Noise mapping an entertainment precinct

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ABSTRACT

Brisbane's Fortitude Valley is an inner city area combining retail, commercial, residential, and entertainment uses. For many years it has been the *melting pot* for new groups and has been the starting point for several major Australian bands. The Valley has seen a large increase in the number of residential apartments over recent years as part of Brisbane's inner city *urban renewal*, which has led to concerns regarding the impact this may have on the future of live music in the Valley. To address this issue, the Brisbane City Council is developing the Valley Music Harmony Plan that includes entertainment precincts with specific noise criteria within the Valley, and will allow informed decisions to be made regarding future development while minimising potential noise conflicts. A *picture* of the existing noise climate in the Valley was required to provide background information for the project. The aim of the study was to provide a noise contour map of the Fortitude Valley Local Plan area for the day, evening and night time periods, and to determine suitable times for these periods given the different nature of the noise climate within the Valley (eg. traffic jams at 1am, evening and night time levels higher than day time noise levels). Modelling and monitoring approaches were considered to produce the noise contours, however monitoring was chosen as the preferred approach as it would incorporate sporadic sources such as people's voices, music, and randomly located mechanical plant. A monitoring strategy was developed and implemented, including safety procedures. Measurements were taken at over 330 locations. The resulting data was used to produce dB(A) and dB(C) contours and provide specific levels outside venues, which provided a clear indication of *hot spots* and areas to be considered for the entertainment precinct. The work concluded that: road traffic noise dominates the ambient levels in many areas; the Valley Heart Precinct has the largest number of entertainment venues and experiences the highest noise levels; in areas with live entertainment the evening period may effectively extend to 1.00am; and patrons and pre-recorded music venues may maintain relatively high ambient noise levels for several hours after the live music has finished. The noise mapping work has proved an invaluable tool in the development of the Valley Music Harmony Plan, which was released in draft form in 2005 by the Brisbane City Council.

INTRODUCTION

Brisbane's Fortitude Valley is an inner city area that is home to a wide range of uses including: live entertainment venues, residential development, retail facilities, commercial and industrial development. For many years it has been the *melting pot* for new groups and has been the starting point for several major Australian bands. The introduction of a large number of residential apartments over recent years as part of Brisbane's inner city *urban renewal*, has raised concerns regarding the potential impact of the future of entertainment venues in the Valley. To address this issue, the Valley Music Harmony Plan is being developed by the Brisbane City Council in consultation with the Liquor Licensing Division, Environmental Protection Agency, the local entertainment industry, and community stakeholders. The concept behind the Valley Music Harmony Plan includes development of entertainment precincts within the Valley with set noise criteria to avoid music venues having to meet lower criteria as new apartments are built closer to the entertainment venues.

In order to develop the plan and allow informed decisions to be made, noise data was required to provide a clear *picture* of the existing noise climate in the Valley. The noise data was required to provide information regarding: the spread of noise sources throughout the Valley, the level of noise, and also the daily variation of noise during a typical week.

The study area was defined by the boundaries of the Fortitude Valley Local Plan (FVLP) area as described in Brisbane City Plan 2000 (Brisbane City Council 2000). It contains seven precincts and covers a large inner city area as shown in Figure 1. The valley presently has a population of over 3000 residents (Henry, Mackenzie 2004).

NOISE MAPPING

Modelling - v - Monitoring

Various approaches can be taken to noise mapping projects. Where the noise sources are well defined, computer models can be used to predict noise levels over a grid of points and contours produced from this data set. This is appropriate for studies of certain noise sources such as transportation noise where there are established models for road, rail and aircraft. These models can also include known point or area sources such as industries – although relevant source and receptor noise measurements would be required. These noise models also require significant amounts of digital terrain data (including buildings), to allow useful data to be predicted. The authors company has undertaken noise modelling projects in Australia, the UK, and Hong Kong, ranging from smaller industrial areas to entire cities including production of noise maps for Hong Kong (1000km^2, population 6.8million, one of the largest noise mapping projects in the world).

However where the noise sources are variable, noise modelling becomes less suitable and noise monitoring of actual levels is more appropriate. Noise sources in the Valley include: road traffic (both free flowing and congested movement at various times of the day), people at cafés/ venues/ on the footpath, entertainment noise, air conditioning plant, and other variable noise sources. Each of these items is difficult to predict using computer models.

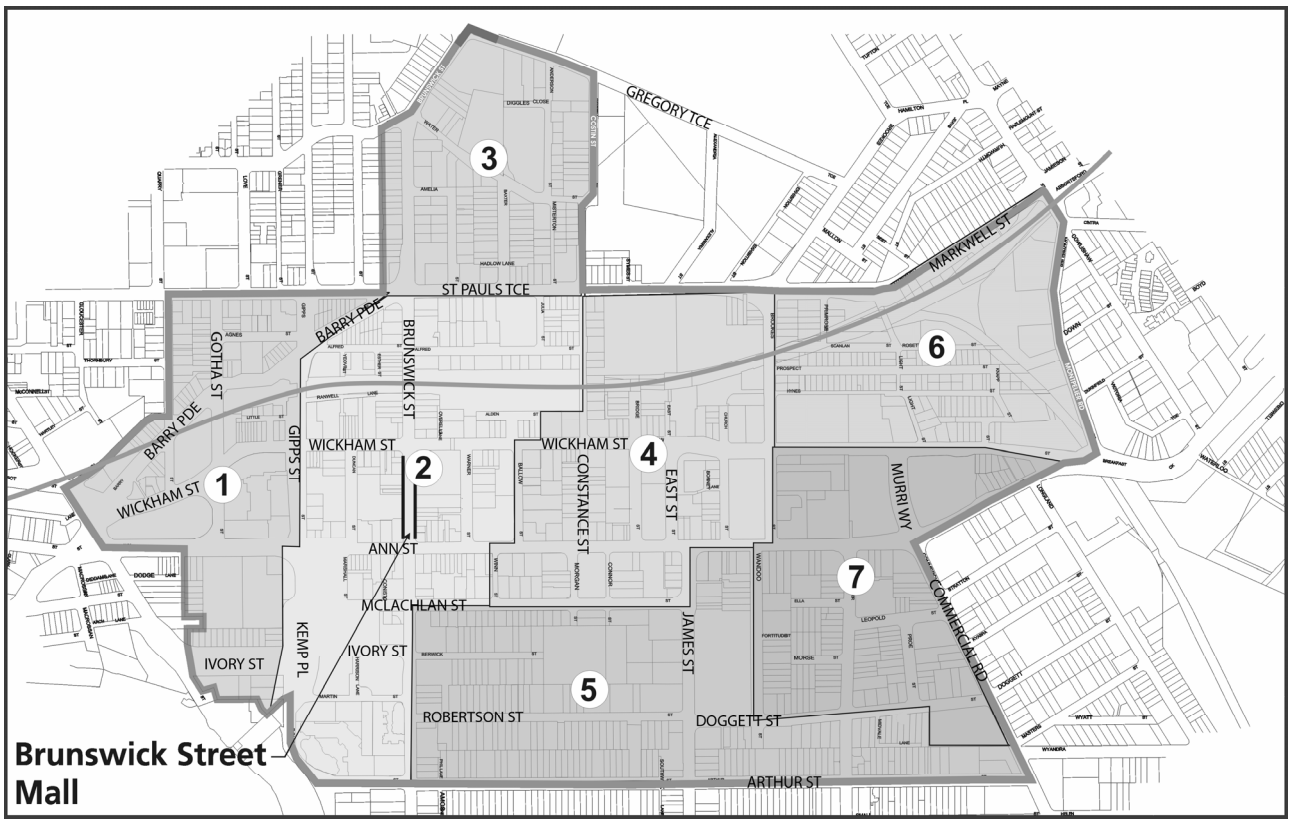

Figure 1. Study area – Fortitude Valley Local Plan showing the seven precincts described in Brisbane City Plan 2000. 1 – Gotha St., 2 – Valley Heart, 3 – Water St., 4 – East St., 5 – James St., 6 – Light St., 7 – Chester St.

Through discussions with the Brisbane City Council, it was agreed that noise monitoring would be the most suitable approach as it would provide a more accurate picture of noise levels in the Valley given the variability of the noise sources and limited digital terrain/ building data.

It was decided that two sets of data were to be provided to deliver the required extent of information:

- Measurements taken at a grid of points spread over the Valley study area, for the day/ evening/ and night periods. From this data, noise contour maps would be produced, to provide a *snap-shot* of typical noise levels.
- Measurements taken via noise logging at selected locations to provide data on the daily variation of noise levels in the Valley.

Noise monitoring grid

In order to produce the noise maps for the Valley, noise monitoring was undertaken over a grid, based on the road network. This was considered to be a practical approach and has previously been used for the Toowoomba Noise Survey (Eddington, Spalding 1986). The monitoring locations were concentrated in areas where there were more noise sources (eg. entertainment areas in Valley Heart, Precinct 2 in Figure 1). The grid typically ranged from 10 – 70m between monitoring locations, with a total number of sites of over 330 locations. This provides a reasonable density of locations over the FVLP area. Figure 2 shows the study area, and the noise monitoring locations. During this work, noise levels were also measured directly outside venues to provide additional data describing the current noise climate in the Valley.

To expedite the monitoring work, two teams with identical sound level meter equipment were used to cover the grid. Measurements were typically taken on the footpath at 5 - 7m from the nearest through traffic, and at 1.5m above street level.

Day, evening, night time periods

The monitoring was designed to capture the typical higher noise levels experienced for each of the day, evening and night time periods. Hence, day monitoring was undertaken on weekdays, and evening and night time monitoring was undertaken on Friday and Saturday nights.

Monitoring was undertaken during the Day (5am – 6pm), Evening (6pm – 12MN), and Night (12MN – 5am) periods as defined in the Brisbane City Council brief. These time periods were nominal only. As the study was to focus on entertainment noise, monitoring was not undertaken during the 'am' and 'pm' peak hour road traffic periods. Avoiding the peak hour periods also assisted in reducing the variation of noise levels at a location over each time period. Monitoring was typically undertaken from: Day 10am – 4.30pm; Evening 8pm – 12MN; Night 12.30am – 4.30am.

Sample time

To enable the large number of locations to be covered in the allocated time frame, levels were measured for 2 minutes at each location, and evening and night monitoring was performed on Friday and Saturday. During monitoring, infrequent noises (eg. trains) and extraneous noise sources (eg. cars starting up near monitoring locations, street sweeper machines, people shouting into the microphone) were excluded from the 2 minute samples.

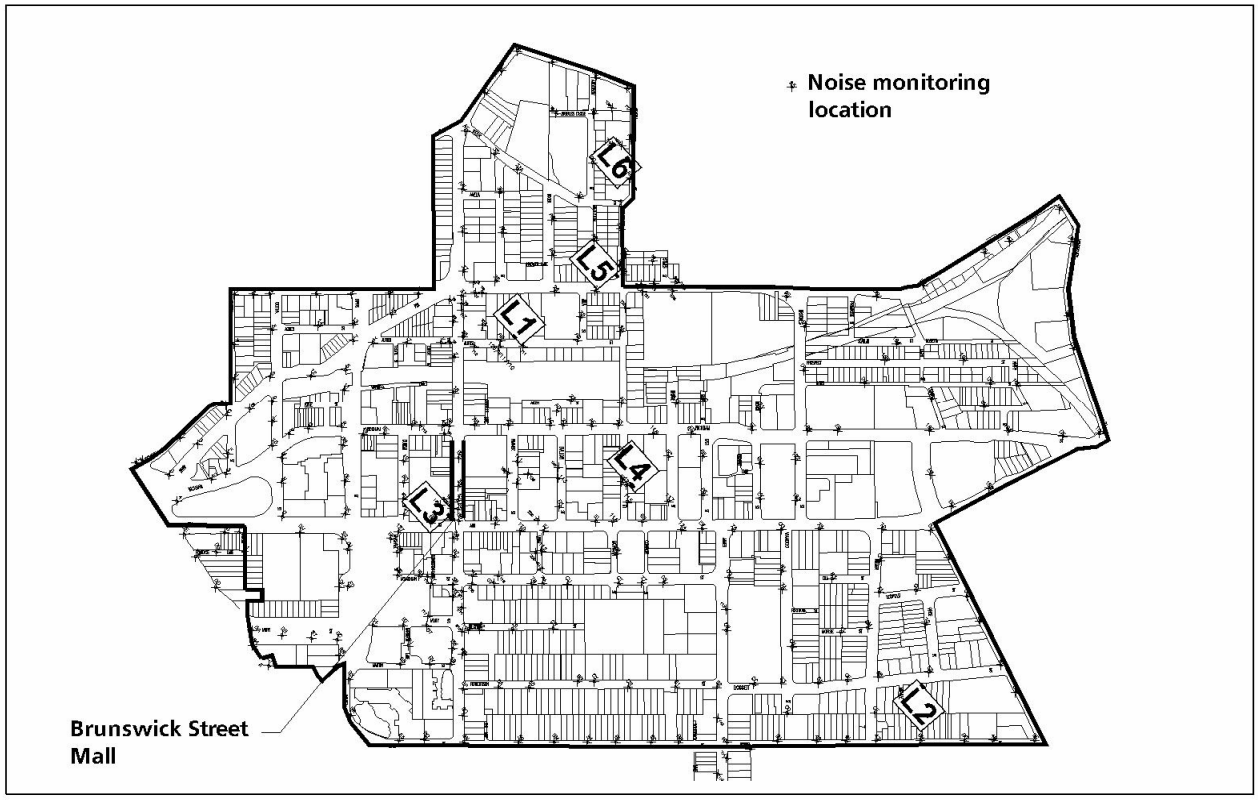

Figure 2. Noise monitoring locations – The density of monitoring locations was varied over the study area to focus on entertainment areas with more noise sources. Logger locations L1 – L6 are also presented.

The 2 minute sample period was found to be a suitable length as it allowed at least two traffic light changes to occur during the sampling period. It is considered that shorter measurements would not have been appropriate, as many of the sites were dominated by traffic noise.

Construction noise was evident at several locations, and at most locations this noise was able to be excluded from the 2 minute measurements. At five randomly selected locations, 15 minute samples were also recorded to allow comparison with the 2 minute samples. A 15 minute sample period is often used for assessment of environmental noise.

Data collection

During noise monitoring the sound level meters were set to collect 5 parameters – L_{max}, L_{10}, L_{eq}, L_{90}, L_{min} , in 1/1 Octave bands (this gives frequency data from 16Hz – 8kHz). L_{max} and L_{min} are the maximum and minimum noise levels measured during the monitoring interval, L_{10} and L_{90} are the levels exceeded for 10% and 90% of the monitoring interval, and L_{eq} is the level with the same energy as the actual fluctuating noise level. Overall levels were stored in *A and C weightings*, to allow the effect of low frequency noise from venues to be considered using a single parameter. This approach is often used by the Liquor Licensing Division in setting noise limits for venues as part of their license conditions.

Monitoring time frame

The majority of the monitoring was undertaken during May 2003. During this period it was noted that several venues did not have entertainment at the time monitoring was undertaken. To address this, contact was made with several venues to confirm when entertainment was being provided and additional monitoring was undertaken around various venues on Thursday, Friday and Saturday evenings in July 2003. Figure 3, shows the locations of venues noted during the noise monitoring work.

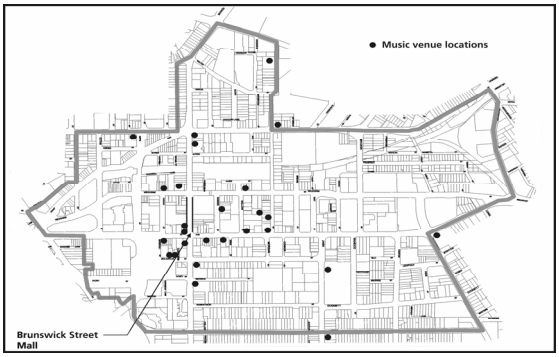

Figure 3. Location of music venues in the Valley, July 2003

SAFETY DURING NOISE MONITORING

The Valley is a busy inner city area of Brisbane, with many licensed premises. Due to the long hours required to be spent in the Valley during the late night and early morning periods, safety of staff had to be considered.

It was decided that staff would work in pairs and that they would remain within sight of each other during monitoring. This was achieved by monitoring at sequential locations along the street grid. Monitoring in pairs also reduced the time required to complete monitoring at the large number of sites.

Contact was made with the Police in the Valley in advance of the monitoring project to discuss general safety in the area, and identify any areas to be avoided. Prior to each monitoring episode, the Police were contacted again to confirm the expected times staff would be working and the approximate area of the Valley to be covered.

NOISE LOGGING

In addition to the attended noise monitoring, noise logging equipment was located at six locations to gather data regarding the daily variation of noise levels over a 1 week period. The equipment was programmed to collect data at 15 minute intervals. The monitoring was undertaken during May/June 2003. The logger locations are shown in Figure 2. The monitoring locations were selected to provide an indication of the range of noise climates in the FVLP area. The locations included: quieter residential/ commercial areas in Doggett and Costin Street (L2 and L6 on Figure 2), apartments in the Valley Heart Precinct in Alfred Street (L1), commercial/ entertainment venue areas in Constance Street (L4 and L5), and the retail/ entertainment venue scene on Brunswick Street Mall (L3). For security reasons the loggers were not located on the footpath, but were located outside premises or on balconies.

LIMITATIONS OF METHODOLOGY

The following limitations should be noted with regard to the methodology employed:

- To capture the desired data in the given time frame, monitoring was undertaken on Friday and Saturday nights (ie. rather than a series of Friday *or* Saturday nights). Limitation - it is expected that there would be variations in noise levels on these nights at different locations in the Valley. Friday and Saturday nights were chosen to represent the typical *louder* evening and night noise levels in the Valley.
- Weekdays were used to capture typical *louder* noise levels during the day time period, as the road traffic and commercial areas are busier than on weekends. Limitation – on some weekends daytime entertainment may cause elevated noise levels in some areas.
- Entertainment noise levels for a given venue vary depending on the type of performance given (eg. a dance party is typically louder than a disco, a band is typically louder than a soloist). In monitoring levels at venues, events were chosen in consultation with the venues that they felt represented a typical *loud* event (eg. live band at The Zoo and Ric's Cafe, dance party at The Tivoli).
- The noise contours produced by the monitoring process do not take into account shielding effects of the buildings (eg. the noise level in a courtyard/driveway behind a building may be quite different to the contour level due to shielding effects of some buildings and reflections from other buildings). However noise levels measured along streets take into account all local effects such as reflection and shielding, and hence the noise contours along the streets are representative.
- Noise contours have been produced using Surfer computer software. As with any contouring work, the program estimates the noise levels over the given area, based on the actual measured data set. Hence the contour noise levels are estimated.
- The noise contours represent the levels at 1.5m above street level and different noise levels would be experienced at more elevated locations (eg. a high rise apartment overlooking a venue may experience higher noise levels due to noise breaking out through the venue roof structure).
- An indicator of the accuracy of the 2 minute monitoring approach can be estimated by comparing the 2 minute and 15 minute noise level readings at identical locations. Analysis of this data at five random locations for each of the day, evening and night time periods indicated that the 2 minute levels typically lie within 3dB(A) of the 15 minute levels.

PRESENTATION OF NOISE DATA

Noise contour maps

Noise contours were produced for L_{eq} and L_{90} parameters for the Day, Evening, and Night time periods based on the measured noise data. Figure 4 shows the *C weighted* noise map produced for the L_{eq} parameter during the evening period. The evening contours include noise levels when venues were operating as they typically all operate during this period. During monitoring and liaison with venues, it was noted that many of the live music venues stop at around 1am, with pre-recorded music (discos and dance parties) continuing through to 3am or 5am. Hence the evening period contours could be interpreted as being relevant until around 1am.

The noise maps were coloured to provide an easy to read set of noise contours ranging from green for lower noise areas to dark red for higher noise areas. Various types of gridding methods were trialled to produce the most useful set of noise contours. The Kriging method was ultimately chosen as it provided reasonable accuracy and a relatively smooth contour shape. In some locations around the boundaries of the monitoring area, *ghost* points were added based on expected levels at these locations to improve the accuracy of the contours at the edges of the study area. A contour interval of 5dB was selected for clarity. The noise contour maps also provided information regarding the presence of entertainment noise at various monitoring locations. The black dots shown on Figure 4 indicate locations where music was audible. This was important to the policy work being undertaken by the Brisbane City Council as music often contains characteristics (eg. low frequency *throb*) that can be perceived to be more annoying than other sources (eg. road traffic noise).

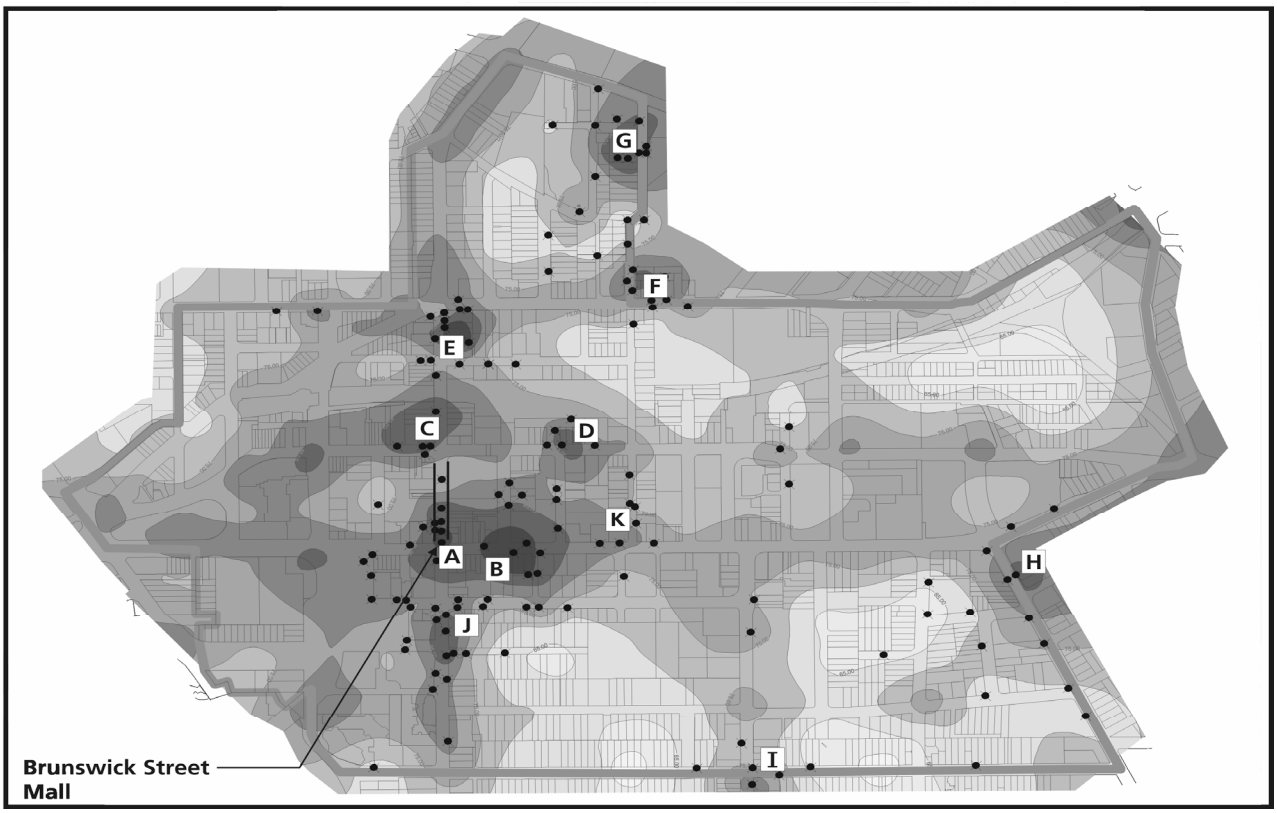

Figure 4. Leq Noise contour map dB(C). Note the higher noise levels (darker contours) near the entertainment areas and major roads. The dots indicate locations where music was audible during monitoring. Locations A – K indicate venue locations referenced in the text.

Noise logging graphs

Noise logging data was presented in level - v - time graphical form to allow weekly and daily trends to be observed. Figure 5 shows the noise logger data for Friday – Saturday at the Ann Street end of Brunswick Street Mall (Valley Heart Precinct, location L3 on Figure 2).

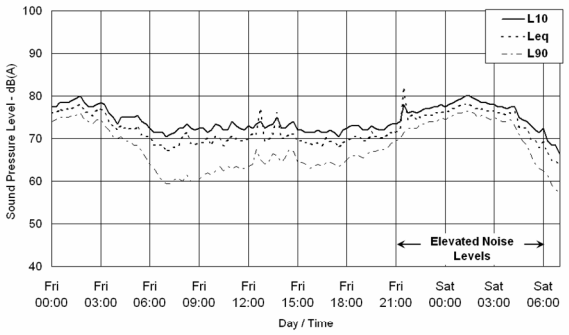

Figure 5. Noise logger data for Friday – Saturday at location L3 on the Brunswick Street Mall, Valley Heart Precinct. Note the elevated noise levels due to entertainment and patrons during Friday evening – Saturday Morning.

MEASURED NOISE LEVELS

Noise contour map levels

The Valley is a busy area of Brisbane, and while there are areas where venue entertainment noise is clearly audible, the dominant noise source in the study area was road traffic noise. Indeed *traffic jams* were seen on several occasions on Wickham Street and Warner Street, as late as 12 midnight on Friday and Saturday evenings. The effect of road traffic noise is seen on the ambient noise contour maps (refer Figure 4) where higher levels follow the major roads including:

- From Brisbane city via St Paul's Terrace, Wickham Street, Ann Street;
- From the Storey Bridge – Kemp Place, Ivory Street, Gipps Street, Barry Parade, Brunswick Street;
- And local roads – Gotha Street, James Street, McLachlan Street, East Street, Murri Way and Commercial Road.

Other transport noise from trains and aircraft were present at times, and for areas along the rail line, the train noise would be significant. (Note that train and aircraft noise was excluded during monitoring due to the transient nature of this noise source as previously discussed, and hence these sources were not reflected in the noise maps.)

From the noise maps it was shown that L_{eq} noise levels along the major roads were typically 70-75dB(A) Day, 65-75dB(A) Evening, and 60-70dB(A) Night. The background L_{90} levels reflected similar trends with noise levels along the major roads typically 60-65dB(A) Day, 55-65dB(A) Evening, and 45-60dB(A) Night.

The noise maps showed significant broadening of the higher noise areas during the day due to commercial activities (eg. furniture retail/manufacturers, dry cleaning facility, car servicing, delivery trucks etc.) in the James Street Precinct areas (refer Figure 1 for precinct areas) along Doggett Street and Robertson Street. While at night these areas experienced relatively low levels due to the residential nature of the area. The Light Street Hill Precinct and Water Street Precinct also experience this marked change from day to night time noise levels. One couple in Prospect Street commented that they found the Light Street Hill area quieter than the outer Brisbane suburb in which they had previously lived.

Noise from people on the footpaths and mall was significant at certain locations in the Valley. During the day the concentration of people was around the shopping and eatery areas (eg. both Chinatown and Brunswick Street malls and James Street). During the evenings the eatery areas were busy until closing time (typically around 10pm for café/ restaurants) followed by the venue crowds which continued to 5am in some areas (eg. Ann Street end of the Brunswick Street mall, Location A on Figure 4). Chinatown mall was typically quiet after 10pm, as were many of the café restaurants on James Street, however some café/ bars remained open until 1am and the patron noise was quite high (eg. L_{eq} = 76dB(A)/ 81dB(C) on the footpath). These elevated levels were mainly due to patrons raising their voice to speak over the amplified music provided by the café/bar.

Venue entertainment noise was clearly audible at various locations, and this is discussed further in the following section.

Air conditioning and other plant noise from commercial premises was audible at some locations (eg. Chinatown mall, Morse St, Costin St, Amelia St) mainly during the evening and night periods. In these locations the plant noise raised the ambient background level L_{90}, while the road traffic typically continued to set the L_{eq} level.

Construction noise was evident at several locations, and at most locations this noise was able to be excluded from the 2 minute measurements. One exception was the construction noise from the large apartment development on the corner of Ann Street and Murri Way (Chester Street Precinct), which included tower cranes that operated continuously during the day.

Venue Noise Levels

There are a large number of entertainment venues in the Valley, and at the time of monitoring there were 26 venues in operation. Figure 3 shows the locations of venues noted during the noise monitoring work. These ranged from live music *halls* such as The Zoo (Location B on Figure 4), Arena (Location E), and The Tivoli (Location G), to smaller live venues such as Ric's Café (Location A), to larger pre-recorded music venues such as The Beat, Family, #12, Monastery, and the GPO. Several of the hotels have one or more music areas used for live or pre-recorded music such as Jubilee (Location F), Waterloo (Location H), Elephant & Wheelbarrow (Location C), Royal George (Location A), Rat & Parrot (Location K), Reefo's (Location K), Dooleys (Location J), Empire (Location A), The Wickham (Location D), QA Hotel (Location I) and Shamrock (Location E). The higher noise levels indicated in Figure 4 at the Ann Street end of Brunswick Street (Location A) were due to venue noise (music and patrons). Venues in the Valley Heart precinct generally add to the ambient noise levels, although the levels outside some venues (eg. Family, #12) were dominated by road traffic noise. Other venues such as the Tivoli, Jubilee Hotel, QA Hotel and Waterloo Hotel have resulted in locally elevated levels, due to the otherwise relatively quiet ambient levels in these areas later in the evening.

Most of these venues are naturally ventilated or only partially air conditioned, and typically operate with doors and windows open. This allows music to escape, adding to the noise climate of the Valley. Many new or refurbished venues have openable facade elements (eg. concertina windows/doors) with the result that even small cafés with amplified music can generate relatively high external music levels. L_{10} music levels outside some venues were relatively high with several in the 80-92dB(A)/ 92-105dB(C) range (L_{eq} 78-90dB(A)/ 90-102dB(C)). However in many cases the entertainment noise was not audible at a distance from the venue, as the ambient noise levels from traffic and people (particularly patrons outside venues speaking over the music) tended to mask the music. For example on the Brunswick Street mall, music L_{eq} levels of 90dB(A) outside Ric's Cafe with a band, were difficult to hear at 25m due to ambient L_{eq} levels of 79dB(A). The traffic L_{eq} noise level along Ann Street was 77dB(A). In other cases where venues were located near quieter areas, the entertainment and patron noise was audible some distance from the source. These included The Tivoli, Jubilee Hotel, Waterloo Hotel and QA Hotel.

There are several locations where new residential development may impact on venues including areas around Costin Street, Alfred Street, and Ann Street/Murri way, and other locations where existing residential premises have limited the use of venues (particularly outdoor spaces such as beer gardens, or venues with openable facades). Some newer venues such as Family and #12 appear to have been built to contain the noise radiating to nearby apartments. It is clear from construction activities in the Valley that substantial residential development is occurring in the Valley.

There are several adult entertainment venues in the Valley, however entertainment noise from these was generally well contained, as the buildings typically had enclosed facades.

Daily Variations in Noise Levels

Noise logging was undertaken at six locations as shown in Figure 2. From the data collected it was found that the Brunswick Street Mall logger (location L3 on Figure 2, Valley Heart Precinct) recorded the highest average noise levels L_{eq} 71dB(A), L_{90} 65dB(A). Figure 5 shows the Friday-Saturday logger graph for this location. The levels would be due to the constant noise from road traffic, people on the mall/ at venues, and entertainment noise from venues. The lowest levels L_{eq} 53dB(A), L_{90} 45dB(A) were recorded on Costin Street near the Tivoli (location L6 on Figure 2, Water Street Precinct). It was interesting to note that the noise levels for the evening and night time periods for the logger on the Brunswick Street Mall were higher than the day time level. The logger on Constance Street opposite Reefo's bar and backpackers (location L4 on Figure 2, East Street Precinct), also showed higher evening levels than the day time levels (expected to be due to evening entertainment/patrons), but lower levels for the night time period.

Analysis of the noise logging data revealed that the Valley Heart Precinct had the highest noise levels and this was due mainly to live music and patron noise at venues on the Brunswick Street Mall. Alfred Street is a quieter part of the Valley Heart Precinct, but still experienced relatively high noise levels. Day time periods were generally able to be defined (eg. 6am to 6pm) for each of the six logger locations, however the change from evening to night time periods was less clear. The logger on the Brunswick Street Mall (location L3 on Figure 2) indicated that the ambient noise levels did not start to decrease until after 1.30am (refer Figure 5), and it was 6am before the levels dropped to the typical day time period level. This is confirmed by the logger data, which shows the mall experiences higher noise levels during the evening and night time periods than during the day time period. The logger opposite Reefo's (location L4 on Figure 2, East Street Precinct), indicated that levels due to music decreased after 1.00am. This is confirmed by the logger data, which shows higher evening noise levels than day time noise levels, but lower night time levels than the day and evening levels.

Hence, in areas near live music venues, the evening period could be considered to extend to 1.00am, although patron and recorded music may maintain elevated noise levels until 6am. In areas removed from venues, or on evenings when the venues are not operating there was a gradual decrease in ambient noise levels after the day time period, and a traditional time of 10.00pm could be considered as the end of the evening period.

CONCLUSIONS

Based on the noise monitoring undertaken between May and July 2003, during the day, evening and night time periods, the following conclusions can be drawn:

- The Valley has several major roads that pass through it and as a result road traffic noise dominates the ambient noise levels in many areas with L_{eq} levels of up to 75dB(A) during the day. The noise contours maps show the higher noise levels near the major roads.
- While noise levels vary considerably throughout the seven precincts in the Valley Local Plan Area, both the noise logging and noise contour maps show that the Valley Heart Precinct experiences the highest noise levels. This is due to live music levels in several areas.
- The Valley Heart Precinct has more music venues than the other six precincts. Noise levels were measured directly outside several venues with live music and the levels ranged from L_{eq} 78-90dB(A)/ 90-102dB(C).
- The noise logging data indicates that day time periods were generally able to be defined (eg. 6am to 6pm) for each of the six logger locations, however the change from evening to night time periods was less clear. In areas with live entertainment, the evening period may effectively extend until 1.00am, while in other areas removed from venues (or on evenings when the venues are not operating) a traditional time of 10.00pm could be considered as the end of the evening period.
- Averaged ambient noise levels on the Brunswick Street Mall were higher for the evening and night time periods than the day time period, due to music and patron noise.
- Patron noise and pre-recorded music may maintain relatively high ambient noise levels for several hours after the live music has finished.

With regard to the methodology applied to undertake the noise mapping work it is considered that the short sample period used to gather data over a larger number of locations provided a reasonable result. Further improvements in the accuracy of the data would be obtained by repeating noise measurements at each location on several occasions, and by limiting the day, evening and night monitoring periods to a smaller duration (eg. 10pm to 12MN rather than 8pm to 12MN) to reduce variations in levels.

ACKNOWLEDGEMENTS

The author wishes to thank members of the Brisbane City Council involved in the Valley Music Harmony Plan work, for their interest and assistance during the noise mapping work. The Council has now produced the Valley Music Harmony Plan (Brisbane City Council 2004), and a paper has been presented on the development of the plan (Henry, Mackenzie 2004) based on the noise mapping work and other studies undertaken by Brisbane City Council. The Valley Music Harmony Plan includes the Valley Heart area as the primary entertainment precinct, with three smaller entertainment precincts around other longstanding venues outside the Valley Heart precinct.

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