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NOISE ANALYSIS BASED ON Leq FOR THE COMBINED SEWAGE STORAGE TUNNEL

SITE 5 STANLEY PARK & VICINITY CITY OF OTTAWA



Prepared for

Explotech Engineering Ltd.

Prepared by

Hugh Williamson Associates Inc.

8th March 2017

NOISE ANALYSIS BASED ON Leq FOR THE COMBINED SEWAGE STORAGE TUNNEL

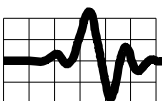
SITE 5 STANLEY PARK & VICINITY

CITY OF OTTAWA

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NOISE ANALYSIS BASED ON Leq FOR THE COMBINED SEWAGE STORAGE TUNNEL

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1.0 Introduction

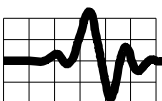
Explotech Engineering Ltd. (Explotech) is providing Noise and Vibration Control recommendations and Monitoring Services to meet the requirements of the City of Ottawa specification Section 02482, for the Combined Sewage Storage Tunnel (CSST), Contract No. ISD14-2036, being constructed by Dragados-Tomlinson Joint Venture (DTJV) in the City of Ottawa. Hugh Williamson Associates has been engaged by Explotech to provide the acoustical consulting services in relation to the preparation of the required Noise Control Plan for each site.

The Noise Control Plan for Site 5, as noted below, was prepared according to the contract requirements² which are based on meeting noise thresholds defined in terms of Lmax, the maximum sound level which occurs over a period of time.

Noise Control Plan for the Combined Sewage Storage Tunnel, Site 5, Stanley Park & Vicinity, 13 February 2017¹.

At the request of the City of Ottawa, this report presents a further analysis of noise from CSST construction at Site 5 based on Leq, the equivalent continuous sound level over a period of time. This Leq based analysis is provided to assist the community in understanding of noise impacts.

In effect, Leq is an energy based average sound level occurring over a period of time. It is the nature of construction activities that sound levels vary considerably over the course of a working period. Therefore, Lmax alone does not necessarily represent the sustained sound occurring over a period that could be of concern for the community. In addition Lmax may not be directly comparable to the impression of sound which would be experienced by people over the construction period. Due to the length of the construction period and the community's concern, expressing noise levels as Leq (equivalent continuous noise level) may provide a



better measure of the impact of noise from the proposed construction. In order to better address the community's concerns relating to noise, the Leq analysis in this report should be considered as well as the Lmax information in the Noise Control Plan¹.

Leq is frequently used as the basis for environmental impact assessment, for example in the assessments of traffic noise and noise from permanent industrial establishments. This is discussed in more detail in Section 3.0.

An advantage of using Leq as an assessment parameter is that it takes into account the cumulative effects of equipment operations taking place concurrently over a period of time. Lmax measures noise events which occur over very brief periods of time, fractions of a second, for most equipment. When several items of equipment are operating concurrently, it is unlikely that sound maxima will occur simultaneously. This implies that Lmax is generally not cumulative when several items of equipment are working concurrently.

All sound levels presented in this report are A-weighted, with units expressed as dBA. A-weighting is an internationally standardized frequency weighting which is applied to sound measurements and approximates the variation in sensitivity of human hearing with frequency (pitch). A-weighting is used almost universally in the assessment of noise impacts on people.

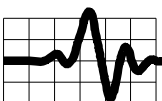
This analysis considers on-site generated noise from CSST construction at Site 5, with on-site taken to mean construction activities, including shaft construction and truck movements, taking place within the Stanley Park staging areas, and, within the boundaries of staging area 5C at the intersection of Queen Victoria Avenue and River Lane. Noise from CSST associated truck movements on public roads is not considered in this analysis.

Brief Summary of the Construction Process

CSST construction at Site 5 will primarily take place at Staging Areas 5A, 5B and 5C, see Figure 1, and can be briefly described as follows.

Shaft Construction occurs at 5A, 5B and 5C and consists of shaft excavation, using equipment such as excavators and hoe rams to create shafts which are approximately 16 m deep. The shafts will be reinforced where needed and lined with concrete. Shaft excavation is expected to commence in March 2017.

Tunneling and Muck Removal. Once the shafts are ready, then tunneling can commence. Between 5A and 5B, and, between 5B and 5C smaller tunnels will be dug using a micro tunneling machine which operates underground. The digging of the main east-west CSST tunnel, from 5A towards the downtown of Ottawa, will utilize a tunnel boring machine operating underground. The material excavated by the tunnel boring machine, called muck, will be moved underground by a rail car system, transported to the surface at 5A then taken away for disposal. The muck cars will be brought to the surface using a gantry crane, the muck emptied into stockpiles is then loaded onto trucks and taken away for



disposal. The detailed design of the muck removal process and equipment operations at 5A is still under development. Muck removal from 5A is anticipated to commence approximately a year after the start of shaft construction.

This Leq based analysis considers noise from shaft construction at 5A, 5B and 5C, plus micro tunneling between 5A and 5B, and between 5B and 5C.

The main east-west tunneling operation utilizes a tunnel boring machine operating underground which is not in itself expected to result in any significant noise at the surface. Muck from the east-west tunneling operation will be brought to the surface at Site 5A which will generate some surface noise, along with other surface equipment such as fans and other auxiliary equipment associated with tunneling.

Noise from the muck removal operation for the main east-west tunneling at Staging Area 5A will be considered prior to the commencement of this phase of construction. This assessment will be completed once DTJV has finalized their equipment selection and construction planning for this phase of the construction.

Noise Monitoring

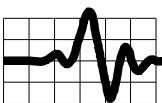
Noise monitoring will take place at various locations near Staging Areas 5A, 5B and 5C, before and during construction activities. Should the monitored Lmax noise data indicate that noise thresholds are exceeded, then as per Specification 02482, the Contract Administrator will be informed and the Contractor shall not resume operations before correcting conditions causing excessive noise. A more detailed description of noise monitoring procedures is contained in the Noise Control Plan for Site 10A.

Points of Reception

Figures 1 to 4 show the Staging Areas and points of reception selected for detailed analysis in the noise modelling. The selected noise sensitive points of reception are representative of locations which will be most impacted by noise from the construction operations at 5A, 5B and 5C. Points of reception are modelled to be 4.5 m above ground and at the external facades of residences.

Staging Areas 5A and 5B are located in Stanley Park. The closest and most affected points of reception (POR's) for activities at 5A and 5B are residences along the west side of Stanley Avenue plus residences and noise sensitive institutions (including Gary Armstrong Hospital and the Embassy of the Peoples Republic of China) to the south and west of Stanley Park.

Staging Area 5C is located at the intersection of Queen Victoria Street and River Lane. The closest and most affected points of reception for activities at 5C are residences in the vicinity of the intersection.



2.0 Construction Sequencing and Worst Cases for Noise Impacts

The Projected Construction Sequencing Summary for CSST operations at Site 5 is contained in Appendix A. This Summary describes in some details the various construction activities, their locations and the projected start and end dates.

In order to consider cases of worst noise impact during shaft construction, a number of operational scenarios have been modeled. In general, the worst noise impacts are those which occur when the noisiest activities are taking place concurrently. Table 1 lists the four worst case scenarios which have been selected for detailed analysis and presented in this report.

The scenarios have been selected based on the projected sequencing and knowledge of the noise levels typically produced by various operations such as hoe ramming, loader movements, truck movements, drilling, etc.

The approximate duration of the scenarios are also given in Table 1. It is noted that noise from down-hole equipment, hoe rams or hydraulic rock drills, at points of reception will decrease as the shaft holes deepen. Initially the shafts will be dug using an excavator to remove loose material down to rock, located approximately 3.5 m below grade. Once rock has been reached, further excavation will occur by hoe ramming or rock drilling and blasting. As the hole deepens, noise from the down-hole equipment reduces at the points of reception because the sides of the holes become more effective as noise barriers. In scenarios 1 to 3, the most severe conditions have been assumed, that is having down-hole equipment at 3.5 m below grade. Over the periods of shaft excavation, shown in Table 1, the contribution to noise from down-hole equipment will decrease.

Noise calculations were carried out using standard methods which are accepted by the City of Ottawa and the Ministry of Environment and Climate Change. The method is based on an International Standards Organization standard for outdoor sound propagation⁸, which is implemented in a software package called CadnaA. The method takes into account the strengths of the noise sources (sound powers) including the following factors.

- Distance attenuation is based on spherical spreading and atmospheric attenuation.
- Ground attenuations, as appropriate.
- Barrier attenuation, buildings for example, as appropriate.
- Heights of points of reception and noise sources.

The results of the Leq calculations are presented in Figures 2 – 13.

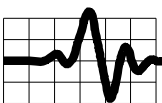
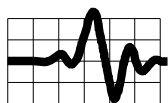


Table 1: Equipment Operations for Worst Case Noise Scenarios during Shaft Construction

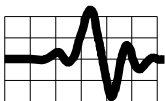
Description	Equipment in operation		
	Site 5A	Site 5B	Site 5C
Scenario 1 Day (07:00 to 19:00) Approx. Duration: 2 months	Standard Hydraulic Rock Drill 3.5 m below grade* Loader, Excavator OR Tunnel Dipper	Loader or Excavator	Hoeram (CAT385C or similar) 3.5 m below grade* Loader, Excavator OR Tunnel Dipper Generator for water pumps
Scenario 2 Day (07:00 to 19:00) Approx. Duration: 2 months	Hoeram (CAT385C or similar) 3.5 m below grade* Loader, Excavator OR Tunnel Dipper	Not in operation	Hoeram (CAT385C or similar) 3.5 m below grade* Loader, Excavator OR Tunnel Dipper Generator for water pumps
Scenario 3 Day (07:00 to 19:00) Approx. Duration: 2 months	Standard Hydraulic Rock Drill 3.5 m below grade* Loader, Excavator OR Tunnel Dipper	Hoeram (CAT385C or similar) 3.5 m below grade* Loader, Excavator OR Tunnel Dipper	Loader or Excavator Generator for water pumps
Scenario 4 Evening or Night (19:00 to 07:00) Approx. Duration: 12 months	No shaft construction, dewatering pumps operating below grade	No shaft construction, dewatering pumps operating below grade	No shaft construction, dewatering pumps operating below grade powered by a <u>diesel</u> <u>generator</u>



Description	Equipment in operation		
	Site 5A	Site 5B	Site 5C
Scenario 5** Approx. Duration: 10 months	Muck removal at site 5A, plus surface equipment to support tunneling, truck loading during restricted hours.	Shaft completed, dewatering	Shaft completed, dewatering

* Noise levels at POR's from down-hole equipment will decrease as excavation deepens to a total depth of approximately 16 m.

** Assessment of noise for Scenario 5 to be completed prior to commencement of muck removal at Site 5A when surface equipment and processes have been selected.



Limitations of the Noise Calculations

The noise calculations are based on noise data gathered from typical equipment operating in similar conditions to those expected at the CSST sites. Actual noise generated can vary from the assumed levels depending on the local conditions and circumstances which are unknown. In addition, local conditions discovered as work proceeds, may dictate that construction methods have to be altered.

Time basis of the Calculations

Leq is the energy equivalent continuous sound level (or average sound level) occurring over a period of time. The calculated sound levels presented for each scenario assume steady continuous operation of the equipment over the period of time. In a given day of operation, certain equipment may not operate for periods. If Leq at a location is monitored over a specific period of time, say 1 hour or an 8 hour day, the monitored Leq would be less than the calculated value if some equipment was in operation only part of the time i.e. not operated continuously.

Assumed Noise Mitigation

The noise mitigation assumed, and included in calculations, includes the following:

1. A 5 m high noise barrier surrounding Site 5C, as recommended in the Noise Control Plan¹.

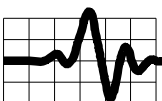
The predicted noise impacts in Figures 2 to 13 are based on the implementation of the noise mitigation as noted above.

Discussion of Worst Case Noise Results

The following points refer to the calculated noise levels for the four worst case scenarios which presented in Figures 2 to 13.

Scenario 1: Worst Case; Secant Wall Construction at Site 5A, Site Preparation at Site 5B and Excavation at Site 5C

- Calculated results are shown in Figures 2, 3 and 4.
- For residences with rear yards on Stanley Park, highest calculated noise levels are approximately 64 dBA and occur at the points of reception near 5B, see Figure 2.
- For residences near 5C, highest calculated noise are approximately 75 dBA and occur at second storey level at points of reception immediately next to 5C, see Figure 3.



Scenario 2: Worst Case; Excavation at Site 5A and Site 5C concurrently, Site 5B not in operation

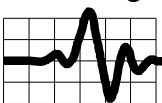
- Calculated results are shown in Figures 5, 6 and 7.
- For residences with rear yards on Stanley Park, highest calculated noise levels are approximately 58 dBA and occur at the points of reception near 5B, see Figure 5.
- For residences near 5C, highest calculated noise levels are approximately 75 dBA and occur at second storey level at points of reception immediately next to 5C, see Figure 6.
- Note that the noise levels in the immediate vicinity of 5C are virtually the same in Scenarios 1 and 2, indicating that noise at 5C is predominated by local 5C activities and little affected by activities at other sites.

Scenario 3: Worst Case; Secant Wall Construction at Site 5A, Excavation at Site 5B and Site Preparation at Site

- Calculated results are shown in Figures 8, 9 and 10.
- For residences with rear yards on Stanley Park, highest calculated noise levels are approximately 68 dBA and occur at the points of reception near 5B, see Figure 8.
- For residences near 5C, highest calculated noise levels are approximately 71 dBA and occur at second storey level at points of reception immediately next to 5C, see Figure 9.

Scenario 4: Worst Case; Evening or Night Work during Shaft Construction at Site 5C, generator in use to operate water pumps, Site 5A and Site 5B not in operation

- Calculated results are shown in Figures 11, 12 and 13.
- Calculations assume that the generator is of the type which has a highly effective noise enclosure, assumed sound power of 92 dBA.
- For residences with rear yards on Stanley Park, highest calculated noise levels due to the generator are approximately 20 dBA, see Figure 8. This is well below the anticipated night time ambient noise level of approximately 40 dBA.
- For residences near 5C, highest calculated noise levels are approximately 54 dBA and occur at second storey level at points of reception immediately next to 5C, see Figure 12. This level is well above the anticipated night time ambient noise level of



approximately 40 dBA. Noise from the generator is likely to cause considerable annoyance and disruption at night.

- It is recommended that DTJV make arrangements with Ottawa Hydro for temporary grid supply at Site 5C so that a generator is not needed to supply power to dewatering pumps.

Scenario 5: Worst Case; Muck removal during main Tunneling at Site 5A.

- Muck removal at Site 5A will be a 24 hour operation for the duration of the main tunneling.
- Assessment of muck removal and associated surface equipment cannot be completed at this time as DTJV has yet to finalize their equipment selection and construction planning for this phase of the construction. The assessment results will be made available to the public once they are completed.

3.0 Assessment Criteria for Leq Noise Levels

In this section of the report, various environmental noise criteria used in Ontario are discussed, including the potential application of such criteria to noise generated by CSST construction at Site 5.

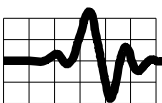
As shown below, there are various Leq based guidelines or regulations in Ontario for industrial noise, road and rail traffic noise and occupational health and safety, however, noise from construction is generally not included in these guidelines or regulations. Noise from construction in Ontario is normally controlled by municipalities through noise by-laws, and in most of these by-laws, including those of the City of Ottawa, the control essentially consists of time of day restrictions on construction activities, with no specific noise level limits.

The City of Ottawa *Combined Sewage Storage Tunnel Specification, Section 02482¹* specifies noise thresholds only for Lmax, not for Leq.

The City of Ottawa Noise By-law, By-law No. 2004 – 253⁵

Relevant portions of the City of Ottawa Noise By-law are summarized below:

- Construction activities may not take place between 10 p.m. and 7 a.m. the following morning, however, on Sundays and statutory or public holidays, construction may not commence before 9 a.m.



- The Director of By-law Services, with agreement from the relevant Ward Councillor(s), can grant an exception to the above.

MOECC Document NPC-300, *Environmental Noise Guideline, Stationary and Transportation Sources – Approval and Planning*³

- This Ontario Guideline references various acts including the Environmental Protection Act and the Municipal Act.
- The guideline specifically states that it does not apply to noise from construction.

City of Ottawa *Environmental Noise Control Guidelines*⁴ (ENCG)

The ENCG supports the planning process by providing noise guidelines for urban development near either transportation, industrial or commercial noise sources, or, by providing noise guidelines for industrial or commercial developments and new roads in the vicinity of noise sensitive land uses such as urban areas, hospitals, schools etc.

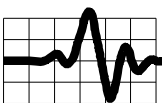
The guideline limits in the ENCG do not apply to noise from construction.

Occupational Health and Safety Act (Ontario), Regulation 381/15

The Occupational Health and Safety Act (OH&S Act) sets a threshold of 85 dBA for the noise exposure of workers without hearing protection. Above this level, hearing protection must be provided by employers and worn by the workers. The 85 dBA threshold is based on Leq over the working day, normally 8 hours.

This 85 dBA threshold in the OH&S Act is based on worldwide research into noise induced hearing loss in workers. The analysis of the research concludes that unprotected workers, who are exposed to 85 dBA and above on a daily basis over extended periods of time, months or perhaps years, have been found to suffer from noise induced hearing loss.

It is understood that persons exposed to noise of the order of 85 dBA, Leq basis, for occasional and brief periods, say less than a few hours, are unlikely to suffer permanent hearing damage. Health Canada⁹ have stated: ‘Sound levels below 70 dBA pose no known risk of hearing loss, no matter how long you listen.’ The predicted noise levels shown in Figures 2 to 13 are outdoor sound levels due to worst case shaft construction activities. Indoor sound levels can be expected to be 10 to 30 dBA less than the outdoor levels.



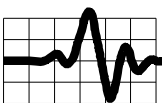
MOECC, Publication NPC-115, Construction Equipment, 1978

This publication gives noise emission standards to be met by construction equipment in Ontario. In our experience virtually all modern mobile construction equipment such as loaders and excavators, carrying out normal duties, meet the requirements of NPC-115. Some type of construction equipment, particularly those used for operations involving percussion such as rock drills and hoe rams, do not meet the requirements of NPC-115.

NPC-115 limits the noise emissions from specific mobile construction equipment. It does not place a limit on noise levels received at points of reception.

Summary of Assessment Criteria for Leq Noise from Construction

- The City Noise By-law imposes time of day restrictions on construction. A temporary exemption can be obtained to allow noise levels from construction up to 90 dBA at points of reception.
- We are not aware of any other City or Provincial regulations, guidelines or documents which suggest limits on Leq noise from construction at points of reception.
- The Ontario OH&S Act places a Leq based limit for exposure of workers without hearing protection at 85 dBA on a full work day.
- Generally it seems that noise from construction has not been subject to prescriptive limits, such as Leq limits, because construction is viewed as a necessary, but temporary activity.
- The worst case analysis for noise during the construction of shafts indicates Leq noise levels of the order of 75 dBA for residential POR's near 5C and 68 dBA for residential POR's which face Stanley Park. These are well below both the 90 dBA allowable as a temporary exemption from the City of Ottawa and the OH&S Act threshold of 85 dBA.



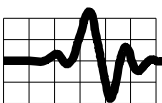
4.0 Summary of Findings

An analysis of Leq noise levels from shaft construction operations at Site 5, Staging Areas 5A, 5B and 5C, has been carried out to provide additional information related to predicted noise impacts at nearby noise sensitive locations. This analysis of Leq noise levels is provided in addition to the Noise Control Plan for Site 5¹, which is based on Lmax sound levels.

Leq is an energy based average sound level occurring over a period of time. It is the nature of construction activities that sound levels vary considerably over the course of a working period. Therefore, Lmax alone does not necessarily represent the sustained sound occurring over a period that could be of concern to the community, and/or, Lmax may not be directly comparable to the impression of sound which would be experienced by people over the construction period. Due to the length of the construction period and the community's concern, expressing noise levels as Leq (equivalent continuous noise level) may provide a better measure of the impact of the noise of construction compared to Lmax.

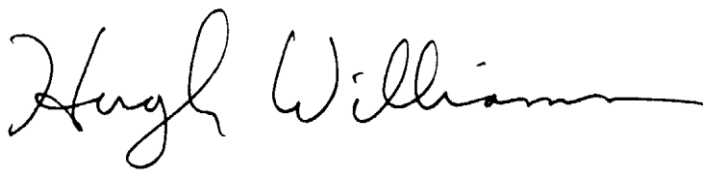
Leq noise analysis has been carried out on what are considered to be the noisiest periods of shaft construction. The results of the analysis are summarized below.

- The highest noise exposures for residences which back onto Stanley Park are calculated to be of the order of 68 dBA on an Leq basis. These levels occur when below surface hoe ramming or rock drilling are taking place in the shafts at Site 5A and 5 B. These portions of shaft construction are not expected to last more than 2 to 3 months and will be planned for during the day.
- The highest outdoor noise exposures for residences adjacent to Staging Area 5C, at the intersection of Queen Victoria Street and River Lane, occur during below surface hoe ramming and are calculated to be of the order of 75 dBA on an Leq basis, with the proposed 5 m noise barrier surrounding 5C in place. Inside the homes, sound levels will be 10 to 30 dBA less than outdoor levels, i.e. 65 dBA or less. To put this in perspective, Health Canada⁹ have stated: 'Sound levels below 70 dBA pose no known risk of hearing loss, no matter how long you listen.' Noise from hoe ramming will reduce as the shaft gets deeper and the hoe ramming is further below grade. The total duration of shaft construction at 5C is not expected to last more than 2 months and will be planned for during the day.
- The above calculated worst case Leq noise levels are well below the OH&S Act⁶ threshold of 85 dBA.
- The shafts will need below grade pumps for de-watering running constantly during the construction process. At 5A and 5B these pumps will use hydro power, however, at 5C the use of a diesel generator at the surface for powering the pump has been discussed. Noise calculations, see Scenario 4, indicate that noise from this generator at



the closest points of reception would be significant and likely to cause disturbance during the night. Hence, it is recommended that arrangements be made with Ottawa Hydro for temporary grid supply at Site 5C so that a generator is not needed.

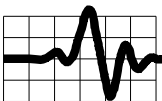
- City of Ottawa and Ontario noise by-laws, regulations and guidelines are reviewed in Section 3.0. It is found that there are no quantitative guidelines or regulations for Leq based noise from construction activities.
- Calculated noise levels in this report are based on noise data from typical construction equipment operating in the conditions expected at Site 5. Actual noise levels may vary due to unanticipated local conditions or necessary changes to construction methods.



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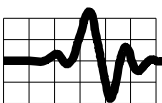


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References

1. Hugh Williamson Associates/Explotech Engineering, *Noise Control Plan for the Combined Sewage Storage Tunnel, Site 5, Stanley Park & Vicinity*, 13 February 2017.
2. City of Ottawa, *Combined Sewage Storage Tunnel, Contract No.ISD14-2036, Section 02482 Noise and Vibration*, 2015.
3. Ministry of Environment and Climate Change, Document NPC-300, *Environmental Noise Guideline, Stationary and Transportation Sources – Approval and Planning*, August 2013.
4. City of Ottawa, *Environmental Noise Control Guidelines*, January 2016.
5. City of Ottawa, *Noise By-Law*, By-law No. 2004 – 253.
6. Occupational Health and Safety Act (Ontario), Regulation 381/15.
7. Ministry of Environment and Climate Change, Publication NPC-115, *Construction Equipment*, August 1978.
8. International Standards Organization, *Acoustics - Attenuation of Sound during Propagation Outdoors, Part 2: General Method of Calculation*, ISO 9613-2: 1996(E).
9. Health Canada, *It's Your Health*, Noise Induced Hearing Loss, September 2016.



Acoustical Terminology

Decibels, dB: Sound levels are expressed in units of decibels, dB. Sound level is 10 times the Logarithm of the squared ratio of the sound pressure over a reference pressure, 20×10^{-6} Pascals.

A-weighting: A-weighting is an internationally standardized frequency weighting which is applied to sound measurements and approximates the variation in sensitivity of human hearing with frequency (pitch).

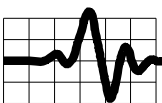
A-weighted decibels, dBA: For sound levels where A-weighting has been applied, the decibel units are written as dBA. IN this report, all reported sound levels have been A-weighted and hence have units of dBA.

Maximum sound level, Lmax: The maximum sound level occurring over a period of time.

Equivalent sound level, Leq: The Logarithmic Energy Equivalent Continuous Sound Level is the constant sound level over the time period in question, that results in the same total sound energy as the actual time varying sound. Leq must be associated with a time period. Leq is a measure of the total sound energy dose over a specified time period. Essentially, Leq is an energy based average sound level over the period of time.

Noise is unwanted sound.

Noise Barrier / Acoustic Barrier: Means a wall, berm wall/berm combination or similar structure, used as a noise control measure, and high enough to break the line-of-sight between the source and the receptor. Noise barriers must have a minimum transmission loss attenuation to be effective.



FIGURES

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- Figure 2:** Scenario 1: Detail Layout Site 5A and 5B – Worst Case; Secant Wall Construction at Site 5A, Site Preparation at Site 5B and Excavation at Site 5C (Day only) (elevation contours at 0.5 meter intervals)
- Figure 3:** Scenario 1: Detail Layout Site 5C – Worst Case; Secant Wall Construction at Site 5A, Site Preparation at Site 5B and Excavation at Site 5C (Day only) (elevation contours at 0.5 meter intervals)
- Figure 4:** Prediction Results, Scenario 1 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)
- Figure 5:** Scenario 2: Detail Layout Site 5A and 5B – Worst Case; Excavation at Site 5A and Site 5C concurrently, Site 5B not in operation (Day only) (elevation contours at 0.5 meter intervals)
- Figure 6:** Scenario 2: Detail Layout Site 5C – Worst Case; Excavation at Site 5A and Site 5C concurrently, Site 5B not in operation (Day only) (elevation contours at 0.5 meter intervals)
- Figure 7:** Prediction Results, Scenario 2 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)
- Figure 8:** Scenario 3: Detail Layout Site 5A and 5B – Worst Case; Secant Wall Construction at Site 5A, Excavation at Site 5B and Site Preparation at Site 5C (Day only) (contours at 0.5 meter intervals)
- Figure 9:** Scenario 3: Detail Layout Site 5C – Worst Case; Secant Wall Construction at Site 5A, Excavation at Site 5B and Site Preparation at Site 5C (Day only) (contours at 0.5 meter intervals)
- Figure 10:** Prediction Results, Scenario 3 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)
- Figure 11:** Scenario 4: Detail Layout Site 5A and 5B – Worst Case; Generator in operation at Site 5C, Site 5A and Site 5B not in operation (Evening or Night) (elevation contours at 0.5 meter intervals)
- Figure 12:** Scenario 4: Detail Layout Site 5C – Worst Case; Generator in operation at Site 5C, Site 5A and Site 5B not in operation (Evening or Night) (elevation contours at 0.5 meter intervals)
- Figure 13:** Prediction Results, Scenario 4 – Generator at Site 5C: Noise Contours, (Noise levels at 4.5 m)

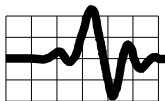


Figure 2: Scenario 1: Detail Layout Site 5A and 5B – Worst Case; Secant Wall Construction at Site 5A, Site Preparation at Site 5B and Excavation at Site 5C (Day only) (elevation contours at 0.5 meter intervals)

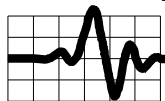
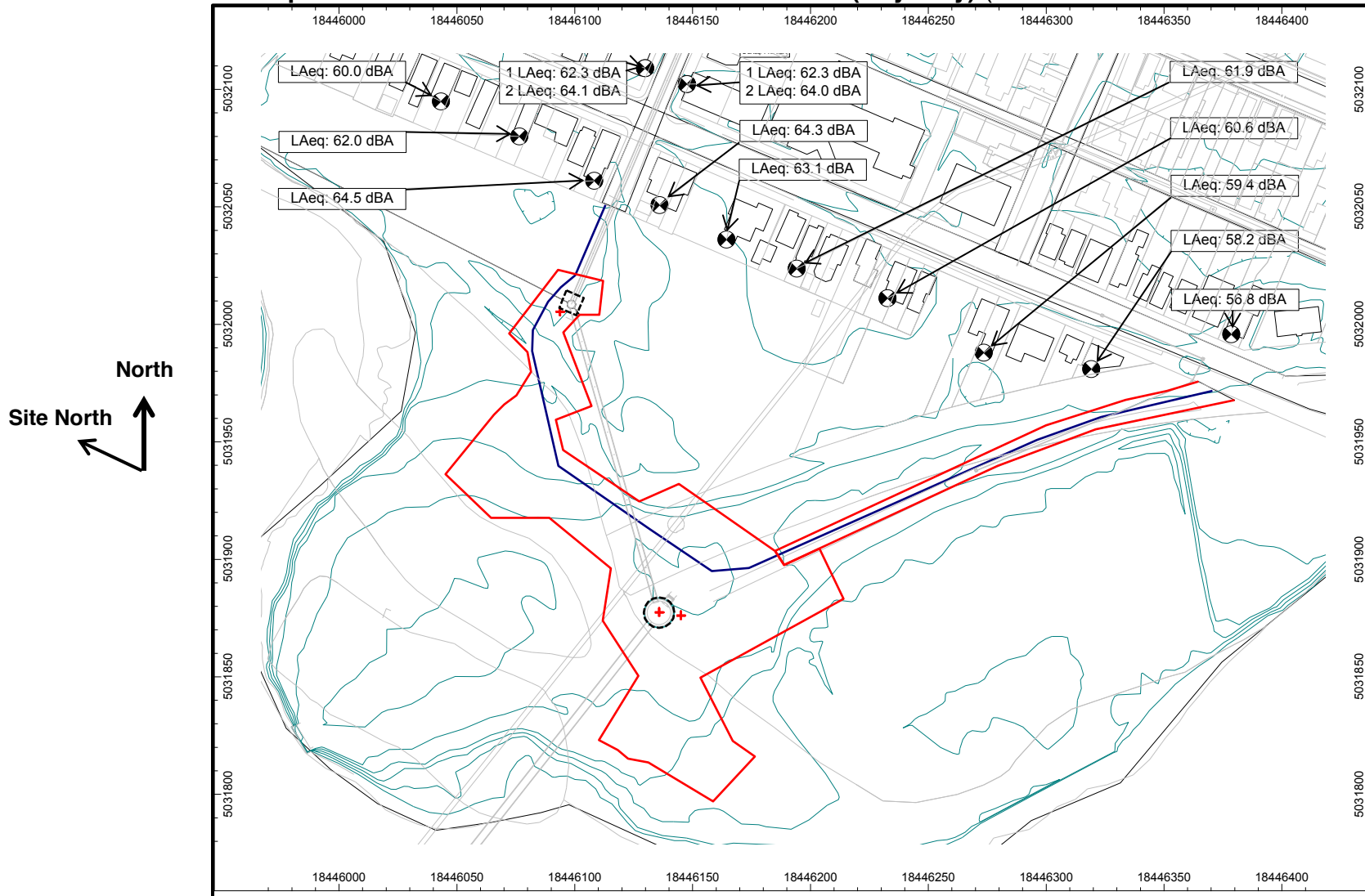


Figure 3: Scenario 1: Detail Layout Site 5C – Worst Case; Secant Wall Construction at Site 5A, Site Preparation at Site 5B and Excavation at Site 5C (Day only) (elevation contours at 0.5 meter intervals)

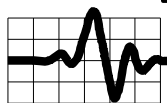
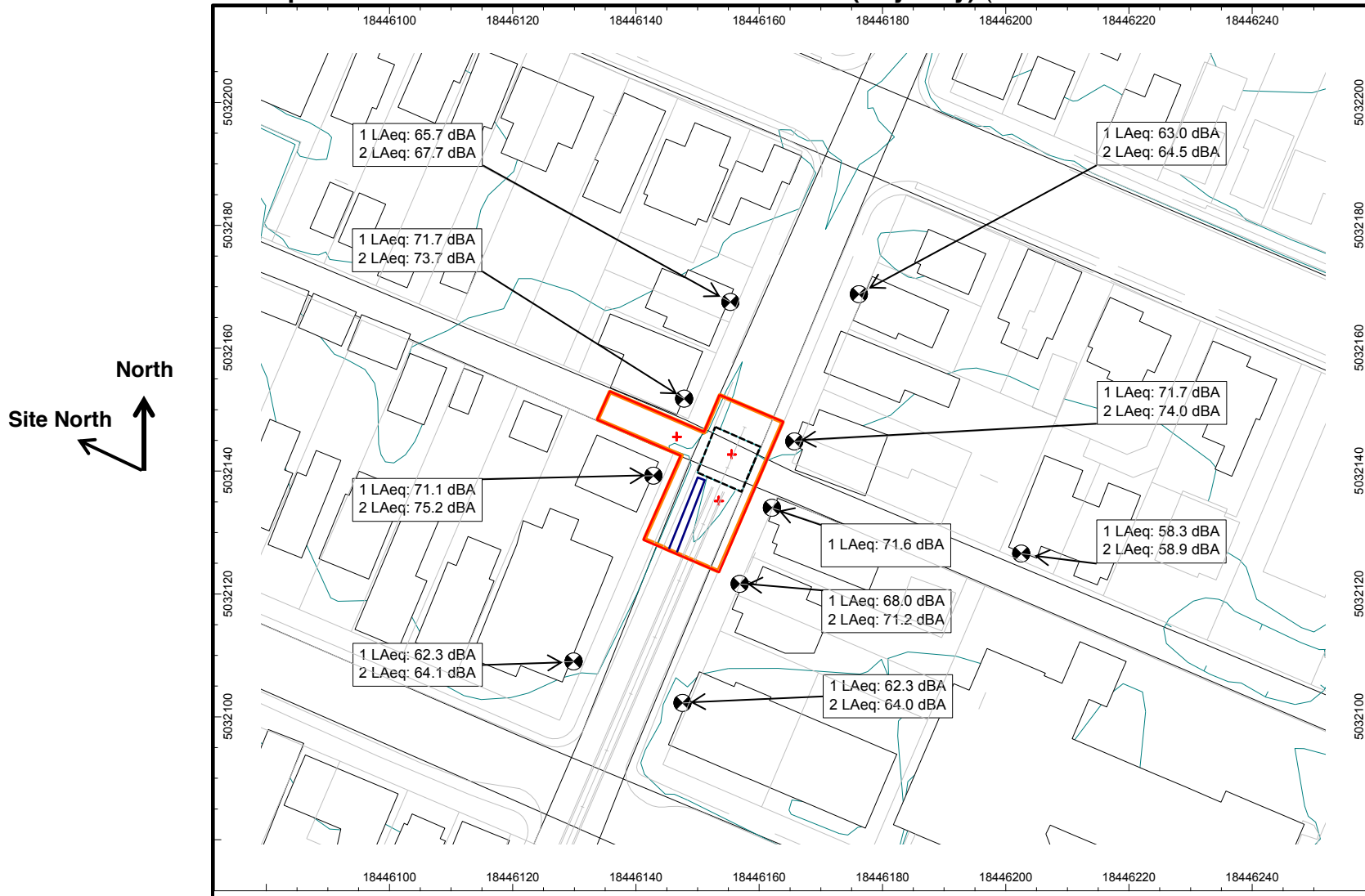


Figure 4: Prediction Results, Scenario 1 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)

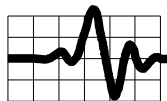
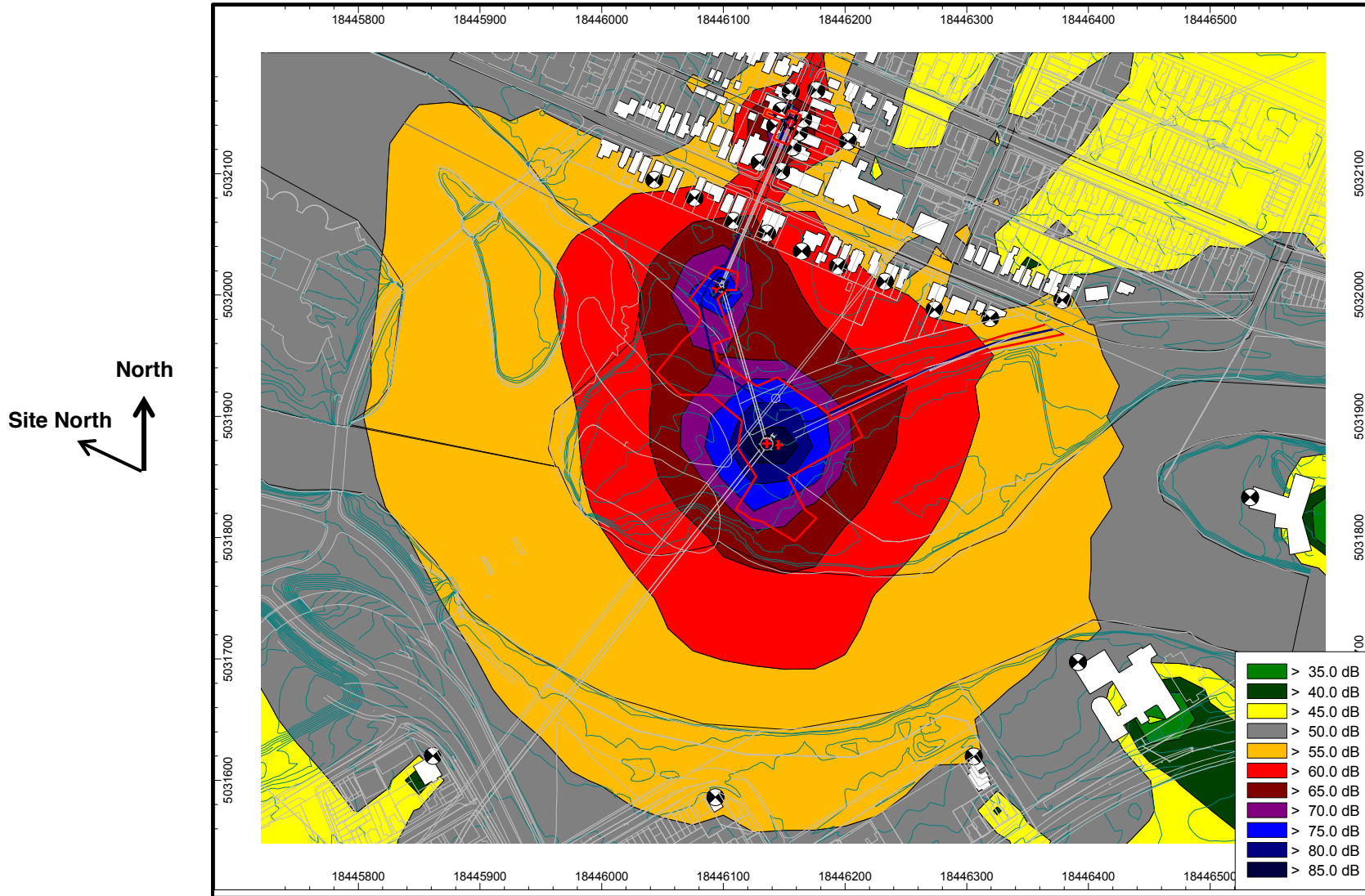


Figure 5: Scenario 2: Detail Layout Site 5A and 5B – Worst Case; Excavation at Site 5A and Site 5C concurrently, Site 5B not in operation (Day only) (elevation contours at 0.5 meter intervals)

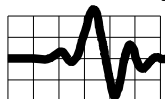
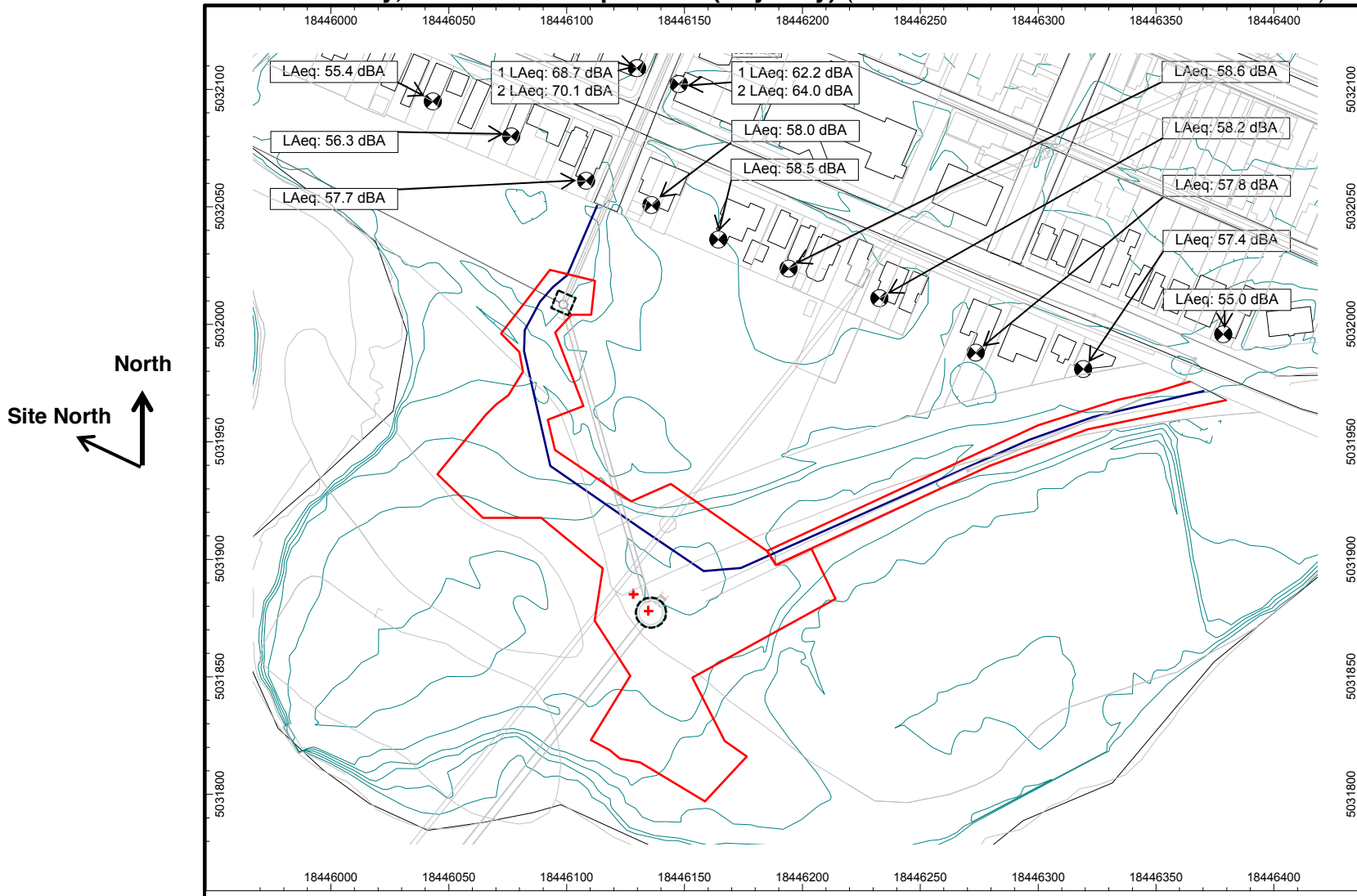


Figure 6: Scenario 2: Detail Layout Site 5C – Worst Case; Excavation at Site 5A and Site 5C concurrently, Site 5B not in operation (Day only) (elevation contours at 0.5 meter intervals)

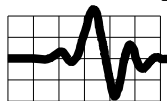
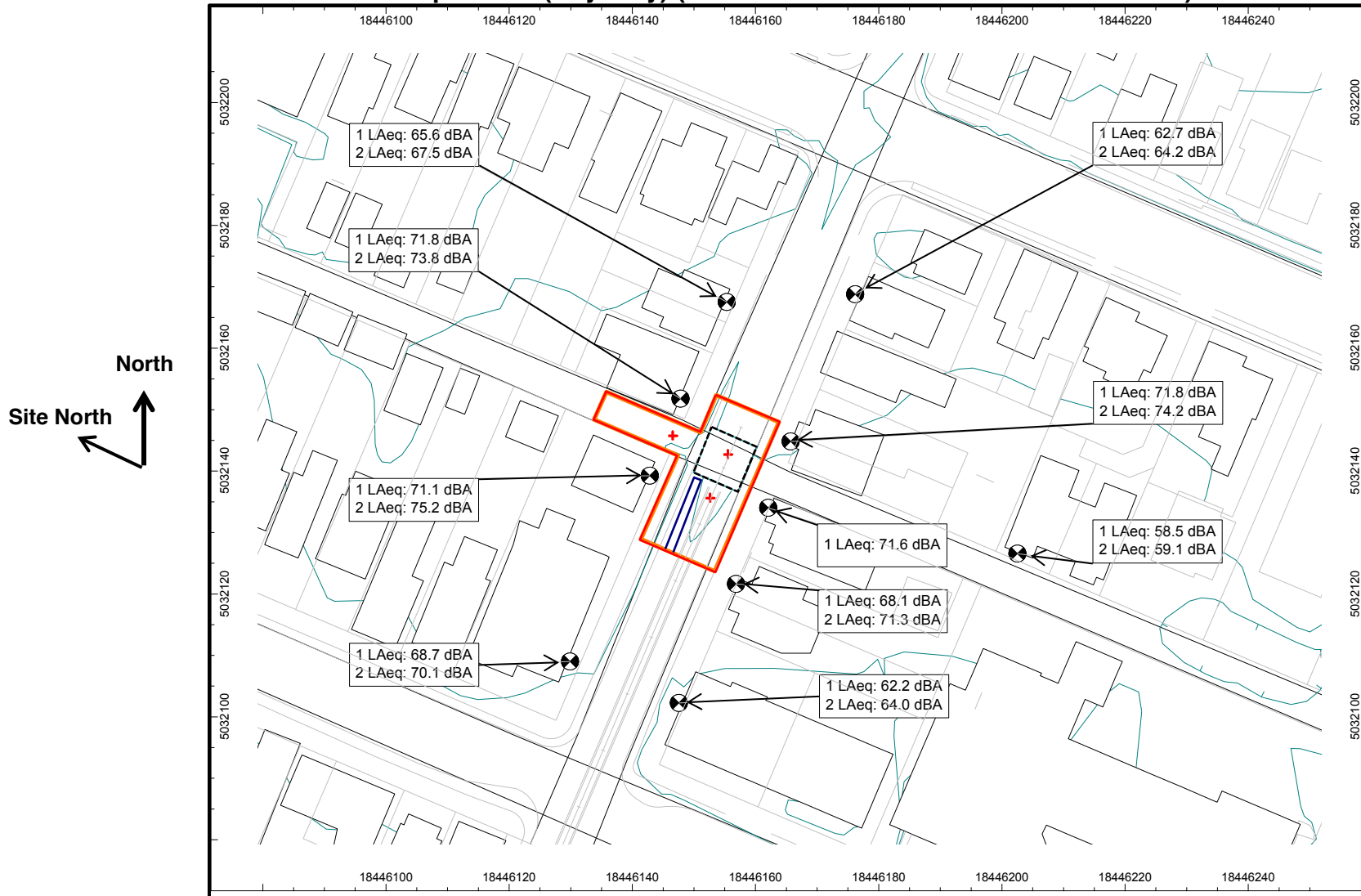


Figure 7: Prediction Results, Scenario 2 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)

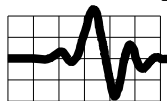
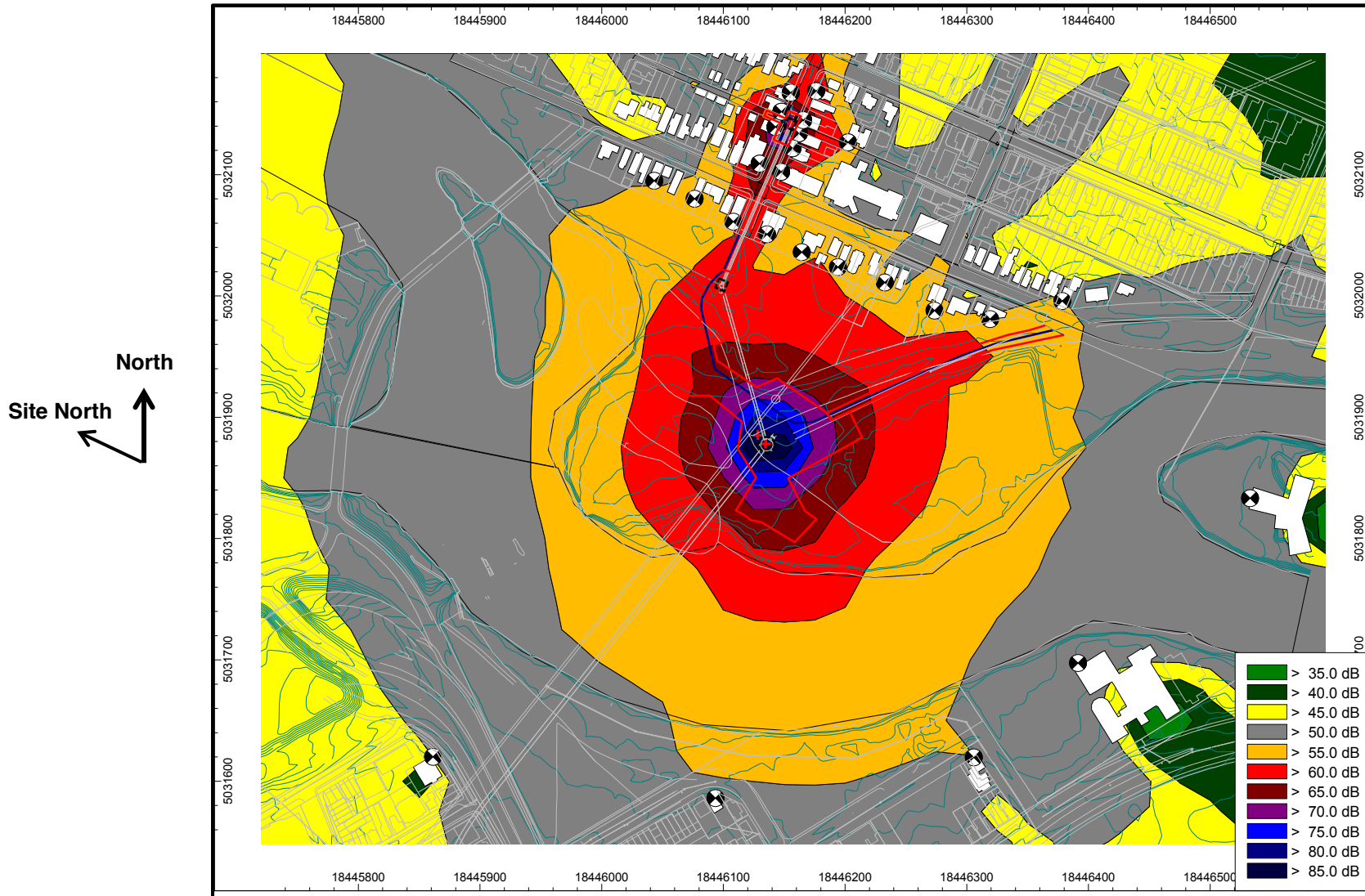


Figure 8: Scenario 3: Detail Layout Site 5A and 5B – Worst Case; Secant Wall Construction at Site 5A, Excavation at Site 5B and Site Preparation at Site 5C (Day only) (contours at 0.5 meter intervals)

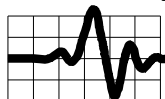
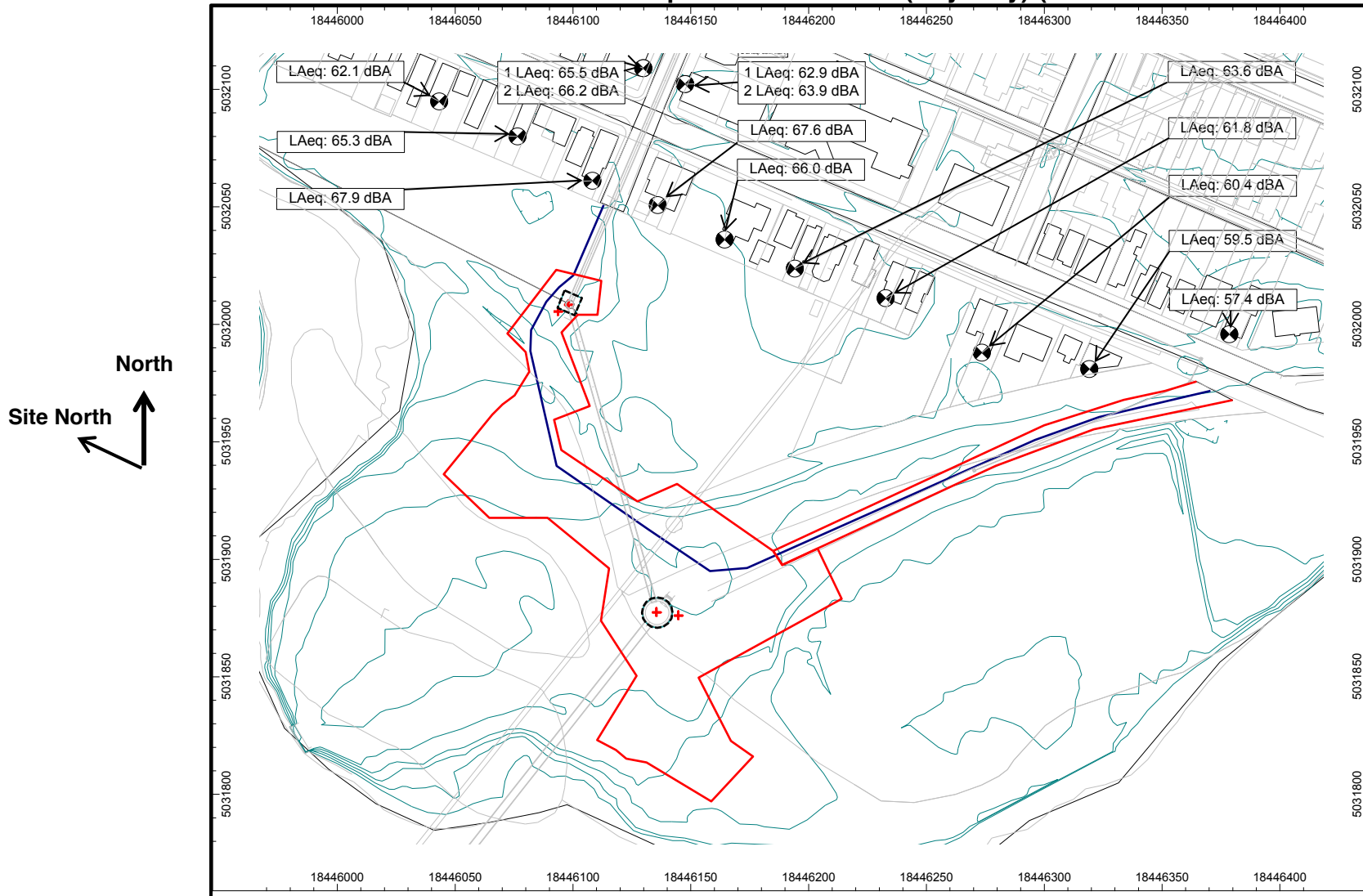


Figure 9: Scenario 3: Detail Layout Site 5C – Worst Case; Secant Wall Construction at Site 5A, Excavation at Site 5B and Site Preparation at Site 5C (Day only) (contours at 0.5 meter intervals)

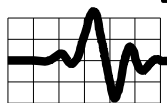
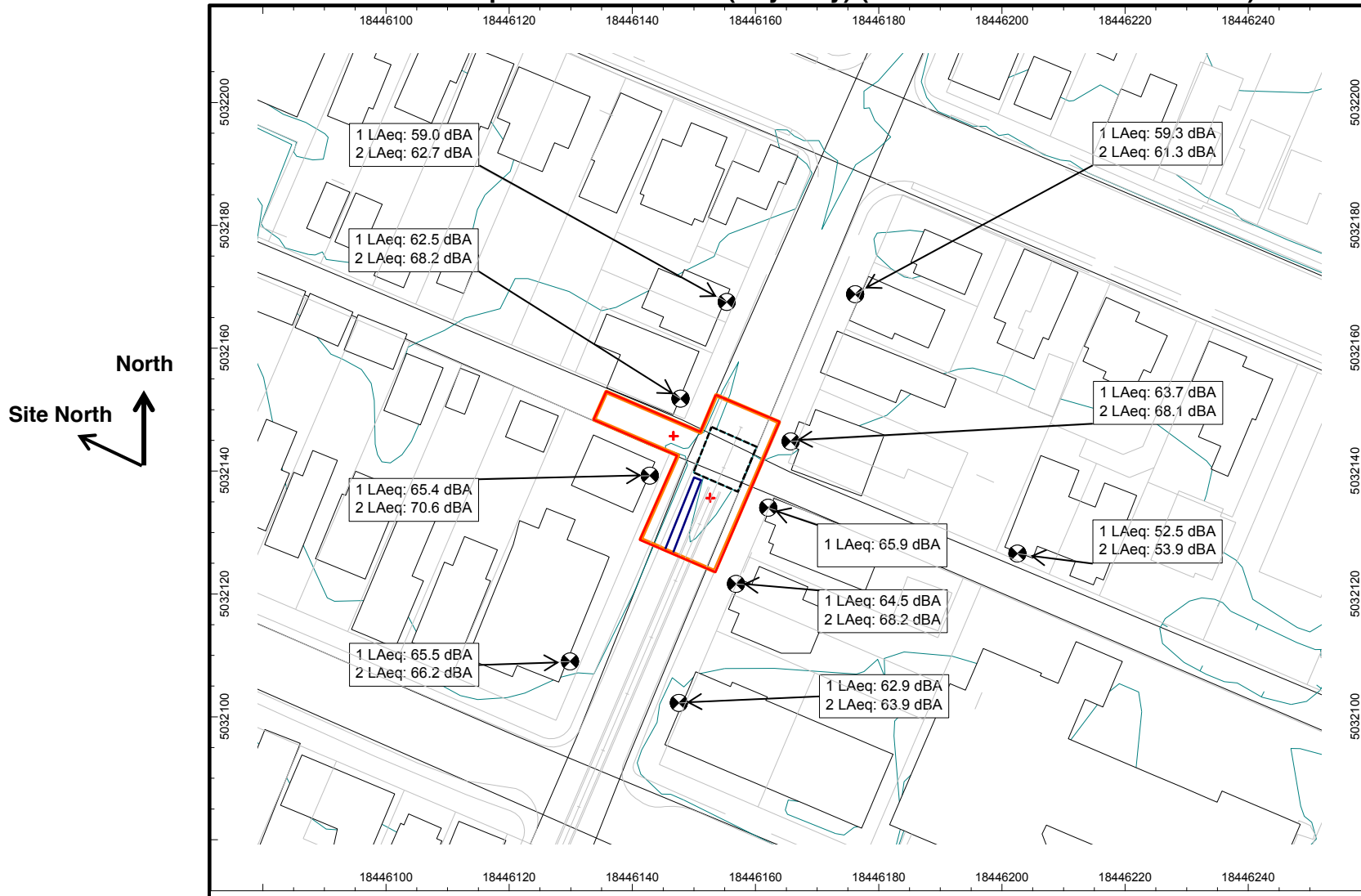


Figure 10: Prediction Results, Scenario 3 - Day only (07:00 to 19:00): Noise Contours, (Noise levels at 4.5 m)

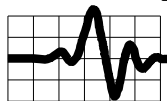
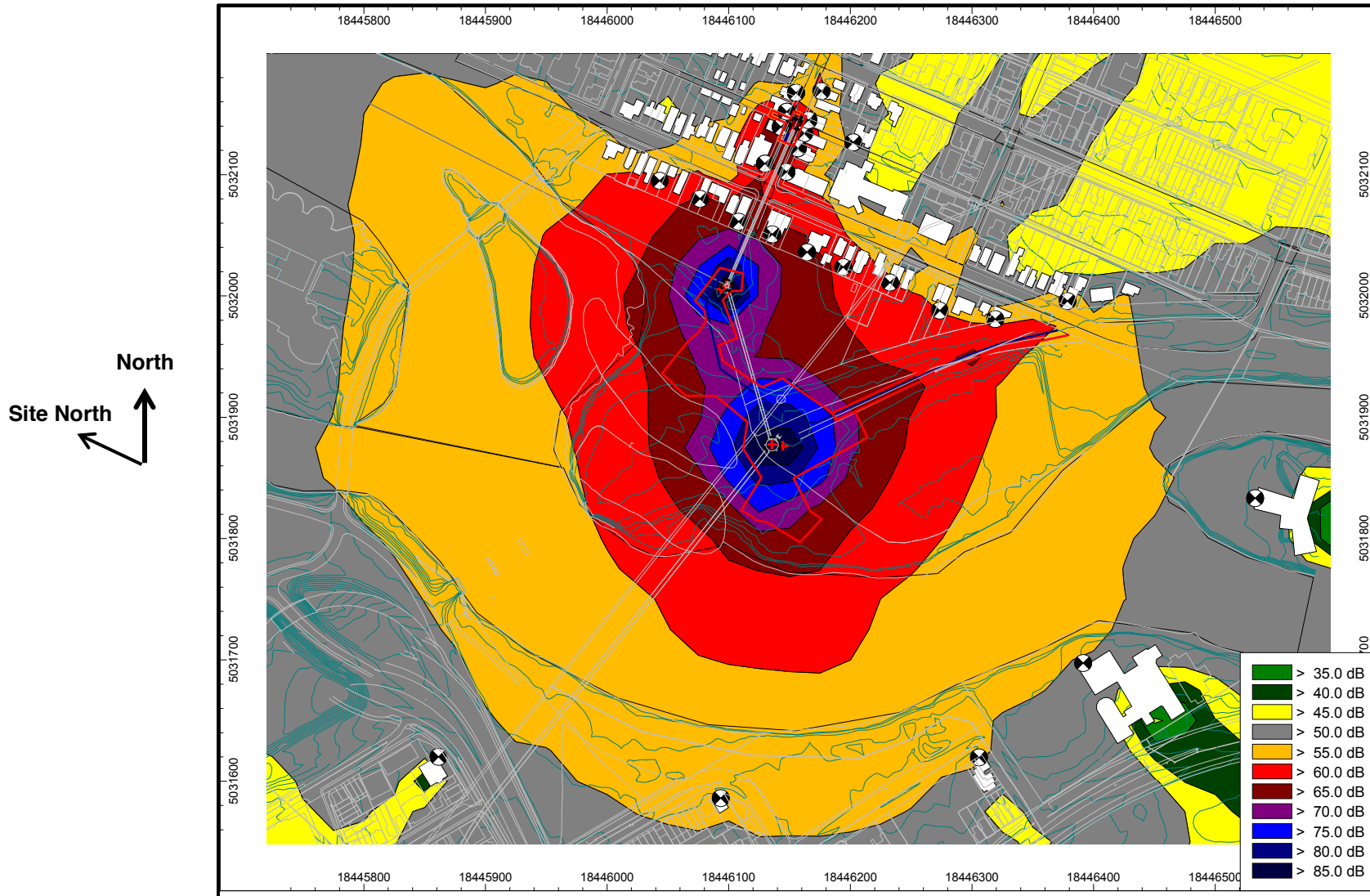


Figure 11: Scenario 4: Detail Layout Site 5A and 5B – Worst Case; Generator in operation at Site 5C, Site 5A and Site 5B not in operation (Evening or Night) (elevation contours at 0.5 meter intervals)

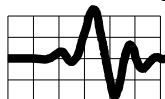
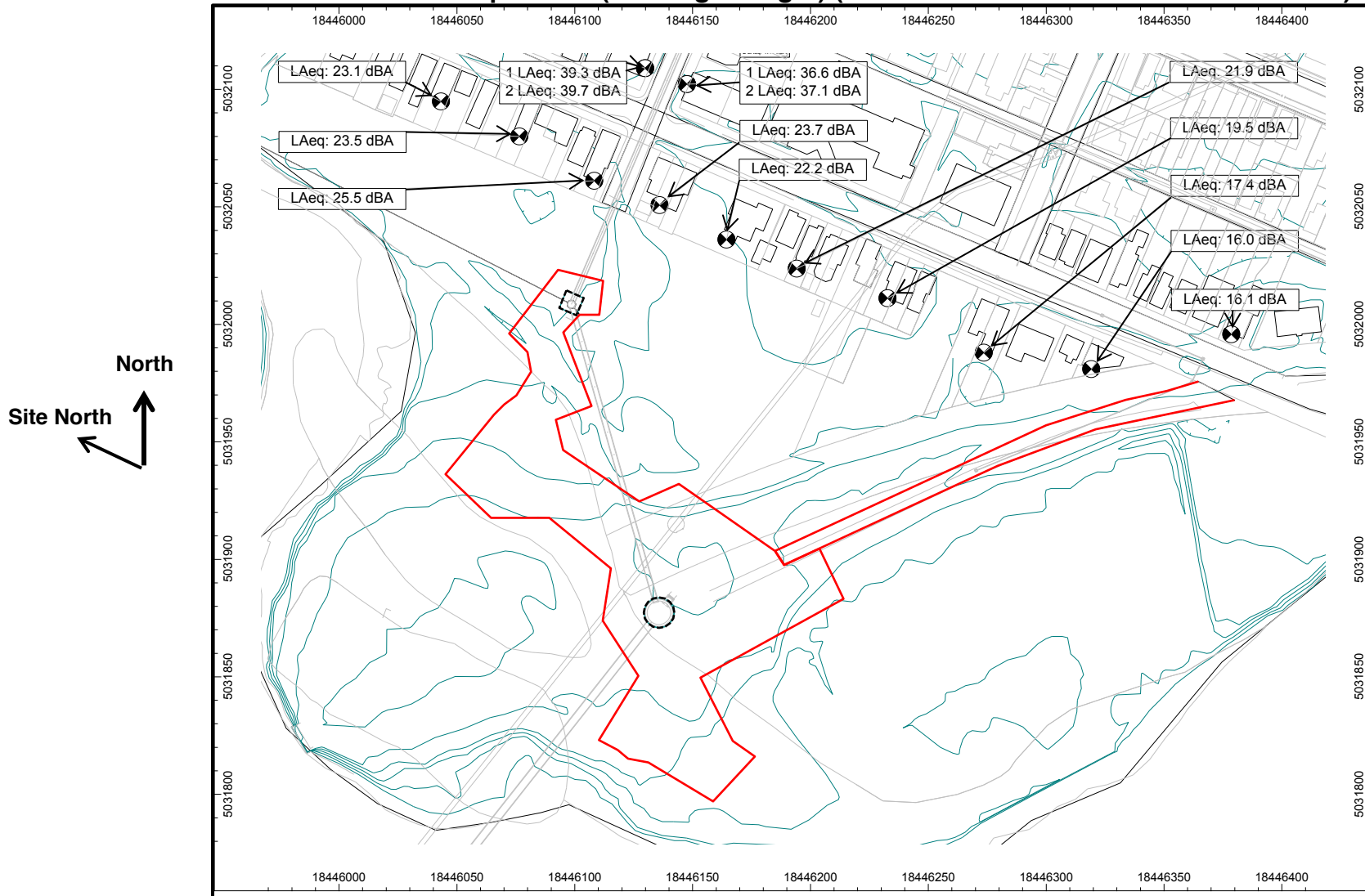


Figure 12: Scenario 4: Detail Layout Site 5C – Worst Case; Generator in operation at Site 5C, Site 5A and Site 5B not in operation (Evening or Night) (elevation contours at 0.5 meter intervals)

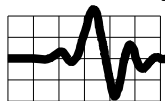
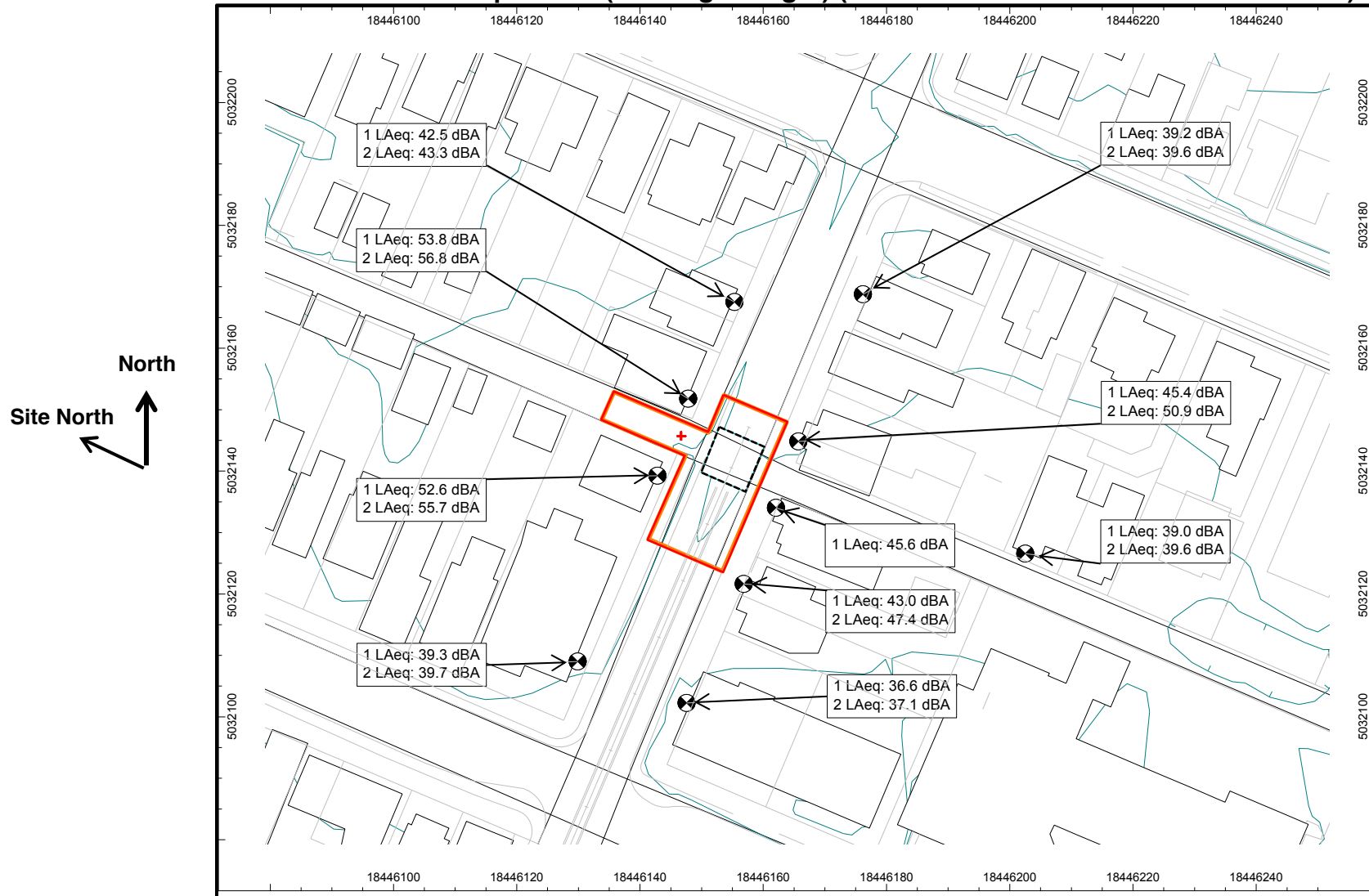
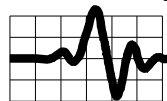
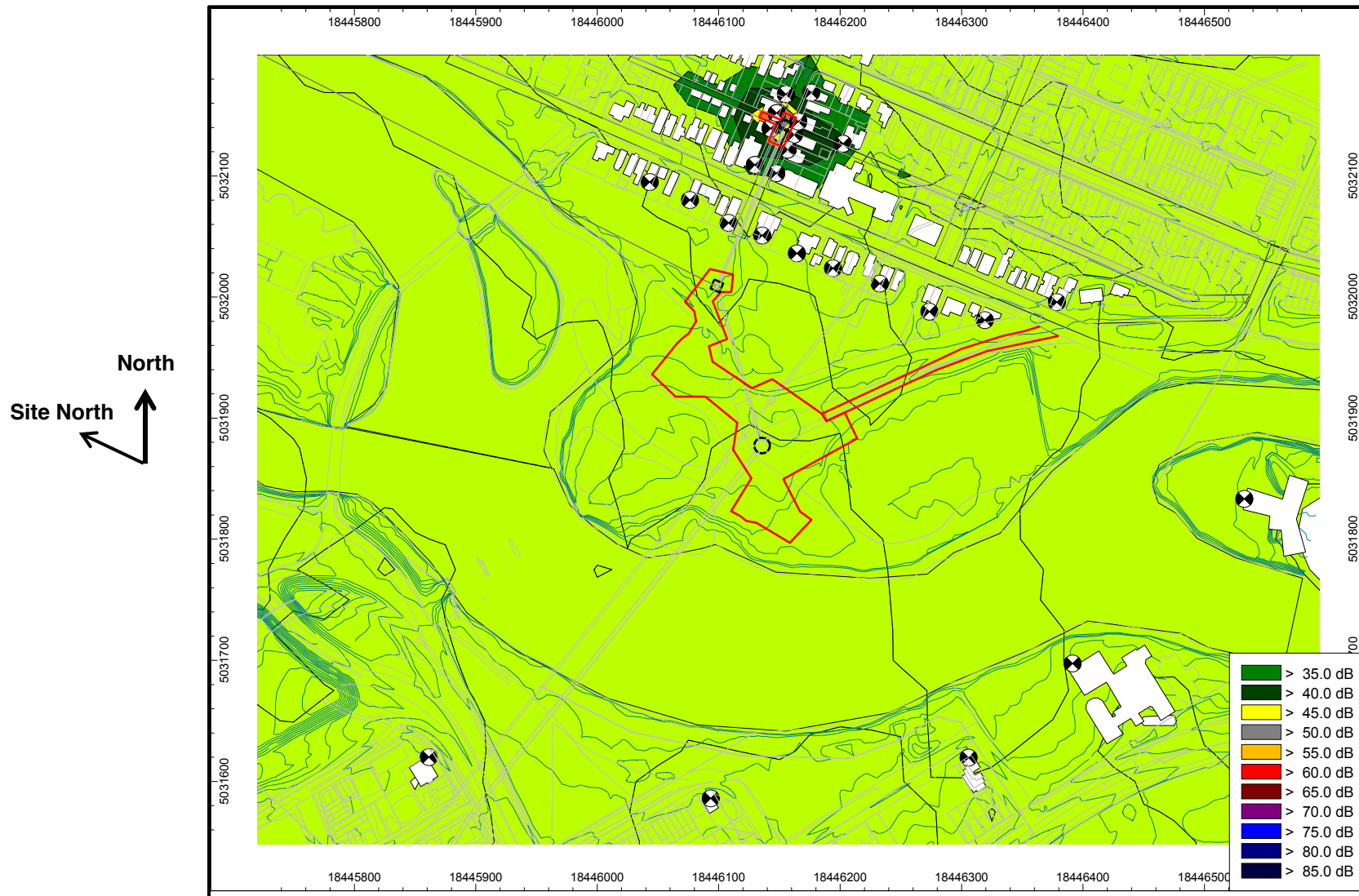
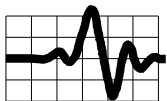


Figure 13: Prediction Results, Scenario 4 – Generator at 5C: Noise Contours, (Noise levels at 4.5 m)



Appendix 1

Combine Sewage Storage Tunnel (CSST) at Site 5 Projected Construction Sequencing Summary As of January 27, 2017



Combined Sewage Storage Tunnel (CSST) at Site 5 Projected Construction Sequencing Summary ⁽¹⁾ As of January 27, 2017

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5a (Stanley Park - Main Chamber and Odour Control Building Area)	IOS Locating & Phase 2 Archaeological Investigation	Mid November 2016	Early December 2016	2-3 weeks	Drill rig will be setup in Stanley Park to core down and find exact location of existing 15m-deep trunk sewer (IOS). Drill rigs used to core down are not excessively noisy. Daytime drilling expected. Little to no material trucking - just drilling crew. Access along pathway. During roughly same period, a Stage 2 archaeological investigation will take place.	Modest noise. Negligible trucking.
	Tree Clearing	Early March 2017	Mid March 2017	2-3 weeks	Activities would be limited to clearing of larger trees outside of the bird nesting season. Stumps and smaller brushes would be left on site for later removal. Tree grabbers, chainsaws, tub grinders and grinders for branches will be used at the site. There will be some noise due to grinding and from the engine of the tub grinder. Daytime work only. Trucking will include hauling felled trees and mulch off site.	Some noise from tree cutting. Modest trucking.
	Traffic Control, Hoarding/Fencing, Site Setup, Tree Protection	Early March 2017	Late March 2017	3-4 weeks	Site setup activities, including installation of the hoarding/fencing and tree protection measures. Modest trucking (fence delivery, etc) and noise.	Modest noise. Modest trucking.
	Build and Grade Temporary Access Roads & Pathways	Early March 2017	Late March 2017	3-4 weeks	Converting the pathway to truck access route (making it more robust), and constructing pathway detours for park users. Will include hauling granular material (3-4 trucks per hour for about a week) and spreading the granular material (bulldozer/grader). Additionally, there would be 3-4 empty trucks per hour leaving the site. Some multi-use temporary pathways also require paving (small pathway paving equipment - one day).	Modest noise. Heavier trucking.

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5a (Stanley Park - Main Chamber and Odour Control Building Area) - continued	Construction of Secant Wall	End of March 2017	End of May 2017	8-10 weeks	Secant wall is a circular watertight enclosure around a deep excavation area (e.g. for a chamber). It is installed before removing the earth in order to mitigate affecting the groundwater table around the excavation. Activities consists of drilling vertically into soil, installing secant piles in a large circle and grouting the circumference to make the chamber area watertight. Handling of the secant piles could generate some noise. Noise Bylaw limits apply to any nighttime work. Marginal trucking for materials and some soils. A small amount of potentially contaminated soil may require disposal off-site during this phase.	Some loud noise associated with driving sheet piles. Modest trucking.
	Earth Excavation	End of May 2017	End of June 2017	3-4 weeks	Once secant walls are built, the earth inside will be removed in order to build the chambers and will be trucked off-site. Some potentially contaminated material could be encountered during the earth excavation for trucking and disposal off-site. Applies to 2 chamber locations at Site 5a (main area). Expect to generate 3-4 trucks per hour hauling excavated earth off-site. Trucks must pass through wash bay prior to exiting the site. There will also be another 3-4 empty trucks returning to the site each hour during this period.	Modest noise. Heavier trucking.
	Installation of Collar Beam	End of June 2017	Early July 2017	2-3 weeks	Shoring for deep excavations. No trucking other than bringing some material in.	Modest Noise. Negligible trucking.
	Rock Excavation	Early July 2017	Mid September 2017	8 -10 weeks	Rock excavation will involve drilling, blasting, shotcrete and bolt installation. Trucking frequency will be low as rock removal is a slow operation compared to earth removal. No rock can be handled (stored and/or removed off-site) afterhours due to Noise Bylaw limits.	Some loud noise from breaking rock. Modest trucking.
	Setup Tunnel Launch Shaft	Mid September 2017	Late November 2017	8-10 weeks	Includes pouring mud slab, hand-mining tail tunnel. Will include trucking, but low frequency due to slow progress of hand-mining 25-30m long tail tunnel to prepare for the Tunnel Boring Machine (TBM) insertion. Modest noise would include handling of excavated rock (loading trucks). No rock can be handled (stored and/or removed off-site) afterhours due to Noise Bylaw limits.	Modest noise. Modest trucking.
	Inserting and Setting up TBM	Early December 2017	Early February 2018	8-10 weeks	Delivery of TBM to site (in pieces), inserting into the launch shaft, reassembly, prepare for launch. Other than trucking in the TBM pieces and associated support equipment/materials, limited trucking and limited noise.	Modest noise. Modest trucking.

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5a (Stanley Park - Main Chamber and Odour Control Building Area) - continued	East-West Tunnel (EWT) Tunneling	Early February 2018	Early December 2018	40-45 weeks (10 months)	TBM progressing along EWT. Spoils (crushed stones - gravel) being extracted from launch shaft and being trucked away. Tunneling 20-22 hours per day, but trucking limited to normal working hours of 12-14 hours (between 7:00AM and 10:00PM). Noise Bylaw limits apply to afterhours activities. Estimate that tunnel spoils will be hauled away at 3 trucks per hour as the tunnel progresses approximately 20 m per day. Another 3 empty trucks will be arriving to the site each hour to be loaded. Tunneling will also require, on average, 3 trucks per day delivering parts for the tunnel lining.	Modest noise. Heavier trucking.
	Construction of Large Chambers (once tunneling complete)	Mid December 2018	Mid September 2019	35-40 weeks (9 months)	Construction of chambers includes the following components: micro piles installation, structure floor, walls and roof construction, ventilation duct, installation of gates, ladders and steps, and backfill. Materials and concrete being delivered to site as required.	Modest noise. Modest trucking.
	Construction of Odour Control Building	Mid March 2017	Mid January 2018	40-45 weeks (10 months)	Typical building construction with material and equipment being delivered to site as required.	Modest noise. Modest trucking.
	Grading and Landscaping	Mid March 2019	Mid September 2019	25-28 weeks (6 months)	Will include hauling away granular material installed as a base for driving vehicles within the staging area and hauling in new topsoil for landscaping. This will be followed by bringing in and installing numerous trees throughout the park. It's estimated that hauling away the granular material would take approximately 2-3 weeks and result in approximately 2-3 trucks per hour during this two to three week period. It is likely that hauling in new topsoil could generate similar trucking at its peak, but would happen later in this period.	Modest noise. Heavier trucking.
Site 5b (Stanley Park - Closer to Queen Victoria Access)	MicroTunnel Launch Shaft Setup, Shoring Installation	Early March 2017	Mid/Late March 2017	2-3 weeks	This is for the diversion sewer that will divert overflows away from Ottawa River and into the CSST. There will be a sewer installed by tunneling between Stanley Park and the intersection of River Lane / Queen Victoria. Activities for this phase include installing shoring into the soil to prepare for excavation of the hole.	Some loud noise associated with driving sheet piles. Modest trucking.

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5b (Stanley Park - Closer to Queen Victoria Access) - continued	Earth Excavation	Mid March 2017	Late March 2017	1 week	Once shoring is installed, the earth material will be excavated and trucked away (maybe 3 trucks per hour for 3-4 days - small volume). The same frequency of empty trucks would also return to the site. Note that some potentially contaminated material could be encountered during the earth excavation for trucking and disposal off-site.	Modest Noise. Heavier trucking (very short duration) when moving soil.
	Rock Excavation	Late March 2017	Late April 2017	3-4 weeks	Rock excavation will involve drilling, blasting, shotcrete and bolt installation, as well as trucking away excavated rock. Trucking frequency will be low as rock removal is a slow operation compared to earth removal. No rock can be handled (stored and/or removed off-site) afterhours due to noise limit bylaws.	Some loud noise from breaking rock. Modest trucking.
	Micro-Tunneling of Diversion Sewer (5b to EWT Outlet Chamber - main shaft)	Early October 2017	Late November 2017	8 weeks	Includes installation of tunneling equipment, plus 2-3 weeks of pilot hole tunneling, 5-6 weeks of back reaming along that pilot hole, and finishing the grouting. The reaming operation (which consists of enlarging the smaller pilot hole to the size required for the sewer) is expected to produce the most trucking as it generates spoils (crushed rock) to be hauled away. Could fill one or two trucks per hour at its peak for that 5-6 week period.	Modest noise. Modest trucking.
	Installation of 3 m Pre-Cast Shaft	Late November 2017	Early February 2018	8-10 weeks	Activities include installing the precast chamber sections, benching and grouting, backfilling, removal of shoring, etc. Small chamber - modest trucking. Similar to installing a big sewer manhole with more parging/grouting and a large gate and related equipment on the inside.	Modest noise. Modest trucking.
	Grading around this shaft 5b	Mid February 2018	End of February 2018	2-3 weeks	Rough grading. Final landscaping is included as part of the landscaping activity described for Site 5a.	Modest noise. Heavier trucking.
Site 5c (Rideau River Collector - Overflow Diversion Chamber - At intersection of River Lane & Queen Victoria) ⁽⁴⁾	Utility Relocation	Mid-February 2017	Early-March 2017	2-3 weeks	Relocation of communication lines by the utility companies from above-ground to underground.	Modest noise. Modest trucking.

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5c (Rideau River Collector - Overflow Diversion Chamber - At intersection of River Lane & Queen Victoria) ⁽⁴⁾ - continued	Traffic Control, Hoarding/Fencing, Site Setup, Utility Relocation and Temporary Sewer Bypass	Early March 2017	Early May 2017	8 weeks	Site setup activities, including installation of the fencing and relocation of utilities and sewers as required. Modest noise and trucking (delivery of fences/piping, hauling away of some material excavated for these relocations, etc).	Modest noise. Modest trucking.
	Shoring	Early May 2017	Late May 2017	2-4 weeks	Includes driving shoring piles into the soil down to the rock elevation and line grouting to permit excavation of soils inside the shored area while supporting the surrounding areas. Installing the shoring will generate some noise - limited to daytime. Modest trucking - limited to hauling shoring material and perhaps some small volume of soils may be hauled away.	Some noise (relatively modest) due to excavating equipment and soil moving. Modest trucking.
	Earth Excavation	Late May 2017	Late May 2017	1-2 weeks	Once shoring is installed, the earth material will be excavated and trucked away (maybe 2-3 trucks per hour - small volume). The same frequency of empty trucks would also return to the site.	Modest noise. Heavier trucking.
	Rock Excavation	Late May 2017	Late July 2017	8 weeks	Rock excavation will involve drilling, blasting, hoe-ramming, shotcrete and bolt installation, as well as trucking away excavated rock. Trucking frequency will be low as rock removal is a slow operation compared to earth removal.	Loud noise resulting from hoe-ramming and rock handling. Modest trucking.
	Micro-Tunneling of Diversion Sewer (5b to River Lane)	Early August 2017	Early October 2017	8-10 weeks	Includes installation of tunneling equipment, pilot hole tunneling, back reaming along that pilot hole, and finishing the grouting. The back reaming operation (which consists of enlarging the smaller pilot hole to the size required for the sewer) is expected to produce the most trucking as it generates spoils (crushed rock) to be hauled away, and will last approximately 5-6 weeks. For this section of the diversion tunnel, it is proposed by the contractor that these reaming spoils be extracted from the shaft located that the intersection of River Lane / Queen Victoria - to be confirmed. Could fill four trucks per day at its peak.	Some modest noise associated with motor for auger. Modest trucking.

Work Location	Task ⁽²⁾	Start Date	End Date	Duration	Details of Work	Truck and Noise ⁽³⁾
Site 5c (Rideau River Collector - Overflow Diversion Chamber - At intersection of River Lane & Queen Victoria) ⁽⁴⁾ - continued	Construction of Chambers (once micro-tunneling complete)	Early October 2017	Early February 2018	16-18 weeks (4 months)	Construction of chambers includes the following components: structure floor, walls and roof construction, installation of weir, ladders and steps, demolition of section of existing overflow sewer, new connections, backfill and removal of shoring. Materials and concrete being delivered to site as required. This phase includes backfill around the chamber, estimated to generate 3-4 trucks per hour hauling backfill material to the site and the same frequency of empty trucks leaving the site - over a period of approximately 1-2 weeks in late January / early February. Other trucking would include concrete trucks during the pours	Modest noise. Heavier trucking during backfill (1-2 weeks), modest otherwise.
	Grading and Rough Reinstatement	Early February 2018	Early March 2018	4 weeks	Grading of the surface, base-coat paving, curbs, sidewalks, rough grading of landscaped areas to prepare for sodding later in the spring (since weather will not permit sodding at this time). Opening of the intersection. Heavier trucking will be during delivery of granular material for road construction (3-4 trucks per hour for a week or so).	Modest noise. Heavier trucking for 1-2 weeks, otherwise modest.
	Post-Construction Final Reinstatement	Early May 2018	Mid May 2018	1-2 weeks	Once weather is warmer, application of final layer of pavement and placement of sod and plantings. No long-term roadway impact as top-lift pavement is expected to be completed in a single day.	Modest noise. Heavier trucking for 2 days of paving.

Important Notes:

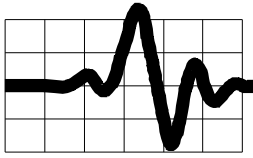
1. This table should be considered to be a living document and presents a best estimate based on the Contractor's submitted construction schedule and the project team's general experience with similar activities. Contractually, the Contractor is NOT required to adhere to this detailed schedule. The Contractor will be submitting detailed schedules and management plans prior to undertaking this work.
2. The activities list is not intended to be an exhaustive list. The City reserves the right to order the Contractor to cease the use of non-conforming equipment or to correct non-conforming procedures or to cease the nighttime construction activities at no cost to the City in the event that noise thresholds are exceeded.
3. Normal (a.k.a. daytime) working hours as defined in the city's Zoning Bylaw is 7:00AM-10:00PM. Outside of these hours (i.e. 10:00PM-7:00AM) is referred to as "afterhours". The Contract Documents stipulate that the following activities will not be permitted afterhours:

- Backing-up construction equipment and vehicles (due to backup alarm)
- Deliveries, including loading/unloading material or excavated muck into trucks
- Operation of equipment, motors and power tools without noise dampening
- Handling sheet piling
- Tree removal, cutting or grinding
- Significant grading operations requiring earth-moving equipment

The Contract Documents further stipulate that a noise monitoring program will be implemented by the Contractor to assess conformance to the stipulated limits. The noise monitoring program will be approved by the Contract Administrator prior to implementation. Exceedances will be reported to the Contract Administrator within 24 hours with a solution to prevent future exceedances.

The column for noise trucking is intended to be a high-level relative comparison. A noisy activity is the label used for activities that include breaking rock, banging steel, etc; other activities are considered to generate modest noise (relative to breaking rock and banging steel). Similarly, heavy trucking is the label used for activities generating 3 to 4 trucks per hour; other activities are considered to generate modest trucking (considerably less than 3-4 trucks per hour).

4. All work at Site 5c (River Lane / Queen Victoria) is limited to daytime activities. No work is currently permitted at this site afterhours (10:00pm to 7:00am). The Contractor may submit a special request for a specific task that is impractical to be completed during daytime, but it would need to be submitted for review and approval by the project team and the Councillor as it is not currently permitted.



RESUMÉ: Dr. HUGH WILLIAMSON, P.Eng.

QUALIFICATIONS: Ph.D. Mechanical Engineering, University of New South Wales, 1972
B.Sc. Mechanical Engineering, (with Distinction), University of Alberta, 1967
Licensed Professional Engineer, Professional Engineers Ontario
Member, Canadian Acoustical Association
Member, American Society of Heating, Refrigeration and Air-conditioning Engineers

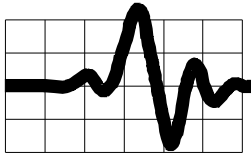
- KEY COMPETENCIES:**
- Architectural and building acoustics, acoustics of office spaces, meeting rooms, auditoriums and studios, noise and vibration control of building mechanical services.
 - Environmental noise and vibration assessments, Environmental Compliance Approval (ECA). Noise assessment for land use planning.
 - Design and testing for speech privacy and for speech secure spaces.
 - Noise impact assessments for development approvals.
 - Transportation noise and vibration assessments.

PROFESSIONAL EXPERIENCE:

Hugh Williamson is a professional engineer with many years of experience in the measurement, analysis and control of noise and vibration. Hugh Williamson Associates was incorporated in 1997 and provides consulting services in architectural, building, industrial, transportation and environmental acoustics and vibration. Clients include architects, engineering firms, industrial firms and government departments. Prior to establishing Hugh Williamson Associates, his career included extensive periods in industry as well as university level research and teaching. He is a former Director of the Acoustics and Vibration Unit at the Australian Defence Force Academy. He has published over 50 engineering and scientific papers and has been an invited speaker on noise and vibration at national and international conferences. He has more than 20 years of experience as a consultant.

CLIENT LIST:

Hugh Williamson Associates provides consulting services to large and small clients including: National Research Council, City of Ottawa, Public Works Government Services Canada, J. L. Richards & Associates, Miller Group, R. W. Tomlinson Limited, Atkinson Schroeter Design Group, and, Bryden Martel Architects.



RESUMÉ: MICHAEL WELLS

QUALIFICATIONS: Registered Architect of NSW, Registration Number: 8111
B. Architecture (Hons), University of Sydney, 2002
B.Sc. Architecture, University of Sydney, 1999
Member, Canadian Acoustical Association

**KEY
COMPETENCIES:**

- Environmental noise and vibration assessments, Environmental Compliance Approval (ECA). Noise assessment for land use planning.
- Architectural and building acoustics, acoustics of office spaces, meeting rooms, auditoriums and studios, noise and vibration control of building mechanical services.
- Industrial noise and vibration assessment and control.
- Transportation noise and vibration.
- Design services including sketch design, design development (development / permit applications), contract documents, tendering and contract administration.

PROFESSIONAL EXPERIENCE:

Michael Wells is a professional Architect registered in NSW with many years of experience in the Architectural and Construction industries. With key competencies in measurement, analysis and control of noise and vibration, Michael Wells joined Hugh Williamson Associates in 2012 and provides consulting services in architectural, building, industrial, transportation and environmental acoustics and vibration. Clients include architects, engineering firms, industrial firms and government departments. Prior to joining Hugh Williamson Associates, his career includes the founding of Michael Wells Architect in Sydney Australia which specialized in the design of institutional, commercial and residential projects. He is a Director of Architectural Workshops Australia and Vision Blue Pty Ltd. He has more than 10 years of experience as a consultant.

CLIENT LIST:

Hugh Williamson Associates provides consulting services to large and small clients including: National Research Council, National Capital Commission, J. L. Richards & Associates, Barry Padolsky Associates, HOK Urbana Architects, Genivar, Nasittuq Corporation, PWGSC, R. W. Tomlinson, Geo. Tackaberry Construction and Miller Paving.