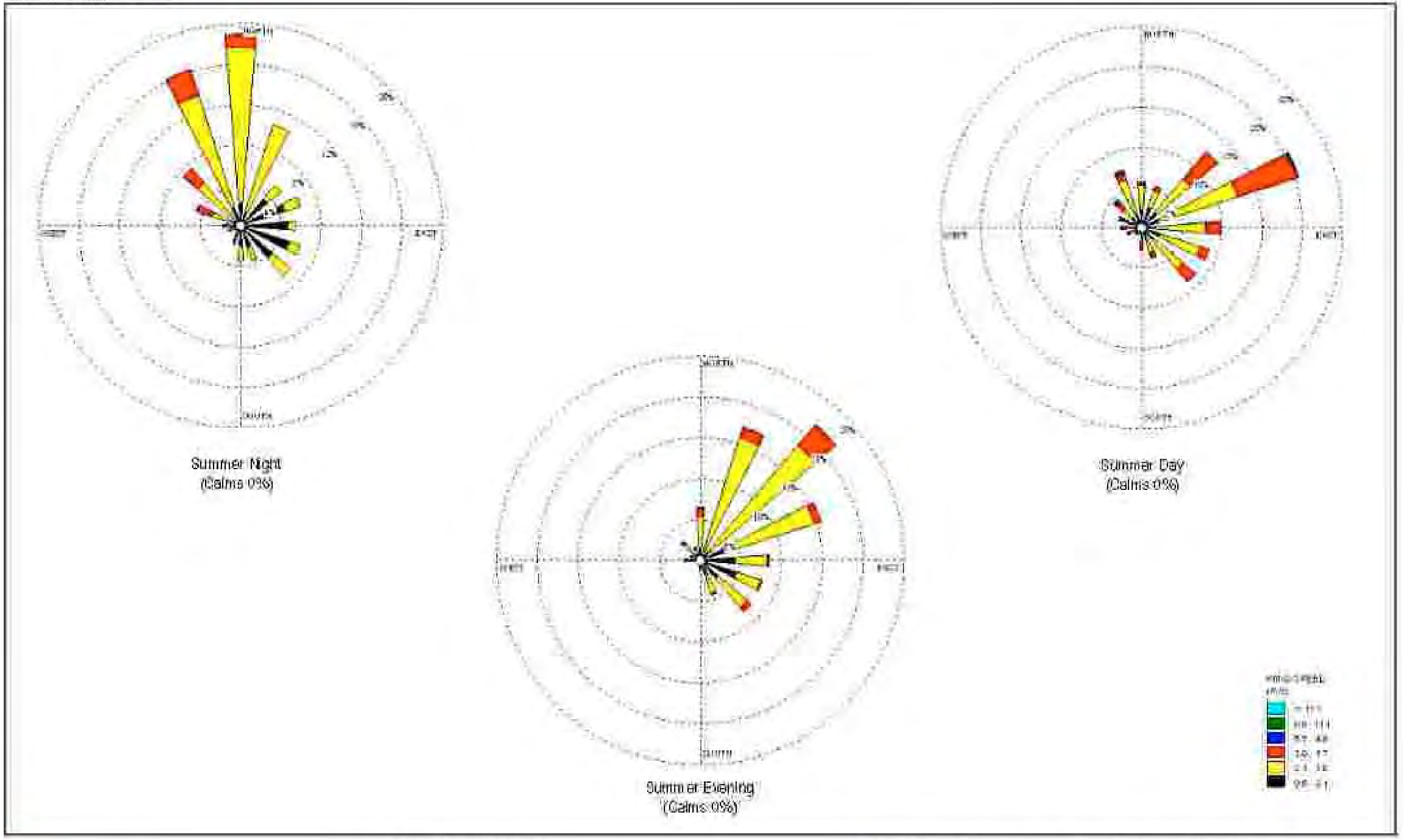
Reference Measurement Location
R10

ATTACHMENT 2: WIND ROSES



ENSR | AECOM

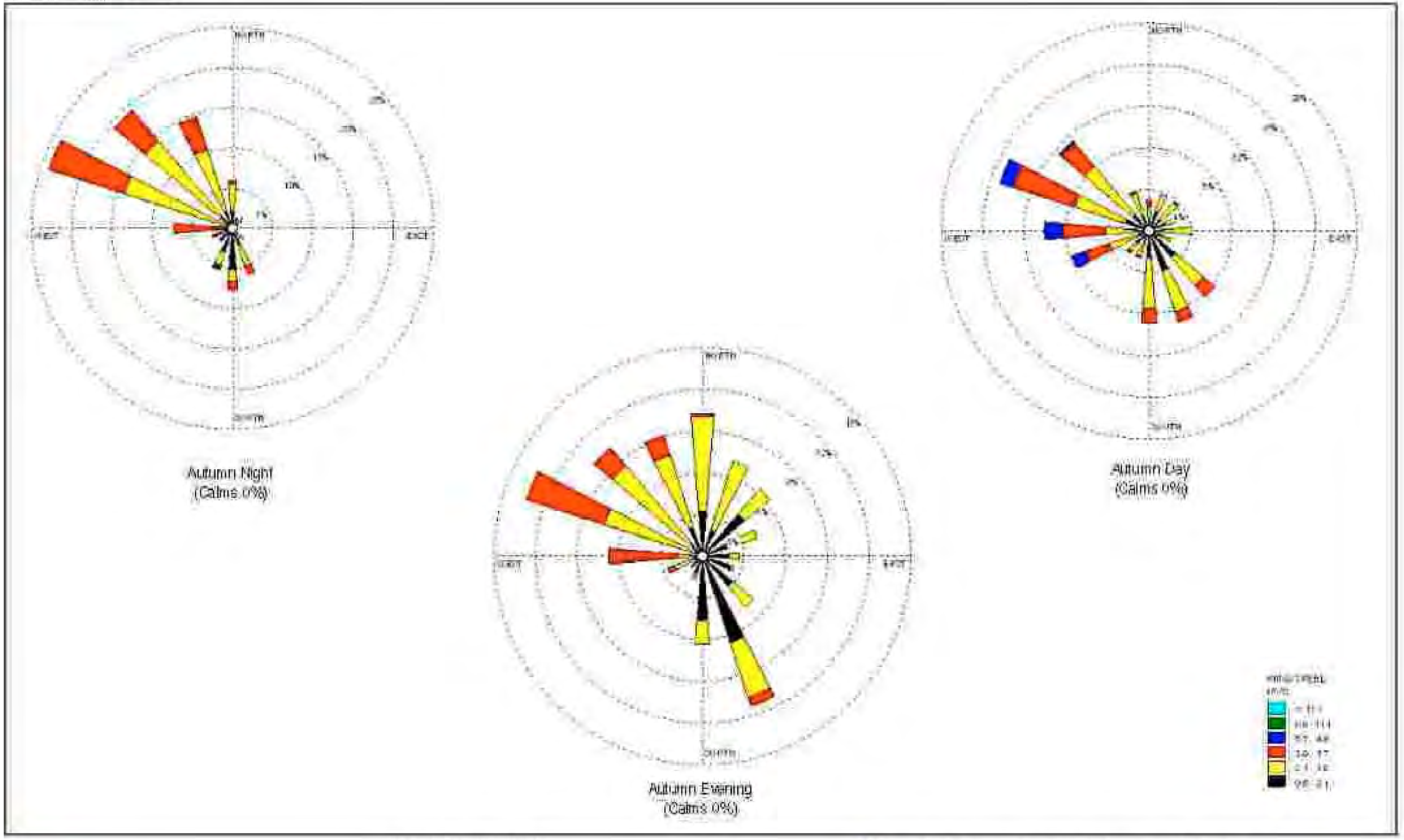
Figure 5 Windroses Spring Night, Day and Evening
Lucas Energy Pty Limited



Meteorological Data Source: TAPM v3.0

ENSR | AECOM

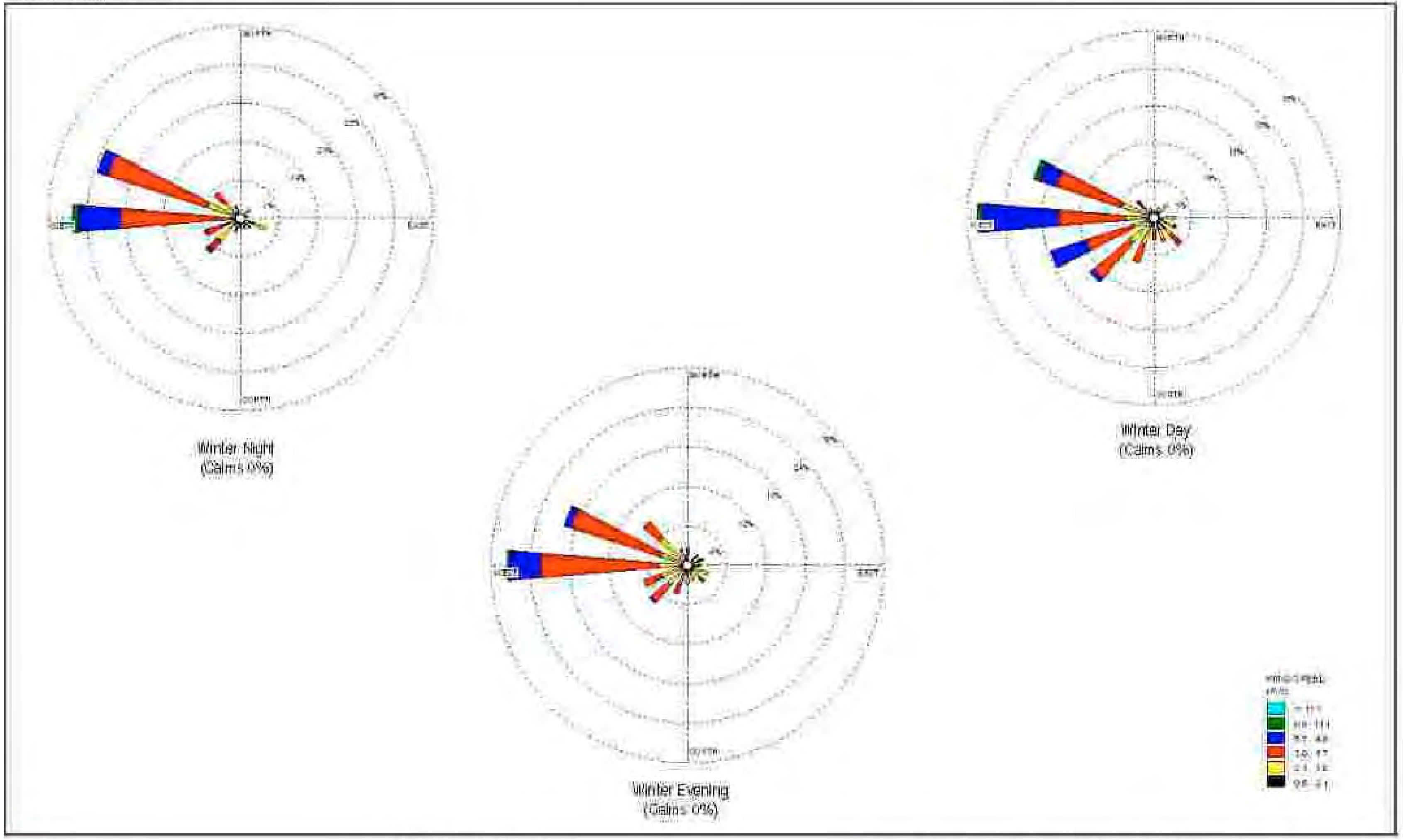
Figure 2 Windroses Summer, Night, Day and Evening
Lucas Energy Pty Limited



Meteorological Data Source: TAPM V3.0

ENSR | AECOM

Figure 3 Windroses Autumn Night, Day and Evening
Lucas Energy Pty Limited



Meteorological Data Source: TAPM v3.0

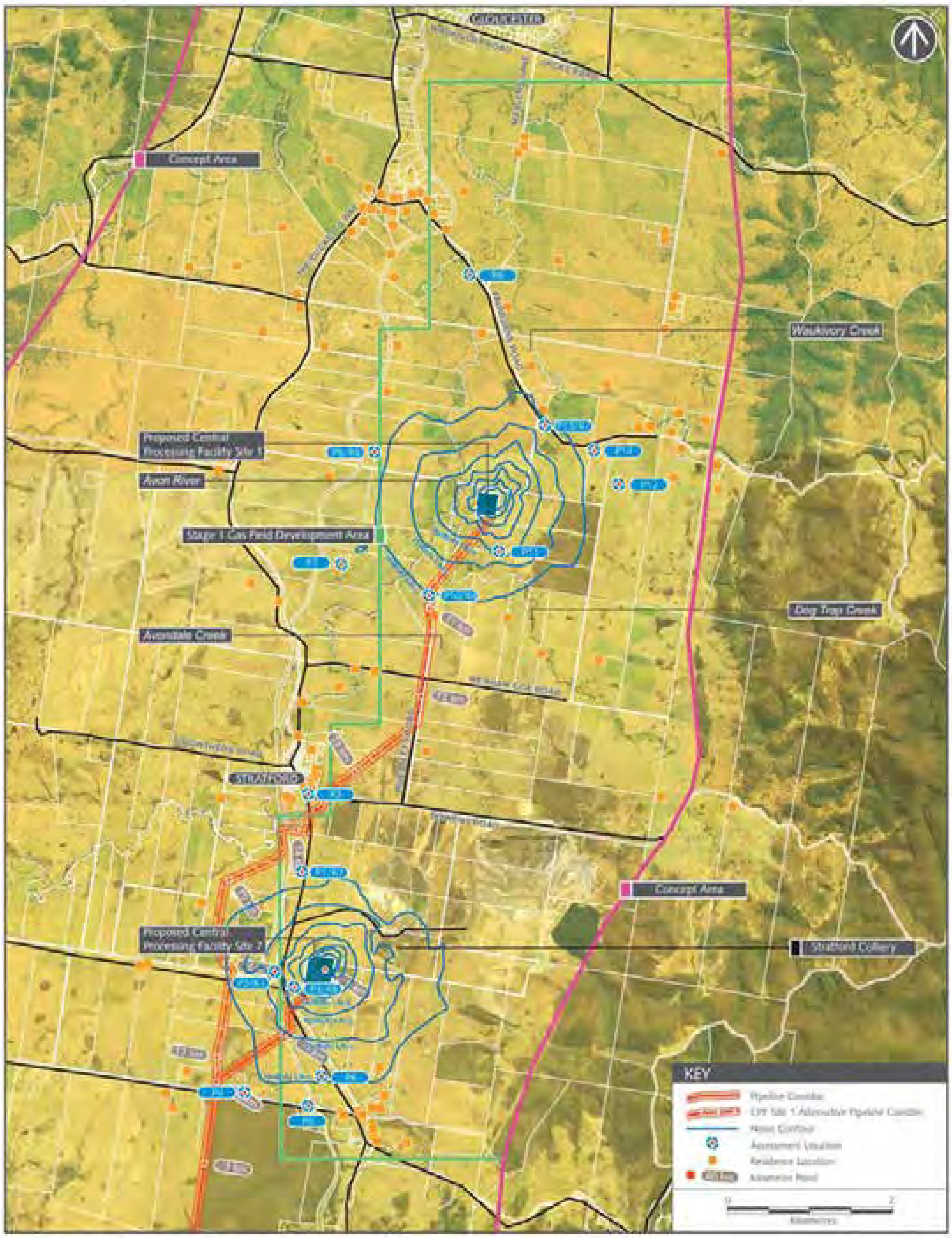
ENSR | AECOM

Figure 4 Windroses Winter Night, Day and Evening
Lucas Energy Pty Limited
Air Quality Impact Assessment
Stratford 2009

ATTACHMENT 3: STABILITY CLASS DATA

Summer							
Class	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Night %	0.0	0.0	0.0	44.3	40.4	15.3	100.0
Day %	4.5	21.9	39.8	33.8	0.0	0.0	100.0
Evening %	0.0	0.0	0.0	43.3	33.9	22.8	100.0
Total for Season (Night, Day, Evening) %	2.3	10.9	19.9	38.9	19.1	8.9	100.0
Autumn							
Class	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Night %	0.0	0.0	0.0	36.1	45.9	17.9	100.0
Day %	0.4	12.0	34.0	52.0	0.9	0.8	100.0
Evening %	0.0	0.0	0.0	32.3	40.8	26.9	100.0
Total for Season (Night, Day, Evening) %	0.2	6.0	17.0	43.4	22.6	10.9	100.0
Winter							
Class	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Night %	0.0	0.0	0.0	48.1	45.7	6.3	100.0
Day %	0.1	5.4	22.0	67.9	3.7	0.8	100.0
Evening %	0.0	0.0	0.0	35.1	52.4	12.5	100.0
Total for Season (Night, Day, Evening) %	0.0	2.7	11.0	55.8	25.8	4.6	100.0
Spring							
Class	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Night %	0.0	0.0	0.0	35.7	43.4	20.9	100.0
Day %	6.1	22.3	34.3	37.3	0.0	0.0	100.0
Evening %	0.0	0.0	0.0	38.2	34.6	27.2	100.0
Total for Season (Night, Day, Evening) %	3.1	11.1	17.2	36.9	20.2	11.5	100.0

ATTACHMENT 4: CPF (SITES 1 and 7) NOISE CONTOUR PLOT (CALM)



AECOM

NOISE CONTOURS - CPF SITE 1 AND SITE 7

ATTACHMENT 5: HDS NOISE CONTOUR PLOT (CALM)

AECOM

NOISE CONTOURS - HEXHAM DELIVERY STATION

ATTACHMENT 6: TERMS AND DEFINITIONS

A-Weighted: See

Adverse weather: Weather effects that enhance noise (that is, wind and temperature inversion) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more that 30% of the nights in winter).

Ambient noise: The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.

Assessment background level (ABL): The single figure background level representing each assessment period day, evening and night (that is, three assessment background levels are determined for each 24-h period of the monitoring period). Its determination is by the tenth percentile method.

Assessment period: The period in a day over which assessments are made: day (0700-0800h), evening (1800 to 2200h) or night (2200 to 0700h).

Background Noise: The underlying level of noise present in the ambient noise, excluding the noise source under extraneous noise is removed. This is described using the L_{A90} descriptor.

Cumulative noise level: Refers to the total level of noise from all sources.

Day: The period between 0700 and 1800hrs (Monday-Saturday) and 0800-1800 (Sunday and Public Holidays).

dB: Abbreviation for decibel-a unit of sound measurement. Given sound pressure to a reference pressure.

dBA: Unit used to measure "A-weighted" sound pressure levels. A-weighting is an adjustment made to sound level measurement to approximate the response of the human ear.

A change of 1 or in the level of a sound is difficult to detect, whilst a 3 to 5 change corresponds to a small but noticeable change in loudness. A 10 change corresponds to an approximate doubling or halving in loudness.

The table below lists examples of typical noise levels.

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

Default parameters: In assessing meteorological enhancement of noise, refers to set values for weather parameters, such as wind speeds and temperature gradients, to be used in predicting source noise levels.

Equivalent Continuous Noise Levels: The level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Evening: Refers to the period between 1800-2200hrs.

ATTACHMENT 6: TERMS AND DEFINITIONS

Extraneous Noise: Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.

Feasible and reasonable measures: Feasibility relates to engineering considerations and what is practical to build; reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors:

- noise mitigation benefits (amount of noise reduction provided, number of people protected)
- cost of mitigation (cost of mitigation versus benefits provided)
- community views (aesthetic impacts and community wishes)
- noise levels for affected land uses (existing and future levels, and changes in noise levels).

Fluctuating Noise: Noise that varies continuously and to an appreciable extent over the period of observation.

Greenfield site: Undeveloped land.

Impulsive Noise: Noise having a high peak of short duration, or a sequence of such peaks. A sequence of such peaks. A sequence of such impulses in rapid succession is termed ‘repetitive impulsive noise’.

Intrusive Noise: refers to noise that intrudes above the background level by more than 5 decibels.

L_{A10}: The A-weighted sound pressure level that is exceeded for 10% of the time over which a given sound is measured.
This is considered to represent the average maximum noise level.

L_{A90}: The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured.
This is considered to represent the background noise.

L_{Aeq}: The equivalent continuous noise level – the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

Long-term annoyance: Prolonged annoyance over months and years.

Median: The middle value in a number of values sorted in ascending or descending order. Hence, for an odd number of values, the value of the median is simply the middle value. If there is an even number of values the median is the arithmetic average of the two middle values.

Meteorological conditions: wind and temperature inversion conditions.

Most-affected locations(s): Locations that experience (or will experience) offensive noise from the noise source under consideration. In determining these locations, one needs to consider existing background levels, exact noise source locations(s), distance from source (or proposed source) to receiver, and any shielding between source and receiver.

Night: The period between 2200 and 0700 (Monday-Saturday) and 2200-0800 (Sunday and Public Holidays)

ATTACHMENT 6: TERMS AND DEFINITIONS

Negotiated agreement: An agreement involving the negotiation of an achievable noise limit in cases where the project specific noise levels cannot be met. The agreement is negotiated between the proponent and the DEC or the proponent and the community. Such an agreement is reached through balancing the merits of a development, the feasibility and reasonableness of available mitigation measures and the noise impacts produced.

Noise criteria: The general set of non-mandatory noise level targets for protecting against intrusive noise (for example, background noise plus 5dB) and loss of amenity (for example, noise levels for various land uses).

Rating Background Level (RBL): the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-h period used for the assessment background level). This is the level used for assessment purposed. It is defined as the median value of:

- all the day assessment background levels over the monitoring period for the day
- all the evening assessment background levels over the monitoring period for the evening; or
- all the night assessment

background levels over the

Non-mandatory: With reference to the proposed policy, means not required by legislation. The proposed policy specifies criteria to be strived for, but the legislation does not make these criteria compulsory. However, the policy will be used as a guide to setting statutory (legally enforceable) limits for licences and consents.

Performed-based goals: Goals specified in terms of the outcomes/performance to be achieved, but not in terms of the means of achieving them.

Receiver: The noise-sensitive land at which noise from a development can be heard.

Stationary noise sources: Sources that do not generally move from place to place, eg. industrial or commercial sources. In general, these include:

Individual stationary sources such as:

- heating, ventilating and air conditioning (HVAC) equipment,
- rotating machinery,
- impacting mechanical sources,
- other mechanical equipment and machinery such as conveyors.

Mobile sources confined to particular location such as draglines and haul trucks.

Facilities, usually comprising many sources of sound, including:

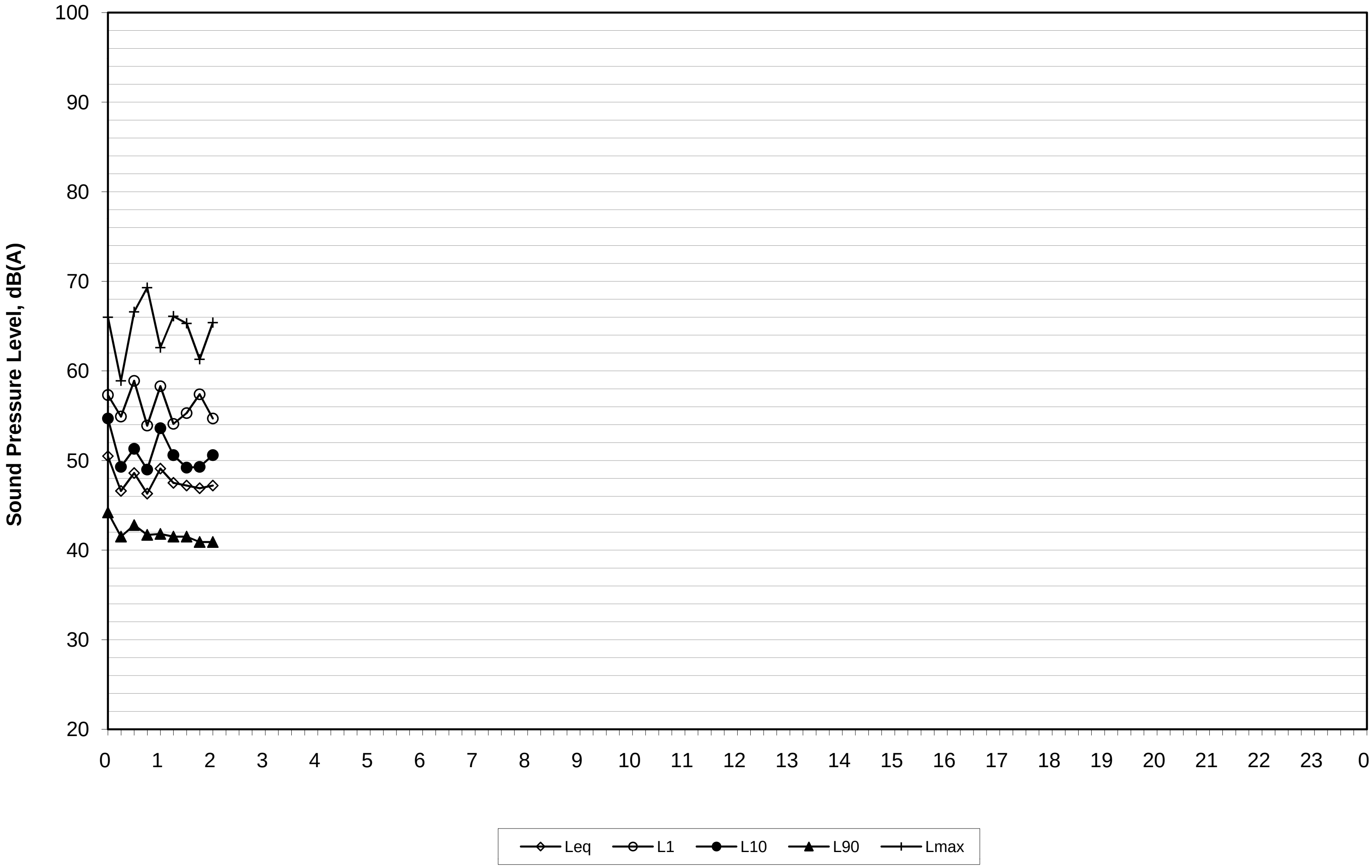
- industrial premises,
- extractive industries,
- commercial premises,
- warehousing facilities,
- maintenance and repair facilities.

(In this case, the stationary source is understood to encompass all the activities taking place within the property boundary of the facility).

Temperature inversion: An atmospheric condition where temperature increases with height above the ground.

Ambient Sound Pressure Levels

Tuesday, 30 June 2009



Reference Measurement Location
R10

Appendix I Preliminary Hazard Analysis

GLOUCESTER COAL SEAM GAS PROJECT

GAS GATHERING AND PROCESSING FACILITIES AND TRANSMISSION PIPELINE

PRELIMINARY HAZARD ANALYSIS

UPDATE

AGL GLOUCESTER L E PTY LTD

PREPARED FOR:	**Stuart Galway**
	AGL Gloucester L E Pty Ltd

DOCUMENT NO:	**J20366-001**
REVISION:	**1**
DATE:	**29 October 2009**

Sherpa Consulting Pty Ltd (ABN 40 110 961 898)
Phone: 61 2 9412 4555
Fax: 61 2 9412 4556
Web: www.sherpaconsulting.com

DOCUMENT REVISION RECORD

REV	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	METHOD OF ISSUE
DRAFT	29/10/2009	Draft for internal review	J. Bertram	-	-	-
A	14/8/2009	Draft for Client Comment	J. Bertram	S. Chia	S. Chia	Email PDF
0	4/9/2009	Final Issue, incorporating client comment	J. Bertram	S. Chia	S. Chia	Email PDF
1	29/10/2009	Updated revision	J. Bertram	S. Chia	S. Chia	Email PDF

RELIANCE NOTICE

This report is issued pursuant to an Agreement between SHERPA CONSULTING PTY LTD ('Sherpa Consulting') and AGL Gloucester L E Pty Ltd which agreement sets forth the entire rights, obligations and liabilities of those parties with respect to the content and use of the report.

Reliance by any other party on the contents of the report shall be at its own risk. Sherpa Consulting makes no warranty or representation, expressed or implied, to any other party with respect to the accuracy, completeness, or usefulness of the information contained in this report and assumes no liabilities with respect to any other party's use of or damages resulting from such use of any information, conclusions or recommendations disclosed in this report.

Title: **Gloucester Coal Seam Gas Project** **Gas Gathering and Processing Facilities and Transmission Pipeline** **Preliminary Hazard Analysis** **Update**	**QA Verified:** P. JOHNSON **Date: 29 October 2009**

CONTENTS

ABBREVIATIONS 7

1. EXECUTIVE SUMMARY AND RECOMMENDATIONS 9
   - 1.1. Purpose and Scope 9
   - 1.2. Study Findings 10
   - 1.3. Societal Risk 13
   - 1.4. Bio-Physical Effects 14
   - 1.5. Conclusions 14
   - 1.6. Recommendations 14

2. INTRODUCTION 16
   - 2.1. Background 16
   - 2.2. Study Objectives 16
   - 2.3. Study Scope 17
   - 2.4. Scope Changes 17
   - 2.5. Study Limitations 18

3. DESCRIPTION OF PROPOSED DEVELOPMENT 19
   - 3.1. Overview 19

4. DESCRIPTION OF GAS WELLS AND GATHERING LINES 20
   - 4.1. Overview 20
   - 4.2. Above-Ground Wellhead 20
   - 4.3. Gas Gathering and Spine Lines 21

5. DESCRIPTION OF CENTRAL PROCESSING FACILITY 23
   - 5.1. Process Description 23
   - 5.2. Major Equipment 23
   - 5.3. Water Treatment Facility 24

6. DESCRIPTION OF EXPORT SALES PIPELINE 25
   - 6.1. Overview 25
   - 6.2. Location Analysis 25
   - 6.3. Nearest Residences 26
   - 6.4. Pipeline Design Issues 27
   - 6.5. Pipeline Safety Design 28

7. DESCRIPTION OF HEXHAM DELIVERY STATION ... 32
7.1. Overview ... 32
8. METHODOLOGY ... 33
8.1. Study Approach ... 33
8.2. Level of Assessment ... 33
8.3. Consequence Criteria ... 34
8.4. Risk Criteria ... 34
9. STUDY ASSUMPTIONS ... 37
9.1. Process Data ... 37
9.2. Aboveground Facilities ... 39
9.3. Gathering Lines, Spine Lines and Transmission Pipeline ... 40
10. HAZARD IDENTIFICATION - OVERVIEW ... 41
10.1. Hazardous Incidents ... 41
10.2. Hazardous Materials ... 41
10.3. Natural Gas Releases ... 41
11. HAZARD IDENTIFICATION – ABOVEGROUND FACILITIES ... 43
11.1. Loss of Containment Scenarios ... 43
11.2. Proposed Safeguards ... 43
11.3. TEG Releases ... 44
11.4. Heating Medium Releases ... 44
11.5. Diesel Releases ... 44
11.6. Flare Operations ... 45
12. HAZARD IDENTIFCATION - PIPELINES ... 46
12.1. Releases from Gathering/ Spine Lines and Export Sales Pipeline ... 46
13. CONSEQUENCE ASSESSMENT ... 52
13.1. Effect Modelling ... 52
13.2. Releases from Aboveground Facilities ... 52
13.3. Releases from Gathering/ Spine Lines and Export Sales Pipeline ... 52
14. FREQUENCY ANALYSIS ... 54
14.1. Aboveground Facility Incident Frequencies ... 54
14.2. ESP Incident Frequencies ... 54
14.3. Gathering Line and Spine Line Incident Frequencies ... 54

15. QUANTITATIVE RISK ASSESSMENT 55
15.1. Overview 55
15.2. Well-Sites Risk Profile 55
15.3. Gas Gathering and Spine Lines Risk Profile 56
15.4. Central Processing Facility (CPF) Risk Profile 59
15.5. Export Sales Pipeline Risk Profile 62
15.6. Hexham Delivery Station (HDS) Risk Profile 65
15.7. Societal Risk 66
15.8. Bio-Physical Effects 66
15.9. Conclusions 67
15.10. Recommendations 67
APPENDIX 1. HAZARD IDENTIFICATION TABLES 68
APPENDIX 2. CONSEQUENCE ASSESSMENT 78
APPENDIX 3. ABOVEGROUND FACILITY INCIDENT FREQUENCIES 89
APPENDIX 4. ESP INCIDENT FREQUENCIES 97
APPENDIX 5. GATHERING AND SPINE LINE INCIDENT FREQUENCIES 102
APPENDIX 6. AERIAL PHOTOS SHOWING NEAREST RESIDENCES TO ESP 107
APPENDIX 7. REFERENCES 115

TABLES

Table 1.1: Distances to Criteria of Individual Risk of Fatality – Export Sales Pipeline........................ 13
Table 4.1: Gathering Line Design Parameters.. 21
Table 4.2: Spine Line Design Parameters... 21
Table 6.1: Export Sales Pipeline Design Parameters 25
Table 6.2: Nearest Residences to Export Sales Pipeline.. 26
Table 6.3: Pipeline Design Specification 29
Table 6.4: Pipeline Depth of Cover 30
Table 8.1: Level of Analysis... 33
Table 8.2: Thermal Radiation Criteria 34
Table 8.3: NSW Land-Use Planning Individual Fatality Risk Criteria.. 35
Table 9.1: Process Data Adopted in PHA 37
Table 15.1: Distances to Criteria of Individual Risk of Fatality – Gathering Lines and Spine Lines 59
Table 15.2: Distances to Criteria of Individual Risk of Fatality – Export Sales Pipeline...................... 63

FIGURES

Figure 15.1: Typical Individual Fatality Risk Contours for Well-Sites... 56
Figure 15.2: Gathering Line Risk Transect... 57
Figure 15.3: Spine Line Risk Transect 58
Figure 15.4: CPF Option 1 Individual Fatality Risk Contours... 60
Figure 15.5: CPF Option 7 Individual Fatality Risk Contours... 61
Figure 15.6: Export Sales Pipeline Risk Transect – DN 450 (Cases 1 and 2)..................................... 64
Figure 15.7: Export Sales Pipeline Risk Transect – DN 250 (Cases 3 - 7).. 64
Figure 15.8: HDS Individual Fatality Risk Contours 66

ABBREVIATIONS

AC	Alternating Current
API	American Petroleum Institute
AS	Australian Standard
CP	Cathodic Protection
CPF	Central Processing Facility
DN	Nominal Diameter
DWTT	Drop Weight Tear Test
EA	Environmental Assessment
EGIG	European Gas Pipeline Incident Data Group
ERP	Emergency Response Plant
ESP	Export Sales Pipeline
FHA	Final Hazard Analysis
GCSG	Gloucester Coal Seam Gas (Project)
GJ/s	Giga-Joules per second
HAZID	Hazard Identification
HAZOP	Hazard and Operability (Study)
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HDS	Hexham Delivery Station
HIPAP	Hazardous Industry Planning Advisory Paper
km	kilometres
KP	Kilometre Post
kPa	kilo-Pascal
kV	KiloVolt
LFL	Lower Flammability Limit
m	metres
MAOP	Maximum Allowable Operating Pressure
mm	millimetres
MPag	MegaPascal (gauge)
MW	MegaWatt
^oC	Degrees Celsius
P&ID	Piping and Instrumentation Drawing
PCV	Pressure Control Valve
PE	Polyethylene
PEL	Petroleum Exploration License
PHA	Preliminary Hazard Analysis
PLC	Programmable Logic Controller

SCADA	Supervisory Control and Data Acquisition
SCC	Stress Corrosion Cracking
scmh	Standard cubic metres per hour
SDV	Shutdown Valve
SMYS	Specified Minimum Yield Strength
TEG	Tri-ethylene Glycol
TJ/d	Tera-Joules per day
VCE	Vapour Cloud Explosion
WHRU	Waste Heat Recovery Unit
WT	Wall Thickness

1. EXECUTIVE SUMMARY AND RECOMMENDATIONS

1.1. Purpose and Scope

AGL Gloucester L E Pty Ltd (AGL) operates a coal seam gas pilot facility in the Gloucester Basin (Licence PEL 285). The location of the PEL area is approximately centred on the township of Stratford, approximately 70 kilometres north of Newcastle in New South Wales. The area extends approximately 60 km north to south and approximately 20 km east to west comprising some 18 blocks and about 1,308 square kilometres. The area completely contains the Gloucester Geological Basin. PEL 285 was granted in 1992. The coal seam gas pilot project was developed and operated by Lucas Energy Pty Ltd on behalf of the joint venture partners AJ Lucas Group Ltd and Molopo Australia.

The gas field is currently being evaluated for commercial gas production with the installation of a pilot gas field project. The pilot gas project is located 7.2 kilometres Southeast of Gloucester town.

Lucas Energy commissioned EPCM Consultants (EPCM) to undertake project management, design and environmental work for the expansion of the project beyond the pilot project stage. In turn, EPCM commissioned Sherpa Consulting Pty Ltd to undertake a Preliminary Hazard Analysis (PHA) for the expanded project (Ref. 1).

AGL Energy acquired the development from the joint venture operators at the end of 2008. Following design changes, AGL wish to update the PHA. The design is still in the conceptual stage. The PHA assumes a full production capacity of 80TJ/d for the gas gathering system and the processing/ compression station at Gloucester, with some sensitivity cases for various capacities and diameters for the gas gathering and spine lines.

AGL Gloucester has engaged Sherpa Consulting Pty Ltd (Sherpa) to update the PHA for the proposed Gloucester Coal Seam Gas (GCSG) Project, including the following features:

- the coal seam gas well-sites
- the gas gathering and spine lines from the well-sites to the Central Processing Facility (CPF)
- the Central Processing Facility
- the Export Sales Pipeline (ESP) from the CPF to the Hexham Delivery Station (HDS)
- the Hexham Delivery Station.

This report summarises the objectives, scope of work, methodology and results of the PHA update.

1.2. Study Findings

Individual fatality risk transects were generated for the gas gathering and spine lines (from the well-sites to the Central Processing Facility) and the gas transmission pipeline between the Central Processing Facility and the Hexham Delivery Station (for pipe running through both R1 and T1 location class areas).

Individual fatality, injury and escalation risk was evaluated (and risk contours generated, as required) for the following facilities:

- the coal seam gas well-sites
- the Central Processing Facility
- the Hexham Delivery Station

The following sections summarise the findings of the risk assessment.

1.2.1. Well-Sites Risk Profile

Risk contours were generated for the well-sites. There will be approximately 110 production well-sites, each with provision for up to 4 well-heads. The following were the results of the assessment of the risk contours:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was found to extend by about 40m from the centre of the well site. This will not extend to any sensitive land-uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was found to extend by about 38m from the centre of the well site. This will not extend to any residential areas as well sites will be located to provide a minimum exclusion zone
- The 5 x 10^{-6} per year individual fatality risk contour (commercial areas) was found to extend by about 20m from the centre of the well site and will not extend to any commercial land-uses.
- The 10 x 10^{-6} per year individual fatality risk contour (active open spaces) was found to extend by about 15m from the centre of the well site and will not extend to any active open spaces.
- The 50 x 10^{-6} per year individual fatality risk contour (industrial areas) was not generated by the well-site hazard scenarios.

The radius of the risk contours for the well-sites depends on a number of factors with a predominant factor being the pressure assumed for the well-site equipment. For the well-sites at the Gloucester coal seam locations, a pressure of 10.2 MPa was assumed based on design rating of well-site equipment upstream of the well-head shutdown valve. The actual operating pressure will be much less than this early in the wellhead life (typically 4 MPa) and will degrade over the operating life of the wellhead. The assumption of a 10.2 MPa pressure will give a conservative estimate of risk level compared with similar facilities where a lower operating pressure is assumed.

1.2.2. Gas Gathering and Spine Lines

The proposed polyethylene gas gathering and spine lines will be provided with marker tape at a minimum of 200 mm above the lines and will be covered to depths of 600 mm, 750 mm (roadway crossings) and 900 mm (creek crossings), following the guidelines of AS4645.3:2008, Table 5.1 (Ref. 2). Gathering and Spine Lines to be constructed of PE100 SDR13.6 polyethylene pipe. Gathering lines will be of 12 mm wall thickness and spine lines of 43 mm wall thickness. The gathering and spine lines will traverse mainly rural land.

Risk transects were produced for the gas gathering and spine lines, showing the individual risk of fatality versus the distance from the centreline of the pipe. A number of cases are considered taking into account a range of pipe diameters and process flow rates.

The risk transects calculated for the gathering and spine lines showed that the risk of fatality would not be expected to exceed about 3 x 10^{-7} p.a. for all cases. Therefore the risk near these pipelines will meet the NSW DoP criteria for all land use types (including sensitive land uses).

1.2.3. Central Processing Facility (CPF) Risk Profile

CPF-1 Option

Risk contours were generated for two proposed CPF location options (CPF-1 and CPF-7). The following assessment findings relate to the **CPF-1** option:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was located within the boundary of the site and does not extend to sensitive land uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was located within the boundary of the site and does not extend to residential areas.
- Risk levels for other land use types (commercial, active open spaces, industrial) were located within the boundary of the site and do not extend to the relevant land use types.

CPF-7 Option

The following were the results of the assessment of the risk contours for **CPF-7**:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was located within the boundary of the site and does not extend to sensitive land uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was located within the boundary of the site and does not extend to residential areas.
- Risk levels for other land use types (commercial, active open spaces, industrial) were located within the boundary of the site and do not extend to the relevant land use types.

1.2.4. Export Sales Pipeline Risk Profile

Risk transects were produced for a number of cases showing the individual risk of fatality versus the distance from the centreline of the pipe. Table 1.1 summarises the distances estimated for the ESP to risk criteria levels for land uses as measured from the centreline of the pipe. This shows the minimum separation distances required for various land use types to ensure compliance with the risk criteria of the NSW DoP.

DN 450 Pipeline – R1 Locations

For the DN 450 pipeline in R1 locations (Case 1), the fatality risk contour level for sensitive land uses (5×10^{-7} per year) was found to extend up to 190 m from the centreline of the pipe, however, sensitive land uses (including hospitals, schools, child care facilities, aged care housing, etc.) were not identified to exist within a this distance from the centreline of the pipeline.

Risk levels with the potential for significant impact to residential areas (1×10^{-6} per year) were shown to extend 35 m from the centreline of the ESP. From a review of the separation distances to the nearest residences identified near the pipeline (Section 6.3), the nearest residences are located as close as 15 m from the pipeline.

These locations are within the first 16 km of the pipeline, in R1 locations. Therefore, Case 1 (with 750 mm DOC and no marker tape) will not comply with the NSW DoP risk criteria. Therefore, additional measures will be required near these locations, such as additional depth of cover and/or marker tape.

DN 450 Pipeline – T1 Locations

For the DN 450 pipeline for T1 locations (Case 2, with 900 mm DOC and marker tape), the fatality risk contour level for sensitive land uses (5×10^{-7} per year) was found to extend up to 41 m from the centreline of the pipeline. Sensitive land uses (including hospitals, schools, child care facilities, aged care housing, etc.) were not identified to exist within a this distance from the centreline of the pipeline.

Risk levels with the potential for significant impact to residential areas (1×10^{-6} per year) were not reached at any distance from the centreline of the ESP.

TABLE 1.1: DISTANCES TO CRITERIA OF INDIVIDUAL RISK OF FATALITY – EXPORT SALES PIPELINE

Case	Distance to Individual Risk of Fatality (m)				
	Sensitive (hospitals, nursing homes)	Residential	Commercial	Active Open Spaces	Industrial
	(5×10^{-7} per year)	(1×10^{-6} per year)	(5×10^{-6} per year)	(1×10^{-5} per year)	(5×10^{-5} per year)
DN 450 Pipeline					
Case No. 1	190	35	Not Reached	Not Reached	Not Reached
Case No. 2	41	Not Reached	Not Reached	Not Reached	Not Reached
DN 250 Pipeline					
Case No. 3	230	215	20	Not Reached	Not Reached
Case No. 4	35	Not Reached	Not Reached	Not Reached	Not Reached
Case No. 5	43	Not Reached	Not Reached	Not Reached	Not Reached
Case No. 6	45	12	Not Reached	Not Reached	Not Reached
Case No. 7	10	Not Reached	Not Reached	Not Reached	Not Reached

1.2.5. Hexham Delivery Station (HDS) Risk Profile

Risk contours were generated for the HDS and the risk assessment showed the following:

- The 0.5×10^{-6} per year individual fatality risk contour (sensitive land-use) was found to extend off-site by a maximum of about 30m. The contour remains within the Zone 4a Industrial Area, and does not reach any sensitive land-uses.
- The 1×10^{-6} per year individual fatality risk contour (residential areas) was found to extend off-site by a maximum of about 20m to the southern boundary of the HDS site. The contour remains almost entirely within the Zone 4a Industrial Area and does not reach any residences.
- The 5×10^{-6} per year individual fatality risk contour (commercial) was found to be contained within the boundary of the HDS site and therefore will not extend to adjacent commercial zones (i.e. retail centres, office or entertainment centre).
- The risk levels for other land use types (active open spaces, industrial) were not generated for the site, i.e. risk levels at the HDS did not reach the criteria levels for these land use types at any point on the HDS site.
- The 50×10^{-6} per year injury risk contours were not generated on the site.
- The 50×10^{-6} per year escalation (accident propagation) risk contours were not generated on the site.

1.3. Societal Risk

Due to the low off-site risk levels at each facility, societal risk was not evaluated.

1.4. Bio-Physical Effects

The following general comments concerning biophysical and environmental impacts were made as a result of the assessment:

- The effects of an accidental emission of methane gas are unlikely to threaten the long-term viability of the ecosystem or any species within any sensitive natural environmental areas which may exist near the proposed development.
- The potential biophysical effects of produced-water (including accidental emission) are evaluated in the Environmental Assessment (EA, Ref. 3).

1.5. Conclusions

A PHA was undertaken to determine the off-site risk profile of the proposed Gloucester Coal Seam Gas (GCSG) Project, including the well-sites, gathering lines, processing facility, transmission pipeline and delivery station.

The PHA found that the off-site risk of fatality, injury and accident propagation posed by the GCSG project meets the requirements of the NSW Department of Planning Risk Criteria for Land-Use Safety Planning (Ref. 4).

The effects of an accidental emission of methane gas are unlikely to threaten the long-term viability of the ecosystem or any species within any sensitive natural environmental areas which may exist near the proposed development. The potential biophysical effects of produced-water are evaluated in the EA (Ref. 3).

1.6. Recommendations

1. It is recommended that, near existing residences in R1 locations (or land identified for future residential use) that are within 35 m of the centreline of the Export Sales Pipeline, safeguards in addition to those provided for Case 1 (DN 450mm pipeline in R1 locations) should be implemented. These additional safeguards may include marker tape and/ or additional depth of cover.

2. The proposed Export Sales Pipeline would not cross any known areas of mine subsidence. However, as this may change in the future, it is recommended that AGL liaise with the Mine Subsidence Board to determine likely future mining activity and the potential for subsidence.

3. The PHA should be updated when final design details are known, particularly for the operation of the flare.

4. Once final design details are known, the design should be HAZOPed, particularly to assess abnormal operating modes such as flare and blowdown operations.

As the design develops, the project is generally required to complete a number of other safety and risk studies, as part of the NSW Department of Planning Seven Stage

Approval Process, which are to be undertaken in accordance with the relevant Departmental guidelines.

2. INTRODUCTION

2.1. Background

AGL Gloucester L E Pty Ltd (AGL) operates a pilot facility for a coal seam gas facility in the Gloucester Basin (Licence PEL 285). The location of the PEL area is approximately centred on the township of Stratford, approximately 70 kilometres north of Newcastle in New South Wales. The area extends approximately 60 km north to south and approximately 20 km east to west, comprising some 18 blocks and about 1,308 square kilometres. The area completely contains the Gloucester Geological Basin. PEL 285 was granted in 1992. The coal seam gas pilot project was developed and operated by Lucas Energy Pty Ltd on behalf of the joint venture partners AJ Lucas Group Ltd and Molopo Australia.

The gas field is currently being evaluated for commercial gas production with the installation of a pilot gas field project. The pilot gas project is located 7.2 kilometres Southeast of Gloucester town.

Lucas Energy commissioned EPCM Consultants (EPCM) to undertake project management, design and environmental work for the expansion of the project beyond the pilot project stage. In turn, EPCM commissioned Sherpa Consulting Pty Ltd to undertake a Preliminary Hazard Analysis (PHA) for the expanded project (Ref. 1).

AGL Energy acquired the development from the joint venture operators at the end of 2008. Following design changes, AGL wish to update the PHA. The design is still in the conceptual stage. The PHA assumes a full production capacity of 80TJ/d for the gas gathering system and the processing/ compression station at Gloucester, with some sensitivity cases for various capacities and diameters for the gas gathering and spine lines.

These assumptions (summarised in Section 9), which may change prior to finalisation of the design, will be reviewed in the Final Hazard Analysis.

2.2. Study Objectives

The objectives of the study were to undertake a Preliminary Hazard Analysis (PHA) of the GCSG Project, in accordance with NSW Department of Planning guidance: Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 (Ref. 5), 'Guidelines for Hazard Analysis', HIPAP No. 4, 'Risk Criteria for Land Use Safety Planning' (Ref. 4) and 'Multi Level Risk Assessment' (Ref. 6).

The Multi-level Risk Assessment Guideline (Ref. 6) was consulted to identify the most appropriate level of risk assessment. This PHA is based on a Level 2 Risk Assessment where the results are sufficiently quantified to allow an assessment of the offsite risk levels against acceptance criteria.

2.3. Study Scope

The scope of the PHA included the following GCSG Project facilities:

- Wellhead and well-site facilities
- Gas gathering lines and spines lines (from well-sites to processing facility)
- Central Processing Facility (CPF)
- Export Sales Pipeline
- Hexham Delivery Station (HDS)
- Gas fired power station located adjacent to the CPF.

NOTE: The tie-in from the Hexham Delivery Station to the Sydney Newcastle Pipeline was not reviewed in the PHA.

2.4. Scope Changes

Since the previous PHA (Ref. 1), the proposed design has changed, requiring an update. The main change is that the CPF will be increased from 60 TJ/day to 80 TJ/day. The compression facility will be provided with a total of 8 compressors (7 duty, 1 standby).

Two options are now proposed for the CPF site, as follows:

- CPF-1 (adjacent to the 'Teidman' property)
- CPF-7 (adjacent to a rail loop)

2.4.1. Gathering Line Case Studies

A total of 110 well sites will be included in the updated project (60 were included in the original PHA). A number of sensitivity cases were considered for the gathering lines as follows:

- Case 1 - 110mm diameter lines with a design flow rate of 2 TJ/day
- Case 2 - 160mm diameter lines with a design flow rate of 4 TJ/day
- Case 3 - 200mm diameter lines with a design flow rate of 6 TJ/day

2.4.2. Spine Line Case Studies

A number of sensitivity cases were assessed for the spine lines as follows:

- Case 1 - 315mm diameter lines with a design flow rate of 10 TJ/day
- Case 2 - 315mm diameter lines with a design flow rate of 20 TJ/day
- Case 3 - 450mm diameter lines with a design flow rate of 10 TJ/day
- Case 4 - 450mm diameter lines with a design flow rate of 20 TJ/day
- Case 5 - 450mm diameter lines with a design flow rate of 40 TJ/day
- Case 6 - 450mm diameter lines with a design flow rate of 60 TJ/day
- Case 7 - 540mm diameter lines with a design flow rate of 40 TJ/day

- Case 8 - 540mm diameter lines with a design flow rate of 60 TJ/day
- Case 9 - 630mm diameter lines with a design flow rate of 40 TJ/day
- Case 10 - 630mm diameter lines with a design flow rate of 60 TJ/day

2.5. Study Limitations

This PHA is based on preliminary process flow diagrams and data from the design basis manual (Ref. 7) and contains calculations based on assumptions relating to process conditions (summarised in Section 9). Distances to the site boundary and equipment locations were interpreted from the preliminary site layout plans.

The biophysical effects of a produced-water release are not addressed in this report (see the Environmental Assessment, Ref. 3).

The tie-in from the Hexham Delivery Station to the Sydney-Newcastle Pipeline was not reviewed in this PHA.

3. DESCRIPTION OF PROPOSED DEVELOPMENT

3.1. Overview

AGL are in the processing of developing the Gloucester Basin (PEL 285) coal seam methane field to full production and to transport processed gas, via a 100 kilometre transmission pipeline, to a connection point on the Sydney-Newcastle Pipeline at Hexham.

The design is in the conceptual phase and a number of assumptions have been made regarding the pipeline and compressor station capacity. This Preliminary Hazard Analysis (PHA) assumes a full production capacity of 80 TJ/d for the gas gathering system and the processing/ compression station at Gloucester. The transmission pipeline options are either a DN 250 transmission pipeline designed to flow the field capacity as well as a DN 450 option which would be used as a gas storage pipeline.

These assumptions (summarised in Section 9), which may change prior to finalisation of the design, will be reviewed in the Final Hazard Analysis.

The subsequent sections provide a description of the proposed Gloucester Coal Seam Gas Project, as described in the Project Basis of Design (Ref. 7).

4. DESCRIPTION OF GAS WELLS AND GATHERING LINES

4.1. Overview

Approximately 110 well-sites (with provision for up to 4 wells per site) will be drilled through an identified coal package with maximum depth up to 1300m dependant on location in the Gloucester basin. These wells will be completed with production casing and zones selected for perforation based on open hole logs. Hydraulic fracturing operations will be designed and carried out in stages on the basis of coal seam thicknesses and proposed perforation intervals.

4.2. Above-Ground Wellhead

The coal seam methane wellheads will be located in one hectare lots during initial drilling and completion reducing to a minimal pad size for ongoing production. Typical arrangements will be an area of 6 m x 4 m for single wellhead sites and approximately 40 m x 30 m for four-wellhead sites.

Each wellhead (up to 4 per well-site) will include the following equipment:

- Down-hole water pump controlled by a variable speed drive, surface hydraulic ram to stroke downhole pump or velocity string are the basic completion that may be installed below the surface wellhead depending on operational requirements
- Wellsite PLC that controls downhole and surface operations, metering calculations and data acquisition and storage for transmittal to the main SCADA computer located at the CPF.
- Carbon steel gas piping connection to the gas gathering system including:
  - Wellhead isolation valve
  - Wellhead shutdown valve configured to close on process disturbances as identified in the HAZOP
  - Wellhead 2-phase separator to remove free water from the gas
  - Full flow relief valve sized for full wellhead gas flow
  - Water pump for pumping separated water into the water distribution system
  - Gas flow meter for measuring wellhead gas flowrate
- Carbon steel liquids line including the following:
  - Isolation valve
  - Water flow meter

There is a specification break on the wellheads between the wellhead and the lower pressure gathering systems. The lower pressure gas pipework is protected from high pressure by a shutdown valve configured to shut on detection of high pressure and a full flow relief valve to provide two layers of protection. The water system is protected from high pressure from the wellhead pump by a pressure switch which will stop the pump. There are no regulators included in the design of the wellheads.

Modifications to the design of any wellhead facility will be covered under a management of change system that may trigger a subsequent HAZOP.

4.3. Gas Gathering and Spine Lines

Gas gathering lines will be provided from the wellhead gas connection to the field spine line connection (with sensitivity cases for diameter and design flow as per Section 2.4.1). Gas gathering lines will be constructed from polyethylene pipe to AS4130:2009 (Ref. 8). Low point drains will be fitted at low points to allow free water to be removed.

Table 4.1 summarises the concept-stage design specifications for the gathering lines.

TABLE 4.1: GATHERING LINE DESIGN PARAMETERS

Gathering Line Design Parameter	Value
Design Pressure	500 kPa
Minimum Design Temperature	0ºC
Maximum Design Temperature	30ºC
Flow Capacity	Sensitivity cases as per Section 2.4.1 (2, 4 and 6 TJ/d)

The gathering lines will then connect to spine lines which will be provided to connect each quadrant of the coal seam methane field to the gas processing facility at Gloucester. Spine lines will be constructed from polyethylene pipe with diameters as given in the sensitivity cases in Section 2.4.2.

Table 4.2 summarises the concept-stage design specifications for the spine lines:

TABLE 4.2: SPINE LINE DESIGN PARAMETERS

Spine Line Design Parameter	Value
Design Pressure	500 kPa
Minimum Design Temperature	2ºC
Maximum Design Temperature	30ºC
Flow Capacity	Sensitivity cases as per Section 2.4.2 (10, 20, 40 and 60 TJ/d)

The polyethylene pipes will be welded together using an automatic electro-fusion welding technique.

The minimum depth of cover for buried polyethylene pipelines will be as follows:

- Under roadways 750 mm (sealed/ non-sealed roads)
- Creek crossings 900 mm
- Other locations 600 mm (soil/ shale)

These depths will be reviewed following the conceptual design stage, including an external load calculation to ensure the piping can absorb the expected external loads from traffic.

All polyethylene gas pipelines will be provided with yellow marker (warning) tape/ polymeric cover strip placed above the pipeline at a depth of 200 mm below the ground level. Where the strip is joined, it is to overlap by at least 150 mm.

The polyethylene line will be tested using a pressure leak test in accordance with AS4645.1.

5. DESCRIPTION OF CENTRAL PROCESSING FACILITY

5.1. Process Description

The function of the CPF will be to condition, compress and meter the gas provided by the field gathering system.

The overall process for gas conditioning is a combination of compression and dehydration via a tri-ethylene glycol (TEG) contactor.

TEG will be regenerated (water removed) and re-used until such time as it is chemically degraded and requires replacement. A very small quantity of TEG may be lost from the system, mainly as carry-over in the water boiled-off from the TEG during regeneration.

There are two design cases for the gas transmission pipeline, each with a different CPF design pressure:

- DN 250 Class 600 pipeline that would have excess capacity to deliver the required flow rate.
- DN 450 Class 900 pipeline that would be used as a gas storage pipeline.

Therefore, the compressors at the CPF will have two different pressure design cases for the discharge; however, the design flowrate will be 80 TJ/d for both pressure cases.

5.2. Major Equipment

The gas processing facility will include the following equipment:

- Suction header connecting the polyethylene spine lines. The polyethylene to carbon steel interface will occur subsurface.
- Inlet separator for removing bulk free water and any hydrocarbons.
- Inlet filter coalescer vessels for final removal of particulates, free water and lubrication oil from the inlet gas stream.
- Inlet pressure control valves for controlling compressor suction pressure.
- Gas Compressor skids (8 off, 7 duty, 1 standby) including:
    - o Inter-stage fin fan coolers coupled to the gas engine. Waste heart recovery units will be provided to use waste heat to aid in energy recovery (e.g. for TEG reboiler)
    - o Gas engine
    - o Reciprocating multistage compressors
    - o Inter-stage dewatering
- Discharge scrubber for removing compressor lube oil prior to dehydration.

- TEG dehydration package including the following:
  - TEG contactor vessel utilising structure packing. The gas flows against a TEG stream to dehydrate the gas to the required pipeline specification
- TEG regeneration skid including:
  - Reboiler for flashing off water from the rich TEG stream
  - Dual redundant electric pumps for injecting lean TEG into the contactor vessel
- Discharge filter coalescer for removing TEG carryover.
- Station backpressure control valve to maintain backpressure on the TEG Contactor.
- Oily water separation system; to collect and separate oily water from the inlet separators, coalescers, inter-stage scrubbers and the discharge scrubber. The system includes:
  - Distribution pipework for connecting the vessels to the oily water separator
  - Separator vessel designed for oil water separation
  - Clean water connection connected to the process water disposal system
  - Oily connection to storage tanks for transport offsite and recycling
  - An activated bentonite waste oil recovery mixer that captures process waste oil in flocculated bentonite of quality for landfill disposal and released water of suitable quality for direct disposal in the evaporation pond pending ongoing water analysis
- Oil storage facility:
  - Oil storage tanks for engine and compressor lube oil storage directly connected to the compressor day tanks
- Instrument, fuel and start gas skid including:
  - Connection to the plant discharge upstream of the back pressure control valve
- Flare system connecting the compressor station suction and discharge pipework and the compressor blowdown to a vent.
- Control room including:
  - SCADA interface for field, pipeline and compressor station telemetry
  - Office and amenities
- Power generation facilities adjacent to the CPF

5.3. Water Treatment Facility

Produced water will be pumped to water storage ponds. The produced water will be pumped from the ponds into a water treatment plant. The water treatment plant will include water filtration, a Reverse Osmosis plant followed by a waste stream brine concentrator where the brine stream will be concentrated for disposal. The treated water stream will then be used for irrigation.

6. DESCRIPTION OF EXPORT SALES PIPELINE

6.1. Overview

Gas from the CPF will be transported to the Hexham Delivery Station (for connection to the Sydney-Newcastle Gas Pipeline) via a 100 km transmission pipeline.

The transmission pipeline options are either a DN 250 transmission pipeline designed to flow the field capacity as well as a DN 450 option which would be used as a gas storage pipeline, designed to AS 2885.1. The PHA study assumed a 450 mm pipeline as the base case, as this is the larger inventory. As a sensitivity case, the DN 250 pipeline option was also assessed for comparison.

Table 6.1 summarises the concept-stage design parameters for the pipeline:

TABLE 6.1: EXPORT SALES PIPELINE DESIGN PARAMETERS

Pipeline Design Parameter	Value
Design Flow Rate DN 250 Case	80 TJ/d
Design Flow Rate DN 450 Case	500 TJ/d
Minimum Design Temperature	-10ºC
Maximum Design Temperature	65ºC
Maximum Allowable Operating Pressure DN 250 Case	10,200 kPa
Maximum Allowable Operating Pressure DN 450 Case	15,300 kPa
Maximum Discharge Pressure (at the delivery station)	6895 kPa
Corrosion Allowance	0 mm

A design factor of 0.72 has been used in the design of the transmission pipeline; however, the governing case for pipelines in T1 class locations is resistance to penetration, therefore, the maximum design factor is 0.72 and in some cases it is lower.

6.2. Location Analysis

The first 64 km of pipeline (from KP 0 to KP 64) will be in a Class R1 location and the following land use and crossing types have been identified:

- Rural land uses (mainly grazing country)
- Isolated farm houses inside and outside the 4.7 kW/m^2 and 12.7 kW/m^2 radiation zones (as identified within 30m of the pipeline)
- Adjacent 11 and 33 kV power lines running parallel or crossing the pipeline
- Gravel and bitumen road crossings
- Minor and intermediate creek crossings
- Non-electrified rail crossing

From KP 64 to KP 96 the class location is R1 with isolated sections of T1 as the pipeline approaches towns. At Hexham (KP100), the location class is T1 with a secondary class of I for industrial land-use. The following land use and crossing types have been identified:

- Towns of Seaham/ Maitland and Hexham
- Adjacent 132 kV power lines running parallel to the pipeline
- Gravel and bitumen road crossings including the Pacific Highway
- Electric rail crossing
- Minor, intermediate and major river crossings

6.3. Nearest Residences

Table 6.3 shows the nearest residences that have been identified near the pipeline (within about 30-40m of the centerline of the pipeline). The table shows the Kilometre Post (KP) measurement, i.e. the distance along the pipeline (from the CPF), the location (east and north co-ordinates) and other identifying data.

Aerial photos showing these locations and the pipeline alignment are given in APPENDIX 6.

TABLE 6.2: NEAREST RESIDENCES TO EXPORT SALES PIPELINE

KP	Lot Plan	Approx. Distance Pipeline to Residence (m)	Easting	Northing	Local Government Area	Comments
2.4	1//1003762	15	398938	6441852	Gloucester Shire Council	Approx 1.8 km West of Craven village on Woods Rd. House located 275m south of Woods Rd
15.5	1//80329	40	398247	6429857	Great Lakes Council	South of Wards River and just north of Monkerai Rd from Bucketts Way
26	17//998668	22	398413	6420688	Great Lakes Council	West of Stroud Rd village. 125m north of Reidsdale rd along Williams rd
	111//546092	33	396426	6414862	Dungog Shire Council	Black Camp Rd. 5km South of Stroud-Dungog Rd
39	122//526671	41	394921	6410313	Dungog Shire Council	Approx 1.4km north of Flat Tops Rd/Black Camp Rd Intersection

KP	Lot Plan	Approx. Distance Pipeline to Residence (m)	Easting	Northing	Local Government Area	Comments
39.8	14//505209	25	394235	6409830	Dungog Shire Council	House currently uninhabitable/ in disrepair. Approx 420m north from Flat Tops/Black Camp Rds intersection
33.3	11//733189	30	390735	6404353	Dungog Shire Council	Black Camp Creek Rd. Approximately 2.5km north of Glen Martin Rd/ Black Camp Creek rd intersection.
61.3	1//705895	30	386364	6392282	Port Stephens Shire council	East Seaham Rd. Approximately 2.3km south of Limeburners Creek Rd intersection

6.4. Pipeline Design Issues

6.4.1. Odourant

The gas will not to be odourised. Odourant will be injected in the sale gas at the Hexham Delivery Station after it has been metered.

6.4.2. Corrosion and Corrosion Allowance

The design corrosion allowance, both internally and externally is zero. The absence of an external corrosion allowance is due to the high integrity of the pipe coating to be applied and cathodic protection practices, the quality assurance measures planned for the prevention of coating defects, and the requirement that the cathodic protection system will be operated and maintained in accordance with AS 2885 Part 3 for the duration of the pipeline design life. Regular cathodic protection potential readings may be supplemented by intelligent pig runs as part of the integrity management program. The pipeline pigging facilities will be sized to accommodate these devices.

6.4.3. Stress Corrosion Cracking

A potential risk on the pipeline is stress corrosion cracking, which has been found on high pressure pipelines in various locations but is more prevalent at coating defects downstream of compressor stations. The higher temperature caused by compression is a significant factor. The mitigation strategy for the ESP will be to use a tri-laminate coating system with improved SCC resistance for the entire length of the pipeline. Additionally:

- after-coolers will be provided for compressor discharges with temperature monitoring

- the immediate downstream section of pipe from the compressors will be of adequate wall thickness to compensate for the temperature de-rating as a result of high temperature and will be designed in accordance with AS4041 and ANSI B 31.3
- the MAOP will be regularly reviewed taking into account any pressure fluctuations experienced during the operating life of the pipeline.

6.4.4. Pipeline Fracture Mitigation

Brittle fracture is extremely unlikely for this pipeline; however, the pipe specification shall require a Drop Weight Tear Test (DWTT) with an 85% shear area transition temperature to match the minimum pipeline design temperature.

Low energy ductile fracture is a remote possibility for the pipeline. To mitigate the likelihood of ductile fracture propagation, the line pipe material will be specified to have adequate fracture toughness to arrest a crack within the initiating pipe. The toughness value used will be calculated using the Battelle Short Form Formula. This is based on assuming a lean gas composition with <5% ethane and <1% higher hydrocarbons.

6.5. Pipeline Safety Design

The design shall comply with all relevant statutory regulations and codes, and industry codes of practice. The criteria for determining safe design shall address construction, operation and maintenance. A Safety Management Study will be prepared for the pipeline, per AS 2885.

6.5.1. Emergency Response Plan (ERP)

The pipeline operator will develop Emergency Response Plans including the need for procurement of emergency equipment. Where necessary, provision will be made for storage and maintenance of emergency response equipment at the appropriate pipeline facilities. All staff will undergo training in emergency scenarios and equipment prior to operation of the pipeline, and at regular intervals during the operation of the pipeline.

6.5.2. Pipe Material

The transmission pipeline options are either a DN 250 transmission pipeline designed to flow the field capacity as well as a DN 450 option which would be used as a gas storage pipeline. The PHA study assumed a 450 mm pipeline.

The pipe specification for the DN 250 and DN 450 options is shown in Table 6.3.

TABLE 6.3: PIPELINE DESIGN SPECIFICATION

Locations	Wall thickness	Penetration Resistance	Material Specification	Toughness Specification
DN 250 Pipeline				
R1 Cross Country	5 mm	5T Tiger Tooth	API 5L X-70 PSL 2	45J
Road rail, intermediate and major creek crossings	7.5 mm	15T Tiger Tooth	API 5L X-42 PSL 2	30J
T1 Class Locations	12.7 mm	40T Tiger Tooth	API 5L X-42 PSL 2	27J
DN 450 Pipeline				
All Locations	11 mm	40T Tiger Tooth	API 5L X-70 PSL 2	90J
Assumptions: 1. Penetration calculations based on B factor of 1 2. Penetration calculations based on Appendix M of AS2885 Part 1: 2007				

6.5.3. Pipe External Coating

The pipeline will be coated with a Tri-laminate coating system.

6.5.4. Pipe Jointing and Joint Coating

Pipes will be joined using a Manual Metal Arc butt welding technique. Welding procedures are subject to the development and qualification of a welding procedure in accordance with the requirements of AS 2885 Part 2.

Pipe joint coating is a three layer epoxy heat shrink sleeve attaches using a qualified procedure and subject to ongoing testing during application.

6.5.5. Depth of Pipeline Cover

The pipeline will be buried for its entire length except for aboveground items such as pipeline stations and transition piping. The minimum depth of cover specification for various locations is shown in Table 6.4.

TABLE 6.4: PIPELINE DEPTH OF COVER

Location	Minimum Depth of Cover
R1 Locations	750 mm
T1 Locations	900 mm
Insider road or rail reserve	1200 mm
Major water course crossing	2000 mm
Intermediate water course crossings	1500 mm
Minor water course crossing	1200 mm
Minor road track crossing	1200 mm under table drain or road surface
Bitumen Road Crossing	1200 mm under the table drain with slabs or 2000 mm under the road surface whichever is greater.
Rail Crossing	1200 mm under the table drain with slabs or 2000 mm under the rail tracks whichever is greater.
Service Crossing	Under the service with a minimum separation of 500 mm with a concrete slab between the two.

6.5.6. Pipeline Marking

The pipeline location will be identified to third parties through its entire length, using a combination of marking techniques, appropriate to the third party risk to the pipeline. In general, the following principles will apply:

- Warning markers will be placed at each change of direction, at fence lines, and each side of road, rail and river crossings.
- Warning markers will be intervisible.
- Marker tape located at a minimum of 300 mm above the buried pipeline and located in the follow areas:
  - In the vicinity of and within pipeline stations
  - Inside road reserve
  - At road and rail crossings
  - At other areas where tape significantly reduces the risk of damage to the pipeline
  - T1 class locations.

In addition, the pipeline location will be made available to the appropriate authorities for marking on public mapping, to land holders, and emergency services. The information will also be provided to a “One Call” buried services information bureau.

6.5.7. Pipeline Pressure Protection

To meet the requirements of AS 2885, two separate methods of pipeline pressure protection will be provided:

- a high pressure transmitter at the inlet to the pipeline, which will override the compressor speed control to slow down all the compressors if the plant discharge pressure reaches the pipeline MAOP.
- a plant outlet shutdown valve which will close on detection of an overpressure in the pipeline inlet.

6.5.8. Pipeline Leak Detection System

Leak detection will be carried out by the following methods:

- 24 hour monitoring of alarms on pressure transmitters via SCADA.
- Metering discrepancy and gas-unaccounted-for monitoring daily.
- General patrolling of the pipeline.
- Current defect assessment surveys and cathodic protection (CP) monitoring

6.5.9. Road and Railway Crossings

At all road and rail crossings, the pipe installation will be designed to resist the external loads imposed by traffic. Casings may be used if required by the railway authority or due to geotechnical considerations. If required, they will utilise concrete casing pipes with the pipeline grouted into position. The pipe will be separated from the casing wall via thinsulators.

Pipe stress from traffic loads at major highways and railways will be formally calculated using the methods of API 1102.

Horizontal Directional Drilling (HDD) and boring techniques may be used at some crossings subject to environmental and constructability considerations.

6.5.10. Cathodic Protection

The pipeline will be protected from external corrosion by an impressed-current cathodic protection system. The system will also accommodate the need to mitigate stray currents from parallel electricity transmission lines and railways along part of the route. The requirements will be specified when the final route is selected and the necessary stray current analysis is performed.

6.5.11. Open Cut Watercourse Crossings

For each major river crossing, individual investigation and design will be carried out. Typical standard designs will be used for the numerous minor watercourse crossings. Further details are provided in the Environmental Assessment report (Ref. 3).

6.5.12. Directionally Drilled Crossings

Locations requiring directional drilling will be identified during detailed construction planning. Further details are provided in the Environmental Assessment report (Ref. 3).

7. DESCRIPTION OF HEXHAM DELIVERY STATION

7.1. Overview

The HDS will include remote shutdown, gas heating, flow control and custody transfer metering. The Hexham delivery station will include the following equipment:

- Inlet shutdown valve for remote pipeline isolation and over pressure shutdown.
- Dual redundant inlet dry gas filtration with isolation for removing dust and other contaminants in the pipeline.
- Dual redundant water-bath heaters connected in series to preheat the gas to ensure it retains a margin above the water dew point.
- Dual redundant flow control valves with overriding pressure control to control gas flow into the downstream pipeline.
- Dual redundant ultrasonic meters to provide custody transfer accuracy metering
- Dual redundant gas chromatographs and dew point analysers to perform gas quality measurement and to provide gas heating values for energy flow calculations.

8. METHODOLOGY

8.1. Study Approach

The PHA for the Gloucester Coal Seam Gas Project was undertaken following the guidelines of the NSW Department of Planning. The methodology for undertaking the PHA is as described in the NSW Department of Planning documents, Hazardous Industry Planning Advisory Paper (HIPAP) No. 6, ‘Guidelines for Hazard Analysis’ (Ref. 5) and HIPAP No.4, ‘Risk Criteria for Land Use Safety Planning’, (Ref. 4).

The following is an outline of the methodology adopted in this PHA:

- Establish the context, including level of assessment and risk tolerability criteria.
- Undertake hazard identification for the proposed development and identify a list of credible scenarios for carrying forward for quantification of consequences and likelihood.
- Undertake a consequence analysis for the identified credible scenarios. Where off-site impact is found to have the potential to occur, carry the scenario forward for frequency analysis.
- Undertake frequency analysis for the scenarios with the potential for off-site impact.
- Undertake quantitative risk assessment by combining the off-site scenario consequences and their associated frequency in order to generate:
    - o risk contours for the well-sites, CPF and HDS
    - o risk transects for the gas gathering and spine lines and the ESP.
- From a review of the risk contours and risk transects, assess the risk to neighbouring land uses against the requirements of the NSW Department of Planning Risk Criteria for Land-Use Safety Planning (Ref. 4).
- Make recommendations for risk reduction, where the risk is found to be intolerable.

8.2. Level of Assessment

Multi Level Risk Assessment (Ref. 6) sets out three levels of risk assessment that may be appropriate for a PHA, as shown in Table 8.1. This document was consulted to identify the level of assessment required in this study.

TABLE 8.1: LEVEL OF ANALYSIS

Level	Type of Analysis	Appropriate if:
1	Qualitative	No major offsite consequences and societal risk is negligible
2	Partially Quantitative	Offsite consequences but with a low frequency of occurrence
3	Quantitative	Where level 1 and 2 are exceeded

Based on a review of the findings of the HAZID, it would not be credible to state that no events had offsite impact without more detailed consequence analysis. Hence a Level 1 Assessment was not considered suitable.

It was decided to follow a Level 2 Assessment (i.e. assess consequences of releases and carry forward incidents with offsite impact to risk assessment).

8.3. Consequence Criteria

The consequences of hazardous incidents which have been assessed in the current study are:

- Release of pressurised natural gas, followed by immediate ignition, resulting in jet fire
- Release of pressurised natural gas, followed by delayed ignition, resulting in flash fire.

The criteria for heat radiation impact from fires used in the study are summarised in Table 8.2.

TABLE 8.2: THERMAL RADIATION CRITERIA

Heat Radiation Level (kW/m^2)	Effect	Critical Criteria
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure.	Injury
6	10% chance of a fatality for extended exposure.	Fatality
10	50% chance of a fatality for extended exposure.	Fatality
14	100% chance of a fatality for extended exposure.	Fatality
23	Likely fatality for extended exposure; chance of fatality for instantaneous exposure Unprotected steel will reach thermal stress temperatures which can cause failures	Escalation potential

8.4. Risk Criteria

The risk guidelines provided in the DoP publication *Risk Criteria for Land Use Safety Planning* (Ref. 4) are outlined in the subsequent sections.

8.4.1. Individual Risk of Fatality

The risk criteria adopted for land use safety planning in NSW are summarised in Table 8.3. The figures quoted show the risk criteria for various land use types to an individual, assuming 24 hour exposure to the risk, with no allowance for the protection buildings may offer or for the potential to move away (escape) from a developing incident.

TABLE 8.3: NSW LAND-USE PLANNING INDIVIDUAL FATALITY RISK CRITERIA

Risk Levels/ Probability of Fatality (per annum)	Land-Use	Limit of Exposure at the Following Locations
0.5×10^{-6}	Sensitive	Hospitals, child-care facilities and old age housing developments.
1×10^{-6}	Residential	Residential developments and places of continuous occupancy such as hotels and tourist resorts.
5×10^{-6}	Commercial	Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres.
10×10^{-6}	Active Open Space	Sporting complexes and active open space areas.
50×10^{-6}	Industrial	Site boundary

8.4.2. Societal Risk of Fatality

The Department of Planning (Ref. 4) suggests that judgements on societal risk be made on the basis of a qualitative approach rather than on specifically set numerical criteria.

Despite the lack of formal societal risk tolerability criteria in NSW, societal risk estimation is warranted only where significant and potentially vulnerable populations exist beyond the boundary of the proposed development.

8.4.3. Risk of Injury

NSW Department of Planning guidelines on land use safety planning (Ref. 4) set criteria for injury risk levels. This is in recognition of the fact that society is concerned with the risk of injury as well as death and that certain members of the community are more vulnerable. The injury risk criteria are discussed in more detail in the following paragraphs.

DoP proposes that a heat radiation level of 4.7 kW/m^2 be considered high enough to lead to injury in people who cannot escape or seek shelter. This level of heat radiation will cause injury after 30 seconds. A risk of injury criteria of 50×10^{-6} p.a. is suggested for fire events. Within the guidelines, this is stated as:

- Incident heat flux at residential areas should not exceed 4.7 kW/m^2 at frequencies of more than 50 chances in a million years.

Department of Planning also proposes criteria for the risk of injury from explosion overpressure and toxic gas dispersion. These have not been reproduced here as the HAZID did not identify explosion or toxic release events with potential offsite impacts.

8.4.4. Risk of Accident Propagation

NSW Department of Planning guidelines on land use safety planning (Ref. 4) present criteria covering accident propagation. The guidelines are aimed at ensuring the likelihood of an accident at one plant triggering an accident at another neighbouring plant is low and that adequate safety separation distances exist. The criterion for accident propagation is:

- Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed a risk of 50 in a million per year for the 23 kW/m^2 heat flux level (23 kW/m^2 is considered the level at which unprotected steel may start to fail).

DoP also proposes criteria for the risk of escalation from explosion overpressure. These have not been reproduced here as the HAZID did not identify explosion events with potential offsite impacts.

8.4.5. Risk to the Biophysical Environment

The risk tolerability criteria suggested by the NSW Department of Planning (Ref. 4) for sensitive environmental areas relate to the potential effects of an accidental emission on the long-term viability of the ecosystem or any species within it. HIPAP No. 4 (Ref. 4) summarises these criteria as follows:

- Industrial developments should not be sited in proximity to sensitive natural environmental areas where the effects of the more likely accident emissions may threaten the long-term viability of the ecosystem or any species within it.
- Industrial developments should not be sited in proximity to sensitive natural environmental areas where the likelihood of impacts that may threaten the long-term viability of the ecosystem, or any species within it, is not substantially lower than the background level of threat to the ecosystem.

Risk to the biophysical environment is discussed in detail in the Environmental Assessment Report (Ref. 3), although it should be noted that the HAZID carried out for this PHA did not identify any accident events with potential for serious environmental impacts.

9. STUDY ASSUMPTIONS

9.1. Process Data

The following process data extracted from the Basis of Design (Ref. 7) were used for the assessment.

TABLE 9.1: PROCESS DATA ADOPTED IN PHA

Potential leak source	Press. (MPag)	Temp. (ºC)	Flow (TJ/day)	PHA Update
Well Sites				
Wellheads	10.2	30	110 x 2 (maximum)	Consequence analysis Risk analysis
Wellhead Production separators	0.5	30	110 x 2 (maximum)	Consequence analysis Risk analysis
Gathering Lines				
Gathering lines (110 off)	0.5	30	110 Gathering Lines with three (3) options: - 110 mm at 2 TJ/day - 160 mm at 4 TJ/day - 200 mm at 6 TJ/day	Consequence analysis Risk analysis
Spine Lines				
Spine lines (2 off)	0.5	30	2 Spine Lines. with ten (10) options - 315 mm at 10 TJ/day - 315 mm at 20 TJ/day - 450 mm at 10 TJ/day - 450 mm at 20 TJ/day - 450 mm at 40 TJ/day - 450 mm at 60 TJ/day - 540 mm at 40 TJ/day - 540 mm at 60 TJ/day - 630 mm at 40 TJ/day - 630 mm at 60 TJ/day	Consequence analysis Risk analysis
CPF Gas Side				
Plant Suction Header Inlet Pressure Control Valve Inlet Separator	0.7 (max.)	30	80	Consequence analysis Frequency analysis Risk analysis
Filter Coalescers (2oo3)	0.7 (max.)	30	2 x 40	Consequence analysis Frequency analysis Risk analysis

Potential leak source	Press. (MPag)	Temp. (ºC)	Flow (TJ/day)	PHA Update
Compressor Suction Pressure Control Valves (1oo2)	0.7 (max.)	30	80	Consequence analysis Frequency analysis Risk analysis
Compressors (7oo8)	16.8 (max.)	55	7 x 11.4	Consequence analysis Frequency analysis Risk analysis
Compressor Discharge Scrubber	16.8 (max.)	55	80	Consequence analysis Frequency analysis Risk analysis
TEG Contactor Towers (2oo2)	16.8 (max.)	55	2 x 40	Consequence analysis Frequency analysis Risk analysis
Particulate Filter	16.8 (max.)	55	80	Consequence analysis Frequency analysis Risk analysis
Meter Skid				
Plant Pressure Control Valve	15.3 (max.)			
Plant Discharge Header				
CPF Utilities				
Horizontal Pit Flare	16.8	-	80	Consequence analysis Frequency analysis Risk analysis
Utility gas skid	1.965	30	4	None
Utility gas recycle				
Lean TEG Storage	[Atm.]	30	2 x 8 m^3	Consequence analysis Frequency analysis Risk analysis
Waste Heat Recovery Unit	TBA	Typically 200-250°C Operating Range	Design details to be determined.	Typical heating medium products are combustible. Not carried forward to consequence/risk assessment

Potential leak source	Press. (MPag)	Temp. (ºC)	Flow (TJ/day)	PHA Update
CPF Power Station				
High Pressure Equipment	0.45	47	0.4 kg/s	Consequence analysis Frequency analysis Risk analysis
Letdown Pressure to gas engines	0.45	47	8 x 0.1 kg/s	Consequence analysis Frequency analysis Risk analysis
CPF Water Side				
The PHA considers this as non-hazardous: non-toxic, non-flammable. Potential for environmental impact is covered in the EA.				None
Export Sales Pipeline				
Transmission Pipeline	15.3 (max.)	30	80	Consequence analysis Risk analysis
HDS				
Scraper receiver	15.3 (max.)	30	80	Consequence analysis Risk analysis
Dry gas filters				
Custody transfer meters				
Bath heaters				
FCV				

9.2. Aboveground Facilities

- The likelihood of vapour cloud explosions is negligible as natural gas will tend to disperse readily in the open air and there are no congested areas at the well-sites, CPF and HDS which could result in the accumulation of unignited gas.
- The direction of jet fire releases from equipment was assumed to be horizontal (in order to evaluate the worst-case heat radiation impact).
- Due to the safeguards in place (aboveground piping, inspection and maintenance vehicle barriers), the likelihood of full bore rupture of pipework is very low and was not carried forward to the risk assessment.
- Where the consequence effect resulting from a release was found to have negligible potential for offsite impact, the scenario was not carried forward for further analysis.
- The assessed risk was based on the parts count undertaken using the P&IDs.
- Isolation valves and equipment on the pressurised side of the isolation valve (e.g. gaskets, fittings) were included in the parts count.
- Pipe lengths were estimated based on site layout drawings and similar plant.

- The analyses conservatively do not account for safeguarding, e.g. isolation and blowdown.
- Injury risk and escalation risk contours were not assessed for the well sites and CPF due to the remoteness of the locations and low population. Escalation and injury risk contours were assessed for the HDS which is located within the industrial zone of Hexham.

9.3. Gathering Lines, Spine Lines and Transmission Pipeline

- The likelihood of vapour cloud explosions is negligible as natural gas will tend to disperse readily in the open air and there are no congested areas near the pipeline which could result in the accumulation of unignited gas.
- The release rates were estimated assuming the maximum pipeline operating pressure.
- The direction of pipeline releases was assumed to be 80% vertical and 20% at 45°.
- The frequency of pipeline releases was based on European Gas Pipeline Incident Data Group (EGIG) data which will be conservative for this proposal. Discussion regarding the applicability of the data to polyethylene gathering lines is provided in APPENDIX 5.
- The analyses conservatively do not account for safeguarding, e.g. isolation and blowdown.

10. HAZARD IDENTIFICATION - OVERVIEW

10.1. Hazardous Incidents

A hazard identification table for the well-sites, gathering lines/ spine lines, CPF, export pipeline and delivery station is given in APPENDIX 1. This table was compiled from a review of previous gas processing facility and pipeline risk assessments and the design basis for the proposed pipeline and facilities.

The description of major hazards for the separate plant sections are discussed in separate sections for clarity. The hazard identification is used as a basis for identifying a list of scenarios for carrying forward to the quantitative risk assessment.

10.2. Hazardous Materials

The proposed project will generate natural gas and produced water. The focus of this PHA was therefore the potential for loss of containment of methane, a highly flammable (hydrocarbon) gas and simple asphyxiant.

The potential biophysical effects of produced water are covered in the Environmental Assessment (Ref. 3).

Other potentially hazardous materials include:

- Triethylene Glycol (TEG) used in the gas dehydration unit
- Heating medium used in the waste heat recovery unit (WHRU) system
- Diesel used for local power generation at the well sites.

10.3. Natural Gas Releases

Ignited gas methane releases from the equipment and pipework could result in:

- Jet fire, if ignited immediately;
- Flash fire, if ignition is delayed; and
- Vapour Cloud Explosion (VCE) if a flash fire occurs within a congested or confined plant area.

Gas releases could result in a jet fire if ignited immediately, resulting in a jet flame. Heat radiation from the jet fire will impact people within the vicinity of the release.

If ignition is delayed, a vapour cloud may form, however as natural gas is buoyant and will disperse easily, the potential for a significant cloud buildup is low. Ignition of the vapour cloud could result in a flash fire.

In the event of a flash fire, the vapour cloud burns rapidly without a blast wave and will flash back to burn as a jet flame from the release point. In the event of a flash fire, there is a high (100%) chance of a fatality within the vapour cloud, but due to the short duration of the flame, there is a low chance of significant impact outside the vapour cloud radius. However, the impact from the jet fire that continues after the flash fire remains.

A vapour cloud explosion (VCE) could occur if the flame front burns through a vapour cloud that is within a congested area, resulting in turbulence (promoting combustion) and flame front acceleration and, hence, the generation of overpressure. The proposed well-site, CPF and HDS equipment layouts do not generate significant congestion; therefore, there is a very low likelihood of flash-fire flame-front acceleration and vapour cloud explosion overpressure.

Therefore explosion events (e.g. VCEs) were not been considered further in this study and jet fires and flash fires were considered to be the significant scenarios.

Notwithstanding, there is a potential for gas accumulation in the compressor-enclosures (at the CPF) to result in an explosion in the event of ignition. The chance of leak resulting in fire and explosion in the compressor enclosure, however, is minimal as the enclosures will be provided with:

- gas detection to detect releases and fire detection to detect lube oil fires;
- forced (fan-driven) ventilation with a trip function which will shutdown and depressurize the compressor in the event of ventilation system failure;
- the main actuated valves (shutdown and vent valves) located outside the enclosure, minimising the number of potential leak sources.

Compressor enclosure explosions were not quantified in this study.

11. HAZARD IDENTIFICATION – ABOVEGROUND FACILITIES

11.1. Loss of Containment Scenarios

The following potential methane release scenarios have the potential to occur at the well-sites, Central Processing Facility (CPF) and Hexham Delivery Station (HDS):

- Loss of containment during pigging operations.
- Loss of containment from pipework (from holes in pipework due to corrosion, impact, etc.).
- Loss of containment from flanged connections, valves, filters, meters, heaters due to flange leaks, instrument tapping point failures, etc.
- External events (bushfire, ground movement, lightning, flooding).

11.2. Proposed Safeguards

The following general safeguards have been included in the design of the proposed well-sites, CPF and HDS to prevent, control and mitigate jet fire incidents at the sites.

11.2.1. Leak Prevention/ Minimisation

- No free oxygen present in the coal seam methane
- Painting of aboveground pipework
- Coating of underground pipework
- Maintenance/ inspection
- Spiral wound gaskets on HP flanged equipment
- Pressure control and shutdown valve on pressure regulating skid
- High fracture tough steel
- Permit to work system
- Management of Change system
- Security fencing
- Vehicle barriers
- Hydrostatic testing of equipment
- 100% radiography of all circumferential welds
- Security fencing around aboveground facilities
- Hazardous area classification as per AS 2430 to minimise the risk of ignition sources
- Gravel or hardstand area inside aboveground facilities around gas filled equipment to minimise the risk of grass fires
- Lightning protection
- Maintenance procedures

- Standard operating procedures

Control

- Monitoring of field, CPF and ESP process parameters via SCADA system
- Remote ESD of well shutdown valves and automated shutdown when process parameters exceed range detailed in HAZOP
- Relieving of stress where ground movement stresses pipework

Mitigation

- Separation distance between release point and site boundary
- Emergency Response Procedures

11.3. TEG Releases

TEG has a flash point of 165°C which will classify TEG as a combustible liquid. Given the low likelihood of ignition of spills of TEG, the impact of TEG releases was not carried forward to consequence and risk assessment.

11.4. Heating Medium Releases

Details of the proposed waste heat recovery system (including circulating oil flow, pressure and temperature) were not available at the time of the current study. An ethylene glycol product or oil (depending on temperature requirements) is typically used in waste heat recovery units to aid energy recovery of compressor units by extracting heat from the gas engine discharge, using a heat exchange in the engine stack. Heating medium is circulated via pumps to heat exchangers in the end user system. It is likely that the heating medium will be used for aiding heating of the TEG reboiler.

Heating medium leaks could occur from the waste heat recovery system, either from pipework or from the heating medium reservoirs. Typical heating medium products will be combustible, i.e. they will have a high flash point. Releases of heating medium will not readily ignite and so pool fires resulting from spill are unlikely to occur. The only scenarios of concern with heating medium will be escalation from external fires which will result in combustion of heating medium. There is no other flammable liquid storage near the heating medium systems and therefore the likelihood of combustion of heating medium is very low. The impact of heating medium releases was not carried forward to consequence and risk assessment.

11.5. Diesel Releases

Diesel generators will be provided at well sites for local power use. No bulk storage of diesel will be provided at the well sites. Diesel generators will be refuelled directly from tankers. Given the low quantities of diesel stored on site and the low flammability, the impact of diesel spills will not be significant and was not carried forward to consequence and risk assessment. Diesel generators will be located outside the designated Hazardous Area as per AS2430 and API RP 500.

11.6. Flare Operations

Operation of the flare has the potential for hazardous impact to personnel. The flare is directed in a lateral direction over the evaporation pond. Blowdown valves will be provided at the CPF inlet and discharge. Flaring will be undertaken under the following circumstances:

- Emergency blowdowns
- Production gas venting
- Compressor unit blowdown (via blowdown valves on individual compressor units)

Potential hazards with the flare operation include:

- Noise generation
- Dispersion of unignited coal seam methane
- Heat radiation from flare operations.

No details of the flare operation have been included in the design basis. It is recommended that the FHA should include analysis of flare operations and the site layout. It is also recommended that the final design be HAZOPed, particularly for abnormal operations including flare operations.

12. HAZARD IDENTIFCATION - PIPELINES

12.1. Releases from Gathering/ Spine Lines and Export Sales Pipeline

The main incident of concern that could result from the operation of the gathering lines and transmission pipeline is a loss of containment, release of coal seam methane to the atmosphere and subsequent ignition. The range of release sizes may range from a small leak to a full bore rupture.

From a literature review of gas pipeline failures, the main cause of pipeline leaks is due to external mechanical damage as a result of third party impact on the pipeline (Ref. 9). Australian industry sources indicate that pipeline failure modes are similar to overseas experience. Anecdotally, failures would appear to be less frequent in Australia compared to overseas experience. However, a compiled source of failure rates for pipelines within Australia is not readily available and estimates of frequency based on reported incidents are therefore not considered reliable.

There are over 21,000 km of major gas transmission pipelines in Australia. Very few incidents have been reported for major Australian pipelines. On this basis, generic European data was used for the frequency assessment as it provides a more statistically valid sample size.

The main types of failure incident reported by the various sources (both overseas and Australian) are:

- External interference from heavy equipment (e.g. mechanical damage to pipe during excavation by third parties)
- Scour damage (e.g. river bed scouring, exposing and damaging pipes)
- Construction and material defects
- Internal and external corrosion and stress corrosion cracking
- Subsidence damage (e.g. banks and levees washing away, exposing and damaging pipes, mine subsidence, construction work near the pipeline)
- Faulty construction (e.g. welding defects, lack of weld testing)
- Ground movement (e.g. buckled pipework from excessive ground movement from earthquakes, slips and ground subsidence)
- Error during ‘hot tapping’

12.1.1. Export Sales Pipeline Release

There is an option to operate the Export Sales Pipeline as a gas storage pipeline. In this mode, there is potential for significant pressure cycling during the operation which needs to be considered in the design. This cycling may impose additional hazards including:

- Fatigue due to pressure cycling

- Stress corrosion cracking which can occur as a result of pressure cycling (with high gas temperature and certain soil conditions).

Fatigue

Fatigue may result in fracture failure, leading to a pipeline rupture in the worst case. However, the impact of fatigue would be readily detectible from the operating history and maintenance inspections conducted during the pipeline life. Early fatigue impact would require restrictions on the pipeline operation, e.g. pressure restrictions or limits on the pipeline life.

Fatigue will be managed by reviewing the pipeline thermal and pressure cycling at each pipeline MAOP review (5 yearly) to determine if the resulting stress cycling has the potential to cause a defect that could initiate a crack and propagate. The evaluation method of BS7910 will be adopted. If the result is found to be unacceptable, mitigation methods would be incorporated into the pipeline operation to reduce the threat to an acceptable level.

Given the effectiveness of the proposed safeguard and the ongoing monitoring of pressure fluctuations, no increase in the failure rate for this failure mode was included in the frequency analysis.

Stress Corrosion Cracking

Stress corrosion cracking (SCC) is a phenomenon which can occur in pipelines that are subject to pressure cycles under high operating temperatures and in soil conditions which are conducive to corrosion. If detected, stress corrosion cracking may require pipeline repairs or may require derating of the pipeline. If undetected, stress corrosion cracking may lead to pipeline failure.

The pipeline design has made allowance to minimise the impact of stress corrosion cracking. This will be provided by use of a tri-laminate coating system with improved SCC resistance for the entire length of the pipeline, which will minimise the impact of external corrosion and by an appropriate design for the cathodic protection system. Additionally:

- after-coolers will be provided for compressor discharges with temperature monitoring
- the immediate downstream section of pipe from the compressors will be of adequate wall thickness to compensate for the temperature de-rating as a result of high temperature and will be designed in accordance with AS4041 and ANSI B 31.3
- the design life of the pipeline will include allowances for fluctuations.

Given the proposed safeguards and the low likelihood of SCC impact, no increase in the failure rate for stress corrosion cracking was included in the frequency analysis.

12.1.2. Location Specific Hazards

Other hazards specific to the locations where the gathering lines and transmission pipeline cross existing geographic features include the following:

- Impact from vehicle loading or construction work near road and rail crossings
- Alternating current induction effects from power lines near the transmission pipeline (not an issue for polyethylene gathering lines)
- Alternating current corrosion (not an issue for polyethylene gathering lines)
- Stray currents from high voltage DC traction lines at the railway line (not an issue for polyethylene gathering lines)

These issues are commonly encountered in pipeline designs in Australia and there are adequate safeguards to mitigate the hazard. The most significant of these are the impact of alternating current (AC) induction and corrosion which is discussed in more detail in the next sections.

Power Line Impacts on Export Sales Pipeline

The pipeline will traverse a route that is parallel to power transmission lines at a number of locations. Appropriate safety measures will be designed and adopted to ensure the safety of personnel and equipment. Typical mitigation measures include selective earthing at particular positions on the pipeline, zinc ribbon installed in the trench with the pipeline, inline isolation installed in the pipeline, restricted access to the pipeline and its facilities, and the use of equi-potential grids or other safety equipment during maintenance of the pipeline. The test points for the cathodic protection system may also be made lockable at all locations depending on final requirements.

Given the safeguards proposed in the design basis document and corrosion protection reports, the impact of AC induction effects near power lines will be minimised and an allowance for an increased failure rate has not been included in the frequency analysis.

Notwithstanding, the impact of power lines near pipelines is a well known hazard and can give rise to additional hazards to the pipeline and to personnel constructing the pipeline or operating and maintaining equipment. Construction hazards are outside the scope of a PHA and have not been included herein.

AC Corrosion

AC corrosion occurs at ‘holidays’ (exclusions or defects in the pipeline coating) as a result of the impact of AC induction near powerlines. The mechanism for the process is not clearly understood, but is more likely to occur under the presence of specific conditions including high current density and low soil resistivity.

The impact of AC corrosion will be assessed in the next design stage in order to mitigate the load current levels to values that are below the critical value which would result in a high likelihood of impact. Inclusion of resistance probes to monitor AC corrosion will be considered.

Notwithstanding, AC corrosion is considered to be of low likelihood and no increase in the failure rate for this failure mode was included in the frequency analysis.

12.1.3. Potential Consequences

Ignited gas release from the pipeline could result in:

- Jet fire, if ignited immediately
- Flash fire, if ignition is delayed
- Vapour Cloud Explosion (VCE) if a flash fire occurs within a congested or confined plant area.

As discussed in Section 10.3, a methane release could result in a jet fire if ignited immediately, or a flash fire if ignition is delayed (allowing a vapour cloud to form following release). As for releases from the well-sites, CPF and HDS, explosion events (VCEs) from pipeline releases have not been considered in this analysis, given the low potential for vapour cloud congestion along the gathering line and transmission pipeline routes.

12.1.4. Pipeline Safeguards

The proposed Export Sales Pipeline will be designed and operated in accordance with AS 2885-2007. The design will meet the requirements for T1 locations, classed as areas developed for residential, commercial or industrial use, where allotments are less than 1 hectare in area and buildings do not exceed 4 floors. The guidelines of AS2885.1 specify that the design for pipelines in T1 locations satisfy a requirement that failure by rupture will not occur and that the maximum energy release rate from the failure will not exceed 10 GJ/s.

The selection and design of the safeguards for protection of pipelines are based on the requirements of AS2885.1 and from previous experience. The following engineered and procedural safeguards are typical of pipeline designs and will be in place).

Protection Against External Damage

- Marker signs
- ‘One-Call‘/ ‘Dial-before-dig’ services
- Pipeline patrols
- Marker tape

Corrosion Protection

- External coating of pipeline
- ‘Holiday’ detection (testing of coating integrity) prior to burial
- Sacrificial anode or impressed current cathodic protection system

- Gas quality with minimal corrosion enhancing components
- Intelligent pigging (transmission pipeline only) to assess pipeline condition

Ground Movement/ Subsidence

The proposed pipeline route would not cross any known areas of mine subsidence. However, as this may change in the future, it is recommended that AGL liaise with the Mine Subsidence Board to determine likely future mining activity and the potential for subsidence.

Resistance to Penetration

The design of the proposed gathering lines and transmission pipeline eliminates the likelihood of rupture from external impact by providing the pipe grades described in Section 6.

Any construction undertaken in the proposed routes designated as location class T1, would not use excavators larger than 30-40 tonnes. Larger equipment would only possibly be used for major industrial developments. In this case, additional procedural controls would be implemented to minimize the likelihood of external impact.

Road & Rail Crossings

The design of the proposed gathering lines and transmission pipeline near road and rail crossings is described in Section 6.

Scour Damage

The likelihood of scour damage near watercourses is minimal because of the small catchment area available near the pipeline. There is also a potential for pipeline floatation near swampy land. The potential for pipe exposure due to scouring and floatation is low because of the structural integrity of the large-diameter, heavy-walled transmission pipeline and because of the regular pipeline patrols.

Vehicle Loading

The likelihood of impact from high vehicle loads is negligible due to the inherent structural integrity of the transmission pipeline (which is much higher compared with typical vehicle loading); gathering lines will not be exposed to significant roads and rail crossing loads.

Construction and Material Defects

The gathering lines and transmission pipeline will be hydrostatically tested to a stress level equal to 100% of Specified Minimum Yield Strength (SMYS). This will provide assurance that the integrity is not compromised by residual flaws that could grow to failure as a result of fatigue.

Acid-Sulphate Soils

Acid sulphate soils occur predominantly in coastal areas where the soils formed underwater and the sea level later receded, leaving behind underground concentrations of iron-sulphide-rich soil. Acid sulphate soils are typically found in coastal plains, wetlands and mangroves.

When the soils remain in an undisturbed and waterlogged state, they remain relatively inactive. However, when the soil is excavated and exposed to oxygen through drainage or excavation, sulphuric acid is produced in large quantities. This results in an environmental impact due to releases of concentrated acid. During the operational phase of the pipeline, residual acid may result in pipeline corrosion.

The effect of acid sulphate soils is mitigated by appropriate management procedures, including limited excavation to minimise the length of open trenches and the time exposed in affected areas; lime neutralisation; and spoil management, including segregated storage of acidic spoil stockpiles and appropriate treatment/ disposal methods.

13. CONSEQUENCE ASSESSMENT

The subsequent sections summarise the consequences analyses undertaken in the PHA. Detailed findings are provided in APPENDIX 2.

13.1. Effect Modelling

Release rates and consequence effects were calculated using the proprietary consequence modelling package Shell FRED Version 5 (Ref. 10).

The assessment took into account the orientation of the release. For buried pipeline, a horizontal jet would be less likely to occur as the jet release would tend to be directed upwards, with the majority of releases in a vertical direction since external impacts would be more likely to occur from above the pipe. Therefore, the assessment of buried pipeline leaks was based on an assumption of 80% of releases being vertical and 20% at 45º.

13.2. Releases from Aboveground Facilities

The hazard identification tables were reviewed to select a set of credible release scenarios and hole sizes to be carried forward for consequence modelling. The following leak scenarios and hole sizes were carried forward for the well-sites, CPF, power station and HDS:

13.2.1. Station Equipment

- Flange gasket leaks – 6 mm equivalent hole size
- Valve body leaks – 10 mm equivalent hole size
- Instrument fitting leaks – 25 mm equivalent hole size

13.2.2. Station Pipework

- Pipework pinhole release (corrosion) - 3 mm equivalent hole size
- Pipework puncture release - 25 mm equivalent hole size

Full bore pipework releases for station pipework were not considered credible as per Section 9.2 and was not carried forward to the risk assessment.

The process data used to evaluate the consequences of releases are summarised in Table 9.1. The distance to jet fire heat radiation levels and flash fire impact zones are provided in APPENDIX 2.

13.3. Releases from Gathering/ Spine Lines and Export Sales Pipeline

The gathering line and transmission pipeline release scenarios carried forward for consequence assessment are jet fires and flash fires resulting from a leak or rupture.

As discussed in APPENDIX 2, the European Gas Pipeline Incident Data Group collects data on the frequency of pipeline failures and reports statistical data by a number of factors including hole sizes (Ref. 9). The data broadly categorises releases in a range of hole sizes:

- pinholes or small holes
- medium holes or punctures
- ruptures

Pinholes can occur due to mechanisms such as corrosion, weld defects, material defects in the pipe itself. The resistance of the pipeline material to crack propagation (its fracture toughness) is an important feature in determining whether the release could propagate, resulting in a full bore rupture of the pipeline. There is a potential for small holes or cracks to propagate, potentially leading to extensive longitudinal cracking with an equivalent hole size equal to the full bore rupture.

Townsend and Fearnehough (Ref. 11) indicate that the majority of leaks are small (pinholes and small holes) and would be less than 10 mm. They also indicate that small leaks from pinholes and small holes do not generally constitute a significant hazard due to the low release rates involved.

Hole sizes in the range from 20 mm to 80 mm are predominantly caused by puncture from external interference. A statistical analysis of hole size from puncture events indicated 40 mm as the mean hole size for punctures (Ref. 12).

As discussed in Sections 6.1 and 12.1.4, the ESP will be designed to meet the requirements of the AS2885.1-2007, which requires that the pipeline eliminate the risk of pipeline rupture in T1 location class areas. The pipeline design will also require that the maximum energy release rate should not exceed 10GJ/s, which, at the MAOP, is greater than the proposed flow through the gathering lines and transmission pipeline.

Based on this data, the following hole sizes were selected for release incidents:

- 10 mm diameter for pinholes and small holes.
- 50 mm for medium holes (selected for conservatism over the 40 mm average hole size determined by Fearnehough, Ref. 6).
- Full-bore rupture, which would not exceed the maximum credible leak rate to meet the requirement for a maximum energy release rate for pipeline in T1 locations.

The process data used to evaluate the consequences of releases are summarised in Table 9.1. The distance to jet fire heat radiation levels and flash fire impact zones are provided in APPENDIX 2.

14. FREQUENCY ANALYSIS

14.1. Aboveground Facility Incident Frequencies

Details of the frequency assessment for the well-sites, CPF, power station and HDS are given in APPENDIX 3. The frequency of jet and flash fire incidents was estimated based on:

- generic failure rates for component releases
- the probability of ignition of the release (which is dependent on the release rate).

A parts count of components was undertaken to determine the total release frequency at each location within each facility.

14.2. ESP Incident Frequencies

Details of the frequency assessment for the Export Sales Pipeline are given in APPENDIX 4, including details regarding the effect of pipeline safeguards on the leak/ failure frequencies.

Frequencies for jet and flash fires were derived from published historical records of pipeline incidents. The frequencies of jet fire and flash fire incidents were estimated based on the:

- frequency of the initiating leak
- probability of immediate ignition for jet fires
- probability of delayed ignition for flash fires.

14.3. Gathering Line and Spine Line Incident Frequencies

Details of the frequency assessment for the Gathering/ Spine Lines and Transmission Pipeline are given in APPENDIX 5.

15. QUANTITATIVE RISK ASSESSMENT

15.1. Overview

The quantitative risk levels for the aboveground facilities are presented as risk contours. The contours indicate the risk level at any point around the facility.

The quantitative risk profile resulting from the operation of the gathering and spine lines and the ESP are presented as risk transects, i.e. a graph of estimated risk level versus the lateral distance from the centreline of the pipe. The graph shows the risk level that a receiver would be exposed to at any lateral distance from the pipe. The graph can also be used to estimate the distance to the relevant risk criteria and to show whether there is adequate separation from the pipeline to adjacent land uses.

15.2. Well-Sites Risk Profile

Risk contours were generated for the well-sites. There are approximately 110 identical well-sites, each with provision for up to 4 well-heads, and a typical risk contour is shown in Figure 15.1. The following were the results of the assessment of the risk contours:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was found to extend by about 40m from the centre of the well site. This will not extend to any sensitive land-uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was found to extend by about 38m from the centre of the well site. This will not extend to any residential areas as well sites will be located to provide a minimum exclusion zone
- The 5 x 10^{-6} per year individual fatality risk contour (commercial areas) was found to extend by about 20m from the centre of the well site and will not extend to any commercial land-uses.
- The 10 x 10^{-6} per year individual fatality risk contour (active open spaces) was found to extend by about 15m from the centre of the well site and will not extend to any active open spaces.
- The 50 x 10^{-6} per year individual fatality risk contour (industrial areas) was not generated by the well-site hazard scenarios.

The radius of the risk contours for the well-sites depends on a number of factors with a predominant factor being the pressure assumed for the well-site equipment. For the well-sites at the Gloucester coal seam locations, a pressure of 10.2 MPa was assumed based on design rating of well-site equipment upstream of the well-head shutdown valve. The actual operating pressure will be much less than this early in the wellhead life (typically 4 MPa) and will degrade over the operating life of the wellhead. The assumption of a 10.2 MPa pressure will give a conservative estimate of risk level compared with similar facilities where a lower operating pressure is assumed.

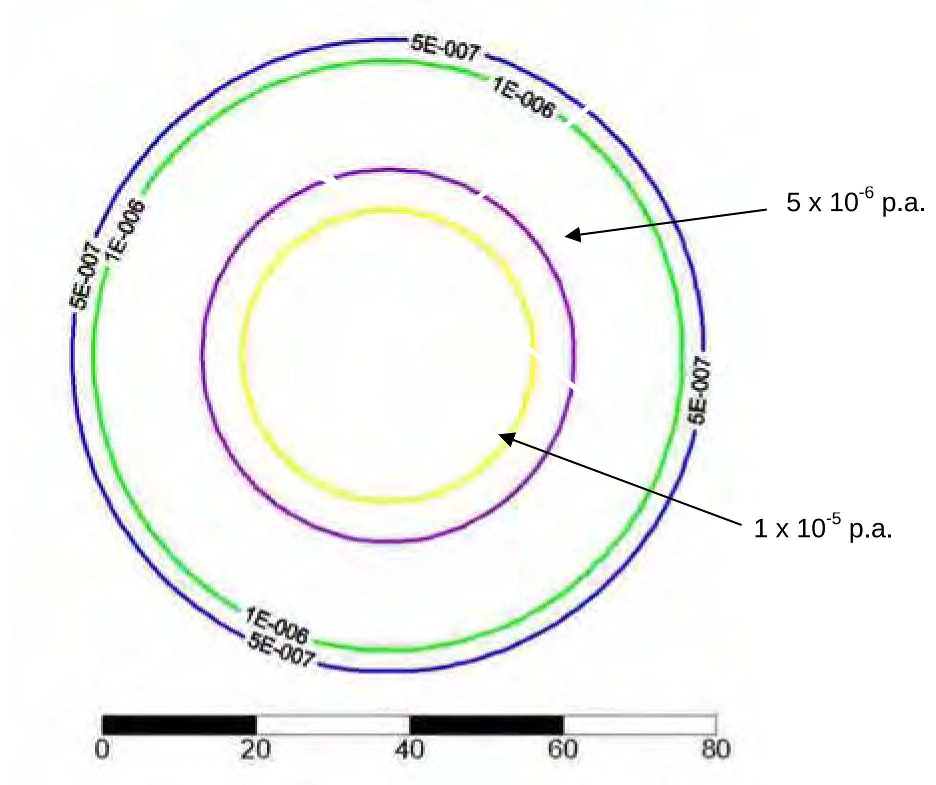


FIGURE 15.1: TYPICAL INDIVIDUAL FATALITY RISK CONTOURS FOR WELL-SITES

15.3. Gas Gathering and Spine Lines Risk Profile

Risk transects were produced, for the gas gathering and spine lines, showing the individual risk of fatality versus the distance from the centreline of the pipe. A number of cases are considered taking into account a range of pipe diameters and process flow rates.

15.3.1. Gathering Line Risk Transects

A number of cases were assessed for the gathering lines as follows:

- Case 1 - 110mm diameter lines with a design flow rate of 2 TJ/day
- Case 2 - 160mm diameter lines with a design flow rate of 4 TJ/day
- Case 3 - 200mm diameter lines with a design flow rate of 6 TJ/day

The risk transects calculated for the gathering lines showed that the risk of fatality would not be expected to exceed about 2 x 10^{-7} p.a. for all cases. The risk transects are shown in Figure 15.2.

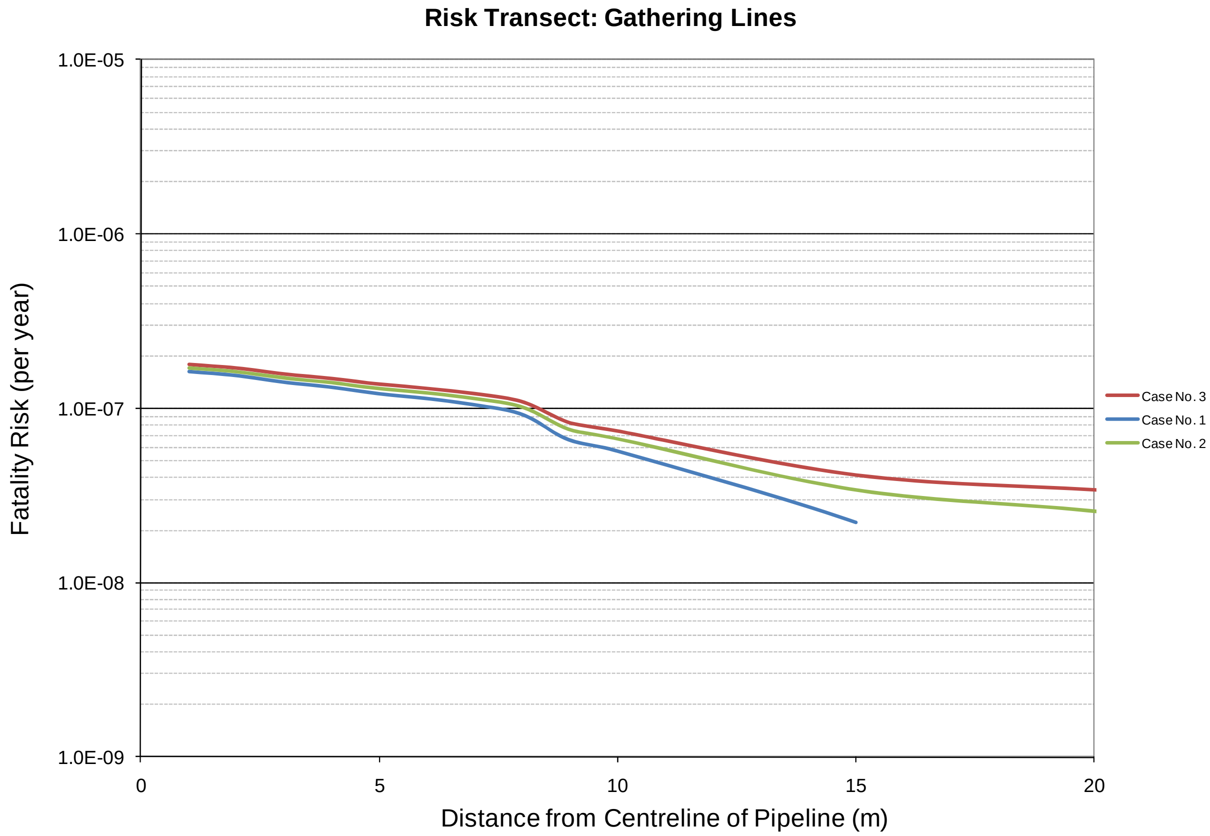


FIGURE 15.2: GATHERING LINE RISK TRANSECT

15.3.2. Spine Line Risk Transects

A number of cases were assessed for the spine lines as follows:

- Case 1 - 315mm diameter lines with a design flow rate of 10 TJ/day
- Case 2 - 315mm diameter lines with a design flow rate of 20 TJ/day
- Case 3 - 450mm diameter lines with a design flow rate of 10 TJ/day
- Case 4 - 450mm diameter lines with a design flow rate of 20 TJ/day
- Case 5 - 450mm diameter lines with a design flow rate of 40 TJ/day
- Case 6 - 450mm diameter lines with a design flow rate of 60 TJ/day
- Case 7 - 540mm diameter lines with a design flow rate of 40 TJ/day
- Case 8 - 540mm diameter lines with a design flow rate of 60 TJ/day
- Case 9 - 630mm diameter lines with a design flow rate of 40 TJ/day
- Case 10 - 630mm diameter lines with a design flow rate of 60 TJ/day

The risk transects calculated for the spine lines showed that the risk of fatality would not be expected to exceed about 3×10^{-7} p.a. for all cases. The risk transects are shown in Figure 15.3.

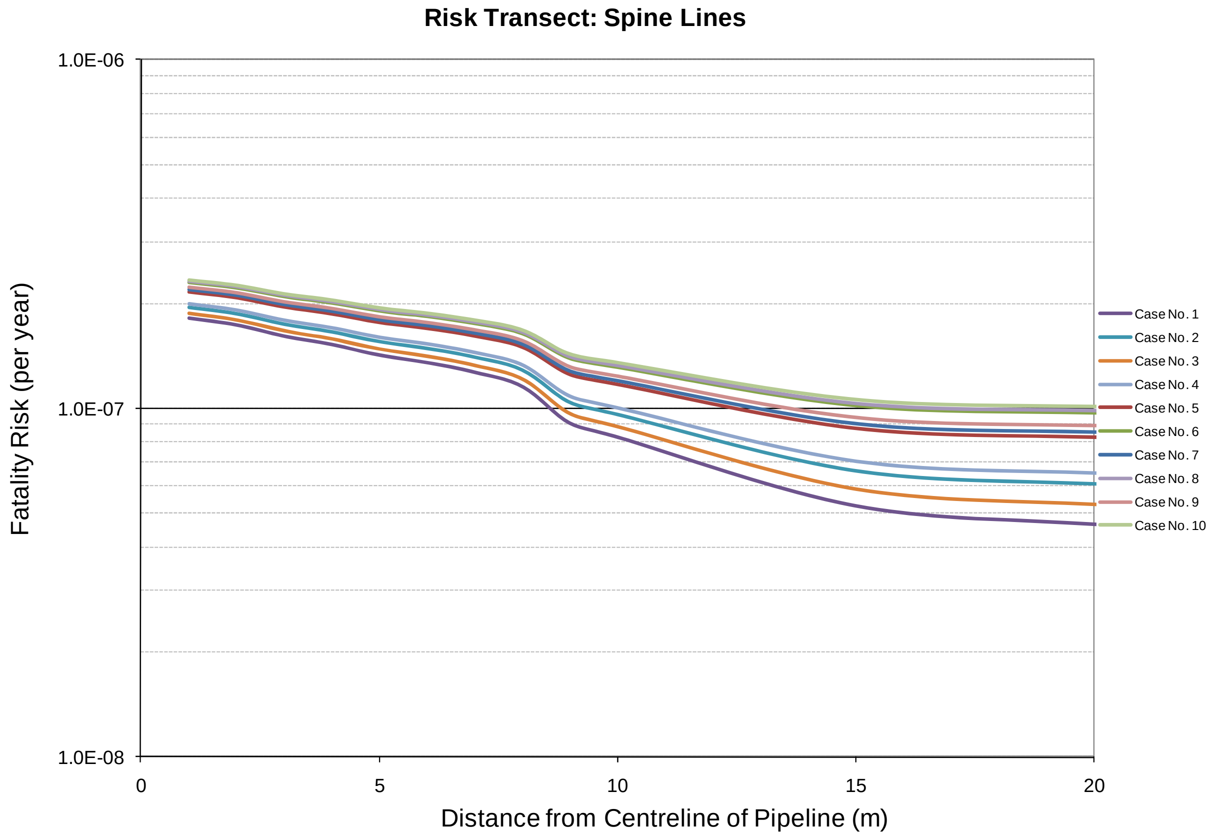


FIGURE 15.3: SPINE LINE RISK TRANSECT

15.3.3. Results of Risk Assessment for Gathering/ Spine Lines

Table 15.1 summarises the distances estimated for the gathering and spine lines to risk criteria levels for other land uses as measured from the centreline of the pipe. This shows that risk levels near the gathering and spines lines do not reach levels which would exceed the risk criteria for all land use types considered by the NSW DoP.

TABLE 15.1: DISTANCES TO CRITERIA OF INDIVIDUAL RISK OF FATALITY – GATHERING LINES AND SPINE LINES

Case	Distance to Individual Risk of Fatality (m)				
	Sensitive (hospitals, nursing homes)	Residential	Commercial	Active Open Spaces	Industrial
	(5 x 10^{-7} per year)	(1 x 10^{-6} per year)	(5 x 10^{-6} per year)	(1 x 10^{-5} per year)	(5 x 10^{-5} per year)
Gathering Line Cases					
Case 1 (110mm 2TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 2 (160mm 4TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 3 (200mm 6TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Spine Line Cases					
Case 1 (315mm 10TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 2 (315mm 20TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 3 (450mm 10TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 4 (450mm 20TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 5 (450mm 40TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 6 (450mm 60TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 7 (540mm 40TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 8 (540mm 60TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 9 (630mm 40TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached
Case 10 (630mm 60TJ/d)	Not Reached	Not Reached	Not Reached	Not Reached	Not Reached

15.4. Central Processing Facility (CPF) Risk Profile

Risk contours were generated for two CPF location options:

- CPF-1 (Figure 15.4)
- CPF-7 (Figure 15.5)

15.4.1. CPF-1 Risk Assessment Results

The following were the results of the assessment of the risk contours for **CPF-1**:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was located within the boundary of the site and does not extend to sensitive land uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was located within the boundary of the site and does not extend to residential areas.

- Risk levels for other land use types (commercial, active open spaces, industrial) were located within the boundary of the site and do not extend to the relevant land use types.

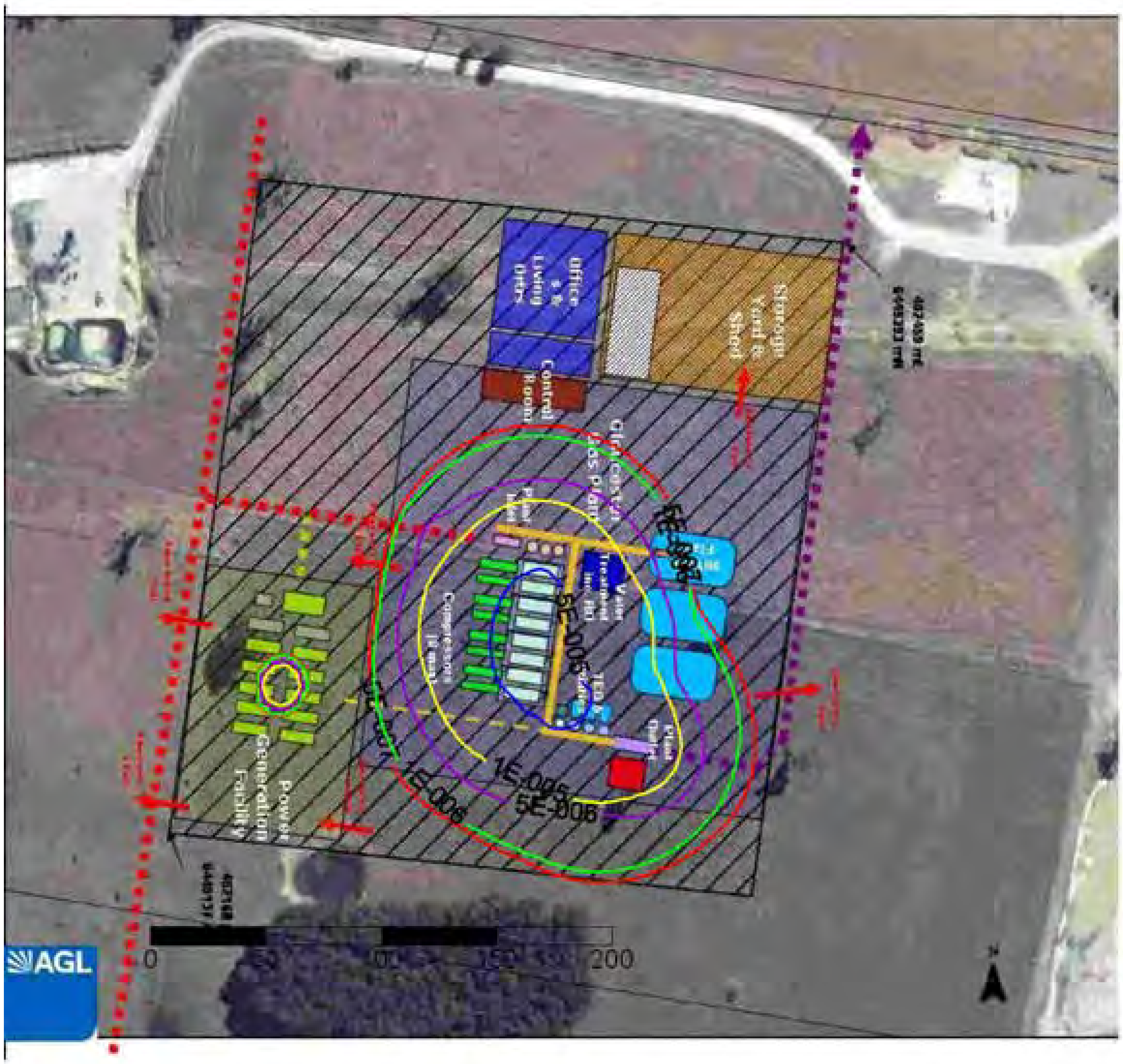


FIGURE 15.4: CPF OPTION 1 INDIVIDUAL FATALITY RISK CONTOURS

15.4.2. CPF-7 Risk Assessment Results

The following were the results of the assessment of the risk contours for **CPF-7**:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was located within the boundary of the site and does not extend to sensitive land uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was located within the boundary of the site and does not extend to residential areas.
- Risk levels for other land use types (commercial, active open spaces, industrial) were located within the boundary of the site and do not extend to the relevant land use types.

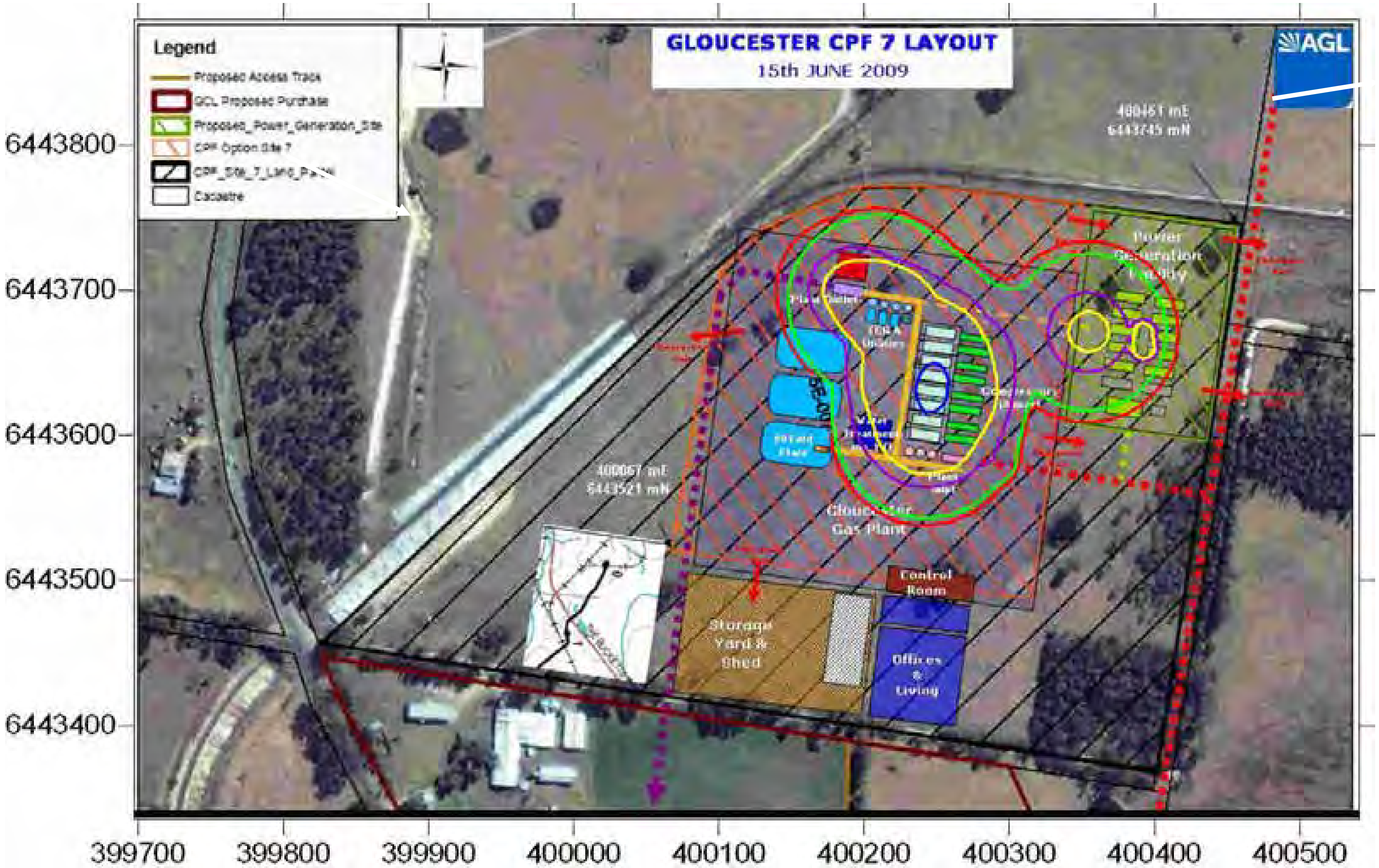


FIGURE 15.5: CPF OPTION 7 INDIVIDUAL FATALITY RISK CONTOURS

15.5. Export Sales Pipeline Risk Profile

A number of sensitivity cases have been assessed taking into account a range of design parameters and safeguards:

- Pipeline diameter (DN 450/250)
- Location class (R1/T1)
- Depth of Cover
- Wall Thickness
- Marker Tape

The following cases have been assessed:

- Case No. 1 – DN 450, R1, 750mm DOC, 11mm WT, no marker tape
- Case No. 2 – DN 450, T1, 900mm DOC, 11mm WT, marker tape
- Case No. 3 – DN 250, R1, 750mm DOC, 5mm WT, no marker tape
- Case No. 4 – DN 250, T1, 900mm DOC, 12.7mm WT, marker tape
- Case No. 5 – DN 250, Road/Rail Crossings, 1200mm DOC, 7.5mm WT, marker tape
- Case No. 6 – DN 250, Intermediate water courses, 1500mm DOC, 7.5mm WT, no marker tape
- Case No. 7 – DN 250, Major water courses, 2000mm DOC, 7.5mm WT, no marker tape

15.5.1. Results of Risk Assessment for Export Sales Pipeline

Risk transects were produced for these cases showing the individual risk of fatality versus the distance from the centreline of the pipe. The DN 450 cases are shown in Figure 15.6 (Cases 1-2) and the DN 250 cases in Figure 15.7 (Cases 3-7).

Table 15.2 summarises the distances estimated for the ESP to risk criteria levels for land uses as measured from the centreline of the pipe. This shows the minimum separation distances required for various land use types to ensure compliance with the risk criteria of the NSW DoP.

DN 450 Pipeline – R1 Locations

For the DN 450 pipeline in R1 locations (Case 1), the fatality risk contour level for sensitive land uses (5×10^{-7} per year) was found to extend up to 190 m from the centreline of the pipe, however, sensitive land uses (including hospitals, schools, child care facilities, aged care housing, etc.) were not identified to exist within a this distance from the centreline of the pipeline.

Risk levels with the potential for significant impact to residential areas (1×10^{-6} per year) were shown to extend 35m from the centreline of the ESP. From a review of the separation distances to the nearest residences identified near the pipeline (Section 6.3), the nearest residences are located as close as 15 m from the pipeline.

These locations are within the first 16km of the pipeline, in R1 locations. Therefore, Case 1 (with 750 mm DOC and no marker tape) will not comply with the NSW DoP risk criteria. Therefore, additional measures will be required near these locations, such as additional depth of cover and/or marker tape.

DN 450 Pipeline – T1 Locations

For the DN 450 pipeline for T1 locations (Case 2, including marker tape), the fatality risk contour level for sensitive land uses (5×10^{-7} per year) was found to extend up to 41 m from the centreline of the pipe, however, sensitive land uses (including hospitals, schools, child care facilities, aged care housing, etc.) were not identified to exist within a this distance from the centreline of the pipeline.

Risk levels with the potential for significant impact to residential areas (1×10^{-6} per year) were not reached at any distance from the centreline of the ESP.

TABLE 15.2: DISTANCES TO CRITERIA OF INDIVIDUAL RISK OF FATALITY – EXPORT SALES PIPELINE

Case	Distance to Individual Risk of Fatality (m)				
	Sensitive (hospitals, nursing homes)	Residential	Commercial	Active Open Spaces	Industrial
	(5×10^{-7} per year)	(1×10^{-6} per year)	(5×10^{-6} per year)	(1×10^{-5} per year)	(5×10^{-5} per year)
DN 450 Pipeline					
Case No. 1	190	35	Not Reached	Not Reached	Not Reached
Case No. 2	41	Not Reached	Not Reached	Not Reached	Not Reached
DN 250 Pipeline					
Case No. 3	230	215	20	Not Reached	Not Reached
Case No. 4	35	Not Reached	Not Reached	Not Reached	Not Reached
Case No. 5	43	Not Reached	Not Reached	Not Reached	Not Reached
Case No. 6	45	12	Not Reached	Not Reached	Not Reached
Case No. 7	10	Not Reached	Not Reached	Not Reached	Not Reached

DN 250 Pipeline – All Cases

The risk assessment for the DN 250 cases was undertaken to compare the distances to risk criteria levels for a number of cases.

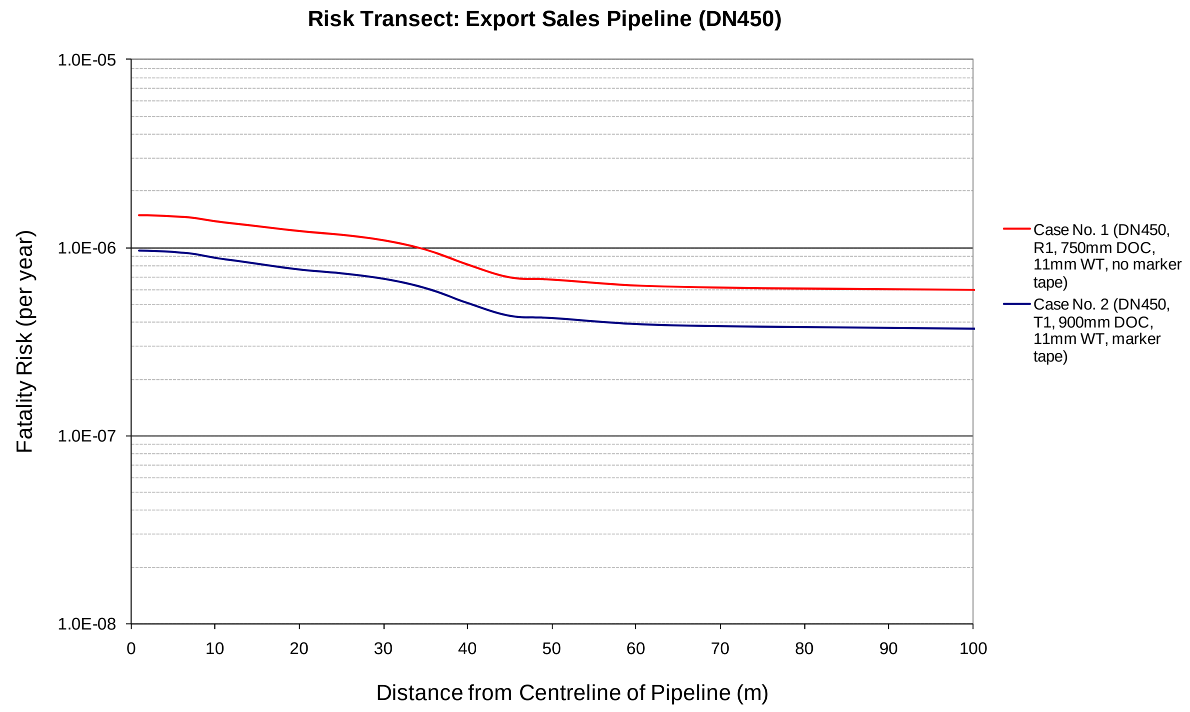


FIGURE 15.6: EXPORT SALES PIPELINE RISK TRANSECT – DN 450 (CASES 1 AND 2)

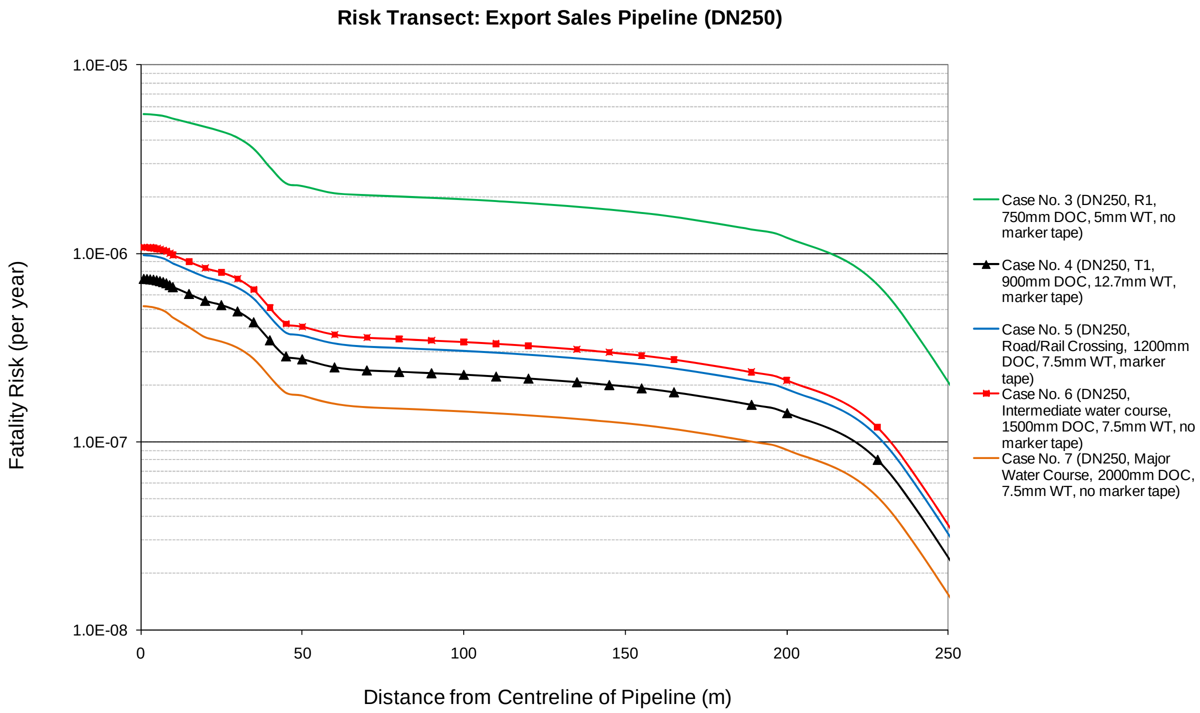


FIGURE 15.7: EXPORT SALES PIPELINE RISK TRANSECT – DN 250 (CASES 3 - 7)

15.6. Hexham Delivery Station (HDS) Risk Profile

The HDS will be located within the Hexham Port and Industry Zone which is Zone 4a as per the Newcastle Local Environment Plan 2003 - Ref. 13), in which there are no sensitive, residential or commercial land-uses (as defined in Table 2 of HIPAP 4, Ref. 4). Risk contours were generated for the HDS and are shown in Figure 15.8.

The findings are as follows:

- The 0.5 x 10^{-6} per year individual fatality risk contour (sensitive land-use) was found to extend off-site by a maximum of about 30m. The contour remains within the Zone 4a Industrial Area, and does not reach any sensitive land-uses.
- The 1 x 10^{-6} per year individual fatality risk contour (residential areas) was found to extend off-site by a maximum of about 20m to the southern boundary of the HDS site. The contour remains almost entirely within the Zone 4a Industrial Area and does not reach any residences.
- The 5 x 10^{-6} per year individual fatality risk contour (commercial) was found to be contained within the boundary of the HDS site and therefore will not extend to adjacent commercial zones (i.e. retail centres, office or entertainment centre).
- The risk levels for other land use types (active open spaces, industrial) were not generated for the site, i.e. risk levels at the HDS did not reach the criteria levels for these land use types at any point on the HDS site.
- The 50 x 10^{-6} per year injury risk contours were not generated on the site.
- The 50 x 10^{-6} per year escalation (accident propagation) risk contours were not generated on the site.

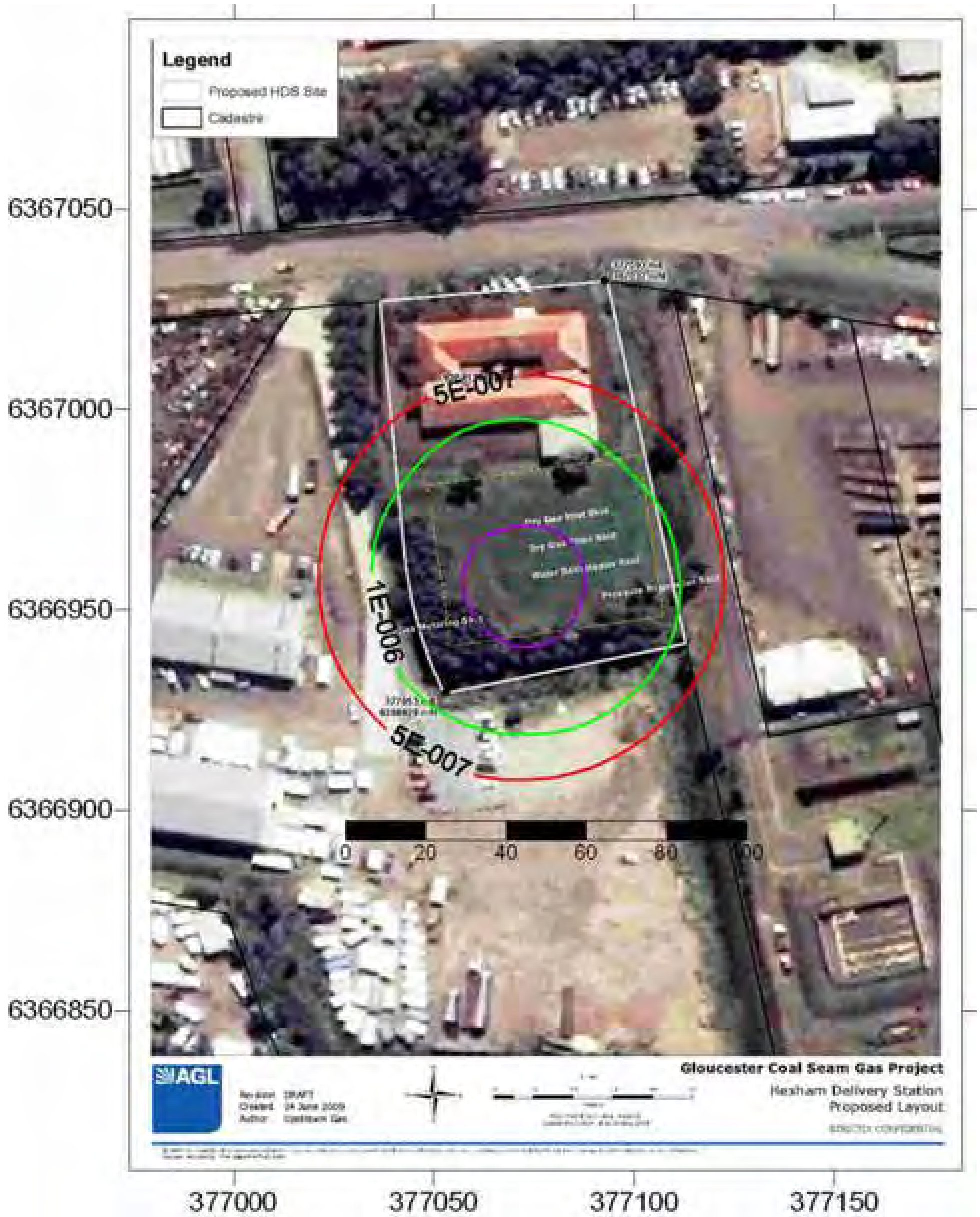


FIGURE 15.8: HDS INDIVIDUAL FATALITY RISK CONTOURS

15.7. Societal Risk

Due to the low off-site risk levels at each facility, societal risk was not evaluated.

15.8. Bio-Physical Effects

The following general comments concerning biophysical and environmental impacts were made as a result of the assessment:

- The effects of an accidental emission of methane gas are unlikely to threaten the long-term viability of the ecosystem or any species within any sensitive natural environmental areas which may exist near the proposed development.

- The potential biophysical effects of produced-water (including accidental emission) are evaluated in the Environmental Assessment (EA, Ref. 3).

15.9. Conclusions

A PHA was undertaken to determine the off-site risk profile of the proposed Gloucester Coal Seam Gas (GCSG) Project, including the well-sites, gathering lines, processing facility, transmission pipeline and delivery station.

The PHA found that the off-site risk of fatality, injury and accident propagation posed by the GCSG project meets the requirements of the NSW Department of Planning Risk Criteria for Land-Use Safety Planning (Ref. 4).

The effects of an accidental emission of methane gas are unlikely to threaten the long-term viability of the ecosystem or any species within any sensitive natural environmental areas which may exist near the proposed development. The potential biophysical effects of produced-water are evaluated in the EA (Ref. 3).

15.10. Recommendations

1. It is recommended that, near existing residences in R1 locations (or land identified for future residential use) that are within 35 m of the centreline of the Export Sales Pipeline, safeguards in addition to those provided for Case 1 (DN 450mm pipeline in R1 locations) should be implemented. These additional safeguards may include marker tape and/ or additional depth of cover.

2. The proposed Export Sales Pipeline would not cross any known areas of mine subsidence. However, as this may change in the future, it is recommended that AGL liaise with the Mine Subsidence Board to determine likely future mining activity and the potential for subsidence.

3. The PHA should be updated when final design details are known, particularly for the operation of the flare.

4. Once final design details are known, the design should be HAZOPed, particularly to assess abnormal operating modes such as flare and blowdown operations.

As the design develops, the project is generally required to complete a number of other safety and risk studies, as part of the NSW Department of Planning Seven Stage Approval Process, which are to be undertaken in accordance with the relevant Departmental guidelines.

APPENDIX 1. HAZARD IDENTIFICATION TABLES

A 1.1. HAZARD IDENTIFICATION

The hazard identification undertaken for the Gloucester Coal Seam Gas Project is summarised in the following tables:

- Well sites – Table A1.1
- Gathering lines and spine lines – Table A1.2
- Central Processing Facility – Table A1.3
- Export Sales Pipeline – Table A1.4
- Hexham Delivery Station – Table A1.5

TABLE A1.1: HAZARD IDENTIFICATION TABLE FOR WELL-SITES

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
1	General leaks and ignition	• Miscellaneous failures • Gasket leak • Instrument fitting leak • Weld failure • Vibration	• Gas release • Jet fire if ignited	• Isolation valves • Pressure monitoring via SCADA system • Electrical design for equipment in hazardous areas • Spiral wound gaskets on flanged equipment	Carried forward to quantitative risk analysis
2	Release from station pipework and ignition	• External damage by third party interference or vehicle impact	• Gas release • Jet fire if ignited	• Pipework is aboveground • Permit to work system for maintenance • Site fenced off	Carried forward to quantitative risk analysis
3	Pinhole leaks and pipework failure	• Internal corrosion • External corrosion • Weld failure • Material defects	• Gas release • Jet fire if ignited	• Corrosion protection • Painting of aboveground pipework • Construction and material defects protection • 100% radiography of all circumferential welds • Hydrostatic test	Carried forward to quantitative risk analysis
4	Valve leaks	• Leak from valve stem • Pinhole or hole in valve body • Hole or rupture in smaller diameter pipework or from leaks in fittings in smaller diameter pipework	• Gas release • Jet fire if ignited	• Robust nature of valve body • Regular inspection of station • Low corrosion potential due to dry gas • Some valves welded into line • Valve specifications • Routine maintenance	Carried forward for further analysis
5	Vessel/ equipment leaks	• Gasket / fitting leaks	• Gas release • Jet fire if ignited	• Station equipment fully monitored by the SCADA system • Maintenance • Flanges fitted with spiral wound gaskets	Carried forward for further analysis
6	Pipework failure/ rupture	• Ground movement • Well blow-out	• Gas release • Jet fire if ignited	• Pipeline integrity • Wall thickness • Stress relief at tie-in points	Low likelihood of causing a loss of containment. Not carried forward to quantitative risk analysis.

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
7	Equipment damage – External events	• Bushfire / grass fire	• Damage to surface facilities leading to leak • Jet fire if ignited	• Bushfire / grass fire protection • Vegetation well cleared from above ground facilities • Security fencing around station in line with hazardous area classification (AS2430/ API RP500) • Gravel or hardstand area within fenced area	Not carried forward to quantitative risk analysis
8	Equipment damage – External events	• Lightning	• Damage to surface facilities leading to leak and ignition and jet fire	• Lightning protection system	Low likelihood of impact. Not carried forward for further analysis
9	High Pressure	• Overpressure	• Pipeline / equipment damage	• Pipework design to MAOP • Monitoring of pressure	Not carried forward to quantitative risk analysis
10	High Temperature	• Over-temperature	• Pipeline / equipment damage	• Design temperature above normal operating temperature	Not carried forward to quantitative risk analysis
11	Release during normal operation/ maintenance	• Releases from operation and maintenance activity (venting)	• Gas release, jet fire if ignited	• Small quantities released • Operating procedures and monitoring • Permit to work system	Not carried forward for further analysis
12	Vandalism	• Location of well-sites	• Equipment damage • Uncontrolled release	• Security fencing • Alarms in buildings • Monitoring of stations	Not carried forward to quantitative risk analysis
13	Diesel fires	• Spills from diesel genset	• Impact to equipment	• No storage at well sites	Not carried forward to quantitative risk analysis

TABLE A1.2: HAZARD IDENTIFICATION TABLE FOR GATHERING AND SPINE LINES

No.	Component	Hazardous Incident	Consequence	Protection or Safety Measure	Comments/Recommendations
1	Pipeline	External interference	Potential impact on pipeline causing leak of natural gas. Jet fire if ignited. Potential injury/fatality	• Depth of cover • Wall thickness • Pipeline patrols	Carried forward to risk assessment
2	Pipeline	Scouring / erosion at waterways / drains leading to exposure of pipeline	Exposed pipeline may be subject to external impact	• Depth of cover provided at waterways/drain crossings • Pipeline patrols	Not carried forward to quantitative risk assessment
3	Pipeline	Floatation of pipeline near swamp	• Exposed pipeline may be subject to external impact • Pipe stress	• Pipeline patrols • High integrity pipeline	Not carried forward to quantitative risk assessment
4	Pipeline	High vehicular loading on pipeline due to roadways (highway) / railway powerline easement roads	• Potential impact on pipeline causing leak of natural gas. • Jet fire if ignited. • Potential injury/fatality	• Depth of cover at road / rail crossings • Pipeline patrol • One-call system	Not carried forward to quantitative risk assessment
5	Pipeline	Pipeline leaks due to weld/ material defects	Potential leak, jet fire if ignited	• Welding procedures • Material Certificates • Hydrostatic testing • QA/QC	Carried forward to quantitative risk assessment
6	Pipeline	Overpressure	Pipeline / equipment damage	• Pipeline designed to meet full 0.5MPa MAOP • Monitoring of system pressure	Not carried forward to quantitative risk assessment
7	Pipeline	Over-temperature	Pipeline / equipment damage	• Monitoring of compressor outlet temperature. • Compressor aftercoolers	Not carried forward to quantitative risk assessment
8	Pipeline	Mine subsidence	Pipeline damage	• The proposed routes would not cross any known areas of mine subsidence.	Not carried forward to quantitative risk assessment

TABLE A1.3: HAZARD IDENTIFICATION TABLE FOR CENTRAL PROCESSING FACILITY

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
1	General leaks and ignition	• Miscellaneous failures • Gasket leak • Weld failure • Vibration	Gas release, jet fire if ignited.	• Isolation valves • Pressure monitoring via SCADA system • Electrical design for equipment in hazardous areas in Compressor Station and Delivery facility • Spiral wound gaskets on flanged equipment • Gas detectors	Carried forward to quantitative risk analysis
2	Pipe impact, hole release and ignition	External damage by third party interference or vehicle impact	Gas release, jet fire if ignited	• Pipework within station is aboveground • Permit to work system for maintenance • Site fenced off	Carried forward to quantitative risk analysis
3	Pinhole leaks (including pipeline)	• Internal corrosion • External corrosion • Weld failure • Material defects	Gas release, jet fire if ignited	• Corrosion protection • Painting of aboveground pipework in station	Carried forward to quantitative risk analysis
4	Pipework failure/rupture	Ground movement	Gas release, jet fire if ignited	• Pipeline integrity • Wall thickness • Stress relief at tie-in points	Low likelihood of causing a loss of containment. Not carried forward to quantitative risk analysis
5	Pipework failure	Construction and material defects	Gas release, jet fire if ignited	• Construction and material defects protection • 100% radiography of all circumferential welds • Hydrostatic test	Carried forward to quantitative risk analysis
6	Equipment damage	Bushfire / grass fire	Damage to surface facilities leading to leak Jet fire if ignited	• Bushfire / grass fire protection • Vegetation well cleared from above ground facilities • Security fencing around station in line with hazardous area classification (AS2430) • Gravel or hardstand area within fenced area	Not carried forward to quantitative risk analysis

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
7	Equipment damage	Lightning	Damage to surface facilities leading to leak and ignition and jet fire	• Lightning protection system	Low likelihood of impact. Not carried forward for further analysis
8	Pipeline	Overpressure	Pipeline / equipment damage	• Pipework design to MAOP • Monitoring of station pressure	Not carried forward to quantitative risk analysis
9	Pipeline	Over-temperature	Pipeline / equipment damage	• Design temperature above normal operating temperature • Compressor Intercooler/ aftercooler	Not carried forward to quantitative risk analysis
10	Valve leaks	• Leak from valve stem • Pinhole or hole in valve body • Leaks from pinhole • Hole or rupture in smaller diameter pipework or from leaks in fittings in smaller diameter pipework	Gas release Jet fire if ignited	• Robust nature of valve body • Regular inspection of station • Low corrosion potential due to dry gas • Some valves welded into line • Valve specifications • Routine maintenance	Carried forward for further analysis
11	Vessel/ equipment leaks	Gasket / fitting leaks	Gas release, jet fire if ignited	• Station equipment fully monitored by the SCADA system • Maintenance • Flanges fitted with spiral wound gaskets	Carried forward for further analysis
12	Release during normal operation/ maintenance	Releases from operation and maintenance activity (venting)	Gas release, jet fire if ignited	• Small quantities released/ Controlled operation • Operating procedures and monitoring • Permit to work system	Not carried forward for further analysis
13	Vent operations (ESD operations)	Auto venting / blowdown operation on ESD	Gas release Fire Explosion	• Gas lighter than air and disperses rapidly • Separation distance from plant area • Gas being discharged at a controlled rate	Carried forward for dispersion analysis
14	Vandalism	Location of stations	Equipment damage Uncontrolled release	• Security fencing • Alarms in buildings • Monitoring of stations	Not carried forward to quantitative risk analysis
15	Compressor Enclosure	Release into enclosure	Gas buildup Explosion	• Ventilation • Gas / fire detection	Not carried forward to quantitative risk analysis

TABLE A1.4: HAZARD IDENTIFICATION TABLE FOR EXPORT SALES PIPELINE

No.	Component	Hazardous Incident	Consequence	Protection or Safety Measure	Comments/Recommendations
1	Pipeline	External interference	Potential impact on pipeline causing leak of natural gas. Jet fire if ignited. Potential injury/fatality	• Depth of cover • Wall thickness • Pipeline patrols	Carried forward to risk assessment
2	Pipeline	Scouring / erosion at waterways /drains leading to exposure of pipeline	Exposed pipeline may be subject to external impact	• Depth of cover / extra wall thickness provided at waterways/drain crossings. Pipeline patrols	Not carried forward to quantitative risk assessment
3	Pipeline	Floatation of pipeline near swamp	Exposed pipeline may be subject to external impact Pipe stress	• Pipeline patrols • High integrity pipeline	
4	Pipeline	High vehicular loading on pipeline due to roadways (highway) / railway powerline easement roads	Potential impact on pipeline causing leak of natural gas. Jet fire if ignited. Potential injury/fatality	• Depth of cover at road / rail crossings • Pipeline patrol • One-call system	Not carried forward to quantitative risk assessment
5	Pipeline	Corrosion due to stray currents	Potential impact on pipeline coating Pinhole leaks Jet fire if ignited	• Pipeline coating • Cathodic protection • Holiday coating checks • Inspection of cathodic protection (probes)	Carried forward to quantitative risk assessment
6	Pipeline	Stress corrosion cracking	Potential leak, jet fire if ignited	• Pipeline coating • Pressure cycling not to exceed design criteria • Welding procedures • Material Certificates • Weld joints radiographed (100%) • Hydrostatic testing • QA/QC	Not carried forward to quantitative risk assessment

No.	Component	Hazardous Incident	Consequence	Protection or Safety Measure	Comments/Recommendations
7	Pipeline	Pipeline leaks due to weld/material defects	Potential leak, jet fire if ignited	• Welding procedures • Material Certificates • Weld joints radiographed (100%) • Hydrostatic testing • QA/QC	Carried forward to quantitative risk assessment
8	Pipeline	Overpressure	Pipeline / equipment damage	• Pipeline designed to meet full MAOP • Monitoring of system pressure	Not carried forward to quantitative risk assessment
9	Pipeline	Over-temperature	Pipeline / equipment damage	• Monitoring of compressor outlet temperature. • Compressor aftercoolers	Not carried forward to quantitative risk assessment
10	Pipeline	AC Induction impact on pipeline from adjacent powerlines	Pipeline damage (corrosion impact) Personnel impact	• AC induction safeguards as proposed • Powerline can be shut off during maintenance	Not carried forward to quantitative risk assessment
11	Pipeline	Stray current and DC voltage impact from railway line	Corrosion and induction	• Design to include control devices, for example, Transformer Rectifier Assisted Drainage (TRAD) unit to divert stray currents	Not carried forward to quantitative risk assessment
12	Pipeline	Mine subsidence	Pipeline damage	• The proposed pipeline route would not cross any known areas of mine subsidence.	Not carried forward to quantitative risk assessment

TABLE A1.5: HAZARD IDENTIFICATION TABLE FOR HEXHAM DELIVERY STATION

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
1	General leaks and ignition	• Miscellaneous failures • Gasket leak • Weld failure • Vibration	Gas release, jet fire if ignited.	• Isolation valves • Pressure monitoring via SCADA system • Electrical design for equipment in hazardous areas in Compressor Station and Delivery facility • Spiral wound gaskets on flanged equipment • Gas detectors	Carried forward to quantitative risk analysis
2	Pipe impact, hole release and ignition	External damage by third party interference or vehicle impact	Gas release, jet fire if ignited	• Pipework within station is aboveground • Permit to work system for maintenance • Site fenced off	Carried forward to quantitative risk analysis
3	Pinhole leaks (including pipeline)	• Internal corrosion • External corrosion • Weld failure • Material defects	Gas release, jet fire if ignited	• Corrosion protection • Painting of aboveground pipework in station	Carried forward to quantitative risk analysis
4	Pipework failure/ rupture	Ground movement	Gas release, jet fire if ignited	• Pipeline integrity • Wall thickness • Stress relief at tie-in points	Low likelihood of causing a loss of containment. Not carried forward to quantitative risk analysis
5	Pipework failure	Construction and material defects	Gas release, jet fire if ignited	• Construction and material defects protection • 100% radiography of all circumferential welds • Hydrostatic test	Carried forward to quantitative risk analysis

No.	Accident/Event	Cause	Consequence	Safeguards	Comments/Recommendations
6	Equipment damage	Bushfire / grass fire	Damage to surface facilities leading to leak Jet fire if ignited	• Bushfire / grass fire protection • Vegetation well cleared from above ground facilities • Security fencing around station in line with hazardous area classification (AS2430) • Gravel or hardstand area within fenced area	Not carried forward to quantitative risk analysis
7	Equipment damage	Lightning	Damage to surface facilities leading to leak and ignition and jet fire	• Lightning protection system	Low likelihood of impact. Not carried forward for further analysis
8	Pipeline	Overpressure	Pipeline / equipment damage	• Pipework design to MAOP • Monitoring of station pressure	Not carried forward to quantitative risk analysis
9	Pipeline	Over-temperature	Pipeline / equipment damage	• Design temperature above normal operating temperature	Not carried forward to quantitative risk analysis
10	Valve leaks	• Leak from valve stem • Pinhole or hole in valve body • Leaks from pinhole • Hole or rupture in smaller diameter pipework or from leaks in fittings	Gas release Jet fire if ignited	• Robust nature of valve body • Regular inspection of station • Low corrosion potential due to dry gas • Some valves welded into line • Valve specifications • Routine maintenance	Carried forward for further analysis
11	Vessel/ equipment leaks	Gasket / fitting leaks	Gas release, jet fire if ignited	• Station equipment fully monitored by the SCADA system • Maintenance • Flanges fitted with spiral wound gaskets	Carried forward for further analysis
12	Release during normal operation/ maintenance	Releases from operation and maintenance activity (venting)	Gas release, jet fire if ignited	• Small quantities released • Operating procedures and monitoring • Permit to work system	Not carried forward for further analysis
14	Vandalism	Location of stations	Equipment damage Uncontrolled release	• Security fencing • Alarms in buildings • Monitoring of stations	Not carried forward to quantitative risk analysis

APPENDIX 2. CONSEQUENCE ASSESSMENT

A 2.1. Introduction

This appendix documents the consequence assessment of the Gloucester Coal Seam Gas Project, including the well-sites, gathering lines, processing facility, transmission pipeline and delivery station. In particular, the following activities undertaken for the consequence analysis are described:

- Selection of release scenarios and hole size
- Jet fire modelling approach
- Flash fire modelling approach
- Dispersion modelling approach
- Results of consequence assessment and associated heat radiation effects

A 2.2. Modelling Approach

A 2.2.1. Leak and Effect Modelling

The consequence modelling for the jet fire scenarios was undertaken using Shell FRED 5.0, which was developed by Shell Global Solutions (Ref. 10).

The impact from flash fire incidents is modelled in Shell FRED as the dispersion distance to half the lower flammability limit (LFL). It is assumed that in a flash fire there is a 100% chance of fatality occurring within the fireball.

A 2.2.2. Meteorological Conditions

The following typical weather conditions were assumed for the consequence assessment:

- “D” Pasquill stability class and 5m/s wind speed for jet fires and flash fires
- “F” Pasquill stability class and 2m/s wind speed for flash fires
- 20^{o}C ambient temperature
- 70% relative humidity

For the assessment of impact from flash fires, the greatest distance for downwind impact was carried forward.

A 2.2.3. Orientation of Release

The angle of release from the gathering lines and transmission pipeline was specified as follows:

- Vertical where the release is 90 degrees to the horizontal plane. Releases due to third party impact will tend to occur on the top of the pipeline.

* Horizontal releases will tend to scour the ground around the pipeline resulting in a crater which will deflect the jet upwards. The release is modelled as a jet flame at 45 degrees to the horizontal plane.

NOTE: In the consequence distance tables, the flame length reported is the total length including flame lift-off from the release point and length of the flame, not the lateral distance from the pipeline. For releases at an angle from vertical, the flame length reported (which results in 100% chance of fatality) may be greater in some cases than the distance to heat radiation levels which result in fatality. This will result in conservative risk levels near the pipeline.

The well-site, CPF and HDS pipework is a mixture of aboveground and underground. In the worst case, it was assumed that the angle of release for station pipework was horizontal. Similarly, fitting releases could occur in any direction, depending on the leak location and the placement of the fitting. Horizontal releases result in the furthest impact distances and would give the worse case results for releases from the stations.

A 2.3. Summary of Findings

A 2.3.1. Gathering and Spine Lines

The release rates, jet fire and flash fire impact distances evaluated for the gathering and spine lines are summarised in Table A2.1.

A number of cases are considered for the consequence assessment of gathering and spine line releases as follows:

Gathering Lines

* 110mm diameter lines with a design flow rate of 2 TJ/day
* 160mm diameter lines with a design flow rate of 4 TJ/day
* 200mm diameter lines with a design flow rate of 6 TJ/day

Spine Lines

* 315mm diameter lines with a design flow rate of 10 TJ/day
* 315mm diameter lines with a design flow rate of 20 TJ/day
* 450mm diameter lines with a design flow rate of 10 TJ/day
* 450mm diameter lines with a design flow rate of 20 TJ/day
* 450mm diameter lines with a design flow rate of 40 TJ/day
* 450mm diameter lines with a design flow rate of 60 TJ/day
* 540mm diameter lines with a design flow rate of 40 TJ/day
* 540mm diameter lines with a design flow rate of 60 TJ/day
* 630mm diameter lines with a design flow rate of 40 TJ/day
* 630mm diameter lines with a design flow rate of 40 TJ/day

A 2.3.2. Well-Sites, CPF and HDS

The release rates, jet fire and flash fire impact distances evaluated for the Well-Sites, CPF and HDS are summarised in Table A2.2.

Design flow rates for equipment are assumed as follows:

- Maximum overall flow rate – 80 TJ/day
- Filter coalescers (2 off) – 2 x 40 TJ/day
- Compressors (8 off, 7 duty, 1 standby) – 7 x 11.4 TJ/day
- TEG Contactor towers (2 off) – 2 x 40 TJ/day

A 2.3.3. Export Sales Pipeline

The release rates, jet fire and flash fire impact distances evaluated for the Gloucester-Hexham Transmission Pipeline are summarised in Table A2.3.

A number of cases are considered for the consequence assessment of export sales pipeline as follows:

- 450mm diameter lines with a design flow rate of 80 TJ/day
- 250mm diameter lines with a design flow rate of 80 TJ/day

A 2.3.4. Power Station

The release rates, jet fire and flash fire impact distances evaluated for the power station located adjacent to the CPF are summarised in Table A2.4.

The following assumptions are made for the power station consequence assessment:

- Station maximum inlet gas pressure – 4.5 barg
- Station inlet operating temperature – 47°C
- Station flow rate – 714 kg/h
- Gas engine flow rate – 8 x 89 kg/h
- Fuel gas letdown pressure – 0.45 barg

TABLE A2.1: GATHERING AND SPINE LINE CONSEQUENCE MODELLING RESULTS

ID Tag	Release Description	Press	Temp	Hole Size	Design Flow Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
								Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		barg	ºC	(mm)	(TJ/d)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
Gathering Lines																	
1	Pinhole	7	30	10	All	0.09	45º	5	6	5	5	4	4	2	0.4	3.0	0.5
2	Puncture	7	30	50	All	2.14	45º	17	22	20	18	16	15	10	2	13.6	2.4
3	110mm Rupture - No Isolation	7	30	110	2	3.10	45º	19	27	25	22	20	18	13	3	17.8	3.6
4	160mm Rupture - No Isolation	7	30	160	4	6.30	45º	25	37	34	30	27	25	19	4	24.0	4.8
5	200mm Rupture - No Isolation	7	30	200	6	9.40	45º	30	44	41	35	32	29	24	5	29.0	6.0
6	Pinhole	7	30	10	All	0.09	Vertical	4	4	3	3	2	2	0.5	0.5	0.4	0.5
7	Puncture	7	30	50	All	2.14	Vertical	15	16	14	11	9	7	3.0	2.4	2.4	2.5
8	110mm Rupture - No Isolation	7	30	110	2	3.10	Vertical	18	21	19	15	13	10	4.2	3.4	3.7	3.6
9	160mm Rupture - No Isolation	7	30	160	4	6.30	Vertical	24	28	25	20	17	14	6.0	4.8	5.5	5.2
10	200mm Rupture - No Isolation	7	30	200	6	9.40	Vertical	28	34	30	24	21	17	7.7	5.8	6.7	6.4
Spine Lines																	
1	Pinhole	7	30	10	All	0.09	45º	5	6	5	5	4	4	2.0	0.5	3.0	0.5
2	Puncture	7	30	50	All	2.14	45º	17	22	20	18	17	15	10.7	2.2	13.6	2.4
3	Rupture - No Isolation	7	30	315	10	15.6	45º	37	57	53	46	42	38	32.0	7.2	39.0	8.2
4	Rupture - No Isolation	7	30	315	20	31.3	45º	48	71	65	57	53	47	40.0	8.6	47.3	9.7
5	Rupture - No Isolation	7	30	450	10	15.6	45º	37	64	59	51	47	43	35.0	8.0	41.7	9.8
6	Rupture - No Isolation	7	30	450	20	31.3	45º	48	77	71	61	56	50	43.4	5.8	48.5	11.4
7	Rupture - No Isolation	7	30	450	40	62.6	45º	64	94	88	76	69	62	54.5	12.2	64.0	13.3
8	Rupture - No Isolation	7	30	450	60	93.8	45º	75	110	102	88	81	73	66.8	13.6	71.4	15.1
9	Rupture - No Isolation	7	30	540	40	62.6	45º	64	97	91	77	72	64	55.0	13.1	64.7	14.6
10	Rupture - No Isolation	7	30	540	60	93.8	45º	75	111	103	89	82	73	67.3	14.9	76.5	15.9
11	Rupture - No Isolation	7	30	630	40	62.6	45º	64	102	95	81	74	67	61.0	14.0	70.0	15.4
12	Rupture - No Isolation	7	30	630	60	93.8	45º	75	115	106	92	84	75	68.0	16.0	76.8	16.5
1	Pinhole	7	30	10	All	0.09	Vertical	4	4	3	3	2	2	0.5	0.5	0.4	0.5
2	Puncture	7	30	50	All	2.14	Vertical	15	16	14	11	9	7	2.8	2.4	2.3	2.5

ID Tag	Release Description	Press	Temp	Hole Size	Design Flow Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
								Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		barg	ºC	(mm)	(TJ/d)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
3	Rupture - No Isolation	7	30	315	10	15.6	Vertical	34	46	42	34	29	25	12.4	4.0	10.4	9.2
4	Rupture - No Isolation	7	30	315	20	31.3	Vertical	45	53	48	38	33	26	12.9	9.9	10.9	10.6
5	Rupture - No Isolation	7	30	450	10	15.6	Vertical	34	57	51	42	37	32	18.0	9.0	14.8	10.9
6	Rupture - No Isolation	7	30	450	20	31.3	Vertical	45	62	56	46	40	33	17.9	11.4	15.2	12.8
7	Rupture - No Isolation	7	30	450	40	62.6	Vertical	60	72	64	51	45	36	18.8	13.7	15.0	14.5
8	Rupture - No Isolation	7	30	450	60	93.8	Vertical	70	81	72	59	50	40	20.9	15.9	17.1	16.5
9	Rupture - No Isolation	7	30	540	40	62.6	Vertical	60	77	69	56	49	40	21.9	14.6	18.0	16.0
10	Rupture - No Isolation	7	30	540	60	93.8	Vertical	70	85	76	60	52	43	22.3	16.4	18.2	17.3
11	Rupture - No Isolation	7	30	630	40	62.6	Vertical	60	83	75	61	53	44	25.0	15.5	20.9	17.2
12	Rupture - No Isolation	7	30	630	60	93.8	Vertical	70	89	81	65	55	45	25.0	17.5	21.2	18.6

TABLE A2.2: WELL-SITES, CPF & HDS CONSEQUENCE MODELLING RESULTS

ID Tag	Plant Area	Hole Size	Press	Temp	Process Rate	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
									Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		mm	barg	°C	(TJ/day)	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
Well-Sites																		
WH1	Well-head	6	102	30	2	40	0.5	Vertical	8	8	7	6	5	4	1	1	1	1
WH2	Well-head	10	102	30	2	40	1.3	Vertical	13	13	11	9	8	6	2	2	2	2
WH3	Well-head	25	102	30	2	40	8.0	Vertical	26	28	25	20	17	13	6	5	5	5
WH4	Well-head	80mm (FB)	102	30	2	40	40	Vertical	50	54	48	38	33	26	9	7	10	10
WS1	Water Separator	6	7	30	2	3.1	0.03	Horizontal	3	4	4	4	4	3	2	0.3	3	0.3
WS2	Water Separator	10	7	30	2	3.1	0.1	Horizontal	5	6	6	6	5	5	3	0.4	4	0.5
WS3	Water Separator	25	7	30	2	3.1	0.5	Horizontal	10	13	12	12	11	11	9	2	8	2
WS4	Water Separator	80mm (FB)	7	30	2	3.1	3.1	Horizontal	20	28	26	25	24	23	26	5	18	5
CPF																		
SH1	Suction Header	6	7	30	40	63	0.03	Horizontal	3	4	4	4	4	3	2	0.3	3	0.3
SH2	Suction Header	10	7	30	40	63	0.1	Horizontal	5	6	6	6	5	5	3	0.4	4	0.5
SH3	Suction Header	25	7	30	40	63	0.5	Horizontal	10	13	12	12	11	11	9	2	8	2
IS1	Inlet Separator	6	7	30	80	125	0.03	Horizontal	3	4	4	4	4	3	2	0.3	3	0.3
IS2	Inlet Separator	10	7	30	80	125	0.1	Horizontal	5	6	6	6	5	5	3	0.4	4	0.5
IS3	Inlet Separator	25	7	30	80	125	0.5	Horizontal	10	13	12	12	11	11	9	2	8	2
FC1	Inlet Filter Coalescer	6	7	30	80	125	0.03	Horizontal	3	4	4	4	4	3	2	0.3	3	0.3
FC2	Inlet Filter Coalescer	10	7	30	80	125	0.1	Horizontal	5	6	6	6	5	5	3	0.4	4	0.5
FC3	Inlet Filter Coalescer	25	7	30	80	125	0.5	Horizontal	10	13	12	12	11	11	9	2	8	2
C11	Compressor 1	6	168	55	11.4	348	0.7	Horizontal	11	15	14	13	13	12	11	2	9	2
C12	Compressor 1	10	168	55	11.4	348	2	Horizontal	17	23	22	20	19	19	19	4	14	4

ID Tag	Plant Area	Hole Size	Press	Temp	Process Rate	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
									Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		mm	barg	^oC	(TJ/day)	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
C13	Compressor 1	25	168	55	11.4	348	12	Horizontal	35	49	48	44	42	40	50	10	36	9
-	Other Compressors as for Comp 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DH1	Discharge Header	6	153	55	80	2225	1	Horizontal	11	14	14	13	12	12	10	2	9	2
DH2	Discharge Header	10	153	55	80	2225	2	Horizontal	16	22	21	19	19	18	18	3	14	3
DH3	Discharge Header	25	153	55	80	2225	11	Horizontal	33	48	46	42	40	39	49	9	34	9
TEG1	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	6	168	55	80	2442	1	Horizontal	11	15	14	13	13	12	11	2	9	2
TEG2	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	10	168	55	80	2442	2	Horizontal	17	23	22	20	19	19	19	4	14	4
TEG3	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	25	168	55	80	2442	12	Horizontal	35	49	48	44	42	40	50	10	36	9
CV1	Regulator/SDV	6	153	55	80	2225	1	Horizontal	11	14	14	13	12	12	10	2	9	2
CV2	Regulator/SDV	10	153	55	80	2225	2	Horizontal	16	22	21	19	19	18	18	3	14	3
CV3	Regulator/SDV	25	153	55	80	2225	11	Horizontal	33	48	46	42	40	39	49	9	34	9
EX1	Scraper Launcher Gas Analysers Export Metering	6	168	55	80	2442	1	Horizontal	11	15	14	13	13	12	11	2	9	2

ID Tag	Plant Area	Hole Size	Press	Temp	Process Rate	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
									Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		mm	barg	°C	(TJ/day)	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
EX2	Scraper Launcher Gas Analysers Export Metering	10	168	55	80	2442	2	Horizontal	17	23	22	20	19	19	19	4	14	4
EX3	Scraper Launcher Gas Analysers Export Metering	25	168	55	80	2442	12	Horizontal	35	49	48	44	42	40	50	10	36	9
UG1	Utility Gas Skid	6	19.65	30	4	16	0.08	Horizontal	4.6	5.9	5.7	5.3	5.2	5.1	3.0	0.4	3.5	0.5
UG2	Utility Gas Skid	10	19.65	30	4	16	0.23	Horizontal	7	9.1	8.7	8.1	7.9	7.7	5.5	0.8	5.5	0.9
UG3	Utility Gas Skid	25	19.65	30	4	16	1.4	Horizontal	14	20	19	18	17	16	16	3	12	3
CPF Station Pipework																		
PIPE-LP1	Low Pressure Pipework	3	7	30	80	125	0.0077	Horizontal	2	2	2	2	2	2	1	0.14	1	0.16
PIPE-LP2	Low Pressure Pipework	25	7	30	80	125	0.54	Horizontal	10	13	12	12	11	11	9	2	8	2
PIPE-HP1	Low Pressure Pipework	3	168	55	80	2442	0.2	Horizontal	6	8	8	8	7	7	5	1	5	1
PIPE-HP2	Low Pressure Pipework	25	168	55	80	2442	12.44	Horizontal	35	49	48	44	42	40	50	10	36	9
PIPE-UG1	Utility Gas Pipework	3	19.65	30	4	16	0.02	Horizontal	3	3	3	3	3	3	1.8	0.2	2.0	0.2
PIPE-UG2	Utility Gas Pipework	25	19.65	30	4	16	1.42	Horizontal	14	20	19	18	17	16	16	3	12	3
HDS																		
IN1	Inlet/Scraper Receiver	6	153	30	80	2409	0.65	Horizontal	11	14	14	13	12	12	10	2	9	2
IN2	Scraper Receiver Dry Gas Filters Custody Meters	10	153	30	80	2409	1.81	Horizontal	16	22	21	19	19	18	18	3	14	3
IN3	Scraper Receiver Dry Gas Filters Custody Meters	25	153	30	80	2409	11.30	Horizontal	33	48	46	42	40	39	49	9	34	9

ID Tag	Plant Area	Hole Size	Press	Temp	Process Rate	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
									Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		mm	barg	^{o}C	(TJ/day)	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
DGF1	Dry Gas Filters	6	153	30	80	2409	0.65	Horizontal	11	14	14	13	12	12	10	2	9	2
DGF2	Dry Gas Filters	10	153	30	80	2409	1.81	Horizontal	16	22	21	19	19	18	18	3	14	3
DGF3	Dry Gas Filters	25	153	30	80	2409	11.30	Horizontal	33	48	46	42	40	39	49	9	34	9
HEAT1	Water Bath Heaters	6	153	30	80	2409	0.65	Horizontal	11	14	14	13	12	12	10	2	9	2
HEAT2	Water Bath Heaters	10	153	30	80	2409	1.81	Horizontal	16	22	21	19	19	18	18	3	14	3
HEAT3	Water Bath Heaters	25	153	30	80	2409	11.30	Horizontal	33	48	46	42	40	39	49	9	34	9
METER1	Custody Meters	6	153	30	80	2409	0.65	Horizontal	11	14	14	13	12	12	10	2	9	2
METER2	Custody Meters	10	153	30	80	2409	1.81	Horizontal	16	22	21	19	19	18	18	3	14	3
METER3	Custody Meters	25	153	30	80	2409	11.30	Horizontal	33	48	46	42	40	39	49	9	34	9
REG1	Regulator Skid	6	153	30	80	2409	0.65	Horizontal	11	14	14	13	12	12	10	2	9	2
REG2	Regulator Skid	10	153	30	80	2409	1.81	Horizontal	16	22	21	19	19	18	18	3	14	3
REG3	Regulator Skid	25	153	30	80	2409	11.30	Horizontal	33	48	46	42	40	39	49	9	34	9

TABLE A2.3: EXPORT SALES PIPELINE CONSEQUENCE MODELLING RESULTS

ID Tag	Release Description	Pressure	Temp	Hole Size	Process Rate	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fire (to Half LFL)	
									Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Width
		barg	ºC	(mm)	(TJ/day)	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
1	Pinhole	153	30	10	80	2409	2	45º	16	21	20	17	16	15	9.9	2.1	13.8	2.4
2	Puncture	153	30	50	80	2409	50	45º	58	83	77	67	62	55	46.4	10.1	56.1	11.0
3	Rupture - No Isolation	153	30	Full Bore (450mm)	80	2409	2409	45º	275	412	385	329	303	268	n/a	n/a	n/a	n/a
6	Rupture - No Isolation	153	30	Full Bore (250mm)	80	2409	1247	45º	211	317	292	251	231	206	232.5	49.2	233.0	45.0
1	Pinhole	153	30	10	80	2409	2	Vertical	15	15	14	11	9	7	2.8	2.4	2.3	2.5
2	Puncture	153	30	50	80	2409	50	Vertical	54	61	55	43	37	30	14.4	11.3	12.1	11.9
3	Rupture - No Isolation	153	30	Full Bore (450mm)	80	2409	2409	Vertical	256	306	274	221	188	150	101.5	35.8	93.4	66.8
5	Rupture - No Isolation	153	30	Full Bore (250mm)	80	2409	1247	Vertical	197	232	209	166	144	116	75.4	26.8	67.0	25.5

TABLE A2.4: POWER STATION CONSEQUENCE MODELLING RESULTS

ID Tag	Plant Area	Hole Size	Press	Temp	Process Rate	Release Rate	Release Orient'n	Jet Fire						D5 Flash Fire (to Half LFL)		F2 Flash Fir (to Half LFL	
								Flame Length	4.7 kw/m^2	6 kw/m^2	10 kw/m^2	14 kw/m^2	23 kw/m^2	Length	Width	Length	Wic
		mm	barg	^{o}C	(kg/s)	(kg/s)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m
Power Station Equipment																	
PSIN1	SDV/Isol Valves Meter/Bypass Valves	6	4.5	47	0.4	0.02	Horiz.	3	3	3	3	3	3	2	0.2	2	0.
PSIN2	SDV/Isol Valves Meter/Bypass Valves	10	4.5	47	0.4	0.06	Horiz.	4	5	5	5	5	4	2	0.4	3	0.
PSIN3	SDV/Isol Valves Meter/Bypass Valves	25	4.5	47	0.4	0.36	Horiz.	8	11	10	10	10	9	7	1	7	1
ENG1HP1	Inlet Filter (Combine 10 Units at one Location) Meter/Bypass	6	4.5	47	0.1	0.02	Horiz.	3	3	3	3	3	3	2	0.2	2	0.
ENG1HP2	Inlet Filter (Combine 10 Units at one Location) Meter/Bypass	10	4.5	47	0.1	0.06	Horiz.	4	5	5	5	5	4	2	0.4	3	0.
ENG1HP3	Inlet Filter (Combine 10 Units at one Location) Meter/Bypass	25	4.5	47	0.1	0.10	Horiz.	5	7	6	6	6	6	4	1	5	1
ENG1LP1	Regulator (all 10 combined) Relief Valve	6	0.45	47	0.1	0.005	Horiz.	2	2	2	2	2	2	1	0.2	2	0.
ENG1LP2	Regulator (all 10 combined) Relief Valve	10	0.45	47	0.1	0.014	Horiz.	2	3	3	3	3	3	2	0.3	3	0.
ENG1LP3	Regulator (all 10 combined) Relief Valve	25	0.45	47	0.1	0.088	Horiz.	5	6	6	6	6	5	4	1	5	1
Power Station Pipework																	
PIPE-PSHP1	PS HP Pipework	3	4.5	47	0.4	0.005	Horiz.	2	2	2	2	2	2	1	0.1	1	0.
PIPE-PSHP2	PS HP Pipework	25	4.5	30	0	0.36	Horiz.	8	11	10	10	10	9	7	1	7	1

APPENDIX 3. ABOVEGROUND FACILITY INCIDENT FREQUENCIES

A 3.1. General

This appendix summarises the results of the frequency assessment for the following:

- Frequency of releases from station equipment and pipework
- Probability of immediate ignition of release and frequency of jet fire
- Probability of delayed ignition of release and frequency of flash fire

A 3.2. Well-Site, CPF and HDS Facilities Release Frequencies

A 3.2.1. Probability of Loss of Containment

Release frequencies were categorised as:

Station Equipment

- Flange gasket leaks – 6 mm equivalent hole size
- Valve body leaks – 10 mm equivalent hole size
- Instrument fitting leaks – 25 mm equivalent hole size

Station Pipework

- Pipework pinhole release (corrosion) - 3 mm equivalent hole size
- Pipework puncture release - 25 mm equivalent hole size

The UK Health and Safety Executive (Ref. 14) reports the frequency of valve, flange and pipework failures, as follows:

- Flange/gasket leaks
- Valve body leaks
- Pipework releases (both small and large release sizes)

Cox, Lees and Ang (Ref. 15) reports the frequency of instrument tapping failure as 1×10^{-4} per fitting-year for a rupture leak.

The release frequency data used for the QRA is summarised in Table A3.1..

TABLE A3.1: COMPONENT LEAK FREQUENCIES

Equipment	Failure Mode	Release Frequency ($\times 10^{-6}$ per year)
Flange gasket leak	6 mm spiral wound gasket leak	50×10^{-6} per flange
Valve body leak	10 mm gland leak	170×10^{-6} per valve
Instrument fitting leak	25 mm leak	100×10^{-6} per fitting
Pipework pinhole release	3 mm leak	7.6×10^{-6} per m
Pipework puncture	25 mm leak	7.6×10^{-6} per m

A 3.2.2. Event Frequencies

Cox, Lees and Ang (Ref. 15) estimates the probability of ignition of leaks in plants, as shown in Table A3.2 (the event tree for release rates between 1 and 50 kg/s is shown below), which is applicable to aboveground facilities.

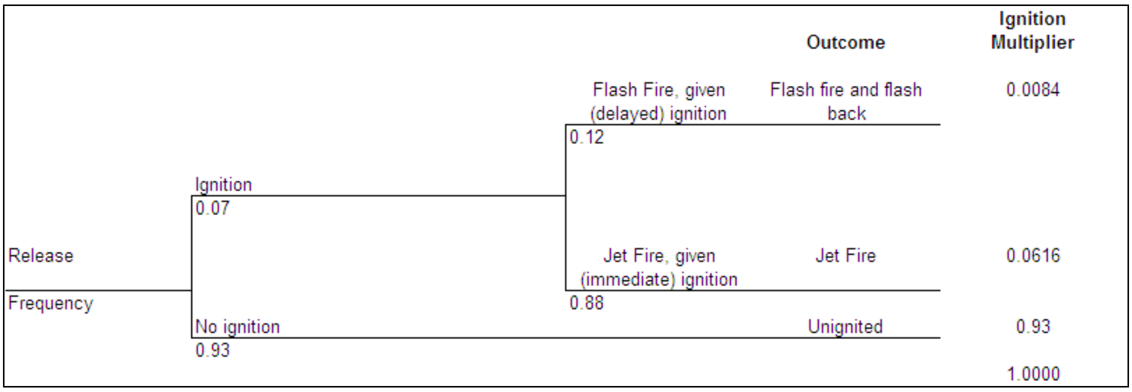


TABLE A3.2: CONDITIONAL PROBABILITIES OF IMMEDIATE AND DELAYED IGNITION GIVEN GAS RELEASE

Leak Size	Ignition Probability (Gas or Mixture)	Conditional Probability of Flash Fire	Immediate Ignition (Jet Fire) Probability	Delayed Ignition (Flash Fire) Probability
<1 kg/s	0.01	0.04	0.0096	0.0004
1 - 50 kg/s	0.07	0.12	0.0616	0.0084
50 kg/s	0.3	0.3	0.21	0.09

A 3.2.3. Parts Count

The parts counts for the well-sites, CPF and power station, and HDS are shown in Table A3.3. The parts count was undertaken using preliminary (concept-phase) drawings and conservative assumptions were made in the absence of detailed information.

TABLE A3.3: COMPONENT PARTS COUNT

Plant Area	Parts Count		
	Flanges	Valves	Instrument Fittings
Well-Sites			
Wellhead (4 off per well-site)	24	12	12
Water Separator (4 off per well-site)	64	44	8
Central Processing Facility			
Suction header	12	16	1
Inlet Separator	10	5	1
Inlet filter coalescers (3 units)	54	27	3
Compressors (per compressor unit)	20	6	5
Discharge header	4	0	2
TEG inlet coalescer, contactor, outlet coalescer	36	18	6

Plant Area	Parts Count		
	Flanges	Valves	Instrument Fittings
Regulator/SDV	4	2	0
Scraper launcher, Gas analysers, Export metering	16	8	2
Utility gas skid	10	4	4
Power Station			
Inlet SDV, isolation valves, meter/bypass valves	32	12	4
Engine inlet Filter and meter/bypass (per engine unit)	17	6	1
Regulator and relief valves (per engine unit)	11	5	1
Hexham Delivery Station			
Inlet/Scraper Receiver	8	4	2
Dry Gas Filters	8	4	4
Water Bath Heaters	12	4	4
Custody Meters	20	7	4
Regulator Skid	12	6	2

TABLE A3.3: WELL-SITE, CPF POWER STATION & HDS FREQUENCIES

Incident Tag No.	Plant Area	Release Description	Leak Frequency (per year)	Probability Jet Fire Given Ignition	Jet Fire Frequency (per year)	Probability Flash Fire Given Ignition	Flash Fire Frequency (per year)
Well-Sites							
WH1	Well-head	Gasket Leak	1.20E-03	0.0096	1.15E-05	0.0004	4.80E-07
WH2	Well-head	Valve Leak	2.04E-03	0.0616	1.26E-04	0.0084	1.71E-05
WH3	Well-head	Fitting Leak	1.20E-03	0.0616	7.39E-05	0.0084	1.01E-05
WH4	Well-head	Pipework Rupture	6.08E-05	0.0616	3.75E-06	0.0084	5.11E-07
WS1	Water Separator	Gasket Leak	3.20E-03	0.0096	3.07E-05	0.0004	1.28E-06
WS2	Water Separator	Valve Leak	7.48E-03	0.0096	7.18E-05	0.0004	2.99E-06
WS3	Water Separator	Fitting Leak	8.00E-04	0.0096	7.68E-06	0.0004	3.20E-07
WS4	Water Separator	Pipework Rupture	3.04E-04	0.0616	1.87E-05	0.0084	2.55E-06
CPF Equipment							
SH1	Suction Header	Gasket Leak	6.00E-04	0.0096	5.76E-06	0.0004	2.40E-07
SH2	Suction Header	Valve Leak	1.02E-03	0.0096	9.79E-06	0.0004	4.08E-07
SH3	Suction Header	Fitting Leak	1.00E-04	0.0096	9.60E-07	0.0004	4.00E-08
IS1	Inlet Separator	Gasket Leak	5.00E-04	0.0096	4.80E-06	0.0004	2.00E-07
IS2	Inlet Separator	Valve Leak	8.50E-04	0.0096	8.16E-06	0.0004	3.40E-07
IS3	Inlet Separator	Fitting Leak	1.00E-04	0.0096	9.60E-07	0.0004	4.00E-08
FC1	Inlet Filter Coalescers	Gasket Leak	2.70E-03	0.0096	2.59E-05	0.0004	1.08E-06
FC2	Inlet Filter Coalescers	Valve Leak	4.59E-03	0.0096	4.41E-05	0.0004	1.84E-06
FC3	Inlet Filter Coalescers	Fitting Leak	3.00E-04	0.0096	2.88E-06	0.0004	1.20E-07
C11	Compressor Unit (per compressor)	Gasket Leak	1.00E-03	0.0096	9.60E-06	0.0004	4.00E-07
C12	Compressor Unit (per compressor)	Valve Leak	1.02E-03	0.0616	6.28E-05	0.0084	8.57E-06

Incident Tag No.	Plant Area	Release Description	Leak Frequency (per year)	Probability Jet Fire Given Ignition	Jet Fire Frequency (per year)	Probability Flash Fire Given Ignition	Flash Fire Frequency (per year)
C13	Compressor Unit (per compressor)	Fitting Leak	5.00E-04	0.0616	3.08E-05	0.0084	4.20E-06
DH1	Discharge Header	Gasket Leak	2.00E-04	0.0096	1.92E-06	0.0004	8.00E-08
DH2	Discharge Header	Valve Leak	0.00E+00	0.0616	0.00E+00	0.0084	0.00E+00
DH3	Discharge Header	Fitting Leak	2.00E-04	0.0616	1.23E-05	0.0084	1.68E-06
TEG1	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	Gasket Leak	1.80E-03	0.0096	1.73E-05	0.0004	7.20E-07
TEG2	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	Valve Leak	3.06E-03	0.0616	1.88E-04	0.0084	2.57E-05
TEG3	TEG Inlet Coalescer TEG Contactor TEG Outlet Coalescer	Fitting Leak	6.00E-04	0.0616	3.70E-05	0.0084	5.04E-06
CV1	Regulator/SDV	Gasket Leak	2.00E-04	0.0096	1.92E-06	0.0004	8.00E-08
CV2	Regulator/SDV	Valve Leak	3.40E-04	0.0616	2.09E-05	0.0084	2.86E-06
CV3	Regulator/SDV	Fitting Leak	0.00E+00	0.0616	0.00E+00	0.0084	0.00E+00
EX1	Scraper Launcher Gas Analysers Export Metering	Gasket Leak	8.00E-04	0.0096	7.68E-06	0.0004	3.20E-07
EX2	Scraper Launcher Gas Analysers Export Metering	Valve Leak	1.36E-03	0.0616	8.38E-05	0.0084	1.14E-05
EX3	Scraper Launcher Gas Analysers Export Metering	Fitting Leak	2.00E-04	0.0616	1.23E-05	0.0084	1.68E-06
UG1	Utility Gas Skid	Gasket Leak	5.00E-04	0.0096	4.80E-06	0.0004	2.00E-07

Incident Tag No.	Plant Area	Release Description	Leak Frequency (per year)	Probability Jet Fire Given Ignition	Jet Fire Frequency (per year)	Probability Flash Fire Given Ignition	Flash Fire Frequency (per year)
UG2	Utility Gas Skid	Valve Leak	6.80E-04	0.0096	6.53E-06	0.0004	2.72E-07
UG3	Utility Gas Skid	Fitting Leak	4.00E-04	0.0616	2.46E-05	0.0084	3.36E-06
CPF Pipework							
PIPE-LP1	Low Pressure Pipework (per m)	Pinhole Leak	3.00E-06	0.0096	2.88E-08	0.0004	1.20E-09
PIPE-LP2	Low Pressure Pipework (per m)	Pipeline Puncture	3.00E-07	0.0096	2.88E-09	0.0004	1.20E-10
PIPE-HP1	High Pressure Pipework (per m)	Pinhole Leak	3.00E-06	0.0096	2.88E-08	0.0004	1.20E-09
PIPE-HP2	High Pressure Pipework (per m)	Pipeline Puncture	3.00E-07	0.0616	1.85E-08	0.0084	2.52E-09
PIPE-UG1	Utility Gas Pipework (per m)	Pinhole Leak	3.00E-06	0.0096	2.88E-08	0.0004	1.20E-09
PIPE-UG2	Utility Gas Pipework (per m)	Pipeline Puncture	3.00E-07	0.0616	1.85E-08	0.0084	2.52E-09
Power Station Equipment							
PSIN1	SDV/Isol Valves Meter/Bypass Valves	Gasket Leak	1.60E-03	0.0096	1.54E-05	0.0004	6.40E-07
PSIN2	SDV/Isol Valves Meter/Bypass Valves	Valve Leak	2.04E-03	0.0096	1.96E-05	0.0004	8.16E-07
PSIN3	SDV/Isol Valves Meter/Bypass Valves	Fitting Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07
ENG1HP1	Inlet Filter (All) Meter/Bypass	Gasket Leak	8.50E-03	0.0096	8.16E-05	0.0004	3.40E-06
ENG1HP2	Inlet Filter (All) Meter/Bypass	Valve Leak	1.02E-02	0.0096	9.79E-05	0.0004	4.08E-06

Incident Tag No.	Plant Area	Release Description	Leak Frequency (per year)	Probability Jet Fire Given Ignition	Jet Fire Frequency (per year)	Probability Flash Fire Given Ignition	Flash Fire Frequency (per year)
ENG1HP3	Inlet Filter (All) Meter/Bypass	Fitting Leak	1.00E-03	0.0096	9.60E-06	0.0004	4.00E-07
ENG1LP1	Regulator (per unit) Relief Valve	Gasket Leak	5.50E-03	0.0096	5.28E-05	0.0004	2.20E-06
ENG1LP2	Regulator (per unit) Relief Valve	Valve Leak	8.50E-03	0.0096	8.16E-05	0.0004	3.40E-06
ENG1LP3	Regulator (per unit) Relief Valve	Fitting Leak	1.00E-03	0.0096	9.60E-06	0.0004	4.00E-07
Power Station Pipework							
PIPE-PSHP1	PS HP Pipework (per m)	Pinhole Leak	3.00E-06	0.0096	2.88E-08	0.0004	1.20E-09
PIPE-PSHP2	PS HP Pipework (per m)	Pipeline Puncture	3.00E-07	0.0096	2.88E-09	0.0004	1.20E-10
HDS Equipment							
IN1	Inlet/Scraper Receiver	Gasket Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07
IN2	Inlet/Scraper Receiver	Valve Leak	6.80E-04	0.0096	6.53E-06	0.0004	2.72E-07
IN3	Inlet/Scraper Receiver	Fitting Leak	2.00E-04	0.0096	1.92E-06	0.0004	8.00E-08
DGF1	Dry Gas Filters	Gasket Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07
DGF2	Dry Gas Filters	Valve Leak	6.80E-04	0.0096	6.53E-06	0.0004	2.72E-07
DGF3	Dry Gas Filters	Fitting Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07
HEAT1	Water Bath Heaters	Gasket Leak	6.00E-04	0.0096	5.76E-06	0.0004	2.40E-07
HEAT2	Water Bath Heaters	Valve Leak	6.80E-04	0.0096	6.53E-06	0.0004	2.72E-07
HEAT3	Water Bath Heaters	Fitting Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07
METER1	Custody Meters	Gasket Leak	1.00E-03	0.0096	9.60E-06	0.0004	4.00E-07
METER2	Custody Meters	Valve Leak	1.19E-03	0.0096	1.14E-05	0.0004	4.76E-07
METER3	Custody Meters	Fitting Leak	4.00E-04	0.0096	3.84E-06	0.0004	1.60E-07

Incident Tag No.	Plant Area	Release Description	Leak Frequency (per year)	Probability Jet Fire Given Ignition	Jet Fire Frequency (per year)	Probability Flash Fire Given Ignition	Flash Fire Frequency (per year)
REG1	Regulator Skid	Gasket Leak	6.00E-04	0.0096	5.76E-06	0.0004	2.40E-07
REG2	Regulator Skid	Valve Leak	1.02E-03	0.0096	9.79E-06	0.0004	4.08E-07
REG3	Regulator Skid	Fitting Leak	2.00E-04	0.0096	1.92E-06	0.0004	8.00E-08
HDS Pipework							
PIPE-HDS1	HDS Pipework (per m)	Pinhole Leak	3.00E-06	0.0096	2.88E-08	0.0004	1.20E-09
PIPE-HDS2	HDS Pipework (per m)	Pipeline Puncture	3.00E-07	0.0096	2.88E-09	0.0004	1.20E-10

APPENDIX 4. ESP INCIDENT FREQUENCIES

A 4.1. Pipeline Release Frequencies

A 4.1.1. Generic Pipeline Failure Data

The failure rate data used for the assessment of the frequency of pipeline releases was derived from the European Gas Pipeline Incident Data Group (EGIG, Ref. 9). The European data are useful because of the significant exposure in terms of kilometre years experienced (approximately 2.4 million kilometre-years from 1970-2001). The large exposure provides a statistically significant basis, particularly when estimating the frequency of different causes of failure. The data also includes factors such as wall thickness, depth of cover, probability of ignition, etc.

The EGIG data, however, are considered conservative when applied to pipelines in Australia. This is because there is a higher density of pipelines and higher population densities along pipeline routes in Europe than in Australia. This will tend to result in higher failure rates for European pipelines compared with the experience of pipelines in Australia, particularly for incidents caused by external interference.

The EGIG database is continually updated and summary data are periodically reported. The data show that the failure rates for pipeline failures are gradually reducing over time, reflecting the improvements in pipeline technology and safeguards. The overall failure frequency reported for the period 1970-2004 was 0.41 incidents per 1000 km-yr compared with a failure frequency of 0.17 incidents per 1000 km-yr for the years 2000-2004.

A 4.1.2. Steel Pipe Failure Frequencies

While the EGIG data are expected to be quite conservative for the Export Sales Pipeline, the data are useful to estimate the frequency of different causes of failures such as corrosion, external interference, material defects, etc.

Table A4.1 summarises the data derived from the EGIG report (Figure 18, Ref.9) for the period 1970-2004. The data are categorised by the identified cause of the incident and show the relative frequency of each cause. The most frequent cause of pipeline failures is due to external interference (52%) with the next most likely causes being construction/ material defects (18%) and corrosion (17%).

The incidence of hot-tap errors (taken as the likelihood of tapping into the wrong pipeline or inadvertently impacting an adjacent pipeline) will be insignificant as there will only be one off-take in the vicinity on the existing main gas pipeline. Therefore the frequency for hot-tap errors has been set to zero.

Pipeline rupture is less likely to occur due to ground movement (e.g. at locations near mining leases due to subsidence or seismic impact from blasting). Whilst the proposed pipeline route would not cross any known areas of mine subsidence, the frequency for ground movement was conservatively carried forward.

TABLE A4.1: BASE FREQUENCIES FOR STEEL PIPELINE FAILURES

Cause	**Pipeline Base Frequency by Cause and Hole Size (per 1000 km-yr)**		
	Pinhole-Crack (d<10 mm)	**Hole (10 mm<d<50 mm)**	**Maximum Hole Size (d>50 mm)**
External Interference	0.05	0.12	0.03
Construction/ material	0.045	0.02	0.005
Corrosion	0.06	0.004	0
Ground Movement	0.008	0.008	0.001
Hot tap error	0	0	0
Other/Unknown	0.025	0.003	0
Total	**0.188**	**0.155**	**0.036**

The base frequencies given in Table A4.1 were then adjusted to take account of the proposed design for the Export Sales Pipeline. The safeguards proposed for the Export Sales Pipeline include:

- Depth of cover
- Wall thickness
- Marker tape

The safeguards proposed for the Export Sales Pipeline and the modifications to failure frequency are discussed in more detail in the following sections.

A 4.1.3. Pipeline Depth of Cover

Table A4.2 summarises the risk reduction factors from the testing reported by Corder (Ref. 16). Note that a reduction factor of 1.0 resulted for depths of cover of 1.11 m and that lower depths of cover result in a reduction factor greater than 1, i.e. there is an increase of the relative frequency of external impact.

TABLE A4.2: REDUCTION FACTORS FOR DEPTH OF COVER

Depth of Cover (m)	Reduction Factor
0.6	1.49
0.75	1.35
0.9	1.21
1	1.11
1.1	1.02
1.2	0.92
1.4	0.73

The various pipeline depth of cover at various locations has been assessed in a number of sensitivity cases.

A 4.1.4. Wall Thickness

The EGIG database also summarises pipeline failure frequencies by wall thickness. Based on the data, the following factors are used for pipe with varying wall thickness.

TABLE A4.3: FREQUENCY MULTIPLYING FACTOR FOR WALL THICKNESS

Pipewall Thickness (mm)	Pinhole	Puncture	Rupture (Full Bore Release)
2.5 (0-5mm)	4.0	2.4	5.8
7.5 (5-10mm)	1.0	1.0	1.0
12.5 (10-15mm)	0.5	0.5	0.5

A 4.1.5. Marker Tape

Corder (Ref. 16) has reported that a damage reduction factor of 1.67 was achieved when marker tape is provided above pipelines based on experimental data derived from testing undertaken by British Gas. Marker tape may not be provided at all locations of the pipeline route, therefore a number of sensitivity cases were assessed with different levels of safeguards.

A 4.1.6. Pipeline Failure Cases Assessed

A number of sensitivity cases have been assessed taking into account:

- Pipeline diameter (DN 450/250)
- Location class (R1/T1)
- Depth of Cover
- Wall Thickness
- Marker Tape

The following cases have been assessed:

- Case No. 1 (DN 450, R1, 750mm DOC, 11mm WT, no marker tape)
- Case No. 2 (DN 450, T1, 900mm DOC, 11mm WT, marker tape)

- Case No. 3 (DN 250, R1, 750mm DOC, 5mm WT, no marker tape)
- Case No. 4 (DN 250, T1, 900mm DOC, 12.7mm WT, marker tape)
- Case No. 5 (DN 250, Road/Rail Crossing, 1200mm DOC, 7.5mm WT, marker tape)
- Case No. 6 (DN 250, Intermediate water course, 1500mm DOC, 7.5mm WT, no marker tape)
- Case No. 7 (DN 250, Major Water Course, 2000mm DOC, 7.5mm WT, no marker tape)

A 4.1.7. Revised Failure Frequencies

The revised failure frequencies incorporating risk reduction factors are summarised in Tables A4.4 for Case 1 for the Export Sales Pipeline (without and with marker tape, respectively). The failure frequencies for the other cases are calculated in a similar

TABLE A4.4: SUMMARY OF FINAL RELEASE FREQUENCIES FOR: EXPORT SALES PIPELINE (CASE 1)

Cause	Pipeline Base Frequency by Cause and Hole Size (per 1000 km-yr)		
	Pinhole-Crack (d<10 mm)	Hole (10 mm<d<50 mm)	Rupture (d>50 mm)
External Interference	0.018	0.043	0.011
Construction/ material	0.045	0.020	0.005
Corrosion	0.030	0.004	0.000
Ground Movement	0.008	0.008	0.001
Hot tap error	0.000	0.000	0.000
Other/Unknown	0.025	0.003	0.000
Total	**0.126**	**0.078**	**0.017**

A 4.1.8. Pipeline Ignition Probabilities

The probability of ignition used in the frequency assessment was based on the EGIG 2005 Report (Ref. 9).

TABLE A4.5: PROBABILITY OF IGNITION FOLLOWING PIPELINE GAS RELEASE

Hole Size	Ignition Probability
Pinhole (10 mm)	3%
Hole (50 mm)	2%
Full Bore Rupture	30%

A 4.1.9. Probability of Leak Detection

The Export Sales Pipeline will be provided with a remote shutdown capability consisting of automatic line break facilities located at the inlet to the CPF and at the inlet to the HDS. The stations will be provided with telemetry which will allow remote monitoring of the pipeline operating conditions. A pipeline rupture would be readily detected by a sudden drop in pipeline pressure which would initiate closure of the shutdown valves.

Due to the large capacity in the line, the rupture release will continue for some time and the release rate will only reduce slowly. This reduces the effectiveness of the isolation in minimising the consequences of rupture.

It is unlikely that pinholes and punctures would be readily detected by remote monitoring and may depend on the operating conditions at the time of the leak. Small releases in remote locations may not be readily detected until a routine patrol of the pipeline occurs. It was assumed that pinhole and puncture releases would not be detected for some time and the release rate was modelled as a steady-state release at the maximum allowable operating pressure.

APPENDIX 5. GATHERING AND SPINE LINE INCIDENT FREQUENCIES

A 5.1. Background

Polyethylene (PE) pipes were introduced to the gas industry in the late 1960s, offering corrosion resistance, resistance to the effects of gas constituents, ease of installation and cost-effectiveness. British Gas (BG) commenced using PE in 1969 and the Gas & Fuel Corporation of Victoria (G&FC) in 1973. In Australia the older "first generation" HDPE was initially used because of local manufacture of raw materials and concerns about the reliability of supply of imported polymers. Although MDPE was known to confer superior properties in terms of resistance to crack growth and long term strength, G&FC, along with Allgas and Sagasco, continued to successfully use "first generation" HDPE. The transition to MDPE commenced during the 1980s.

PE almost totally replaced metallic pipe materials within the material's size and pressure range, such that in 1988, G&FC reported annual usage of 280 km of Class 250 (250 kPa) and 1162 km of Class 575 (575 kPa) in sizes up to 50mm. At the time, it was reported that the failure rate was approximately 200 to 300 p.a.[1], with the highest percentage in 1983 being due to point loading (64%), whereas the highest percentage in 1986 was due to mechanical damage (66%). Mechanical damage and point loading have accounted for the vast majority of identified PE pipe failures over the period reported. The reduction in point loading failures was attributable to improved installation standards and the use of thicker walled Class 575 HDPE pipe, with its improved resistance to localised loads, such as rock impingement.

In 1989, BG commenced use of PE 100 HDPE for higher pressure applications (up to 7 bar) and larger diameters, the key attributes being improved long term strength, stress crack resistance, and resistance to rapid crack propagation.

In 1993, new Australian Standards, AS 4130(Int) and AS 4131(Int) were introduced for PE pipes and compounds to incorporate the new grades and appropriate performance requirements. In 1995, AS/NZS 4130 and AS/NZS 4131 were introduced, covering all pressure applications, including fuel gas.

In 2001, these Standards were revised to reflect the latest developments and test requirements were increased to reflect the improved material properties, especially for PE 100 grades. In addition, resistance to slow crack growth requirements were increased for both PE 80 and PE 100 in order to reflect requirements of the U.K. gas industry and latest ISO proposals. These increased levels provide further assurance of

[1] Reported by M. Stahmer, Chairman, PIPA Polyolefins Technical Committee December, 2008, in *Polyethylene - The Optimum Gas Pipe Material?* It is not clear what measure applies (presumably per the population exposed, i.e. 280km) nor what level of incident occurred. Therefore it is not possible to derive meaningful failure frequencies.

long term performance under adverse conditions, such as surface damage and localised loading.

PE 100 materials are now being frequently used in Europe and Scandinavia for fuel gas applications at pressures up to 10 bar, with both pipes and fittings available in PE 100 material. In Australia, PE 100 systems have been designed to operate at pressures up to 1050 kPa (Tumut Pipeline Project).

Developments in polyethylene pipe and fitting materials continue to improve already outstanding properties and afford the asset owner confidence in long term durability.

A 5.2. Failure Modes: PE versus Steel

The predominant failure modes for steel pipelines (in decreasing order of prevalence) are[2]:

- external interference (e.g. excavation works)
- construction/ material problems
- corrosion
- design flaws
- ground movement
- hot tap errors

By comparison, the predominant failure mode for plastic pipework has also been external impact, usually due to excavation works. However, it has been shown that PE piping has a larger resistance to external force than steel pipe and impact tends to result in smaller puncture sizes[3]. Visco-elastic materials such as PE deform under load, allowing stresses to relax and stresses to be shed.

Construction and material problems in plastic piping tend to lead to brittle-like failures, which are the second most frequent failure mode in polyethylene pipeline systems; although, mainly in older-generation piping which tended to fail prematurely due to brittle cracking. Brittle-like cracking has been linked to stress intensification generated by external forces acting on the pipe[4]. Examples of conditions that can generate stress intensification include differential earth settlement (particularly at connections with more rigidly anchored fittings), excessive bending (as a result of installation configurations, especially at fittings), and point contact with rocks or other objects. Limiting shear and bending forces at plastic service connections to steel mains via steel tapping tees was deemed to be a major contributor to minimising stress intensification.

Corrosion is not an issue for PE piping, as it is for steel pipe.

---

[2] 6th Report of the European Gas Pipeline Incident Data Group - EGIG

[3] Synnerholm, L., *Gas Pipes – Qualification of Plastic Pipes for 10 Bar*, Proceedings of Plastic Pipes XI, Munich Germany 3 September 2001

[4] US National Transportation Safety Board Pipeline Special Investigation Report NTSBlSlR-98101

The performance of PE during ground-movement situations (earthquake) was demonstrated during the 1995 earthquake in Kobe, Japan, following which Osaka Gas found failures in steel/ iron pipework but none in PE systems.

Hot tapping is an inherently hazardous process and errors are mainly a function of human error (poor workmanship); both steel and PE piping is susceptible to hot tap error leading to pipe failures.

A 5.3. PE Pipe Failure Data

Failure/ reliability data for new-generation PE pipework is not readily available in the open literature. Although the American Gas Association began undertaking leak surveys for US gas distribution networks), the data comprises significant sections of old-generation PE piping which cannot be readily applied to third-generation (PE100: higher crack-resistant, higher-pressure) pipework.

Based on the preceding discussion, it is considered that the performance (integrity) of PE pipe is as good as, if not better than, steel for the pipe size and rating indicated above. Therefore, it is proposed that the EGIG pipe failure data is representative of, if not conservative for, PE piping with the following modifications (to account for physical limitations):

Failure Mode	**Pipeline Failure Frequency (per 1000km-yr)**	**Comment**
External Interference	0.2	The frequency of external interference was carried forward as the likelihood of interference does not depend on pipe material.
Construction/ Material	0.07	Although there has been a reduction in point loading failures (attributable to improved installation standards) failure due to construction issues was carried forward.
Corrosion	-	PE is not vulnerable to corrosion.
Ground Movement	0.017	Whilst PE has performed effectively under earthquake situations, this value was conservatively carried forward.
Hot tap error	0.02	Carried forward.
Other/Unknown	0.028	Carried forward.
Total	**0.315**	**-**

Table A5.1 summarises the data derived from the EGIG report for the period 1970-2004, as applied to PE piping.

TABLE A5.1: BASE FREQUENCIES FOR PE PIPELINE FAILURES

Cause	Pipeline Base Frequency by Cause and Hole Size (per 1000 km-yr)		
	Pinhole-Crack (d<10 mm)	**Hole (10 mm<d<50 mm)**	**Maximum Hole Size (d>50 mm)**
External Interference	0.05	0.12	0.03
Construction/ material	0.045	0.02	0.005
Corrosion	-	-	-
Ground Movement	0.008	0.008	0.001
Hot tap error	-	0.02	-
Other/Unknown	0.025	0.003	0
Total	**0.128**	**0.171**	**0.036**

The base frequencies given in Table A5.1 were then adjusted to take account of the proposed design for the Gathering and Spine lines.

The safeguards proposed for the Gathering and Spine lines include:

- Marker tape at a minimum of 200 mm above the buried pipeline.
- Depth of cover: 600 mm (depth of cover for roadway and creek crossings was not assessed as this will be lower risk).
- Wall thickness: 12 mm for DN 125 Gathering Lines and 43 mm for DN 450 Spine Lines (Note: EGIG analyses are provided for up to 15 mm wall thickness; hence application to 43 mm-thick spine lines is conservative).

The provision of these safeguards will result in a reduction in the likelihood of external interference leading to pipeline damage.

The minimum depth of cover for the Gathering and Spine lines is 600 mm therefore an increase in the relative frequency of external interference by a factor of 1.49 was used (based on the risk reduction factors listed in Table A4.22).

The revised failure frequencies incorporating risk reduction factors are summarised in Table A5.2 for the Gathering Lines and Table A5.3 for the Spine lines.

TABLE A5.2: SUMMARY OF FINAL GATHERING LINE FAILURE FREQUENCIES

Cause	Pipeline Base Frequency by Cause and Hole Size (per 1000 km-yr)		
	Pinhole-Crack (d<10 mm)	Hole (10 mm<d<50 mm)	Rupture (d>50 mm)
External Interference	0.024	0.058	0.014
Construction/ material	0.045	0.020	0.005
Corrosion	-	-	-
Ground Movement	0.008	0.008	0.001
Hot tap error	0.000	0.020	0.000
Other/Unknown	0.025	0.003	0.000
Total	**0.102**	**0.109**	**0.020**

TABLE A5.3: SUMMARY OF FINAL SPINE LINE FAILURE FREQUENCIES

Cause	Pipeline Base Frequency by Cause and Hole Size (per 1000 km-yr)		
	Pinhole-Crack (d<10 mm)	Hole (10 mm<d<50 mm)	Rupture (d>50 mm)
External Interference	0.022	0.054	0.013
Construction/ material	0.045	0.020	0.005
Corrosion	-	-	-
Ground Movement	0.008	0.008	0.001
Hot tap error	0.000	0.020	0.000
Other/Unknown	0.025	0.003	0.000
Total	**0.100**	**0.105**	**0.019**

A 5.3.1. Pipeline Ignition Probabilities

The probability of ignition for gathering and spine line release is as for the ESP (Table 4.5).

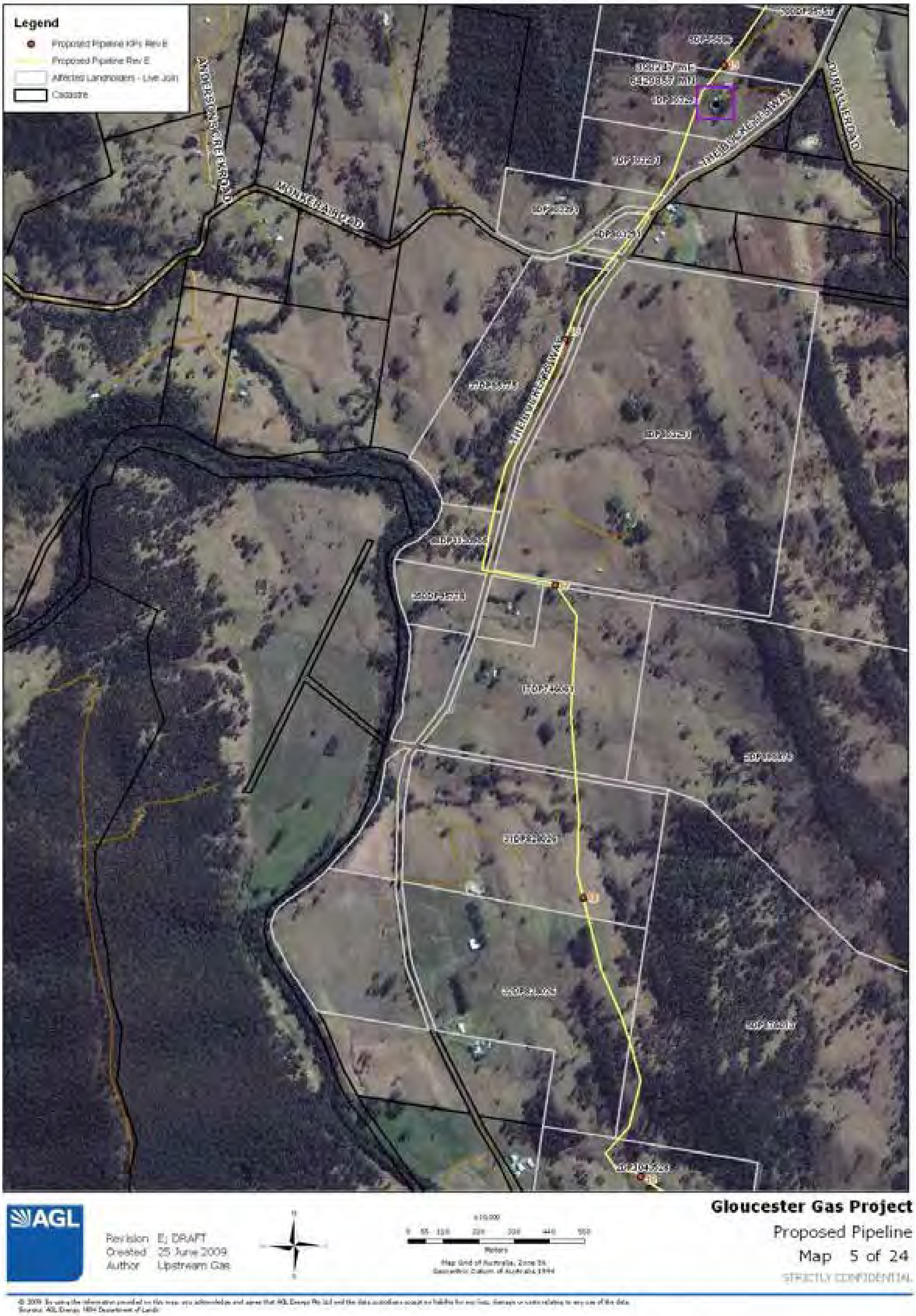
TABLE A4.5: PROBABILITY OF IGNITION FOLLOWING PIPELINE GAS RELEASE

Hole Size	Ignition Probability
Pinhole (10 mm)	3%
Hole (50 mm)	2%
Full Bore Rupture	30%

APPENDIX 6. AERIAL PHOTOS SHOWING NEAREST RESIDENCES TO ESP

The follow figures show the locations of the nearest residential properties located near the pipeline (within 30-40m of the pipeline).

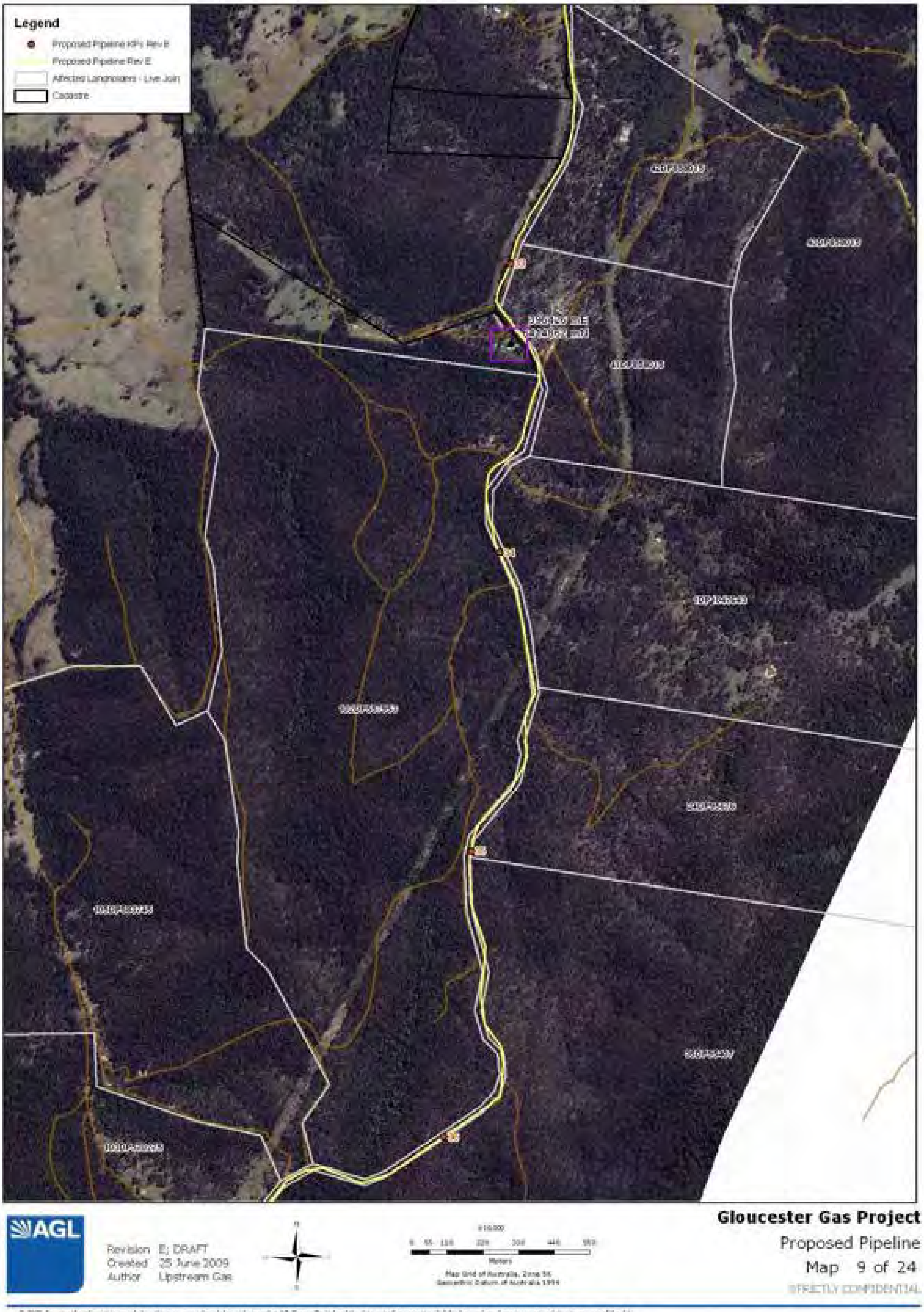

Legend
Proposed Pipeline Rev E
Cadastre
UPPER AVON ROAD
PARKERS ROAD
WOODS ROAD
THE BUCKETTS WAY
Gloucester Gas Project
Proposed Pipeline
Map 1 of 24
STRICTLY CONFIDENTIAL
AGL
Revision E; DRAFT
Created 25 June 2009
Author Upstream Gas



Legend
Proposed Pipeline KPs Rev E
Proposed Pipeline Rev E
Affected Landholders - Live Join
Cadastre
MONKERAI ROAD
Revision E; DRAFT
Created 25 June 2009
Author Upstream Gas
Metres
Gloucester Gas Project
Proposed Pipeline
Map 5 of 24
STRICTLY CONFIDENTIAL

sherpa consulting

sherpa consulting



Document: J20366-001 APPENDIX 6
Revision: 1
Revision Date: 29 October 2009
Document ID: Appendix I_20366-001-Rev 1-2003_31Oct09

Gloucester Gas Project

Proposed Pipeline

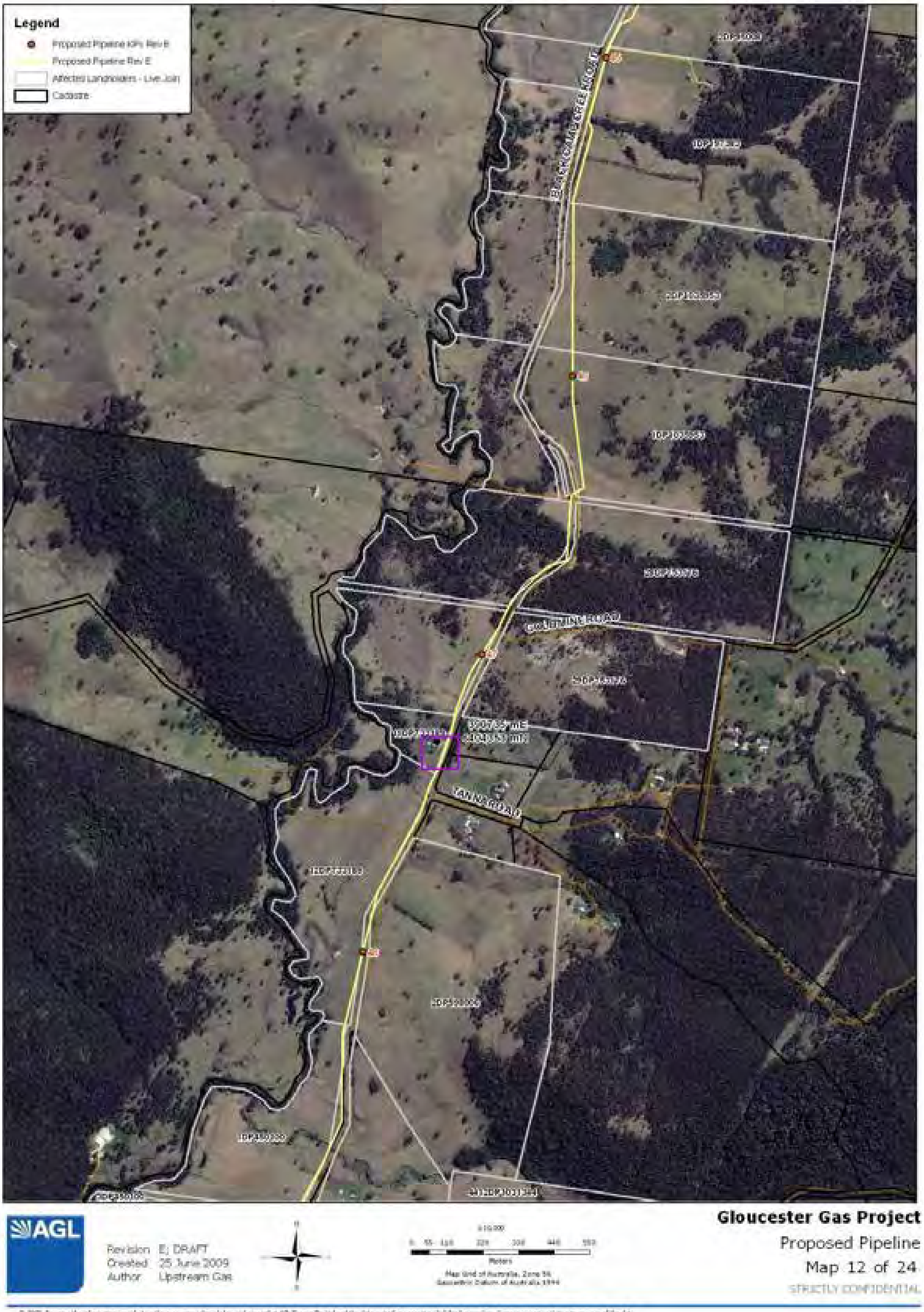
Map 10 of 24

STRICTLY CONFIDENTIAL

AGL

Revision E; DRAFT
Created 25 June 2009
Author Upstream Gas

Map Grid of Australia, Zone 56
Geocentric Datum of Australia 1994


Legend
Proposed Pipeline KPs Rev E
Proposed Pipeline Rev E
Affected Landholders - Live Join
Cadastre
TANNS ROAD
AGL
Revision E; DRAFT
Created 25 June 2009
Author Upstream Gas
Meters
Gloucester Gas Project
Proposed Pipeline
Map 12 of 24
STRICTLY CONFIDENTIAL


Legend
Proposed Pipeline KPs Rev E
Proposed Pipeline Rev E
Cadastre
Revision E; DRAFT
Created 25 June 2009
Author Upstream Gas
Meters
Gloucester Gas Project
Proposed Pipeline
Map 16 of 24
STRICTLY CONFIDENTIAL

APPENDIX 7. REFERENCES

1 Sherpa Consulting Pty Ltd (2008): 'Lucas Energy Pty Ltd, Gloucester Coal Seam Gas Project, Preliminary Hazard Analysis, EPCM Consultants Pty Ltd', Report No. J20315-001, Revision 2.

2 Standards Australia (2008): 'AS/NZS 4645.3:2008: Gas Distribution Networks - Plastics Pipe Systems'

3 ENSR Australia Pty Ltd (2008): 'Gloucester Coal Gas Project Environmental Assessment, Volume 1 Main Report'.

4 Planning NSW (2002): 'Hazardous Industry Planning Advisory Paper No.4: Risk Criteria for Land Use Safety Planning', Sydney NSW.

5 Department of Urban Affairs and Planning (1997): 'Hazardous Industry Planning Advisory Paper No.6 - Guidelines for Hazard Analysis', Sydney NSW.

6 NSW Department of Planning (1999): 'Multi-Level Risk Assessment', Sydney NSW.

7 Lucas Energy Pty Ltd (2008): 'Gloucester Gas Project Design Basis', Doc. No.: G-GEN-E-DB-C-020929-Design Basis, Revision C, September 2008.

8 Standards Australia (2008): 'AS/NZS 4130:2009: Polyethylene (PE) pipes for pressure applications'

9 European Gas Pipeline Incident Data Group (2005): '6th EGIG Report 1970-2004, Gas Pipeline Incidents', 6th Report of the European Gas Pipeline Incident Data Group (EGIG), Report Number EGIG 05.R.0002.

10 Shell Global Solutions: 'Technical Manual Shell FRED, V5'.

11 Townsend, N.A & Fearnehough, G.D (1986): 'Control of Risks from UK Gas Transmission Pipelines', Proceedings 7th Symposium on Line Pipe Research, American Gas Association, Oct.1986, Houston, USA.

12 Fearnehough, G.D. (1990): 'Pipeline Safety', Pipeline Technology Conference, Royal Flemish Society of Engineers, Oostende, Belgium.

13 http://www.newcastle.nsw.gov.au/__data/assets/pdf_file/0006/5478/LEP_2003_Map_1.pdf

14 Health and Safety Executive (2002): 'Offshore Hydrocarbon Release Statistics, HID Statistics Report HSR 2001 002', January 2002.

15 Cox, A.W., Lees, F.P. & Ang, M.L. (1992): 'Classification of Hazardous Locations', IChemE, Rugby, England.

16 Corder, I (1995): 'The Application of Risk Techniques to the Design and Operations of Pipelines' paper presented to IMechE,1995.

Appendix J Soil Landscapes

Potential Soil Landscapes for the Pipeline

Soil Landscape	Characteristics	Areas Affected	Limitations
Residual Landscapes			
br- Brecon	Undulating rises to low hills on Carboniferous sediments Moderately deep well to imperfectly drained brown Soloths and yellow Soloths Some shallow Lithosols Deep well drained brown Podzolic Soils	Patterson Mountain and Clarencetown Hill region	Water erosion hazard Foundation hazard (highly plastic soils) Moderate shrink swell subsoils High run-on Seasonal water-logging
hba- Half Moon Brush (landscape variant)	Undulating to rolling ridge tops	As per hb	As per hb
ri- Rivermead	Moderately broad to extensive level to gently undulating alluvial terraces Well drained yellow Earths and red Earths Shallow imperfectly drained Brown Podzolic Soils Some Chocolate Soils and Brown Clays	Hunter Plains and Patterson Mountains region	High foundation hazard Localise flood hazard Seasonal water-logging (on imperfectly drained terraces)
wg- Wallalong	Undulating low hills on Permian Dalwood sediments Yellow and black Soloths Rapidly drained Lithosols Well drained Brown Podzolics and Yellow Podzolic Soils	East Maitland Hills Region	High water erosion hazard Foundation hazard High run-on (localised) Seasonal water logging (localised) Shallow soils (localised) with very high acidity and low fertility
wra-Williams River (landscape variant)	Narrow low level terrace deposits	As per wr	As per wr
kra – Karuah River	Narrow to moderately broad terraces	As per kr	Localise flood hazard Poor drainage Gully erosion risk Permanently high water tables (localised) Seasonal water logging Sheet erosion risk
Colluvial Landscapes			

Soil Landscape	Characteristics	Areas Affected	Limitations
gi- Gilmore Hill	Steep conical hills on Carboniferous sandstone and ignimbrites Bleached Loams/Lithosols Well to iperfectly drained yellow Soloths and Grey Earths	Clarencetown Region	Steep slopes Water erosion hazard Rock outcropping Foundation hazard Shallow, Stony, strongly acid soils of low fertility
hb- Half moon Brush	Rolling to steep hills on Carboniferous sediments Moderately deep well drained Earthy Loams and shallow structured loams Some yellow Soloths, Lithosols and well drained Yellow Podzolic Soils	Clarencetown Region	Steep Slopes Mass movement hazard Water erosion hazard Shallow stony soils
sea- Seaham (landscape variant)	Steep slopes with narrow rock benches	As per se	As per se
hh- Hungry Hill	Rolling to steep slopes on Carboniferous volcanics Rapidly drained Bleached Loams Some chocolate soils	Patterson Mountain Region	Steep slopes Mass movement hazard Shallow Stony soils Seasonal water logging on lower slopes and benches
gb – Gloucester Buckets	Rolling to very steep hills on Permian basic and acid volcanics and sediments Bleached Leptic Tenosols and classic Rudosols	Stroud – Gloucester Basin	Steep slopes Mass movement hazard Rockall hazard High sheet erosion risk Rock outcrop Shallow strongly acid stony soils of low fertility

Soil Landscape	Characteristics	Areas Affected	Limitations
lr – Lawlers Range	Steep hills on Carboniferous sediments Shallow well drained Bleached Leptic Tenosols Well drained Chernic-Leptic Tenosols Well drained Red Kandosols and Brown Kandosols	Monkerai Hills region	Steep slopes Mass movement hazard Rock outcrop Sheet erosion risk Shallow strongly acid stony soils of low fertility
wi – Williams Range	Steep hills and mountains on Carboniferous sediments Well to rapidly drained Bleached Leptic Tenosols Well drained Chernic-Leptic Tenosols Orthic Tenosols Well drained Red Kandosols Red Dermosols	Barrington – Chichester Mountains	Steep slopes High mass movement hazard High sheet erosion risk Shallow strongly acid stony soils of low fertility Potential aluminium toxicity
wia – Williams Range (landscape variant)	Dry exposed slopes with dry schlerophyll forests	As per wi	As per wi
wda – Wards River (landscape variant)	Slopes greater than 20%	As per wd	Mass movement hazard
Erosional Landscapes			
bh- Balwarra Heights	Rolling low hills on Permian sediments Well drained Yellow Podzolic Soils, Red Podzolic Soils, Brown Podzolic Soils and Lithosols	East Maitland Hills Region	Moderate foundation hazard Water erosion hazard High run-on (localised) Seasonal water logging (localised) Localised steep slopes with mass movement hazard
cl- Clarencetown	Undulating low hills on Carboniferous sediments Moderately well to imperfectly drained yellow Soloths Well drained Lithosols	Clarencetown Hills Region	Very high water erosion hazard Shallow soils Rock outcrop Seasonal water logging (localised) Stony acid soils of low fertility

Soil Landscape	Characteristics	Areas Affected	Limitations
gw- Glen Williams	Undulating low hills to gently undulating rises on Carboniferous volcanics and sediments Well to imperfectly drained Yellow Podzolic Soils Well drained Bleached Loams and Brown Podzolic Soils Some Yellow Podzolic Soils	East Maitland Hills Region	Water erosion hazard Foundation hazard (localised deep terrace soils) High run-on (localised) Seasonal water logging (localised) Shallow soils (localised) Strongly to extremely acid soils of low fertility and high potential aluminium toxicity with high sodic/dispersible sub soils
se- Seaham	Undulating low hills to rolling hills on Carboniferous sediments Well to imperfectly drained yellow and brown Soloths Some well drained Bleached Loams and Lithosols	Paterson Mountain Region	High water erosion hazard Shallow soils Rock outcrop (localised) Seasonal water logging and high run-on (localised) Strongly acid soils of low fertility
tma- Ten Mile Road (landscape variant)	Rolling low hills with slope gradients 10-20% on Carboniferous sediments and acid volcanics Well to imperfectly drained brown and yellow Soloths Bleached Loams / Lithosols	Medowie Lowlands and Clarence Hills Region	High water erosion hazard Localised shallow soils High run-on and seasonal water logging Strongly to extremely acid soils of low fertility
go – Gloucester	Undulating low hills on Permian sediments Moderately to well drained Brown Sodosols Grey Kurosols Well drained Bleached-Leptic Tenosols	Stroud – Gloucester Basin	Sheet erosion risk Gully erosion risk Seasonal water logging (lower slopes) Tree dieback Strong acid soils of high potential aluminium toxicity Low permeability Low fertility Low wet bearing strength High sodicity / dispersion

Soil Landscape	Characteristics	Areas Affected	Limitations
ma – Marshdale	Undulating to rolling hills and low hills on Carboniferous sediments Imperfectly drained Yellow Sodosols Well drained Bleached-Leptic Tenosols	Clarencetown Hills region	High sheet erosion risk High gully erosion risk High run on Seasonal water logging of lower slopes Strongly acid sodic dispersible soils of high erodibility Low fertility High aluminium toxicity
sr – Stroud Road	Rolling to undulating low hills on Permian Alum Mountain Volcanics Well drained Vertic Brown Dermosols Well drained Red Ferrosols Well drained Chernic - Leptic Tenosols Black Vertosols	Stroud – Gloucester Basin	High engineering hazard Gully erosion risk Mass movement hazard Steep slopes Seasonal water logging Sheet erosion risk Localised shallow soils and rock outcrop High shrink swell soils (localised) Strongly acid soils (localised) High fertility soils (localised) Low permeability soils (localised)
tm – Ten Mile Road	Undulating low hills with on Carboniferous sediments and acid volcanics Well to imperfectly drained brown and yellow Soloths Bleached Loams / Lithosols	Clarencetown Hills region	High water erosion hazard Localised shallow soils High run-on and seasonal water logging Strongly to extremely acid soils of low fertility
wr – Wards River	Rolling low hills on sediments of the Gloucester Coal Measures Imperfectly drained Brown Kurosols Moderately drained yellow and grey Kurosols Well drained Bleached Leptic Tenosols	Stroud – Gloucester Basin	High gully erosion risk High sheet erosion risk Rock outcrop (localised) High run on and seasonal water logging Steep slopes (localised) Very strongly acid highly erodible soils of very low fertility and

Soil Landscape	Characteristics	Areas Affected	Limitations
			high aluminium toxicity Shallow soils (localised)
Alluvial Landscapes			
hu- Hunter	Extensive alluvial plains or alluvium derived from the Hunter and Paterson Rivers Moderately well to imperfectly drained Prairie Soils Imperfectly to poorly drained Brown Clays Some well drained Chernozerms Well to imperfectly drained Alluvial Soils Well drained Siliceous Sands	Lower Hunter Plains Region	Flood hazard Foundation hazard Permanently high water tables (localised) Seasonal water logging (localised) Productive arable land and soils of high fertility
hub- Hunter (landscape variant)	Ox-bows recent overland deposits crevasse splays and broad levees	As per hu	As per hu
sc- Sandy Creek	Narrow alluvial plains on recent alluvium derived from Carboniferous sediments and volcanics Alluvial soils Moderately well drained Siliceous Sands	Paterson Mountains and Clarencetown Hills	Flood hazard Foundation hazard Permanently high water tables Seasonal water logging High run-on Water erosion hazard Groundwater pollution hazard Localised non-cohesive soils
wr- Williams River	Flat to gently undulating, narrow to moderately broad floodplains on recent alluvium Imperfectly to poorly drained alluvial soils and Prairie Soils Well drained alluvial soils on levee deposits and low terraces	Along the Williams River in the Clarencetown Hills Region	High Flood hazard Permanently high water tables Seasonal water logging Foundation hazard Water erosion hazard Very strongly acid soils of low fertility and potential aluminium toxicity

Soil Landscape	Characteristics	Areas Affected	Limitations
gua – Gloucester River (landscape variant)	Broad level alluvial plains derived from the Permian Alum Mountain Volcanics Brown Dermosols and Black Vertisols	As per gu	As per gu
Estuarine Landscapes			
bf- Bobs Farm	Broad interbarrier estuarine flat Very poorly drained Humic Gleys	Tomago Coastal Plain	Permanently high water tables Seasonal water logging Foundation hazard Flood hazard Potential Acid Sulfate Soils
fc- Fullerton Cove	Tidal flats and creeks in tidal inlets and estuaries Very poorly drained Solonchacks	Lower Hunter Plains and Medowie Lowlands	Flooding Wave erosion hazard Foundation hazard Saturated Saline Potential Acid Sulfate Soils
mf- Millers Forest	Extensive alluvial plains on recent sediments Imperfectly to poorly drained Prairie Soils	Lower Hunter Plains	Flood hazard Permanently high water tables Seasonal water logging Foundation hazard Low wet bearing strength soil
Transferral Landscapes			
wga- Wallalong (landscape variant)	Alluvial fans and drainage plains	As per wg	As per wg
cn –Craven	Low wide drainage depressions on Quaternary alluvium Imperfectly drained Natric Yellow Kurosols	Stroud Gloucester Basin	Severs gully erosion risk Potential discharge area High run on Dryland salinity High sheet erosion risk Seasonal water logging Poor drainage Flood hazard (localised) Strongly acid highly erodible sodic / dispersible soils

Soil Landscape	Characteristics	Areas Affected	Limitations
krb – Karuah River (landscape variant)	Alluvial fans	As per kr	As per kr
Swamp Landscapes			
hs- Hexham Swamp	Broad swampy estuarine backplains Waterlogged Humic Gleys	Hunter delta	Flood hazard Permanently high water tables Seasonal water logging Foundation hazard Ground water pollution hazard Localised tidal inundation Highly plastic Potential Acid Sulfate Soils of low fertility
Stagnant Alluvial Landscapes			
bc – Black Camp Creek	Low level terraces and valley flats on Quaternary alluvium derived from Carboniferous sediments Imperfectly drained Natric Brown Kurosols	Clarencetown Hills and Dungog Region	Flood hazard Seasonal water logging Sheet erosion risk Gully erosion risk Poor drainage and permanently high water tables (swamps) High run on (localised) Strongly acid soils of low fertility and low permeability
gu – Gloucester River	Broad level alluvial plains Imperfectly drained Yellow Chromosols Very poorly drained Redoxic Hydrosols	Stroud – Gloucester Basin	Flood hazard Seasonal water logging Poor drainage and permanently high water tables (swamps) Low permeability soils of low wet bearing strength

Table 1: Potential Soil Landscapes for the GFDA

Soil Landscape	Characteristics	Areas Affected	Limitations
Transferral Landscapes			

Soil Landscape	Characteristics	Areas Affected	Limitations
cn –Craven	Low wide drainage depressions on Quaternary alluvium Imperfectly drained Natric Yellow Kurosols	Stroud Gloucester Basin	Severs gully erosion risk Potential discharge area High run on Dryland salinity High sheet erosion risk Seasonal water logging Poor drainage Flood hazard (localised) Strongly acid highly erodible sodic / dispersible soils
cna – Craven (landscape variant)	Low gradient alluvial fans	As per cn	As per cn
Erosional Landscape			
go – Gloucester	Undulating low hills on Permian sediments Moderately to well drained Brown Sodosols Grey Kurosols Well drained Bleached-Leptic Tenosols	Stroud – Gloucester Basin	Sheet erosion risk Gully erosion risk Seasonal water logging (lower slopes) Tree dieback Strong acid soils of high potential aluminium toxicity Low permeability Low fertility Low wet bearing strength High sodicity / dispersion
Stagnant Alluvial			
gu – Gloucester River	Broad level alluvial plains Imperfectly drained Yellow Chromosols Very poorly drained Redoxic Hydrosols	Stroud – Gloucester Basin	Flood hazard Seasonal water logging Poor drainage and permanently high water tables (swamps) Low permeability soils of low wet bearing strength
Swamp Landscape			

Soil Landscape	Characteristics	Areas Affected	Limitations
cnb – Craven (landscape variant)	Narrow elongated swamps	As per cn	As per cn

Appendix K Heritage Assessment

Prepared for:

AGL

Level 8, 160 Queen Street
Melbourne, Vic, 3000

Gloucester Coal Seam Gas Project Environmental Assessment: Heritage

Gloucester to Hexham, NSW

Final

AECOM

15 September 2009

Document No.: S7003806_FNL_Heritage_15Sep09

Environment

AECOM

Distribution

Gloucester Coal Seam Gas Project Environmental Assessment: Heritage
Gloucester to Hexham, NSW

15 September 2009

Copies	Recipient	Copies	Recipient
1	**Stuart Galway** **Lands & Approvals Manager** **AGL** 22 Tate Street Gloucester NSW 2422		

By

ENSR Australia Pty Ltd (trading as AECOM)
ABN: 34 060 204 702
Level 5, 828 Pacific Highway Gordon NSW 2072
PO Box 726 Pymble NSW 2073
Ph: +61 2 8484 8999 Fax: +61 2 8484 8989

Rick Bullers
Senior Archaeologist

Technical Peer Reviewer:	Date:
	15/9/09
For **Neville Baker** Principal Archaeologist	

"This page has been left blank intentionally"

Contents

EXECUTIVE SUMMARY ES1

1.0 INTRODUCTION........ 1

1.1 Project Background 1

1.2 Aims........ 2

1.3 Study Area........ 2

1.4 Project Team 2

1.5 Report Structure 3

1.6 Limitations........ 3

2.0 EXISTING ENVIRONMENT........ 5

2.1 Environmental Context 5

2.1.1 Climate 5

2.1.2 Geology and Soils 5

2.1.3 Topography and Hydrology........ 6

2.1.4 Vegetation 7

2.1.5 Fauna 7

2.1.6 Summary of Environmental Conditions........ 7

2.2 Ethnohistoric Context 8

2.2.1 Aboriginal Occupation 8

2.3 European Occupation........ 12

2.4 Archaeological Background........ 13

2.4.1 Regional Context........ 13

2.4.2 Local Context 14

2.4.3 Predictive Model of Site Location........ 16

3.0 METHODOLOGY........ 19

3.1 Aboriginal Heritage Survey........ 19

3.1.1 Survey Areas and Sample Areas 19

3.2 Historic Heritage Survey........ 21

3.3 Specific Actions 21

3.4 Fieldwork Dates........ 22

3.4.1 Fieldwork – Phase 1........ 22

3.4.2 Fieldwork – Phase 2........ 22

4.0 ABORIGINAL COMMUNITY CONSULTATION 23

4.1 Stage 1 – Notification and Registration of Interest........ 23

4.2 Stage 2 – Briefing and Methodology Advice 24

4.3 Stage 3 – Fieldwork (Phase 1) 25

4.4 Stage 4 – Circulation of Draft Report........ 25

4.4.1 Comments: Awabakal Descendants Traditional Owners Aboriginal Corporation 25

4.4.2 Comments: Awabakal Traditional Owners Aboriginal Corporation........ 26

4.5 Stage 5 – Additional Fieldwork (Phase 2) 26

4.6 Stage 6 – Circulation of Amended Draft Report........ 27

4.6.1 Comments: Awabakal Descendants Traditional Owners Aboriginal Corporation 27

4.6.2 Comments: Awabakal Traditional Owners Aboriginal Corporation ... 27

5.0 ABORIGINAL HERITAGE RESULTS ... 29

5.1 Fieldwork Constraints and Opportunities ... 29

5.1.1 Effective Survey Coverage ... 29

5.2 Findings ... 31

5.3 Summary ... 34

5.4 Identified Aboriginal Cultural Heritage Sites ... 34

5.5 Identified Potential Archaeological Deposits ... 37

5.6 Discussion ... 40

5.7 Aboriginal Site Potential in Unsurveyed Areas ... 42

5.7.1 Unsurveyed Areas ... 42

5.7.2 Aboriginal Site Patterning ... 43

5.7.3 Aboriginal Site Predictions ... 43

6.0 HISTORIC HERITAGE RESULTS ... 45

6.1 Listed Historic Heritage Items in the Study Area ... 45

6.2 Historic Sites Identified in the Field Survey ... 46

6.3 Discussion ... 48

7.0 CULTURAL HERITAGE SIGNIFICANCE ... 49

7.1 Principles of Assessment ... 49

7.2 Aboriginal Cultural Heritage ... 49

7.2.1 Scientific Value ... 49

7.2.2 Educational Value ... 50

7.2.3 Cultural (Social) Value ... 50

7.2.4 Assessment ... 51

7.2.5 Overall Aboriginal Heritage Significance ... 53

7.3 Historic Heritage ... 53

7.3.1 Assessment Criteria ... 53

7.3.2 Significance Assessment of Unlisted Historic Items ... 54

8.0 IMPACT ASSESSMENT ... 57

8.1 Project Construction Details ... 57

8.1.1 The Field Area ... 57

8.1.2 Gas Pipeline ... 58

8.2 Impacted Area ... 58

8.3 Discussion ... 59

8.3.1 Scarred Trees ... 60

8.3.2 Open Sites ... 60

8.3.3 Historic Heritage ... 61

9.0 APPLICABLE POLICY AND LEGISLATION ... 63

9.1 Commonwealth Legislation ... 63

9.1.1 Aboriginal and Torres Strait Islander Heritage Protection Act 1984 ... 63

9.2 New South Wales Legislation ... 63

9.2.1 Environmental Planning and Assessment Act 1979 ... 63

9.2.2 Heritage Act (1977) ... 64

9.2.3 National Parks and Wildlife Act 1974 ... 64

9.3 Local Government 65
9.3.1 Gloucester Local Environmental Plan 2000 66
9.3.2 Great Lakes Local Environmental Plan 1996 66
9.3.3 Dungog Local Environmental Plan 2006 67
9.3.4 Port Stephens Local Environmental Plan 2000 67
9.3.5 Maitland Local Environmental Plan 1993 67
9.3.6 Newcastle Local Environmental Plan 2003 68
10.0 HERITAGE MANAGEMENT COMMITMENTS 69
10.1 General Heritage Management Commitments 69
10.2 Aboriginal Heritage Management 70
10.3 Historic Heritage 73
11.0 REFERENCES 75

List of Tables

Body Report

Table 1: AHIMS Registered Sites within the Search Area 15
Table 2: Survey Areas used for Identifying Targeted Sampling Areas 19
Table 3: Aboriginal Stakeholders identified for this Project 24
Table 4: Ground Surface Visibility Classes 30
Table 5: Effective Cover Classes 30
Table 6: New Site Types Identified within the Study Area 31
Table 7: Transects Conducted in Each LALC Area 31
Table 8: Sites Identified in Forster LALC Boundaries 32
Table 9: Sites Identified in Karuah LALC Boundaries 33
Table 10: Sites Identified in Worimi LALC Boundaries 33
Table 11: Sites Identified in Worimi LALC Boundaries 34
Table 12: Aboriginal Sites in Relation to Named Water Courses and Stream Order 40
Table 13: Number of Aboriginal Sites Showing Stream Order and Site Type 41
Table 14: Number of Aboriginal Site Types Identified at Increasing Distances to Water Sources 41
Table 15: Ground Visibility Ranking and Artefact Locations 41
Table 16: Historic Heritage Items Listed in the LGAs traversed by the Study Area 45
Table 17: Items within the Study Area listed on Heritage Instruments 45
Table 18: Significance Assessment of Aboriginal Sites Identified During the Field Survey 51
Table 19: Grades Used to Determine Heritage Value 54
Table 20: Significance Assessment of Unlisted Non-Indigenous Places Identified in the Field Survey 55
Table 21: Area Impacted by the Project (both CPF Options) 59
Table 22: Management Commitments for Aboriginal Heritage Sites within the Study Area 70
Table 23: Management Commitments for Potential Archaeological Deposits 72
Table 24: Management Requirements for Historic Items within the Study Area 73

Tables Section

Table T1: Transects Sampled and Effective Coverage
TableT2: Aboriginal Sites Identified During the Field Survey
TableT3: Potential Archaeological Deposits Identified During the Field Survey
Table T4: Historic Heritage Items Identified During the Field Survey

List of Plates

Body Report

Plate 1: A lithograph of Chief Boomerang of Dungog, NSW, c.1848 9
Plate 2: Oil Painting by Joseph Lycett of a Corroboree at Newcastle, c.1815-1825 10
Plate 3: Watercolour of an Aboriginal camp near Port Stephens, dated 1826 11
Plate 4: Image of Fred Ward, aka Captain Thunderbolt, artist/date unknown 13

Plates Section

Plate P1: Example of typical (0%) ground surface visibility (Transect 3 on Avon River)
Plate P2: Example of transect where ground surface visibility was <10%
Plate P3: Example of a large eroded exposure on the banks of a second order creek in Transect 21
Plate P4: The highly damaged scar on the trunk of a dead eucalypt at LEA1
Plate P5: Site view of LEA2. Artefacts are in the eroding bank of a gully draining into the Avon River. Looking NE
Plate P6: One of the grey mudstone flakes found at LEA2
Plate P7: Site view of LEA3. Artefact is on the downhill side of a long contour bank. Looking ENE
Plate P8: Small silcrete core found at LEA3
Plate P9: Site view of LEA4. The artefact is (was) laying beside the gate post. Looking south
Plate P10: A red fine-grained siliceous core found at LEA4
Plate P11: Site view of LEA5. The artefact is lying on the northern (uphill) side of this stump
Plate P12: Core found at LEA5
Plate P13: Location of LEA6. The two artefacts are located on either side of the small drainage line. Exposure is along a vehicle track fording the drainage line.
Plate P14: A white mudstone core found at LEA6
Plate P15: The unusual-shaped scar on a eucalypt tree beside Bottle Corner Gully at LEA7
Plate P16: Site view of LEA8 looking south east. Artefacts are located where the blue folder is lying.
Plate P17: Silcrete artefact found at LEA8
Plate P18: Site view of LEA9. Artefacts are on exposure in bottom left of picture. Looking NNE across ford over Deadmans Creek, next to Clarence Town Road.
Plate P19: Silcrete artefacts found at LEA9
Plate P20: The large eucalypt said to be emblazoned by Captain Thunderbolt.
Plate P21: Hut and Stockyards at LEH3
Plate P22: Stockyard at LEH4
Plate P23: Pile of bricks at LEH5
Plate P24: Hut at LEH6
Plate P25: Stockyards at LEH7
Plate P26: Bridge at LEH9
Plate P27: Bridge at LEH9
Plate P28: Mound at LEH10
Plate P29: Bridge at LEH11

List of Appendices

Appendix A AHIMS Search Results
Appendix B Aboriginal Community Consultation Log and Comments

Executive Summary

The following is a summary of the findings of this report:

- A review of the Aboriginal Heritage Information Management System (AHIMS) database administered by Department of Environment, Climate Change and Water (DECCW) suggest there are 13 previously recorded Aboriginal sites within the concept area and a 1,000 m wide pipeline buffer zone. However, only six sites occur within the study area – the field area and a 100 m wide pipeline corridor. Scrutiny of these records reveals that:
  - two sites (AHIMS #37-2-0336 and #37-2-0337) were erroneously identified as being in the study area near Clareval when they were, in fact, located in the Hunter Valley; they have since been destroyed under a s.90 permit;
  - two open campsites in the field area were not re-identified due to access restrictions (#38-1-0008 and #38-1-0031);
  - one, an isolated stone artefact at a reputed massacre site along the pipeline route was not re-identified during the survey; and
  - one, a Bora ground (#38-1-0006) was re-identified during the survey;
- three known but unrecorded Aboriginal sites, all isolated stone artefacts, occur in the field area, probably on Tiedman's Block;
- a total of nine previously unrecorded Aboriginal sites were identified during the field survey – two (possible) scarred trees, four low-density artefact scatters, and three isolated finds. Two are expected to be impacted by the proposal;
- a total of 14 potential archaeological deposits were identified during the survey. Five are expected to be impacted by the proposal;
- alternative routes were recommended to the proponent in order to minimise the potential for impacts to these sites;
- there are no indications at present that there are specific Aboriginal cultural (social) heritage values that would be affected by the development, except for the previously listed Bora ground (AHIMS #38-1-0006) and the reputed massacre site (#38-4-0010). However the pipeline alignment is not likely to physically impact these sites;
- there are no previously heritage-listed historic heritage items within the study area;
- there is one item that has been nominated for listing on the Register of the National Estate (RNE) – the Vale of Gloucester – but has not yet been formally registered. The field area component of the study area is located within a large tract of this item;
- a total of 11 items of potential historic heritage value were identified during the field survey. One of these is considered to be of local heritage significance and three exhibit features that may be of historic heritage value pending further research;
- on the basis of this assessment, it is considered the proposed development may encounter subsurface Aboriginal objects. It is recommended that the proponent prepare an Aboriginal Heritage Management Plan (AHMP) to manage the risk of impact to Aboriginal objects; and
- on the basis of this assessment, it is considered the proposed development is unlikely to encounter historic heritage relics.

"This page has been left blank intentionally"

1.0 Introduction

1.1 Project Background

ENSR Australia Pty Ltd (trading as AECOM) and hereafter referred to as AECOM was commissioned by AGL to manage the planning approval process and pre-construction Environmental Management Plans (EMPs) for the proposed coalbed methane gas extraction and transport system between Gloucester and Hexham, NSW (hereafter referred to as 'the project'). As part of the process, AECOM was tasked to prepare an Aboriginal and historic heritage assessment of the proposed gas field and pipeline corridor to inform an Environmental Assessment (EA) being prepared by AECOM on behalf of AGL. The EA is being prepared under Part 3A of the *Environmental Planning and Assessment Act 1979*.

The Concept Plan involves the development of plant and infrastructure for the extraction of coal seam gas (CSG) from the Gloucester Basin and transport to markets in the Newcastle and Sydney Regions. The Concept Plan includes the development of well sites and associated infrastructure within the Field Area. Concept Approval is being sought for a staged Gas Field Development within the Field Area, including development of wells, gas and water gathering lines, and associated infrastructure and activities.

Project Approval is being sought for the following components of the project (**Figure 1.1** in **Volume 4** of the EA):

- proposed well site locations within the Stage 1 GFDA of the Field Area, access roads, gas and water gathering systems and other associated infrastructure;
- construction and operation of the Central Processing Facility (CPF) in the Stage 1 GFDA; and
- construction and operation of a 103.5 km pipeline within a 100 m wide corridor from Stratford to Hexham[1].

The heritage assessment involved the survey and inspection of lands directly impacted by the project with particular emphasis on areas where ground impacts are expected.

Relevant legislation, summarised further in **Section 9.0**, is the *Environmental Planning and Assessment Act 1979*, *Heritage Act 1977* and the *National Parks and Wildlife Act 1974*. Relevant guidelines include the *Aboriginal Cultural Heritage: Standards & Guidelines Kit* (NPWS 1997) and the *Burra Charter* (Australia ICOMOS 1999). The Aboriginal consultation process for this project followed the *Interim Community Consultation Requirements for Applicants* (DEC 2004).

[1] The final length of the pipeline is not yet known as it depends on the final location for the CPF. Two CPF locations are currently being considered: one near Stratford on a property known as Tiedmans Block, and one immediately south of the Gloucester Coal rail loop. The pipeline will be 103.5 km to Tiedmans Block or 95.2 km to the rail loop. This report assumes the furthest pipeline length, i.e. 103.5 km.

1.2 Aims

The overall aim of this assessment was to identify the Aboriginal and historic heritage values of the project lands, identify potential development impacts on those values and provide suitable management recommendations. To achieve these aims the following objectives were established:

- to consult with the relevant local Aboriginal community groups regarding the specific social value of land in the study area;
- to understand the regional research context of any Aboriginal sites or objects, and any historic sites or items, in the study area;
- to identify documented Aboriginal heritage sites/objects and/or historic heritage sites within the study area;
- to identify and record any previously unrecorded Aboriginal sites and objects, and any historic sites or items within the study area;
- to assess the cultural significance of Aboriginal sites and objects in the study area in consultation with Aboriginal stakeholders;
- to assess the cultural significance of historic heritage sites and items in the study area; and
- to prepare recommendations on the management of Aboriginal and historic heritage values within the study area, when compared with the proposed development footprint.

1.3 Study Area

The project land, hereafter referred to as the 'study area,' is located between Gloucester and Hexham, NSW. It comprises the Stage 1 GFDA and the 103.5 km pipeline corridor, to a width of 100 m, from a CPF located in the vicinity of Stratford to the Hexham Delivery Station near Newcastle. Initially, a 1,000 m wide buffer zone was established along the corridor route to allow for amendments to the pipeline route. The pipeline corridor follows existing service easements where possible. The study area consists of mainly pastoral grazing land, but includes parts of the Karuah River, Williams River, and the Hunter River and numerous creeks and water courses.

1.4 Project Team

The Project Team consists of archaeologists and other specialists from AECOM, and representatives of the local Aboriginal community. Ruth Baker (AECOM Principal Environmental Scientist) directed the EA project and provided QA for this report. Neville Baker (AECOM Principal Archaeologist) directed the heritage assessment project and provided technical review of this report. Rick Bullers (AECOM Senior Archaeologist) managed the heritage assessment project, conducted the fieldwork and was principal author of this report. Leigh Bate and Geordie Oakes (AECOM Archaeologists) assisted with the fieldwork and co-authored the report. Medard Boutry (AECOM Heritage Consultant) conducted background research. Lee-Anne Bishop and Tim Osborne provided administrative and drafting support. Stuart Galway (AGL, Land & Approvals Manager) was the client's representative.

1.5 Report Structure

The report structure relates to the sections of the report and their contribution to the study.

- **Section 2.0** provides environmental and archaeological contextual information;
- **Section 3.0** describes the assessment methodology employed;
- **Section 4.0** describes the methodology and results of consultation with the Aboriginal community;
- **Section 5.0** lists the Aboriginal sites and objects identified in the study area, and discusses the results of the field survey;
- **Section 6.0** lists the historic heritage sites and items identified in the study area, and discusses the results of the field survey;
- **Section 7.0** discusses the significance values within the study area;
- **Section 8.0** discusses the potential impacts associated with the development;
- **Section 9.0** describes legislation guiding Aboriginal and historic heritage management; and
- **Section 10.0** provides succinct management recommendations regarding the Aboriginal and historic heritage values of the study area.

1.6 Limitations

Predictions have been made about the probability of subsurface archaeological materials occurring within the study area. It is possible that materials may occur in any landscape context, and the assessment of subsurface materials refers to the likelihood of occurrence based on surface indications and environmental context.

AECOM has undertaken a search of the Aboriginal Heritage Information Management System (AHIMS) held by Department of Environment, Climate Change and Water (DECCW). The search results are provided in **Appendix B**. Register searches are constrained by the amount of data in the register and the quality of that data (for example grid references can be inaccurate). Large areas of NSW may not have been systematically searched and may contain Aboriginal objects and other heritage values not recorded on AHIMS. Additionally, the AHIMS reports database can only be searched by the title of the report, which may not indicate the geographical location of the area covered. This means that it is possible that some known sites and some reports may have been omitted from this study. Sites and reports are regularly added and removed from AHIMS and therefore the accuracy of information provided from AHIMS is only valid on the day the register is searched.

A summary of the statutory requirements regarding Aboriginal and historic heritage is provided in **Section 9.0**. This is provided based on experience with the heritage system in NSW and does not purport to be legal advice. It should be noted that legislation, regulations and guidelines change over time, and users of the report should satisfy themselves that the statutory requirements have not changed since the report was written.

"This page has been left blank intentionally"

2.0 Existing Environment

2.1 Environmental Context

An analysis of the natural resources available in a region are used to aid investigations of Aboriginal heritage to gain an understanding of the environmental conditions faced by hunter-gather societies, and consequently, the range of cultural remains that may be expected. Natural resources include the flora and fauna that may have provided food and material resources, and are linked to the hydrology, geology and soil types in a region.

Water availability is a major influence on the intensity of Aboriginal occupation and evidence, usually in the form of flaked stone artefacts, is often associated with permanent or semi-permanent water sources.

Soil types are influential as accumulating sediments can cover cultural remains while areas of sediment removal through erosion can either uncover buried archaeological material or transport small items away from the original depositional context. Soil analysis has important ramifications for archaeological research through the potential impact of different soils on human activity (such as agricultural exploitation) and the impact of the soils on archaeological evidence (such as post-depositional movement). The soils known to occur throughout the study area are identified here in order to delineate their nature and impact on the survival and location of archaeological material.

A detailed description of archaeological and historical evidence is also presented below to further analyse and interpret the spatial distribution and likelihood of archaeological material occurring within the study area.

Information on the geology, soil landscapes and topography in the region is presented below. This data was used in the development of the fieldwork methodology and discussion on the results of the field inspection at the end of this report.

2.1.1 Climate

The climate between the Gloucester and Hexham region is variable, with temperatures ranging from 0-15°C in the winter months to 25-42°C during summer. The region is prone to protracted periods of dry weather, particularly in summer. Rainfall, particularly in the southern regions around Hexham, is variable and largely affected by coastal patterns. Rainfall in the northern regions around Gloucester is influenced by the mountainous terrain. The average rainfall in the Barrington Tops area is 2,500 mm, with the average in the southern areas being 900-1,000 mm (Bureau of Meteorology 2008). In the mountains far north of the area the climate is at times sub-alpine with snow not uncommon during the winter months.

2.1.2 Geology and Soils

The soils of the NSW North Coast region reflect the geology on which they lie and the local topography. Generally the soils are sandy in areas of sedimentary and quartz rich geology and highly fertile loams occur over basalts.

The soil types that are most common along the pipeline route are typically yellow podzolic, erosional and colluvial with alluvial plains (Floodplains/Terraces and Coastal Alluvial Plains). The topsoil textures range from loamy sand through to clay loam (Gay 2000: 9). The depth of the A-horizon ranges from 0.2 metres on the slopes and ridges to 0.5 meters in the alluvium (Stratford Coal EIS 1994: 2-3).

The NSW North Coast region principally consists of Devonian and Permian age bedrock that is a part of the New England Fold Belt. The bedrock of this region has been closely faulted as it was thrust over the northern margin of the Sydney Basin. The Great Escarpment was created by erosion from rivers and steams formed around 80-100 million years ago. The chief rock types that encompass the NSW North Coast geology are slates, shales, phyllite, quartzites, carboniferous mudstones, claystones and sandstones lithic to quartz (AHMS 2008: 163).

The study area lies on the Permian Craven Coal measures which surrounds the Hunter Valley lowlands. These form part of the Stroud-Gloucester Syncline consisting of conglomerate, sandstone, mudstone, arkose and coal (Newcastle 1:250,000 Geological Series S1-56-2).

2.1.3 Topography and Hydrology

The study area traverses a range of major river valleys from the Avon River valley at the northern end, through the Wards River, Karuah River, Williams River and Hunter River valleys, to Hexham in the south. Many ephemeral, semi-permanent or permanent watercourses flow through the study area. The major watercourses have headwaters in the hills and mountains to the east and west of the valley lowlands. The major rivers that the proposed pipeline crosses are the Karuah, Williams and Hunter Rivers, with a range of first- through to fourth-order watercourses along the route.

Watercourses in the study area were assessed using the Strahler system of stream order classification. In the Strahler system a watercourse segment with no tributaries is designated a first-order segment. A second-order segment is formed by the joining of two first-order segments, a third-order segment is formed by the joining of two second-order segments and so on. With the Strahler system, there is no increase in stream order when a segment of one order is joined by another of a lower order. A first-order creek, being ephemeral and little more than a drainage line, increases to a fourth-order creek, which carries a larger amount of water.

One of the major watercourses that flow along the western boundary of the field area is Dog Trap Creek. A second major watercourse is Waukivory Creek, which runs from the eastern boundary of the field area across to the western boundary. Both creeks drain into the Avon River, which also runs the length of the field area’s western boundary.

Black Camp Creek is a major creek line that follows large portion of the pipeline route. It commences as a series of first-order streams west of Stroud in the north and flows southwards becoming progressively larger before flowing into to the Williams River near Glen Martin as a fourth-order plus stream.

There are several major inland landscape features of the NSW North Coast which include low foothills and ridges and valleys that run into the steep slopes and gorges of the Great Escarpment. The fault lines in the area control the structural patterning of these features. The foothills of the Great Escarpment have steep slopes with relief up to 750 m, where as the narrow alluvial plains have relief of up to 250 m (AHMS 2008: 162).

2.1.4 Vegetation

The study area consists of a combination of cleared land for grazing, agriculture, and currently consists of thick layers of grassland communities. The area is undergoing a rapid and continual change from its former rural use to hobby farming and urban residential use. Uncleared bushland remains on steeper slopes and in isolated pockets, largely along water courses. The study area has a diverse range of plant species, which correspond to the different soil substrates, the topographic variation and the climatic differences encountered across the region.

Eucalypt forests grow on soils derived from granites. The dominant species include blackbutt (*Eucalyptus pilularis*), Sydney blue gum (*E. saligna*), spotted gum (*E. maculata*), grey gum (*E. punctata*), forest red gum (*Eucalyptus tereticornis*), red bloodwood (*Corymbia gummifera*), brush box (*Tristania conferta*) and white mahogany (*E. acmenoides*) (AHMS 2008: 165).

In areas of dry, open flats, the vegetation community consists of white gum, blackbutt (*E. pilularis*), forest red gum (*E. tereticornis*) and grey box. In the hills of valleys and ranges, dry sclerophyll forests and woodlands of spotted gum, grey gum, blackbutt, red bloodwood and white mahogany (AHMS 2008: 165).

2.1.5 Fauna

The Atlas of NSW Wildlife lists 479 faunal species located within the Local Government Areas of Gloucester, Dungog and Maitland. Species recorded includes 45 species of amphibians, 58 species of reptiles, 93 species of mammal and 283 species of birds, although 10 bird species, 15 mammal species and one reptile species are introduced and were not an available food resource for pre-Colonial hunter-gatherers.

Common species include swamp wallaby (*Wallabia bicolor*), kangaroo (*Macropus* sp.), short-beaked echidna (*Tachyglossus aculeatus*), yellow-bellied glider (*Petauroides australis*), spotted-tail quoll (*Dasyurus maculatus.*), flying fox (*Pteropus sp.*), common ring-tailed possum (*P. peregrinus*), common brush-tailed possum (*Trichosurus vulpecula*), platypus (*Ornithorhynchus anatinus*), northern brown bandicoot *(Isoodon macrourus*), Gould's wattled bat (*Chalinolobus gouldii*), common wombats (*Vombatus ursinus.*), various marine mammals (whales, dolphins and seals), eastern water dragon (*Physignathus lesueurii*) and red-bellied black snake (*Pseudechis prophyriacus*).

The composition of marine and estuarine fish, crustacean and mollusc species is not known, but is presumed to have been fairly abundant, particularly in the Lower Hunter region, and available as a food source to the coastal people inhabiting the area prior to European settlement.

2.1.6 Summary of Environmental Conditions

Climatic conditions between the Gloucester and Hexham areas are generally mild. Within this area there are several climatic zones. The coast is generally sub-tropical consisting of hot summers, sub-humid on the slopes and a temperate with warm summers and no dry season in the uplands (AHMS 2008: 162). Rainfall is generally higher and more reliable in summer but, because soil moisture availability tends to remain high throughout the year, the area experiences good conditions for ground cover growth and a low risk of erosion from climatic causes.

Although the current flora and fauna inhabiting the study area is not necessarily representative of the range and quantity present prior to European settlement, the composition of flora and fauna species present are indicative that there were probably sufficient resources to support a moderate-sized population of hunter-gatherers throughout the study area.

The relatively abundant water resources and reliable rainfall also provided suitable conditions for European settlement. The area was settled fairly early in the Colony's history (**Section 2.2.2**) by the Australian Agricultural Company (AA Company), who recognised the region's potential for agricultural production.

2.2 Ethnohistoric Context

A discussion on the ethnographic context of the study area will provide a social context for understanding the heritage significance of Aboriginal and historic sites.

2.2.1 Aboriginal Occupation

Prior to European settlement, the study area was inhabited by people of three Aboriginal language groups (Aus Anthrop 2008):

1. The far northern section of the study area was occupied by people of the Birpai language group, also known in the various literature as Biribay, Biribi, Birippi, Birrapee, Birripai, Birripi, Bripi, Brippai and Waw-wyper. According to Tindale (1974: 192) this territory covered an area of some 7,300 square km, extending from the Manning River at Taree south to Cape Hawke (near Forster) on the coast, and inland to the dividing range around Gloucester in the south west and the head of the Hastings River in the northwest.
2. The majority of the study area was inhabited by people of the Worimi language group (Warrimee, Warramie, Gadang, Kattang (language name), Kutthung, Guttahn, Cottong, Wattung, Watthungk, Kutthack, Gingai, Gringai, Gooreenggai and Port Stephens tribe). This language group covered a relatively small area of some 3,900 square kilometres along the NSW coast which, according to Tindale (1974: map supplements), extended from Hunter River to Forster near Cape Hawke along coast; at Port Stephens; inland to near Gresford; about Glendon Brook, Dungog, head of Myall Creek and south to Maitland.
3. The far southern section of the study area was inhabited by people of the Awabakal language group (Awaba, Awabagal, Awabakal, Kuri Kuringgai, Lake Macquarie tribe, Minyowa (horde at Newcastle), Minyowie and Newcastle tribe). The Awabakal lands were relatively small (1,800 sq km), abutting the southern boundary of the Worimi and extended southwards to around Norah Head near Wyong (Tindale 1974).

Traditional Aboriginal groups were self sufficient, highly mobile bands of hunter gatherers (Mulvaney & Kamminga 1999: 79). The degree of mobility depended on the environment, seasonality and ceremonial movement. It was generally in areas where resources were scarce that groups moved around more frequently and broadly. Conversely, areas of abundance generated less frequent movement, within narrower corridors.

Both Tindale (1974) and Elkin (1932: 359) agree that the Hunter River formed the natural boundary for the Worimi and the neighbouring Awabakal to the south. However Enright (1932: 75) believed that the Worimi lands extended south to Norah Head (covering the Awabakal lands), which highlights the inherent difficulties on defining pre-European distribution of Aboriginal people using ethnographic data alone.

A limited amount of contemporary ethnographic material was collected on the traditional life of the Birpai, Worimi and Awabakal people. Details of the social structure of the Birpai, Worimi and Awabakal are rather ambiguous, as many of these systems had broken down by the time they were recorded (Brayshaw 1987: 36). Each of the groups formed separate closed social networks, differentiated by dialect and totemic beliefs (Ramsland 2001: 16). The economy of the Birpai, Worimi and Awabakal was similar to other coastal and hinterland groups in New South Wales, with a reliance on a staple food source while exploiting other seasonal resources.

Each group consisted of a number of self-governing territorial units known as 'hordes', of about 50 members from several families (Ramsland 2001: 16; Brayshaw 1987: 36; Sokoloff 1980: 3). Elkin (1932) lists four local Worimi groups, Garuagal, Maiangal, Gamipingal, and Burai-gal, the last-named probably being the same as Bahree. Some of the horde-like names listed by Mathews (1897, in Tindale 1974), including Bahree, probably belong to this and adjoining tribes.

Spiritual authority for the Aboriginal peoples of south-eastern Australia was vested in a large number of supernatural beings, but there was a common belief in an All-Father sky deity who held various names. To people of much of inland NSW he was *Baayama* or *Biame* ('The Great Shaper,' 'Thunder-God' or 'Great One'), who formed the world by shaping the cosmos from a pre-existing primeval void (O'Rourke 1997: 173). To the peoples of the Central Coast, he was *Daramalan* or *Goin*. These deities were said to be able to return to earth to punish transgressors of marriage rules, and could also return during certain initiation rituals (Berndt 1947: 334-336).

Plate 1: A lithograph of Chief Boomerang of Dungog, NSW, c.1848

National Library of Australia, nla.pic-an8152989

Ceremonial customs differed from one Aboriginal nation to the next. However Bora[2] ceremonies were generally associated with Biame, and involved ritual practice including law, dance, scarification and other bodily modification (AHMS 2008: 48; Attenbrow 2003: 126-128) (**Plate 2**). Bora grounds are typically either a single circle constructed of mounded earth, or two circles joined by a smoothed pathway (Brayshaw 1987: 86). It has been noted of the Birpai that at some Bora ceremonies any hostility or animosity between hordes would cease for the duration of the ceremony (Ramsland 2001: 16).

Plate 2: Oil Painting by Joseph Lycett of a Corroboree at Newcastle, c.1815-1825
National Library of Australia, enhancement of image DG 228

Burials were the main method of disposing of the dead, although some cremations have been found on Worimi land. In the case of burials the cadaver was placed into a pit in the ground, covered in bark, and then covered in soil, so the location of the grave is not clearly visible on the surface (Brayshaw 1987: 86).

According to Sokoloff (1980: 30) accounts of shelters built by the Worimi indicate the local people built a variety of structures, depending on the availability of material and the period of residence and could be either simple shelters of a few sheets of bark leaning on a pole against a tree or fallen log, or slightly more elaborate using forked sticks, tied together, and covered in bark sheets (**Plate 3**).

[2] Bora is the name given to both a male initiation ceremony and the site on which it was performed.

Plate 3: Watercolour of an Aboriginal camp near Port Stephens, dated 1826
National Library of Australia, nla.pic-an2818328

The equipment used by the Birpai, Worimi and Awabakal was often light weight and portable and made from stone, wood, shell, bone and skin (Kuskie 2004). These included stone tools and hatchets, clubs, spears, boomerangs, drinking vessels, net bags, nullas, yam sticks, canoes, fishing lines, nets, shell hooks and Gunyahs, which were small huts made from bark and tree branches (Ramsland 2001: 17; Kuskie 2004; Brayshaw 1987: 76). To exploit the marine resources, and to cross rivers, the Worimi built canoes from a single sheet of carefully selected stringybark (*Eucalyptus obliqua*), tied together at the ends and daubed with clay to make it watertight (Sokoloff 1980: 31-32).

The population of the region at the time of contact is not known, but it would be fair to surmise a relatively dense population, as there are numerous reports of large gatherings of Aborigines, including a Birpai bora ceremony with over 500 attendees (Ramsland 2001: 16). This intense level of occupation appears to date only to the last 4,000 years, following the stabilisation of coastline, but colonisation may extend back to 30 – 40,000 years BP (Kuskie and Kamminga 2000 in Kuskie 2004: 19). There is however, few landscape contexts that exist in which archaeological evidence of older occupation would be conserved.

Brayshaw (1987: 74-82) presented an extensive list of subsistence resources used by the Worimi, many of which would most likely have been exploited by the Birpai and Awabakal. These include *Zamia spiralis* seeds once they had been soaked for several weeks in a creek, then pounded and roasted, grasses, roots and tubers, giant lily (*Doryanthus excelsa*), ferns, macropods, possum, bandicoot, eels and fish, echidnas, emus and other avifauna, goanna, snakes and honey (Brayshaw 1987).

Movement around each territory may have been influenced by the seasonal availability of certain resources (Kuskie and Kamminga 2000 in Kuskie 2004: 19). Men were responsible for catching larger game, sometimes using large groups to corner macropods before killing them, or even using a narcotic made from Acacia bark to poison waterholes to catch fish (Brayshaw 1987: 79; Sokoloff 1980: 10). Women were responsible for catching smaller game and collecting plant resources (Sokoloff 1980: 8).

By 1818 European settlement extended as far north as the Hunter Valley and brought a period of decline in Aboriginal population numbers, largely due to the smallpox pandemic that caused an unknown number of deaths between 1830 and 1832. Due to the cumulative affect of interference, disease, displacement and conflict, Aboriginal populations all over NSW began to diminish noticeably around this time. The traditional life of the Awabakal and Worimi were also affected by the creation of the port of Newcastle on the Hunter River in the late 18th century, while the Biripai were affected more by the arrival of the cedar cutters and farmers in the early 19th century (Ramsland 2001: 25).

2.3 European Occupation

Europeans first settled the Newcastle region in 1804 when a convict settlement was established. By 1819 Newcastle had outlived its usefulness as a convict prison and Governor Lachlan Macquarie decided to find a suitable location to move the prison. An influx of free settlers into the Newcastle area and the prison being deemed to be too close to Sydney were the main reasons that the prison was moved to an alternate location (AHMS 2008: 65). However the greater Hunter Valley was still closed to free settlement up until 1825 because of its close proximity to the Newcastle penal colony.

The Australian Agricultural (AA) Company was incorporated in London in 1824 following negotiations with the British Government for a grant of 1 million acres of land in New South Wales on the condition that certain sums of money should be expended in the development and improvement of the land so granted (Sands 1925). In 1826 the Chief Agent for the AA Company, Robert Dawson, explored the Karuah River valley, naming places as he travelled.

Dawson continued to follow the valley north, arriving where Gloucester now stands in November 1826. As the land appeared ideal for grazing and agriculture early settlement was encouraged. An outpost at Stroud was settled by the AA Company in 1827. By 1832 Stroud had become a self-contained village and as early as 1836, the company's storehouses and much of the convict labour force were located there. By 1850, it had become the company's headquarters.

By the end of the 19th century the AA Company began to sell off land. A development company, Gloucester Estate Limited, purchased land in the Gloucester area for twelve shillings and sixpence per acre. Subdivision and good promotion by Gloucester Estate Limited resulted in rapid growth with land selling between twenty shillings and five pounds an acre by the end of 1903.

Hexham was first settled during the 1820s. Originally Hexham was sited in the Ironbark Creek area where the Church of England was built in 1849, but the village was moved to the north with the opening of the railway which shipped coal from the Minmi mines (Suters Architects 1997 in AHMS 2008: 40). It was named after the town of Hexham in England, as its nexus with Newcastle and the Hunter River mirrored the link between the city of Newcastle-on-Tyne and its historic neighbour, Hexham.

Maitland itself was not established until 1833, but by this time Europeans had been in the region for more than a decade. Their impacts on the land and on Aboriginal populations were pervasive and long-lasting, with the introduction of new animals, crops, commodities, customs and diseases. Change saw the displacement of Aboriginal populations and landscapes totally altered to accommodate European farming and industrial practices. It is only through the writings of L.E. Threlkeld (Gunson 1974) that Aboriginal society at European contact has been recorded and known to us today. Threlkeld was a missionary residing in the lake Macquarie area who made detailed and careful observations on Aboriginal customs, language, lifestyles, and social boundaries of the Lower Hunter and Newcastle regions (ENSR 2008).

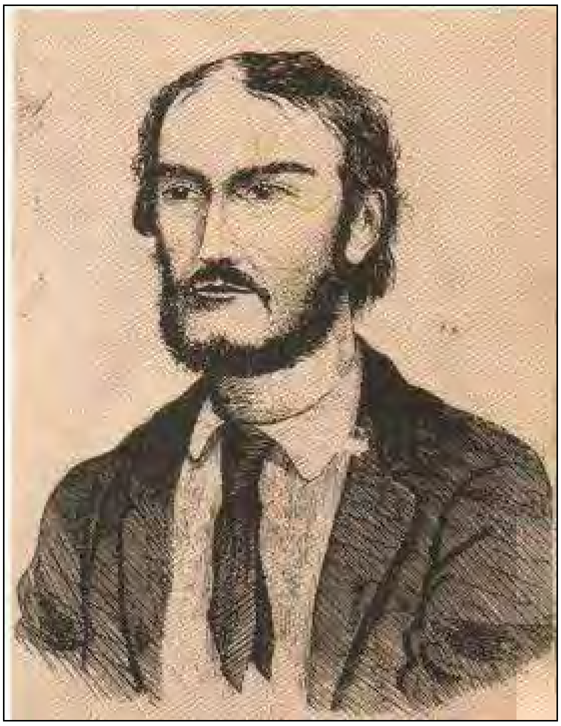


Plate 4: Image of Fred Ward, aka Captain Thunderbolt, artist/date unknown
http://dreamsis29.tripod.com/AboutThunderbolt.htm

There were two notorious figures in the history of the Upper Hunter Valley from the mid 1850s, a bushranger named Captain Thunderbolt (real name Fred Ward) and his partner Maitland Aborigine Mary Ann Bugg. The famed horse thief and bushranger was on the run for almost 20 years, operating in the Hunter Valley, Liverpool Plains and central NSW (Blyton et al 2004: 36-41). In 1866 he held up a hotel in Gunnedah and for the next year conducted a series of robberies of stations and mail coaches in the Barraba-Manilla districts. Thunderbolt was shot dead by Constable Alexander Walker during a highway robbery at Uralla on 25 May 1870. Captain Thunderbolt was acknowledged as the most successful and the last of the 'professional' bushrangers' (Openheimer, 1992: 92-107). Historic places relating to Captain Thunderbolt can be found throughout the region, including the study area.

2.4 Archaeological Background

The archaeological background section outlines the known Aboriginal sites in the region and provides a review of previous studies undertaken in the area. This section will provide a synthesis, which has been used in subsequent site prediction methods.

2.4.1 Regional Context

There have been relatively few archaeological surveys carried out in the lowlands of the Gloucester – Stroud region. Surveys include lands along Bucketts Way between Gloucester and Stratford (Griffith 1992), the Wards River area (Brayshaw 1981), and the Karuah River at Stroud (Appleton 1993). No Aboriginal sites were identified during these surveys.

Brayshaw (1984) conducted a survey of lands between Craven and Dog Trap Creek prior to the development of the Stratford Mine. Two sites – a low density artefact scatter and an isolated find – were located on footslopes 500 m south east of the end of Parkers Road. The artefact scatter was located on the edge of an ephemeral water course and was assessed as having low scientific/archaeological significance. Another three sites were located in the region during a survey as part of the Stratford Mine EIS (Brayshaw & Byrne 1994). Again, these were low density artefact scatters or isolated finds located in association with first order ephemeral creeks. Another site was located by Gay (2000) adjacent to an ephemeral water course 400 m east of Avondale Creek on the Stratford Mine lease area. This site was an isolated find of a single stone artefact.

From these studies, it is apparent that the most common Aboriginal site type to be found in the region are low density open sites consisting of stone artefact scatters or isolated finds, most likely in association with ephemeral or permanent water sources. The small number of surveys in the region reflect the minimal development that has occurred in the Gloucester region, and the low number of objects located is probably related to the generally low ground surface visibility due to good pasture growth in reliable rainfall areas.

Further south, the higher density development in the Lower Hunter Valley has seen a much broader level of archaeological research. Artefact scatters and isolated finds have been the most frequently recorded site types (Kuskie 2004: 23). To a lesser degree axe-grinding grooves, middens, bora/ceremonial sites, burials, scarred trees, stone arrangements, rock shelters with art, fish traps and places of historic or traditional Aboriginal significance have been located in the lower Hunter Valley.

Kuskie (2004) believes that most sites within the lower Hunter are typically artefact scatters, containing less than ten artefacts, occurring at a low density and situated within close proximity to drainage lines. Past investigations also demonstrate that occupation was also focused along the margins of the wetlands.

A test excavation program undertaken by Silcox and Ruig (1995: 36) around the margins of the Hexham Wetlands demonstrated that archaeological material was widespread and occurred in silcrete concentrations of varying sizes and density, separated by stretches of ground where much lower artefact numbers were present. This shows the possibility of higher densities of artefacts sharing an association with the location of specific activity areas. But this does not mean that areas of low artefact numbers were not on the perimeter of high density areas. It is more than likely, however, that when a continuous series of test pits have been dug and a low density is consistent, this is taken as a sign that the distribution pattern does not consist of widely spaced discrete concentrations.

Therefore, research indicates that stone artefact scatters are the predominant archaeological site type in this region, typically buried within the upper soil horizon, manufactured mostly from silcrete or mudstone. Smaller proportions of stone artefact assemblages are of quartz, petrified wood and other igneous material.

2.4.2 Local Context

A search of the Department of Environment, Climate Change and Water's (DECCW) Aboriginal Heritage Information Management System (AHIMS) database suggest that there are 13 registered Aboriginal sites within the 331 km² search area of the pipeline corridor and concept area (**Table 1** and **Figures 19.1** to **19.16** in **Volume 4** of the EA). These sites were plotted onto a map of the study area, revealing that out of the 13 registered sites, there were six sites of interest: four within a 100 m wide buffer corridor of the pipeline (i.e. potentially within the path of the proposed construction) and two in the field area.

One of the sites within the pipeline buffer zone (AHIMS #37-2-0336) and another site (AHIMS #37-2-0337) have erroneous positions recorded in AHIMS. These sites were recorded within the Mt Arthur Coal Mine Lease Area in the Hunter Valley; they are not within this study area. They have since been destroyed during a previous development pursuant to a Section 90 consent to destroy under the *National Parks and Wildlife Act 1974*.

Of the remaining sites within the pipeline corridor (AHIMS #38-1-0006) was re-identified during the survey, although an error in coordinate recording shows the site to be further south than it actually is (**Figures 19.1** to **19.16** in **Volume 4** of the EA). Further south, an isolated stone artefact site (AHIMS #38-4-0010) is recorded on the banks of Little Black Camp Creek. This site is recorded in AHIMS as where a massacre took place. It was formerly recorded as an "Aboriginal Place", but this reference was removed on 6 November 1997 because the site is not a formally declared Aboriginal Place. This site was not re-identified during the survey, except for the general locality.

The sites within the field area (AHIMS #38-1-0008 and 38-1-0031) were not re-identified during this survey due to access restrictions on the Stratford Coal Mine Lease.

Table 1: AHIMS Registered Sites within the Search Area

Site No.	Site name	MGA Easting*	MGA Northing*	Site type
37-2-0336*	MAN 31; Mt Arthur North	398805	6422089	Open Camp Site
37-2-0337*	MAN 32; Mt Arthur North	398805	6421989	Open Camp Site
37-1-0003	Gloucester	402159	6457785	Open Camp Site
38-1-0006*	Washpool Bridge	397765**	6417239**	Bora Ring Site
38-1-0008#	Craven; Parkers Road	402995	6442779	Bora/Ceremonial
38-1-0010*	Little Black Camp Creek	391085	6404939	Aboriginal Place – removed 6 Nov 1997
38-1-0027	Honey Scarred Tree	401305	6425989	Open Camp Site, Scarred Tree
38-1-0031#	Isolated find No.1	402505	6446814	None (not defined)
38-1-0033	Honey Tree (002)	401265	6426489	None (not defined)
38-4-0148	Kanwarry	377455	6379769	Isolated Find: Aboriginal Place – removed 6 Nov 1997
38-4-0151	Green rocks	377475	6378159	Midden
38-4-0325	Tarro	375005	6368939	Isolated Find
38-4-1027	LimeBurner Creek Rd	387284	6394519	Isolated Find

* AHIMS registered sites within the 100 m wide the pipeline corridor.

** Corrected MGA coordinates. The coordinates in AHIMS (397660E 6417050N) are erroneous.

AHIMS registered sites within the field area.

In addition to the sites registered in AHIMS, there are several other known sites in the study area. In 2007 the Forster Local Aboriginal Land Council was requested to carry out an Aboriginal heritage assessment, in association with archaeologist Allan Lance, of a parcel of land near Stratford for the Stratford Pilot Project (FLALC 2007). During the survey three stone artefacts – each an isolated find – were identified. A small stone artefact, found 150 m from a watercourse, and another stone artefact, found on a ridgeline, suggests that the ridgeline was used as a walking track (FLALC 2007: 6). These sites have not yet been recorded in AHIMS. The FLALC report does not provide a specific location for any of the sites they found; however, it appears that the sites were found in the vicinity of Dog Trap Creek, probably on the property known as Tiedman's block, where gas wells have already been established under the pilot project.

2.4.3 Predictive Model of Site Location

Material evidence of Aboriginal occupation is one of the main indicators of the significance of an area to the Aboriginal community. Such physical evidence is the basis upon which archaeology operates. Physical signs of Aboriginal occupation vary in type, location and extent. However, from current knowledge of the Aboriginal occupation in the Gloucester to Hexham region, it is possible to draw predictions regarding the likelihood of finding sites in the study area. The predictive modelling in this project used a combination of desktop reviews of previous surveys in the region with existing Aboriginal site data. This was followed by a physical inspection of the study area to verify those sites and to locate and record any new sites.

There are several factors that can affect or constrain where Aboriginal people are most likely to have been, where they have left evidence of their activities and/or the degree to which that evidence might be observable in the present material record. Such constraints for Aboriginal people are largely environmental factors such as availability of permanent or ephemeral water, availability of food resources, availability of material resources (e.g. suitable rock sources) and shelter from sun, wind or rain. However, appropriate geomorphological attributes also contribute to site preservation. The interplay of these factors allows certain types of material culture evidence to be retained in the environment.

The potential for finding Aboriginal sites in the study area can be summarised as follows:

1 ***Stone artefacts***: stone artefact sites may occur as either single artefacts (or 'isolated finds') or as 'artefact scatters,' which are generally defined as two or more artefacts within 50 m of each other, or a concentration of artefacts at a higher density than the surrounding 'background scatter.'

Artefact scatters can represent evidence of camp sites, hunting or gathering events, event sites (such as stone tool manufacture) or as transitory movement through the landscape. An artefact scatter may consist only of material on the ground surface, which has been exposed by erosion forces, or it may be indicative of a sub-surface deposit.

However surface evidence (or the lack of surface evidence) does not necessarily indicate the potential, nature or density of sub-surface material. Extensive excavations have shown that areas with no surface evidence often contain sub-surface deposits buried beneath current ground surfaces.

Stone artefacts, whether isolated finds or artefact scatters, are likely to occur in the study area along gentle to very gentle gradient spurs, along the ridge crests or along the simple slopes that characterise much of the study area. It is predicted that higher densities of stone artefacts are likely to occur within close proximity to drainage lines running east to west through the study area.

2 ***Scarred Trees***: scarred trees are commonly found in NSW and many are recorded in the Lower Hunter region. Scarred trees can be either culturally, naturally or accidentally produced. Cultural scars can be either Aboriginal or European in origin. Scars may be formed accidentally by passage of farm machinery or some other form of impact. Scars can also occur naturally as a result of trauma, storm activity (e.g. lightning strikes), fire, fauna activity (e.g. insects, termites, birds and stock), impact and abrasion, ring-barking and other farmland or woodland management activities.

Aboriginal scarred trees occur in many environmental contexts and their presence or absence cannot be reliably predicted. While only a low proportion of mature trees (older than 220 years) bear scars that can reliably be identified as Aboriginal in origin, the actual proportion has not been quantified and cannot be accurately predicted.

The study area appears to have been heavily logged in the past century and there is a lack of mature trees in the area. This means that scarred tree occurrence is highly unlikely, although it is possible that mature trees do still occur in some parts of the study area, particularly along the margins of watercourses (third-order creeks or larger).

3 ***Quarry Sites***: a lithic quarry is the location where a source of raw stone material is exploited (Hiscock and Mitchell 1993: 32). Quarry sites will only occur where there are exposures of a stone type suitable for manufacture of stone implements.

Lithic quarries are only likely to exist in the study area where outcrops of a suitable raw material exist. Considering the underlying geology of the region, the potential for lithic quarry sites to occur in the study area is considered to be low, except in the area east of Seaham, where Hanson Quarries is currently quarrying silcrete.

4 ***Grinding Grooves/Engraving Sites***: Grinding grooves are elongated narrow depressions, usually formed in soft sedimentary rocks, and generally associated with water courses. Grinding grooves are usually formed by the shaping and sharpening of ground-edge axes.

Occurrence of these types of sites relies on the presence of outcrops of sedimentary bedrock. The underlying bedrock, consisting of large expanses of sandstone, suggests that there is a moderate potential for such sites to occur in the study area.

5 ***Stone Arrangements***: These sites include mounds, circles, lines or other patterns of stone arranged by Aboriginal people for cultural purposes. Some were associated with ceremonial sites and others were associated with mythological or sacred sites. Hill tops, ridge crests and valley flats that contain outcrops of stone or surface stone, and have been subjected minimal impacts from recent land-use practices, are potential locations for this type of site.

6 ***Bora Grounds***: These sites are generally large circles of raised earth of varying diameters used for ceremonial purposes. The soil was scraped to form a ring. Typically, the Bora ground consisted of a pair of earth circles, the large circle being associated with a smaller circle situated perhaps 300 m away. The two circles were joined by a pathway. The smaller circle sometimes contained an inner circle formed from trees stood upside down with their roots intact. The earth circles were often accompanied by carved trees and/or ground carvings.

There is one previously-recorded Bora site within the study area. Bora grounds are very rare. Consequently, the study area is considered to have a low potential for further such sites.

7 ***Mythological/Traditional Sites***: mythological sites may occur anywhere in the landscape, although such sites are often located at natural landscape features. Other sites of contemporary significance include massacre sites (locations of violent clashes between early settlers and Aboriginal people), traditional camp sites and contact sites. Consultation with the local Aboriginal community is required to identify these types of site.

8 ***Burials***: Aboriginal people tended to place human remains in hollow trees, caves or sand deposits. Burials are usually only detected when eroding out of creek banks or sand deposits or when disturbed by development. The likelihood of detecting burial sites during archaeological survey is very low.

Although the potential for burial sites to occur in the study area is considered to be low, their presence cannot be discounted.

Gay's (2000) survey of the proposed Bowens Road North Project at Stratford identified one isolated find (a broken flake manufactured from a fine-grained siliceous material) which was located in a dam wall on the creek flats south of Wenham Cox Road (AHIMS #38-1-0031). This find, although being of low significance, provides one of the only available platforms on which to predict what site types may occur within the field area. Gay considered that there was low potential for archaeological deposits to occur within her study area, with the exception of flats within 100 m of Dog Trap Creek where she considered the potential to be moderate. Thus for the immediate area around Gloucester isolated finds of stone artefacts are considered to be the main site type likely to be found and, for the purposes of prediction, are most likely to occur within 100 m of larger creeks with reliable water.

For the Dungog-Stroud area the common site type is the 'open camp site' consisting of an artefact scatter. With the exception of an isolated 'Bora ceremonial site' in the Stroud area, there are no other known sites along the pipeline route from Stroud to Hexham, although many sites have been found in the lower Hunter Valley generally. This suggests that there may be a higher possibility of locating open camp sites south of Stroud along the pipeline route. The low number of recorded sites to date is probably a function of the lack of development in those regions.

Aboriginal sites can be found in any landform context, but a predictive model seeks to identify landforms that provide the most likely locations where Aboriginal artefacts may be found. Although there is very limited information on which to base predictive modelling for the northern end of the study area, there are generally accepted patterns of site location that may be used to base a targeted survey. These include:

- the banks of major rivers;
- the banks and floodplains of major and minor creeks;
- areas of lower, mid and upper foot slopes;
- the crests of low ridges in close proximity to water courses; and
- areas adjacent to natural water bodies (e.g. swamps, billabongs, water holes).

3.0 Methodology

3.1 Aboriginal Heritage Survey

A strategic approach was considered the most practicable and efficient means of identifying and assessing key Aboriginal heritage issues within a study area that has a linear length of some 103 km and includes a field area encompassing some 50 km^2.

This approach also conforms to the Director-General's Requirements (DGRs), which state:

> *Indigenous and Non-Indigenous Heritage – the EA must include a justified and tiered assessment of impacts to indigenous and non-indigenous heritage, including:*
>
> - sufficient information to demonstrate the likely impacts of the proposal on indigenous heritage values (archaeological and cultural), consistent with Guidelines for Aboriginal Cultural Impact Assessment and Community Consultation (DEC, July 2005) including measures to avoid, minimise, manage and/or offset impacts. The EA must demonstrate effective consultation with indigenous stakeholders in determining impacts and developing mitigation options; and
> - sufficient information to demonstrate the likely impacts of the proposal on non-indigenous heritage values (including heritage vistas) consistent with the guidelines in the NSW heritage Manual. Where impacts to State or local non-indigenous heritage items are proposed, a statement of heritage significance must be included and measures identified to mitigate and manage impacts.

3.1.1 Survey Areas and Sample Areas

The approach used for the Aboriginal heritage survey consisted of identifying known Aboriginal sites, places, issues and values, together with a predictive model (**Section 2.3.3**) to define target sample areas for intensive survey.

In order to effectively sample the proposed route of the pipeline, the entire length of the easement was divided into Survey Areas (SA). The SAs were delineated by major geographical boundaries and thus were not uniform in length/area. Within each survey area targeted sampling areas were selected for intensive pedestrian survey

Table 2: Survey Areas used for Identifying Targeted Sampling Areas

Survey Area	Location
Avon River Valley SA	Survey area consists of the portion of the study area within the geographic context of the Avon River. This area includes the entire field area and the section of the delivery pipeline from Stratford in the north to Craven in the south.
Wards River SA	Survey area consists of the portion of the study area within the geographic context of Wards River. This area includes the section of the delivery pipeline from Craven in the north to the Wiesmantels locale in the south.
Karuah River SA	Survey area consists of the portion of the study area within the geographic context of the Karuah River. This area includes the section of the delivery pipeline from the Wiesmantels locale in the north to Stroud Road in the south.

Survey Area	Location
Black Camp Creek SA	Survey area consists of the portion of the study area within the geographic context of the Black Camp Creek. This area includes the section of the delivery pipeline from Stroud Road in the north to Glen Martin in the south.
Williams River SA	Survey area consists of the portion of the study area within the geographic context of the Williams River. This area includes the section of the delivery pipeline from Glen Martin in the north to Brandy Hill in the south.
Hunter River SA	Survey area consists of the portion of the study area within the geographic context of the Hunter River. This area includes the section of the delivery pipeline from Brandy Hill in the north to Hexham in the south.

The predictive model suggested that Aboriginal sites in the study area would most likely be found in proximity to one of the rivers and/or major creek lines that cross the proposed pipeline route, particularly on or near the crest of the low ridges that also cross the easement. Several minor tributaries also cross the study area and, although these were considered to have less potential than the major creeks, the possibility of Aboriginal sites occurring could not be completely discounted. Therefore, the physical inspection of the study area used all these areas as a basis for targeted surveys for Aboriginal sites and objects (**Figures 19.1** to **19.16** in **Volume 4** of the EA). A variety of different contexts – of both potentially high and low archaeological sensitivity – were chosen, including the following:

- the banks of major rivers;
- the banks and floodplains of major and minor creeks;
- areas of lower, mid and upper foot slopes;
- the crests of low ridges in close proximity to water courses;
- areas adjacent to natural water bodies (e.g. swamps, billabongs, water holes);
- areas that had been completely cleared or cultivated; and
- areas that have been partially cleared, but still retain small stands of timber.

It should be noted, however, that the concept of Aboriginal heritage is not confined to material evidence, i.e. archaeological sites. Instead, it is much broader in scope, encompassing such factors as language, stories and ritual. To investigate Aboriginal heritage values not related to archaeological sites relies on contact with the local Aboriginal community for advice. The method adopted to explore this issue was to consult the local Aboriginal community using DECCW's *Interim Community Consultation Requirements for Applicants* (see **Section 4.0**).

In light of the limited response from Aboriginal stakeholders regarding this project (**Section 4.0**), there was limited information regarding the values of the study area to the Aboriginal community. Therefore the investigation focused on the identification of Aboriginal heritage values relating to archaeological sites. Field survey methods were adopted to verify existing Aboriginal site records, investigate and record new archaeological sites, ensure their accurate recording and provide sufficient background information to provide an assessment of cultural significance to the extent that surface survey allows.

3.2 Historic Heritage Survey

The methodology used for identifying the historic heritage values of the study area comprised a desktop review of previous heritage reports associated with the study area in conjunction with a review of relevant heritage databases to identify heritage sites currently listed in and around the study area.

Databases searched included the NSW Heritage Office's (DoP) Heritage Database for the Gloucester, Great Lakes, Dungog, Port Stephens, Maitland and Newcastle Local Government Areas (LGAs), including the State Heritage Register (SHR), relevant government agency section 170 registers and relevant Regional Environmental Plans (REPs) and Local Environmental Plans (LEPs). Searches were also made of the Australian Heritage Database encompassing the Register of the National Estate (RNE), the National Heritage List (NHL), the Commonwealth Heritage List (CHL) and World Heritage List (WHL).

Field survey for historic sites was conducted in conjunction with the Aboriginal heritage survey.

3.3 Specific Actions

The methodology comprised:

- a search of the DECCW AHIMS database for records of existing Aboriginal heritage sites within the study area;
- a search of relevant historic heritage databases for records of existing historic heritage items within the study area;
- a review of relevant archaeological reports lodged in DECCW's archaeological reports library at Hurstville;
- consultation with Aboriginal community groups following DECCW's interim guidelines (discussed further in **Section 4.0**);
- field survey by an AECOM archaeologists and representatives of the local Aboriginal communities where available, following transects that sought to investigate targeted areas of the study area that were considered most likely to contain Aboriginal sites and/or historic heritage sites. This approach is consistent with the DGRs. A 100% coverage of the entire study area was not considered feasible and the locations targeted included 200 m either side of all major rivers and creeks and tributaries crossing the study area, as well as adjacent ridgelines and low hill tops;
- transects were generally conducted in an 'out-and-back' fashion from various access points along the pipeline, plus random walks. This allowed greater coverage of the study area by using the line's centre line as a reference point. The outward leg followed one side of the pipeline and the return leg followed the other side. In this fashion a 100 m-wide corridor was traversed in each transect;
- inspection of all ground exposures for evidence of artefacts;
- inspection of all mature trees within 50 m either side of the proposed route of the pipeline for evidence of scars; and
- photographing the study area and noting environmental and archaeological aspects.

3.4 Fieldwork Dates

Fieldwork was carried out in two phases:

3.4.1 Fieldwork – Phase 1

Phase 1 of the fieldwork was carried out over 10 days between 6 and 17 October 2008. The entire GFDA and pipeline route was surveyed during this period.

3.4.2 Fieldwork – Phase 2

Following the inclusion of additional lands within the GFDA (at the southern and eastern ends of the GFDA) and the rerouting of several small sections of the pipeline, additional fieldwork was carried out to survey these areas. The survey was carried out over four days between 15 and 18 June 2009.

4.0 Aboriginal Community Consultation

Aboriginal community consultation was undertaken in accordance with the DEC (2004) *Interim Community Consultation Requirements for Applicants* (ICCRs) and the DEC (2005) Draft *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation*. These guidelines outline a process of inviting Aboriginal groups to register their interest in being party to consultation (including local newspaper advertising), seeking responses on proposed assessment methodology, and seeking comment on proposed assessments and recommendations. The guidelines require proponents to allow ten working days for Aboriginal groups to respond to invitations to register, and then 21 days for registered Aboriginal parties to respond to a proposed assessment methodology.

An Aboriginal community consultation log is attached at **Appendix B**.

4.1 Stage 1 – Notification and Registration of Interest

Specifically, consultation consisted of the following:

- advertisement of the project in local newspapers, inviting Aboriginal groups to register interest (this task was coordinated by the proponent);
- letters were sent to the following organisations requesting advice on Aboriginal stakeholders to consult and any known heritage issues to be taken into consideration (mailed or faxed 24 July 2008):
    - Department of Environment, Climate Change and Water (DECCW);
    - Forster Local Aboriginal Land Council (FLALC);
    - Karuah Local Aboriginal Land Council (KLALC);
    - Worimi Local Aboriginal Land Council (WLALC);
    - Awabakal Local Aboriginal Land Council (ALALC);
    - Mindaribba Local Aboriginal Land Council (MLALC);
    - Native Title Tribunal for a search of claims affecting the study area;
    - Office of Registrar for Aboriginal Land Claims;
    - Gloucester Shire Council;
    - Great Lakes Shire Council;
    - Dungog Shire Council;
    - Port Stephens Council;
    - Maitland City Council;
    - Newcastle City Council; and
- known Aboriginal organisations around the study area were contacted, as a result of advice received from the above organisations (refer **Appendix B**).

DECCW did not respond to the request. The Native Title Tribunal responded on 2 September 2008 informing that the study area was not overlapped by any claim of determination.

The Office of Registrar for Aboriginal Land Claims responded on 30 July 2008 advising of Aboriginal owners for the Worimi Conservation Lands at Stockton, near Newcastle. The Worimi Conservation lands are located to the southeast of the study area and are not affected by the project.

The Newcastle City Council responded on 8 August 2008 with a list of four relevant Aboriginal stakeholder groups within the Newcastle LGA. The Gloucester, Great Lakes, Dungog, Port Stephens and Maitland Councils did not respond.

As a result of this process, and after the 10-day response period required under the ICCRs, two Aboriginal groups – Karuah LALAC and Mindaribba LALC – registered their interest in being consulted. There was no response from Forster, Worimi and Awabakal LALCs, but these organisations were automatically registered anyway, giving a total of five registered groups after Stage 1 of the consultation process.

4.2 Stage 2 – Briefing and Methodology Advice

Briefing letters were sent to the Aboriginal groups that initially registered their interest (Stage 1), as well as other groups known to AECOM, on 25 August 2008 advising the proposed methodology for the survey.

Mindaribba LALC replied by fax on 27 August 2008 agreeing with the methodology as put forward. In addition a further three Aboriginal stakeholder groups formally registered their interest:

- Awabakal LALC responded on 8 September 2008 registering their interest, but provided no comment on the proposed methodology. (This organisation had already been automatically registered.)
- Awabakal Traditional Owners Aboriginal Corporation (ATOAC) and Awabakal Descendents Traditional Owners Aboriginal Corporation (ADTOAC) registered their interest on 15 September 2008, agreeing with the proposed methodology.

There was no response from Forster LALC, Karuah LALC or Worimi LALC.

As a result of Stage 2 of the consultation process, and after the 21-day response period required by the ICCRs, at total of seven Aboriginal community groups were registered as stakeholders in the project. A list of all registered stakeholders is provided in **Table 3**.

Table 3: Aboriginal Stakeholders identified for this Project

Organisation	Contact Name
Forster Local Aboriginal Land Council	Tim Kelly
Karuah Local Aboriginal Land Council	Margaret Wright-Wilson; Dave Feeley
Worimi Local Aboriginal Land Council	Andrew Smith
Mindaribba Local Aboriginal Land Council	Rick Griffiths
Awabakal Local Aboriginal Land Council	Cheryl Kitchener
Awabakal Traditional Owners Aboriginal Corporation	Kerrie Brauer
Awabakal Descendents Traditional Owners Aboriginal Corporation	Shane Frost

4.3 Stage 3 – Fieldwork (Phase 1)

Letters were initially sent to the five registered LALCs on 22 September 2008 offering positions in the fieldwork team and, at the same time, requesting feedback on any known cultural heritage issues for the study area. A detailed fieldwork schedule was attached to the letters of offer.

Three groups – Karuah LALC, Worimi LALC and Mindaribba LALC – accepted the offer for participation in the fieldwork. There was no response from either Awabakal LALC or Forster LALC, despite follow up phone calls. Consequently there were no representatives of Forster LALC or Awabakal LALC involved in the field survey. Since there was no response from Awabakal LALC, offers of employment were sent to ATOAC and ADTOAC to participate in fieldwork for areas south of the Hunter River.

As a result of this process, three of these groups took part in the fieldwork. Fieldwork participants included:

- Wayne Ping (Karuah LALC) participated in the survey of lands within Karuah LALC boundaries, specifically from Wards River in the north, to the Williams River at Clarence Town in the south;
- Paul Robinson (Worimi LALC) participated in the survey of lands within Worimi LALC boundaries, specifically from the Williams River at Clarence Town in the north, to the next Williams River crossing near Seaham in the south; and
- Shane Frost (ADTOAC) participated in the survey of lands south of the Hunter River, which is considered Awabakal country, but is encompassed by both Awabakal LALC and Mindaribba LALC.

Mindaribba LALC accepted the offer of fieldwork, agreeing to the schedule of activities. However, during a subsequent follow-up telephone call to confirm their availability on the scheduled day, Mindaribba LALC indicated that a representative was not available that week (and was possibly available the following week). With a very limited window of opportunity to conduct the fieldwork, the only available time for conducting the fieldwork within Mindaribba's boundaries was as set out in the schedule as originally provided and agreed to. Consequently representatives of Mindaribba LALC were not involved in Phase 1 of the field survey.

4.4 Stage 4 – Circulation of Draft Report

Following Phase 1 of the field survey, a draft report was circulated to the seven Aboriginal stakeholder groups on 17 December 2008. As no response had been received, a follow-up letter was sent on 24 March 2009 inviting comment on the draft document. As a result AECOM received responses from ADTOAC and ATOAC. Both stakeholder groups considered the report to be "reasonably comprehensive" but raised the following concerns as outlined below. No responses were received from the remaining five groups.

4.4.1 Comments: Awabakal Descendants Traditional Owners Aboriginal Corporation

Awabakal Descendants Traditional Owners Aboriginal Corporation made the following comments:

- agreed that PAD19 should be monitored during construction work (a subsequent realignment of the pipeline to circuit the eastern extent of the Woodbury Ridge means that this PAD will not be affected by the project);
- requested that they be consulted during the development of the Aboriginal Heritage Management Plan;

- requested the Management Requirements include a clause requiring cessation of works should Aboriginal artefacts be uncovered, and DECCW and stakeholders notified; and
- noted the Hexham area holds cultural and spiritual significance to the Aboriginal stakeholders.

4.4.2 Comments: Awabakal Traditional Owners Aboriginal Corporation

Awabakal Traditional Owners Aboriginal Corporation made the following comments:

- pointed out that limited survey was unlikely to locate all Aboriginal artefacts in the impact area;
- requested that references to “Aboriginal Community” be changed to “Aboriginal Stakeholders” as a more appropriate label;
- requested monitoring be carried out for the pipeline works to mitigate damage to potential sites; and
- noted that the Hexham area holds cultural and spiritual significance to the Aboriginal stakeholders.

The above comments have been addressed in this report.

4.5 Stage 5 – Additional Fieldwork (Phase 2)

Subsequent to the distribution of the draft report, an additional lands were incorporated into the field area and several changes were made to the route of the pipeline. Consequently additional fieldwork was carried out to survey the additional field area and amended pipeline route. Field survey was limited to amended areas only. The additional field area occurred within the Forster LALC area and this organisation was invited to take part in fieldwork. The amendments to the pipeline route occurred within the Karuah and Mindaribba LALC areas, and both these organisations participated in the field survey.

As a result of this process, two of these organisations took part in the fieldwork. Fieldwork participants included:

- Ron Tisdell, Vanessa Saunders and Martin Feeney (Karuah LALC) participated in the survey of the amended pipeline route within Karuah LALC boundaries, specifically from around Clareval in the north to the northern section of Black Camp Road in the south; and
- Roberta Campbell (Mindaribba LALC) participated in the survey of the amended pipeline route within Mindaribba LALC boundaries, specifically from the Williams River at Seaham in the north, to the Hunter River at Hexam in the south.

Forster LALC initially indicated an interest in participating in the fieldwork. However, subsequent attempts to advise fieldwork dates and confirm their availability on the scheduled day, received no response. Consequently representatives of Forster LALC were not involved in Phase 2 of the field survey.

4.6 Stage 6 – Circulation of Amended Draft Report

A copy of the draft of this report, with amendments following the Phase 2 fieldwork, was circulated to the registered Aboriginal stakeholder groups on 18 August 2009.

As a result AECOM received a response from ADTOAC on 1 September 2009, who wished to clarify comments made in the previous comments phase (see **Section 4.6.1** below). A response was also received from ATOAC (letter dated 31 August 2009). No responses were received from the remaining six groups.

4.6.1 Comments: Awabakal Descendants Traditional Owners Aboriginal Corporation

Awabakal Descendants Traditional Owners Aboriginal Corporation made the following comments regarding the amended draft report:

- "we would only be interested in being involved in the Aboriginal Heritage Management Plan in regard to the section of the gas project which concerns the proposed development area within the Awabakal Traditional Tribal Country"; and
- "we would like the above statement added into the draft so as to clarify our position".

This clarification was added to the management commitments in **Section 10.2**.

4.6.2 Comments: Awabakal Traditional Owners Aboriginal Corporation

Awabakal Traditional Owners Aboriginal Corporation made the following comments regarding the amended draft report:

- suggested that the writings of Rev. L. Threkeld offer a more complete overview of the Awabakal people. Further ATOAC pointed out that anthropologists do not have the capability to adjudicate on the spirituality of any particular locality or site; this is the exclusive right of traditional owners;
- recommended that the value of 'place' be considered within the "Heritage and Cultural weighting" so as to ensure "the protection and conservation of Places and Objects which impact significantly on the spirituality, cultural, historic and general legacy needs of Aboriginal people to address inequalities in social and community well being";
- requested clarification in **Section 7.2.3** regarding the lack of information provided by Aboriginal stakeholders on cultural (social) heritage values. ATOAC had previously expressed reluctance to share their cultural heritage with others in respect to aspects of cultural significance that connects them to their country;
- believe that all the relevant Aboriginal stakeholders should be consulted during the proposed AHMP where it is appropriate to their cultural area of association;
- recommend that monitoring is necessary to examine the possible survival and integrity of any Aboriginal sites that may be present within the Proposed Pipeline Project area;
- suggested that further analytical research is needed concerning the region. Recommend that AGL consider the advantages of implementing a Research Excavation Methodology Design for the AHMP to address research questions which are common to the Hunter region. The research design would "pioneer active principles to unravel the geological history of the regions [sic] layers to encompass and create a data collective of the regions ethos"; and

- believe that caution is recommended because the draft report does not address the impact on the environment surrounding the proposed pipeline. ATOAC are concerned with the extent of potential damage that the excavation itself will create on Aboriginal sites, including access roads for trucks as well as the supporting equipment that is needed.

The above comments have been addressed in this report.

A detailed consultation log and Aboriginal community comments are presented in **Appendix B**. In addition, specific comments regarding the cultural significance of the study area (and any associated “sites”) and report recommendations will be incorporated into **Sections 7.0** and **10.0** respectively.

5.0 Aboriginal Heritage Results

This section provides the results of the background research and fieldwork components of the assessment.

A total of nine new Aboriginal cultural heritage sites and 14 potential archaeological deposits were identified during the field survey.

5.1 Fieldwork Constraints and Opportunities

In addition to the constraints identified in **Section 2.4.3**, further constraints for archaeologists include the extent to which Aboriginal activity is represented by preserved evidence, the degree to which post-depositional processes have affected the archaeological record, the extent to which land-use (e.g. cultivation or development) has altered the archaeological landscape, the time of year and the conditions under which a survey is conducted.

The study area, for the more than half its length (approx 55%), was located within various cleared easements for roads, transmission lines and pipelines, that had undergone various levels of disturbance by previous land management practices. These easements are covered with a thick cover of low pasture grass, bracken, sedge and various low weed species to a height of less than 100 mm. The majority of sampling areas (transects) offered very poor surface visibility of 0% (**Plate P1**). Some areas offered slightly higher visibility, although still less than 10% of the ground surface (**Plate P2**).

Small ground surface exposures (1 m^2 to 10 m^2) occur sporadically throughout the study area, although several larger exposures occur (**Plate P3**), particularly as stream-bank erosion. These exposures are most prevalent along the banks of creeks and rivers and occur as the result of flood-scouring. Such flood-scouring, although offering one of the best areas of surface visibility, is also a source of sediment loss, and therefore a source of potential impacts on in situ archaeological deposits. In the majority of sample areas, there was little surface lithic material evident, even in bare-earth exposures.

5.1.1 Effective Survey Coverage

To calculate effective survey coverage, the ground surface visibility along the route needs to be quantified. This information was recorded for sites and for the sample areas. Effective survey coverage is calculated on the basis of the total area surveyed, exposure and ground surface visibility. Because of the nature of the survey (total pedestrian) and the proposed development (a linear excavation), and because a representative sample of landscape units were recorded, an analysis of the 58 sample areas (transects) provides the basis for assessing effective survey coverage along the route.

Details of ground surface visibility and effective survey coverage for each transect are provided in **Table T1** at the back of this report.

Effective survey coverage is a function of the amount of ground surface available for detecting surface artefacts. The amount of ground surface visibility is determined by the amount of ground cover (vegetative cover) over the entire transect, the number and total area of exposures in the transect, and the amount (area) of those exposures with bare soil visible. As can be seen from **Table 4** below, ground surface visibility (and therefore the area of each transect available for detecting artefacts, was extremely low. A total of 52 transects (90%) had a ground surface visibility of less than 10%. Impediments to ground surface visibility in this survey included grass, leaf litter, very thick regrowth (e.g. *Melaleuca spp.* or *Eucalyptus spp.* woodland regrowth) and/or woody weed growth (e.g. *Lantana camara*). Good recent rainfalls throughout the study area have ensured that ground layer species throughout the study area had grown to provide luxurious pasture with near 100% ground coverage. Heavy rainfall hampered survey in the area around McClement Swamp, near Brandy Hill, where the ground surface became totally inundated.

Table 4: Ground Surface Visibility Classes

Exposure Area	No. of Transects	Percentage
< 0.01%	7	12
0.01 – 1.0%	25	43
1.01 – 10.0%	20	34
10.01 – 50.0	1	2
50.01 – 100.0%	5	9
Total	**58**	**100**

As a result of the low level of ground surface visibility, effective survey coverage was generally very low, with nearly three-quarters of sample areas (42 transects) having an effective coverage of 1.0% or less. In all 54 transects (93%) had an effective coverage of 10 percent or less (**Table 5**). This result could be extrapolated to the entire study area; in other words the effective coverage in 96% of the study area was less than 10%.

Table 5: Effective Cover Classes

Effective Cover Class	No. of Transects	Percentage
< 0.01%	6	10
0.01 – 1.0%	36	62
1.01 – 10.0%	12	20
10.01 – 50.0	2	4
50.01 – 100.0%	2	4
Total	**58**	**100**

5.2 Findings

A total of nine Aboriginal sites with artefactual evidence were located in the field area or along the 103.5 km of the pipeline route. These are predominantly low density artefact scatters (n=4), followed by isolated finds (n=3) and scarred trees (n=2), and (**Table 6**). A Bora ring (AHIMS #31-1-0006) is recorded adjacent to the pipeline route (**Figures 19.1** to **19.16** in **Volume 4** of the EA), and was reidentified during the Phase 2 of the field survey. In addition, a further 14 potential archaeological deposits (PADs) were also identified.

Table 6: New Site Types Identified within the Study Area

Site Type	Number	Percentage
Isolated Find	3	13
Artefact Scatter	4	17.4
Scarred Tree	2	8.7
PAD	14	60.9
Total	**23**	**100**

For ease of reference, the results are presented according to the relevant LALC boundaries. Detailed descriptions of all sites can be found in **Section 5.4** and **TableT2** at the end of this report. **Table 7** shows the number of transects conducted in each LALC area.

All sites identified in the survey were assigned a unique ID. Aboriginal sites were prefixed “LEA” and Historic sites were prefixed “LEH”. PADs were simply prefixed “PAD”.

Table 7: Transects Conducted in Each LALC Area

LALC	No. of Transects	Length of Transects (km)	Length of Pipeline (km)	Percentage (%)
Field Area				
Forster (GFDA)	12	16.77	-	-
Forster (CPF)	1	0.50	-	-
Sub-Total	**13**	**17.27**		
Pipeline				
Forster (Pipeline)	7	4.20	21	20.0
Karuah	24	14.74	46	32.0
Worimi	10	1.92	26	7.4
Mindaribba	4	5.69	10	56.9
Awabakal	0	0	0.5	0
Sub-Total	**45**	**26.42**	**103.5**	**25.5**
Total Transects	**58**	**43.69**	**103.5**	**42.2**

Results within Forster LALC Boundaries

The proposed development has two components within this LALC boundary:

- the field area, consisting of 147 grid squares (each measuring 600 x 600 m) between, and eastwards of, Gloucester and Stratford. The development proposal calls for a total of 110 gas wells to be developed in the field area. In total, the field area measures approximately 50.3 km^2; and
- a total of 21 km of the proposed pipeline (20.2% of the total), between Stratford in the north and Wards River in the south.

A total of 20 transects were conducted (**Table 7**), constituting some 4.2 km (20%) of the total linear length of the proposed pipeline within this LALC boundary, 16.77 km of transects within the field area and 15.5 ha for the proposed CPF location.

A total of five Aboriginal sites and five PADs were identified in this LALC area (**Table 8**). The Aboriginal sites consist of three isolated finds, a single low-density artefact scatter and a possible scarred tree (see **Sections 5.4** and **5.5** and **TableT2** for site descriptions).

Table 8: Sites Identified in Forster LALC Boundaries

Site ID	Site Type
LEA1	Scarred tree
LEA2	Isolated find
LEA3	Artefact scatter
LEA4	Isolated find
LEA5	Isolated find
PAD1	PAD
PAD2	PAD
PAD3	PAD
PAD4	PAD
PAD5	PAD

Results within Karuah LALC Boundaries

A total of 46 km of the proposed pipeline (44.4% of the total pipeline) occurs in this LALC area, from Wards River in the north to the Williams River at Clarence Town in the south. A total of 24 transects were conducted, constituting some 14.7 km (31.9%) of the total linear length of the proposed pipeline within this LALC boundary.

A total of two new Aboriginal sites and six PADs were identified in this LALC area (**Table 9**). These sites consist of a single isolated find and a single low-density artefact scatter. In addition one existing AHIMS-registered site, a Bora ring, was relocated on Black Camp Road (see **Sections 5.4** and **5.5** and **TableT2** for site descriptions).

Table 9: Sites Identified in Karuah LALC Boundaries

Site ID	Site Type
LEA6	Isolated Find
LEA7	Artefact Scatter
AHIMS #38-1-0006	Bora ground
PAD6	PAD
PAD7	PAD
PAD8	PAD
PAD9	PAD
PAD10	PAD
PAD11	PAD

Results within Worimi LALC Boundaries

A total of 26 km of pipeline (25.1% of the total length) passes through the Worimi LALC area, from the Williams River at Clarence Town in the north to the Williams River near Seaham in the south. A total of ten transects were conducted, constituting some 1.9 km (7.4%) of the total linear length of the proposed pipeline within this LALC boundary.

No Aboriginal sites were identified in this LALC area. However, two PADs were identified (**Table 10**). One PAD (PAD 13) is located where an outcrop of silcrete raw material is located on a slope overlooking the Williams River. Silcrete is a material favoured by Aboriginal people for the manufacture of stone tools.

Table 10: Sites Identified in Worimi LALC Boundaries

Site ID	Site Type
PAD12	PAD
PAD13	PAD: raw material outcrop

Results within Mindaribba LALC Boundaries

A total of 10km of pipeline (9.7% of the total length) passes through the Mindaribba LALC area, from the Williams River near Seaham in the north to the Hexham Bridge in the south. A total of 10 transects were conducted, constituting some 5.7 km (57%) of the total linear length of the proposed pipeline within this LALC boundary.

There were two new Aboriginal sites and one PAD identified within the corridor of the pipeline in this LALC boundary (**Table 11**). The two Aboriginal sites are both low-density artefact scatters located along the west bank of Deadmans Creek, approximately 130 m apart. It is considered that there is likely to be a sub-surface archaeological deposit associated with and between both these sites, although any deposit is also likely to be of low density.

Table 11: Sites Identified in Worimi LALC Boundaries

Site ID	Site Type
LEA8	Artefact scatter
LEA9	Artefact scatter
PAD14	PAD

Results within Awabakal LALC Boundaries

A total of 0.5 km of pipeline (0.5% of the total length)passes through the Awabakal LALC area at Hexam, at the pipeline's terminus immediately after crossing the Hunter River. Due to the very short stretch of pipeline within this LALC boundary, and the highly disturbed nature of the landscape, there were no transects conducted in this LALC area.

There were no Aboriginal sites or PADs identified in this area.

5.3 Summary

Of the total of 103.5 km[1] of proposed pipeline, a total of 26.4 km (25.5%) was surveyed to a width of 100 m along the corridor. In addition, a total of 17.2 km of transects were conducted within the field area, including the proposed CPF sites.

5.4 Identified Aboriginal Cultural Heritage Sites

The following section describes Aboriginal cultural heritage sites identified during the field survey. A total of nine new Aboriginal sites and 14 PADs were identified within the field area and along the proposed pipeline route.

Site LEA1 (MGA Coordinates: 0402611E 6452503N)

Site LEA1 is located on Mitchell's property on the western bank of the Avon River, approximately 400 m west of its confluence with Waukivory Creek (**Figures 19.1** to **19.16** in **Volume 4** of the EA). (Approximately 300 m north east of the Fairbairn Road bridge over the Avon.)

Site LEA1 is a dead eucalypt (species unknown) with a large scar on the western side (**Plate P4**). The scar is approximately 400 mm wide at its widest point, and tapers to a uniform point at the top and extends to a flat bottom, 400 mm from the ground. It is approximately 2.2 m long. The scar is in extremely poor condition with the surface completely decayed and the tree hollowed out within. The scar is not uniform in shape (ovoid at the top but straight horizontal at the base). Identification of this scar as an Aboriginal cultural site is not conclusive due to the poor condition of the scar, however based on the balance of probability the site is considered to be an Aboriginal site.

[1] At present there are two options for the location of the CPF being considered: one near Stratford on Tiedman's Block and one immediately south of the Gloucester Coal rail loop. The length of the pipeline quoted here includes the extended pipeline to the Tiedmans Block CPF option. Should the Gloucester Coal rail loop location be chosen, the pipeline length will be 95.2 km (8.1 km shorter).

Site LEA2 (MGA Coordinates: 0402011E 6449027N)

Site LEA2 is located on the eastern side of Dog Trap Creek on Tiedman's Block (owned by Lucas Energy), approximately 200 m south east of its confluence with the Avon River (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate P5**).

Site LEA2 is small artefact scatter consisting of two mudstone (grey) flakes (**Plate P6**) that lies approximately 10 m east of the creek bank in a small, dry tributary that comes off the eastern side of the creek and then turns south east. The site is located in a very short eroded section out of the tributary's northern bank.

Site LEA3 (MGA Coordinates: 0402096E 6449859N)

Site LEA3 is situated on the eastern side of the Avon River on Tiedman's Block (owned by AGL). The site is located approx 200 m NE of the ford over the Avon River (just north of its confluence with Dog Trap Creek). It lies within a small re-entrant in the low ridge that runs along the eastern bank of the Avon River at this point (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate P7**). The site is an isolated find consisting of a single, small, silcrete multi-platform, unifacial core measuring 24 mm long by 7 mm wide (**Plate P8**). The site is approximately 100 m east of the river bank. Other lithic material in the exposures consists mainly of ironstone gravel.

Within the re-entrant there is an extensive "L-shaped" contour bank that has been excavated around the eastern and northern sides. Running parallel to, and on the northern side of the contour bank, is an extensive exposure (~5 m wide by 30 m long) where the fill for the bank has been excavated. There is also a small exposure 2 m south and 4 m west of the NE corner of the bank. This is where the artefact is located. The total area of disturbance caused by these features is estimated to be 200 m^2. Vegetation cover is estimated at 60% in the exposures, 100% elsewhere. Stock tracks and cattle pads provide some ground surface visibility along the creek dams. No other artefacts were located in these areas despite thorough investigation.

Site LEA4 (MGA Coordinates: 0398996E 6442117N)

Site LEA4 is located on the southern side of Woods Road, Craven, at the front of Yates' property (1DP1003762). The single artefact is situated on the road verge next to the western-most fence post next to a timber stock gate at the front of the property (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate** P9). The site is an isolated find of a core, measuring 32 mm long by 23 mm wide by 10 mm thick (**Plate P10**). The platform shows a minor amount of cortex, there is a negative flake scar with two scar ridges, a bulb of percussion, and possible usewear on one of the lateral margins. The artefact is formed from a coarse-grained siliceous material that may be silcrete, although it is of a darker, greyish-red than the material seen elsewhere in the Gloucester region.

There is very little exposure here except around the fence posts. However, there is extensive ground surface exposure around the shed behind the gate and extending some 20-30 m southwards to where the property's driveway comes close to the eastern boundary fence. It is estimated that the total exposure in this area 50 m^2. Ground surface visibility is estimated to be about 60% in the exposure but 0% elsewhere due to thick pasture cover.

During a subsequent visit to this site two days after first recording, the artefact could not be found.

Site LEA5 (MGA Coordinates: 0398904E 6440693N)

Site LEA5 is located on the rising gentle slope approximately 200 m north of Coal Creek on Bosma's property (2DP1003762) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site is located on an exposure on the northern side of a large tree stump that has been left on a pedestal of eroded soil (**Plate P11**), 2 m west of the property's eastern boundary fence (adjacent to a large wooded block to the east) and 30 m south of an east-west fence and gate. The tree stump is sitting 0.5 m above current ground level, which shows the amount of sheet erosion that has occurred in this area.

The site is an isolated find consisting of a single single-platform, multi-facial core, measuring 34 mm long by 26 mm wide by 7 mm thick (**Plate P12**). There is a single negative flake scar and a possible bulb of percussion. Other scars do not show diagnostic features.

The site is located on a 4 x 3.5 m (14 m^2) exposure that has a total surface lithic density of approximately 5 lithics/m^2. Other nearby exposures have 20+ lithics/m^2. Ground surface visibility in the exposures is estimated to be about 80%, and only 10% elsewhere due to thick pasture ground cover.

Site LEA6 Isolated Find (MGA Coordinates: 0394945E 6410460N)

Site LEA6 is located on James and Hull's property, on the western side of Black Camp Road (122DP526671). It is situated on the northern side of a first-order drainage line that runs westwards about 100 m away into Black Camp Creek, and about 200 m north of the house (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate P13**). It lies on a large exposure formed by sheet erosion caused by vehicles, about 3 m from the eastern boundary fence, next to the road verge.

The site is an artefact scatter consisting of two stone artefacts: a thin mudstone core, measuring 44 mm long by 32 mm wide by 10 mm thick (**Plate P14**), and an indurated mudstone flake, measuring 24 mm long by 17 mm wide by 8 mm thick.

Both artefacts lie on an exposure measuring 10 x 2 m (20 m^2) and there is a fairly dense scatter of surface lithics (50-100/m^2) within the exposure, but no other artefacts were found. The artefacts lie about 15 m apart.

Site LEA7 Scarred Tree (MGA Coordinates: 0394770E 6410201N)

Site LE7 is located on Bottle Corner Gully, a second order creek that crosses Black Camp Road running east to west, and draining into Black Camp Creek (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It lies about 30 m west of the creek crossing and about 2 m from the northern creek bank. It is located on James and Hull's property (122DP526671).

The site is a scarred tree that *may* be of Aboriginal cultural origin (**Plate P15**). The scar is elliptical or diamond-shaped and non-uniform in shape, and measures 650 mm long by 280 mm wide by 70 mm deep, and the base 480 mm above the ground surface. The surface of the scar is fairly rough and is deteriorating; however it is till intact and there is what appears to be an axe cut near the apex. The scar is on the southern side of a large smooth-barked eucalypt.

The unusual shape of this scar lends some doubt as to its identification as an Aboriginal scarred tree. The shape of the scar could indicate impact damage rather than cultural scarring, and on the balance of probabilities, it is considered that the scar is not cultural in origin.

There are also a number of very new oblong bark removal scars up the bole of the tree that are flush with the bark surface. There is no edge build up/repair indicating very recent formation. The bole is densely marked with claw marks and several goannas were observed climbing trees in the area. It is possible that the newer scars were formed by these animals' activities.

Site LEA8 (MGA Coordinates: 0378005E 6384593N)

Site LEA8 is located on the western side of Deadmans Creek (approximately 1 km south east of the Brandy Hill Quarry complex on land owned by Hanson Quarries), off Clarence Town Road, approximately 140 m north of the road about 4 m back from the bank edge (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate P16**).

The site is small artefact scatter consisting of two stone artefacts (**Plate P17**): a white silcrete medial flake, measuring 36 mm long by 14 mm wide by 9 mm thick, and red silcrete flaked piece, measuring 12 mm long by 12 mm wide by 6 mm thick. The only diagnostic features on these objects are flake scar ridges, offering some doubt as to the identification of these objects as artefacts. Both artefacts lie on an exposure measuring 1 x 2 m (2 m2). No other lithic material was observed. The artefacts lie about 0.5 m apart. The site is considered to be part of a continuous subsurface deposit incorporating LEA9 (130 m south east).

Site LEA9 (MGA Coordinates: 0378093E 6384498N)

Site LEA9 is located on the western side of Deadmans Creek (approximately 1 km south east of the Brandy Hill Quarry complex on land owned by Hanson Quarries), off Clarence Town Road, about 10 m north of the road about 4 m back from the bank edge (**Figures 19.1** to **19.16** in **Volume 4** of the EA and **Plate P18**).

The site is a small artefact scatter consisting of two white silcrete broken flakes (**Plate P19**), measuring 13 x 21 x 6 mm and 18 x 15 x 3 mm respectively. The only diagnostic features on these objects are flake scar ridges, offering some doubt as to the indentification of these objects as artefacts. Both artefacts lie on an exposure measuring 6 x 4 m (24 m^2) about 4 m north of the roadside fence. Visibility within the exposure is about 70-80%. The artefacts lie about 0.2 m apart. The site is considered to be part of a continuous subsurface deposit incorporating LEA8 (130 m north west).

5.5 Identified Potential Archaeological Deposits

In addition to the identified Aboriginal cultural heritage sites listed above, a total of 14 potential archaeological deposits (PADs) were identified. PADs are areas that may have subsurface deposits identified primarily by the types of landforms that are considered most likely to contain subsurface artefacts rather than any surface indication of material evidence. The PADS are identified where the proposed route of the pipeline passes either along the banks of a watercourse, along lower foot slopes in close proximity to a watercourse, or on a low ridge or hill crest in close proximity to a watercourse (see original predictive model **Section 2.4.3** and ground-truthed site location model **Section 5.7.3**).

PAD 1 (MGA Coordinates: 0404041E 6450702N)

PAD 1 is located on Cole's property; northern side of Waukivory Creek, approx 150 m east of the house and sheds (**Figures 19.1** to **19.16** in **Volume 4** of the EA). This PAD is located on a small spur off the low ridge overlooking a billabong and creek flats, within 100 m of Waukivory Creek. The PAD is considered to by 30 m x 20 m. This site is within the general route of a proposed gas spine line.

PAD 2 (MGA Coordinates: between 0399018E 6439629N and 398768E 6439872N)

PAD 2 is located on the southern side of Spring Creek on Harris' property (417DP753173). The PAD is considered to be a 20 x 20 m area on the southern side of the creek on the low rise to the road (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

PAD 3 (MGA Coordinates: 0339052E 6439271N)

PAD 3 is located approximately 110 m SSW of the house on Burnet's property (2DP874695) on the southern side of Spring Creek (Berrico) Road (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site lies at the crest of a spur that leads down towards Spring Creek and is situated in a copse at the top of the hill.

The area covered by the PAD is estimated to be about 30 m north to south by 30 m east to west, centred over the position above. The ground surface visibility on this slope was 0% due to a very thick layer of pasture grass/fireweed. There were no exposures in this area.

PAD 4 (MGA Coordinates: between 0399575E 6436300N and 0398971E 6436391N)

PAD 4 is located on the southern side of Bull Creek on a small terrace above the creek channel (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It is considered to follow the creek channel to a width of 100 m wide to a depth of up to 50 m from the creek bank.

PAD 5 (MGA Coordinates: between 0399540E 6434799N and 0399371E 6434689N)

PAD 5 is located on a low rise on the northern side of Chainy Flat Creek on Chapman's property (6DP1107984). It follows a north westerly direction, and is considered to be 100 x 20 m (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

PAD 6 (MGA Coordinates: between 0397686E 6417213N and 0397206E 6417273N)

PAD 6 is situated on Osborn's property on Black Camp Road (9DP95639 and 681DP95674). It is located in the vicinity of site AHIMS #8-1-6 where Black Camp Creek Road heads south, then does a sharp right-angle turn to the west. It is considered to have two parts (**Figures 19.1** to **19.16** in **Volume 4** of the EA):

1. a 200 x 50 m section along the gentle foot slope where the road is oriented N-S; and
2. a 400 x 50 m section along the north side of the road where the road is oriented E-W, and includes a long narrow, shallow spur that runs NNE.

This PAD is associated with a registered Bora ceremony site (AHIMS 38-1-0006).

PAD 7 (MGA Coordinates: 0396931E 6417094N)

PAD 7 is situated on Osborn's property on Black Camp Road (676DP1114165) on a long, gentle NW facing spur (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The PAD straddles both sides of the road. It is estimated to be approximately 300 m long by about 30 m wide (9000 m^2). It is truncated by the road easement which has been heavily disturbed. It is recommended that the gas pipeline remains within the road easement.

PAD 8 (MGA Coordinates: between 0394950E 6410465N and 0394794E 6410318N)

PAD 8 is situated on James and Hull's property, on the western side of Black Camp Road (122DP526671) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It consists of a 180 x 40 m (7200 m^2) strip encompassing the east-west drainage line north of the house (see Site LEA6) from the boundary fence 60 m west to Black Camp Creek, thence south along the gentle slope fronting black Camp Creek to the vehicle ford 120 m south.

PAD 9 (MGA Coordinates: between 0394949E 6410417N and 0393137E 6409065N)

PAD 9 is located on a low spur on the south side of Cedar Tree Creek on the northern side of Black Camp Creek Road, on Muddle's property (14DP95008) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The PAD is considered to be approximately 150 m long by 40 m wide oriented to the spur.

PAD 10 (MGA Coordinates: between 0391213E 6407650N and 0391052E 6407688N)

PAD 10 is located on low north westerly spur on the southern side of Black Camp Creek on the western side of (Old) Black Camp Creek Road (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It is considered to cover an area of 150 x 80 m oriented with the spur.

PAD 11 (MGA Coordinates: between 0389067E 6395054N and 0389126E 6394908N)

PAD 11 is located on the eastern side of Boatfall Creek on a low ridge that follows the course of the creek. It is located on Allen's property (10DP1040379). It is considered to be at least 100 m long by 20 m wide, oriented along the ridge (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

PAD 12 (MGA Coordinates: between 0382530E 6389641N and 0382439E 6389658N)

PAD 12 is situated at the northern end of James' property (100DP1039833). The landform consists of a low E-W ridge along the northern property boundary (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It is considered to run the extent of the ridge before it rises sharply on to high hills to the east.

PAD 13 (MGA Coordinates: 0382073E 6388896N)

PAD 13 is located on O'Keefe's property (151DP1067987), off Holmwood Road (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It is located on the northern side of a west-facing spur line, approximately 30 m west of the eastern boundary fence in a relatively cleared corridor through the woodland. This location is a source of raw material (red silcrete) that is commonly used in the manufacture of stone tools. The area consists of a 5 x 5 m surface scatter of silcrete cobbles and at least one large rock that is mostly buried (**Plate P2**), indicating the material is *in situ* and suggests that a seam runs through this location. As such there is the potential that sub-surface indications exist of Aboriginal usage. Due to the cleared corridor, this area was considered by the proponent as an alternative route for the pipeline. However, the original alignment has been retained, thus avoiding this PAD.

PAD 14 (MGA Coordinates: between 0380274E 6386745N and 0380097E 6386726N)

PAD 14 is located on the southern side of Carmichaels Creek, which drains into the Williams River (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It consists of a very low ridge on the southern side of creek flats; the property is currently used as horse agistment. It is considered to be 100 x 10 m, oriented with the ridge.

5.6 Discussion

A total of nine previously unidentified Aboriginal sites and 14 PADs were identified within the field area and along the 103.5 km of the pipeline route covered by this report (**TableT2** and **TableT3**). The Aboriginal sites were predominantly open camp sites (n=7) with the remainder being possible scarred trees (n=2).

In order to discuss the distribution of sites found along the route, a number of analyses were undertaken to explore the factors affecting site location. Ground visibility, existing land-use impacts, taphonomic factors, stream order and distance to water were analysed in terms of site type and the size of artefact scatters. These analyses were based on the data derived from the site and sample area recordings (**Table T1**, **TableT2** and **TableT3**). The results of these analyses are summarised as follows:

- all the sites (n=9) were found relatively close to a reliable water source with more than half (n=5; 55%) associated with stream order ranking of 4 or higher (**Table 12**);
- four sites (44%) were located in the vicinity of an ephemeral water course (i.e. stream orders with a ranking of 3 or lower) (**Table 12**). By far the majority of sites and PADs are associated with higher order streams of 4 and above (**Table 13**);
- the majority of sites consisting of a single stone artefact (isolated finds) were associated with ephemeral, low order water courses. Most artefact scatter sites and both scarred trees were associated with higher stream orders of 4 and above (**Table 13**);
- of the “open sites” identified in the survey, a higher proportion were artefact scatters (n=4; 44%) compared to “isolated finds” (n=3; 33%) (**Table 13**). However, in all four cases the “artefact scatters” consisted only of a maximum of two artefacts, suggesting that artefact densities in the study area are generally low;
- in relation to distance from a water source, nearly three-quarters of the sites (n=7; 77%) were found within 50 m of a water source. The remainder (n=2; 22%) were found up to 200 m from the nearest water source (**Table 14**);
- scarred trees appear to be almost exclusively found within 10 m of a larger water source (**Table 13** and **Table 14**), although this is more likely be a result of extensive vegetation clearance rather than a predisposition by Aboriginal people to select trees close to water;

Table 12: Aboriginal Sites in Relation to Named Water Courses and Stream Order

Name of Water Course	Stream Order	No. of Sites*
N/A	N/A	1
Avon River	4+	2
Dog Trap Creek	4	1
Coal Creek	2	1
Black Camp Creek	4	1
Bottle Corner Gully	4	1
Deadmans Creek	3	2
Total		**9**

* does not include potential archaeological deposits

Table 13: Number of Aboriginal Sites Showing Stream Order and Site Type

Stream Order	Isolated Find	Artefact Scatter	Scarred Tree	PAD	Total
N/A				1	1
1	1				1
2	1			2	3
3		2		2	4
4	1	2	2	8	13
Billabong				1	1
Total	**4**	**4**	**2**	**14**	**23**

Table 14: Number of Aboriginal Site Types Identified at Increasing Distances to Water Sources

Distance to Water Source (m)	Isolated Find	Artefact Scatter	Scarred Tree	Total
0 – 10 m		3	2	5
11 - 20				0
21 - 30	1			1
31 - 40				0
41 - 50		1		1
51-100	1			1
101-200	1			1
Total	**3**	**4**	**2**	**9**

Table 15: Ground Visibility Ranking and Artefact Locations

Visibility	Isolated Find	Artefact Scatter	Total
< 0.01%	-	-	-
0.01 – 1.0%	-	-	-
1.01 – 10.0%	-	-	-
10.01 – 50.0	-	-	-
50.01 – 100.0%	2	5	7
Total	**2**	**5**	**7**

- all the stone artefact sites (n=7; 77%) were found in areas where visibility was good (> 50%). These sites were usually found in bare earth exposures amongst thick pasture. There were no sites found where visibility was less than 50% (**Table 15**);
- visibility throughout the study area caused a general limitation on the potential for site discovery. The sample area data, being based on a random selection of landscape contexts, provides the best indications for overall visibility along the route (**Table 4**). From this, it is clear that visibility along the route was generally very poor, with 96% of transects having less than 10% visibility;
- no part of the proposed route could be described as 'undisturbed.' Levels of disturbance along the route varied, but most sites were located in fairly lightly disturbed contexts, which were only associated with vegetation clearance and minor pastoral/agricultural infrastructure works.

In areas where the soil is bare but not heavily eroded, surface evidence (or lack thereof) can sometimes be an unreliable guide to subsurface archaeological content. The lack of surface lithic material evident in the many surface exposures of the study area does not necessarily mean that there are no sub-surface artefacts. The assessed potential for subsurface deposits in the landforms of each transect are provided in **Table T1** at the back of this report.

5.7 Aboriginal Site Potential in Unsurveyed Areas

As discussed in **Section 3.1** the field survey used a targeted sampling approach to identify Aboriginal sites within the pipeline corridor and field area, and areas where potential archaeological deposits may occur. This section provides a general Aboriginal site location model covering areas of the study area that were not surveyed. Although the survey identified a relatively low number of Aboriginal sites, some general predictions may be made on the results.

5.7.1 Unsurveyed Areas

A number of sections of the proposed pipeline easement could not be included in the heritage assessment either because landowners had not granted the proponent permission to gain access either generally or for the cultural heritage survey specifically. These were designated 'No-Go" areas.

Of the original areas targeted for survey, the following 'No-Go' areas were identified in the study area:

- creek lines in the lower foothills of the range east of Gloucester; several owners – no access granted; field area altered to avoid properties, therefore access deemed unwarranted;
- Glen Martin Road: Broadbent's properties – 21280 892DP262981 and 21290 893DP262981 – owner unavailable for contact; access deemed unwarranted due to visual inspection of the landforms; and
- East Seaham Road: Rushworth's property – 21580 185DP1114256 – no access granted; access deemed unwarranted due to visual inspection of the landforms.

5.7.2 Aboriginal Site Patterning

From the results in **Section 5.6** it can be seen that open sites are the main Aboriginal site type likely to be encountered in the study area. They appear to be found in two contexts:

1. in areas of greatest water reliability, particularly in association with higher order water courses (≥ stream order 4); and
2. on lower to mid foot slopes that overlook a water source, but are slightly elevated to avoid periodic flooding.

There were no open sites found on ridge tops during the survey; indicating that sites on ridge tops in the study area are rare. However, such sites are commonly found on this type of landform elsewhere, particularly where low ridges are in close proximity to reliable water, and the paucity of sites in the study area is probably due to poor ground surface visibility during the survey.

The second Aboriginal site type identified in the study area was scarred trees. Upper stratum vegetation has been largely cleared within the study area, leaving only remnant patches within the margins of watercourses, along some road margins or as isolated copses surrounded by cleared pasture. Therefore, the occurrence of scarred trees will only be associated with these areas. Additionally, much of the vegetation observed during the survey was regrowth; there were few mature trees observed that are old enough to carry cultural scars. It should also be noted that the two sites identified in the field survey –LEA1 and LEA6 – are only identified as “possible” scarred trees; the diagnostic features of each site were not sufficient to identify them definitively (Long 2005).

5.7.3 Aboriginal Site Predictions

The patterning of Aboriginal site locations allows the development of a general Aboriginal site location model covering areas of the study area that were not surveyed. While it is accepted that Aboriginal people lived in all areas of the environment and left evidence in all parts of the landscape, this discussion focuses on landscape areas where past repeated Aboriginal activity left the most obvious and enduring archaeological signature, suitable for interpretation and heritage management.

Open sites, comprising stone artefacts on the open ground, or as subsurface deposits, are likely to occur within 50 m of a high order creek or river, although they may be found up to 200 m from a water source. Open sites are less likely to be found adjacent to ephemeral low order streams. These sites are likely to occur on largely undisturbed ground that has not been disturbed by building, road or dam construction or landscaped areas.

Although, there were no ridge-top open sites found during the survey, it is likely that such sites will occur on low ridges, especially if such ridges are located within 100 m of a reliable water course.

It should be noted that the pipeline corridor traverses longitudinally (i.e. southerly) along the valleys of several major creeks and rivers (**Section 3.1.1**). There are many water courses that drain off the bordering hills and ranges and drain eastwards (or westwards) into the main streams, and are consequently crossed by the pipeline.

The 14 PADs identified during the survey were determined on the predictive model stated above and were located where the pipeline corridor is currently aligned. Although the alignment of the pipeline route has avoided the majority of the PADs identified in this survey, it is considered that five PADs will be impacted. It is considered that realignment of the pipeline will not avoid these PADs because Aboriginal open sites could occur along any part of the associated watercourses. Therefore, the heritage management commitments in **Section 10.0** have been based on that assumption.

With little evidence of stone artefacts located during the survey, and with few sites previously located and recorded, actual artefact densities within the study area cannot be made with any accuracy. All studies to date, including this study, indicate that artefact densities are likely to be very low (probably $<1/m^2$).

6.0 Historic Heritage Results

AECOM undertook a search of the NSW Heritage Branch (DoP) Heritage Database on 14 August 2008 for the Gloucester, Great Lakes, Dungog, Port Stephens, Maitland and Newcastle local government areas (LGAs). The search identified a total of 1,474 historic heritage sites listed within those LGAs (**Table 16**). The majority of listed items are located within the urban areas of towns in the region, e.g. Gloucester, Stroud, etc.

Table 16: Historic Heritage Items Listed in the LGAs traversed by the Study Area

LGA	No. of Historic Heritage Items Listed			
	SHR	s.170	LEP/Gaz	Total
Gloucester	1	1	64/11	77
Great Lakes	4	1	60/0	65
Dungog	19	0	0/138	157
Port Stephens	7	3	32/0	42
Maitland	35	24	234/1	294
Newcastle	37	100	703/0	840
Total	**103**	**129**	**1,243**	**1,475**

Only one item listed on a heritage instrument was identified within the pipeline corridor (i.e. within 100 m of the proposed gas pipeline route) or within the field area (**Table 17**). This item – the Vale of Gloucester – though listed, is a nomination for the RNE and is not formally registered.

Table 17: Items within the Study Area listed on Heritage Instruments

Item	Location	List
Vale of Gloucester	Approximately 25,000 ha, comprising generally the upper Avon River catchment south of Gloucester and part of the Gloucester River catchment between Faulkland and Gloucester.	RNE (Indicative Place)

6.1 Listed Historic Heritage Items in the Study Area

The following listed item is located in the study area:

Vale Gloucester

The Vale of Gloucester was nominated for listing on the RNE. The nominated area consists of approximately 25,000ha, comprising generally the upper Avon River catchment south of Gloucester and part of the Gloucester River catchment between Faulkland and Gloucester (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

The Vale includes the headwaters of the Avon River. The northern section of the Vale is overshadowed by the Bucketts Range to the west and the Mograni Range to the north-east. The ranges are predominantly granite and volcanic in origin, contrasting markedly with the shale derived low hills and undulating topography of the valley. The ranges are heavily timbered in contrast to the largely cleared grazing land of the valley floor. The vale in which the township of Gloucester is situated, is surrounded by heavily forested ranges which serve as a spectacular backdrop to the rural lands of the slopes and valley floor.

The Vale was nominated for listing on the RNE for the following reasons:

> *Scenic value: the town of Gloucester is surrounded by a series of low hill ranges which dominate the valley floor and provide a spectacular backdrop to the agricultural activity that takes place in the valley. Historical: the vale of Gloucester was discovered in 1826 by the chief agent of the Australian agricultural company, Mr Robert Dawson. During development of the vale for sheep raising and later for cattle, the homestead was built.*

The assessment panel recommended the item be included, but the Commission deferred it. Its current status is 'Indicative Place,' meaning that it is not yet registered but is currently undergoing assessment.

6.2 Historic Sites Identified in the Field Survey

A total of 11 historic places, which are not currently listed on a heritage instrument, were identified and recorded during the field survey. Furthermore, all are built-structures, compared to the heritage-listed site – the Vale of Gloucester (**Section 6.1**) – which is a cultural landscape.

The heritage survey was undertaken at the same time as the Aboriginal survey. The survey was designed to incorporate the locations of known historical places. Historic sites frequently occur in similar areas to Aboriginal sites as both are looking for similar characteristics – flat land on which to camp/build and ready access to water.

NB. Although all places identified in the field survey are listed here, the significance assessment (**Section 7.3**) shows that not all items are considered to be 'heritage' items. This section provides a brief description of each place.

Site LEH1 Cobb and Co Hut (MGA Coordinates: 0398142E 6429351N)

This site is located at the old 'Weismantles Inn' at the Monkerai Road turnoff from the Bucketts Way, to the north of Maddens property, at 1655 The Bucketts Way, Weismantels. It is situated on the eastern side of Buckets Way, approximately 150 m off the side of the road and approximately 180 east of the pipeline route (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

Since this item is not in the path of the proposed pipeline, it was not inspected.

Site LEH2 European Scarred Tree (MGA Coordinates: 0397480E 6427560N)

This site is located on Wielgosinkski's property, Buckett's Way, near Stroud Road (31DP828026). It is situated on the eastern side of Bucketts Way, approx 100 m south of Groom Creek (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

The site consists of a single box-type eucalypt tree that was said to have been emblazoned with the initials of Fred Ward (aka Captain Thunderbolt) (**Plate P20**). Although the tree was not seen close up, discussions with the owner indicate that the story is an urban myth and the tree is, in fact, relatively recent regrowth. The size of the bole tends to support that theory.

Another local tale is that Groom Creek is so-named because it is where Thunderbolt is said to have groomed his horse. There is no corroborating evidence for this.

Site LEH3 Hut and Stockyards (MGA Coordinates: 0396564E 6416168N)

This site is located on Gorton's property, off the western side of Black Camp Road, west of Stroud (3DP744888). It is situated about 20 m from the road edge (**Figures 19.1** to **19.16** in **Volume 4** of the EA).

The hut is an end-gabled, rectangular timber hut (**Plate P21**). The walls are framed with round-log corner posts with top and bottom beams. They are clad with vertical timber slabs (most are missing off the front and side walls, but mostly intact on the rear wall). The roof is clad with corrugated iron and the gables are also clad with several small sheets of corrugated iron. The roof appears to be newer than the rest of the hut since it is framed with sawn timber joists and rafters. There is a single door and window at the front. There is no glass in the window but there is a leaf hinge attached to the frame indicating a timber shutter. There are also the remains of a very small galvanised-iron water tank and stand at the southern end.

About 20 m south of the hut is an old stockyard with newer extensions that may still be in use. Several sections of old timber fence lie around the hut consisting of timber posts with rebates for two rails. A small refuse scatter is located about 5 m south of the hut.

Site LEH4 Stockyard (MGA Coordinates: 0395584E 6411836N)

This site is located on Fearon and Nosworthy's property on Black Camp Road (103DP570275) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). It is a small stockyard measuring about 20 x 10 m with a stock ramp and chute at the southern end (**Plate P22**). It appears to have had three pens, but many of the fences have fallen down leaving gaps in the structure. It is constructed of 1.5 m high round-log posts (at ~3 m centres) with three split-log rails and a top-rail. All rails are wired to the posts. The stock ramp has a base of coarse rock that was probably covered in loose gravel that has since been washed away. The rock fill is between vertical round log sides.

Site LEH5 Brick Pile (MGA Coordinates: 0395201E 6411570N)

This site is on Farrell's property on the eastern side of Black Camp Road (35DP95407). It lies just north of the confluence of the road and the transmission line easement (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of a small pile of red-orange bricks and rocks (**Plate P23**). The bricks have a "V" notch on one surface and the remains of mortar is still attached. The bricks are stacked in a neat pile indicating that they are not in situ, but probably come from a former house/hut site nearby (location unknown).

Site LEH6 Hut (MGA Coordinates: 0394663E 6410184N)

This site is located on James and Hull's property, on the western side of Black Camp Road (122DP526671) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). This site consists of a hut that has been added to over many years (**Plate P24**). It is clad in various states of corrugated iron (walls and roof), has a skillion-form roof, and measures approximately 20 x 4 m. It has a small 'settler's hut' type chimney and a small water tank and stand at the SE end. It appears to have been added-to and now has what appears to be a vehicle bay at the NW end. The hut appears to be serviceable but is showing signs of marked deterioration. The roof cladding at the SE end is held down by the weight of several sawn timber beams lying on top. Several rusting farm implements lie along the rear wall.

Site LEH7 Stockyard (MGA Coordinates: 0394609E 6410020)

This site is located on James and Hull's property, on the western side of Black Camp Road (122DP526671) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of a stockyard that was originally constructed of round log posts with round log rails wired to the posts (**Plate P25**). Several sections appear to have been either repaired or extended using round log posts with sawn timber rails (also attached by wire). The interior of the yards have been reinforced by wire mesh; the yard appears to be in useable condition though modifications mean that it has only moderate integrity.

Site LEH8 Bridge (MGA Coordinates: 0393225E 6409125N)

This site is located on Black Camp Road on the Cedar Tree Creek crossing, adjacent to Muddle's property and 20 m SE of "Margaret's Folly" (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of a small vehicular bridge measuring 10 x 3.5 m, consisting of several longitudinal log spans side by side and covered in coarse rubble (**Plate P26**). There are two large mature eucalypt trees at each corner of the SW end. The base of the northernmost tree has grown over one of the side longitudinal spans suggesting the bridge has been in existence for many years. The bridge is similar to many existing farm-track bridges still evident in the Gloucester region.

Site LEH9 Bridge (MGA Coordinates: 0391638E 6408132N)

This site is located on the old section of Black Camp Road, on the road easement adjacent to Muddle's property (33DP95007) (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of a small vehicular bridge measuring 10 x 2.5 m, consisting of several longitudinal log spans side by side and covered in coarse rubble (**Plate P27**). The central log spans have collapsed making the bridge impassable. The bridge is similar to many existing farm-track bridges still evident in the Gloucester region, and is of the same construction style as site LEH8.

Site LEH10 Mound (MGA Coordinates: 0376589E 6371963N)

This site is located at Woodberry, Greenways Creek, approx 150 SE of the Hunter Water pipeline crossing over Greenways Creek (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of 3 x 3 m earth mound that appears to be the foundations of a former structure that has since been demolished (**Plate P28**). The mound has battered sides and rises 0.5 m above the surrounding flats. This site is possibly the foundations of a former pump house. No structural remains extant. The site is considered to have low heritage significance.

Site LEH11 Bridge (MGA Coordinates: 0376590E 6371984N)

This site is located at Woodberry, Greenways Creek, approx 150 SE of the Hunter Water pipeline crossing over Greenways Creek (**Figures 19.1** to **19.16** in **Volume 4** of the EA). The site consists of an old timber bridge over Greenways Creek, measuring 8 x 2 m (**Plate P29**). The bridge is constructed of timber sleepers over round-log longitudinal bearers (x5). The sleepers are fastened to the bearers by large-diameter iron spikes. Some sleepers are missing and most of those remaining are decayed to various degrees.

6.3 Discussion

As stated previously, the inclusion of these items does not imply that they are considered to be 'heritage' items, which implies a level of significance. Rather they are a list of items that were considered to be historic features in the landscape worthy of assessment of heritage significance. The heritage significance assessment (see **Section 7.3**) identified one item that is considered to have local heritage significance, and three items that were considered to have potential significance but further research is required.

7.0 Cultural Heritage Significance

This section provides an assessment of the Aboriginal heritage significance of the study area within a local, regional and national framework. This section can be divided into two distinct parts, a scientific assessment and an Aboriginal cultural assessment of social value. The former is undertaken by the archaeologist and investigates the scientific importance of the sites identified, while the latter is provided by discussions and input from the relevant Aboriginal stakeholders.

7.1 Principles of Assessment

Heritage sites, objects and places hold value for communities in many different ways. The nature of those heritage values is an important consideration when deciding how to manage a heritage site, object or place and balance competing land-use options. The many heritage values are summed up in an assessment of “Cultural Significance”.

The primary guide to management of heritage places is the Australia ICOMOS Charter for Places of Cultural Significance (The Burra Charter) 1999. The Burra Charter defines cultural significance as follows:

> *Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations.*
>
> *Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects.*
>
> *Places may have a range of values for different individuals or groups.*

This assessment has sought to identify heritage objects and sites within the study area and obtain enough information to allow the values of those objects and sites to be determined.

This significance assessment will be limited to an assessment of Aboriginal heritage significance only.

7.2 Aboriginal Cultural Heritage

The criteria for the assessment of the ‘heritage significance’ of Aboriginal sites are the site’s scientific, educational significance and social/cultural value.

7.2.1 Scientific Value

Scientific value is assessed according to the research potential of a site. Rarity and representativeness are also related concepts taken into account. Research potential or demonstrated research importance is considered according to the contribution that a heritage site can make to present understanding of human society and the human past. Heritage sites, objects or places of high scientific significance are those that provide an uncommon opportunity to inform us about the specific age of people in an area, or provide a rare glimpse of artistic endeavour or provide a rare chronological record of changing life through deep archaeological stratigraphy.

The comparative rarity of a site is a consideration in assessing scientific significance. A certain site type may be “one of a kind” in one region, but very common in another. Artefacts of a particular type may be common in one region, but outside the known distribution in another.

The integrity of a site is also a consideration in determining scientific significance. While disturbance of a topsoil deposit with artefacts does not entirely diminish research value, it may limit the types of questions that may be addressed. A heavily cultivated paddock may be unsuited to addressing research questions of small-scale site structure, but it may still be suitable for answering more general questions of implement distribution in a region and raw material logistics.

The capacity of a site to address research questions is predicated on a definition of what the key research issues are for a region. In the region the key research issues revolve around the chronology of Aboriginal occupation and variability in stone artefact manufacturing technology. Sites with certain backed implements from the Holocene are very common, but sites with definite Pleistocene evidence are extremely rare, and hence of extremely high significance if found.

Sandra Bowdler and Anne Bickford suggest that the value of a place/object can be judged by answering the following questions:

> Can the site contribute knowledge which no other resource can?
>
> Is the knowledge relevant to general questions about human history or other substantive subjects?

To adequately assess significance, evidence is required which includes information about the presence of subsurface deposits, integrity of these deposits, nature of site contents and extent of the site. A review of information about previously recorded sites within the local area and region enables the rarity and representativeness of a site to be assessed (**Section 2.4**).

High significance is usually attributed to sites that are so rare or unique that the loss of the site would affect our ability to understand aspects of past Aboriginal use/occupation for an area. In some cases a site may be considered highly significant because its type is now rare due to destruction of the archaeological record through development. Moderate significance can be attributed to sites which provide information on an established research question. Low significance is attributed to sites which cannot contribute information about past Aboriginal use/occupation of an area. This may be due to site disturbance or the nature of the site's contents.

7.2.2 Educational Value

The educational value of a site or a suite of sites is their potential to be used by members of the wider community for on-site lectures, tour and displays.

7.2.3 Cultural (Social) Value

Aspects of social significance are applicable to sites, objects and landscapes that are important to the local Aboriginal community. The importance involves both traditional links with specific areas as well as an overall concern by Aboriginal people for sites generally and their continued protection.

Aboriginal sites with archaeological evidence are all of value to the Aboriginal community because they represent a tangible connection with pre-European Aboriginal life. For this reason, we often report what we perceive to be the social value of a site to the Aboriginal community based on their comments and advice.

In acknowledgement that the Aboriginal community themselves are in the best position to identify levels of cultural significance a copy of this draft report was distributed to the Aboriginal stakeholders involved in the project and their comments on values, both social and cultural, were incorporated into the assessment prior to its finalisation.

Local Aboriginal community groups were consulted regarding the methodology used in this assessment and, where possible, involved in the field survey. Prior to the field survey, all registered Aboriginal stakeholders were requested to provide information on the cultural heritage values of the study area. There was very little response to that request, with the exception of ATOAC, who expressed reluctance to share their cultural heritage with others "in respect to aspects of the cultural significance that connects them to their country (ATOAC, letter dated 6 April 2009, **Appendix B**). However this is at odds with a later statement made (ATOAC, letter dated 31 August 2009, **Appendix B**) which stated that only traditional owners have the right to comment on cultural values (spirituality) of any particular location or site. ATOAC are, in effect, say that only they can comment on the cultural (social) values of the study area, but they are not going to.

Therefore it is difficult to draw any conclusions regarding those values.

7.2.4 Assessment

Table 18 below gives the significance assessment of the Aboriginal sites identified during the heritage investigations.

Table 18: Significance Assessment of Aboriginal Sites Identified During the Field Survey

Site ID	Site Type	Scientific Assessment	Educational Assessment	Social/Cultural Assessment	Significance
LEA1	Scarred Tree	The poor condition of the tree provides some doubt as to whether the scar is culturally formed: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA2	Artefact Scatter	Two stone artefacts of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA3	Isolated Find	Single stone artefact of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA4	Isolated Find	Single stone artefact that exhibited very few diagnostic features: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA5	Isolated Find	Single stone artefact of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA6	Artefact Scatter	Two stone artefacts of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*

Site ID	Site Type	Scientific Assessment	Educational Assessment	Social/Cultural Assessment	Significance
LEA7	Scarred Tree	The shape of the scar on this tree is unusual and makes identification as a cultural scar doubtful: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA8	Artefact Scatter	Two stone artefacts of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*
LEA9	Artefact Scatter	Two stone artefacts of similar style to artefacts found elsewhere: *Low*	Of limited educational value: *Low*	Not given	*Low*
AHIMS #38-1-0006	Bora ground	Re-identified during survey, and is probably of *high* scientific value.	Unsuitable for educational use: *Low*	Not given	*High*

Scientific Significance Assessment

The sites found during the heritage assessment of the Coal Seam Gas Project were either single stone artefacts, very low density stone artefact scatters, or scarred trees that were either too damaged or of such unusual shape as to render their identification as cultural scars doubtful.

These sites offer little potential for advancing scientific knowledge of the Aboriginal occupation of the study area. On that basis the sites found in the study area are considered to offer no scientific value. The Bora Ground is considered to be of high scientific value.

Educational Significance Assessment

The isolated nature of these sites, together with their lack of scientific value, is considered to render very little value in providing an educational source for the wider community. On that basis the sites found in the study area are considered to have little educational value, with the exception of the bora ground on Black Camp Road.

Social/Cultural Significance Assessment

During the initial consultation process there were no views expressed by the Aboriginal community on the cultural value of the study area. A copy of the draft of this report was circulated to registered Aboriginal stakeholders after the Phase 1 fieldwork to seek their input. Comments from that draft were incorporated into this report, although no site-specific comments were received.

Following completion of Phase 2 fieldwork, as a result of amendments to the pipeline route and additions to the field area, a revised copy of this draft report was circulated to registered Aboriginal stakeholders for comment.

All comments from the Aboriginal community were included in the text of the final report where appropriate and written comments were attached in **Appendix B**.

7.2.5 Overall Aboriginal Heritage Significance

This section presents the overall Aboriginal heritage significance of the study area. This significance assessment can be considered a combination of the scientific, educational and cultural values, or an overview of the importance of a particular area through Aboriginal heritage sites and places. The subsequent retention or manipulation of these values will be the rationale behind the management strategy presented in **Section 9.2.**

Subject to feedback from the relevant Aboriginal communities regarding the cultural value of these sites, the overall heritage significance of these sites is considered to be low.

7.3 Historic Heritage

An assessment of significance for historic items is undertaken to explain why a particular site is important and to enable the appropriate site management strategies to be determined. Cultural significance is defined in the *Australian ICOMOS Charter for the Conservation of Places of Cultural Significance* (the *Burra Charter*) as 'aesthetic, historic, scientific or social value for past, present or future generations' (Article 1.1). Cultural significance may be derived from the fabric of a place, association with a place, or the research potential of a place. The significance of a place is not fixed for all time, and what is of significance to us now may change as similar items are located, more historical research is undertaken and community tastes change.

The process of linking this assessment with a site's historical context has been developed through the Department of Planning (DoP) and the NSW Heritage Management System and is outlined in the Heritage Assessment Guidelines of the *NSW Heritage Manual*. The Heritage Assessment Guidelines establish seven evaluation criteria, reflecting significance categories and representativeness, by which a place can be evaluated in the context of State or local historical themes.

7.3.1 Assessment Criteria

The heritage significance criteria are:

Criterion (a) – an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).

Criterion (b) – an item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).

Criterion (c) – an item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).

Criterion (d) – an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.

Criterion (e) – an item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area).

Criterion (f) – an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area).

Criterion (g) – an item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments.

Different components of a place may make a different relative contribution to its heritage value. Loss of integrity or poor condition may diminish significance. In some cases it may be useful to specify the relative contribution of an item's elements. While it is useful to refer to Table 19 when assessing this aspect of significance, it may need to be modified to suit its application to each specific item.

Table 19: Grades Used to Determine Heritage Value

Grading	Justification	Status
Exceptional	Rare or outstanding item of local or State significance. High degree of intactness. Item can be interpreted relatively easily.	Fulfils criteria for local or State listing
High	High degree of original fabric. Demonstrates a key element of the item's significance. Alterations do not detract from significance.	Fulfils criteria for local or State listing.
Moderate	Altered or modified elements. Elements with little heritage value but which contribute to the overall significance of the item.	Fulfils criteria for local or State listing.
Little	Alterations detract from significance. Difficult to interpret.	Does not fulfil criteria for local or State listing.
Intrusive	Damaging to the item's heritage significance.	Does not fulfil criteria for local or State listing.

Following Kerr (2000) the cultural significance of a precinct or element within a precinct can be expressed in three broad ways (these encompass the significance criteria above) through:

- the ability to demonstrate an aspect of the precinct's significance. For example the fabric on the site could demonstrate how a site was used;
- the association of the precinct with an important event or a particular person. The association may not require physical evidence of the event; and
- the ability of archaeological remains in a precinct to answer relevant research questions.

These three ways of expressing significance apply as much to archaeological remains as they do to the built environment or the landscape. It is conceivable that archaeological remains may not have any research potential but have strong historical associations or a high ability to demonstrate an aspect of history.

The relationship between an item and its historical context underlies this assessment process. Historical themes provide a context within which the heritage assessment criteria are applied, especially if historical values are critical to an understanding of an item's heritage significance.

7.3.2 Significance Assessment of Unlisted Historic Items

This section assesses the significance of the buildings and structures identified in the fieldwork. It assesses them as a group as they share many common elements. The evaluation criteria outlined in the NSW Heritage Branch guideline *Assessing Heritage Significance* have been used to undertake the assessment of the following heritage items. **Table 20** provides a succinct assessment of each item's significance and **Figures 19.1** to **19.16** in **Volume 4** of the EA details each site plotted within the study area boundary and its level of significance.

Table 20: Significance Assessment of Unlisted Non-Indigenous Places Identified in the Field Survey

Site ID	Name	Significance Criteria	Significance Assessment	Significance
LEH1	Cobb and Co Hut	-	Further research and inspection required.	*Deferred assessment*
LEH2	Unnamed Tree	-	Further evidence required.	*Deferred assessment*
LEH3	Hut and Stockyard	g	An interesting pastoral hut dating from the late 19th century, that retains many relics of former pastoral life.	*Local*
LEH4	Stockyard	-	This stockyard is similar to any one of hundreds of similar items still extant.	*None*
LEH5	Brick Pile	-	This site does not display any evidence of historic heritage value.	*None*
LEH6	Hut	-	An interesting hut that exhibits some features of early construction but is largely obscured by subsequent additions. Further research required.	*Deferred assessment*
LEH7	Stockyard	-	This stockyard is similar to any one of hundreds of similar items still extant.	*None*
LEH8	Bridge	-	The bridge is similar to many existing farm-track bridges still evident in the Gloucester region.	*None*
LEH9	Bridge	-	The bridge is similar to many existing farm-track bridges still evident in the Gloucester region.	*None*
LEH10	Mound	-	This site is not considered to have any heritage value.	*None*
LEH11	Bridge	-	This site is not considered to have any heritage value.	*None*

To summarise:

- One item – Vale of Gloucester – is already listed on a heritage instrument and was not reassessed here.
- One unlisted place located during the survey – LEH3 – was assessed as having local heritage significance.
- Three unlisted places – LEH1, LEH2 and LEH6 – appear to exhibit features that may have local heritage value, but further research is required. Assessment was deferred pending further research.
- The remaining seven places identified during the survey are considered to have no heritage value.

8.0 Impact Assessment

This section provides an assessment of the impacts of the development on the cultural heritage values of the study area.

8.1 Project Construction Details

The project involves the reconstruction of:

- the installation of 110 wells in Stage 1 GDFA (the field area);
- the installation of approximately 38.1 km of gathering lines and 28.9 km of spine lines, totalling 67 km. Access tracks will also be constructed within the field area, but the footprint of this area was not available at the time of writing. For the purposes of this impact assessment the total length of access tracks is assumed to be 10 km;
- the construction of a central processing facility (CPF) within the field area. Two options are currently being considered for the location of the CPF:
  - "Facility 1" on Tiedman's Block, south of Gloucester; or
  - "Facility 7" immediately south of the Gloucester Coal Mine rail loop; and
- the installation of buried gas pipeline from the field area to the terminus at Hexham. The length of the pipeline will depend on the final location of the CPF:
  - the pipeline length if CPF "Facility 1" on Tiedman's Block is selected is approximately 103.5 km; or
  - the pipeline length if CPF "Facility 7" is selected is approximately 95.2 km.

The study area consists of a total area of 59.9 km^2 consisting of:

- approximately 50.33 km^2 (5033 ha) for the field area; and
- approximately 9.52 km^2 (952 ha) for the gas pipeline survey area.

The following subsections describe the specific construction detail.

8.1.1 The Field Area

The field area will be impacted by the construction of approximately 110 wells spaced at approximately 600 m intervals. The wells will have an initial impact area of 90 x 90 m (0.81 ha) during drilling (the hardstand for each well will be reduced to 15 x 15 m (0.0225 ha) during production, with the remaining land restored). A series of underground gathering lines and spine lines will be constructed to convey the gas from the well heads to the CPF.

The CPF will cover an area of approximately 7.18 ha for CPF "Facility 1" or 6.4 ha for CPF "Facility 7".

8.1.2 Gas Pipeline

The methane gas pipeline between the CPF at Stratford and the delivery point at Hexham will be approximately 103.5 km if "Facility 1" is chosen for the CPF or 95.2 km long if "Facility 7" is chosen for the CPF. Construction of the pipeline will consist of clearing and grading a temporary construction corridor up to 30 m wide along the entire route. This will involve vegetation clearance and impact to topsoil within this corridor. The survey sampled a corridor up to 100 m wide to allow for minor alterations to the intended route.

It is intended that, where possible, existing infrastructure corridors/easements such as transmission line easements or Telstra telephone cable corridors, will be used to site the pipeline. Many of these areas have already received a high level of disturbance, particularly those where cable burial has occurred.

Trenching

The gas pipeline will involve removal of topsoil along the route, which will be stockpiled for later site remediation. A trench (approximately 0.6 m wide by 1.2 m deep) will be excavated to lay the pipe. The trench will then be backfilled and the topsoil replaced. Access and maintenance tracks will also be established where required.

Major roads and railways will be bored to minimise construction impact.

River and Creek Crossings

Two methods are proposed for laying the pipe across rivers and creeks:

- major water courses, such as the Avon, Karuah, Williams and Hunter Rivers, as well as some high order creeks, will be installed by drilling a parabolic bore beneath the river channel. This method of crossing will have the least impact (in terms of archaeological sites) as the entry/exit point will be located some distance back from the banks; the distance will depend on the depth/distance of bore-hole required; and
- minor water courses, ephemeral streams and tributaries will be crossed by open cut trenching; the depth and width of the cutting will depend on the geology and hydrology of the particular creek. This method is likely to have the greatest impact on potential archaeological sites.

Restoration

At the completion of the installation process, the corridor will be restored as near as practicable to its original condition. Remedial works include backfilling using excavated material and replacement of topsoil.

8.2 Impacted Area

Table 21 below presents the area of the study area that will be impacted by the development. The table provides a calculation of impact for both CPF site options.

It is likely that approximately 7.2% to 7.5% of the study area will be directly affected by ground-breaking activities during the project (4.3 or 4.5 km^2 of an estimated 59.9 km^2 study area).

Table 21: Area Impacted by the Project (both CPF Options)

	CPF "Facility 1"	CPF "Facility 7"
Area of main pipeline impact	3.1 km^2 (103.5km long by 30 m wide)	2.9 km^2 (95.2 km long by 30 m wide)
Area of the CPF	0.064 km^2	0.072 km^2
Area of 110 well heads (90 x 90 m)	0.891 km^2	0.891 km^2
Area of gathering lines within Field Area	0.381 km^2 (38.1 km long by 10 m wide)	0.381 km^2 (38.1 km long by 10 m wide)
Area of access tracks within Field Area	0.025 km^2	0.025 km^2
Percentage of study area impacted by groundbreaking activity	6.62%	6.30%
Total area impacted	**4.461 km^2**	**4.269 km^2**

8.3 Discussion

Throughout the survey, archaeological sites and potential archaeological deposits were identified and their positions relative to the intended route of the pipeline recorded. On this basis, the nature of impacts of the proposed development on heritage sites has been assessed. Sample areas included a 100 m wide corridor to allow for flexibility in the placement of the final pipeline route, and to ensure that alignment changes and construction activity to could be managed to minimise inadvertent damage to heritage sites.

All identified sites within the KLALC, MLALC and WLALC boundaries were visited with members of the local Aboriginal community (see **Section 4.0**). During the Phase 1 fieldwork and first draft report period, a number of minor realignment recommendations were made to the proposed pipeline route, to avoid impact to identified sites. Management outcomes (**Section 10.0**) were made in consultation with representatives of these groups. Due to timing, MLALC did not participate in Phase 1 of the fieldwork, but a large area of their area (south of the Hunter River) was inspected by another member of the local Aboriginal community (ADTOAC). However MLALC representatives participated in the fieldwork under Phase 2. FLALC did not participate in either stage of the field work. Several attempts to contact FLALC by email, mail and telephone received no response (see **Section 4.0**). Consequently, the management recommendations for sites and PADs within the boundaries of those two groups are yet to be discussed and confirmed.

TableT2, **TableT3** and **Table T4** at the back of this report list all heritage sites, both Aboriginal, historic and PADs. The sites were recorded in relation to the proposed route at the time of the survey. A series of mitigation recommendations were provided to the proponent and these have subsequently been incorporated into the design of the pipeline.

Potential impacts to the sites identified are graphically represented in **Figures 19.1** to **19.16** in **Volume 4** of the EA. The locations of known Aboriginal sites, together with potential sites, are overlain on an aerial photo with the pipeline route shown. The figure provides a useful guide to where development activities, and the position of the easement, may impact on observed Aboriginal or historic heritage sites.

The results section shows that there are seven existing Aboriginal sites occurring in close proximity to the study area:

8.3.1 Scarred Trees

Two possible scarred trees are located in the study area. One (LEA1) is situated in the field area within 2 m of the Avon River. It is understood that no construction activity, particularly well heads, will be conducted so close to the river or major creeks (T. Laurie, pers. comm.) and therefore it is considered that there will be no impacts to this site.

The other scarred tree (LEA7) is located in close proximity (30-45 m) to the proposed pipeline route, on its northern side. Amendments were recommended to keep the proposed route in the road easement and avoid crossing the creek on private property. Trees in the road easement were checked for evidence of cultural scarring; none was evident. This recommendation was incorporated into the final route of the pipeline, and it is therefore considered that no impacts to this site will occur.

The threats to scarred trees (in general) lie in the need for the easement to be largely cleared to provide clear access to the pipeline. However, the majority of the pipeline route passes through pasturelands that have been largely cleared of mature vegetation capable of bearing cultural scars. For the majority of the study area, upper stratum vegetation only occur along the banks of water courses, some of which will require clearing to allow construction of the pipe trench. All prominent water sources were inspected during the survey; no evidence of cultural scarring was found. On that basis AECOM considers that the project will have no detrimental affect on these sites.

8.3.2 Open Sites

Sites with stone artefacts, either as isolated finds or artefact scatters, were the most frequently occurring site types, although very few were located during the survey. In addition to very few surface artefacts being located, the majority of sample areas exhibited very low numbers of surface stone material in general.

As discussed in **Section 5.0**, the archaeological assessment suggests that stone artefacts are very infrequent within the study area and, at best, occur at a very low density in the subsoil. With such a low relative footprint, the excavations associated with construction of the proposed infrastructure are not considered likely to constitute disturbance that diminishes the scientific value of Aboriginal heritage.

The development will retain large undeveloped areas (92.5% of the study area) that will preserve any subsurface Aboriginal heritage intact. The balance of any possible affect on subsurface Aboriginal heritage values is considered to be readily mitigated by the retention of the majority of the study area as undeveloped land.

There is potential impact to subsurface Aboriginal artefacts in the areas identified by surface artefacts at LEA8 and LEA9, as well as five identified PADs. Low density artefact scatters at LEA2, LEA3, LEA5 and LEA6 may also be indicative of subsurface deposits but these sites are unlikely to be impacted by the proposal. The area surrounding the stone artefact at LEH4 has been heavily disturbed by roadworks, fence and building development. The potential for disturbance to *in situ* archaeological deposits is considered to be low.

Of the existing AHIMS-registered sites, three open sites occur within the study area. AHIMS #38-1-0008 is located in the southeast corner of the field area adjacent to the eastern boundary and is not expected to be impacted by the proposal. AHIMS #38-1-0031 occurs in the field area on land occupied by Stratford Coal and is not expected to be impacted by this project.

Of the existing AHIMS sites, there is potential for impact to one site – AHIMS #38-4-0010. This site consists of an isolated stone artefact but, more importantly, is said to be the site of a massacre. The site is located off the western side of the road easement along the banks of Little Black Camp Creek. A recommendation that the pipeline remain within the disturbed road easement to avoid any impacts in this area has been incorporated into the final alignment.

There is also potential for impact to three known Aboriginal sites (not registered on AHIMS) on Tiedman's Block in the field area. These sites, recorded by FLALC as part of the Stratford Pilot Project (FLALC 2007), consist of three stone artefacts, one at each of three separate locations. The FLALC report does not provide a specific location for any of the sites they found; however, it appears that the sites were found in the vicinity of Dog Trap Creek, probably on the property known as Tiedman's block, where gas wells have already been established under the pilot project. It is recommended that, should the final site of the CPF occur on Tiedman's Block, then salvage of these artefacts be conducted under the provisions of an AHMP in consultation with FLALC.

As can be seen in **Section 5.6**, areas within 50 m of a major watercourse (stream order 4 and above) present the most likely areas of encountering Aboriginal artefacts in the study area. However, the surface indications found during this study indicate that artefact densities are likely to be very low.

Other Stone-based Sites

There were no other stone-based sites (e.g. engravings, grinding groves or rock shelters) identified in the study area. Since the survey took a targeted approach, it is possible that such sites do exist in the study area, particularly in the areas north of and including Black Camp Road. There were very few outcrops of suitable sedimentary rock material evident in any of the survey sample areas. On that basis it is considered that the potential for impacts to these types of sites is low.

The hills to the north west of Seaham has large deposits of silcrete raw material, a material favoured by Aboriginal people for the production of stone tools. Silcrete is currently quarried at Brandy Hill Quarries, a large quarry complex operated by Hanson Quarries to the west of Seaham. Surface scatters of silcrete raw material was observed along the transmission line easement (Transect 50).

Ceremonial/Mythological Sites

There was no archaeological evidence of any ceremonial sites identified in the survey, with the exception of a previously recorded Bora ground on Black Camp Creek Road (AHIMS #38-1-006). A recommendation that the pipeline remain within the disturbed road easement to avoid any impacts in this area has been incorporated into the final alignment. However, it is recommended that an archaeologist and a representative of the local Aboriginal community member be present while excavations occur in this area, to ensure that no impacts to the Bora ground occur.

There are no known mythological sites likely to be impacted by the development.

8.3.3 Historic Heritage

Items Identified During the Field Survey

A total of 11 historic sites were identified in the study area; of these only one is considered to have local heritage significance, whilst significance assessment of a further three sites was deferred pending further research. As with Aboriginal sites, where the proposed pipeline alignment passed within close proximity to an identified historic site (whether of heritage value or not), recommendations were provided to the proponent on possible realignments that would mitigate potential impact to the site. These recommendations were implemented, and the final pipeline alignment has been re-routed to avoid these sites.

Due the targeted nature of the field survey, not all areas of the pipeline route were assessed during the field survey. It is possible that places of historic heritage value may occur in the study area that were not identified, particularly in the case of historic archaeological deposits. However, for the majority of its route, the pipeline crosses relatively open pasturelands, where evidence of historic built heritage is likely to be either non-existent or, at best, easily visible. Therefore on the balance of probability, AECOM considers that the potential for impacts to unknown historic heritage is low.

Heritage-Listed Items

Of the 1,475 heritage listed items within the relevant LGAs (**Table 16**), only one is located within the study area (**Table 17**). The remainder are considered unlikely to be impacted by the proposed development. Below is an assessment of impacts on the tem in the study area that is currently heritage-listed.

Vale of Gloucester (Register of the National Estate)

The Vale of Gloucester was nominated for listing on the RNE due to the outstanding visual amenity afforded by the Avon Valley floor bordered by the spectacular ranges to the east and west. The nomination's current status as an Indicative Place indicates that the nomination has not yet been accepted by the Australian Heritage Council (the status simply means that it somewhere in the assessment process).

The listing provides the following note under condition and integrity:

> *Development should not detract from the essentially rural nature of the area, and be harmoniously sited in respect to the more outstanding features of the landscape.*

The nomination for inclusion on the RNE was based on two parts, its scenic amenity (which is not within the scope of this report) and its historic value. The nomination listed its historic value as being based on the fact that the Vale was discovered by the (then) chief agent of the Australian Agricultural Company, Robert Dawson, and that a homestead was built while the area was being developed for sheep-raising.

The Vale nomination covers a vast area (250 km^2) whilst the field area incorporates only about 16% of that area; the majority of the Vale (about 84%) will not be affected by the development. In addition, the development occurs almost wholly on the valley floor, well away from the "more outstanding features of the landscape" such as The Bucketts to the west and the ranges to the east. The majority of the development will be subsurface and is not considered to be detrimental to the rural nature of the area. Except in the immediate vicinity of the CPF, which is located adjacent to the existing rail loop to the Stratford Coal mine, all lands associated with the development will retain their existing (rural/agricultural) uses.

It is considered that there will be no detrimental impacts to the Vale on a historic heritage basis. As such, the effect of introducing another industry to the area is not considered to be a significant impact.

9.0 Applicable Policy and Legislation

9.1 Commonwealth Legislation

9.1.1 Aboriginal and Torres Strait Islander Heritage Protection Act 1984

The purpose of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Heritage Protection Act) is the preservation and protection from injury or desecration of areas and objects in Australia and in Australian waters that are of particular significance to Aboriginal people in accordance with Aboriginal tradition.

Under the Heritage Protection Act the responsible Minister can make temporary or long-term declarations to protect areas and objects of significance under threat of injury or desecration. The Act can, in certain circumstances, override state and territory provisions, or it can be implemented in circumstances where state or territory provisions are lacking or are not enforced. The Act must be invoked by or on behalf of an Aboriginal or Torres Strait Islander or organisation.

The Act is administered by the Department of the Environment, Water, Heritage and the Arts.

9.2 New South Wales Legislation

The following New South Wales legislation protects aspects of cultural heritage and is relevant to development activities in the study area.

9.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act requires that consideration be given to environmental impacts as part of the land use planning process. In NSW environmental impacts are interpreted as including cultural heritage impact. Three parts of the EP&A Act are most relevant to Heritage. Part 3 relates to planning instruments, including those at local and regional levels; Part 4 controls development assessment processes; and Part 5 refers to approvals by determining authorities.

Part 3A provides an approvals regime applying to all major projects. Major projects are defined under State Environmental Planning Policy (Major Projects) 2005 (SEPP 2005). It also applies to those projects which the Minister believes are required to deliver particular government plans or programs, known as critical infrastructure projects. Part 3A applies to all projects where the Minister has the approval role. Under Part 3A, the Minister can issue a project approval or a concept approval. Both maintain the requirement for consultation with the community and relevant State Government agencies, however the requirement for certain other permits and licences is removed under Part 3A.

Section 75B(2) of the EP&A Act makes provision for ‘major projects’ to be identified through various means, including by way of declaration as a listed project in SEPP 2005, or by notice in the Gazette.

The proposed project is classified as a 'major project' under Part 3A.

- Under section 75U of the EP&A Act, projects approved under Part 3A do not require a permit under section 87 or a consent under section 90 of the NPW Act. Under the Part 3A provisions, the Minister for Planning is the consent authority and has ultimate responsibility for determining matters relating to Aboriginal heritage. However, for the preparation of an Environmental Assessment, the Director-General will issue environmental assessment requirements under s.75F, in consultation with other relevant public authorities and have regard to the need for the requirement to assess any key issues raised by those public authorities. In practice this usually means that Part 3A still requires assessment of potential impacts to European and Indigenous heritage and such assessment is generally equivalent to the normal assessment process under the NPW Act and Heritage Act.

9.2.2 Heritage Act (1977)

The *Heritage Act 1977* was enacted to conserve the environmental heritage of New South Wales. Under section 32, places, buildings, works, relics, moveable objects or precincts of heritage significance are protected by means of either Interim Heritage Orders (IHO) or by listing on the State Heritage Register (SHR). Items that are assessed as having State heritage significance can be listed on the SHR by the Minister on the recommendation of the Heritage Council.

Archaeological relics (any relics that are buried) are protected as either SHR items or, when not SHR items, by the provisions of section 139. Under this provision it is illegal to disturb or excavate any land knowing or suspecting that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed. In such cases an excavation permit under section 140 is required. Note that no formal listing is required for archaeological relics; they are automatically protected.

Proposals to alter, damage, move, damage or destroy places, buildings, works, relics, moveable objects or precincts protected by an IHO or listed on the SHR require an approval under section 60. Demolition of whole buildings will not normally be approved except under certain conditions (section 63). Some of the sites listed on the SHR or on LEPs may either be 'relics' or have relics associated with them. In such cases, a section 60 approval is also required for any disturbance to relics *associated* with a listed item.

9.2.3 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act), administered by DECCW, is the primary legislation for the protection of Aboriginal cultural heritage in NSW. One of the objectives of the NPW Act is:

> *The conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including but not limited to: (i) places, objects and significance to Aboriginal people…* (s.2A(1)(b))

Part 6 of the NPW Act provides specific protection for Aboriginal objects and places by making it an offence if impacts are not authorised. An Aboriginal Heritage Impact Permit (AHIP) should be obtained if impacts on Aboriginal objects and places are anticipated. AHIPs can be issued under ss.87 and 90 of the NPW Act.

Sections 86 and 87

Under section 86 of the NSW *National Parks and Wildlife Act 1974* (NPW Act) it is an offence to:

a) disturb or excavate any land, or causes any land to be disturbed or excavated, for the purpose of discovering an Aboriginal object; or

b) disturb or move on any land an Aboriginal object that is the property of the Crown, other than an Aboriginal object that is in the custody or under the control of the Australian Museum Trust.

…except in accordance with the terms and conditions of an AHIP issued under s.87 of the NPW Act.

Section 90

Under section 90 of the NPW Act it is an offence to:

> *knowingly destroy, deface or damage, or knowingly cause or permit the destruction or defacement of or damage to, an Aboriginal object or Aboriginal place…*

…unless under an AHIP issued by the Director-General under s.90, subject to such conditions and restrictions as are specified in the AHIP. Therefore an AHIP issued under s.90 should be obtained if impacts on Aboriginal objects and places are anticipated.

For the purposes of the Act:

- An *Aboriginal object* is any deposit, object or material evidence (that is not a handicraft made for sale) relating to Aboriginal habitation of NSW, before or during the occupation of that area by persons of non-Aboriginal extraction (and includes Aboriginal remains).
- An *Aboriginal place* is a place declared so by the Minister administering the NPW Act because the place is or was of special significance to Aboriginal culture. It may or may not contain Aboriginal objects.

Consultation with the Aboriginal community is required under DECCW policy when an application for an approval under Part 6 of the NPWS Act or Part 3A of the EP&A Act is considered. The consultation process used in this study is outlined in more detail in **Section 4.0**.

9.3 Local Government

Under the provisions of the EP&A Act, Local Environmental Plans (LEPs) and Regional Environmental Plans (REPs) are prepared by a Local Government Council. An LEP defines some of the rules relating to the development of an area or a particular site. It contains information on the zoning of land and any special provisions relating to the development of the land. An LEP is enforceable after it is published in the Government Gazette (i.e. “gazetted”) by the NSW Minister for Planning. Typically, LEPs and REPs have provisions that protect items of environmental heritage.

There are six LEPs that affect this project:

1 Gloucester Local Environmental Plan 2000;

2 Great Lakes Local Environmental Plan 1996;

3 Dungog Local Environmental Plan 2006;

4 Port Stephens Local Environmental Plan 2000;

5 Maitland Local Environmental Plan 1993; and

6 Newcastle Local Environmental Plan 2003.

9.3.1 Gloucester Local Environmental Plan 2000

The *Gloucester Local Environmental Plan 2000* (GLEP) is the statutory (legal) planning document that applies to the whole of the Gloucester LGA.

The GLEP requires that a development consent is required should any proposed impact to non-Aboriginal heritage be required (Clause 42). Should impact to Aboriginal archaeological sites be required, the Gloucester Council may grant consent following the lodgement of an assessment which meets DECCW guidelines and following comment from DECCW upon the application, and following consent under NPWS Act (Clause 45(1)). Should impact to non-Aboriginal archaeological sites be required, the Gloucester Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application, and following consent under the Heritage Act (Clause 45(2)).

Should development occur within the vicinity of a heritage item, heritage conservation area, archaeological site, potential archaeological site or any building, works or relic more than 50 years old, Council must assess impacts of the development (Clause 46).

Heritage items, heritage conservation areas, archaeological sites and potential archaeological sites are listed in Schedule 5 of the GLEP.

9.3.2 Great Lakes Local Environmental Plan 1996

The *Great Lakes Local Environmental Plan 1996* (GLLEP) is the statutory (legal) planning document that applies to the whole of the Great Lakes LGA.

The GLLEP requires that a development consent is required should any proposed impact to non-Aboriginal heritage be required (Clause 21(4)). Should impact to Aboriginal archaeological sites be required, the Great Lakes Council may grant consent following the lodgement of an assessment which meets DECCW guidelines and following comment from DECCW upon the application, and following consent under NPWS Act (Clause 21(7)). Should impact to non-Aboriginal archaeological sites be required, the Gloucester Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application, and following consent under the Heritage Act (Clause 21(8)). Should impact to heritage items of State significance be required, the Gloucester Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application (Clause 21(11)).

Should development occur within the vicinity of a heritage item, heritage conservation area, archaeological site or potential archaeological site, Council must assess impacts of the development (Clause 21(5)).

Heritage items are listed in Schedule 2 of the GLLEP.

9.3.3 Dungog Local Environmental Plan 2006

The *Dungog Local Environmental Plan 2006* (DLEP) is the statutory (legal) planning document that applies to the whole of the Dungog LGA.

The DLEP requires that a development consent is required should any proposed impact to Aboriginal or non-Aboriginal heritage be required (Clause 25(1)). Should impact to Aboriginal heritage places be required, the Dungog Council may grant consent following the assessment of a heritage impact statement which meets DECCW guidelines and following comment from DECCW upon the application (Clause 25(2)). Should impact to non-Aboriginal archaeological sites be required, the Dungog Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application (Clause 25(2)).

Heritage items and heritage conservation areas are listed in Schedule 3 of the DLEP.

9.3.4 Port Stephens Local Environmental Plan 2000

The *Port Stephens Local Environmental Plan 2000* (PSLEP) is the statutory (legal) planning document that applies to the whole of the Port Stephens LGA.

The PSLEP requires that a development consent is required should any proposed impact to non-Aboriginal heritage be required (Clause 55). Should impact to Aboriginal archaeological sites be required, the Port Stephens Council may grant consent following the lodgement of an assessment which meets DECCW guidelines and following comment from DECCW upon the application (Clause 59(1)). Should impact to non-Aboriginal archaeological sites be required, the Port Stephens Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application (Clause 59(2)).

Should development occur within the vicinity of a heritage item, heritage conservation area, archaeological site or potential archaeological site, Council must assess impacts of the proposed development (Clause 60).

Items of State and local heritage significance are listed in Schedule 2 of the PSLEP.

9.3.5 Maitland Local Environmental Plan 1993

The *Maitland Local Environmental Plan 1993* (MLEP) is the comprehensive statutory (legal) planning document that applies to the whole of the Maitland LGA.

The MLEP requires that a development consent is required should any proposed impact to non-Aboriginal heritage items (Clause 32) or heritage conservation areas (Clause 33) be required. Should impact to heritage items of State significance be required, the Port Stephens Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application (Clause 34). Should development occur within the vicinity of a heritage item, Council will require an assessment of impacts (Clause 38).

The MLEP does not list any specific controls in relation to objects of Aboriginal heritage significance, although the MLEP's definition of the term “relic” is somewhat ambiguous.

Heritage conservation areas are listed under Schedule 1 and heritage items are listed in Schedule 2 of the MLEP.

9.3.6 Newcastle Local Environmental Plan 2003

The *Newcastle Local Environmental Plan 2003* (NLEP) is the comprehensive statutory (legal) planning document that applies to the whole of the Newcastle LGA, with the exception of Newcastle City which is subject to a separate LEP.

The NLEP requires that a development consent is required should any proposed impact to non-Aboriginal heritage be required (Clause 55). Should impact to Aboriginal archaeological sites be required, the Newcastle City Council may grant consent following the lodgement of an assessment which meets DECCW guidelines and following comment from DECCW upon the application (Clause 31). Should impact to non-Aboriginal archaeological sites be required, the Port Stephens Council may grant consent following the lodgement of an assessment and following comment from the Heritage Council upon the application (Clause 32). Should development occur within the vicinity of a heritage item or a heritage conservation area, Council may require submission of a heritage impact statement (Clause 33).

Heritage items and heritage conservation areas are listed in Schedule 6 of the PSLEP.

10.0 Heritage Management Commitments

The following heritage management commitments are made regarding the project. These are made on the basis of:

- legal requirements under the provisions of Part 3A of the EP&A Act;
- the findings of the field survey and previous work done in the study area;
- the assessed heritage significance of the archaeological sites;
- the assessed heritage potential of PADs;
- the stated interests of the Aboriginal community; and
- the likely impacts resulting from the various components of the proposed development.

The heritage management commitments are provided in two levels:

- general commitments that are applicable to all sites and the study area as a whole (**Section 10.1**); and
- specific commitments for Aboriginal sites (Section 10.2) and historic sites (Section 10.3).

10.1 General Heritage Management Commitments

While it is considered that there is a low potential for impacts to Aboriginal or historic heritage, the following general heritage management commitments are made:

- Aboriginal sites/objects and historic heritage places/items within 100 m of the pipeline will need to be identified and flagged so that construction crews will not accidentally damage them[4].
- An Aboriginal Heritage Management Plan (AHMP) should be developed with provisions for dealing with any Aboriginal object or site that may be encountered in the course of construction. The AHMP will detail procedures for management of existing Aboriginal heritage sites and procedures for management of objects that are encountered during the construction phase of the development (e.g. procedures for construction in the vicinity of known sites and PADs, procedures for the discovery of skeletal remains, procedures for the discovery of unrecorded Aboriginal objects). The Awabakal Descendants Traditional Owners Aboriginal Corporation have requested they be consulted during the development of the AHMP, for the portion of the pipeline route within traditional Awabakal lands south of the Hunter River. ATOAC recommend that all relevant Aboriginal stakeholders be consulted for the AHMP for their areas of cultural association. Management commitments in the AHMP will include, but not limited to, the management commitments outlined in this section and in **Section 10.2** below.
- All standing structures will be avoided by the pipeline construction footprint.

---

[4] The exception to this is if they are on neighbouring property that will not be impacted by construction work.

- Should historical archaeological sites be encountered during the excavation process, then work will cease at that location and a qualified historical archaeologist consulted.
- Should Aboriginal archaeological sites be encountered during the excavation process, then work will cease at that location and DECCW and the relevant Aboriginal stakeholders notified.
- Construction crews will be made aware of the potential for cultural heritage values to occur in the project area. Training and induction will be provided and reinforced during regular toolbox talks.

10.2 Aboriginal Heritage Management

The findings of this assessment can be summarised as:

- a review of the AHIMS database administered by DECCW suggest there are five previously recorded Aboriginal sites within a 1 km-wide buffer zone along the pipeline route or within the field area. However two sites (AHIMS #37-2-0336 and #37-2-0337) were erroneously identified as being in the study area near Clareval when they were, in fact, located in the Hunter Valley; they have since been destroyed under a s.90 permit. Two were not re-identified due to access restrictions (#38-1-0008 and #28-1-0027). One, a bora ground (#38-1-0006), was re-identified during the survey;
- a total of nine Aboriginal sites were identified during the field survey – two (possible) scarred trees, four low-density artefact scatters, and three isolated finds;
- a total of 14 potential archaeological deposits were identified during the survey;
- alternative routes were recommended to the proponent in order to minimise the potential for impacts to these sites;
- there are no indications at present that there are specific Aboriginal heritage values that would be affected by the development, except for the archaeological deposit associated with LEA8 and LEA9; and
- on the basis of this assessment, it is considered the proposed development may encounter subsurface Aboriginal objects. It is recommended that the proponent prepare an Aboriginal Heritage Management Plan (AHMP) to manage the risk of impact to Aboriginal objects.

Table 22 details management requirements for Aboriginal sites identified in the study area. This includes the ultimate impact and management requirements for each site.

Table 22: Management Commitments for Aboriginal Heritage Sites within the Study Area

Site ID	Within Study Area?	Final Impact?	Final Management Requirement
LEA1	Yes. Field Area	No	Nil. This site is considered to be too close to the creek bank to be affected.
LEA2	Yes. Field Area	No	Nil. It is understood that the proponent is not considering any further development in this area.
LEA3	Yes. Field Area	No	Avoid any ground-breaking activities within 100 m of this location.

Site ID	Within Study Area?	Final Impact?	Final Management Requirement
LEA4	Yes. Within the pipeline Buffer Zone	No	Nil. A subsequent inspection of the site on 10 October 2008 failed to relocate the object, despite it being located in a prominent position.
LEA5	Yes. Buffer Zone	No	Pipeline alignment should be approximately 20 m further west (i.e. 30 m from the site) to avoid impacts from trenching and spoil deposition. Should realignment be unfeasible and damage to the site unavoidable, surface artefact collection should be conducted.
LEA6	Yes. Buffer Zone	No	Nil. Alignment of the pipeline is within the disturbed road easement and will avoid this site.
LEA7	Yes. Buffer Zone	No	Nil. Alignment of the pipeline is within the disturbed road easement and will avoid this site
LEA8	Yes. Buffer Zone	Potential	Recommend test excavation along the western bank of Deadmans Creek and collection of surface artefacts.
LEA9	Yes. Buffer Zone	Potential	Recommend test excavation along the western bank of Deadmans Creek and collection of surface artefacts.
AHIMS #38-1-0008	Yes. Field Area	No	Nil. Gas field infrastructure is not expected to impact this site.
AHIMS #38-1-0031	Yes. Field Area	No	Nil. Gas field infrastructure is not expected to impact this site.
AHIMS #38-1-0006 *(This site was re-identified during the survey and was not given a new site ID).*	Yes. Buffer Zone	Potential	Ensure pipeline alignment remains in road easement on the eastern side of Black Camp Road. Recommend retaining archaeologist and Aboriginal community representative to monitor construction in this area, under AHMP procedures.
AHIMS #38-4-0010	Yes. Buffer Zone	Potential	Ensure pipeline alignment remains in road easement on eastern side of Black Camp Road. Recommend retaining archaeologist and Aboriginal community representative to monitor construction in this area, under AHMP procedures.
Three unrecorded sites on Tiedman's Block (FLALC 2006)	Yes. Field Area	Potential	Existence of these sites not verified. Should CPF Facility 1 be chosen as the CPF site, then consultation with FLALC should be conducted and if the sites are within the proposed footprint, they should be salvaged under AHMP procedures.

The following table (**Table 23**) details management requirements for potential archaeological deposits identified in the study area. This includes the ultimate impact and management requirements for each PAD.

Table 23: Management Commitments for Potential Archaeological Deposits

Site ID	Within Study Area?	Final Impact ?	Final Management Requirement
PAD1	Yes. Field Area	No	Nil required. The pipeline route was moved approximately 20 m westwards to climb the ridge via a shallow re-entrant between two spurs to avoid the PAD.
PAD2	Yes. Buffer Zone	Yes	PAD unavoidable. Provisions of AHMP apply.
PAD3	Yes. Buffer Zone	No	Nil. Proposed alignment does not impact PAD.
PAD4	Yes. Buffer Zone	Yes	PAD unavoidable. Provisions of AHMP apply.
PAD5	Yes. Buffer Zone	Yes	PAD unavoidable. Provisions of AHMP apply.
PAD6	Yes. Buffer Zone	No	Nil. It is recommended that the gas pipeline remains within the road easement. Recommend retaining archaeologist and Aboriginal community representatives to monitor excavation works in this area of Black Camp Road, under the provisions of an AHMP.
PAD7	Yes. Buffer Zone	No.	Nil. Alignment of the gas pipeline remains within the road easement.
PAD8	Yes. Buffer Zone	No	Nil. Alignment of the gas pipeline remains within the road easement.
PAD9	Yes. Buffer Zone	No	Nil. The pipe line is located within the disturbed road easement and will pass to the south of this PAD; impact is unlikely.
PAD10	Yes. Buffer Zone	No	Nil. The pipe line is located within the disturbed road easement and will pass to the east of this PAD; impact is unlikely.
PAD11	Yes. Buffer Zone	Yes	PAD unavoidable. Provisions of AHMP apply.
PAD12	Yes. Buffer Zone	Yes	PAD unavoidable. Provisions of AHMP apply.
PAD13	Yes. Buffer Zone	No	Nil. The present alignment along the fence line is considered to be sufficient to minimise impact to this area.
PAD14	Yes. Buffer Zone	No	Nil. Current alignment of pipeline will pass to the north of this PAD; no impacts are expected.

10.3 Historic Heritage

The findings of this assessment can be summarised as:

- there are a total 1,475 heritage-listed items in the LGAs where the study area is located (**Table 16**);
- there are no previously heritage-listed historic heritage items within the study area;
- there is one item that has been nominated for listing on the Register of the National Estate (RNE) – the Vale of Gloucester – but has not yet been formally registered. The field area component of the study area is located within a large tract of this item;
- a total of 11 items of potential historic heritage value were identified during the field survey. One of these is considered to be of local heritage significance and three exhibit features that may be of historic heritage value pending further research; and
- on the basis of this assessment, it is considered the proposed development is not likely to encounter historic heritage items or relics.

Table 24 details management requirements for historic heritage items identified in the study area. This includes the original impact of the proposed route, shows recommendations made to avoid impacts to the identified sites, and the ultimate impact and management requirements for each site.

Note also that the recommendations in **Table 24** reflect that the proponent has made the changes to alignment recommended to them in the initial management recommendation on 17 October 2008.

Table 24: Management Requirements for Historic Items within the Study Area

Site ID	Within Study Area?	Final Impact?	Final Management Requirement
LEH1	Yes. Buffer Zone	No	Nil required. This building is located greater than 100 m outside the proposed alignment (and on the opposite side of the highway) and is therefore not considered to be under threat from the pipeline.
LEH2	Yes. Buffer Zone	No	Nil required. The current alignment of the pipeline is approximately 80 m west of the item.
LEH3	Yes. Buffer Zone	No	Nil required. This item is located more than 100 m west of the proposed alignment and is not considered to be under any threat from the development. Should realignment be considered in the vicinity of this site any ground-breaking activities should not be conducted within 50 m of the building with preference given to the eastern side of Black Camp Road or within the road easement.
LEH4	Yes. Buffer Zone	Potential	The pipe line is located within the disturbed road easement and will pass to the east of this site; however the site is adjacent to the road side and impacts may occur during construction.
LEH5	Yes. Buffer Zone	No	The pipe line is located within the disturbed road easement and will pass to the east of this site; however the site is adjacent to the road side and impacts may occur during construction.

Site ID	Within Study Area?	Final Impact?	Final Management Requirement
LEH6	Yes. Buffer Zone	No	Nil required. The pipeline will pass 100 m west of this site. No impacts expected.
LEH7	Yes. Buffer Zone		Nil required. The pipeline passes 100 m north of the site. No impacts expected.
LEH8	Yes.	Possible	Nil required. This item is not considered to have heritage significance.
LEH9	Yes.	Possible	Nil required. This item is not considered to have heritage significance.
LEH10	Yes. Buffer Zone	No	Nil required. Pipeline passes 100 m west of this site. No impacts expected.
LEH11	Yes. Buffer Zone	No	Nil required. Pipeline passes 100 m west of this site. No impacts expected.
Vale of Gloucester	Field Area	No detrimental impact	Nil required. Some effect due to introduction of new industry within the Vale of Gloucester agricultural area, however, the impacts are not considered to be detrimental or significant (refer below for further discussion)

11.0 References

Appleton, J., 1993. *The archaeological investigation of the site installations and in-ground storage tanks of the proposed Stroud Water Supply Augmentation, Central Coast, NSW*. Report for Lyall Macoun Consulting Engineers.

Archaeological & Heritage Management Solutions Pty Ltd (AHMS). 2008 Queensland Hunter Gas Pipeline. Environmental Assessment – Aboriginal Heritage Assessment. On behalf of Manidis Roberts.

Attenbrow, V., 2003. *Investigating Sydney's Aboriginal past: investigating the archaeological and historical records*. University of NSW Press, Sydney.

AusAnthrop, 2008. Australian Aboriginal tribal database. http://www.ausanthrop.net/resources/ausanthrop_db/detail.php?id_search=585#, retrieved 7 July 2008.

Baker, N., 1993. *Archaeological testing of the RZM Pty Ltd Plant 9 planned sand mine run adjacent o Moffats Swamp, Richardson Road, Medowie M.L.1067*. Report to RZM Pty Ltd

Baker, N., 1994. *Moffats Swamp Dune – final report on archaeological site salvage, testing & artefact analysis*. Report to RZM Pty Ltd

Berndt, R.H., 1947-8. Wuradjeri magic and 'Clever Men'. *Oceania* 17-18: 327-365; 60-94.

Blyton, G,. Heitmeyer, D. & Maynard, J. 2004. *Wannin Thanbarran: a history of Aboriginal and European contact in Muswellbrook and the Upper Hunter Valley*. Muswellbrook Shire Aboriginal Reconciliation Committee, Muswellbrook, NSW.

Brayshaw, H., 1981. *Archaeological survey of Blue Metal Industries coal mine sites at Stratford and Wards River.* Report for Dames & Moore.

Brayshaw, H., 1981. *Archaeological Survey of Proposed Site of Tomago Aluminium Smelter near Hexham*. Report for Tomago Aluminium Co. Pty Limited.

Brayshaw, H., 1984. *Archaeological survey of coal lease area, Stratford, NSW*. Report for Dames & Moore.

Brayshaw, H., 1987. *Aborigines of the Hunter Valley: a study of colonial records*. Bicentennial Publication No 4, Scone and Upper Hunter Historical Society, Scone, NSW.

Brayshaw, H. & Byrne, D., 1994. *Stratford EIS updated archaeological assessment*. Report for AGC Woodward-Clyde PTY Ltd.

Bureau of Meteorology, 2008. Climate Data Online – Average annual and monthly rainfall http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp?period=an&area=ns, retrieved 16 October 2008.

DEC, 2004. *Interim Community Consultation Requirements for Applicants.* Department of Environment and Conservation, Sydney.

DEC, 2005. Draft *Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation*. Department of Environment and Conservation, Sydney.

Department of Mines, 1966. *Newcastle 1:250,000 Geological Series Sheet S1 56-2*. NSW Department of Mines, Sydney.

Dean-Jones, P. 1989a *Report of an Archaeological Survey of the Old Delta Colliery Site, Mt Vincent Rd, Near Maitland*. Unpublished report to Patterson Britton & Partners Pty Ltd.

Dean-Jones, P., 1990. *Newcastle Bight Aboriginal Sites Study*. Report to NPWS & National Estate Grants Committee

Elkin, A.P., 1932. Notes on the social organisation of the Worimi, a Kattang-speaking people. *Oceania* 2: 359-363.

Enright, W.J., 1932. The Kattang (Kutthung) or Worimi: an Aboriginal tribe. *Mankind*: 75-77.

ERM, 2007. *Tomago Powerlines – Preliminary Heritage Appraisal*. Report to Energy Australia

Environmental Resources Management (ERM), 2005. *Lot 2 DP1044250 McDonalds Road, Pokolbin: Aboriginal heritage assessment*. Report prepared for Pioneer Concrete (NSW) Pty Ltd.

ENSR, 2008. *Section 87 Aboriginal Heritage Impact Permit #2810 for Thornton North Water Trunk Main – Test Excavation Report*. Report for Hunter Water Corporation.

Griffith, T., 1992. *Preliminary inspection for Aboriginal sites and archaeological material along the proposed optic fibre cable route from Stratford to Gloucester, NSW*. Report for Telecom Australia.

HLA ENSR, 2007. *Powerline Corridor for Connection to TransGrid Bulk Supply Point - Preliminary Heritage Appraisal*. Report for Energy Australia

Kuskie, P.J. 2004. *An Aboriginal Heritage Assessment of 'Investigation Area C' at Thornton North, Lower Hunter Valley, New South Wales*. A report to Beechwood Homes and CPG Estates.

Matthei, L.E., 1995a. *Soil landscapes of the Newcastle 1:100,000 sheet* report. Department of Land and Water Conservation, Sydney.

Matthei, L.E., 1995b. *Soil landscapes of the Newcastle 1:100,000 sheet* map. Department of Land and Water Conservation, Sydney.

Mulvaney, J. & Kamminga, J. 1999. *Prehistory of Australia*. Smithsonian Institute Press, Washington.

Oxley, J., 2007. *Aboriginal sites investigation and cultural heritage assessment: Stratford Pilot Project, Gloucester. Forster Local Aboriginal Land Council*. Report for Lucas Energy.

Sands, J., 1925. *New South Wales: its resources and business possibilities*, edited by J.H. Nancarrow, Sydney.

Suters Architects, 1997. *Newcastle City Wide Heritage Study*.

NPWS, 1997. *Aboriginal Cultural Heritage Standards and Guidelines Kit.* National Parks and Wildlife Service, Hurstville.

O'Rourke, M., 1997. *The Kamilaroi lands: north-central New South Wales in the early 19th century*. Published by the author, Griffith, ACT.

Oppenheimer, J., 1992. Thunderbolt's Mary Ann – an Aboriginal bushranger. *Journal of the Royal Australian Historical Society* 78(3-4): 92-107.

Sokoloff, B., 1980. *The Worimi: hunter gatherers at Port Stephens*. Raymond Terrace and District Historical Society.

Silcox, R. and Ruig, J. 1995. *Test Excavations on a Rural Residential Estate at Black Hill, Tarro, NSW*. Unpublished report to P. & S. Evans.

“This page has been left blank intentionally”

Tables

"This page has been left blank intentionally"

Table T1: Transects Sampled and Effective Coverage

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
T1	N extent S extent	0402438 0402748	6452866 6452539	River banks, terraces, flats	Avon River; Martin's property (see also T35). This transect traversed only the eastern banks of the Avon River due to access restrictions on the western side. The banks of the river are not uniform in height (5 m on the eastern side; 3 m on the western side). There are extensive river flats (floodplain) on both sides, with the flats on the eastern side extending 200 m wide to the base of a low-lying ridge line (see T36). The flats are completely cleared with only occasional isolated eucalypts occurring. The flats have a thick cover of pasture grasses with 0% visibility, except in a long 200 mm wide cattle track along the fenced river bank (total exposure area ~. Very little lithic material was observed in this transect.	0.0027	33.33	0.0009	100	0.0009	33.33
T2	NE extent SW extent	0402746 0402204	6452140 6451955	River banks, terraces, flats	This transect consist of a short section of the Avon River from the Fairbairn Road bridge to the confluence of Waukivory Creek on Mitchell's property. Here, the river gully itself is 3-4 m deep and about 5 m wide. The bank on the north side is quite steep but levels out onto a relatively wide flat (floodplain). The south side is a little lower. Vegetation is almost completely thick pasture and weed (100% cover) with eucalypt/Melaleuca open woodland occurring in the river margins. Exposures were limited to flood-scours in the river banks (total area about 300 m^2). Visibility in these scours was about 90%. Archaeological potential is considered to be low due to heavy disturbance and previous flood events. One possible Aboriginal site (LEH3) occurs here.	3.426	0.88	0.03	100	0.03	0.88
T3	NE extent SW extent	0403414 0403303	6452458 6452264	Ridge crest	Martin's property, Gloucester area. This transect sampled a low-lying (20-30 m high) ridge to the east of the Avon River (running SE-NW). The ridge crest is about 100 m wide with gentle slopes down to creek and river flats. A deeply eroded ephemeral water course runs E-W on the south side of the ridge. Eroded banks show soils to be	1.35	3.70	0.05	100	0.05	3.70

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					thin O horizons overlying a deep B horizon of clay. Total exposed area about 500 m^2.There were no other exposures evident away from the gully. Very few lithics observed - about 10/m^2 density; no suitable raw material for stone-working. Archaeological potential is considered to be low.						
T4	N extent S extent	0402746 0402743	6452140 6451290	River banks, terraces, flats, lower foot slopes	Avon River; Samson's property. The transect traversed both banks of the Avon River on Samson's property from boundary to boundary. The transect is contiguous with T4 to the north and T35 to the south. The river gully is 3-4 m deep in this section with 500-600 m wide river flats on the eastern side and 10-20 m wide flats on the western side. The western side then slopes upwards to a small ridge line where the farm buildings are located. These are highly disturbed. There are also occasion small (3 m wide) river terraces at the southern end of the transect. The property is mostly cleared with a thick cover of pasture grass offering 0% visibility, except for minor flood-scour erosion scars in the river banks (total area ~100 m^2). The river channel retains tall-stratum vegetation. Very little lithic material was observed within the transect.	5.1	0.20	0.01	100	0.01	0.20
T5	W extent E extent	0402743 0404041	6451290 6450702	4th order creek, creek flats and terraces, low ridge crests and steep side slopes, back swamps	Waukivory Creek, Gloucester area; Gary Cole's property. Waukivory Creek meanders through an extensive area of creek flats (100-300 m wide) through most of the transect, except at the eastern end where a series of low ridges and spurs lay close to the northern banks, with a series of small back swamps between. Vegetation consists mainly of thick pasture and weeds (100% cover) with a thin belt of taller vegetation in the creek line. Soils ranged from uniform brown alluvial silt at the western end to duplex soils at the eastern end consisting of alluvial silt A horizon over a bleached yellow clay B1 horizon and a course gravel/cobble B2 horizon. Exposures were limited to cattle tracks and pads along most fences along the creek (280 m^2), and a 20 m^2 exposure on a spur at the eastern end and	8.52	0.35	0.03	100	0.03	0.35

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					flood scours in the banks sides (total exposed area about 300 m^2). Very few lithics observed except for gravel/cobbles in the creek bed and in the lower horizons of a few exposed soil profiles. A few mature eucalypts in the creek line but no scars observed. Archaeological potential along the creek flats within 100 m of the creek is considered low; potential along the low-lying spurs and ridge crests at the eastern end are considered to have moderate potential. One of these spurs is considered to be a PAD (PAD6).						
T6	N extent S extent	0402170 0401905	6451215 6448327	River banks, terraces, flats	Tiedman's Block. The transect straddles the confluence of Avon River and Dog Trap Creek. Transect incorporated a 2 km section of the eastern bank of the Avon River, and a 1.2 km section of Dog Trap Creek (both banks) as far as its confluence with an unnamed water course that rises near the Stratford Coal Mine. Vegetation on the eastern side is mainly very thick pasture grasses/weeds including plantain and fire weed; land use on this side is mainly grazing. The western side is cultivated with oats and/or lucerne to feed the dairy industry which is prevalent on that side of the Avon. Upper stratum vegetation is restricted to a narrow belt on the margins of the river and creeks. About 400 m south of the confluence, this vegetation stops abruptly and the creek banks are completely cleared and covered only in pasture grasses. There is a wide floodplain along the western side, but there is a very low ridge that comes within 50 m of the Avon on the eastern side but the distance increases to around 400-500 m south of the confluence. Ground visibility in this transect is extremely limited: 0%, except in very limited exposures formed mainly by 200 mm wide cattle pads on the river banks, flood-scours on the river banks themselves, and around contour-banks near the confluence. Total area ~500 m2. Archaeological potential on the creek flats is considered to be low, but on low ridges within 100 m of the creek the potential is moderate.	17.46	0.29	0.05	100	0.05	0.29

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
T7	N extent S extent	0401798 0401999	6447537 6457069	Creek flats, floodplain, marshland	Avondale Creek, from Wenham Cox Road to the confluence of Dog Trap Creek. The landscape in this transect is characterised by a shallow creek gully winding through an extensive floodplain, rising to a low N-S ridge line on the western side, approximately 100 m west of the creek channel (this is where the farm buildings are located). The vegetation in the transect consists of cleared pasture/weeds throughout, with sedges and reeds occurring in the creek margins and in the marsh areas of the southern end of the transect. These southern areas also consist of large stands of paperbark low woodland. There were no exposures evident in this transect. Ground visibility in the transect was 0% and no lithic material was observed.	3.066	0.00	0	100	0	0.00
T8	E extent W extent	0403803 0401905	6446654 6448327	Creek banks, flats, terraces, lower footslopes, lower spur crest	Dog Trap Creek; Ellis (Denyer) Property. This transect traversed a long section of the creek on both sides. The eastern end consisted of undulating flats on both sides of the creek, with the topography more pronounced at the eastern end where it begins to rise towards the ranges on the eastern side of the Avon River valley. There is a long ridgeline that passes parallel to the south bank of the creek, where the transect traversed lower foot slopes. At the far western end the creek opens to wide creek flats and flood plain where it meets the confluence of Avondale Creek. The landscape in this transect consists of mostly cleared pasture with taller vegetation occurring only in the creek margins. The pasture was very thick offering 0% visibility, except in exposures caused by flood scours in the creek banks and in cattle tracks and pads (total area ~150 m^2). Soils in this area were duplex with a thick alluvial A horizon over a red clay B horizon over a bedrock of sandstone. Lithic concentrations in the exposures ranged from $1/10m^2$ to $100+/m^2$, but there was no evidence of any material suitable for the manufacture of stone tools.	15.18	0.10	0.015	100	0.015	0.10
T9	N extent	403551	6445241	1st & 2nd order	Gloucester Coal Mine lands, off Bowens Road, Stratford. Generally low lying creek flats, inundated after rain, rising to the tall hills on the	600	1200	3	3.6	0.06%	0.0020

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
	S extent	403714	6444756	creeks, creek flats, low-lying swamp, simple slope (3-10%), hill crest	eastern side of the Vale of Gloucester. Vegetaion consists of paperpark and eucalypt woodland with understory of gras, pasture and reeds in the creeklines. Creek chanels are largely shallow and intermingled. Exposures were very few consisting of a few on midslopes at the southern end of the transect (total area about 20 m2). Very few lithic examples observed anywhere in the transect, and no raw material. Archaeological potential considered to be low.						
T10	N extent S extent	0401522 0402242	6442888 6441710	1st order creek, creek banks and flats, simple slope (3-10%)	Southern end of the GFDA, Gloucester Coal lands, near Stratford. Generally low lying creek flats, inundated after rain, rising to the tall hills on the eastern side of the Vale of Gloucester. The area is generally a large, cup-shaped drainage depression, approx. 200 m wide, with a low ridge to the west and rising to lower foothills in the east. The creek channel is shallow (<0.5 m), narrow (1-2 m) but gets slightly deeper (1-2 m) and wider (<2.5 m) at far SE end near transmission easement. The area is vegetated almost wholly by open pasture to a height of 0.5 m and ground surface visibility is <1% throughout. Exposures are limited to minor streambank erosion (50 m2) throughout. Few indications of any lithic material. Low potential for archaeological deposit.	1560	1560	3	4.68	1.28%	0.0600
T11	N extent S extent	0401245 0402215	6442454 6441528	Spur crest, ridge crest	Southern end of the GFDA, Gloucester Coal lands, near Stratford. This area lies immediately adjacent to T2 on the spur crest off the foothills to the east (south of T2) which become a ridgeline west of T2. The ridgeline is elevated approx. 10-15 m above the creek. The ridge and spur are vegetated almost completely by tall pasture grass (up to 1 m tall in places) with 100% cover; virtually no upper stratum. Exposures are completely restricted to a dam wall (10 m2 total). No evidence of cattle pads. No lithic material observed. The ridgeline has a moderate potential for subsurface deposits, higher than the adjacent creek flats due to the periodic inundation of these flats.	1700	1700	3	5.1	0.04%	0.0020

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
T12	N extent S extent	0401460 0401717	6443480 6441460	2nd order creek, creek flats	Southern end of the GFDA, Gloucester Coal lands, near Stratford. This transect follows the creek from a point just north of Glen Road and follows the creek to a point where it meets T2 adjacent to Parkers Lane. It runs west of, and adjacent to, T3.The creek is wide (5-10 m) and deep (up to 4 m) at the southern end, with moderate stream bank erosion, and narrows and shallows to insignificant levels at the northen end. Vegetation at the southern end consists of thick upper and mid stratum with grass/weed ground cover. The northern half is almost completely improved pasture with occasional woodland copses. Ground cover is near 100% throughout. The ground surface is boggy and often inundated, particularly at the northern end. Archaeological potential is considered to be low.	3440	3440	3	10.32	11.63%	1.2000
T13	W extent E extent	0399860 0400418	6443464 6443463	Simple slope (gentle); swamp; ridgeline	Between Parkers Lane and the Stratford Coal Rail Loop, Craven. This area is the proposed site of the CPF. It consists of open paddocks on a very gentle slope (<3%), with a ridge along the western and northern boundaries descending to a low-lying swampy area in the SE corner of the block. The block is mainly covered in low, thick pasture grasses (<5% visibility), with ocasional small copses of eucalypt woodland regrowth, mainly in the eastern end of the block. The swampy area consists of paperbark closed woodland. Exposures were limited to isolated cattle hoof scrapes, minor exposures on a dam wall, and larger exposures on a raised artificial mound extending along the western boundary adjacent to the rail loop. Total exposure area approximately 200m2. No lithics observed; archaeological potential in this area considered to be low.	N/A	N/A	N/A	15.5	1.29%	0.2000
T14	N extent S extent	0399705 0399780	6445477 6445021	River banks, terraces, flats, lower	Avon River; Isaac's property, near Stratford. This transect sampled an area where the proposed pipeline traversed within 100 m of the Avon River. The landscape in this sample area consisted of the meandering river channel (5 m deep x 5 m wide) with narrow river terraces, river flats and a gently incline lower slope rising to a N-S	1.86	0.16	0.003	100	0.003	0.16

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				foot slopes	ridge where the railway and Buckett's Way are located. This slope is highly disturbed by original vegetation clearance and the development of the railway and road. Near the track crossing the railway is a stockyard and a large cutting measuring approximately 5 x 4 m. The density of lithic material in this cutting is approximately 20+/m^2, but no suitable raw material for stone tool manufacture was observed. Immediately west of the cutting was a very small outcrop of sandstone, but no grinding grooves were observed. Ground cover in this area consisted of very thick pasture/weeds offering 0% visibility.						
T15	N extent S extent	0399229 0399014	6442376 6442124	1st order drainage depression	Woods Road, Craven. Property on northern side of road. This area consists of a very shallow drainage depression between two low rises; there is no watercourse channel. Improved pasture throughout with isolate woodland copses. Exposures limited to cattle pads along fence lines (approx 10 m2 in total). No lithic material observed; trees are regrowth only. Archaeological potential is low.	410	820	2	1.64	0.012	0.0033
T16	N extent S extent	0399035 0398979	6442386 6441967	1st order creek, lower slopes	Drainage line across Woods Road, Craven; Wallace / Yates properties. The landscape in this area is characterised by a shallow, ephemeral drainage line (no gully) with gently incline slopes rising to low ridgelines on either side of the water course. The northern side of Woods Rd (Wallace) is largely cleared pasture/weeds with occasional small copses of eucalypt woodland regrowth. Disturbance on this side is limited to dam construction. Exposures consist of the dam wall (150 m^2; 40% visibility), and isolated natural exposures on the lower slopes associated with eucalypt regrowth and cattle tracks along the fence lines. The southern side of Woods Rd (Yates is more heavily disturbed with shed, fence and driveway construction. The road and associated verges are also heavily disturbed. Exposures on this side are more extensive around the built structures and totals some 50 m^2 with 60% ground surface visibility. The surrounding area	1.696	1.18	0.02	40	0.008	0.47

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					is cleared and covered in pasture offering 20-30% visibility. Site LEA4 was located in this transect.						
T17	N extent S extent	0398849 0399017	6441101 6439232	gentle slopes, steep slopes, spur crests, 2nd order creek, 4th order creek	Coal Creek and Spring Creek; Bosma / Harris properties, off Spring Creek Road, Craven. This transect followed a relatively long section of the transmission line easement where the proposed pipeline is to placed. It follows a N-S fence line (with thick eucalypt woodland on the eastern side). The western side (with the easement is completely cleared with thick pasture growth. Occasional small copses of eucalypt woodland occur in the paddocks and along creek margins. The transect traversed the second order Coal Creek with deep creek gully and gentle slopes either side. the south side traversed a high ridge, then a steep spur southwards to cross the creek flats of 4th order Spring Creek, then southwards up a spur line. The vegetation consisted mainly of pasture grasses/weeds with taller stratum occurring only in the creek margins and as small regrowth copses on ridge crests. Ground surface visibility ranged from 0% in the south to 10% in the north. Disturbance was largely limited to original vegetation clearance, fence construction and power line construction. Several large exposures were evident along the fence line at the northern end associated with a vehicle track and caused by sheet erosion (total 1000 m^2; 40% ground surface visibility); the banks of Coal Creek are convoluted with many areas of exposure (~50 m^2; 50% visibility). One Aboriginal site (LEH5) and one PAD (PAD 1) was identified in this transect.	7.52	1.46	0.11	40	0.044	0.59
T18	N extent S extent	0399422 0399488	6438224 6437903	3rd order creek, terraces, lower gentle slopes	Unnamed creek crossing, Craven area; Wolfenden property. This transect sampled a 3rd order creek that rises to the west in the steep hills of Lawlers Range. The creek gully is convoluted, 3 m deep with steep, deeply incised banks. Either side of the creek, the land rises in a gentle incline (~4%) to low spur crests to the north and south. The vegetation is mostly thick pasture and weeds with 100% ground	1.974	1.52	0.03	100	0.03	1.52

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					cover. There were no exposures on the slopes. Exposures were limited to the flood-scoured banks of the creek gully and several minor tributaries (total area 300 m^2). Soils in the creek gully were duplex with alluvial soils over a clay B horizon. soils in the tributaries were a skeletal, uniform clay soil. Density of surface lithics in exposures was ~1/10m^2. There was no evidence of any suitable raw material for stone tool manufacture.						
T19	N extent S extent	0399457 0399439	6436490 6435979	4th order creek, lower spur, gentle slope, steep lower slope	Bull Creek crossing, Wards River; Harrison / Grant properties. The landscape in this transect consists of a gently inclined lower slope that descends northwards, ending abruptly in the steep sides of the creek gully. A 10 m wide terrace on the northern side rises abruptly up a steep (15%) slope. Vegetation consists of thick pasture on the southern side. The northern side is characterised by thick eucalypt and melaleuca regrowth in the easement, as well as grass, tussock grass and taller stratum within the creek margins. Exposures were limited to small (1-2 m^2) exposures in the creek banks and small (0.5 m^2) exposures amongst the melaleuca regrowth on the northern slope. Total exposure size was about 10 m^2. Grass cover ranged from 95% on the northern slopes and 100% cover on the southern side. Very few lithics observed except for patches of cobble in the creek bed.	3.084	0.03	0.001	100	0.001	0.03
T20	N extent S extent	0399337 0399472	6434852 6434731	4th order creek, creek flats, low ridge	Chainy Flat Creek; Chapman property, Wards River. This sample area consists of a narrow, shallow creek gully meandering through a 50 m wide creek flat with low, gently inclined ridges either side. Vegetation consists of pasture grasses/weeds (100% cover) with taller stratum in the creek line. Exposures were limited to flood-scours in the creek banks, a small vehicle ford, various cattle tracks and two large exposures in the ridge slope on the northern side. Total exposure area about 100 m^2. Soils were uniform, pedal sandy loams in the A horizon (no B horizon evident). Lithic material was	0.728	1.37	0.01	100	0.01	1.37

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					restricted to isolated patches of river gravel in the creek bed and banks and sandstone-based lithic material in the exposures on the northern slopes; none observed elsewhere.						
T21	N extent S extent	0399346 0399063	6433403 6432908	2nd order creek, 3rd order creek, lower footslopes, creek flats, spur crest	Unnamed creeks on Howard's property, Wards River area. This transect traverses several landform elements commencing with a steep (>10%) spur at the northern end before crossing the 3rd order creek, a 50 m wide creek flat and then along a gently inclined lower slope, which runs parallel to the 2nd order creek. Vegetation consists almost completely of thick pasture grasses and weeds with 100% cover, except in the creek lines where taller stratum and sedge occur. There is a very large exposure (500 m^2; 100% visibility) on the spur slope where the soil profile shows a deep, skeletal, uniform soil above a conglomerate C horizon. Other minor exposures occur in the flood-scoured banks (50 m^2; 100% visibility) and the road cutting (30 m^2; 100% visibility). A low density scatter of lithic material was evident in these exposures but no suitable material for stone tool manufacture.	2.292	2.53	0.058	100	0.058	2.53
T22	N extent S extent	0398429 0398511	6430890 6430413	Lower footslopes, spur crests	Moylan / Holmes properties, near Wiesmantels. This transect sought to sample a series of 1st order creeks at the base of a steep escarpment 2 km west of Mammy Johnsons River and north of the Karuah River. The transect followed a cleared transmission line easement through a bush block (Moylan), then veered NW along the base of the escarpment (Holmes). The landscape consisted of a series of rolling spur lines (easterly aspect; 8-10% gradient) that have been cleared of vegetation except for thick pasture and weed cover (100% cover). The only exposures occur near fence lines (~15m^2; 80% cover; lithic density 1/3m^2) and on the upstream edge of a dam (~3 m^2; 60% cover; lithic density 20+/m^2). No suitable material for stone tools was observed.	1.944	0.09	0.0018	100	0.0018	0.09

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
T23	N extent S extent	0397617 0397648	6428777 6427648	2nd order creek, 4th order creek, river flats, loer gentle slopes	Karuah River, Groom Creek and Black Soil Creek, traversing Moylen, Madden and Welgosinski properties and RLPB Stock Route. The pipeline route here follows a narrow strip of land between Black Soil Creek / Karuah River and the Bucketts Way. At the southern end it veers across the road to cross Groom Creek before veering back to the western side of the road again. Vegetation consists of thick pasture ground cover (100% cover) with taller stratum in the River and creek margins; there is also a stand of very mature eucalypts (n= 20+) in the RLPB block. Many exhibit large scars but these are considered to be the result of natural causes such as fire and insect attack. Exposures are limited to several minor exposures associated with Groom Creek (total 10 m^2) with few lithics (1-2 m^2). The creek bank is highly disturbed with a large area of fill deposited. Soils along the bank are a uniform clay. This area is considered to have a low potential for subsurface deposits.	4.68	0.02	0.001	100	0.001	0.02
T24	E extent W extent	0398026 0397778	6428117 6428230	1st & 2nd order creeks, simple slope (3-10%)	Yad-el property, Bucketts Way, 1 km south of Monkerei Road. A wide double creek crossing, just east of a concluence of un-named 1st and 2nd order creeks. The landscape rises sharply to the east. The landscape consists of low but thick (>90% cover) open pasture with isolated eucalypt trees and/or small copses. Exposures are limited to streambank erosion, where some banks are up to 2 m high (but mostly <1 m), and within cattle pads throughout. Total exposure area is approximately 200 m2. Visibility within exposures is approximately 70-80%. Lithics consist of sandstone cobbles and boulders on hillslopes with sandstone and shale gravel throughout. No raw material was observed. Archaeological potential is considered to be low.	1500	1500	5	7.5	0.27%	0.0200
T25	N extent S extent	0398098 0398087	6427691 6427501	2nd order creek, simple	Groom Creek crossing, accessed via Yad-el. A second order creek within a very steep-sided valley. Virtually no creek flats. Creek chanel here is 1.5 m deep x 2 m wide, with some minor streambank	370	740	5	3.7	100.00%	3.7000

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				slopes (>10%)	erosion. Vegetation includes an ironbark/spotted gum canopy in the creekline (no mature trees) with a grass understorey (80% cover); some lantana. No archaeogical potential observed here.						
T26	N extent S extent	0397888 0398023	6426634 6426388	1st order creek confluence, simple slopes (>10%), mid-slope bench	Edwards property, off Buckets Way, Clareval. Located in a fairly steep-sided valley with the confluence of two first-order creeks. Within the 'V' of the confluence there is a relatively flat mid-slope bench, approximately 10 m above creek level. The remainder of the area consists of steep simple slopes. Upper stratum vegetation is confined to upper slopes, remainder is very low, thick pasture (>90% cover). Exposures are limited to minor streambank erosion (10 m2 total) and about 10 m2 within cattle pads. Lithics limited to sandstone gravel and cobbles on hillslopes. No raw material. Low archaeological potential.	780	1000	5	5	100.00%	5.0000
T27	N extent S extent	0398361 0398469	6425517 6424312	1st, 2nd & 3rd order creeks, saddles, simple slopes (3-10%)	Shultz property, north side of Duralie Coal Mine Road, near Clareval. Pipeline traverses steeply undulating country crossing several creeklines with steep-sided valleys. Vegetation consists of low, thick pasture (100% cover) with isolated trees and woodland copses nearby. Very few exposures: minor streambank erosion and isolated cattle hoof scrapes - total for transect about 50 m2. Very limited occurrence of any lithic material - volcanic cobbles on hillslopes, none in creek beds (100% reed cover). No raw material observed. Low potential for archaeological deposit.	1320	2640	5	13.2	0.04%	0.0050
T28	N extent S extent	0398646 0398827	6423574 6423104	1st & 2nd order creeks, simple slope (3-10%), sour crest, dam	Shultz property, adjacent to Bucketts Way, near Clareval. Pipeline route here runs close to Bucketts Way (following an optical fibre cable route), crossing several 1st order drainage lines, then veering eastwards over a spur crest to cross another 2nd order creek. Slopes range from <3% to around 10%. Vegetation mostly low, thick pasture (>90% cover) with isolated individual trees and small copses. Exposures occur around dam and along banks of southern-	530	1060	5	5.3	1.32%	0.0700

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				near house	most creek (about 70 m2 total for transect). Lithics consist of various volcanic-type rocks around the dam; no raw material, no artefacts. Low potential for deposit.						
T29	N extent S extent	0398175 0398281	6422518 6421426	River flats, river terrace, lower gentle slopes	Karuah River Crossings (x2) on Williams / Schultz / Jones / Wilson properties, Clareval area. In this sample area the pipeline crosses from the western side of the Karuah River where the pipeline traverses steeply undulating lands (Williams), to a wide river terraces (50-100 m wide) and flats (100-150m wide) on the eastern side, before crossing again to the western side about 800 m to the south. The flats on the western side are much narrower before rising steeply on the foot slopes to the west of Williams Road. The land is mostly cleared grazing paddocks with thick pasture and weed (100% cover), except for the river margins which have a taller stratum. Exposures were limited to flood-scours on the river banks (200 m^2). Lithics were limited to river gravel and cobbles on the river bed and banks. No suitable stone for artefacts located. A thin scatter of freshwater mussel shells was located on the eastern bank of the river (northern crossing) at MGA 0398226E 6422360N scattered over an area of 100 m^2. The scatter is not considered to be a midden. This area has been heavily disturbed by pastoral activities; the archaeological potential is considered to be low.	4.52	0.44	0.02	100	0.02	0.44
T30	NE extent SW extent	0398278 0398121	6420313 6420123	4th order creek, creek flats, steep spur, lower foot slope	Dingo Creek Crossing; Bratfield property, Stroud Road area. This transect samples the last creek crossing before the two options (Black Camp Creek Rd and Ramstation Creek) commence. The crossing lies approximately 400 m north of the confluence of Dingo and Ramstation Creeks. A steep ridgeline to the west of Dingo Creek descends to the creek gully, which is 1-2 m wide and up to 2 m deep. the creek flats are relatively narrow on the eastern side (about 40-50 m wide) and extensive on the western side as they form part of the Ramstation Creek flats. On the western side there is a steep	1.488	0.67	0.01	100	0.01	0.67

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					spur that rises to the NW. Sandstone outcrops occur on both the spur and in the creek banks, but there was no evidence of engravings visible. Vegetation was limited to thick pasture on the flats and spur (100% cover) with taller eucalypt stratum in the creekline and as an obvious tree-line on the mid-upper slopes of the spur (20 m+ elevation above creek). Observable soils in the creek profile showed a uniform brown alluvial loam. The archaeological potential in this area is considered to be low on the flats, but moderate on the lower spur.						
T31	NE extent SW extent	0398177 0397366	6419919 6419627	4th order creek, creek flats, lower foot slope	Ramstation Creek crossing (Ramstation option); Bratfield property. This area is situated about 800 m west of T18 and T19. The area is characterised by the meandering channel of Ramstation Creek which is 8-10 m wide and 3-5 m deep. There is a narrow river terrace on the northern side of the creek and extensive flats on both sides before rising gently onto low ridges. The flats and terraces are generally covered in thick pasture/weed (100% cover) with taller stratum in the creek line. Exposures consist of cattle tracks along fence lines; under the overhanging vegetation on the creek banks (2 m wide), and in extensive flood-scour erosion banks on the creek margins. Total exposure area is about 300 m^2. The soil profile in the creek bank shows a deep duplex soil with dark alluvial A1 horizon over a bleached A2 above a red-orange clay B horizon. Lithic material was restricted to sandstone boulders in the creek line (no engraving/grooves observed) and gravel/cobbles in the creek bed. There was very little lithic material on the banks and exposures and no suitable stone tool material observed. This area is considered to have low archaeological potential.	2.364	1.27	0.03	100	0.03	1.27
T32	N extent S extent	0397745 0397767	6418619 6418291		Rumble/Walters property, Black Camp Road						

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
T33	N extent S extent	0397845 0397806	6417889 6417513	4th order creek, lower gentl slopes, creek flats	Barnes Creek, Black Camp Road; Walters / Osborne properties. This transect sampled a narrow corridor between the road and creek. The creek gully here is deeply cut (5-6 m deep; 3-20 m wide) with a high gradual slope at the north culminating before dropping very steeply into the creek gully. The south bank rises more gradually to the south and is not as high (<10%; 2 m high). The creek has a sharp bend and the easement crosses the creek twice before emerging onto wide creek flats at the southern end. Vegetation cover consisted of thick pasture with 100% cover except in the creek gully which had a taller stratum. Exposures were only evident in cattle tracks, on a dam wall north of the creek, and in flood-scours in the creek banks. Total exposure about 10 m^2. No lithic material observed. Archaeological potential is considered to be low.	1.52	0.07	0.001	100	0.001	0.07
T34	NE extent SW extent	0397729 0397807	6417368 6417514	4th order creek, 2nd order creek, lower slopes, creek flats and terraces, low spurs	Barnes Creek, Black Camp Creek Road; Osborne property. This transect follows a narrow strip between the creek and the road, traversing along the creek margin on gentle foot slopes and low spurs, and includes a crossing of a minor ephemeral 2nd order creek. Vegetation consists of cleared pasture (100% cover) and taller stratum in the creek margins. Exposures limited to minor areas along the creek banks (~200 m^2). Sandstone outcrops occur on the banks of Barnes Creek. A stand of mature gums occurs in a creek bend at the western end but no scars were evident. The far western end rises up a large spur with a northerly aspect. Minor exposures (1 m^2 - 20 m^2) occur throughout the transect. surface lithic density ranges from 1/5 m^2 to 20+/m^2. No suitable stone-working material identified. A bora ring (AHIMS # 38-1-006) has previously been recorded in this area but was not relocated during the survey. Archaeological potential is considered to be moderate in this area and a PAD (PAD4) is located on the large spur at the western end. it is recommended that the pipeline remains within the road easement,	3.927	0.51	0.02	100	0.02	0.51

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					which is heavily disturbed, to avoid possible impacts to sub-surface deposits.						
T35	NE extent SW extent	0396750 0396599	6416301 6416116	4th order creek, creek flats, terraces, low spur lines	Barnes Creek crossing, Black Camp Creek Road, Gorton's property. In this area, the pipeline route veers eastwards and crosses the creek approximately 200 m east of a bend in the road. The area is characterised by the meandering creek winding through narrow creek flats with gently inclined westerly-aspect spur lines on either side. The vegetation has been cleared either side of the creek margins and in a N-S strip through which the proposed easement runs. On the northern side the ground cover is thick pasture (100% cover) and on the clearings on the southern side have a thick cover of low paperbark regrowth (100% cover). Few exposures observed (total area ~ 10 m^2). Few lithics observed except in creek banks, but no suitable stone material for artefacts. No mature trees. Archaeological potential considered to be low. A historic heritage place (LEH4) was identified in this area.	0.956	0.10	0.001	100	0.001	0.10
T36	NE extent SW extent	0395584 0395204	6411836 6411344	Steep upper slopes, steep lower slopes, 2nd order creek, creek flats	Black Camp Creek Road, "Bottle Corner", adjacent to Watson's property. This transect commences high on a steep ridgeline and descends sharply to the south before crossing a narrow, shallow tributary of Black Camp Creek, with narrow creek flats on the southern side. This area is very steep and thickly vegetated throughout. Ground visibility was 0% except in the road easement. The only lithics observed were gravel/cobbles in the creek bed. This area was considered to have low archaeological potential. Two historic heritage items were identified adjacent to the road (LEH5 and LEH6).	1.762	0.00	0	100	0	0.00
T37	NE extent SW	0394949 0394609	6410417 6410020	4th order creek banks,	Black Camp Creek and Bottle Corner Gully; James and Hull property. This transect samples the southern banks of Black Camp Creek, the eastern bank of Bottle Corner Creek and a 2nd order	3.144	0.32	0.01	100	0.01	0.32

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
	extent			2nd order creek, creek flats, gentle lower slopes, hill crest	tributary that drains westwards into Black camp Creek. The transect traverses along lower slopes south of Black Camp Creek, and crosses a minor 2nd order drainage line at the NE end, Bottle Corner Creek mid-way before rising gently to a small hill crest at the SW end. Vegetation consisted of pasture grass (100% cover) except in various exposures. Taller stratum occurred in the creek lines. Exposures consisted of sheet erosion scars formed on vehicle tracks, minor natural exposures (1 m^2), flood-scours in creek banks and in cattle tracks/pads. Total exposure area is considered to be 100 m^2. Many lithics in the exposures (100+/m2), but few pieces of suitable raw material. Two Aboriginal sites (LEA6 and LEA7) and two historic sites (LEH7 and LEH8) were identified in this area. In addition the archaeological potential at the northern end is considered to be medium to high and a PAD measuring 180 x 30 m (PAD5) was identified.						
T38	NE extent SW extent	0393294 0393061	6409287 6409118	2nd order creek, terraces, flats, low hill, spur, and lower foot slope	Black Camp Road; Muddle property, including "Margaret's Folly" - Cedar Tree Creek crossing. The pipeline traverses the property close to the road reserve, but within private property. The transect started on the foot slope of a large hill at the northern end, came down onto creek flats that ranged from 40-200m wide. It then dropped 1 m onto a 50 m wide creek terrace (swampy with a small drainage line). The creek gully was about 1 m below the northern terrace, about 10 m wide with bare, sandy banks underneath the creek line tree canopy. On the southern side, the creek banks emerged onto a narrow (10 m wide) creek terrace, which then started to rise gradually up the side of a spur. The only exposures occurred on the creek banks and along the fence line to the south east of the crossing (total area ~ 200 m^2). There were no lithics in the creek line and about 10/m^2 along the fence line. No artefacts. Two mature eucalypt trees situated on the northern foot slope were	1.152	1.74	0.02	100	0.02	1.74

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					devoid of scars. Apart from the taller creek line vegetation, the rest of the landscape uniformly consisted of pasture grass/fireweed with 100% cover. One potential historic heritage site (LEH9) was located in this area.						
T39	NE extent SW extent	0391642 0391259	6408158 6407806	4th order creek, 3rd order creek, gentle lower slopes, very low spurs, creek flats	Black Camp Creek, off (Old) Black Camp Creek Road; Muddle property. This transect samples a section of the pipeline along the edge of a road easement where it passes in close proximity to Black Camp Creek. At the NE end, the transect passes over an un-named third order creek that drains northwards into Black Camp Creek. West of this creek is a very low spur with a northerly aspect, and a narrow belt of gentle lower slope before the road turns southwards. The SW end is characterised by creek flats before rising over another low spur (westerly aspect) at the southern end. Transect was almost completely cleared pasture (100% cover), except for the creek margins, which had the usual taller strata. Exposures were limited to the road itself (800 m^2; 100% visibility), the banks of the 3rd order creek and dam wall (200 m^2; 20% visibility). Soils were duplex with a thin A horizon of grey-brown pedal sandy loam over a thicker orange clay B horizon. Lithic material was minimal off the road, but densely scattered 50+/m^2 on the road surface. No suitable material observed; no mature trees observed. A potential historic heritage site (LEH10) was identified in this area.	4.2	2.38	0.1	100	0.1	2.38
T40	N extent S extent	0391216 0391161	6406326 6406179	4th order creek, moderately steep lower foot slope, creek flats and	Black Camp Road; Rodgers & Herbert property "Bynsam Ponds". This transect samples an un-named 4th order creek crossing, which drains westwards into Black Camp Creek. The creek gully is 5-10 m wide x 1-4 m deep and has sheer sides. The creek winds through relatively wide flats between two spur lines with a westerly aspect. Vegetation is thick pasture throughout (100% cover) except in the creek margins (taller stratum of eucalypts and paperbark). very few exposures except in creek sides (ranges from 1 m^2 - 10 m^2; total	0.96	0.42	0.004	80	0.0032	0.33

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				terraces, spur with gentle slopes	area ~40 m^2; visibility 80%). Very little lithic material observed in exposures (~1/5 m^2); no suitable stone material identified. Archaeological potential considered to be low.						
T41	NE extent SW extent	0391172 0391082	6405095 6404881	4th order creek, creek flats & terrace, gentle lower slope	Little Black Camp Creek, Black Camp Road; Carlton property. This transect sampled the creek crossing just east of its confluence with Black Camp Creek. The area consists of the meandering creek gully winding through a narrow strip of creek flats on both sides with gentle lower slopes north and south. Vegetation consisted of eucalypt open woodland on the slopes and flats on the southern side to woodland in the creek margins and cleared pasture on the northern flats. Ground cover consisted of pasture grasses and thick leaf litter throughout (0% visibility). Occasional exposures of about 1-2 m^2 occur on the southern side with dense lithic scatters of 100+/m^2 (mostly ironstone material) - total exposure area about 50 m^2. The area is considered to have low archaeological potential.	1.398	0.36	0.005	90	0.0045	0.32
T42	N extent S extent	0390377 0390398	6401576 6401367	2nd order creek, steep spurs	Bridge Creek, Glen Martin Road; Gorton / Smith properties, Glen Martin. This transect samples the crossing of a very steep second order creek that rises between the steep sides and spurs of Pretty Hill (elev. 190 m) on the northern side and Table Top (elev. 239 m) on the southern side. The creek drains westwards and southwest until it meets the Williams River at Glen Martin. The creek margins have a low forest upper stratum, while the slopes consist of thick pasture grasses/weeds, which extends under the forest cover (100% ground cover). Exposures were limited to the margin of the dam on the southern side of the creek (~60 m^2), another along the fence line on the southern side (~10 m^2) and occasional scours along the creek banks (10 m^2). Total exposed area is 80 m^2. The soil along the dam edge shows a thin duplex soil with a bleached A2 horizon overlying an orange clay B horizon. There were virtually no lithic materials	1.272	0.63	0.008	90	0.0072	0.57

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					observed anywhere in the transect. Archaeological potential is considered to be low.						
T43	N extent S extent	0390337 0390312	6400228 6399996	3rd order creek, creek flats, spur slopes, swamp	Glen Martin Road; Horn's property. This transect crosses an un-named 3rd order creek that drains westwards into Bridge Creek. The creek drains through a fairly narrow belt of flats bordered to the north and south by two low spur crests (westerly aspect). Vegetation consists mainly of thick pasture grasses with occasional purple-top, paperbark and eucalypts scattered along the flats and creek margin, and sedge/tussock grass in the swampy area near the road. Groundcover offered 0% visibility except in a few minor exposures along the creek banks (total area <20 m^2). Soils were alluvial loams in the creek gully; subsoils not observed. Very few lithics observed; no suitable raw material; no mature trees. Archaeological potential is considered to be low.	1.404	0.14	0.002	100	0.002	0.14
T44	NE extent SW extent	0389161 0388974	6394985 6394902	4th order creek, low ridge crests and slopes	Boatfall Creek crossing, Glen Martin Road, Clarence Town; Allen's property. Topography in this area consists of generally undulating, low-lying creek flats surrounding Boatfall Creek. Low ridges lay adjacent to the creek on the eastern side. Vegetation consisted mainly of thick pasture with taller stratum in the creek line and along creek terraces and occasional isolated trees in the paddocks. Soils were duplex clays. Exposures consisted of vehicle and cattle tracks, a single scour at the western end of the transect and a 3 m wide belt of bare earth along the eastern bank of the creek (total area about 100 m^2). Very few lithic materials observed even in the creek bed. Archaeological potential is considered to be low.	1.212	0.83	0.01	100	0.01	0.83
T45	N extent S extent	0382363 0382137	6389652 6389225	narrow river flats with natural	Williams River area, near Seaham; James' property. This transect samples an area of undulating river flats punctuated by a large back swamp and small second order water courses, backed by a high ridgeline to the south west. Vegetation was pasture grasses and	2.91	0.86	0.025	80	0.02	0.69

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				levee, 2nd order creek, low-lying ridges, back swamp, steep footslopes	weeds, with isolated copses or individual eucalypts scattered throughout; sedgeland and paperbark woodland around the swamp margins. Two mature eucalypts occur on a ridge crest on the northern boundary of the property (no scars). Exposures consist on large recently burnt patch of pasture (200 m^2), cattle tracks, flood-scours along creek banks (20 m^2) and along the steep foot slopes on the western side of the back swamp. Total exposure area (250 m^2). Minor sandstone outcrops occur behind the back swamp (no engravings/grooves evident). Ground surface visibility 0% except in exposures (80%). No lithics observed except behind the swamp associated with sandstone bedrock; no suitable material for stone tools. Archaeological potential is considered to be low-moderate on the ridgeline at the northern end of the property; low elsewhere.						
T46	N extent S extent	0382064 0382080	6388916 6388806	Spur crest & slopes	Williams River area, near Seaham; O'Keefe property. This transect samples a low-lying rocky spur (westerly aspect) that rises above the floodplains of the Williams River. Vegetation cover consisted of young eucalypt woodland (regrowth) with pasture ground layer (20% visibility). Exposures consisted of several natural exposures throughout the area (2-20 m^2; total exposure area 40 m^2). Lithic material occurs throughout the transect but is mainly granitic material. A small outcrop of silcrete occurs on a cleared easement 40 m west of the fence line (although this is not an Aboriginal site as such, it is designated LEH8 as a means of identifying it as a possible source of raw material for stone-tool manufacture). Archaeological potential is considered low to moderate.	0.444	0.90	0.004	100	0.004	0.90
T47	N extent Mid-point S extent	0382091 0382089 0381395	6388463 6388272 6387790	marshland, very low spur, low ridge crest,	Williams River margins; Parker / Hughes properties, Seaham area. This area is low-lying floodplain associated with the Williams River margins and is truncated by areas of extensive marsh/swamp and very low ridges. Vegetation was entirely pasture grass on the higher landforms and sedge/reed in the low-lying swamps. Isolated copses	6.204	0.08	0.005	100	0.005	0.08

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
				floodplain flats, gentle lower slope	of eucalypt woodland regrowth occur on some higher landforms. There were few exposures except for stock pads and tracks in the horse paddocks at the northern end and along a fence line adjacent the transmission line easement at the southern end. Total exposed area ~50 m^2. Very few lithics observed; densities in exposure at southern end 2-10/m^2. No suitable stone-working material; no mature trees; no sandstone bedrock. Archaeological potential considered to be low.						
T48	NE extent SW extent	0380856 0380607	6387311 6387173	narrow river flats, natural levee, low-lying ridge, back swamp	Williams River, northern bank; Duncan property. This transect samples an area of the Williams River bank (eastern side). Although the area within 100 m of the river was surveyed, it is likely that there will be no impacts to this area since the pipeline will be drilled beneath the river channel starting about 100 m away from the river bank. The main areas of interest were the low ridgeline and the back swamp. Vegetation consisted of thick pasture/weeds on the flats and low ridge (also eucalypt woodland on ridge) with small copses of paperbark woodland around the backswamp and along minor drainage lines. Ground visibility was about 10% in the pasturelands and about 20% in the few exposures associated with vehicle tracks (~20 m^2). No lithics observed at all; no mature eucalypts (no scars); no sandstone bedrock. Archaeological potential considered to be low in low-lying areas; possibly moderate in the low ridge.	1.71	0.12	0.002	10	0.0002	0.01
T49	NE extent SW extent	0380207 0380058	6386865 6386757	Spur crest, steep lower foot slopes, 3rd order creek, creek flats	Williams River area, off Clarence Town Road, Seaham; Forjacs' property. This transect samples an area of the western bank of the Williams River. Much of the flats within about 100 m of the river bank will be unaffected since the pipeline will be drilled beneath the river channel. A moderately steep spur descends south easterly to meet the flats and shallow channel of Carmichaels Creek, which drains westerly in to the river. Vegetation was pasture (100% cover with eucalypt open woodland on the steep spur slopes and paperbark	0.732	0.27	0.002	100	0.002	0.27

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					along the creek margin. Exposures consisted of narrow cattle tracks on the spur slope (20 m^2; 100% visibility). Isolated granitic boulders occur in isolated areas of the transect, and some silcrete material occurs on the spur (no artefacts). Archaeological potential is considered to be low due to steep terrain and regular flooding.						
T50	N extent S extent	379846 379846	6386588 6385825	Simple slopes (v. gentle, gentle, mod.-steep. Creek flats, 1st, 2nd, 3rd order creeks	Jackass and Carmichael Creeks, off Clarence Town Road, Seaham; Elbourne property (7DP708057). Transect follows an existing 50 m-wide transmission line easement from due east of Rockgidgel Hill northwards across Jackass Creek, thence northeast over a high steep ridge to the banks of Carmichael Creek, thence eastwards over undulating terrain with 1st order drainage lines off the ridge, to meet Clarence Town Road north of Seaham. The easement has been cleared of all upper stratum, although bounded each side by eucalypt woodland; Ground cover is pasture/weeds with about 80% cover. The Jackass Creek flats have been modified by pastoral activities including dam and track construction. Small exposures scattered throughout (total 500 m2). Archaeological potential is considered to be low, except on the northern side of Jackass Creek where it is considered to be low-moderate.	1800	1800	3	5.4	100.00%	5.4000
T51	W extent E extent	377971 378155	6384445 6384655	3rd order creek, creek flats	Deadmans Creek crossing, Clarence Town Road (northern side), Seaham; Hansom Quarry Ltd's lands. Topography in this area consists of generally low-lying creek flats surrounding Deadmans Creek. Creek channel is 10-20 m wide and 3-4 m deep with steep banks to creek flats. Vegetation consisted mainly of thick pasture on the flats, with taller stratum in the creek line. Soils were duplex clays. Exposures consisted of minor vehicle and cattle tracks, and single scours beneath the canopy of trees along the creek banks (total area about 100 m2). Very few lithic materials observed on the western	540	1080	3	3.24	1.54%	0.0500

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					side of the creek; higher quantities on the eastern side though these appear to be imported road-base gravel. Archaeological potential is considered to be moderate on the western side of the creek.						
T52	N extent S extent	0376863 0376963	6383293 6382909	Floodplain, wetland (swamp)	North western margins of McClement Swamp, Brandy Hill. Topography in this area consists of extremely low-lying swamp margins, periodically inundated. At the time of survey, heavy rain had fallen and the ground surface was covered in water and the soils saturated. There are no low rises in this area, except to the east where rural housing has been developed. No lithic material was observed. Isolated tree copses occur, but are all regrowth. The area traversed by the pipeline route is considered to have low archaeological potential.	1150	1150	3	3.45	0.00%	0.0000
T53	View point (looking SW through arc of 40°)	376847	6381325	Floodplain, wetland (swamp), 1st order creek	Eastern margins of McClement Swamp and Barties Creek, accessed via Warrigal Close, Brandy Hill. The land in this area was inundated at the time of survey, which precluded ground survey. Survey was by vehicle-based observation of landforms only. However the low-lying, periodic flooding of this area suggests a low archaeological potential along the pipeline route. The rises to the east (currently under rural subdivision) are considered to have moderate archaeological potential.	0	0	3	0	0.00%	0.0000
T54	N extent S extent	0377291 0377748	6379113 6378561	Floodplain, wetland (swamp), modified creek	Eastern margins of Barties Creek and south eastern extent of McClement Swamp; "Hinton Vale", of Hinton Road, Osterley. Topography in this area consists of extremely low-lying creek flats and swamp margins, periodically inundated. At the time of survey, heavy rain had fallen and the ground surface was covered in water and the soils saturated. The creek channel itself has been extensively modified by agricultural activity and the pipeline route follows an existing fibre-optic cable route. There are no low rises in this area, except to the east where rural housing has been	710	710	3	2.13	0.00%	0.0000

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					developed, and Kanway Hill itself. The land in this area was inundated at the time of survey, which precluded ground survey. Survey was by vehicle-based observation of landforms only. However the low-lying, periodic flooding of this area, the modifications to the creek channel and the existing trenching for fibre-optic cables suggests a low archaeological potential along the pipeline route. The rises to the east (currently under rural subdivision) are considered to have moderate archaeological potential.						
T55	N extent S extent	0377682 0377603	6377613 6377182	River flats, floodplain	Hunter River (south bank); Peacock's property, off Duckenfield Road, Duckenfield. This transect samples an area of low-lying river flats/floodplain on the southern bank of the Hunter River. The area is completely cleared for grazing and is covered in 100% cover of pasture grasses through the transmission line easement (20 m wide). Either side of the route, the paddocks have been recently ploughed showing bare earth (80% visibility). No lithic material was evident; no mature trees were in the vicinity; no sandstone outcrops evident. Archaeological potential is considered to be low.	1.764	79.93	1.41	100	1.41	79.93
T56	N extent S extent	0376506 0376445	6372409 6371987	3rd order creek, swamp, floodplain	Chichester-Newcastle pipeline (Hunter Water easement); Greenways Creek crossing off Woodberry Road, Woodberry. This transect sampled an area of low-lying floodplain where the easement crossed Greenways Creek between the Hunter River to the east and Woodberry Swamp to the west. The proposed gas pipeline will be in the transmission line easement, rather than the water pipeline easement. Vegetation in the area consisted almost exclusively of thick pasture (100% cover); upper stratum consisted of *Allocasuarina* open woodland in a wide belt along the creek margins (But ground cover was still thick pasture). Exposures were limited to minor areas	1.72	0.06	0.001	100	0.001	0.06

Transect No	Point	MGA Easting	MGA Northing	Landforms	Description	Area (Ha)	Exposure (%)	Exposure (Ha)	Visibility (%)	Detection Area (Ha)	Effective Coverage (%)
					along the creek bank and in cattle tracks in the paddocks (total exposure area ~10 m^2). Archaeological potential in this area is considered to be low.						
T57	View point (looking SW through arc of 30°)	376603	6371648	3rd order creek, swamp, floodplain	Greenways Creek, off eastern side of Woodbury Road, north east of Woodbury. The land in this area was inundated at the time of survey, which precluded ground survey. Survey was by vehicle-based observation of landforms only. However the low-lying, periodic flooding of this area suggests a low archaeological potential along the pipeline route. The rises to the south and west (Woodbury ridge) are considered to have moderate to high archaeological potential.	0	0	3	0	0.00%	0.0000
T58	N extent S extent	0378076 0377804	6367604 6367346	Disturbed terrain, swamp margins	Old Punt Road, Tomago. Transect follows the western side of the road verge across what was formerly wetland adjacent to the Hunter River to the caravan park. Roadsides heavily modified. Caravan park occupies a slight rise over the swamp, but the rise is comprised almost completely of imported fill. Archaeological potential in this area is considered to be low.	440	880	3	2.64	100.00%	2.6400