UBC Gage South & Environs
Noise Impact Analysis

Prepared for:

University of British Columbia
Campus & Community Planning

File: 0205-12A

February 27, 2012

BKL CONSULTANTS LTD.
#308 - 1200 Lynn Valley Road, North Vancouver, B.C. V7J 2A2

e-mail: sound@bkl.ca · website: www.bkl.ca
Phone: (604) 988-2508 · Fax: (604) 988-7457

Executive Summary

Some people have raised concerns that student activities or bus loop and traffic noise may trigger noise complaints from tenants of potential future university rental housing in the 'Area Under Review' within the Gage South and Environs study area of the UBC Vancouver Campus. The purpose of this study is to assess the potential noise impact on any future university rental housing in the context of two possible development scenarios as provided by UBC, Concept A and Concept B, and whether rental housing is a reasonable possibility in this noise context.

The following potential noise effects have been considered for the two design concepts:

1. Music noise generated in the future MacInnes Field;
2. Pit patron speech noise generated between the SUB and Gage Towers;
3. Bus noise generated in the future diesel bus loop;
4. Road traffic noise on Wesbrook Mall; and
5. Mechanical equipment noise from nearby buildings such as the future Aquatic Centre.

The main focus of this report is what effects should be addressed at the site of potential future multi-storey university rental housing for faculty, staff, and students within the 'Area Under Review' along Wesbrook Mall.

Available solutions include noise mitigation at:

1. The source (location, orientation of noise source and controlling loudness of source);
2. The path (introduction of noise barriers, either passive, such as buildings not sensitive to noise, or dedicated sound walls); and/or
3. The receiver (through building location, orientation and facade design).

The purpose of this assessment was to apply best practice and due diligence consideration of environmental noise in land use planning. The intent was not to ensure that noise complaints will be completely avoided, but that they can be minimized to the extent practical.

Based on the assumptions used, the land use for the potential university rental residential development should not be ruled incompatible for acoustic reasons. Concept A is preferred from an acoustical perspective because it would provide an amenity space (the courtyard) where environmental noise levels are lower. Day-to-day noise (i.e. non-event noise) will not be excessive although windows may need to be shut at times (e.g. to block out occasional nighttime Pit patron noise) and consideration of comfort with indoor temperatures and ventilation may need to be considered during the design process because of this. Mechanical equipment noise is also potentially significant but can usually be effectively dealt with during the detailed design phase.

Concert noise, while likely excessive at some locations, should not be a problem to deal with at the potential Wesbrook Mall university rental housing due to the anticipated higher noise tolerance of non-permanent residents in rental housing, provided that the recommendations below are followed. The highest music noise levels at this location are similar to the highest existing music noise levels at UEL housing. Depending on the stage configuration, music noise levels could be significant at the

future University Boulevard university rental housing site, and measures should be taken at the detailed design stage to reduce this impact. It should also be reinforced that actual music noise levels are likely lower than those predicted in this study.

The following best practices are recommended:

- Potential noise impacts from mechanical equipment at the future Aquatic Centre be assessed and mitigated during the detailed design of the Aquatic Centre;
- An environmental noise study be performed for future rental housing at the building permit stage to ensure that day-to-day levels (i.e. non-event levels) do not exceed Canada Mortgage and Housing Corporation (CMHC) *Road and Rail Noise: Effects on Housing* criteria;
- Depending on the results of the environmental noise study, architectural improvements in building facade construction be implemented as required to reduce indoor noise levels. Some of these techniques include:
    - increasing glazing and airspace thickness in double-pane windows;
    - reducing the size of windows; and
    - increasing the mass of the exterior wall construction.
- Residents are notified in advance of events using strategies such as organizing "notification trees" that include notices to strata councils, individuals and property managers and consideration of developing and maintaining an online events calendar. In many cases, infrequent noise impacts can be made into "must see" events when proper notice is made and good community relations are maintained.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

Some people have raised concerns that student activities or bus loop and traffic noise may trigger noise complaints from tenants of potential future university rental housing in the 'Area Under Review' within the Gage South and Environs study area of the UBC Vancouver Campus. The purpose of this study is to assess the potential noise impact on any future university rental housing in the context of two possible development scenarios as provided by UBC, Concept A and Concept B, and whether rental housing is a reasonable possibility in this noise context.

The following potential noise effects have been considered for the two design concepts:

1. Music noise generated in the future MacInnes Field;
2. Pit patron speech noise generated between the SUB and Gage Towers;
3. Bus noise generated in the future diesel bus loop;
4. Road traffic noise on Wesbrook Mall; and
5. Mechanical equipment noise from nearby buildings such as the future Aquatic Centre.

The main focus of this report is what effects should be addressed at the site of potential future multi-storey university rental housing for faculty, staff, and students within the 'Area Under Review' along Wesbrook Mall.

The noise sensitivity of residents at the possible rental housing site is anticipated to be more tolerant than the noise sensitivity of residents at existing UEL housing due to the demographic of younger, one and two person households more sympathetic to university activities and related noise, frequent turn-over, and the assumption that tenants could be prescreened through forewarning them of surrounding noise in rental agreements. UBC has received some complaints from the UEL residents regarding noise at MacInnes Field festivals in the past. Figure 1.1 shows the study area and components for one of two conceptual designs.

Normally, noise impact scenarios either deal with a new noise source (e.g. new bus loop) or a new noise receptor (e.g. new housing), but not with new sources and receptors simultaneously, as they do for this project. This unique situation provides more flexibility to the developer in dealing with potential noise impacts. Available solutions include noise mitigation at:

1. The source (location, orientation of noise source and controlling loudness of source);
2. The path (introduction of noise barriers, either passive, such as buildings not sensitive to noise, or dedicated sound walls); and/or
3. The receiver (through building location, orientation and facade design).

Study Area

SUB South Microphone Location

SUB North Microphone Location

Student Union Boulevard

SRC Microphone Location

"Area Under Reivew"

SRC

Mechanical Equipment Noise

Concept A Possible University Rental Housing

Existing UEL Housing

Assumed Pedestrian Path

Exisitng SUB

Mechanical Equipment Noise

Future Aquatic Centre

Wesbrook Mall

Future SUB

Concept A Bus Loop

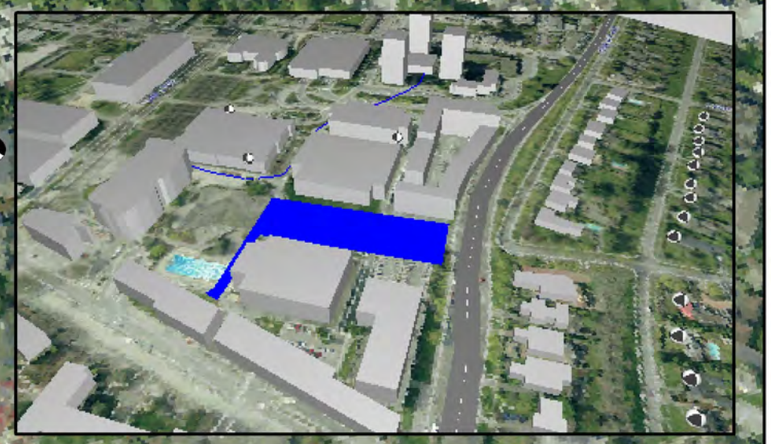
Future Field

War Memorial Gym

GSAB

Existing UEL Housing

Future University Rental Housing



N

Figure 1.1:
Study Area
Concept A Design

Noise Sources and Receivers

File: 0205-12A
Date: February 2012

BKL Consultants in Acoustics

The purpose of this assessment was to apply best practice and due diligence consideration of environmental noise in land use planning. The intent was not to ensure that noise complaints will be completely avoided, but that they be minimized to the extent practical.

2.0 Acoustic Terminology

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

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

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

The L_{eq} can be measured over any period of time using an integrating sound level meter. Some common time periods used are 24 hours, noted as the L_{eq24}, daytime hours (07:00 to 22:00), noted as the L_d, and nighttime hours (22:00 to 07:00), noted as the L_n. As the impact of noise on people is judged differently during the day and during the night, 24 hour noise metrics have been developed that reflect this. The day-night equivalent sound level (L_{dn}) is one metric commonly used to represent community noise levels. It is derived from the L_d and the L_n with a 10 dB penalty applied to the L_n to account for increased sensitivity to nighttime noise.

3.0 Methodology

3.1 Transportation, Pedestrian and Mechanical Equipment Noise Criteria

Potential land use incompatibility of potential university rental housing to its typical surrounding planned context and typical Wednesday noise levels has been assessed using the American National Standards Institute (ANSI) standard S12.9-2007 Part 5, *Quantities and Procedures for Description and Measurement of Environmental Sound - Part 5: Sound Level Descriptors for Determination of*

Compatible Land Use (ANSI 2007). Wednesday was chosen due to the increased patron traffic on most Wednesdays at the Pit Pub in the SUB and associated increase in Pit patron speech noise as people walk to and from Gage Towers.

Using this ANSI standard, the future rental housing has been classified as "Residential - Multi-Story Limited Outdoor Use". Land use compatibility classifications are summarized in Table 3.1.

Table 3.1: Land Use Compatibility Guidelines for Residential - Multi-Story Limited Outdoor Use

Land Use	L_{dn} (dBA) Values			
	Compatible	Marginally Compatible	Compatible with Sound Insulation	Incompatible
Multi-Story Residential Limited Outdoor Use	< 60	60 - 65	65 - 75	> 75

3.2 Music Noise Criteria

Due to the infrequent occurrence of concerts (anticipated to be two per year and until 9 pm only) and their unique sound characteristics (tones, "pumping" bass), land use compatibility cannot be adequately assessed using the aforementioned ANSI standard. At a given A-weighted (dBA) decibel level, music is considered to be more annoying than neutral noise such as busy road traffic noise for the following reasons:

- Music has a "message" contained in vocals, rhythms and tones and the brain is instinctively always searching for messages or patterns within sound or noise. As a result, music is much more difficult for the brain to ignore or filter out.
- The higher amounts of low frequency noise (bass) produced by large subwoofers at concerts more readily penetrate building facades, resulting in louder interior noise levels even though the exterior noise level is at the same A-weighted (dBA) level.

The UK *Code of Practice on Environmental Noise Control at Concerts* (The Noise Council 1995) contains guidance to minimize the disturbance or annoyance of concert noise in the surrounding community. The recommended day time (09:00 to 23:00) noise levels depend on the number of concert days per year in three groups: 1-3, 4-12 or 13-30. For events continuing past 23:00, the guideline recommends that music noise should not be audible within the noise-sensitive premises.

Assuming that two concert days occur per year, the recommended limit to enable "successful concerts to be held whilst keeping to a minimum the disturbance caused by noise" is a 15 minute L_{eq} ($L_{eq15min}$) of 65 dBA.

As part of BKL's work with the City of Vancouver's North East False Creek land use study, BKL has recommended an indoors design target $L_{eq15min}$ of 40 to 50 dBC. However, that criterion is not recommended for this project because of the higher tolerance of the proposed type of university rental housing (non-permanent, and younger one and two person households) and the fewer events per year (as compared to the number at Rogers Arena plus BC Place plus future outdoor amenity space events).

By way of comparison, some local municipalities have varying approaches and limits relating to the control of music noise. The City of Vancouver Noise Control By-Law No. 6555 has a limit for continuous sound (the sound level exceeded for 3 minutes in a 15 minute period) of 60 dBA during the daytime from an intermediate zone to a quiet zone. The limit varies depending on the source and receiver zones, but this is the zoning that was applied to noise from the old Plaza of Nations to the south side of False Creek and is likely how the City would zone this area. These limits are more restrictive than the UK code, but they are limits that apply to all types of noise and make no distinction between daily noise events and events that occur a limited number of times per year.

The City of Burnaby's Noise or Sound Abatement Bylaw No. 7332 does not apply to concert noise at Deer Lake Park, as per Section 16B (1).

The City of Victoria's Noise Bylaw No. 03-12 exempts:

> *(c) the use, in a reasonable manner, of an apparatus or mechanism for the amplification of the human voice or music in a public park, public facility or square in connection with a public meeting, public celebration, athletic or sports event or other public gathering, if*
>
> *(I) that gathering is held under a permit issued under the authority of the Parks Regulation Bylaw, or*
>
> *(ii) that gathering has received prior approval under section 20,*
>
> *(iii) if the noise produced by that gathering does not exceed 90 dB when received at a Point of Reception or such other lower sound level specified in the permit or approval.*

However, it is BKL's opinion that a received level of 90 (dBA assumed) for the duration of a concert could generate complaints.

BKL recommends use of the UK code of practice as a reasonable and fairly conservative standard, tailored to concert noise specifically, with consideration of the number of events per year. This L_{eq} limit, 65 dBA in a 15 minute period, is still within the range of standards in other BC municipalities.

3.3 Noise Predictions

Noise predictions were performed to assess the noise sources against the criteria. Internationally recognized standards including ISO 9613-2 (ISO 1996) and NMPB-Routes-2008 (NMPB 2009a, NMPB 2009b), as implemented in the outdoor sound propagation software Cadna/A (Version 4.2) were used to estimate time-averaged noise levels. The study area included the 8 ha planning area plus

the future university rental housing on University Boulevard and the first two rows of single family UEL housing on the east side of Wesbrook Mall. Noise predictions were not made for mechanical equipment associated with the future Aquatic Centre since details were unavailable.

Model calculations were performed in octave bands, considering ground cover, topography and sound shielding and reflecting buildings. Annual average temperature and humidity were used in the model settings. A moderate temperature inversion was assumed to represent typical, but not absolute, worst case conditions.

In order to approximate the ground effect on sound propagation, paved areas were specified as acoustically hard ground areas while the remaining study area was modelled as soft ground (i.e. grassland, loose soil). Ground contours were imported into the Cadna/A noise modelling software to estimate terrain shielding effects. Buildings were also defined to account for building shielding and reflecting effects. Two orders of sound reflections were considered.

Concert noise emission was estimated based on BKL measurements of an REM (rock band) concert at the Deer Lake Park outdoor venue in Burnaby (BKL 2008). Since this was a "performance primary" concert with the UBC concerts likely better classified as "festival" events, it is likely that UBC concert noise has been overestimated. However, measurements of MacInnes Field concerts were not feasible due to project schedule constraints.

Road traffic noise emission from Wesbrook Mall was estimated using traffic volumes entered into the NMPB-Routes-2008 model. Twenty-four hour volumes were estimated from the eight hour data using 24-hour traffic volume patterns from Vancouver.

Bus loop and Pit patron sound power levels were estimated based on field measurements. Even though the bus loop will be moving to a new location, it was assumed that the total noise level emission from the bus loop would remain the same. Currently, there are 11 drop off and pick up bays. In the future, there will be 5 drop off and 8 pick up bays, and the layover bays will be underground. Pit patron speech noise was assumed to emanate from one pedestrian path even though measurements were taken at two locations. The future Pit patron noise was also assumed to remain the same.

Sound contours were calculated on 5 m by 5 m grids within the study area for a receiver height of 4 m. Outdoor facade noise level predictions were also performed at all storeys of buildings, but since the results remained in the same categories shown by the sound contours, these values were not displayed.

3.4 Baseline Noise Measurements

Unattended continuous noise measurements were conducted by BKL Consultants at three locations:

1. Student Union Building - North Entrance
2. Student Union Building - Southeast Corner
3. Student Recreation Centre - Southeast Corner

Figure 1.1 shows the measurement locations within the study area.

4.0 Baseline Measurement Results

Two 16-hour continuous noise measurements were conducted at the rooftop of the Student Union Building (SUB) on January 4-5, 2012 to assess noise levels produced by the Pit Pub patrons. However, due to an equipment malfunction, data was not collected at one of the locations. As a result, the two measurements were repeated on January 25-26, 2012.

The first measurement was located above the north entrance of the building at the north edge of the roof. The microphone was approximately 11 metres above the ground. The second measurement was located near the southeast corner of the building at the south edge of the roof. The microphone was approximately 9 metres above the ground.

Speech noise from Pit patron traffic was identified by listening to simultaneously recorded audio files. The total speech sound energy for the evening was analyzed and a summary of the results are shown in Table 4.1.

Table 4.1: Pit Patron Measurement Results

Measurement Location	Date	Duration of Speech Noise (hr)	L_{eq} (dBA)
SUB North	January 25-26, 2012	1.66	54
SUB South	January 25-26, 2012	3.32	53

These levels were used in the Cadna/A 3D model to calibrate the noise produced by the Pit Pub patrons along the assumed pedestrian paths. According to a customer count conducted at the Pit Pub, approximately 1,100 customers were recorded on the night of January 4, 2012 and approximately 800 customers were recorded on the night of January 25, 2012. This difference was reflected in the model by adding a correction factor of 1.4 dB which represents the logarithmic difference in the number of patrons. In other words, the intent of the model was to approximate conditions that existed during the busier January 4, 2012 evening.

A three-day measurement continuous noise measurement was also conducted at the lower roof of the Student Recreation Centre on January 5-8, 2012 to assess the noise levels produced by the bus activity within the UBC bus loop. The measurement was located at the southeast corner of the building at a height of approximately 10 metres above the ground. Significant noise sources at this location include bus activity and road traffic along Wesbrook Mall. The daily results are summarized in Table 4.2.

Table 4.2: Bus Loop Measurement Results

Measurement Interval	Date	L_{dn} (dBA)	L_{eq24} (dBA)	L_d (dBA)	L_n (dBA)
1: Thurs-Fri	January 5-6, 2012	65	62	64	55
2: Fri-Sat	January 6-7, 2012	64	62	64	54
3: Sat-Sun	January 7-8, 2012	62	59	61	54

To be conservative, the average of the first two days of the measurement were used to calibrate the Cadna/A model's prediction of bus loop noise. Since road traffic along Wesbrook Mall formed part of the total noise levels measured, traffic count data at the intersection between Wesbrook Mall and Student Union Boulevard were used to model road sources for a more accurate calibration of the model.

5.0 Noise Predictions and Impact Assessment

5.1 Transportation and Pit Patron Speech Noise

Figures 5.1 and 5.2 show the predicted L_{dn} for land use layout context in Concepts A and C provided by UBC. Using the guideline limits in ANSI S12.9 Part 5, sound insulation should be considered for the east facade of the proposed residential developments fronting Wesbrook Mall due to the small setback distance. Typical sound insulation improvements include increasing glazing and airspace thickness in double-pane windows, reducing the size of windows, and increasing the mass of exterior wall construction. The land use compatibility is marginal for the other outside facades (excluding the courtyard-facing facades) but would not require an acoustic study recommending sound insulation.

5.2 Music Noise

Figure 5.3 shows the predicted $L_{eq15min}$ for the existing scenario. It was predicted that there are 18 residences where the 65 dBA criterion is currently exceeded, with the highest level predicted at 78 dBA, or 13 dBA above the criteria.

With many possibilities for loudspeaker location and orientation, some variation in received music noise levels are possible. Eight possibilities were modelled with results summarized in Table 5.1. Figure 5.4 shows predicted sound contours for Concept A with the stage located at the northeast corner of the future field and the speakers facing west.

It is likely that the highest concert noise levels at UEL residences will be similar to the existing case but that the total number of residences that exceed the criteria can be significantly reduced due to additional distance and building shielding attenuation. Also, University Boulevard Future Rental Housing will be louder if the stage is located at the south end of the field or if the loudspeakers are facing the housing.

Study Area

SUB South Microphone Location

SUB North Microphone Location

Student Union Boulevard

"Area Under Reivew"

SRC Microphone Location

SRC

Mechanical Equipment Noise

Assumed Pedestrian Path

Concept A Possible University Rental Housing

Existing UEL Housing

Exisitng SUB

Mechanical Equipment Noise

Future Aquatic Centre

Wesbrook Mall

Future SUB

Future Field

Concept A Bus Loop

War Memorial Gym

GSAB

Existing UEL Housing

Future University Rental Housing

N

Land Use
Noise Classification

- Compatible
- Marginal
- Sound Insulation
- Incompatible

Figure 5.1:
Predicted Concept A Land Use Noise Classification due to Transportation plus Late Night Pedestrian Noise Over a Typical Wednesday 24-Hour Period

File: 0205-12A
Date: February 2012

BKL
Consultants in Acoustics

Study Area

SUB South Microphone Location

SUB North Microphone Location

Student Union Boulevard

"Area Under Reivew"

SRC Microphone Location

SRC

Mechanical Equipment Noise

Mechanical Equipment Noise

Assumed Pedestrian Path

Exisitng SUB

Future Aquatic Centre

Concept C Possible University Rental Housing

Existing UEL Housing

Concept C Bus Loop

Wesbrook Mall

Future SUB

Future Field

War Memorial Gym

GSAB

Existing UEL Housing

Future University Rental Housing

N

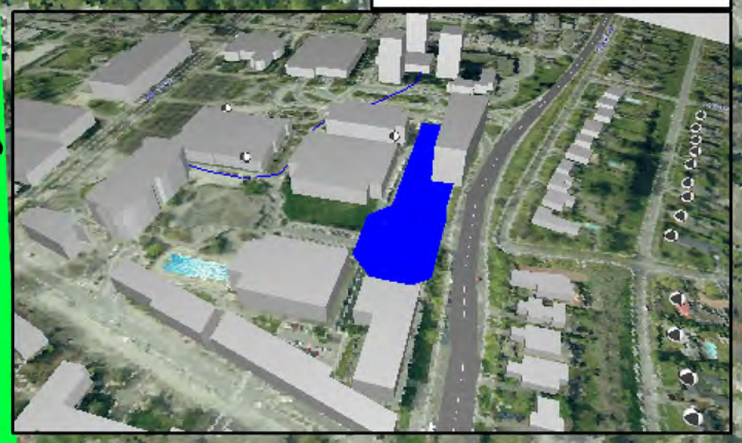
Land Use
Noise Classification

- Compatible
- Marginal
- Sound Insulation
- Incompatible

Figure 5.2:
Predicted Concept C Land Use Noise Classification due to Transportation plus Late Night Pedestrian Noise Over a Typical Wednesday 24-Hour Period

File: 0205-12A
Date: February 2012

BKL Consultants in Acoustics



Study Area

Student Union Boulevard

"Area Under Reivew"

SRC

Exisitng SUB

MacInnes Field

Speaker Location

Existing Aquatic Centre

War Memorial Gym

GSAB

Wesbrook Mall

Existing UEL Housing

Existing UEL Housing

N

Leq15min

- > 65 dBA
- > 70 dBA
- > 75 dBA
- > 80 dBA
- > 85 dBA
- > 90 dBA
- > 95 dBA
- > 100 dBA

Figure 5.3:
Assumed Existing
Concert Noise Levels
Loudest 15 Minutes
Speakers Facing West

File: 0205-12A
Date: February 2012

BKL
Consultants in Acoustics

Study Area

Student Union Boulevard

"Area Under Reivew"

SRC

Concept A
Possible University
Rental Housing

Existing UEL Housing

Exisitng SUB

Future
Aquatic Centre

Future
SUB

Speaker
Location

Future
Field

Concept A
Bus Loop

Wesbrook Mall

War Memorial Gym

GSAB

Existing UEL Housing

Future University Rental Housing

N

Leq15min

- > 65 dBA
- > 70 dBA
- > 75 dBA
- > 80 dBA
- > 85 dBA
- > 90 dBA
- > 95 dBA
- > 100 dBA

Figure 5.4:
Predicted Concept A
Concert Noise Levels
Loudest 15 Minutes
Speakers Facing West

File: 0205-12A
Date: February 2012

BKL
Consultants in Acoustics

Table 5.1: Summary of Predicted Concert Noise Levels

Stage Configuration	Concept	Wesbrook Mall Potential University Rental Housing
		Highest $L_{eq15min}$ (dBA)
Stage at east end of MacInnes Field, Speakers facing west	Current (2012)	n/a
Stage at north end of field, Speakers facing south	Concept A	82
	Concept C	78
Stage at south end of field, Speakers facing north	Concept A	82
	Concept C	80
Stage at southeast corner of field, Speakers facing west	Concept A	77
	Concept C	76
Stage at northeast corner of field, Speakers facing west	Concept A	80
	Concept C	77

5.3 Mechanical Equipment Noise at Aquatic Centre

Based on BKL's experience on past projects, there is a potential for rooftop equipment on the new Aquatic Centre to cause significant disturbance to the potential adjacent university rental housing within the study area. However, potential noise impacts can usually be dealt with effectively in the detailed design stage in a straightforward fashion by predicting levels using detailed building design information and relocating or providing noise mitigation for noisy equipment. Noise mitigation is usually in the form of an acoustic enclosure.

6.0 Conclusions and Recommendations

Based on the assumptions described above, the land use for the potential university rental residential development should not be ruled incompatible for acoustic reasons. Concept A is preferred from an acoustical perspective because it would provide an amenity space (the courtyard) where environmental noise levels are lower. Day-to-day noise (i.e. non-event noise) will not be excessive although windows may need to be shut at times (e.g. to block out occasional nighttime Pit patron noise) and consideration of comfort with indoor temperatures and ventilation may need to be considered during the design process because of this. Mechanical equipment noise is also a potential problem but can usually be effectively dealt with during the detailed design phase.

Concert noise, while likely excessive at some locations, should not be a problem to deal with at the future Wesbrook Mall university rental housing due to the anticipated higher noise tolerance of the proposed type of non-permanent residents in university rental housing, provided that the recommendations below are followed. The highest music noise levels at this location are similar to the highest existing music noise levels at UEL housing. The stage configuration is important to reduce problematic music noise levels at the future University Boulevard rental housing. It should also be noted that actual music noise levels are likely lower than those predicted in this study.

The following best practices are recommended:

- Potential noise impacts from mechanical equipment at the future Aquatic Centre be assessed and mitigated during the detailed design of the Aquatic Centre;
- An environmental noise study be performed for future rental housing at the building permit stage to ensure that day-to-day levels (i.e. non-event noise) do not exceed Canada Mortgage and Housing Corporation (CMHC) *Road and Rail Noise: Effects on Housing* criteria;
- Depending on the results of the environmental noise study, architectural improvements in building facade construction be implemented as required to reduce indoor noise levels. Some of these techniques include:
  - increasing glazing and airspace thickness in double-pane windows;
  - reducing the size of windows; and
  - increasing the mass of the exterior wall construction.
- Residents are notified in advance of events using strategies such as organizing "notification trees" that include notices to strata councils, individuals and property managers and consideration of developing and maintaining an online events calendar. In many cases, infrequent noise impacts can be made into "must see" events when proper notice is made and good community relations are maintained.

Report Prepared By:

BKL Consultants Ltd.
per:
Mark Bliss, P.Eng.

BKL Consultants Ltd.
per:
Gary Mak, E.I.T.

References

American National Standards Institute (ANSI). 2007. Quantities and Procedures for Description and Measurement of Environmental Sound - Part 5: Sound Level Descriptors for Determination of Compatible Land Use. Reference No. ANSI/ASA S12.9-2007 Part 5. New York, Acoustical Society of America.

BKL Consultants Ltd. 2008. North East False Creek High Level Review, Entertainment & Transportation Noise Study. Vancouver, BKL Consultants Ltd.

Canada Mortgage and Housing Corporation (CMHC). 1986. Road and Rail Noise: Effects on Housing. Ottawa, Canada Mortgage and Housing Corporation.

International Organisation for Standardization (ISO). 1996. Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation. Reference No. ISO 9613-2:1996. Geneva, International Organisation for Standardization.

NMPB-Routes-2008. 2009a. Guide méthodologique, Prévision du bruit routier, Volume 1: Calcul des émissions sonores dues au trafic routier. Référence Sétra: 0924-1. SETRA (Service d'études sur les transports, les routes et leurs aménagements).

NMPB-Routes-2008. 2009b. Methodological guide, Road noise prediction, volume 2: NMPB 2008 - Noise propagation computation including meteorological effects. Référence: LRS 2008-76-069. SETRA (Service d'études sur les transports, les routes et leurs aménagements).

The Noise Council. 1995. Code of Practice on Environmental Noise Control at Concerts. London, The Noise Council.