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NOISE MAPPING OF THE UNIVERSITY OF TECHNOLOGY

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Abstract: This study aimed to determine noise sources and levels on the campus of the University of Technology, Baghdad, Iraq, using SounPlan7.2 software for noise mapping for different situations. Models were used to investigate the impact of different situations for campus development, including: constructing new buildings and parking lots , and removal of noise protection walls. Noise mapping for these modeled situations showed potential variations of 10dB(A) in noise levels. The main noise sources in the campus are electrical generators, traffic roads, parking lots, and workshops with open doors which emitted high noise levels exceeding 85dB(A). According to the World Health Organization (WHO), when noise levels exceeding 55dB(A), the campus noise environment can be classified under the unpleasant, annoyance, and uncomfortable environment.

Keywords: *University campus, Noise mapping, Noise protection wall, Insertion loss*

رسم الخارطة الضوضائية للجامعة التكنولوجية

الخلاصة: تهدف هذه الدراسة إلى تحديد مصادر الضوضاء ومستويات الضوضاء في حرم الجامعة التكنولوجية، بغداد، العراق، وذلك باستخدام برنامج SounPlan7.2 لرسم الخرائط الضوضائية لحالات مختلفة. تم استخدام نماذج للبحث في تأثير حالات مختلفة لتطوير الحرم الجامعي، بما في ذلك إضافة مبان جديدة ومواقف السيارات ، و إزالة جدران الحماية من الضوضاء. أظهر رسم الخرائط الضوضائية لهذه الحالات على امكانية تغييرات محتملة في مناسيب الضوضاء بحدود ١٠ ديسيبل أ . مصادر الضوضاء الرئيسية في الحرم الجامعي هي المولدات الكهربائية ، طرق المرور ، مواقف السيارات، وابواب ورش العمل المفتوحة والتي ينبعث منها مناسيب ضوضاء عالية تتجاوز ٨٥ ديسيبل أ. وفقا لمنظمة الصحة العالمية (WHO) فان البيئة الضوضائية للحرم الجامعي يمكن ان تصنف بانها مزعجة وغير مريحة مع مناسيب ضوضاء تزيد على ٥٥ ديسيبل أ.

1. Introduction

In the modern world, agglomerations are both sources of noise and are affected by noise. Researchers and practitioners from academic institutions and agencies dealing with occupational safety, health, and the environmental, have increasingly focused on the role of noise pollution in human activity, including impacts on productivity (e.g., concentration, communication, learning, study) and on physiological or psychological adverse health effects (e.g., hearing loss, acoustic trauma, annoyance and stress) [1¬5].

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Numerous studies have investigated the noise sources that adversely impact students and staff at educational institutions (e.g., university campuses) and have found that traffic, electrical generators, and noise emissions from laboratories can exceed the World Health Organization (WHO) guidelines for acceptable noise pollution levels (55 dB (A)) [6–10].

The noises generated and experienced within built environments (e.g., university campuses) change according to the addition or removal of buildings, traffic infrastructure (i.e., roads, parking lots), and/or other noise sources (e.g., electrical generators). Noise mapping is considered the best way to understand noise emission distributions and to estimate the number of affected people [11–13].

This study aimed to identify noise sources and noise distribution on the campus of the University of Technology, Baghdad, Iraq. Noise mapping was conducted based on three situations: (1) the observed environment with and without generators; (2) a modeled situation in which planned infrastructure (i.e., new buildings and parking lots) were assumed; and (3) a modeled situation in which walls at the front and back of the university campus, which currently provide some protection from noise sources (e.g., traffic), were removed.

2. Materials and Methods

2.1. *Study Area*

The University of Technology site is located in central Baghdad, between the Mohamed Al-Qasim Expressway and Industry Street. The campus covers 0.2 km^2 and hosts a population of 10,000 staff and students. Campus buildings range in height from 3.6 to 25.2 m and consist of 1–7 floors. For security purposes, 4m high and 0.4m wide pre-cast reinforced concrete walls runs along the front and back boundaries of the campus.

2.2. *Noise Sources*

The campus is exposed to five main noise sources: roads, parking lots, electrical generators, human gatherings, and workshops with open doors.

The main roads include the Mohamed Al-Qasim Expressway, Industry Street, and smaller side roads. It was adopted constant factors such as road surface, lane width and central reservation, and variable factors such as vehicle flow rate and mean speed that change with time (day, night and peak hours), for measurement noise emissions from roads.

The study site is impacted by four parking lots, including three within the campus confines (one of which is under construction). The capacity of the on-campus lots ranges from 170 to 500 vehicles, while the fourth lot, situated on a small side road, has a 200-vehicle capacity.Number of vechiles, parking lot type and road surface are the .easurements in parking lotsmain parameters used to noise m

The campus contains 25 electrical diesel generators (500 kVA and 100kVA) that provide back up to the main electrical power, which is unstable and is often shut down for several hours during the working day.

Significant human noise is generated in squares, gardens, and the campus stadium, where students congregate for different activities.
Finally, noise is emitted from the open doors for ‘industrial’ workshop buildings (e.g., tinsmithing, blacksmiths, turnery).

2.3. *Noise Mapping*

Noise mapping was conducted using the SoundPlan software operated using both observed data and hypothesized data based on different assumptions (RLS-90, DIN ISO9613-2) [14]. Noise mapping was dependent on equivalent continuous A-weighted sound pressure levels (in decibels) for an 8-hr working day, using Eqs.(1–2) [11]:

$$L_{Aeq,T} = 10log\left[\frac{1}{t_2-t_1}\int_{t_1}^{t_2}\frac{p_A^2}{p_o^2}dt\right] \quad (1)$$

where $L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level (dB) determined over time interval (T), starting at t_1 and ending at t_2; p_o is the reference sound pressure (20 µPa); and $p_{A(t)}$ is the instantaneous weighted sound pressure of the sound signal; and:

$$L_p = L_W - 20\log(r) - 8 \quad (2)$$

where L_p is the sound pressure level in dB(A), L_W is the sound power level of the source in dB(A), and r is the distance of noise propagation from a point source over a flat terrain. Sound power levels were taken from the software library.

To determine the effectiveness of noise protection walls, an insertion loss formula (3) was used [15]:

$$IL = L_{P(BEFORE)} - L_{P(AFTER)} \quad (3)$$

where IL is the insertion loss in dB(A), $L_{P\,(BEFORE)}$ is the sound pressure level in dB(A) for a given point without the noise protection wall, and $L_{P(AFTER)}$ is the sound pressure level in dB(A) at that same point with a noise protection wall.

For noise mapping measurements, a sound and vibration meter with an analyzer (SVAN957 Type 1) was used and all measurements were taken according to ISO-1996 [11] and using an identical approach. For modeled situations, the sound power levels assumed for diesel generators, students gatherings in gardens and squares, and workshops, were 111 dB(A)/m^2, 83dB(A)/m^2, and 105 dB(A)/m^2, respectively [14].

3. Results and Discussion

3.1. Road Characteristics

Vehicle flow rate and mean speed measurements were taken according to traffic engineering requirements [16] as shown in Table 1.

Table 1. Road characteristics

Road	Vehicle flow rate (v/hr)		Mean speed (km/hr)		Road surface	Lane width (m)		Central reservation width (m)
	Light*	Heavy*	Light*	Heavy*		left	right	
Mohamed Al-Qasim Expressway	9868	1488	95	85	Smooth asphalt	13.5	13.5	3
Industry Street	1502	6	50	45	Smooth asphalt	7.5	7.5	2
Small road side	100	20	50	45	Smooth asphalt	3.25	3.25	----

* Light vehicles = less than 3500 kg (e.g., cars, vans, minibuses, motorcycles). Heavy vehicles = more than 3500 kg (e.g., trucks).

3.2. Noise Mapping Using Observed Data

Noise mapping using measured data (Fig. 1a) confirmed that parking lots and workshops with open doors are the main noise sources, producing maximum noise levels of 85–95 dB(A). For roads (i.e., Mohamed Al-Qasim Expressway and Industry Street), the campus walls acted as noise protection and decreased road noise levels inside the campus by 10dB(A).

Under normal conditions, generators increased noise levels by 10–20dB(A), which interfered with the levels of noise from traffic infrastructure (i.e., roads and parking lots). However, under the worst observed conditions (i.e., all generators in operation), generators represented a major noise source that greatly reduced low noise areas (i.e., those under 65dB(A); (Fig. 1b).

The maximum noise levels around generators ranged from 85 to 95 dB(A), and were equal to or more than 95dB(A) in areas where more than one generator was operating or where a generator was operated adjacent to the corner of a building where the sound reflections cause the amplify of noise.

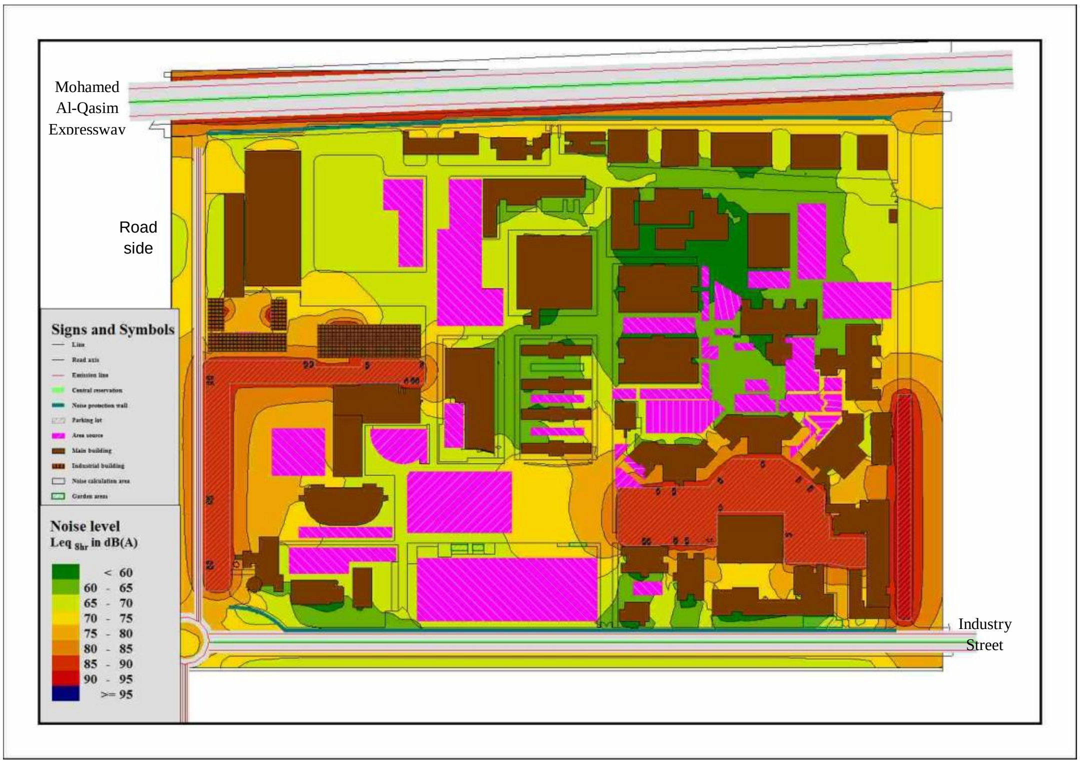

Figure 1a.Noise mapping with electrical generators turned off (The University of Technology, Baghdad)

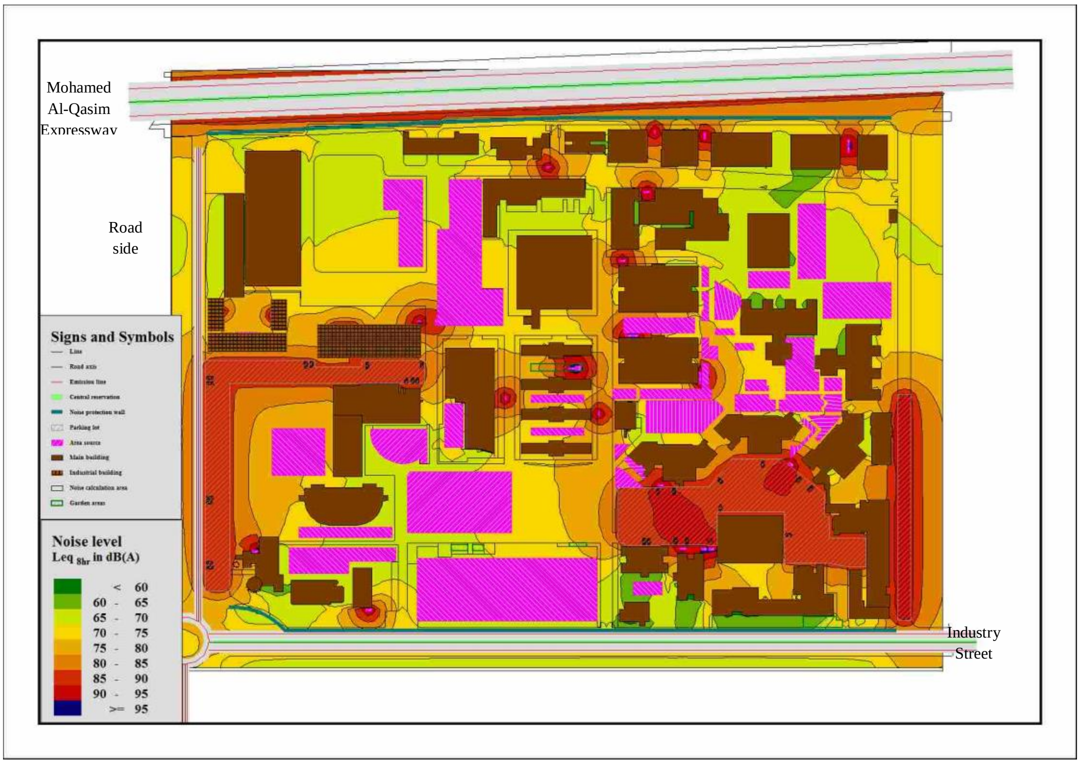

Figure 1b. Noise mapping with electrical generators turned on (The University of Technology, Baghdad)

3.2. Noise Mapping Assuming Implementation of Planned Infrastructure

To increase capacity and develop university infrastructure, the construction of new buildings and an extra parking lot have been suggested. By assuming the implementation of this plan, a modeled noise map was produced (Fig. 2). With the generators turned on, the results suggest that the proposed buildings would work to buffer noise emissions, reducing the noise levels from open workshops doors, electrical generators, and traffic infrastructure by about 10dB(A) in adjacent areas. However, the results showed that with the proposed parking lot, noise pollution with all generators running would increase by more than 10dB(A). In particular, this increase would impact adjacent buildings and student gathering areas.

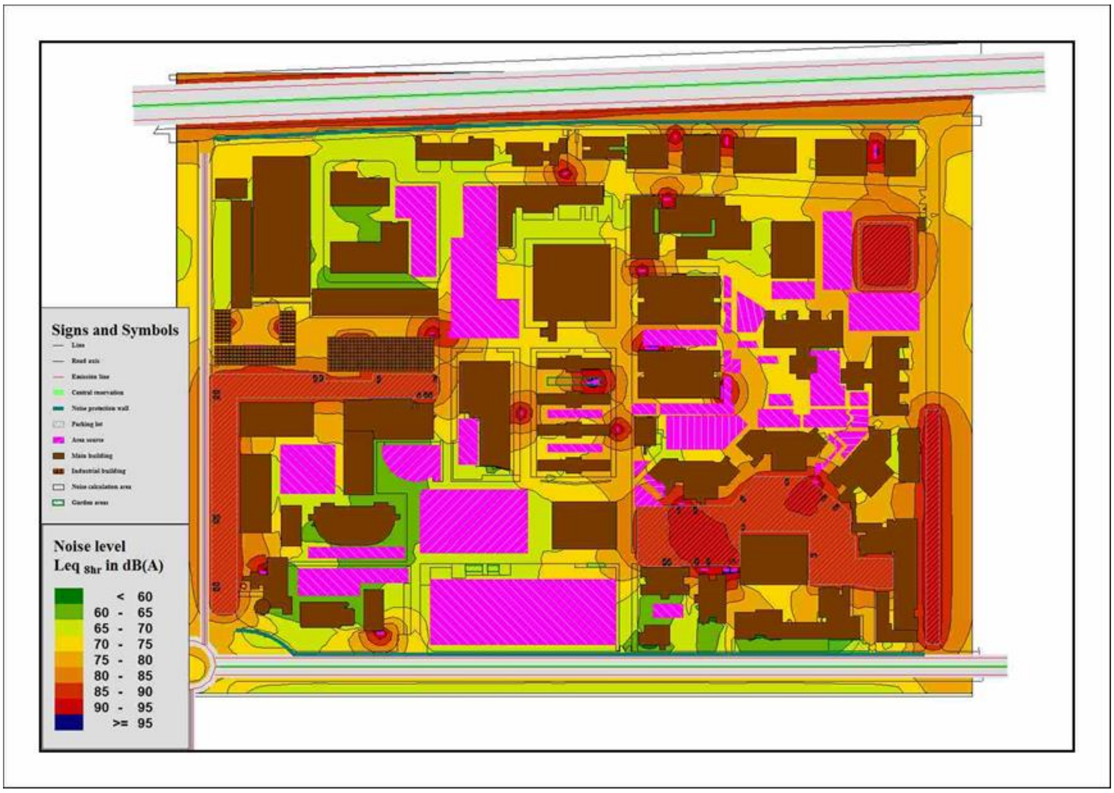

Figure 2. Noise map of the University of Technology, Baghdad, assuming the construction of proposed buildings and parking lots and with electrical generators turned on.

3.3. Noise Mapping Without Campus Boundary Walls

For security reasons, all government departments and universities at Baghdad City are surrounded by pre-cast concrete walls of 2.5–4 m in height. These walls have noise protection characteristics, including a solid structure and heights of more than 1.5 m [15,17,18]. In this situation, parameter Insertion Loss (IL) was used to check the effectiveness of noise protection walls (barriers) by measuring noise levels at certain receiver points (Fig. 3). The results showed IL values that did not exceed 10 dB (A) when the boundary walls were in place (Fig. 4). However, even 5dB(A) IL reduces sound energy by 68% (i.e., by a readily perceptible level), while 10dB(A) IL reduces sound energy by 90% [15]. Therefore, even pre-cast reinforced concrete walls without any specialized noise absorption materials can decrease noise pollution.

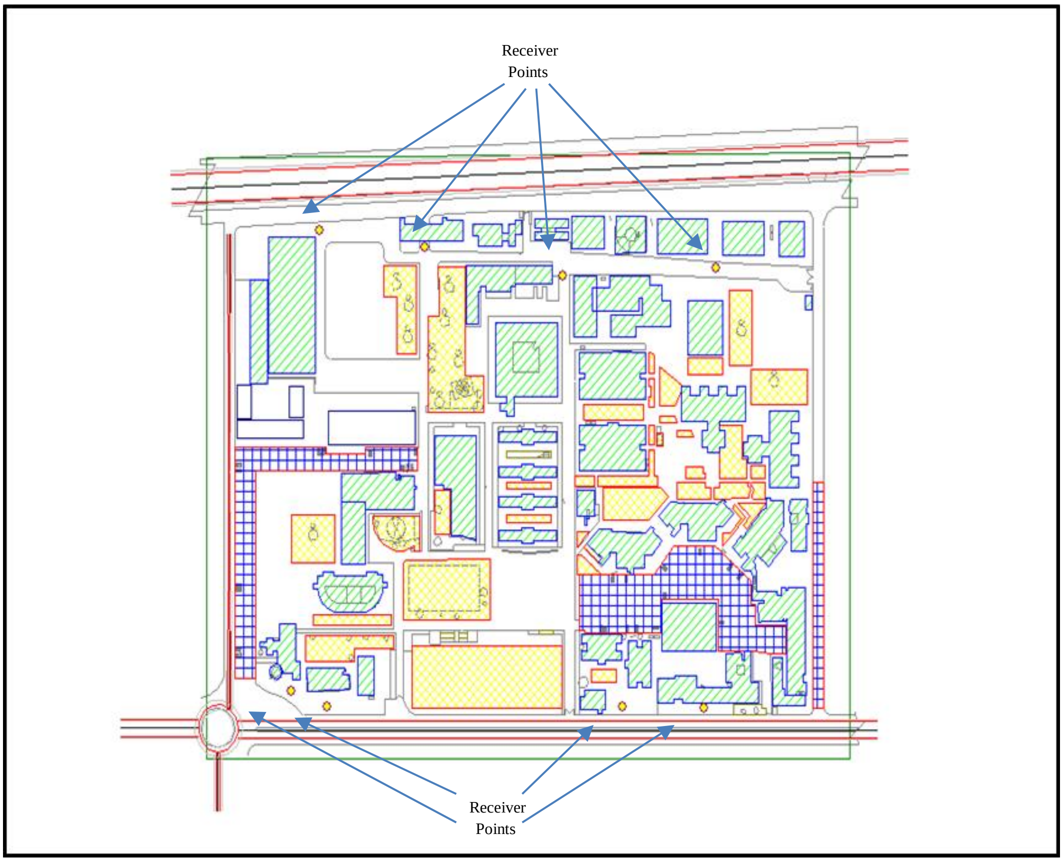

Figure 3. Map of the University of Technology, Baghdad, showing receiver point locations for parameter Insertion Loss (IL) analysis with and without boundary walls.

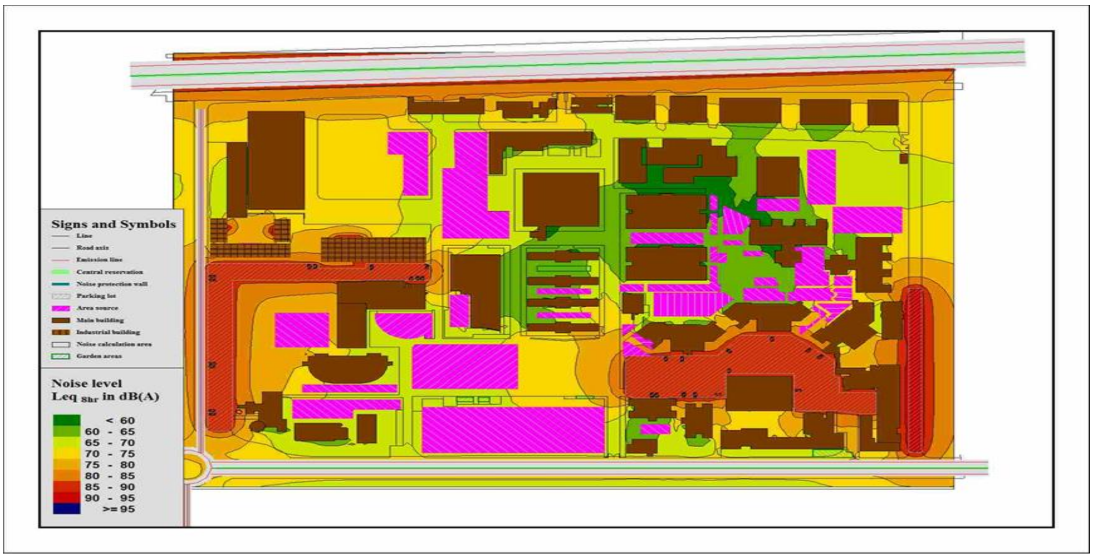

Figure 4. Noise map of the University of Technology, Baghdad, assuming the removal of boundary walls and with electrical generators turned off.

3.4. Campus Noise Environment

According to the noise mapping with different situations, all the campus users (staff and students) can be noticed the changes in noise levels, that have adverse effects on their usually activities and events, because these changes exceeding 10 dB(A). In the normal case, the human ear perceives noise level increases in three stages: 3 dB(A) is barely perceptible, 5 dB(A) is ~1.5 times as loud, and 10 dB(A) is perceived as a doubling in loudness, so the increases in 10 dB(A) or more lead the people to complain and resent from the noise [19].

4. Conclusions

The real measurements were identical to the assumptions and readings of the SoundPlan software, so, these noise mappings can be adopted for knowing the noise level propagation outdoors and take the appropriate decisions such as modification the university scheme , adding the sound insulation in the buildings and re-distribution the electrical diesel generators within the campus for reducing the noise effects.

The noise mapping produced for the different situations suggested potential noise level changes of 10dB (A) or more. Where changes represent an increase in noise, the campus can be classified under the unpleasant, annoyance, and uncomfortable ratings of the WHO, especially in public areas.

Increasing noise levels in the vicinity of electrical generators overshadow noise emissions from other sources. Most of these generators run without an enclosure, and where they exist, enclosure doors are left open to reduce excess heat, further increasing noise emissions. However, along with the existing boundary walls, the construction of proposed buildings on the campus would decrease noise levels by ~10dB(A) in the immediate vicinity.

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