Toronto District School Board

April 21, 2017

Dear Parents/Guardians,

We are writing further to our letter dated April 7, 2017, where we committed to posting the *Phase II Risk Assessment Report* on the school website when it was received by the TDSB. The *Phase II Risk Assessment Report* has now been received by the TDSB and a copy is attached.

The report was prepared by an independent expert, Environmental Consulting Occupational Health (ECOH), retained by the TDSB as part of a comprehensive risk management strategy undertaken by the TDSB regarding the development of a high-rise residential apartment building on the property adjacent to John Fisher Junior Public School known municipally as 18-30 Erskine Avenue, Toronto by KG Apartment Holdings II Inc. (the "Developer").

Student and staff safety are the top priority if and when the construction of a new building next to the school proceeds. As a reminder, the TDSB has developed and implemented a comprehensive risk mitigation strategy based on the following Guiding Principle:

> *The TDSB is acting, and will continue to act, in a good faith effort to address legitimate concerns related to the Development so as to meet its obligations to provide appropriate school accommodation for students. The TDSB's primary concerns are the safety of students and staff and the safety and integrity of the John Fisher building. The TDSB considers transparency with parents, staff and the public to be of utmost importance in this process.*

The report and the recommendations contained in the report are under review by the TDSB. In this regard, the TDSB has retained Walters Forensic Engineering Inc. to undertake a peer review of the report and to assist the TDSB in its consideration of the mitigation measures recommended by ECOH and the related issue of whether to operate the school at the current location during construction. A peer review is the process of subjecting one expert's findings and conclusions to the scrutiny of others who are experts in the same field. This will provide the TDSB with third-party validation of, or challenge to, ECOH's findings that **"ECOH is of the opinion that risks can and should be mitigated to a level where students can remain in the school during construction."** The TDSB will seek to engage in discussions with the City and the Developer on the recommended mitigation measures, including as to feasibility, logistics and responsibility.

The TDSB will host a public meeting on May 3, 2017, to address and discuss the *Phase II Risk Assessment Report* (representatives from the Developer, ECOH, Walters Forensic Engineering Inc. and the City have been invited and are expected to attend) and answer questions from parents/guardians and staff of John Fisher. The meeting will be held at North Toronto Collegiate Institute at 17 Broadway Avenue (Auditorium) commencing at 7:00 p.m. Prior to that time, the TDSB will make a written statement setting out its position.

Sincerely,

Bacopoulos

Associate Director, Facilities, Sustainability and Employee Services

ECOH
Environmental Consulting
Occupational Health

April 21, 2017

Mr. Angelos Bacopoulos
Associate Director
Facilities, Sustainability and Employee Services
Toronto District School Board

Re: Phase II Risk Assessment: Construction Hazards John Fisher Public School

Dear Mr. Bacopoulos:

At the request of the Toronto District School Board (TDSB), **ECOH** has prepared the attached Phase II risk assessment of potential hazards associated with construction of a residential tower on Erskine Avenue adjacent to the site of John Fisher Public School.

This report follows on the Phase I risk assessment that was sent to you on March 13, 2017 and is appended to the Phase II report. Whereas Phase I was a generic risk assessment based on a review of the literature and other public information, the Phase II report is based on site-specific information, consisting primarily of the Construction Mitigation Plan and attachments provided by the developer. At the request of TDSB, the Phase II risk assessment includes an opinion as to whether students should be removed from the school while construction is under way.

The attached report presents our assessment of the residual risks that are likely to remain after application of the mitigation measures specified by the developer. As stated in the report, construction of the tower entails some risks to John Fisher Public School that cannot be eliminated. As can be inferred from this, the only way to fully eliminate such risks (i.e. zero risk tolerance) is if there is no construction in the neighborhood. Nevertheless, it is ECOH's opinion that if the project proceeds, risks can and should be mitigated to a level where students can remain in the school during construction. The report presents recommendations for achieving a risk mitigation level acceptable for continued occupancy of the school. A key element of these recommendations is ongoing monitoring of hazards during construction and prompt action to remedy any problems that arise.

We thank you for the opportunity to be of service to the TDSB.

Yours truly,

Environmental Consulting Occupational Health

Om Malik, PhD, PEng, CIH, ROH, FAIHA, QP$_{RA}$
Principal and CEO

Attachment

ECOH
Environmental Consulting
Occupational Health

RISK ASSESSMENT
HAZARDS FROM CONSTRUCTION PROJECT NEAR
JOHN FISHER PUBLIC SCHOOL

PHASE II

Submitted to:
Toronto District School Board

Presented by:
ECOH
75 Courtneypark Drive West, Unit 1
Mississauga, ON L5W 0E3

ECOH Project No. 17201

April 21, 2017

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A 35-story residential building has been proposed for the site of 18-30 Erskine Avenue in Toronto, adjacent to the property of John Fisher Public School (JFPS), a school under the jurisdiction of the Toronto District School Board (TDSB). TDSB has engaged ECOH Management Inc. (ECOH) to assess risks posed to JFPS occupants during construction and after completion of the building.

This report presents results of a Phase II risk assessment, building on results of Phase I, a preliminary risk assessment which was based on a literature review and limited site-specific information. The Phase II assessment evaluates risks more specifically associated with the planned construction, based on additional site-specific information, primarily provided by the developer. At the request of TDSB, the Phase II risk assessment includes an opinion as to whether students should be removed from the school while construction is under way.

Hazards were identified in five categories: chemical, physical, biological, safety and psychosocial. Risks were assessed using a risk matrix (Table A) that combined ratings of hazard severity and probability of harm.

Table A Risk Assessment Matrix

Severity	Very remote P0	Remote P1	Improbable P2	Possible P3	Likely P4
Catastrophic S4	Low	Low	Medium	High	High
Major S3	Very Low	Low	Medium	Medium	High
Moderate S2	Very Low	Low	Low	Medium	Medium
Minor S1	Very Low	Very Low	Very Low	Low	Low

Probability

Potential impacts on learning as well as on health and safety were considered for each hazard, and risks were assessed for four stages of the project: demolition, excavation, construction and finished building. Where the developer provided new information on intended risk mitigation measures, the revised risk ratings represent residual risk, i.e. risk remaining after application of those measures. A summary of ratings is provided in Table B.

Table B: Summary of Risk Ratings

Table B Health and Learning Risk Ratings		Risk - Health					Risk - Learning			
		Stage					Stage			
	Hazard	Demolition	Excavation	Construction	Finished Building		Demolition	Excavation	Construction	Finished Building
Chemical Hazards	Asbestos	Low	Low	Very Low	NA (not applicable)		Low	Low	Very Low	NA
Chemical Hazards	Lead & Mercury	Low	Low	Very Low	NA		Very Low	Very Low	Very Low	NA
Chemical Hazards	Diesel exhaust	Medium	Medium	Medium	Low		Medium	Medium	Low	Low
Chemical Hazards	Crustal Dust	Low	Low	Low	NA		Low	Low	Low	NA
Chemical Hazards	Respirable Crystalline Silica	Low	Low	Low	NA		Very Low	Very Low	Very Low	NA
Chemical Hazards	Asphalt fumes	NA	NA	Low	NA		NA	NA	Low	NA
Chemical Hazards	Volatile Organic Compounds (VOCs)	Very Low	Very Low	Low	Very Low		Very Low	Very Low	Low	Very Low
Chemical Hazards	Indoor Air Quality	Medium	Medium	Medium	NA		Medium	Medium	Medium	NA
Physical Hazards	Noise (windows closed)	Low	Low	Low	NA		Low	Low	Low	NA
Physical Hazards	Noise (windows open)	High	Medium	Medium	NA		High	Medium	Medium	NA
Physical Hazards	Vibration	Low	Low	Low	NA		Medium	Medium	Low	NA
Physical Hazards	Radon	Low	Low	Low	NA		Low	Low	Low	NA
Physical Hazards	Welding Radiation	Low	Very Low	Low	NA		Very Low	Very Low	Very Low	NA
Biological Hazards	Pests (excluding microbes)	Medium	Medium	Medium	Very Low		Medium	Low	Low	Very Low
Biological Hazards	Microbes	Low	Low	Low	Very Low		Low	Low	Low	Very Low
Safety Hazards	Traffic	Medium	Medium	Medium	Low		Low	Low	Low	Very Low
Safety Hazards	Cranes	NA	NA	Medium	NA		NA	NA	Medium	NA
Safety Hazards	Falling Objects	Low	Low	Low	Low		Low	Very Low	Low	Very Low
Safety Hazards	Structural Stability & Water Table	NA	Low	NA	NA		NA	Low	NA	NA
Safety Hazards	Fire and Explosion	Low	Low	Medium	NA		Low	Low	Medium	NA
Safety Hazards	Electrical & Utilities	Low	Low	Low	NA		Low	Low	Low	NA
Safety Hazards	Access to site	Low	Low	Low	Low		Low	Low	Low	Low
Psychosocial Hazards		Medium	Medium	Medium	Low		Medium	Medium	Medium	Low

EXECUTIVE SUMMARY

ECOH is of the opinion that risks can and should be mitigated to a level where students can remain in the school during construction. The following measures are recommended to achieve a risk mitigation level acceptable for continued occupancy of the school:

1. Noise mitigation measures:

    a. Plans should proceed to move the playground to the east end of the school to reduce noise exposure while staff and students are outdoors;

    b. Install double-paned windows that provide good seals and meet the expected Sound Transmission Class (STC) ratings;

    c. A boundary wall, at least 12 feet high, should be erected at the west boundary of the school. This will further reduce the noise in the classrooms, offices and play areas. In addition, it will reduce school occupants', especially children's, access to the construction site and the completed building, reduce construction workers' access to the school and help control pests;

2. Indoor Air Quality: Provide air conditioning to eliminate the need to open windows during hot weather. Opening windows will subject occupants to potentially high noise and increased dust. While unit air conditioning will help to relieve this problem, central air conditioning is a more effective solution;

3. Asbestos: Remove all friable asbestos containing materials (ACM), preferably prior to the start of the project but certainly before the start of excavation, to eliminate the hazard of release of asbestos fibres due to vibration;

4. Lead: Prior to the start of the project but certainly before the start of excavation, remove all lead-containing paint that may be flaking, otherwise deteriorating or accessible to children, to eliminate the possibility of exposure to lead by inhalation as well as by ingestion;

5. Traffic: Increase vigilance to ensure children are not endangered by increased traffic; hold discussions with city officials on the advisability of designating Erskine Avenue a one-way street;

6. Crane(s): Address specific measures related to luffing jib tower crane safety (as discussed in section 6.2.); specify the number of cranes that might be used at a given time; ensure there is a lift plan that provides protection, especially for lifting heavy loads to great heights;

7. Establish a detailed fire safety plan for the construction project (as discussed in section 6.5);

8. Air monitoring for dust and diesel emissions:

    a. Regularly monitor for PM2.5 in addition to PM10 during demolition, excavation and construction stages of the development, as discussed in section 3.3;

    b. A plan for regularly monitoring for oxides of nitrogen (NOx) should be established;

c. Action levels should be established as discussed in sections 3.3 and 3.4, with detailed corrective measures to be taken (promptly) if action levels are exceeded;

d. Air monitoring for PM10, PM2.5 and NOx should be conducted at JFPS as well as at the project property line;

9. Microbial and pest infestations: The care-taker at JFPS should be trained to provide increased vigilance in JFPS for possible mould and pest infestations with abatement and pest control measures where needed;

10. Structural integrity of the JFPS building: The care-taker at JFPS should be trained to look for visible signs and symptoms of structural damage and to seek professional help as appropriate;

11. Falling Objects: Provide netting as required by the City of Toronto to ensure that any falling object is adequately captured; ensure that netting and other barriers and measures are adequate (e.g. in terms of strength, mesh and placement) to prevent any potential for objects to land off the construction site;

12. Radon: Monitor for radon in JFPS to establish the base line radon levels, followed by regular monitoring. If there is any increase, investigate whether the cause is related to cracks in the foundations which are otherwise not discernible;

13. Vibration: Monitor vibration levels at JFPS, if warranted by perceived vibration, structural damage, or vibration levels measured by the developer/constructor; and

14. Enforcement: The Phase II risk assessment is predicated on mitigation steps proposed by the developer as a part of the Construction Mitigation Plan (CMP) or documents and responses exchanged with ECOH. Establish a co-operative plan with the developer to ensure that risk mitigation measures are implemented as expected, hazards are controlled, and corrective action is taken immediately if expectations are not met. The plan should include third party monitoring and procedures for resolving issues. The third party chosen must have a demonstrated perspective of all the risks identified and the sensitive populations at risk.

All risk mitigation measures should be supported through a co-operative plan whereby mitigation implementation and hazard control will be monitored by a third party during all stages of construction, with prompt action on the part of TDSB and the developer to address any issues.

If on the other hand, no credible third party is on-site to monitor and document the constructor's daily activities and empowered to take action when and if necessary, we would deem the risk to fall within an unacceptable range and would not recommend continued occupancy during construction.

1. INTRODUCTION

A 35-story residential tower has been proposed for the site of 18 Erskine Avenue in Toronto, adjacent to the property of John Fisher Public School (JFPS), a school under the jurisdiction of the Toronto District School Board (TDSB). KG Group, the developer of the proposed building (which was previously identified as 30 Erskine Avenue), indicated that it may take up to three years to complete the project.

Due to concerns for the health, safety, learning and development of students, the TDSB engaged ECOH Management Inc. (ECOH) to assess risks posed to JFPS occupants during demolition, excavation, and construction of the tower and after building completion. ECOH proposed a four- phased approach to the risk assessment, comprising:

- **Phase I: Generic Risk Assessment**: hazard identification and a qualitative assessment based on reviews of the literature and relevant available information;
- **Phase II: Site Specific Risk Assessment**: characterizing identified risks based on specific information about the project site and construction plans; TDSB also requested that the Phase II risk assessment include an opinion as to whether students should be removed from the school while construction is under way;
- **Phase III: Site Monitoring**: monitoring the degree of hazard exposure when the project is under way; and
- **Phase IV: Post-Construction Assessment**: to be conducted after project completion to assess conditions during ongoing occupancy of the school in relation to the completed project.

For the Phase I assessment, ECOH identified hazards in five categories: chemical, physical, biological, safety and psychosocial. Risks were assessed using a risk matrix that combined ratings of hazard severity and probability of harm. Potential impacts on learning as well as on health and safety were considered for each hazard, and risks were assessed for the four stages of the project: demolition, excavation, construction and finished building. Detailed results of the Phase I assessment are contained in a report submitted by ECOH to TDSB titled “Preliminary Risk Assessment, Hazards from Construction Project near John Fisher Public School” dated March 13, 2017 (Appendix).

Phase I was a generic risk assessment based on a review of the literature and other publicly available information. In conducting the Phase I assessment, ECOH had only limited information specific to this project and did not discuss risk mitigation measures with the constructor or developer. In the absence of full information on risk mitigation measures, there was considerable uncertainty associated with the Phase I risk ratings, which were intended as preliminary indicators of potential risk or level of concern. Therefore, ECOH was requested to proceed with Phase II “Site -Specific Risk Assessment”. The Phase II assessment, represented by this report, more specifically characterizes risk based on information about the project site and construction and risk mitigation plans.

To carry out the Phase II assessment, ECOH investigators met with the developer (KG Group), shared the results of the Phase I assessment, and asked for information about risk mitigation and construction plans for this project. The developer provided written responses to ECOH's questions and mitigation plans developed by their consultants. In addition, the developer also shared their construction mitigation plan (CMP). Details of the construction activities (below and above grade) are described in the CMP and are therefore not repeated in this report.

In addition, ECOH contacted City of Toronto officials in the Planning, Building Transportation and Health departments to get their perspectives and views on the subject. ECOH also retained two subject matter experts, Hite Engineering Corporation (www.hite-engineering.com) – a consulting engineering firm that specializes in construction safety, and Intrinsik (www.intrinsik.com) - a scientific and regulatory consulting firm providing expert toxicology and regulatory advice for the protection of human health and the environment, to provide advice on safety and health considerations.

The approach to the assessment, including methodology, assumptions and limitations are described in Section 2. Findings and ratings of the hazards are provided in Sections 3 through 7. Recommendations and Conclusions are in Sections 8 and 9.

Information about the nature of the hazards considered, and general considerations about the likelihood of harm are described in depth in the Phase I report. Risks were assessed based on hazard severity and probability of harm, using a risk matrix modified from the Phase I report. As hazard severity (ability to cause harm) does not change with mitigation (unless the end point is changed), the only change resulting from mitigation is in the probability that harm would occur. The assessed risks in this Phase II report should be considered the residual risk if the *specified mitigation plans are implemented, diligently adhered to and strictly enforced.* For the most part, discussion of hazard impacts and rationale for hazard severity ratings are not repeated in the Phase II report; therefore, the Phase I report (appended to this report) should be consulted for further details about potential effects of each hazard.

2. METHODS AND CONSIDERATIONS

2.1 Hazard Identification

Hazards were grouped into standard categories of environmental and occupational hazards, as set out in Table 2.1.

Table 2.1. Identified Hazards

Chemical Hazards	Physical Hazards	Biological Hazards	Safety Hazards	Psychosocial Hazards
Asbestos Lead Respirable Crystalline Silica Diesel Exhaust (including particulates and gaseous constituents) Dust Volatile Organic Compounds Asphalt fumes Indoor Air Quality	Noise Vibration Radon Welding Radiation	Pests Microbial agents	Traffic Cranes Falling & Moving Objects Structural Stability & water table issues Fire and explosion Utility Issues Electrical Access to site or school	Stress Effects on learning environment (not elsewhere considered), including lighting and limitations on outdoor activities (recess)

2.2 Risk Assessment Approach

The risk posed by a given hazard is a function of two factors:

- The inherent severity of the hazard – i.e. how much harm it can potentially cause. Harm can be any change in body functions affecting health status or change in mental condition affecting learning and development; and
- The probability that the hazard will cause harm. In the case of a health hazard, this is usually a function of the level of exposure; in the case of a safety hazard it is the probability that the hazard will lead to an event that can cause injury or other harm.

In conducting an assessment, each hazard is rated based on the severity of its potential effects, and the probability that it would cause those effects, or of an exposure level that may cause harm. A common way to combine these two factors is through a matrix, one dimension of which represents severity of the hazard, with the other representing probability.

Matrices used for assessment purposes typically divide severity and probability into 3,4 or 5 levels. Guidance material on risk assessment matrices emphasizes that, "There is no one simple or single way to determine the level of risk. Ranking hazards requires the knowledge of the …activities, urgency of situations, and most importantly, objective judgement" (1). In constructing the matrix used for this assessment, ECOH consulted Canadian Standards Association (CSA) Standard Z1002, Occupational health and safety - Hazard identification and elimination and risk assessment and control (2) and the American National Standards Institute (ANSI) Z10, Occupational Health and Safety Management Systems Standard (3).

While the Phase I assessment used a 4 x 4 matrix to rate potential risks, it was decided to use a 5 x 4 matrix for the Phase II assessment, adding a probability level at the low end of the range. This is because, with more detailed information on the site and construction plans, it is necessary to show how probability ratings may be affected by risk mitigation measures. Similarly, overall risk levels are divided into four bands rather than three. This allows the ratings to reflect the changes in probability and risk levels expected in view of the specific site information and construction plans. Severity ratings, however, have not been changed, because the severity of the hazard is intrinsic to that hazard.

Definitions for severity and probability used to rate each hazard, and construction of the matrix are described in the following sections.

2.3 Effects and Construction Stages Considered

ECOH was asked to consider hazards as they may affect the school differently in separate stages of construction, and when the building is complete. ECOH was also asked to consider not only impacts on health and safety, but also on learning. Accordingly, the criteria for severity were applied to separately rate potential impacts on health and safety, and potential impacts on learning. The criteria for probability were applied separately for four stages of the project: demolition, excavation, construction, and finished building. As a result, eight separate ratings are derived for each hazard (4 stages for health and safety impacts plus 4 stages for learning impacts).

As explained in the Phase I report, in considering potential health effects of the hazards, the assessment was based on the most sensitive population exposed. In most cases, this was children. The Phase I report provides a detailed explanation of why children may be more sensitive than adults to some health hazards.

2.4 Rating Criteria

Criteria used to rate the severity (S) and probability (P) for each hazard are shown in Tables 2.2 and 2.3, with S1 and P0 the lowest ratings. The severity criteria are the same as for Phase I; the probability criteria include one new level at the low end. To retain consistency with Phase I probability levels P1 through P4, this lowest level has been designated P0. To elaborate on definitions of probability levels, Table 2.3 includes wording for comparable probability levels in CSA Z1002 (2), Table A.9. It should be noted that probability ratings are based on exposure or probability of the hazard above background levels.

Table 2.2. Criteria for Severity Rating

Rating	Criteria
S4 -Catastrophic	Death or permanent total disability in the short-term Complete system loss, major property damage Major disruption of learning (e.g. school closure for one week or more)
S3 -Major	Chronic / Irreversible Permanent, partial or temporary disability in excess of three months including chronic effects that may not occur until many years after exposure Serious disruption of learning (e.g. property damage, school downtime one day or more; inability to carry on normal teaching and classroom activities)
S2 -Moderate	Reversible Injury that can cause loss of time from work or school Minor property damage; downtime to school operation less than one day Moderate disruption of teaching or learning due to annoyance, distraction, anxiety
S1 -Minor	No health or safety deviation from baseline Minor annoyance or distraction

Table 2.3. Probability Criteria

Rating	Criteria*	Definition for comparable levels, CSA Z1002
P4- Likely	Could occur several times during that stage of the project	Can occur as a result of varying conditions in the hazard zone and is expected as a result of circumstances associated with the product, process or service
P3- Possible	Could occur during that stage of the project	Can occur as a result of foreseeable occasionally varying conditions and is known to have occurred occasionally
P2- Improbable	Not likely to occur during that stage of the project	Can occur as a result of foreseeable faults or failures of controls and is known to have occurred infrequently
P1 – Remote	Very unlikely to occur during that stage of the project	Can occur as a result of a foreseeable and rare combination of circumstances, or of foreseeable faults or failures of controls, and is known to have occurred very infrequently
P0- Very Remote	Extremely unlikely to occur during that stage of the project	Can occur as a result of a foreseeable and rare combination of circumstances and is known to have occurred at some point.

*based on probability or exposure levels above background

2.5 Risk Assessment Matrix

The matrix used to combine Severity and Probability ratings and group them into bands is shown in Table 2.4.

Table 2.4. Risk Assessment Matrix

Severity						
Severity	Catastrophic S4	Low	Low	Medium	High	High
Severity	Major S3	Very Low	Low	Medium	Medium	High
Severity	Moderate S2	Very Low	Low	Low	Medium	Medium
Severity	Minor S1	Very Low	Very Low	Very Low	Low	Low
		Very remote P0	Remote P1	Improbable P2	Possible P3	Likely P4

Probability

2.6 Evidence Sources

Evidence sources for this Phase II assessment included the evidence considered for the Phase I assessment, a supplementary literature review on some issues, ECOH reports and observations at JFPS, and additional information provided by the developer and the City of Toronto.

After transmittal of information to ECOH, the developer consolidated most of it into a revised Construction Mitigation Plan dated April 6, 2017 (CMP) (4) which appended and referenced the documents previously provided. Other documents provided by the developer and not included in the CMP and appendices were:

- KG response specifically addressing questions posed by ECOH (5)
- Letter to KG from exp Services Inc. regarding air quality (6)
- Post construction Pest Management Protection Program by Orkin group (7)

Findings from these sources, and risk ratings based on these findings, are described for each hazard group in Sections 3 to 7.

3. CHEMICAL HAZARDS

3.1 Asbestos

Although new uses of asbestos in buildings are prohibited, asbestos remains present in many building materials. As explained in the Phase I report, exposure to asbestos in occupied buildings occurs mainly through inhalation of airborne fibres released from asbestos-containing materials (ACM). Such exposure can cause a severe lung disease called asbestosis and also increase the risk of cancer. In view of these potential effects, severity of asbestos exposure was rated S3. Probability was rated P3 or possible, with resulting risk rating of medium for Phase I..

3.1.1 Potential Exposure

The release of fibres from the ACM depends on the condition of the ACM, wear and tear of the ACM and if the ACM is disturbed, as it may be when subjected to impact or vibration. In the Phase I assessment, ECOH identified three possible sources of asbestos that could cause exposure as a result of the project: ACM in the JFPS building; ACM in the building to be demolished; and asbestos in the brake pads of vehicles that may be used at the construction site.

ACM in JFPS: ECOH and other consultants to TDSB have surveyed JFPS and identified confirmed ACM and materials that are presumed to contain asbestos (presumed ACM). Confirmed ACM includes ceiling tiles, parging cement on fittings, cellulose and tar paper on straight run pipe, and aircell insulation on straight run pipes. Presumed ACM includes plaster in various locations, window caulking, drywall joint compound, vinyl floor tiles, bell and spigot joints, fire doors, asbestos chalkboard and transite asbestos cement on ceilings. The latest asbestos survey carried out by ECOH in March 2017 showed ACM to be in good condition, no friable ACM in the occupied areas and a robust asbestos management plan in place. Under these conditions, release of asbestos fibres is not expected.

The Phase I report also identified a possibility that vibration transmitted to JFPS structures due to demolition and excavation on the adjacent project may facilitate release of asbestos fibres from ACM in otherwise satisfactory to good condition. To further consider this possibility, the developer was asked to provide a vibration report. A vibration report by HGC Engineering was included as Appendix 6 in the CMP; a letter from HGC addressing issues identified in the Phase I report was also attached to the CMP as Appendix 5.

Vibration levels are measured as peak particle velocity (PPV) and the units of measurement are millimeters per second (mm/s). According to the report prepared by HGC Engineering, the predicted worst case peak particle velocity (PPV) for the JFPS building is 2 mm/s during excavation and foundation work. The HGC report recommends cautionary vibration limits (PPV) of 3 mm/s for sensitive or heritage-designated buildings (of which JFPS is one).

The HGC report further stated that because of uncertainties in vibration levels, HGC recommends vibration monitoring appropriate to the nature of the activity being conducted on the project site. If vibration levels become a concern, as HGC states they may during certain operations, a change in methods can be adopted.

Based on the facts that the anticipated vibration levels are low, and the ACM in JFPS is in good to satisfactory condition, and the developer's intent to monitor vibration during construction, the probability of fibre release from the ACM in JFPS due to the construction project is rated as remote (P1). This is a change from the generic Phase I assessment where the exposure potential was estimated as possible (P3).

ACMs in the building to be demolished: A Designated Substance survey report of the building to be demolished, conducted in March and August 2016 (CMP Appendix 9), stated that ACM was present in the building. The developer provided a clearance letter dated September 1, 2016, (CMP Appendix 10) indicating that ACM had been removed. The hazard has therefore been eliminated from this source.

Asbestos in Brake Pads of construction vehicles: As mentioned in the Phase I assessment, another possible source of asbestos from the proposed project is brake pads, if they are used on the construction vehicles. Although asbestos is no longer used in products manufactured in Canada, the Ontario Ministry of Labour has warned that aftermarket brake pads containing asbestos are still imported into the country (8). While this is mainly a hazard for mechanics working on vehicles, some asbestos fibres may be released from brake pads in use on vehicles. In response to a query from ECOH about the use of asbestos brake pads on construction vehicles, the developer stated, "Given that the actual application of brakes on the site is limited due to the site activities, the size of the site and speed limitation on Erskine Avenue, this risk would be negligible." There is good reason to accept that assessment and therefore asbestos exposure potential from this source is rated as extremely remote (P0).

3.1.2 Risk Assessment

As discussed, the probability of asbestos fibre release and resulting exposure due to the project is judged to be remote (P1). Based on the criteria for severity (S3) and a probability rating of P1, the resultant health risk is rated low for health and learning during the demolition, excavation and construction stages. Maintenance of low risk levels can be assured through vibration monitoring at JFPS during project activities involving higher vibration potential, along with modifications of methods should vibration levels exceed criteria, as recommended by HGC Engineering. In addition, regular inspections of ACM and presumed ACM should be conducted within the school, to ensure that there is no damage with potential for fibre release.

Ratings and explanations for severity, probability and risk for health and learning for each stage are provided in Table 3.1.

Table 3.1. Risk Rating for Exposure to Asbestos

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increases risk of cancer (long latency; would not appear for many years, if at all)	P1	The vibration report predicts worst case PPV vibration at the JFPS building to be below recommended criteria for heritage buildings – therefore remote probability that fibres will be released from ACM in the school due to vibration; this can be further assured by vibration monitoring and regular inspection of ACM conditions; there is very low potential for release from brake pads on vehicles	Low
	Learning	S2	Anxiety due to potential for asbestos exposure (e.g. among staff) may have adverse effect on learning	P1		Low
Excavation	Health	S3	As above	P1	As above	Low
	Learning	S@		P1		Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Construction	Health	S3	As above	P0	Vibration at JFPS due to the project is not predicted after the excavation stage	Very Low
	Learning	S2		P0		Very Low
Finished Building	Health	NA	NA (not applicable)	NA	Not applicable: no expected source of asbestos or cause of fibre release	NA
	Learning	NA		NA		NA

3.2 Lead and Mercury

As stated in the Phase I report, lead-based paints may remain present in older buildings. Exposure to lead in buildings occurs mainly through inhalation and ingestion of lead-containing dust (e.g. from flaking lead paint). As the potentially harmful health impacts of lead described in the Phase I report will not change with any mitigation steps, the severity ratings will remain the same. However, the potential for exposure may vary depending on circumstances and the mitigation steps undertaken.

As mercury is contained in many electrical components, this section considers the possibility of mercury as well as lead exposure.

3.2.1 Potential Exposure

Lead

In the Phase I assessment, ECOH identified three potential sources of lead that could impact exposure: lead-containing paint in JFPS; lead paint in the building to be demolished; and lead in the soil on the project site.

Lead-containing paint in JFPS: ECOH and other consultants to TDSB have surveyed JFPS and identified lead-containing paint in some locations. The TDSB management plan will ensure that this paint is maintained in good condition.

The Phase I report identified vibration transmitted to the JFPS structure due to demolition and excavation as a possible cause of release of lead dust from paint inside the school. The vibration report by HGC Engineering (CMP Appendix 6) was reviewed to assess this possibility. As noted in the previous section, the predicted vibration levels are low (2mm/s) and hence potential for release of lead dust due to vibration is judged to be remote.

Lead-containing paint in the building to be demolished: The 2016 Designated Substance report for the building to be demolished (CMP Appendix 9) stated that lead based paints were present in the building. ECOH therefore asked the developer for further information about demolition methods. The developer responded as follows:

"…if materials coated with lead-based paint are tested and found to be below the leachate threshold, any loose lead flakes will be scraped off, so as to ensure that they do not become airborne during the demolition. The rest of the material will be removed as part of the structural demolition. If the material is above the threshold, all material will be removed according to MOE and MOL standards, prior to structural demolition. As with all the structural demolition, … dust will be controlled by constantly wetting the building during demolition with water hoses and water cannons."

The response went on to refer to the developer's Dust Management Program (CMP Appendix 7).

In view of these procedures and the low anticipated time for demolition (about 10 days), the probability of release of lead dust from this source and the resulting probability of lead exposure is judged to be remote (P1).

Lead in soil and ground water: As discussed in the Phase I report, lead and other heavy metals are common constituents of the Canadian soils. ECOH therefore asked the developer to provide copies of the Environmental Site Assessments (ESA) for the project site. Phase I and Phase II ESAs and an update dated December 21, 2016 were appended to the CMP (CMP Appendix 12).

The Environmental Site Assessment reported on tests of concentrations of lead and other heavy metals in the site soil and groundwater. Concentrations were found to be detectable but below applicable standards set by the Ministry of the Environment and Climate Change (MOECC). Based on the low concentration of lead in soil and groundwater, it is concluded that exposure to lead above background levels from this source is extremely remote and hence the probability of lead exposure from this source is rated P0.

Mercury

The Designated Substance Assessment carried out at the building to be demolished identified the presence of fluorescent lamps and CFL bulbs that are known to contain mercury. ECOH therefore requested the developer to provide plans for handling electrical equipment that may contain mercury in the building to be demolished. The developer's response stated that electrical equipment of this nature would be removed prior to demolition, thereby preventing potential for exposure to mercury.

3.2.2 Risk Assessment

The potential for exposure to lead arising from the construction project is judged to be remote during demolition and excavation and very remote during construction. Therefore, the risks associated with exposure to lead vary from low (during demolition and excavation) to very low during construction. Table 3.2 provides the risk ratings for lead exposure on health and learning for each stage of construction.

Table 3.2. Risk Rating for Exposure to Lead

<table>
<tr><th rowspan="2">Stage</th><th rowspan="2">Effects</th><th colspan="2">Severity</th><th colspan="2">Probability</th><th rowspan="2">Risk Rating</th></tr>
<tr><th>Severity Rating</th><th>Severity Rationale</th><th>Probability Rating</th><th>Probability Rationale</th></tr>
<tr><td rowspan="2">Demolition</td><td>Health</td><td>S3</td><td>Neurological & cognitive effects</td><td>P1</td><td rowspan="2">Lead-painted materials that may be present in the building to be demolished will be removed in a manner that prevents lead from becoming airborne; vibration levels unlikely to be sufficient to dislodge lead from surfaces in JFPS. Electrical equipment that may contain mercury is planned to be removed prior to demolition.</td><td>Low</td></tr>
<tr><td>Learning</td><td>S1</td><td>No disruption of learning (cognitive effects are considered to be health effects)</td><td>P1</td><td>Very Low</td></tr>
<tr><td rowspan="2">Excavation</td><td>Health</td><td>S3</td><td rowspan="2">As above</td><td>P1</td><td rowspan="2">Soil on project site does not contain elevated levels of lead; vibration levels unlikely to be sufficient to dislodge lead from surfaces in JFPS</td><td>Low</td></tr>
<tr><td>Learning</td><td>S1</td><td>P1</td><td>Very Low</td></tr>
<tr><td rowspan="2">Construction</td><td>Health</td><td>S3</td><td rowspan="2">As above</td><td>P0</td><td rowspan="2">Construction materials very unlikely to contain lead; vibration very unlikely to be sufficient to dislodge any lead paint in JFPS</td><td>Very Low</td></tr>
<tr><td>Learning</td><td>S1</td><td>P0</td><td>Very Low</td></tr>
</table>

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Finished Building	Health	NA	Not applicable (NA)	NA	Not applicable: No anticipated source	NA
	Learning	NA		NA		NA

3.3 Diesel Exhaust

As explained in the Phase I assessment, diesel exhaust is a mixture of gases and particles generated from combustion engines in cars, trucks and heavy machinery (9). Construction vehicles and equipment that are powered by diesel engines emit more than 40 toxic particulates and gaseous components, including carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), nitrogen oxides (NOx), sulphur oxides and particulate matter (10) (11). Health effects of these constituents include their respiratory effects and potential to cause cancer.

This section considers exposure to nitrogen oxides as part of diesel exhaust, though these substances are discussed separately in the Phase I assessment. Sulphur oxides, which were also discussed separately in the Phase I assessment. are not discussed here because they were judged to constitute a lower risk, and will therefore be successfully mitigated if risks of diesel emissions including nitrogen oxides are controlled.

The Phase I assessment identified diesel exhaust including nitrogen oxides from vehicles and construction equipment among the hazards that could risk the health and safety of JFPS occupants. The probability of exposure to diesel exhaust was considered likely (P4) and the risk was rated high.

The developer was asked to provide a diesel emissions modelling study, measures to control emissions from the parking garage of the finished building, and confirmation that emissions from all diesel and combustion equipment meets Canadian and Ontario standards. In addition, ECOH sought information from City of Toronto Public Health about their opinions on mitigating risks.

The developer provided a response to the Phase I assessment prepared by exp Services Inc., a Dust Management Plan also prepared by exp (CMP Appendix 7), and KG's response to questions posed by ECOH.

3.3.1 Potential Exposure

The response by exp Services Inc. states that diesel emissions are minimized through the active enforcement of equipment measures with the Site Health and Safety Plan. exp's response and the Dust Management Plan state the following measures for controlling diesel emissions:

- Pre-use, pre-project and annual inspections of equipment;
- Use of new or well-maintained heavy equipment with fully functional emission control systems/muffler/exhaust system baffles, including diesel exhaust scrubbers or catalytic converters;
- Minimizing operation and idling of vehicles, avoid operating and idling gas-powered equipment during smog advisories;
- Limiting queuing for arriving vehicles;
- Preventive maintenance of equipment;
- Monitoring for carbon monoxide, which is an indicator of exhaust emissions;
- All equipment will be authorized to operate in Canada and Ontario;
- Limitation of excavation activities during unfavourable weather conditions; and
- The intent that power be provided by Toronto Hydro, but in the event that a generator is required, Tier 3 generators would be used and they would be located on the west side of the property (further away from JFPS).

The exp response states that TDSB plans to provide air conditioners for all rooms and wood hoarding on the west property line. However, at this time, TDSB does not have definite plans for these controls, and they are therefore not considered in assessing risks.

While the proposed measures will provide some mitigation of diesel emissions, uncertainty remains as to the level of exposure. Therefore, air monitoring is appropriate to ensure that occupants of JFPS are not exposed to elevated levels of diesel exhaust.

The Dust Management Plan provides for real time monitoring of PM10 at the property boundary. (PM means "particulate matter"; "10" denotes dust particles with diameters of 10 microns or less). Monitoring will include background, upwind and downwind monitoring. Concentrations will be recorded every 15 minutes and averaged over 24 hours. The intent is to ensure that concentrations remain below the Ministry of the Environment and Climate Change (MOECC) Ambient Air Quality Criterion (AAQC) of 50 $\mu g/m^3$ (micrograms per cubic meter) averaged over 24 hours.

As described by MOECC, "an AAQC is a desirable concentration of a contaminant in air, based on protection against adverse effects on health or the environment. The term 'ambient' is used to reflect general air quality independent of location or source of a contaminant." (12)

The Dust Control Plan states that if 15-minute concentrations exceed 30 µg/m^3 above background, additional dust control measures will be employed to ensure the AAQC is not exceeded.

The plan to monitor for PM10 is not sufficient to assess airborne concentrations of diesel emissions, which have lower particle sizes. In assessing concentrations of diesel emissions, it is more appropriate to monitor for PM2.5 (particles with a diameter of 2.5 microns or less). Monitoring for carbon monoxide as a proxy for diesel emissions, which is provided for in the Dust Management Plan, is also not sufficient to assess whether the diesel exhaust is adequately controlled.

An appropriate benchmark for PM2.5 concentrations is 25 µg/m^3 above background. This is based on MOECC's statement in the AAQC document that "… as a minimum, the contribution of primary PM2.5 from a single facility to ambient levels of PM2.5, should be no more than 25 µg/m^3 (24 hr)… This 25 µg/m^3 (24 hr), with no conversion to other averaging times, can be used as a guide for decision making in the close vicinity of individual sources, which are primary emitters of PM2.5". (12)

Toronto Public Health has indicated in verbal communications with ECOH that in its comments on the demolition application it intends to recommend monitoring for PM2.5 in addition to PM10.

It is also advised that monitoring be conducted for nitrogen oxides. This is because NOx from diesel emission sources are a particular short-term concern due to their capacity to cause asthma in children. Therefore, monitoring should be conducted for NOx at the property line, with a 1-hour action level of 80 ppb (150 µg/m^3) above background for further mitigation action. This is based on the 1 hour ambient air criterion for NOx of 100 parts per billion (ppb) (188 µg/m^3) derived by the US Environmental Protection Agency (EPA) (13)

In response to ECOH's request to the developer regarding measures to control emissions from the parking garage of the finished building, KG stated that exhaust vents from the parking garage will be re-located to the northwest corner of the building from the southeast corner, further away from JFPS property. This change to the plans were made at the request of the City of Toronto after location of these vents were flagged in the Phase I assessment.

3.3.2 Risk Assessment

There remains some uncertainty about the extent of exposure to diesel exhaust, especially as the developer did not provide specific information about the equipment to be used and the number of pieces of equipment used at one time. However, if the proposed mitigation steps are diligently implemented, the probability of harm would be reduced from likely (P4) to possible (P3) during the demolition and excavation stages when the heaviest equipment will be used. Probability during the construction stage is rated P2 or improbable. These result in risk ratings for health of medium during demolition, excavation and construction stages.

Probability could be further reduced through monitoring for PM2.5 and nitrogen oxides, provided that corrective action is taken if levels are found to exceed the recommended action levels.

Probability of exposure due to the finished building is considered remote (P1), as presence of diesel equipment would be rare and the exhaust vents have been re-located further away from JFPS. Ratings for each stage are explained in Table 3.3.

Table 3.3. Risk Rating for Exposure to Diesel Exhaust including Nitrogen Oxides

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increased risk of cancer and respiratory diseases	P3	Emissions from equipment will be mitigated by stated control measures, but uncertainty remains in the absence of verification by PM2.5 and NOx monitoring	Medium
	Learning	S2	Annoyance due to odours, irritation	P3		Medium
Excavation	Health	S3	As above	P3	See above	Medium
	Learning	S2		P3		Medium
Construction	Health	S3		P2	Construction equipment less likely to emit high levels of diesel exhaust	Medium
	Learning	S2		P2		Low
Finished Building	Health	S3		P1	Possible emissions from parking garage will be mitigated by moving the exhaust further away from the school; minimal vehicle increase above baseline	Low
	Learning	S2		P1		Low

3.4 Dust (Crustal or Not Otherwise Classified – NOC)

As explained in the Phase I assessment, when evaluating potential exposure to particulate matter, also referred to as dust, it is important to distinguish between crustal and combustion sources because there are pronounced differences in terms of human health effects.

Crustal particulate matter is typically larger in size and is associated with mechanical and abrasive processes such as wind erosion, road dust raised by vehicular motion, tire and brake wear, sanding and grinding operations. In construction operations, crustal particulate matter can become airborne due to the movement of soil and demolition/excavation/building activities. The weight of evidence suggests that crustal PM is of markedly lower toxicity than PM derived from combustion processes such as fossil fuel-fired vehicles and equipment.

The size of the particulate matter is directly related to its effect, with smaller particle sizes posing the greatest threat because they have the ability to penetrate deep into the lungs and may enter the bloodstream (14). Exposure to these particles can impact both the respiratory and cardiovascular systems. Large particles are of less concern because they do not penetrate as deeply into the lungs as smaller particles, although they can cause eye, nose and throat irritation.

Following the Phase I study, the developer was asked to provide a dust modelling study and specific dust prevention and control measures. In addition, ECOH sought information from City of Toronto Public Health about their opinions on mitigating risks from particulate matter.

The developer provided a response prepared by exp Services Inc., a Dust Management Plan also prepared by exp (CMP Appendix 7), and KG's response to questions posed by ECOH.

3.4.1 Potential Exposure

As explained in the Phase I assessment, all construction stages involve potential for exposure to crustal particulate matter from demolition of the existing building, movement of soil and construction activities. The level of off-site exposure to dust is dependent on the type of construction activity, the distance from the site, the wind direction and speed, as well as any implemented dust mitigation measures.

The Dust Management Plan prepared by exp Services Inc. contains a variety of dust control measures including wet methods, covering of soil and other material, washing of vehicles and surfaces, adjustment of work during high winds, and worker training. Exp's response to the Phase I assessment states that dust control measures will be consistent with the requirements of Toronto Public Health.

As explained in the previous section, the Dust Management Plan also provides for real time monitoring of PM10 at the property boundary. The intent is to ensure that concentrations remain below the Ministry of the Environment Ambient Air Quality Criterion (AAQC) of 50 $\mu g/m^3$ (micrograms per cubic meter) averaged over 24 hours. The Dust Control Plan states that if 15-minute concentrations exceed 30 $\mu g/m^3$ above background, additional dust control measures will be employed to ensure the AAQC is not exceeded.

Toronto Public Health has indicated in verbal communications with ECOH that in its comments on the demolition application it intends to recommend monitoring for PM10.

3.4.2 Risk Assessment

The dust control measures specified by exp Services and the developer are expected to satisfactorily control crustal dust, provided that corrective action is taken if PM10 concentrations exceed the action level of 30 µg/m^3. Therefore, probability of overexposure is rated remote, P1, during all construction stages, resulting in a risk rating of low. This hazard is not applicable to the finished building. Explanations are provided in Table 3.4.

Table 3.4. Risk Rating for Exposures to Crustal Dust

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Irritation	P1	Dust control measures, reinforced by monitoring and corrective measures if action level exceeded, are expected to control exposure	Low
	Learning	S2	Annoyance	P1		Low
Excavation	Health	S2	As above	P1	As above	Low
	Learning	S2		P1		Low
Construction	Health	S2		P1		Low
	Learning	S2		P1		Low
Finished Building	Health	NA	NA	NA	Not applicable: no source expected	NA
	Learning	NA		NA		NA

3.5 Silica

As explained in the Phase I assessment, potential effects from exposure to crystalline silica vary greatly with the particle size, concentration and duration of exposure. The form of silica that can cause harmful respiratory health effects is respirable crystalline silica, i.e. silica in crystal form that is airborne as particles small enough to be inhaled into the deepest parts of the lungs (the respirable fraction). Construction activities that may generate airborne silica include demolition, excavation, and chipping, drilling, sawing and similar activities on concrete or masonry.

3.5.1 Potential Exposure

Activities that control airborne dust will also serve to control airborne respirable silica. Therefore, the information requested and received from the developer and Toronto Public Health concerning dust control, as described in the preceding section, was also considered in evaluating the probability of exposure to silica.

These measures are judged to be satisfactory in controlling exposure of respirable crystalline silica, provided that corrective action is taken if monitoring for PM10 shows concentrations to exceed 30 µg/m^3. This is because studies have generally found concentrations of free crystalline silica in respirable construction dust to range up to 10% (15)(16). Therefore, at a PM10 concentration of 30 µg/m^3, the concentration of free crystalline silica would likely be less than 3 µg/m^3, below the 24-hour AAQC of 5 µg/m^3, with a ratio of action level: AAQC the same as that for PM10.

3.5.2 Risk Assessment

As the criteria for severity ratings have not changed, severity for silica remains S3, as set out in the Phase I assessment. The dust control measures specified by exp Services and the developer are expected to satisfactorily control silica along with crustal dust, provided that corrective action is taken if PM10 concentrations exceed the action level of 30 µg/m^3. Therefore, probability of overexposure is rated as remote, P1, during all construction stages, resulting in a risk rating of low. There is no expected source of airborne silica from the finished building.

Ratings for each stage are provided in Table 3.5.

Table 3.5. Risk Rating for Exposure to Silica

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increases cancer risk if inhaled in respirable size and crystalline form	P1	Dust control measures, reinforced by monitoring and corrective measures if action level exceeded, are expected to control exposure	Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S1	Will not disrupt learning	P1		Very Low
Excavation	Health	S3	As above	P1	As above	Low
	Learning	S1		P1		Very Low
Construction	Health	S3		P1		Low
	Learning	S1		P1		Very Low
Finished Building	Health	NA	Not applicable	NA	Not applicable: No source of silica-containing dust	N/A
	Learning	NA		NA		NA

3.6 Asphalt Fumes

3.6.1 Potential Exposure

The Phase I assessment considered the possibility of exposure to asphalt on the JFPS property if it is applied on the parking lot or roof of the building to be constructed at 18 Erskine Avenue. Therefore, the developer was asked to provide information on expected use of asphalt.

In response, the developer stated that there will be no asphalt applied on the parking lot or driveway. If there is a requirement for asphalt on the roof, the asphalt kettle will be located on the roof and secured appropriately.

As there will be no asphalt used at ground level, and as the roof is 35 stories in the air, the probability of exposure to asphalt fumes on the JFPS property is considered remote (P1).

3.6.2 Risk Assessment

Based on the criteria for severity and probability ratings set out in section 2.5, asphalt fumes are considered a low risk for health and learning, as explained in Table 3.6.

Table 3.6. Risk Rating for Exposure to Asphalt Fumes

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA
Excavation	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA
Construction	Health	S3	Respiratory effects, CNS depression, possible carcinogen	P1	Asphalt will not be applied at ground level. It may be used on the roof and if used, the kettles will be placed on roof, making the likelihood of exposure at JFPS remote.	Low
	Learning	S3	Distracting or irritating odour	P1		Low
Finished Building	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA

3.7 Volatile Organic Compounds (VOCs)

Volatile Organic Compounds (VOCs) are a group of carbon-based substances that are liquid but readily evaporate at room temperature. Many compounds such as turpentine and kerosene are widely known and used as solvents or fuels. The gases given off when these substances evaporate, called vapours, can often be smelled at low concentrations and may be irritating.

The Phase I risk assessment discussed the possibility that VOCs may become airborne during demolition or excavation if VOCs are present in excavated soil or water or released from any containers such as fuel tanks on site. Phase I also considered the possibility that vibration from demolition or excavation may cause damage to the JFPS building resulting in vapour intrusion, if there is VOC contamination of soil or groundwater (17).

Other possible sources are VOC-containing products used during the construction stage. These may include paints, coatings, and adhesives.

Documents reviewed for the Phase II assessment included the Environmental Site Assessment (ESA) (CMP Appendix 12) and KG's response to queries regarding VOC-containing products.

As the documents reviewed provide information on organic compounds that may not be volatile, these are considered in this risk assessment as well as VOCs.

3.7.1 Potential Exposure

The ESA reported on conditions and prior uses of the site, and testing of soil and groundwater for organic compounds. Relevant information from the ESA included the following:

- There were previously dry cleaning operations on and near the site. However, soil and groundwater testing did not reveal the presence of any detectable concentrations of chlorinated organic compounds that may be associated with dry cleaning.
- The ESA considered whether underground storage tanks used for heating oil or coal were present on site. It found no indication that such tanks had been present. Tests of soil and groundwater did not reveal detectable concentrations of petroleum hydrocarbon fractions that are associated with heating fuel. No aboveground tanks were observed.
- Tests found detectable concentrations of polycyclic aromatic hydrocarbons (PAHs) in soil on the site but these were below the Ontario Ministry of the Environment and Climate Change (MOECC) standards. (PAHs are organic compounds produced by incomplete combustion.)
- The ESA also commented on the possibility that polychlorinated biphenyls (PCBs) may be present in electrical equipment, such as transformers, capacitors and fluorescent light ballasts in the building to be demolished. PCB-containing equipment was not observed on the site, but the inspection did not include the interior of the building on site.

In response to a query from ECOH, the developer stated that items such as ballasts that may contain PCBs will be removed prior to demolition. In response to a query about VOC-containing products to be used during the construction stage, the developer stated that all products for paints, coatings and adhesives will be low VOC.

The possibility of structural damage to the JFPS building due to vibration is considered in section 4.2. This is relevant to the probability of vapour intrusion associated with structural damage. Predicted vibration levels are such that structural damage is not expected. Given the absence of VOCs in ground water and the low levels of vibration, the probability of vapour intrusion due to the project is considered very remote.

3.7.2 Risk Assessment

As there is very remote probability of vapour intrusion or exposure to VOCs from other sources during demolition and excavation, probability of exposure during these stages is rated P0.

Given the use of low VOC products and the wide dissipation of any organic vapours that may be emitted, the probability of exposure to VOCs during the construction stage is considered to be remote.

Therefore, based on the criteria for severity and probability ratings set out in section 2.5, VOCs and other organic compounds are considered to have very low risk for health and learning during the demolition and excavation stages and low risk during the construction stage. Explanations and ratings for health and learning for each stage are provided in Table 3.7.

Table 3.7. Risk Rating for Exposure to VOCs

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Possible effects on liver, kidney, blood, nervous system, respiratory systems. Most are reversible but some chronic effects are not	P0	In view of results of soil and water sampling, the probability of exposure during demolition is judged to be very remote	Very Low
	Learning	S2	Annoyance, distraction due to odours	P0		Very Low
Excavation	Health	S3	As above	P0	In view of results of soil and water sampling, the probability of exposure during excavation is judged	Very Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S2		P0	to be very remote; low probability of structural damage makes probability of vapour intrusion also very remote	Very Low
Construction	Health	S3	As above	P1	Low VOC products (e.g. paints, coatings, adhesives) will be used; any vapours emitted will dissipate over a wide area	Low
	Learning	S2		P1		Low
Finished Building	Health	S3	As above	P0	No source expected beyond normal conditions, e.g. cleaning products, some use of paints and adhesives	Very Low
	Learning	S2		P0		Very Low

3.8 Indoor Air Quality Comfort Factors

3.8.1 Potential Exposure

Indoor air quality (IAQ) comfort factors include thermal comfort (indoor temperature, relative humidity and air movement), contaminants in air (particulates, gases, vapours) and freshness of air. As explained in the Phase I assessment, the absence of mechanical air conditioning at JFPS engenders a risk of poor IAQ during hot weather when classroom windows are usually opened. If outdoor levels of noise and dust are objectionable, school occupants may be faced with a choice of opening windows and therefore enduring high noise or dust levels, or closing the windows which may result in adverse indoor conditions. If windows are kept closed, the amount of fresh air will be reduced, thereby increasing the probability of concerns related to poor indoor air quality. Similarly, when windows are closed during hot weather there is an increased likelihood that temperatures will at times exceed guidelines and pose a risk of adverse heat-related effects.

3.8.2 Risk Assessment

The Phase I assessment rated probability of exposure to poor indoor air quality and comfort factors as P4 or likely, because if windows are kept closed during hot weather in the absence of conditioned air, indoor temperatures and air quality are likely to reach unsatisfactory levels. This rating is not changed in the Phase II assessment, given the possibility that opening windows will lead to unacceptable conditions due to noise and possibly dust in the external environment. Therefore, indoor air quality comfort factors are considered a medium risk for learning and health during all construction stages (depending on weather conditions). This risk could be mitigated by providing air conditioning, making it unnecessary to open the windows during hot weather. Ratings for health and learning for each stage are provided in Table 3.8.

Table 3.8. Risk Rating Related to IAQ

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Possibility of heat-related illness, reactions to lack of fresh air	P4	Increased heat in hot humid weather if windows must be kept closed due to outdoor noise and dust (if there is no air conditioning); lack of fresh air if windows kept closed	Medium
	Learning	S2	Distraction, irritability, adverse impacts on learning from increased heat	P4		Medium
Excavation	Health	S2	As above	P4	As above	Medium
	Learning	S2		P4		Medium
Construction	Health	S2		P4		Medium
	Learning	S2		P4		Medium
Finished Building	Health	NA	NA	NA	No change from baseline conditions	NA
	Learning	NA		NA		NA

4. PHYSICAL HAZARDS

4.1 Noise

As explained in the Phase I assessment, noise is defined as unwanted sound. Adverse effects of noise considered in the Phase I assessment include auditory effects such as hearing loss and non-auditory effects including annoyance, cognitive impairment, sleep disturbance, stress, and cardiovascular health. Effects on learning include speech intelligibility and academic performance impacts. As described in the Phase I report, children are especially sensitive to effects of noise.

Based on these effects, the Phase I assessment rated the severity of noise as S3 for both health and learning. Probability of exposure was rated P4, or likely, during demolition, excavation and construction stages, resulting in a risk rating of high.

Following the Phase I assessment, the developer was asked to provide a noise modelling study and noise mitigation plan for the construction project. In response, the developer provided a letter dated March 29, 2017 from HGC Engineering on Noise and Vibration Considerations for John Fisher Public School, Construction Management Plan, 18 Erskine Avenue, Toronto (CMP Appendix 5).

4.1.1 Potential Exposure

The HGC report notes that the City of Toronto noise by law (Chapter 591) requires that construction equipment be equipped with an effective exhaust or intake-muffling device or other sound attenuation device of a type specified by the manufacturer, which is in good working order and in constant operation. The letter goes on to state that "no adverse acoustic impact on the health or learning of the students is anticipated". The basis for this conclusion includes the following assertions by HGC:

- There is a fair degree of naturally occurring noise mitigation simply due to the fact that a blank wall of the school faces the bulk of the construction site and the play area will be relocated farther away from the construction site by a buffer zone;
- Solid wood hoarding, a minimum of 2.4 m tall, should surround the site. This will provide a nominal 6 dB attenuation for sound from mobile equipment that is operating at grade on the construction site to students at grade. (It is noted that in the KG Response to ECOH, item # 5, it is stated that hoarding must be at least 1.8 meters high. This should be clarified. For the purpose of the noise assessment, it is assumed that the hoarding will be 2.4 m high and provides the 6dB attenuation claimed by HGC);
- For much of time, the excavation equipment will be operating below grade and will experience a higher degree of acoustic shielding, although some sources will be elevated above the hoarding and receive less shielding. Note that, while higher hoarding will provide some additional benefit, it will not be practical to completely shield all second storey windows from all activities on site;

- We understand that the school will install solid hoarding on their property which will provide an added 10 m buffer space and improved sound attenuation;
- It is understood that the TDSB will be providing every classroom and every office in the school with air conditioner units which will allow windows to remain closed;
- Tower cranes are generally not a significant noise source; and
- As the building rises, activities on the upper floor slabs will be shielded by the floor slabs themselves and further, once the curtain wall is installed, noise from internal construction activities will no longer be an issue.

In addition to these statements, HGC provided advice to the developer for other noise mitigation practices, including:

- Implement and enforce a no-idling policy for dump trucks, excavators and delivery trucks;
- Streamline the delivery access route to minimize truck movements on site. This will be further facilitated if Erskine Avenue is reconfigured to be a one-way street heading west;
- As much as practical, locate the staging area on the west side of the construction site, aligned with the blank wall of the school; and
- If an option exists, keep activities on the west side of the floor.

In addition to HGC's recommendations, the CMP included the following noise mitigation measures:

"The construction manager will work to minimize any excessive noise impacts…[and] employ following best management practices on site.

- The use of truck and equipment mufflers, including periodic inspections to ensure proper operation.
- Low pitch back up alarms.
- Limited truck or equipment idling.
- Provide temporary power connection to hydro grid to minimize the use of onsite generators.
- Smooth surfaces, except for the mud mat, on construction site and public ways to minimize unnecessary noise from potholes or irregularities."

The HGC letter states that the Phase I report "dramatically overstates" anticipated noise levels at the school but failed to provide the information requested (number of pieces of equipment that may be used at one time, information about the noise-emitting characteristics of the equipment that will be used, etc.) to determine site specific noise levels at each stage. Of necessity therefore, this assessment had to be based on reasonable assumptions of equipment typically used at different stages of high rise construction projects and authoritative published sources of noise levels from such equipment. Assessment of noise-related risk inside the school is based on anticipated noise from construction activities only and does not include noise from other sources such as traffic.

Our Phase II assessment also does not include two of the noise attenuation elements referred to in the HGC letter; the hoarding wall to be built by TDSB and installation of air conditioners in every classroom and office. This is because TDSB has said that, at present, it does not have plans to install air conditioning in every classroom and office or erect hoarding on school property.

In assessing noise risk, this report uses a benchmark of 45 dBA in an unoccupied classroom. The 45 dBA level is based on Ontario Ministry of Environment's Environmental Noise Control Guidelines (NPC-300) (18) which recommend that indoor noise resulting from road traffic not exceed 45 dB(A) in schools and daycare centres. A benchmark for outdoor noise levels we accepted is the World Health Organization (WHO) guidelines that recommend that noise from external sources in outdoor playgrounds not exceed 55 dB(A) (19)

Noise levels inside the school were calculated for three areas considered the most likely to be affected by noise due to their proximity to the project: the classrooms and offices near the west wall, north wall, and far west wall as shown in Figures 4.1 and 4.2. Our calculations took into account the noise generated during different stages of construction, distance from the construction site, the hoarding (to be erected by the developer), and sound transmission class (STC) of the building components. (The Sound Transmission Class [STC] is a single number rating of the sound insulation capacity of various building elements. It is obtained by comparing the noise reduction performance of building elements at various frequencies against a standard noise reduction curve (20).) Calculations were made for conditions with windows closed and with windows open, as they would normally be during hot weather in the absence of air conditioning.

To get a better idea of the condition of the relevant building components (walls, windows, doors etc.), one of the investigators visited the school to make visual observations relevant to noise transmission.

The investigator observed that the exterior walls of the areas shown in Figures 4.1 and 4.2 consist of an 8-inch brick layer with lath and plaster. On the first floor, there are two classrooms along the north wall and one classroom on the far west wall. As well, there are offices on the far west wall and a stairwell on the west wall. On the second floor, there are two classrooms each on the north and far west walls. Rooms in the west area of the basement are used for a lunch room and daycare.

Approximately 6% to 40% of the area of exterior walls is covered by doors and windows. Moreover, it was observed that the windows could not be closed tightly and had no weather stripping around them. Wooden exit doors were present on the far west and the west walls on the first floor.

Figure 4.1. West end of the school facing the construction site

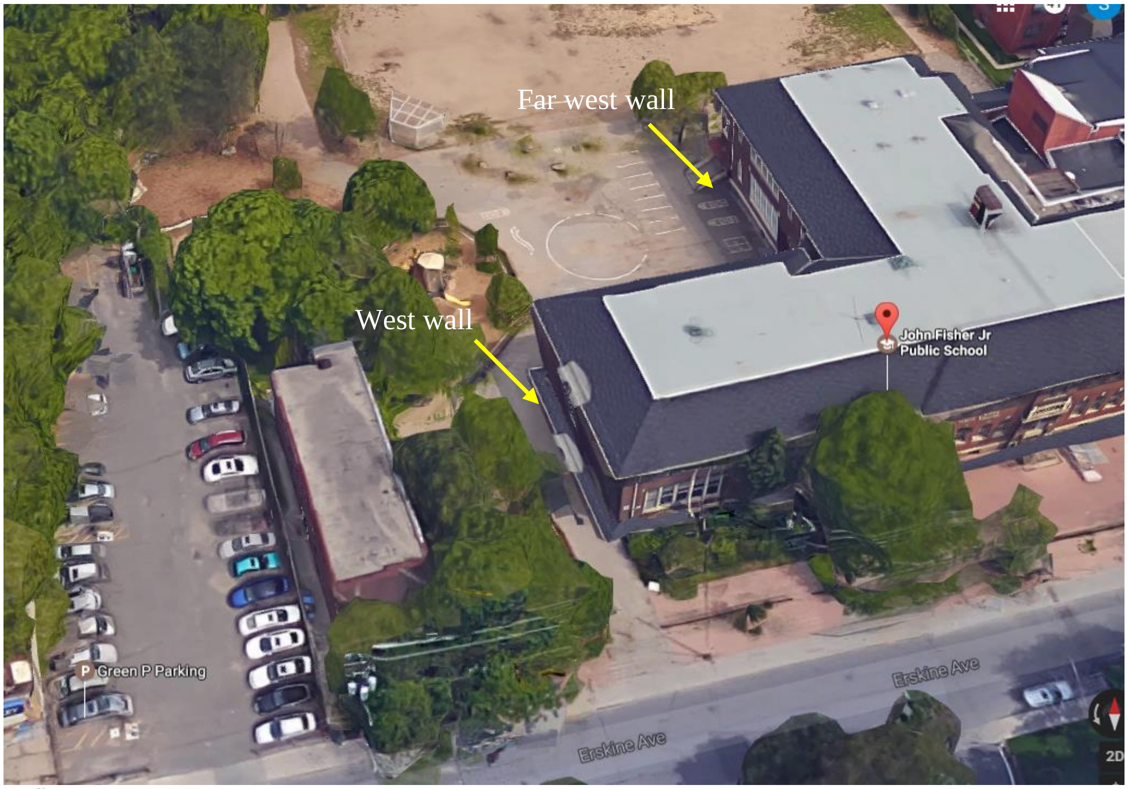


Figure 4.2: North end of the school building with classrooms

Calculations for noise levels were made using the Roadways Construction Noise Model software (RCNM) issued by the US Federal Department of Transportation (21). This software includes actual measured noise levels for specific pieces of construction equipment and takes into account typical per cent usage, which addresses HGC's point that it cannot be assumed that equipment is used all the time. It allows for input of noise shielding values and distance from the source, giving results in maximum (L_{max},) and average (L_{eq}) noise levels. L_{eq} is the preferred method to describe sound levels that vary over time, resulting in a single decibel value which takes into account the total sound energy over the period of interest.

Calculated noise levels are based on the following:

- Equipment used in each stage as shown in Table 4.1. (It is noted that more equipment than these may be used at any one time; however, due to the properties of sound, there is minimal effect of adding more noise sources);
- A noise attenuation of 6 dB is achieved by the 2.4m hoarding wall as set out in the HGC letter;
- The following Sound Transmission Class (STC) values are used, based on visual observation of building components and published STC values:
    - STC for 8-inch-thick brick wall is 52 (22)
    - STC for single pane glass windows is 25 (23)
    - STC for wood doors (1-3/4" wood) is 32 (24)

For calculations of interior noise with windows on the north and far west walls open, it is assumed that the only attenuation is from the hoarding wall and distance from the source.

Table 4.1 shows results of the calculations in terms of L_{eq} for each stage, with windows open and closed at each location. Given that there are no current plans to install air conditioning in the school, it is necessary to anticipate the noise levels when windows are open.

Table 4.1 Estimates of noise inside school during construction stages

Area of school	Distance from the noise source (meters)	Estimated transmitted noise level inside school: Leq dB(A)					
		Demolition Stage		Excavation Stage		Construction Stage	
		Assumed equipment: excavator, dozer, front end loader, pickup truck		Assumed equipment: jackhammer, backhoe, tractor		Assumed equipment: concrete mixer truck, concrete pump truck, crane, grader	
		Windows Closed	Windows Open	Windows Closed	Windows Open	Windows Closed	Windows Open
West wall (window does not open)	15	30.8	NA	33.4	NA	32.1	NA
Far west wall	44	31.6	67.2	34.3	69.3	32.9	67.9
North wall	27	34.8	70.5	37.5	73.5	36.1	72.1

Given the uncertainties of the equipment that will be used and other variables such as actual location of the equipment on the project site, attenuation provided by the excavation pit and partially completed building, and actual sound transmission loss inside JFPS, it is not possible to predict precise noise levels during construction. However, estimates indicate that noise levels in some school areas including classrooms, offices, lunch room and daycare, are likely to exceed the benchmark of 45 dB(A) during all construction stages when windows are open.

Actual noise levels with windows closed may be higher than those shown in Table 4.1, due to the relatively poor closure and sealing of windows observed in the school. However, noise is unlikely to exceed the benchmark of 45 dB(A) with windows closed.

Noise in the outside area on the west side of JFPS directly east of the project is expected to be comparable to the values shown in Table 4.1 for windows open, and is therefore likely to exceed the WHO benchmark for outdoor playgrounds of 55 dBA. Noise levels on the east side of JFPS were estimated using RCNM as well as the MAS Interactive Sound Level Calculator (25), which provides estimates of noise at a receptor, taking into account the noise source, distance from the source and barriers. These estimates indicate that noise in the area to be used as a playground on the east side of JFPS (location of current parking lot), is likely to be below the benchmark of 55 dB(A).

Risk levels for noise exposure depend on the location of the receptor (inside or outside; distance from the source), and whether windows are open or closed. Therefore, we have assessed probability of exposure above benchmarks for two scenarios:

Scenario 1: Inside, windows closed, or outdoors, east end of school

Scenario 2: Inside, windows open, or outdoors, west end of school

For Scenario 1, probability of exposure above the benchmarks is rated remote or P1 for all construction stages. Probability for Scenario 2 is rated P4 or likely, during demolition. In view of the attenuation factors mentioned by HGC for excavation (acoustic shielding below grade) and construction (shielding by building components and increasing distance from source), probability for Scenario 2 during these stages is rated P3 or probable.

4.1.2 Risk Assessment

Risk ratings for health and learning for the two scenarios and various construction stages range from low to high. These ratings are shown in Table 4.2.

Measures can be taken to provide additional noise mitigation at JFPS. Plans should proceed to move the playground to the east end of the school. As demolition is projected to take about two weeks, if it is conducted during vacation periods when the school has lower occupancy, it is possible that occupants could be moved to the eastern part of the school further from the project. Efforts should be made to provide good seals on windows to ensure they meet the expected Sound Transmission Class ratings. Air conditioning should be provided so that windows do not need to be opened during hot weather.

Table 4.2. Risk rating for noise exposure

Stage	Effects	Severity		Probability			Risk Rating	
		Severity Rating	Severity Rationale	Scenario 1 Inside, windows closed & outside, east end of JFPS	Scenario 2 Inside, windows open & outside, west end of JFPS	Probability Rationale	Scenario 1 Inside, windows closed & outside, east end of JFPS	Scenario 2 Inside, windows open & outside, west end of JFPS
Demolition	Health	S3	Cognitive, stress and cardiovascular effects	P1	P4	Noise-emitting characteristics of equipment; distance from school; sound attenuation	Low	High
	Learning	S3	Annoyance, disturbance, speech intelligibility, effects on academic performance	P1	P4		Low	High
Excavation	Health	S3	See above	P1	P3	See above; additional attenuation due to work below grade	Low	Medium
	Learning	S3		P1	P3		Low	Medium
Construction	Health	S3	See above	P1	P3	See above; additional attenuation by building under construction and increasing height of work	Low	Medium
	Learning	S3		P1	P3		Low	Medium
Finished Building	Health	NA	No anticipated source of high noise levels	NA	NA	No anticipated source of high noise levels	NA	NA
	Learning	NA		NA	NA		NA	NA

4.2 Vibration

In the Phase I assessment, it was noted that construction vibration represents a potential concern for three reasons: health impact, general irritation and annoyance that could impact learning, and structural impact on the JFPS building. Direct health effects of vibration, as explained in the Phase I assessment, are not likely at levels that may be encountered from construction vibration. However, it is possible that construction may cause levels of vibration that can be perceived and cause annoyance.

Table 4.3 outlines human perception of motion/acceleration in relation to vibration levels (26). The degree to which a person is annoyed depends in part on their activities at the time of the disturbance.

Table 4.3. Vibration and Human Perception of Motion*

Approximate Vibration Level (mm/s)	Degree of Perception
0.10	Not felt
0.15	Threshold of perception
0.35	Barely noticeable
1.0	Noticeable
2.2	Easily noticeable
6.0	Strongly noticeable

*Note: The approximate vibrations (in floors of buildings) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

Indirect effects to health can result from damage to the building structure, by allowing infiltration of hazards such as radon or VOCs, or by damaging building materials that may release asbestos fibres or lead from paint. These possibilities are addressed in sections 3.1, 3.2, 3.7, and 4.3.

The Phase I assessment rated the probability of vibration affecting health or learning as remote or P1, with a resulting risk rating of low. Following the Phase I assessment, ECOH asked that the developer provide a vibration modelling study and vibration control plan, including assessment of the impact of vibration on JFPS building. In response, the developer provided an "Assessment of Construction Vibration Potential for 18 Erskine Avenue", issued by HGC Engineering (HGC) on February 23, 2017 (CMP Appendix 6) , a letter of opinion from HGC entitled "Noise and Vibration Considerations for John Fisher

Public School," dated March 29, 2017 (CMP Appendix 5), and response to questions posed by ECOH (5).

ECOH also asked City of Toronto Buildings Department for comments on the developer's vibration reports. In response, Toronto Buildings commented that:

> "The applicant of the proposed development at 30 Erskine Avenue has submitted the required vibration control form… Toronto Building will not sign off the first building permit (including a demolition permit), until the following activities are confirmed by the Professional Engineer on record, responsible for Vibration Control: 1) A zone of influence has been established; 2) Pre-construction (condition) surveys of neighbouring buildings which fall within the Zone of Influence have been completed; 3) A pre-construction consultation meeting has taken place; 4) Establishment of a monitoring program and mitigation measures to reduce vibration within the zone of influence. Once a building permit is issued, the developer is required to monitor vibration levels for properties that fall within the Zone of Influence."

4.2.1 Potential Exposure

As noted in the Phase I assessment, City of Toronto Municipal Code (Bylaw 514-2008) governs acceptable vibration levels for construction projects. Table 4.4 shows the maximum peak particle velocities (PPV) at various frequencies allowed in the Bylaw.

Table 4.4. Frequency and Maximum Allowable PPV for Construction Projects, Toronto Municipal Code

Frequency of vibration (Hz)	**Vibration Peak Particle Velocity (mm/sec)**
< 4	8
4-10	15
>10	25

As JFPS is characterized as a heritage building by the City of Toronto, HGC has suggested the use of a more conservative "cautionary criterion" (or "action limit") when evaluating vibration monitoring results. HGC notes that the action limit is designed to incorporate a safety factor, to better assure that the limits in the Bylaw are not exceeded during project work. HGC's suggested action limit for "sensitive or heritage-designated buildings" is a PPV of 3 mm/s at all vibratory frequencies. HGC concludes that this action limit is unlikely to be exceeded, provided due care is exercised during demolition, excavation and construction work. Should the action limit be exceeded, a prompt response should ensure that allowable vibration levels are not exceeded.

HGC's March 29 letter concludes that the JFPS building is outside the vibration "Zone of Influence" (ZOI) as defined under City of Toronto By-Law 514-2008 (areas where PPV may exceed 5 mm/s). However, a strip of the JFPS property closest to the project is within the ZOI.

HGC's predicted worst case vibration level at the JFPS building is 2 mm/s. Based upon this projection, HGC concludes that "no adverse vibration impacts are anticipated". HGC also suggests that construction, fit-out and maintenance projects that occur within the school have a much greater potential to generate significant vibration and resultant vibrational impacts upon the school foundations, versus the project work at 18 Erskine Ave.

As noted in HGC's report, the extent to which vibration propagates through the soil underlying the general project area, including JFPS, can only be approximated. HGC bases its projected vibration levels on typical vibration levels generated by various construction activities, found in published reference materials and gleaned from HGC's experience with similar projects in the City of Toronto. This implies that HGC's projected ZOI is an approximation based upon best available data. HGC has also noted that they cannot predict the types of construction equipment that might be used during project work or how "aggressively" it may be used by the operators.

HGC's projected ZOI is further based upon the assumption that vibratory compaction or other "significant percussive/vibratory activities" will not occur at any time during the project, and that all specifics set forth in Petra Consultants Ltd.'s "Structural Assessment Demolition Method" issued February 2017 (CMP Appendix 8) are followed during demolition. HGC also indicated that to maintain the established ZOI, vibratory pile driving and vibratory sheet pile installation must not occur. The CMP states that those activities will not be conducted.

Despite its projections, HGC has still recommended that non-automated, short-term vibration monitoring be conducted at JFPS "at the start of key construction activities with the potential for vibration impact", including the start of demolition, shoring, excavation, and any percussive/vibratory activities required during the work. ECOH infers that this recommendation is based upon a need to exercise caution, given the reliance of HGC on assumptions and approximations in establishing the ZOI. Furthermore, HGC has recommended that attended short-term vibration monitoring be performed "in the event of vibration-related complaints being received from the school". Automated monitoring has also been recommended, but only for monitoring of the structure at 10 Erskine Avenue, which is located closer to the construction site than JFPS.

HGC and the developer have not addressed vibration that may be caused by tracked equipment travelling on paved sections of asphalt (i.e. City streets or the existing Green P parking lot that will fall within the project perimeter). As noted in ECOH's Phase I assessment, large tracked equipment travelling on asphalt/hard surfaces can generate substantial vibration. Should tracked equipment travel along Erskine Avenue in front of JFPS, such vibration could be generated closer to JFPS than the construction site boundary. It is ECOH's understanding that tracked equipment will be delivered and removed from the site on flat-bed trucks and stored in the construction staging area within the construction site perimeter.

Assuming that vibration levels remain below those predicted by HGC, health impacts and damage to the structural integrity of JFPS are not expected. The predicted level of 2 mm/s may be noticeable and cause annoyance to occupants of JFPS, with potential for some impact on learning. Indirect harm from infiltration or harmful building materials is not likely, as discussed in Sections 3.1,3.2, 3.7, and 4.3.

4.2.2 Risk Assessment

Based on the predicted vibration levels in the HGC report, combined with monitoring and corrective measures if the action level is exceeded, the probability of vibration having an impact on building structure and health is rated P1 or remote during all construction stages. However, vibration levels may be high enough to cause annoyance with resulting impacts on learning during the demolition and excavation stages, with some possibility during the construction stage. Therefore, the probability rating for learning impacts during demolition and excavation stages is P3, or possible, and during construction is P2, or improbable, resulting in respective risk ratings for learning of medium and low. No vibration is expected once the building is completed.

Ratings and explanations for severity, probability and risk for health and learning for each stage are provided in Table 4.5.

Table 4.5. Risk Rating for Exposure to Vibration

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Acute effects like nausea, fatigue and vertigo; health impacts if structure is affected.	P1	Predicted vibration levels lower than standards but high enough to be perceived; annoyance can result from vibration at levels acceptable for structure and health; assumes tracked vehicles will not be operated on public road	Low
	Learning	S2	Annoyance	P3		Medium

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Excavation	Health	S2	See Above	P1	See Above	Low
Excavation	Learning	S2	See Above	P3	See Above	Medium
Construction	Health	S2	See Above	P1	Vibration levels likely to be lower than during demolition and excavation; assumes tracked vehicles will not be operated on public road	Low
Construction	Learning	S2	See Above	P2	Vibration levels likely to be lower than during demolition and excavation; assumes tracked vehicles will not be operated on public road	Low
Finished Building	Health	NA	See Above	NA	No expected vibration source	NA
Finished Building	Learning	NA	See Above	NA	No expected vibration source	NA

4.3 Radon

Radiation is energy emitted from and travelling away from a source. Two types of radiation were discussed in the Phase I assessment: radon and welding radiation.

In the Phase I assessment, it was noted that increased radon exposure to staff and students due to excavation, construction or demolition-related vibration is unlikely, and that any radon gas potentially present in the existing structure on the project site does not present a hazard to occupants of JFPS. While project-related vibration could theoretically increase the number or extent of cracks in the foundation of JFPS with resulting potential for radon infiltration, it is noted in the Phase I assessment that other influences, such as seasonal temperature changes, are more likely to be responsible for any cracking of the foundations.

The Phase I assessment rated the probability of radon exposure associated with construction impacts as P2 or improbable. As a carcinogen, radon has a severity rating of S3, resulting in a risk rating of medium.

Additional information considered for the Phase II assessment included the "Assessment of Construction Vibration Potential" for 18 Erskine Avenue, issued by HGC Engineering

(HGC) on February 23, 2017 (CMP Appendix 6), a letter of opinion from HGC titled "Noise and Vibration Considerations for John Fisher Public School" dated March 29, 2017 (CMP Appendix 5), and KG Group's response to questions posed by ECOH (5). Essential points of these communications are described in section 4.2.

4.3.1 Potential Exposure

The potential for vibration to occur at levels that would cause even hairline cracking of the JFPS foundation walls is judged to be very unlikely, provided that:

- Tracked vehicles are transported on Erskine Avenue on a wheeled vehicle and their movement on the project site is subject to attended, short-term vibration monitoring as a potentially significant "vibratory activity";
- Monitoring is performed as recommended by HGC; and
- Any exceedances of the action limit are immediately acted upon.

4.3.2 Risk Assessment

Given the unlikelihood of cracking of JFPS foundation walls due to construction vibration, the probability of an increase in radon levels within the school due to project work is rated as P1 or remote, resulting in a risk rating of low for health and learning during all demolition, excavation and construction stages. Ratings and explanations are provided in Table 4.6.

For additional assurance, it can be verified that radon does not present a hazard by performing radon measurements at the school prior to, during, and after the construction project work.

Table 4.6. Risk Rating for Exposure to Radon

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Lung Cancer	P1	Predicted vibration levels not expected to impact JFPS building and cause radon release; vibration levels will be monitored	Low
	Learning	S2	Anxiety, apprehension	P1		Low
Excavatio	Health	S3	See Above	P1	See above	Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S2		P1		Low
Construction	Health	S3	See Above	P1	See above	Low
	Learning	S2		P1		Low
Finished Building	Health	NA	Not applicable	NA	Not applicable	NA
	Learning	NA		NA		NA

4.4 Welding Radiation (Ultraviolet / Visible / Infrared)

4.4.1 Potential Exposure

As indicated in the Phase I assessment and confirmed by KG Group, welding will take place during various stages of the construction project.

The Phase I assessment discussed the probability that radiation from welding arcs, particularly during the demolition and construction stages, could cause eye damage if the arc were viewed without any shielding in place. As noted in the Phase I assessment, children's eyes are more sensitive than those of adults to radiation emitted from a welding arc. The Phase I report noted that harm can be prevented if controls are in place to block direct viewing or skin exposure to welding arcs by JFPS staff or students.

Information considered for the Phase II assessment includes the Construction Mitigation Plan and KG's response to a query from ECOH regarding shielding of welding operations..

KG's response to ECOH indicates that welding during the excavation stage of the project will take place only within the excavation pit, and hoarding walls will be erected at the perimeter of the construction site so individuals standing outside the perimeter fence, including members of the public and JFPS staff and students, cannot view welding arcs.

KG has further indicated that any welding/cutting operations that will take place above-grade during the demolition or construction stages of the project will only take place when the arc is effectively shielded by welding curtains/screens, and that efforts will be made to conduct welding operations inside a designated area inside the building that is located away from openings in the perimeter of the building.

4.4.2 Risk Assessment

With the identified mitigation steps in place, the probability that JFPS occupants will be exposed to welding radiation is considered very remote during excavation and remote during the other construction stages, resulting in risks ranging from very low to low.

Vigilance will be required to ensure that welding curtains/screens are erected properly so that it is not possible for individuals outside the site to view the welding arc, particularly at a low viewing angle.

Ratings and explanations for severity, probability and risk for health and learning for each stage are provided in Table 4.7.

Table 4.7. Risk Rating for Exposure to Welding Radiation

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Retinal Burns, Damage to Cornea or Conjunctiva	P1	Developer has committed to shielding welding arcs	Low
	Learning	S1	No interference with learning expected	P1		Very Low
Excavation	Health	S3	Retinal Burns, Damage to Cornea or Conjunctiva	P0	Welding will be completed behind perimeter hoarding walls, and below-grade in excavation pit	Very Low
	Learning	S1	No interference with learning expected	P0		Very Low
Construction	Health	S3	Retinal Burns, Damage to Cornea or Conjunctiva	P1	Developer has committed to shielding welding arcs	Low
	Learning	S1	No interference with learning expected	P1		Very Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Finished Building	Health		Not applicable		Not applicable: no visible welding anticipated when building finished	N/A
	Learning					N/A

5. BIOLOGICAL HAZARDS

5.1 Pests/ Disease Vectors

5.1.1 Potential Exposure

As indicated in the Phase I assessment, pests present a potential health hazard to staff and students at JFPS both as a direct result of physical damage from bites (skin punctures, wounds, etc.) or transmission of infection or disease. The severity of harm from pests was rated S3 or major, and probability in the Phase I assessment was rated P3 or possible, with a resulting risk rating of medium.

Following the Phase I assessment, the developer was asked for information on the pest control plan. Information provided in response included a Pest Management Protection Program (7) prepared by Orkin/PCO Services Corporation (Orkin/PCO) and KG's response to questions posed by ECOH (5).

With respect to the excavation and construction stages, the developer's response includes commitments to minimize attraction of pests to the site by conducting training sessions on pest control for site workers, posting printed information on-site regarding effective pest control measures, maintaining the construction and staging areas free of garbage, and enforcing proper storage of garbage on-site in heavy-duty refuse containers with properly fitting lids. Furthermore, the developer has committed to establishing designated lunch/break areas with nearby refuse containers and dedicated garbage areas with refuse containers on each floor of the building during its construction. Sub-trades will be assigned the responsibility of ensuring all waste on each floor under construction is transferred to the designated refuse containers at least once daily, and of transferring the contents of the refuse containers into the larger site garbage bins to avoid overfilling. The developer notes that the larger site garbage bins will be also be emptied/removed as required to prevent overfilling.

The response also states that if pest concerns are identified, an appropriate Pest Control service will be engaged to ensure the pests are removed from the site. The revised CMP of

April 6, 2017 states that where there is wildlife on the site, the constructor shall ensure that a professional removal company is employed.

The Pest Management Protection Program developed by Orkin/PCO addresses pest management in the completed building. The plan includes a minimum of monthly visual inspections for pest infestations in common areas, monthly insecticide treatment of common area locations where the risk of infestation is deemed to be high, and monthly servicing of installed rodent traps. Response to rodent or insect concerns within residential units is dependent upon those concerns being reported to management, but issues affecting individual units are unlikely to impact surrounding properties such as JFPS. The developer has further indicated that the waste storage area will be located within the parking garage, sealed by structural walls and "odour-insulation", and will be chilled to 5-8°C to control odour that could attract pests. All facility waste bins will be stored in the waste storage area until the weekly waste pickup day.

If diligently implemented, the mitigation measures referenced in the developer's plans will serve to control many of the pests that may be present. They do not, however, address the hazard of standing water on the construction site that could encourage breeding of insect pests, as noted in the Phase I assessment. Such pools of stagnant water can develop on tarping over building materials on-site, in depressions in the ground, on top of containers, or other areas described by the Chartered Institute of Environmental Health (27), especially considering the large quantities of water required for dust suppression, as set out in the Dust Management Plan, and other construction activities. The documents provided also do not specifically address measures for preventing entry of rodent or other animal pests onto the construction site via sewers or other open service lines during the excavation or construction stages.

5.1.2 Risk Assessment

The probability of exposure to pests during the construction stages is considered P3 or possible during the demolition stage, as the developer's plans do not address the possibility of pests within the building to be demolished. In view of the mitigation measures described in the developer's documents, probability during excavation and construction stages is rated P2 or improbable. Resulting risk ratings are medium for health and medium to low for learning. Risks could be further reduced by addressing possible infestation associated with demolition, stagnant water and entry of pests onto the site (27). Probability of exposure for the finished building, based on the mitigation measures in the Orkin/PCO plan, is rated P0 or remote, with a risk rating of Very Low. Additional mitigation can be provided by TDSB through increased vigilance and pest control measures on JFPS property.

Ratings and explanations for severity, probability and risk for health and learning for each stage are provided in Table 5.1.

Table 5.1. Risk Ratings for Pests

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Animal bite - injury, infection & other diseases Mosquito-borne diseases	P3	Possible release of pests from infestation or open sewers into surrounding buildings; possible presence of pests in building to be demolished	Medium
	Learning	S2	Distraction, annoyance from, or fear of, pests	P3		Medium
Excavation	Health	S3	See above	P2	Increased potential for mosquito breeding in water and release of pests from infestation or open sewers	Medium
	Learning	S2		P2		Low
Construction	Health	S3	See above	P2	See above	Medium
	Learning	S2		P2		Low
Finished Building	Health	S3	See above	P0	Building waste chilled and stored indoors in designated area until day of pickup. Monthly inspections of common areas by Orkin/PCO for pests	Very Low
	Learning	S2		P0		Very Low

5.2 Microbial Organisms

Microbes are microscopic-scale organisms, such as fungi, bacteria and viruses. As discussed in the Phase I assessment, possible exposure to microorganisms may occur due to aerosolization (i.e. becoming airborne) of biological materials (e.g. feces, urine, hair, feathers) during demolition or of organisms in the soil during excavation. Exposure may cause respiratory effects and allergic reactions. In the Phase I assessment, the probability of exposure was rated P3 or possible, with a resulting risk rating of medium.

5.2.1 Potential Exposure

Additional information considered for the Phase II assessment included the Designated Substance Survey of the building to be demolished (CMP Appendix 9), the Dust Management Plan (CMP Appendix 7), a response by exp Services Inc. to the Phase I assessment and KG's response to ECOH's questions.

Provisions of the Dust Management Plan include wet methods to suppress dust, covering of soil and other materiel, washing of vehicles and surfaces, adjustment of work during high winds, and worker training. Exp's response to the Phase I assessment states that dust control measures will be consistent with the requirements of Toronto Public Health. KG's response to ECOH's questions states that they will survey the mould present in the building to be demolished, "at which point we would abate the mould as per MOE and MOL regulations".

Proper abatement of mouldy materials before demolition and dust suppression procedures are expected to be adequate to control exposure to airborne mould. These should be accompanied by good housekeeping to prevent the possibility of growth and dispersal of other microorganisms.

5.2.2 Risk Assessment

Taking into consideration mould abatement and dust suppression measures included in the developer's plans, the probability of exposure to microbial agents, in particular fungal spores, is rated P2 or improbable during all construction stages, with resulting risk ratings of low. Mitigation can be assured by adequate attention to control of biological hazards on site, e.g. through good housekeeping, avoiding stagnant water, proper bagging of contaminated materials. Probability of exposure due to the finished building is judged very remote, P0, with a resulting risk rating of very low. Explanations are provided in Table 5.2.

Table 5.2. Risk Rating for Exposure to Microbial Organisms

Stage	Effects	Severity		Probability		
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	Risk Rating
Demolition	Health	S2	Respiratory allergies, skin infections, flu - like illness	P2	There is possibility of exposure to microbial spores from dust generated during demolition but exposures are improbable if mould abatement and dust suppression measures are followed.	Low
	Learning	S2	Allergic responses can interfere with learning and teaching	P2		Low
Excavation	Health	S2	See above	P2	Dust generated from excavation of soil may contain microbial agents but exposure will be controlled by dust suppression methods.	Low
	Learning	S2		P2		Low
Construction	Health	S2	See above	P2	Good housekeeping on site should prevent growth of microbes; dust suppression methods will prevent any present from becoming airborne	Low
	Learnin	S2		P2		Low
Finished Building	Health	S2	See above	P0	Pest control plan, proper housekeeping and waste disposal.	Very Low
	Learning	S2		P0		Very Low

6. SAFETY HAZARDS

6.1 Traffic

As described in the Phase I report, JFPS is located near the busy Yonge and Erskine intersection. Erskine Avenue is a two-way (direction) road and increased traffic congestion is anticipated due to construction of the tower. The probability of a traffic incident was rated P3 or possible during the demolition, excavation and construction stages, and P2, improbable, when the building is completed. Because a traffic incident could be catastrophic and disruptive, the Severity rating for health is S4 and for learning is S2. Therefore, in the Phase I assessment, the risk for health was rated high for the construction stages and medium for the completed building.

In the recommendations for the Phase I assessment, the developer was asked to provide a road safety, transport and access plan for construction vehicles and other equipment, along with information on staging area, traffic routes and parking details for construction and workers' vehicles. In response, the developer provided a Road and Traffic Management Plan by BA Group (CMP Appendix 4), and a response to questions posed by ECOH.

In addition, ECOH asked City of Toronto Transportation Services about their comments on traffic plans for the site.

6.1.1 Probability of Harm

City of Toronto Transportation Services has advised that the developer will be required to install a covered walkway with lighting fronting the site to add safety for pedestrians. The developer has stated that they will be utilizing overhead protection along the entire south property line on Erskine. An engineered system will be used for this application.

In an email exchange with the developer, City of Toronto Transportation Services required that there be no parking or queuing of vehicles on Erskine or Keewatin Avenues. The developer agreed that this would be added to the traffic plan.

The traffic plan provided by the developer includes gate locations, additional signage, and construction vehicles access routes. It also indicates that trained traffic control persons will be required to direct street traffic during construction equipment maneuvering on Erskine Avenue. The drawings indicate that construction equipment will approach the site in a westward direction. Deliveries of heavy equipment will be through the construction access gates and equipment will remain on site until completion of their work. Tractors will be detached from the trailer and parked during unloading. A no-idling policy will be enforced. Snow removal from the site will be maintained. The staging area will be located on the project site. The developer has also indicated that parking has been arranged off site for construction workers and there will be no construction worker parking on Erskine Avenue.

The developer's response to ECOH noted a TDSB policy that parent pickup and drop off for JFPS is on Keewatin Avenue. It also stated that the City is considering making Erskine

Avenue one way westbound and Keewatin Avenue one way eastbound. However, in response to inquiries from ECOH, City of Toronto Transportation Services indicated that it is not pursuing plans to make these streets one-way. Further, consultation with JFPS officials indicates that, while parents are encouraged to drop off children on Keewatin Avenue, this is not a requirement. In fact, most drop-offs and pickups, including school bus loading and unloading, occurs on Erskine Avenue.

There remains potential for considerable traffic congestion on Erskine Avenue, given the high volume of use by both parents and construction vehicles during the construction stages, and from increased occupancy after the building is complete. The measures to be implemented by the developer will mitigate this risk to a degree. However, there are no specific measures that take account of the volume of school-related traffic (parents and school buses) at JFPS. Furthermore, if construction vehicles are on Erskine Avenue or obstruct sidewalks during school drop off or pick up times, pedestrians as well as other drivers could be at increased risk. Measures that could be implemented to reduce this risk include timing of construction vehicle traffic and sidewalk obstruction on Erskine Avenue to avoid high activity periods for JFPS.

6.1.2 Risk Assessment

While there remains an expectation of increased traffic volume related to the development, the mitigation measures to be introduced reduce the probability of an adverse incident to P2 or improbable during all construction stages, resulting in a medium risk to health and low risk to learning. Given a relatively low increase of traffic above baseline when the building is finished, the probability is rated P1 (remote) for health and P0 (very remote) for learning. Ratings are explained in Table 6.1.

Table 6.1. Risk Rating for Traffic Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	**Health**	S4	Driving distractions; safety hazards; possibility of severe injury or death	P2	High vehicle / equipment movement, congestion on Erskine Avenue given high volume of school and construction activity; mitigating controls	Medium
	Learning	S2	Minimal distraction in classroom; distraction during outdoor activities	P2		Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	**Severity Rationale**	**Probability Rating**	**Probability Rationale**	
Excavation	**Health**	S4	As above	P2	As above	Medium
	Learning	S2		P2		Low
Construction	**Health**	S4	As above	P2	As above	Medium
	Learning	S2		P2		Low
Finished Building	**Health**	S4	As above	P1	Some traffic increase with new residents, remote probability of harm in view of relative change from current levels	Low
	Learning	S2		P0		Very Low

6.2 Cranes

The Phase I assessment considered the probability of an adverse crane event which, though rare, can be disastrous. Crane incidents were therefore given a severity rating of S4. The Phase I probability rating for the construction stage was P3, or possible, resulting in a risk rating of high.

Information requested of the developer for the Phase II assessment included information on overhang of the crane over JFPS property and a lift plan, in addition to general safety procedures. Information sent by the developer included a Tower Crane Safety Program, (CMP Appendix 14), a description of the type of crane to be used (CMP Appendix 13), and a response to questions posed by ECOH. Information with respect to the number of cranes to be deployed was not provided.

6.2.1 Probability of Harm

In response to ECOH's question about crane safety practices, the developer stated that "all materials will be unloaded from our internal staging area, and no loads or crane swings will be over the JFPS area."

The developer's Tower Crane Safety Program states that all work will be in accordance with the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. It also states that the installation, operating, testing, inspection and maintenance of tower cranes will be in accordance with CSA Standard Z248-04, Code for Tower Cranes.

The developer indicated that the type of crane to be used will be a Luffing Jib Tower Crane. This type of crane is frequently used for tall urban construction because it can operate in a relatively tight space.

Guidance material on Luffing Jib Tower Cranes by the United Kingdom Health and Safety Executive (HSE) has noted that this type of crane has been known to collapse in high winds. The HSE therefore has issued a Safety Alert with guidance on avoiding such incidents by ensuring that the crane is placed in the correct out of service position when it is not in use (28). Other guidance material has pointed out that crane operators must be trained specifically on luffing jib crane safe practices and that the manufacturer must be consulted on safe out of service settings (29)(30).

The Tower Crane Safe Practices document provided by the developer does not address out of service practices, safety measures specific to luffing jib tower cranes, or measures to be taken in adverse weather condition, particularly high winds. It also does not provide the lift plan requested by ECOH.

6.2.2 Risk Assessment

Cranes are not expected to be present during demolition and excavation phases and of course no cranes will be in the vicinity when the building is finished. Hence there is no risk of a crane-related incident during demolition, excavation and finished stages.

A crane is only expected to be on site during the construction stage. Given the mitigation measures specified by the developer and the fact that the crane will not swing over JFPS property, the probability of a crane event has been assigned a probability rating of P2 (improbable), resulting in a risk rating of Medium during the construction stage. Further mitigation can be achieved by addressing safety measures specific to a Luffing Jib Tower Crane and measures to be taken in adverse weather conditions, in particular high winds. In addition, a lift plan is needed to specify protections to be observed, especially for lifting heavy loads to great heights. An explanation of ratings is provided in Table 6.2.

Table 6.2. Risk Rating for Crane Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demoliti	Health	NA		NA	It is presumed that there are no cranes during demolition	NA

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	NA	It is presumed that there are no cranes during demolition	NA		NA
Excavation	Health	NA	It is presumed that there are no cranes during excavation	NA	It is presumed that there are no cranes during excavation	NA
	Learning	NA		NA		NA
Construction	Health	S4	Death or serious injury in the event of a crane collapse	P2	Safe work practices have been provided; the crane will not swing or lift loads over JFPS; however the safe practices do not address measures to be taken when the crane is out of service or in adverse weather conditions, measures specific to Luffing Jib Tower Cranes, or a lift plan, particularly addressing precautions for lifting heavy loads to great heights	Medium
	Learning	S4	Loss of concentration due to emergency responders, police, school closure due to accident	P2		Medium
Finished Building	Health	NA	Cranes are not present in the completed building	NA	Cranes are not present in the completed building	NA
	Learning	NA		NA		NA

6.3 Falling Objects

The Phase I assessment identified falling objects and collapsed scaffolds as one of the hazards that could risk the health and safety of JFPS occupants. The probability of such an occurrence was considered possible (P3) and the risk for health was rated high. The developer was requested to provide plans to mitigate risks due to falling objects. In response, the developer provided the CMP of April 6, 2017, including figures showing safety netting, hoarding and overhead protection, a demolition plan (CMP Appendix 8), and a response to ECOH's questions. In addition, ECOH approached City of Toronto officials and requested their opinion on risk mitigation.

6.3.1 Probability of Harm

The developer has stated that they will undertake the following mitigation steps:

- Double stacked safety fencing and a safety netting system will be utilized at all unenclosed areas during tower construction.
- The tower will be constructed so that only a maximum of 8 storeys would be open at any given time.
- The open storeys will be enclosed with double stacked safety fencing from top to bottom.
- All material will be secured in a manner that will prevent it from falling or blowing off the building in windy conditions.

City of Toronto Transportation Services informed ECOH that the developer will:

- Need to install a covered walkway fronting the site with lighting to add safety for pedestrians. As the staff and students of the JFPS are also pedestrians and may use the same walkways, the proposed requirement of a covered and lighted walkway would also provide protection for them.
- The building will be required to be encased in netting to prevent items blowing off in high winds.

It is noted that there is ambiguity in the statements provided by the developer, as the HGC response regarding noise recommends a 2.4 m high barrier and the response regarding public protection refers to 1.8 m high hoarding.

6.3.2 Risk Assessment

In view of the intended use of a covered walkway, safety fencing and netting, the probability of harm from falling or moving objects is rated P0 or very remote during excavation and for the finished building, and P1 or remote during demolition and construction, assuming that the proposed mitigation steps and the City requirements are diligently implemented, and that the netting and barriers employed are adequate (e.g. in terms of strength, netting mesh and placement) to prevent the possibility of any falling object migrating off the construction site. This results in low risk ratings for health, and very low to low ratings for learning. Rationale for the ratings is given in Table 6.3.

Table 6.3. Risk Rating for Falling Objects

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	A large object that is windblown or horizontally displaced can strike a person or a part of the school (e.g. a glass window) causing serious injury or death	P1	Mitigation measures set forth in Demolition plan.	Low
	Learning	S3	Learning disrupted due to emergency response or school damage	P1		Low
Excavation	Health	S4	As above	P0	Work will take place below grade	Low
	Learning	S3		P0		Very Low
Construction	Health	S4	As above	P1	Control measures, e.g. safety netting, will mitigate this risk	Low
	Learning	S3		P1		Low
Finished Building	Health	S4	As above	P0	Very remote likelihood that objects displaced from new building would reach JFPS property	Low
	Learning	S3		P0		Very Low

6.4 Structural Stability and Water Table Impacts

Potential hazards arising from excavation and trenching activities include cave-ins and water table impacts which could affect the stability of adjacent properties. In the Phase I assessment, the probability of such events was rated P1 or remote.

The developer was asked to provide information on an excavation plan showing how JFPS would be protected. In response, the developer provided a shoring plan and engineer's letter (CMP Appendix 11) and responses to ECOH questions.

6.4.1 Probability of Harm

The engineer's letter verified that shoring design will be in accordance with City requirements and provide an effective excavation support system that will eliminate discernible impact on the adjacent property. It also stated that monitoring of the TDSB structure will be conducted to confirm shoring performance during active excavation. The monitoring will allow assessment of the shoring conditions and adjustment of design as the work progresses. In addition, vibration will be monitored, as described in section 4.2 of this report. Assuming that appropriate adjustments to procedures will be made if warranted by monitoring results, these measures can be expected to adequately mitigate risks related to structural stability.

6.4.2 Risk Assessment

Given the oversight of excavation, the monitoring program, and adjustments based on monitoring results, the probability of damage to JFPS during demolition and excavation remains rated P1 (remote), with a resulting risk rating of low. This hazard is not applicable during the other stages. Rationale is given in Table 6.4.

Table 6.4. Risk Rating for Hazards Due to Structural Instability and Water Table Impacts

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	NA	Not applicable	NA	Not applicable	N/A
	Learning	NA		NA		N/A

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Excavation	Health	S4	Damage to building could cause severe injury	P1	Remote probability of impact on school, given monitoring and adjustment of procedures where warranted	Low
	Learning	S4	Damage to building could seriously disrupt school operations	P1		Low
Construction	Health	NA	Not applicable	NA	Not applicable	N/A
	Lear	NA		NA		N/A
Finished Building	Health	NA	Not applicable	NA	Not applicable	N/A
	Learning	NA		NA		N/A

6.5 Fire and Explosion

The Phase I assessment considered the risk of fire and explosion during construction. Given the absence of specific information, the probability was rated P3 or possible. As the severity was rated S4, the resulting risk rating was high. The developer was asked to provided details of the Fire Safety Plan. In response, the developer provided the CMP of April 6 and responses to ECOH questions.

6.5.1 Probability of Harm

In response to ECOH’s queries and the revised CMP, the developer stated that

- Prior to demolition and excavation all utility locates will be completed and utilities cut off from main lines;
- Flammable liquids and gases will be stored in approved containers;
- Fire extinguishers will be provided;
- Fire trucks and emergency vehicles will have access to the site;
- Compressed gas cylinders will be properly stored;
- Staff will receive fire extinguisher awareness and WHMIS training;

- The new building will have integrated fire life safety systems including full coverage sprinkler systems; and
- A Fire Safety plan for the completed building will be signed by the Toronto fire Department prior to occupancy.

While the mitigation measures included in the developer's response will help to control fire risks, they do not constitute a full Fire Safety Plan covering construction stages.

6.5.2 Risk Assessment

In view of the mitigation measures stated by the developer, the probability of fire and explosion has been rated P1 (remote) during the demolition and excavation stages, and P2 (improbable) during the construction stage. This results in risk ratings of medium for construction and low for the other stages, as explained in Table 6.5. This risk is considered not applicable for the finished building because there is no risk above the current baseline.

Table 6.5. Risk Rating for Fire and Explosion Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Serious injury may result from major fire or explosion	P1	Presence of combustible materials, but relatively low risks which are expected to be effectively controlled through stated mitigation measures	Low
	Learning	S4	Major damage to school may occur	P1		Low
Excavation	Health	S4	As above	P1	Precautions related to utility locates expected to be adequate to control risks.	Low
	Learning	S4		P1		Low
Construction	Health	S4		P2	Presence of combustible materials, pressurized gases, sources of ignition, electrical equipment; lack of complete Fire Safety Plan	Medium
	Learning	S4		P2		Medium
Finished Building	Health	NA	NA	NA	Not applicable: no increased probability above baseline	NA
	Learning	NA		NA		NA

6.6 Electrical and Utilities

The Phase I assessment considered risks involving electricity and other hazards associated with underground and overhead utilities. The probability of electrical hazards was rated P3 or possible during the excavation and demolition stages. As the severity rating is S4, this resulted in a risk rating of high during these stages. Utility-related hazards were considered separately in the Phase I assessment, but here are considered together with electrical hazards.

Information provided by the developer and considered for the Phase II assessment included the CMP and KG's response to ECOH's queries regarding health and safety procedures and fire safety.

6.6.1 Probability of Harm

In its response to ECOH questions, the developer stated that prior to demolition and excavation all utility locates will be completed and utilities cut off from main lines. The CMP states that an assessment of overhead power lines will be conducted prior to start of the job. Provisions will be taken to ensure that equipment including cranes will not encroach on the power lines. The stated mitigation measures and strict adherence to regulated requirements are expected to mitigate risk associated with electrical hazards and utilities.

6.6.2 Risk Assessment

The harm caused by a possible electrocution or other hazard related to utilities results in a severity rating of S4 for health. In view of the stated mitigation measures, the probability has been rated as P1 or remote, assuming that the provisions of the CMP are diligently implemented and enforced. As a result, risk of electrical and utility hazards for this project is judged to be low for health and learning during the construction stages as shown in Table 6.6. This hazard is not applicable to the finished building.

Table 6.6. Risk Rating for Electrical Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Electrical shock may cause severe injury or death	P1	Remote likelihood of electrical hazard during demolition	Low
	Learning	S2	Electrical outage will disrupt learning; disruption due to emergency response	P1		Low
Excavation	Health	S4	As above	P1	Risk mitigation for utility locates, remote possibility of contact with overhead line	Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S2		P1		Low
Construction	Health	S4	As above	P1	Procedures for avoiding contact with overhead power lines.	Low
	Learning	S2		P1		Low
Finished Building	Health	NA	Not applicable	NA	Not applicable: no anticipated source	NA
	Learning	NA		NA		NA

6.7 Access to Site/ School

As noted in the Phase I assessment, access to the construction site by children, or conversely, access to the school site by people present on the construction site, could result in safety issues affecting children and security issues for the school. While the severity of such a hazard could be catastrophic (S4), the probability for the Phase I assessment was rated remote (P1).

6.7.1 Probability of Harm

In response to ECOH's request for information, the developer provided a response to ECOH's questions and the CMP of April 6, 2017, including drawings showing public protection hoarding, and information on fencing. In these documents, the developer stated that:

- During working hours, full time on-site supervision and safety management will be provided;
- Construction hoarding/fencing will be installed around the perimeter of the site;
- After-hours security may be provided by a CCTV system; and

- At the completion of the building a new fence will separate the site from JFPS property.

6.7.2 Risk Assessment

In view of the measures that will be taken by the developer, the probability of hazards associated with access to the site is rated as P1 or remote, resulting in a risk rating of low, as shown in Table. 6.7.

A boundary wall at least 12 feet high, erected at the west boundary of the school, will further reduce access to the site/building and to the school, both during and after the construction and hence reduce the low risk to very low risk.

Table 6.7. Risk Rating for Access to Site/School Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Severe injury possible if child should access site	P1	Remote likelihood of access by children to site and intrusion into school, given full time on-site supervision during school hours	Low
	Learning	S4	Serious consequences possible if intruder should access school	P1		Low
Excavation	Health	S4	As above	P1	As above	Low
	Learning	S4		P1		Low
Construction	Health	S4	As above	P1	As above	Low
	Learning	S4		P1		Low
Finished Buildi[illegible]	Health	S4	As above	P1	Remote likelihood above baseline levels	Low

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S4		P1	of intrusion into school	Low

7. PSYCHOSOCIAL HAZARDS

7.1 Potential Harm

A major psychosocial hazard discussed in the Phase I risk assessment is stress, which is a secondary hazard largely related to the effects of coping with other construction-related hazards. As mentioned in the Phase I assessment, conditions related to construction that may augment stress include:

- Annoyance due to noise and vibration;
- Increased traffic;
- The need for increased vigilance over children playing near the construction zone;
- Possible emergencies;
- Disruptions in normal routines; and
- The need for increased surveillance of school site conditions, e.g. related to security, structural damage.

To the extent that these hazards have been mitigated by the measures discussed in this Phase II assessment, stress will be concomitantly reduced.

Other psychosocial hazards discussed in the Phase I assessment were lighting and limitations on outdoor activities such as recess. There is no new information regarding the lighting (shadowing) impact of the proposed building on JFPS. While risks associated with dust and noise are expected to be mitigated by the measures considered in this assessment, it remains possible that at times they will be at levels that restrict outdoor activities.

7.2 Risk Assessment

Because there may be some stress arising from construction of the building at 18 Erskine Avenue, and as outdoor activities may be restricted at times, it is considered possible that psychosocial hazards will affect JFPS occupants. Therefore, the probability rating remains P3 or possible, resulting in a risk rating of medium for health and learning during the demolition, excavation and construction stages. Ratings for each stage are provided in Table 7.1.

Table 7.1. Risk Rating for Psychosocial Hazards

Stage	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Health effects on the hormonal balance mechanisms due to stress, response to noise, traffic, and other hazards	P3	Stressors associated with hazards and conditions present during demolition, excavation and construction stages; safety concerns or higher exposure to hazards such as noise and dust outdoors, which may limit outdoor activities such as recess	Medium
	Learning	S2	Coping strategies, stress response affecting learning and teaching; reduced time outdoors, with decrease in benefits from recess and other outdoor activities	P3		Medium
Excavation	Health	S2	As above	P3	As above	Medium
	Learning	S2		P3		Medium
Construction	Health	S2	As above	P3	As above, plus additional shade late in day	Medium
	Learning	S2	Above, plus shade effects	P3		Medium
Finished Building	Health	S2	Shade effects	P1	Some additional shade after school hours	Low
	Learning	S2		P1		Low

8. RECOMMENDATIONS

Risks to John Fisher Public School from construction of the tower at 18 Erskine Avenue cannot be eliminated. Nevertheless, application of the risk mitigation measures that the developer has specified are expected to bring residual risks for most of these hazards to a low or very low level.

Exceptions where the residual risk is medium to high are listed below. All are risks to health and learning unless otherwise noted. All are medium risks except for noise, which is high with the windows open or outdoors on the west side of the school.

- Diesel exhaust
- Indoor air quality
- Noise (with windows open or outdoors, west side of school)
- Vibration (learning only)
- Pests
- Traffic (health only)
- Cranes
- Fire
- Psychosocial

TDSB has asked ECOH to provide an opinion on whether students should be removed from JFPS during construction. As risks cannot be eliminated, this is a question of risk tolerance. It is noted that relocating students, with additional inconvenience and possible additional travel distance and time, also poses risks to health, safety and learning. Furthermore, some, albeit low, risks will be associated with occupancy of JFPS after completion of the building.

It is ECOH's opinion that risks can and should be mitigated to a level where students can remain in the school during construction. The following measures are recommended to achieve a risk mitigation level acceptable for continued occupancy of the school:

1. Noise mitigation measures:
   a. Plans should proceed to move the playground to the east end of the school to reduce noise exposure while staff and students are outdoors;
   b. Install double-paned windows that provide good seals and meet the expected Sound Transmission Class (STC) ratings;
   c. A boundary wall, at least 12 feet high, should be erected at the west boundary of the school. This will further reduce the noise in the classrooms, offices and play areas. In addition, it will reduce school occupants', especially children's, access to the construction site and the completed building, reduce construction workers' access to the school and help control pests;
2. Indoor Air Quality: Provide air conditioning to eliminate the need to open windows during hot weather. Opening windows will subject occupants to potentially high noise

and increased dust. While unit air conditioning will help to relieve this problem, central air conditioning is a more effective solution;

3. Asbestos: Remove all friable asbestos containing materials (ACM), preferably prior to the start of the project but certainly before the start of excavation, to eliminate the hazard of release of asbestos fibres due to vibration;
4. Lead: Prior to the start of the project but certainly before the start of excavation, remove all lead-containing paint that may be flaking, otherwise deteriorating or accessible to children, to eliminate the possibility of exposure to lead by inhalation as well as by ingestion;
5. Traffic: Increase vigilance to ensure children are not endangered by increased traffic; hold discussions with city officials on the advisability of designating Erskine Avenue a one-way street;
6. Crane(s): Address specific measures related to luffing jib tower crane safety (as discussed in section 6.2.); specify the number of cranes that might be used at a given time; ensure there is a lift plan that provides protection, especially for lifting heavy loads to great heights;
7. Establish a detailed fire safety plan for the construction project (as discussed in section 6.5);
8. Air monitoring for dust and diesel emissions:
    a. Regularly monitor for PM2.5 in addition to PM10 during demolition, excavation and construction stages of the development, as discussed in section 3.3;
    b. A plan for regularly monitoring for NOx should be established;
    c. Action levels should be established as discussed in sections 3.3 and 3.4, with detailed corrective measures to be taken (promptly) if action levels are exceeded;
    d. Air monitoring for PM10, PM2.5 and NOx should be conducted at JFPS as well as at the project property line;
9. Microbial and pest infestations: The care-taker at JFPS should be trained to provide increased vigilance in JFPS for possible mould and pest infestations with abatement and pest control measures where needed;
10. Structural integrity of the JFPS building: The care-taker at JFPS should be trained to look for visible signs and symptoms of structural damage and to seek professional help as appropriate;
11. Falling Objects: Provide netting as required by the City of Toronto to ensure that any falling object is adequately captured; ensure that netting and other barriers and measures are adequate (e.g. in terms of strength, mesh and placement) to prevent any potential for objects to land off the construction site;

12. Radon: Monitor for radon in JFPS to establish the base line radon levels, followed by regular monitoring. If there is any increase, investigate whether the cause is related to cracks in the foundations which are otherwise not discernible;
13. Vibration: Monitor vibration levels at JFPS, if warranted by perceived vibration, structural damage, or vibration levels measured by the developer/constructor; and
14. Enforcement: The Phase II risk assessment is predicated on mitigation steps proposed by the developer as a part of the CMP or documents and responses exchanged with ECOH. Establish a co-operative plan with the developer to ensure that risk mitigation measures are implemented as expected, hazards are controlled, and corrective action is taken immediately if expectations are not met. The plan should include third party monitoring and procedures for resolving issues. The third party chosen must have a demonstrated perspective of all the risks identified and the sensitive populations at risk.

9. CONCLUSION

This Phase II risk assessment has examined hazards associated with the construction of the tower at 18 Erskine Avenue that might reasonably be assumed to pose a risk to JFPS occupants, with respect to health, safety or learning. Each hazard has been assessed for risks to health, safety and learning for four stages of the project, taking into account exposure potential and the risk mitigation measures specified by the developer. A summary of risk ratings for each hazard for each stage is provided in Table 9.1.

Even where residual risks are expected to be low or very low, diligent monitoring and enforcement will be needed to ensure adherence to all mitigation measures. Failure to diligently adhere to all mitigation measures can have serious consequences. Therefore, mechanisms should be put in place for TDSB and the developer to monitor hazard controls and quickly resolve any issues that may affect health, safety, learning or development of JFPS staff and students.

ECOH is of the opinion that risks can and should be mitigated to a level where students can remain in the school during construction. Section 8 provides recommendations to mitigate risks to a level where continued occupancy is acceptable. All risk mitigation measures should be supported through a co-operative plan whereby mitigation implementation and hazard control will be monitored by a credible third party during various stages of construction, with authority to enforce prompt remedial action on the part of TDSB and the developer to address identified issues.

If on the other hand, no credible third party is on-site to monitor and document the constructor’s daily activities and empowered to take action when and if necessary, we would deem the risk to fall within an unacceptable range and would not recommend continued occupancy during construction.

Table 9.1 Health and Learning Risk Ratings		Risk - Health				Risk - Learning			
		Stage				Stage			
	Hazard	Demolition	Excavation	Construction	Finished Building	Demolition	Excavation	Construction	Finished Building
Chemical Hazards	Asbestos	Low	Low	Very Low	NA (not applicable)	Low	Low	Very Low	NA
	Lead & Mercury	Low	Low	Very Low	NA	Very Low	Very Low	Very Low	NA
	Diesel exhaust	Medium	Medium	Medium	Low	Medium	Medium	Low	Low
	Crustal Dust	Low	Low	Low	NA	Low	Low	Low	NA
	Respirable Crystalline Silica	Low	Low	Low	NA	Very Low	Very Low	Very Low	NA
	Asphalt fumes	NA	NA	Low	NA	NA	NA	Low	NA
	Volatile Organic Compounds (VOCs)	Very Low	Very Low	Low	Very Low	Very Low	Very Low	Low	Very Low
	Indoor Air Quality	Medium	Medium	Medium	NA	Medium	Medium	Medium	NA
Physical Hazards	Noise (windows closed)	Low	Low	Low	NA	Low	Low	Low	NA
	Noise (windows open)	High	Medium	Medium	NA	High	Medium	Medium	NA
	Vibration	Low	Low	Low	NA	Medium	Medium	Low	NA
	Radon	Low	Low	Low	NA	Low	Low	Low	NA
	Welding Radiation	Low	Very Low	Low	NA	Very Low	Very Low	Very Low	NA
Biological Hazards	Pests (excluding microbes)	Medium	Medium	Medium	Very Low	Medium	Low	Low	Very Low
	Microbes	Low	Low	Low	Very Low	Low	Low	Low	Very Low
Safety Hazards	Traffic	Medium	Medium	Medium	Low	Low	Low	Low	Very Low
	Cranes	NA	NA	Medium	NA	NA	NA	Medium	NA
	Falling Objects	Low	Low	Low	Low	Low	Very Low	Low	Very Low
	Structural Stability & Water Table	NA	Low	NA	NA	NA	Low	NA	NA
	Fire and Explosion	Low	Low	Medium	NA	Low	Low	Medium	NA
	Electrical & Utilities	Low	Low	Low	NA	Low	Low	Low	NA
	Access to site	Low	Low	Low	Low	Low	Low	Low	Low
Psychosocial Hazards		Medium	Medium	Medium	Low	Medium	Medium	Medium	Low

10. STATEMENT OF LIMITATIONS

This risk assessment comprised a review of hazards associated with construction of the tower at 18 Erskine Avenue that may pose a risk to occupants of John Fisher Public School at 40 Erskine Avenue. In conducting this assessment, ECOH has exercised a degree of thoroughness and competence that is consistent with the environmental, health and safety profession.

ECOH is a consulting company with experience in conducting environmental, health and safety risk assessments for public and private sector organizations. Consultants who contributed to this assessment hold the following professional qualifications: Professional Engineer, Certified Industrial Hygienist, Registered Occupational Hygienist, Medical Doctor, Professional Geoscientist (Ltd.), Qualified Person for Risk Assessment. The external parties consulted (Intrinsik and Hite Engineering) have qualifications in toxicology and construction safety and engineering.

ECOH, to the best of its knowledge, considers the information presented to be reliable and the opinions expressed to be consistent with professional standards. ECOH cannot, however, guarantee the completeness or accuracy of information supplied to ECOH by third parties.

ECOH is an environmental, health and safety consulting company, and as such does not intend any results or conclusions presented in this report to be construed as legal advice. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ECOH accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions based on this report.

ECOH appreciates the opportunity to be of service to TDSB in conducting this Phase II risk assessment.

ECOH
Environmental Consulting & Occupational Health

Om Malik, PhD, PEng, CIH, ROH, FAIHA, QP_{RA}
Principal and CEO

REFERENCES

1. CCOHS. Risk Assessment : OSH Answers [Internet]. 2006 [cited 2017 Feb 2]. Available from: http://www.ccohs.ca/oshanswers/hsprograms/risk_assessment.html

2. CSA Z1002-12 Occupational Health and Safety- Hazard Identification Risk Assessment and Control. CSA Group, Z1002-12 2012 p. 58.

3. Smith J, Riley P. ANSI Z10 Risk assessment. 2005.

4. 18 Erskine Holdings Inc. Construction Mitigation Plan - 18 Erskine. Toronto; 2017.

5. KG Group. KG Group Response to ECOH. Toronto; 2017.

6. exp Services. Response to Air Quality Concerns Preliminary Risk Assessment Hazards from Construction Project Near John Fisher Public School Phase I. Brampton, Ontario; 2017.

7. Orkin/PCO. Pest Management Protection Program. Toronto; 2017.

8. ON MOL. Alert: Asbestos Hazard in Vehicle Brake Repair [Internet]. Government of Ontario, Ministry of Labour; 2013 [cited 2017 Feb 2]. Available from: https://www.labour.gov.on.ca/english/hs/pubs/alerts/i34.php

9. Agency USEP. Health Assessment Document For Diesel Engine Exhaust [Internet]. Environmental Protection. 2002 [cited 2017 Feb 2]. Available from: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060#area

10. Office of Environmental Health Hazard Assessment (OEHHA). Health Effects of Diesel Exhaust. Exposure [Internet]. 2001; Available from: oehha.ca.gov/media/downloads/calenviroscreen/indicators/diesel4-02.pdf

11. Lewis MP. Estimating fuel use and emission rates of nonroad diesel construction equipment performing representative duty cycles. 2009.

12. Standards Development Branch Ontario Ministry of the Environment. Ontario's Ambient Air Quality Criteria. 2012.

13. US Environmental Protection Agency. Primary National Ambient Air Quality Standard for Nitrogen Dioxide; Final Rule. 40 CFR Parts 75 (26) 2010 p. 6474–537.

14. USEPA. Particle Pollution and Your Health. USEPA [Internet]. 2003;(September):2. Available from: http://www.airnow.gov/index.cfm?action=pubs.index

15. Stacey P, Thorpe A, Roberts P. Levels of respirable dust and respirable crystalline silica at construction sites RR878 Levels of respirable dust and respirable crystalline silica at construction sites. Vol. RR878, Health and Safety Executive. 2011.

16. National Centre for Environmental Assessment. Ambient Levels and Noncancer Health Effects of Inhaled Crystalline and Amorphous Silica : Health Issue Assessment. Research Triangle Park, NC; 1996.

17. Connecticut Department of Health. Vapor Intrusion of VOCs Evaluating the Risks to Buildings in Your Town. Environ Occup Heal Assess Progr. 2012;(8):1–7.

18. Ontario Ministry of the Environment. Environmental Noise Guideline Stationary and

Transportation Sources – Approval and Planning Publication NPC-300. Publication NPC-300. 2013.

19. Birgitta Berglund , Thomas Lindvall DHS. Guidelines for Community Noise - World Health Organization. World Health Organization; 1999.

20. Berger, Elliott H. Royster, Larry H. Royster, Julia D. Driscoll, Dennis P. Layne M. Noise Control Engineering 8. In: Noise Manual. 2003. p. 1–21.

21. FHWA. Roadway Construction Noise Model [Internet]. 2017. Available from: http://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/

22. Technical Notes 5A - Sound Insulation - Clay Masonry Walls. 2000;(August).

23. Rating STC, Ratings WSTC, Have W. STC RATINGS What is. 2017.

24. PRICE 5. Sound Transmission Class Guidance. 1999;1–5.

25. Consultancy EH. How to use Sound Attenuation due to Propagation (aka " Geometrical Divergence ") Sound Attenuation due to a Barrier - ISO 9613-2 : 1996 (up to Ground Effect (refection and absorption) - ISO 9613-2 : 1996. 2017. p. 2–4.

26. Vibration: Northern Expressway Environmental Report.

27. Chartered Institute of Environmental Health. Pest minimisation Best practice for the construction industry. Natl Pest Advis Panel [Internet]. Available from: www.cieh-npap.org

28. UK Health and Safety Executive. HSE Safety Alert - Preventing catastrophic failure of luffing jib tower cranes in high winds [Internet]. 2014 [cited 2017 Apr 10]. Available from: http://www.hse.gov.uk/safetybulletins/luffing-jib-tower-cranes.htm

29. Dahm A. Designing safety into luffing jib tower cranes - KHL Group - International Cranes and Specialized Transport [Internet]. International Cranes and Specialized Transport. 2009 [cited 2017 Apr 13]. Available from: http://www.khl.com/magazines/international-cranes-and-specialized-transport/detail/item34529/Designing-safety-into-luffing-jib-tower-cranes

30. Kessel H-G. KHL Group - A Challenging Angle for Tower Cranes [Internet]. 2014 [cited 2017 Apr 13]. Available from: http://www.khl.com/app/detail/item102481/A-challenging-angle-for-tower-cranes

31. Hite Engineering Corporation - Hazard Identification and Mitigation Report. A report prepared for ECOH dated April 10, 2017

APPENDIX

PHASE I (PRELIMINARY) RISK ASSESSMENT

ECOH
Environmental Consulting
Occupational Health

March 13, 2017

Mr. Angelos Bacopoulos
Associate Director
Facilities, Sustainability and Employee Services
Toronto District School Board

Re: Preliminary Risk Assessment: Construction Hazards John Fisher Public School

Dear Mr. Bacopoulos:

At the request of the Toronto District School Board (TDSB), **ECOH (Environmental Consulting & Occupational Health)** has prepared the attached preliminary risk assessment of potential hazards associated with construction of a residential tower on Erskine Avenue adjacent to the site of John Fisher Public School.

This report represents Phase I of the risk assessment process, and is a generic risk assessment based on a review of the literature and other publicly available information. In conducting this phase of the assessment, ECOH had only limited information specific to this project and did not discuss risk mitigation measures with the constructor or developer. In the absence of full information on risk mitigation measures, there is considerable uncertainty associated with the risk ratings. These ratings should therefore be considered preliminary indicators of potential risk or level of concern.

ECOH is prepared to undertake Phase II of the risk assessment, which will be based on specific risk mitigation measures as they become available.

We thank you for the opportunity to be of service to the TDSB.

Yours truly,

Environmental Consulting & Occupational Health

Om Malik, PhD, PEng, CIH, ROH, FAIHA, QP_{RA}
Principal and CEO

Attachment

PRELIMINARY RISK ASSESSMENT
HAZARDS FROM CONSTRUCTION PROJECT NEAR
JOHN FISHER PUBLIC SCHOOL

PHASE I

Submitted to:
Toronto District School Board

Presented by:
ECOH
75 Courtneypark Drive West, Unit 1
Mississauga, ON L5W 0E3

ECOH Project No.: 17201

March 13, 2017

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Executive Summary

A 35-story residential building has been proposed for the site of 30 Erskine Avenue in Toronto, adjacent to the property of John Fisher Public School (JFPS), a school under the jurisdiction of the Toronto District School Board (TDSB). TDSB has engaged ECOH Management Inc. (ECOH) to assess risks posed to JFPS occupants during construction and after completion of the building.

This report presents results of a Phase I risk assessment, which includes hazard identification and a qualitative assessment of risks. Information considered for this assessment was obtained from reviews of the literature and relevant available information about the project and the school. Requirements, standards and guidelines to mitigate risks were reviewed.

Hazards were identified in five categories: chemical, physical, biological, safety and psychosocial. Risks were assessed using a risk matrix (Table A) that combined ratings of hazard severity and probability of harm.

Table A Risk Assessment Matrix:

Severity				
Catastrophic S4	**Medium**	**Medium**	**High**	**High**
Major S3	**Low**	**Medium**	**Medium**	**High**
Moderate S2	**Low**	**Medium**	**Medium**	**Medium**
Minor S1	**Low**	**Low**	**Low**	**Medium**
	Remote P1	**Improbable P2**	**Possible P3**	**Likely P4**

Probability

Potential impacts on learning as well as on health and safety were considered for each hazard, and risks were assessed for four stages of the project: demolition, excavation, construction and finished building.

A summary of ratings is provided in Table B. Given the absence of information specific to the proposed project, there is considerable uncertainty in rating risks for this Phase I assessment, and ratings should be regarded as indicators of level of concern.

Recommendations are made regarding additional information to be requested from the developer.

Table B: Health and Learning Risk Ratings		Potential Risk - Health Stage				Potential Risk - Learning Stage			
	Hazard	Demolition	Excavation	Construction	Finished Building	Demolition	Excavation	Construction	Finished Building
Chemical Hazards	Asbestos	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Lead	Medium	Medium	Low	NA	Low	Low	Low	NA
	Respirable Crystalline Silica	Medium	Medium	Medium	Low	Low	Low	Low	Low
	Diesel exhaust	High	High	Medium	Low	Medium	Medium	Medium	Low
	Crustal Dust	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Nitrous oxides (Nox)	High	High	Medium	Low	Medium	Medium	Medium	Low
	Sulphur Oxides (SOx)	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Volatile Organic Compounds (VOCs)	Low	Low	Medium	Low	Low	Low	Medium	Low
	Asphalt fumes	NA	NA	Medium	NA	NA	NA	Medium	NA
	Indoor Air Quality	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
Physical Hazards	Noise	High	High	High	NA	High	High	High	NA
	Vibration	Low	Low	Low	Low	Low	Low	Low	Low
	Welding Radiation	Medium	NA	Medium	NA	Low	NA	Low	NA
	Radon	Medium	Medium	Medium	NA	Medium	Medium	Medium	NA
Biological Hazards	Pests (excluding microbes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
	Microbes	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Safety Hazards	Traffic	High	High	High	Medium	Medium	Medium	Medium	Low
	Falling Objects	High	Medium	High	Low	Medium	Medium	Medium	Low
	Cranes	NA	NA	High	NA	NA	NA	High	NA
	Structural Stability & Water Table	Medium	Medium	NA	NA	Medium	Medium	NA	NA
	Fire and Explosion	Medium	High	High	Medium	Medium	High	High	Medium
	Utilities	NA	Medium	NA	NA	NA	Medium	NA	NA
	Electrical	Medium	High	High	Medium	Low	Medium	Medium	Low
	Access to site	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Psychosocial Hazards		Medium	Medium	Medium	Low	Medium	Medium	Medium	Low

1. INTRODUCTION

A 35-story residential building has been proposed for the site of 30 Erskine Avenue in Toronto, adjacent to the property of John Fisher Public School (JFPS), a school under the jurisdiction of the Toronto District School Board (TDSB). The school serves 485 students and houses a daycare centre, The French Connection. JFPS is listed as a historic site and was initially constructed in 1887. Concerns have been raised by school and daycare staff and parents regarding risks posed to school occupants by the project, during demolition, excavation, construction, and after the building is complete.

In response, TDSB has engaged ECOH Management Inc. (ECOH) to assess risks posed to JFPS occupants during construction and after completion of the building. ECOH has proposed a phased approach, comprising up to four phases:

Phase I: Generic Risk Assessment: This phase comprises hazard identification and a qualitative assessment based on reviews of the literature and relevant available information. As this phase is conducted in the absence of specifics on the planned construction, it is largely a generic assessment that will point to potential risk and level of concern about each hazard. It also includes identifying relevant standards and guidelines for risk mitigation, both in Toronto and elsewhere.

Phase II: Site Specific Risk Assessment: This phase will more specifically characterize risk based on specific information about the project site and construction and demolition plans for the proposed project.

Phase III: Site Monitoring: This phase will comprise monitoring the degree of hazard exposure when the project is under way.

Phase IV: Post-construction assessment: This phase will be conducted after project completion, and assess conditions during ongoing occupancy of the school in relation to the completed project.

This report presents findings of the Phase I assessment. The approach to the assessment, including methodology, assumptions and limitations are described in Section 2. Findings and ratings of the hazards are provided in Section 3 through 7. , Recommendations and Conclusions are in Sections 9 and 10. Intrinsik, a firm specializing in toxicology and risk assessment, contributed to this report.

2. METHODS AND CONSIDERATIONS

2.1 Phase I Assessment

Phase I of this project is a generic assessment conducted in the absence of specific information about the degree of exposure to each hazard. While the developer's Construction Mitigation Plan was available to ECOH, there are numerous gaps in specific information about the project. Therefore, there is considerable uncertainty in evaluating risks in this Phase 1 assessment, and findings should be considered a gauge of level of concern..

2.2 Hazard Identification

In consultation with TDSB and parents, ECOH identified a list of hazards that may be posed by construction of the planned development. In conducting our research, several additional hazards were identified. Hazards were grouped into standard categories of environmental and occupational hazards, as set out in Table 2.1.

Table 2.1. Identified Hazards

Chemical Hazards	Physical Hazards	Biological Hazards	Safety Hazards	Psychosocial Hazards
Asbestos Lead Respirable Crystalline Silica Diesel Exhaust (including particulates and gaseous constituents) Dust Volatile Organic Compounds Asphalt fumes Indoor Air Quality	Noise Vibration Radon Welding Radiation	Pests Microbial agents	Traffic Cranes Falling & Moving Objects Structural Stability & water table issues Fire and explosion Utility Issues Electrical Access to site or school	Stress Effects on learning environment (not elsewhere considered), including lighting and limitations on outdoor activities (recess)

2.3 Risk Assessment Approach

The risk posed by a given hazard is a function of two factors:

- The inherent severity of the hazard – i.e. how much harm it can potentially cause. Harm can be any change in body functions affecting health status or change in mental condition hence affecting learning and development; and
- The probability that the hazard will cause harm. In the case of a health hazard, this is usually a function of the level of exposure; in the case of a safety hazard it is the probability that the hazard will lead to an event that can cause injury or other harm.

In conducting an assessment, each hazard is rated based on the severity of its potential effects, and the probability that it would cause those effects, or of an exposure level that may cause harm. A common way to combine these two factors is through a matrix, one dimension of which represents severity of the hazard, with the other representing probability.

Matrices used for assessment purposes typically divide Severity and Probability into 3,4 or 5 levels. There is no single correct way to construct a matrix. Guidance material on risk assessment matrices emphasizes that, "There is no one simple or single way to determine the level of risk. Ranking hazards requires the knowledge of the …activities, urgency of situations, and most importantly, objective judgement" (1). In constructing the matrix used for this assessment, ECOH consulted Canadian Standards Association (CSA) Standard Z1002 (2) and the American National Standards Institute (ANSI) Z10, Occupational Health and Safety Management Systems Standard (3).

ECOH has used a 4 x 4 matrix to rate potential risks, which have been grouped into High, Medium and Low bands. Explanations of effects considered, definitions for Severity and Probability used to rate each hazard, and construction of the matrix are described in the following sections.

2.4 Effects and Construction Stages Considered

In consultations with TDSB staff and parents, ECOH was asked to consider hazards as they may affect the school differently in separate stages of construction, and when the building is complete. ECOH was also asked to consider not only impacts on health and safety, but also on learning. Accordingly, the criteria for severity were applied to separately rate potential impacts on health and safety, and potential impacts on learning. The criteria for probability were applied separately for four stages of the project: demolition, excavation, construction and finished building. As a result, eight separate ratings are derived for each hazard (4 stages for health and safety impacts plus 4 stages for learning impacts).

2.4.1 Health Effects

In considering potential health effects of the hazards under consideration, the assessment was based on the most sensitive population exposed. In most cases, this was children. There are a few exceptions, such as stress or reproductive hazards, to which adults are more sensitive but for the most part, children are more sensitive than adults to health hazards, especially chemical hazards. As described by the World Health Organization, (4) children and adults have very different physiologies and behaviours resulting in differential exposures and effects of environmental hazards. Reasons for this differential are explained in Section 3.1 on Chemical Hazards. Where the literature has pointed to other specific sensitivities of children, these are addressed in the sections on the relevant hazard.

2.4.2 Learning and Development Effects

Learning effects considered were those effects either on the learning environment or effects on individuals, other than health effects, that may disrupt the learning experience. (Examples of such effects on individuals are annoyance, anxiety and distraction.). Where hazards can impact cognitive ability through disrupting a physiological mechanism, it is considered a health effect, rather than a learning effect.

2.5 Rating Criteria

Criteria used to rate the severity (S) and probability (P) for each hazard are shown in Table 2.2, with S1 and P1 the lowest ratings.

Note that probability ratings are based on exposure or probability of the hazard above background levels.

Table 2.2. Criteria for Severity Rating

Rating	Criteria
S4 -Catastrophic	Death or permanent total disability in the short-term Complete system loss, major property damage Major disruption of learning (e.g. school closure for one week or more)
S3 -Major	Chronic / Irreversible Permanent, partial or temporary disability in excess of three months including chronic effects that may not occur until many years after exposure Serious disruption of learning (e.g. property damage, school downtime one day or more; inability to carry on normal teaching and classroom activities)
S2 -Moderate	Reversible Injury that can cause loss of time from work or school Minor property damage; downtime to school operation less than one day Moderate disruption of teaching or learning due to annoyance, distraction, anxiety
S1 -Minor	No health or safety deviation from baseline Minor annoyance or distraction

Table 2.3. Probability Criteria

Rating	Criteria*
P4- Likely	Could occur several times during that phase of the project
P3- Possible	Could occur during that phase of the project
P2- Improbable	Not likely to occur during that phase of the project
P1- Remote	Very unlikely to occur during that phase of the project

*based on probability or exposure levels above background

2.6 Risk Assessment Matrix

The matrix used to combine Severity and Probability ratings and group them into bands is shown in Table 2.4.

.

Table 2.4. Risk Assessment Matrix

Severity					
	Catastrophic S4	**Medium**	**Medium**	**High**	**High**
	Major S3	**Low**	**Medium**	**Medium**	**High**
	Moderate S2	**Low**	**Medium**	**Medium**	**Medium**
	Minor S1	**Low**	**Low**	**Low**	**Medium**
		Remote P1	**Improbable P2**	**Possible P3**	**Likely P4**

Probability

2.7 Evidence Sources

Evidence sources for this Phase I assessment included documentation specific to the school and project, where available. Evidence was also collected from a literature and internet search.

Information specific to the project and school included:

- The developer's proposal documents and City staff reports available on the City of Toronto web site;
- The Construction Mitigation Plan provided by 18 Erskine Holdings Inc. and Deltera Contracting Inc.;
- Designated Substance Surveys of John Fisher Public School;
- Information obtained through conversations with City and TDSB representatives;
- Site plans and maps; and
- A 2013 submission by a parents' group to the City regarding the proposed development.

The literature search was conducted using the internet and academic databases. References are appended to this report. Sources retrieved from these searches included:

- Academic studies;
- Government and institutional reports and web sites;
- Laws, standards and guidelines issued by standard-setting bodies and government agencies; and
- Information retrieved from the internet about relevant similar situations.

Other relevant information that was considered included results of noise and air monitoring made under somewhat similar conditions (conducted by ECOH or retrieved online).

Findings from these sources, and ratings of Severity, Probability and Risk based on these findings, are described for each hazard group in Sections 3 to 7.

3. CHEMICAL HAZARDS

3.1 Health Assessment Considerations

3.1.1 Sensitivity of Children to Chemical Hazards

As explained in Section 2, assessment of the severity of health hazards was based on effects on the most sensitive population exposed. In most cases, this is children. The World Health Organization explains several reasons why children may be more sensitive to chemical hazards, including the following:

- Children are shorter than adults. This means that the air that they breathe is physically lower to the ground than the air breathed by an average adult. Many substances have a greater relative density than air, meaning they will accumulate in a concentration gradient with the highest concentrations of the substance located closest to the ground (4). This implies that children will be exposed to higher concentrations of these substances than adults.

- A child's resting breathing rate is faster than that of an adult. An average infant's breathing rate is 3 times that of an average adult, and an average 6-year-old's is double that of an average adult (4). Thus every minute, a child will inhale and exhale more air per kilogram of body weight than an adult. Accordingly, substances inhaled from either indoor or outdoor air are delivered to children at higher internal doses than adults. Depending upon the substance in question, this means a child may be more susceptible to negative health effects associated with agents absorbed through the lungs or respiratory tract than an adult, and may exhibit a more rapid response to such agents, particularly those agents that cause acute (short-term, quick-acting) health effects (5).

- Children tend to be more physically active than adults. Physical activity results in an increase in respiration rate above resting levels. Therefore, when considering an average child's overall breathing rate compared to an average adult's overall breathing rate, the difference in rates is even more pronounced than the difference in resting breathing rate (4).

- Young children are more likely to touch surfaces and come into contact with the ground than adults, and having smaller bodies, a child's skin surface area relative to overall body weight is greater than that of an adult. Children are therefore more likely to receive a higher dose of any substances present on surfaces or on the ground that can be absorbed through the skin.

- Children exhibit much greater "hand-to-mouth" behaviour (more likely to touch surfaces and then place their hands in their mouths) than adults, and are more likely to try to consume substances that are not food (6). Therefore, their risk of ingesting toxic substances and suffering adverse health effects is also greater (4).

- Children have immature physiological systems (e.g. immune response, excretory mechanisms, etc.) for responding to toxic substances to which they are exposed (6).

- Children are likely to live longer than adults after the time of exposure, and therefore have longer periods of time over which diseases may manifest as a result of exposure to chemical, biological or physical hazards, particularly chronic hazards, i.e. those whose adverse health effects can take a long time to develop or that accumulate in the body (6).

- Children are actively growing and developing. The impact of chemical, biological or physical hazards on children has the unique potential to disrupt or alter normal physiological development, and cause lifelong damage (6).

- Children absorb nutrients as well as substances that the body treats as similar to nutrients (e.g. lead) more efficiently than adults. For example, a toddler can absorb from 40-70% of an ingested dose of lead compared to 5-20% absorption in adults (6).

- Children often have a far poorer ability to understand the dangers posed by hazards in their environment and to take precautionary steps to avoid exposure to such hazards (6).

Some of these factors apply to physical and biological hazards as well as chemical hazards, which will be discussed in sections 4 and 5.

3.1.2 Carcinogenicity

Some of the hazards assessed in this report are carcinogens (cancer-causing agents). Carcinogens do not cause cancer in everyone who is exposed, but can increase the risk of getting cancer. Usually cancer does not occur until long after the exposure, and only in a very small percentage of the people who have been exposed. Carcinogens are usually considered to not have a threshold response: that is, there is no level that is considered "safe" and the degree of risk increases with the amount of exposure. It is therefore considered prudent to reduce exposure to the lowest practical level.

Exposure to the carcinogens discussed in this report are expected to be at very low levels. Carcinogen exposure that may be caused by the construction project will in most cases add to a baseline level of the agent already present in the environment. In view of the severity of the potential effect (cancer) and because there is not judged to be a "safe" level of exposure, carcinogens have been given a severity rating of S3 (major) in this assessment. The probability ratings given for carcinogens in this assessment are based on the likelihood that exposure may occur due to the project, not on the likelihood that someone may get cancer as a result.

3.2 Asbestos

3.2.1 Potential Effects

Asbestos is a naturally occurring mineral that was widely used in building materials due to its strength, insulating and fire resistant properties. Exposure to asbestos may occur through inhalation of airborne fibres. Exposure to high airborne concentrations of asbestos fibres can cause a severe lung disease called asbestosis. Exposure to asbestos can also increase the risk of cancer. The types of cancer associated with asbestos are lung cancer and mesothelioma, cancer of the lining of the lung. There is generally a long period (15+ years) between asbestos exposure and development of asbestosis or cancer. Risks of cancer due to asbestos exposure are higher for individuals who smoke.

Since low concentrations of asbestos fibres in air are not detectable without the use of air monitoring instruments, they will not have a direct effect on learning. However, in view of the widespread concern about asbestos, the potential for increased exposure may elevate anxiety, which can in turn impact learning.

3.2.2 Potential Exposure

Although new uses of asbestos in buildings are prohibited, asbestos remains present in many building materials. These are commonly referred to as asbestos-containing-materials (ACM). Asbestos in Ontario buildings is regulated by the Ontario Ministry of Labour under Regulation 278/05, Asbestos on Construction Projects and in Buildings and Repair Operations. This regulation requires building owners to maintain an ACM registry and to repair or remove any ACM that may release asbestos fibres into the air.

Regulation 278/05 also imposes strict requirements and controls on the removal of asbestos before a building is demolished. Therefore, it can be assumed that any asbestos in the building currently on the project site will have been removed prior to demolition in a manner that will prevent release of asbestos into the environment. However, a possible source of airborne asbestos is the ACM in JFPS, if it should release fibres due to vibration or building damage resulting from construction activities.

No quantitative information was found on the degree to which asbestos fibres may be released due to construction vibrations. However, some relevant information points toward the likelihood that this could occur.

Guidance material on asbestos by agencies such as the US EPA advises that asbestos fibres may be dislodged from ACM due to vibration (7). The US Federal Transit Administration, in a manual that addresses vibration from construction, notes that "Ground vibration from construction activities very rarely reach the levels that can damage structures, but…A possible exception is the case of old, fragile buildings of historical significance where special care must be taken to avoid damage. The construction activities that typically generate the most severe vibrations are blasting and impact pile-driving." (8). As JFPS may be considered an old building of historical significance, it is possible that it is vulnerable to such vibrations. Deltera's Construction Mitigation Plan (25) states that shoring systems will not be pile-driven, which will help to minimize vibrations.

ECOH and other consultants to TDSB have surveyed JFPS and identified ACM (confirmed ACM) and materials that are presumed to contain asbestos (presumed ACM), pending results of any future laboratory tests. TDSB maintains an asbestos database and an Asbestos Management Plan to ensure that all ACM is maintained in good condition to prevent fibre release.

Confirmed ACM present in JFPS includes ceiling tiles, parging cement on fittings, cellulose and tar paper on straight run pipe, and aircell insulation on straight run pipes. Presumed ACM includes plaster in various locations, window caulking, drywall joint compound, vinyl floor tiles, bell and spigot joints, fire doors, asbestos chalkboard and transite asbestos cement on ceilings. Of these materials, the parging cement on fittings, cellulose and tar paper, and aircell pipe insulation were friable (capable of being crushed by hand and therefore most susceptible to fibre release).

If the ACM is in good condition, fibre release is very unlikely. However, it is possible that vibration from the construction project, especially during the demolition and excavation phases, could cause damage to ACM with resulting potential for fibre release.

Another possible source of asbestos from the proposed project is brake pads, if they are used on the construction vehicles. Although asbestos is no longer used in products manufactured in Canada, the Ontario Ministry of Labour has warned that aftermarket brake pads containing asbestos are still imported into the country (9).While this is mainly a hazard for mechanics working on vehicles, some asbestos fibres may be released from brake pads in use on vehicles.

3.2.3 Risk Assessment

Based on the criteria for Severity and Probability Ratings set out in section 2.5, asbestos is considered to have medium risk for health and learning during the demolition, excavation and construction phases which may cause vibration that will affect the JFPS building.

Ratings and explanations for Severity, Probability and Risk for Health and Learning for each stage are provided in Table 3.1.

Table 3.1. Risk Rating for Exposure to Asbestos

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increases risk of cancer (long latency; would not appear for many years, if at all)	P3	Causes vibration which may damage ACM in JFPS with resulting potential for asbestos fibre release; low potential for release from brake pads on vehicles	Medium
	Learning	S2	Anxiety due to potential for asbestos exposure (e.g. among staff) may have adverse effect on learning	P3		Medium
Excavation	Health	S3	As above	P3	As above	Medium
	Learning	S2		P3		Medium
Construction	Health	S3	As above	P2	Low potential for increased vibration; low potential for release from brake pads on vehicles	Medium
	Learning	S2		P2		Medium
Finished Building	Health	S3	As above	P1	No expected source of increased vibration	Low
	Learning	S2		P1		Low

3.3 Lead

Lead is a naturally occurring metallic element found in rock and soil. Until the 1990's, it was widely used as an anti-knock agent in gasoline and in a variety of building materials including pipes and paints. Because of its previous widespread use, Canadians are exposed to low levels of lead in food, drinking water, air, dust, soil, and products.

3.3.1 Potential Effects

The major health effects of lead that are of concern with respect to this risk assessment are its effects on child development. In a 2013 review on lead, Health Canada reports a number of adverse neurological and cognitive effects of lead exposure on children (10), including effects on behaviour and attention. Health impacts of lead on adults include effects on the cardiovascular, kidney and reproductive systems.

3.3.2 Potential Exposure

Exposure to lead may occur through ingestion or inhalation of lead-containing dust. Elevated exposure to lead may occur from lead in soil, settled lead-containing dust, or dust released from lead-painted surfaces. Children are more likely to be exposed than adults because they frequently put contaminated hands and objects in their mouths. Drinking water can be contaminated with lead if it is within lead-containing piping systems, though this is not a route of exposure relevant to this project.

Lead is widely present in soil and dust in Canada, due both to its natural occurrence in soil and from lead-containing products. Studies cited by Health Canada point to varying background levels of lead in soil in many communities, and to lead in dust in many households. Therefore, soil and dust from the project site may contain some lead, but concentrations would not necessarily be elevated above background levels unless there were a source of additional lead contamination, or the building to be demolished contains lead.

Lead may be present in paint on surfaces in JFPS. The only documented lead-containing paint shows a very low level in an inaccessible area (the boiler room). But unless paint in other areas of the school are known to be lead-free, there is a possibility that vibration from the project may generate lead-containing dust and flakes.

3.3.3 Risk Assessment

Based on the criteria for Severity and Probability Ratings set out in section 2.5, lead is considered to have medium risk for health and low risk for learning. The medium risk rating for health is derived because the probability of exposure during demolition and excavation is rated as P3, as it is not known whether the soil on the project site has elevated lead levels, whether the building to be demolished contains lead, or what dust control measures will be used. Furthermore, since all soil in Canada contains lead, any migration of dust from site soil to the school premises may result in some increased presence of lead-containing dust. The probability of release of lead from within JFPS is considered low.

It should be noted that lead's neurological and cognitive effects can affect an individual child's learning, but these are included as health effects. Table 3.2 provides the risk ratings for lead exposures on Health and Learning for each stage of construction.

Table 3.2. Risk Rating for Exposure to Lead

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Neurological & cognitive effects	P3	Lead may be present in project site soil and/or in existing building to be demolished; lead may be present and dislodged from paint in JFPS	Medium
	Learning	S1	No disruption of learning (cognitive effects are considered to be health effects)	P3		Low
Excavation	Health	S3	As above	P3	As above	Medium
	Learning	S1		P3		Low
Construction	Health	S3	As above	P1	Construction materials very unlikely to contain lead; vibration very unlikely to be sufficient to dislodge any lead paint in JFPS	Low
	Learning	S1		P1		Low
Finished Building	Health		Not applicable (N/A)		Not applicable: No anticipated source	N/A
	Learning					N/A

3.4 Silica

Silica (SiO_2) is a compound containing silicon and oxygen and is the second most abundant mineral in the Earth's crust (11).It is largely found in sand, rock and mineral ores. There are several different forms of silica, with crystalline silica being the highest potential concern for human health. Types of crystalline silica include quartz, cristobalite, tridymite and tripoli (11).

3.4.1 Potential Effects

The potential effects from exposure to crystalline silica vary greatly with the particle size, concentration and duration of exposure. Crystalline silica is classified as carcinogenic to humans by the International Agency for Research on Cancer; however, this classification was specifically for quartz and cristobalite inhaled from occupational sources (12). Epidemiological studies have shown a potential increase in lung cancer from occupational exposure to silica, especially in quarry and granite workers. Other potential health effects resulting from silica exposure include silicosis, pulmonary tuberculosis, chronic obstructive pulmonary diseases and autoimmune disease (13)(14)(15). The form of silica that can cause these effects is respirable crystalline silica, i.e. silica in crystal form that is airborne as particles small enough to be inhaled into the deepest parts of the lungs (the respirable fraction).

3.4.2 Potential Exposure

Exposure to crystalline silica dust is typically via the inhalation pathway. Exposures to silica during construction are of potential concern due to the fact that many building materials contain silica, including brick, concrete, cement, mortar, granite, sandstone, slate, quartzite, rock and stone, sand, fill dirt, topsoil and asphalt containing rock and stone (16)(11). During construction, abrasive activities can generate airborne silica-containing dust. Activities that may increase exposure to respirable crystalline silica include (11):

- Chipping, hammering and drilling of rock;
- Crushing, loading, hauling and dumping of rock;
- Sawing, hammering, drilling, grinding and chipping of concrete or masonry structures;
- Demolition of concrete or masonry structures;
- Road construction; and
- Tunneling, excavation and earth moving of soils with high silica content.

A study of exposure to silica on construction sites obtained data from 1,452 personal air samples measuring quartz and respirable dust at construction sites (17) and found overall geometric mean exposure to be 0.13 ±5.9 milligrams per cubic meter (mg/m^3) for quartz (crystalline silica) and 1.36 ±5.5 mg/m^3 for respirable dust, with the highest levels associated with grinding, drilling and tunneling in enclosed spaces (17). These levels indicate that occupational exposure may frequently exceed the current Occupational Exposure Limit for respirable crystalline silica (quartz) in Ontario of 0.05 mg/m^3 for an 8-hour day.

The potential for exposure to silica dust is highly dependent on the specific materials that are being encountered during demolition or construction, with off-site exposures expected to be much lower than on-site. Potential for off-site migration is also dependent on wind speed and direction. Obtaining site-specific information on whether there are materials that may contain silica either in the existing building, or in construction of a new building, is vital to accurately characterizing and assessing potential risks from exposure to silica. Airborne concentrations of respirable crystalline silica that may migrate off site would not be high enough to cause silicosis but because there is no threshold for carcinogenicity, there is some possibility that they may increase the risk of cancer.

3.4.3 Risk Assessment

Based on the preliminary literature search results and the criteria for Severity and Probability Ratings set out in section 2.5, the risk and level of concern for silica is considered to be medium during the demolition and construction phases. Additional site-specific data is required to more accurately assess risks. Ratings for each stage are provided in Table 3.3.

Table 3.3. Risk Rating for Exposure to Silica

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increases cancer risk if inhaled in respirable size and crystalline form	P3	Crushing of building materials such as concrete slabs may generate respirable dust containing silica	Medium
	Learning	S1	Will not disrupt learning	P3		Low
Excavation	Health	S3	As above	P3	Breaking up of soil and earth may generate respirable dust containing silica	Medium
	Learning	S1		P3		Low
Construction	Health	S3	As above	P3	Drilling, grinding of silica-containing materials such as concrete slabs may generate respirable dust containing silica	Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S1		P3		Low
Finished Building	Health		Not applicable		Not applicable: No source of silica-containing dust	N/A
	Learning					N/A

3.5 Diesel Exhaust

Diesel exhaust is a mixture of gases and particles generated from combustion engines in cars, trucks and heavy machinery (18). Construction vehicles and equipment that are powered by diesel engines emit more than 40 toxic air contaminants, including carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (19) (20). Due to the prevalence of diesel vehicles in Canada, most people are exposed to diesel exhaust on a regular basis (21).

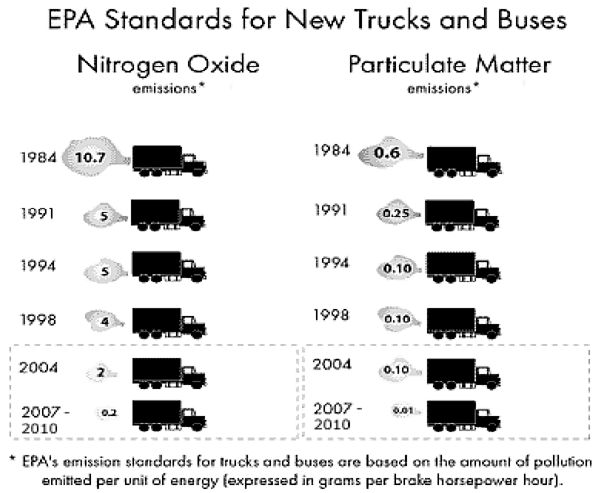
3.5.1 Potential Effects

Due to the fact that diesel is a complex mixture of gases and particles, the health effects are related both to the individual constituents and exposure to diesel exhaust as a whole (21). A health assessment conducted on diesel found that long-term exposure to diesel exhaust could pose a risk of lung cancer as well as other respiratory system damage (18). Diesel exhaust has been classified as carcinogenic (cancer-causing) to humans by the International Agency for Research on Cancer (IARC). For short term exposures, the study found that transient irritation and inflammatory responses were typical, but the severity was highly variable among individuals. There is also evidence that exposure to diesel can exacerbate allergies and asthma (18). Additionally, a recent study conducted by Health Canada looked at the health risks associated with exposure to diesel exhaust and concluded that it is associated with significant population health impacts in Canada and efforts should continue to further reduce emissions and human exposures (21).

3.5.2 Potential Exposure

Exposure to diesel largely occurs via inhalation of exhaust from diesel-powered engines. In the past, these engines emitted higher amounts of exhaust than they do now, due to improvements in technology and more stringent emissions standards; however, diesel exhaust remains a large component of air pollution, especially in urban areas (22) (Figure 3.1).

Figure 3.1.: US EPA Emission Standards for Constituents of Diesel Exhaust (1984-2010)



People who live or work in urban areas and/or near major traffic routes likely have higher exposures to diesel exhaust. With respect to construction activities, diesel-powered equipment and trucks would contribute to ambient levels of diesel in the air. The potential for off-site migration of diesel exhaust is dependent on the activities being conducted (e.g., running heavy machinery), the distance from the site, and wind speed and direction. A study considered the contribution of construction equipment exhaust to air pollution and found that "bulldozers account for the largest share in all airborne emissions, and the excavator is the second biggest contributor for CO_2, NOx, and particulate matter (PM) emissions" (23).

Another study estimated emission rates from several different models of construction equipment, including bulldozers, backhoes, loaders, and excavators (24). The emission rates (in g kW-1 hr-1) ranged from: (i) 9 ±5 to 316 ±6 for CO_2; (ii) 0.05 ±0.04 to 2.83 ±0.04 for NOx; (iii) 0.006 ±0.002 to 0.29 ±0.026 for hydrocarbons; and (iv) 0.01 ±0.03 to 1.50 ±0.05 for CO. The authors suggest the use of emission control technology.

Deltera's Construction Mitigation Plan (25) provides the following statement with respect to the use of heavy machinery on-site:

"Provisions shall be taken to ensure that all heavy machinery on the site is used according to applicable regulations, standards and codes. Machinery shall be used according to manufacturer's instructions and shall be operated only by competent persons".

3.5.3 Risk Assessment

Based on the preliminary literature search results and the criteria for Severity and Probability ratings set out in section 2.5, the risk and level of concern for diesel exhaust is considered to be high during the demolition, excavation and construction phases. Additional site-specific data is required to more accurately assess risks.

Probability of exposure for the finished building is considered low, as presence of diesel equipment would be rare. Ratings for each stage are provided in Table 3.4.

Table 3.4. Risk Rating for Exposure to Diesel Exhaust

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Increased risk of cancer and respiratory diseases	P4	Emissions from demolition equipment	High
	Learning	S2	Annoyance due to odours, irritation	P4		Medium
Excavation	Health	S3	As above	P4	Emissions from excavation equipment	High
	Learning	S2		P4		Medium
Construction	Health	S3		P3	Construction equipment less likely to emit high levels of diesel exhaust	Medium
	Learning	S2		P3		Medium
Finished Building	Health	S3		P1	No regular source of diesel emissions; may be occasional presence of diesel equipment	Low
	Learning	S2		P1		Low

3.6 Dust (Crustal or Not Otherwise Classified – NOC)

Dust, also known as particulate matter (PM), is a broad term used to describe particles that can be transported through air and deposited on the ground and other surfaces. Whether dust is harmful to health is highly dependent on the size and composition of the particles. Larger particles, such as PM10 are of less concern than smaller particles, such as PM2.5 or PM1, with the numerical value describing the size of the particle in micrometers (e.g., PM10 = particulates <10 μm in diameter).

When evaluating potential exposure to PM it is also important to distinguish between crustal and combustion sources since there are pronounced differences in terms of human health effects.

Crustal particulate matter is typically larger in size (PM10-2.5) and is associated with mechanical and abrasive processes such as wind erosion, road dust raised by vehicular motion, tire and brake wear, sanding and grinding operations. In construction operations, it is possible to have higher amounts of crustal particulate matter due to the movement of soil and demolition/excavation/building activities. A number of studies have examined the effect of crustal PM on the respiratory health of urban and rural populations, and have found much weaker evidence for direct health effects relative to what has been reported for urban populations where much of the PM exposure is due to combustion processes (e.g. vehicular traffic, fossil fuel-fired power plants etc.).

Particulate matter that is generated from combustion (e.g. transportation, industrial processes and burning) is smaller in size and of more concern for human health. The vast majority of data on the human health effects of particulate matter exposure come from large urban cities where much of the PM is combustion-derived, and/or formed from secondary atmospheric reactions (such as photooxidation, condensation, nucleation etc.). Although there is some inconsistency and variability in the available studies (which likely in part, reflects differing chemical and biological composition of the dust particles), the weight of evidence suggests that crustally-derived PM is of markedly lower toxicity than PM that is derived from combustion processes.

3.6.1 Potential Effects

The size of the particulate matter is directly related to its effect, with smaller particle sizes posing the greatest threat since they have the ability to penetrate deep into the lungs and may enter the bloodstream (26). Exposure to these particles can impact both the respiratory and cardiovascular systems. Large particles are of less concern since they do not penetrate as deeply into the lungs as smaller particles, although they can cause eye, nose and throat irritation. Exposure to particulate matter in urban areas has been associated with higher rates of morbidity and mortality (sickness and death) (27)(28). Fossil fuel combustion, biomass burning and construction related activities are considered major sources of elevated PM in urban areas. The PM component of air pollution (including combustion sources) has been classified as carcinogenic by the IARC (29).

Some people may be at a higher risk of experiencing effects from particulate matter, including people who have heart or lung disease, older adults, and children. However, the US environmental protection agency states that “healthy children and adults have not been reported to suffer serious effects from short-term exposures, although they may experience temporary minor irritation when particle levels are elevated.”

3.6.2 Potential Exposure

The primary route of exposure to dust is through inhalation of particulate matter; however, incidental ingestion and dermal contact are also possible pathways. In the vicinity of construction activities, including demolition, excavation, and construction, there is potential for exposure to crustal particulate matter from movement of soil and other building activities. Additionally, there is potential for exposure from combustion sources, including on-site equipment and trucks moving to and from the site. In a study that looked at the levels of PM in the vicinity of demolition activities, the authors found that:

"During structural demolition, local concentrations of PM10 42 meters (m) downwind of a demolition site increased 4- to 9-fold above upwind concentrations (6-hr averaging time). After adjusting for background PM10, the presence of dusty conditions was associated with a 74% increase in PM10 100 m downwind of demolition sites (24-hr averaging times). During structural demolition, short-term peaks in real-time PM10 (30-sec averaging time) occasionally exceeded 500g/m^3" (30).

The level of off-site exposure to dust is dependent on the type of construction activity, the distance from the site, the wind direction and speed, as well as any implemented dust mitigation measures. Deltera's Construction Mitigation Plan (25) has identified measures for the control of dust as part of a 'Construction Air Quality/Dust Control program' to be implemented on an as needed basis:

"Where required, trucks will be cleaned of mud, prior to leaving the site. Street flushing and sweeping will be provided as needed and to the satisfaction of the municipality and the conservation authority. The requirements for a mud mat will be determined on a case-by-case basis."

The City of Toronto has approved recommendations for demolition and excavation dust control developed in collaboration with Toronto Public Health. These include several measures for reducing dust generation and limiting exposure to particulate matter both on and off-site:

- Wetting of all soft and hard surfaces and any excavation face on the site (daily), with the addition of calcium chloride or other recognized materials as a dust suppressant, if required;
- Cleaning of road pavement and sidewalks for the entire frontage of the property to a distance of 25m from the property line (daily);
- Designation of truck loading points to avoid trucks tracking potentially contaminated soil and demolition debris off site;
- All trucks and vans leaving the site should be cleaned of all loose soil and dust from demolition debris including the washing of tires and sweeping or washing of exteriors and tailgates;
- Tarping all trucks leaving the site which have been loaded with indigenous soil or demolition debris;
- An air monitoring program, if necessary, as determined through consultation with the Medical Officer of Health; and
- Supervision of the dust control measures by a qualified environmental consultant if necessary, as determined through consultation with the Medical Officer of Health.

3.6.3 Risk Assessment

Based on the preliminary literature search results and the criteria for Severity and Probability ratings set out in section 2.5, the risk and level of concern for crustal dust is considered to be medium during the demolition, excavation and construction phases. Additional site-specific data is required to more accurately assess risks. Ratings for each stage are provided in Table 3.5. Combustion dust on this project arises from diesel equipment and is addressed under section 3.5.

Table 3.5. Risk Rating for Exposures to Crustal Dust

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Irritation	P3	Dust generated by demolition of building	Medium
	Learning	S2	Annoyance	P3		Medium
Excavation	Health	S2	As above	P3	Dust generated by excavation of soil	Medium
	Learning	S2		P3		Medium
Construction	Health	S2		P2	Less dust generated by construction activities, e.g. drilling, grinding	Medium
	Learning	S2		P2		Medium
Finished Building	Health	S2		P1	No source expected beyond normal activities	Low
	Learning	S2		P1		Low

3.7 Nitrogen Oxides (NOx)

Nitrogen oxides (NOx) are gaseous mixtures composed of nitrogen and oxygen, with the two most toxicologically relevant forms being nitric oxide (NO) and nitrogen dioxide (NO_2) (31). Nitrogen oxides are released into the air from the exhaust of motor vehicles, the burning of coal, oil or natural gas and during several industrial processes (e.g., electroplating). According to the National Pollutant Release Inventory (NPRI) "in 2011 the major ambient releases of NOx in Canada were from mobile sources (50% of total emissions), mostly from off-road and on-road diesel engines" (21).

3.7.1 Potential Effects

The main exposure pathway of atmospheric NOx is inhalation. Inhaling low levels of NOx can lead to irritation of the eyes, nose, throat and lungs. This can lead to coughing, shortness of breath, wheezing, tiredness and nausea (31). People who may be more susceptible to the effects of NOx include individuals with allergies, asthma or chronic obstructive pulmonary disease (COPD) (21). Exposure to high levels of NOx can result in "burning, spasms and swelling of tissues in the throat and upper respiratory tract, reduced oxygenation of body tissues, a build-up of fluid in the lungs and death" (31). A study conducted on construction workers exposed to various agents including nitrogen dioxide found that there was a decline in lung function, measured via forced expiratory volume in 1 second (FEV1), experienced over 6 years of occupational exposure (32).

3.7.2 Potential Exposure

Emissions from fuel-burning equipment, especially diesel equipment, are a potential source of nitrogen oxides from this project. Nitrogen oxides that are released into the atmosphere are rapidly broken down by reactions with other compounds in the air. For example, nitrogen dioxide reacts with chemicals produced by sunlight to create nitric oxide, a component of acid rain. Nitrogen dioxide also reacts in the atmosphere to create ozone and smog (31). Higher levels of exposure may be experienced by people living near combustion sources such as coal-burning plants and areas with high motor vehicle traffic (31). Households that have gas stoves, or burn a lot of wood or kerosene have higher levels of NOx exposure. Additionally, cigarette smoke contains NOx, so smokers or people exposed to second hand smoke may have higher NOx exposures. In relation to construction activities, exposure to NOx typically occurs from the exhaust released into the air from equipment and trucks on and around the site. A study that measured levels of dust and gas on a construction site found that workers were exposed to average nitrogen dioxide levels of 0.4-0.9 parts per million parts air (ppm) with the highest values exceeding10 ppm (33). The highest levels exceed the Ministry of Labour Occupational Exposure Limit (for an 8-hour workday) of 3 ppm. However, off-site exposure to NOx is expected to be lower than levels experienced by on-site workers.

3.7.3 Risk Assessment

Based on the preliminary literature search results and the criteria for Severity and Probability ratings set out in section 2.5, the risk and level of concern for NOx is considered to be high during the demolition, excavation and construction phases. Additional site-specific data is required to more accurately assess risks. Ratings for each stage are provided in Table 3.6.

Table 3.6. Risk Rating for Exposure to NOx

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Respiratory effects, irritation	P4	Emissions from demolition equipment	High
	Learning	S2	Annoyance	P4		Medium
Excavation	Health	S3	As above	P4	Emissions from excavation equipment	High
	Learning	S2		P4		Medium
Construction	Health	S3		P3	Less diesel equipment used during construction phase	Medium
	Learning	S2		P3		Medium
Finished Building	Health	S2		P1	Some increase in vehicles, but generally not diesel equipment	Low
	Learning	S2		P1		Low

3.8 Sulphur Oxides (SOx)

Sulphur oxides (SOx) are a group of gases that are comprised of sulphur and oxygen, and include sulphur monoxide (SO), sulphur dioxide (SO_2), and sulphur trioxide (SO_3). The most common compound is SO_2, which is largely formed through the reaction of sulphur contained in raw materials (e.g., coal, oil, metal-containing ores) reacting during combustion and refining processes (34). Sulphur dioxide is a colourless gas with a strong odour. In nature, it is released into the atmosphere through volcanic eruptions (35).

3.8.1 Potential Effects

Exposure to SOx, including sulphur dioxide, is primarily through inhalation. At very high levels, SO_2 can be hazardous to human health. Exposure to 100 ppm of SO_2 in air can lead to burning of the nose and throat, difficulty breathing and severe airway obstruction. Additionally, there is some evidence that long-term (≥20 years) exposure to lower levels of SO_2 (0.4-3.0 ppm) can lead to changes in lung function (36). However, confounding factors and exposure to other chemical compounds make it difficult to attribute effects to SO_2 alone. Some individuals may be more sensitive to the effects of SO_2, such as people with asthma who may experience respiratory effects at concentrations as low as 0.25 ppm. Typical outdoor concentrations of sulphur dioxide range from 0-1 ppm (36).

3.8.2 Potential Exposure

People can be exposed to SOx in a variety of ways including breathing in SOx, mainly SO_2, or through skin contact. Under pressure SO_2 can exist in a liquid state and it is easily dissolved in water. Although individuals can be exposed to SO_2, the group with the highest potential for exposure is workers (36). A potential source of SOx from this project is the exhaust from diesel and other combustion engines. Gasoline-burning engines emit much less SOx than diesel-fueled equipment, and all types of vehicles emit less SOx than NOx (37).

3.8.3 Risk Assessment

Based on the preliminary literature search results and the criteria for Severity and Probability ratings set out in section 2.5, SOx is considered to have medium risk during the demolition, excavation and construction phases. Additional site-specific data is required to more accurately assess risks. Ratings for each stage are provided in Table 3.7.

Table 3.7. Risk Rating for Exposure to SOx

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Respiratory effects	P3	Diesel equipment used during demolition phase	Medium
	Learning	S2	Irritation	P3		Medium
Excavation	Health	S3		P3	Diesel equipment used during excavation phase	Medium
	Learning	S2		P3		Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Construction	Health	S3	As above	P2	Less diesel equipment used during construction phase	Medium
Construction	Learning	S2		P2		Medium
Finished Building	Health	S3	As above	P1	Some increase in vehicles, but generally not diesel equipment	Low
Finished Building	Learning	S2		P1		Low

3.9 Asphalt Fumes

Asphalt (also known as bitumen) is a dark brown, sticky material derived from refined crude oil. At normal temperatures it is in solid or semi-liquid form and contains a mixture of chemicals made primarily from carbon and hydrogen, with smaller quantities of sulphur, oxygen and nitrogen (38). When used for roofing or paving, asphalt is heated, releasing vapours that then cool into solid particles (asphalt fume). The odour threshold of asphalt is very low, meaning it can be smelled at very low concentrations. These odours are primarily the result of sulphur compounds with very low odour thresholds.

3.9.1 Potential Effects

Studies of the health effects of asphalt vapours and fumes have been done with roofing and road paving workers, whose exposures are higher than those near roofing and paving operations. However, studies of workers exposed to asphalt have been hard to interpret because of confounding factors; that is, exposure of the workers to other substances that may cause the same health effects.

In studies of exposed asphalt workers, exposure to asphalt has been reported to cause eye, nose and throat irritation. Exposure to asphalt has also been reported to cause headache, fatigue and nausea. Lower respiratory tract symptoms have been reported, such as coughing, wheezing and shortness of breath. Acute and chronic bronchitis have also been reported among asphalt workers. Direct skin contact with asphalt can cause skin irritation and dermatitis, and contact with hot asphalt can cause burns (40). However, the U.S. National Institute for Occupational Safety and Health (NIOSH) has said that eye and skin problems experienced by asphalt-exposed roofing workers could not be attributed to asphalt exposure specifically, because the workers were also exposed to coal tar pitch (38).

IARC has identified bitumens as "probably carcinogenic" to exposed asphalt (oxidized bitumen) roofing workers, and "possibly carcinogenic" to exposed road paving workers (39)(41). However, the American Conference of Governmental Industrial Hygienists (ACGIH) has listed asphalt as "Not Classifiable as a Human Carcinogen". This notation is given to those agents (chemicals) that are of concern due to their potential to be carcinogenic to humans, but which cannot be assessed conclusively because of insufficient data (42). Furthermore, many confounding factors (e.g. worker exposures to carcinogens such as coal tar, asbestos and cigarette smoke) mean that the direct attribution of increased cancer risk due to exposures to asphalt alone is difficult (38). Fumes from paving asphalt are expected to have lower concentrations of potentially harmful substances than roofing asphalt (43) (46).

No research has been identified that assessed health effects beyond short-term irritation for those in the vicinity of asphalt roofing operations. One 1998 study reported on building occupants' complaints of nausea, eye and upper respiratory tract irritation during a roofing operation in which low-level exposure to hydrocarbon compounds, presumably from asphalt kettles, was detected as a result of improper ventilation of the building (45).

In this regard, the World Health Organization (WHO) has stated that:

"In situations where individuals from the general population live or work near asphalt production facilities or roofing or paving operations, the potential for dermal and/or respiratory exposure to asphalt fumes and vapours exists. The frequency and concentration of these potential exposures may be lower for the general population than for workers. However, in the general population, there are individuals who may be more sensitive to exposures and therefore exhibit more symptoms or other effects. The extent to which these symptoms occur in the general population has not been studied" (40).

Exposure of the public or occupants of buildings where asphalt is being applied can be mitigated through good control practices such as placement of the asphalt kettle so that fumes will not enter the building, enclosure of the kettle and control of the asphalt temperature.

3.9.2 Potential Exposure

An asphalt kettle may be used at 30 Erskine Avenue during the construction of the facility roof. Similarly, an asphalt kettle and/or paving machinery may be used for construction of any surface driveways or parking lots.

Individuals near asphalt roofing operations can be exposed to asphalt fumes and vapours through inhalation or absorption through the eyes or nose. As noted by the U.S. National Institute for Occupational Safety and Health (NIOSH) (43), exposure levels at a given worksite depend upon:

- Environmental conditions (e.g. wind speed and direction, ambient temperature);
- Work practices during asphalt kettle operation (e.g. frequency of opening kettle lid, temperature of asphalt);

- Work practices during application of asphalt; and
- Other work tasks in the area that could release asphalt fumes and vapours (e.g. removal of old roofing)

Due to the low odour threshold of asphalt fumes and vapours, asphalt-related odours may be experienced on JFPS property, depending on the location of the kettles.

3.9.3 Risk Assessment

As details of roofing and paving operations are not available, exposure to asphalt fumes is considered possible during the construction phase, and therefore given a probability rating of P3. Based on the criteria for Severity and Probability ratings set out in section 2.5, asphalt fumes are considered a medium risk for health and learning, as explained in Table 3.8.

Table 3.8. Risk Rating for Exposure to Asphalt Fumes

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA
Excavation	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA
Construction	Health	S3	Respiratory effects, CNS depression, possible carcinogen	P3	Asphalt fumes may migrate onto school property, depending on the composition of the asphalt and location of the kettle	Medium
	Learning	S3	Distracting or irritating odour	P3		Medium
Finished Building	Health	NA	No asphalt use envisaged	NA	No asphalt use envisaged	NA
	Learning	NA		NA		NA

3.10 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are a group of carbon-based substances that are liquid but readily evaporate at room temperature. Many compounds such as turpentine and kerosene are widely known and used as solvents or fuels. The gases given off when these substances evaporate, called vapours, can often be smelled at low concentrations and may be irritating.

3.10.1 Potential Effects

Exposure to VOCs generally occurs through inhalation of their vapours. While many VOCs can cause skin irritation or be absorbed through the skin, direct skin contact is not a route of exposure relevant to this project.

VOCs include a wide variety of chemicals that can affect many different body systems and cause a range of health effects of varying severity depending on the exposure concentrations and the individual substance (47). Their effects may include eye and respiratory irritation, kidney and liver damage, and cardiovascular effects. Some such as benzene can cause cancer, and others such as methylene chloride can cause reproductive effects. Among their most common effects are central nervous system effects such as drowsiness or dizziness, which may be accompanied by nausea. There is some evidence that VOCs are associated with higher risks of allergy and asthma, but the evidence for this is uncertain (48).

As previously noted, children may be more sensitive to chemical hazards than adults. A study of school children in Italy found that children living in industrial areas with higher environmental concentrations of VOCs had higher rates of school absence due to cough, sore throats and colds, compared to a control group of students living in an area with lower VOC concentrations. The study cited other reports with similar findings (49).

Many VOCs have very low odour thresholds, meaning that they can be smelled at very low airborne concentrations. Their odours may be perceived as unpleasant, annoying or distracting, even at levels not considered likely to cause health effects.

3.10.2 Potential Exposure

Background concentrations of VOCs are present in the air in many North American communities from a variety of indoor and outdoor sources including building materials (50). Therefore, it is expected that school occupants are already exposed to background levels of VOCs. However, there may be some increase of VOC levels due to the project. There is a remote risk that VOCs may become airborne during demolition or excavation if VOCs are present in excavated soil or water or released from any containers such as fuel tanks on site. There is also a remote probability that vibration from demolition or excavation may cause damage to the JFPS building resulting in vapour intrusion, if there is VOC contamination of soil or groundwater (51).

More likely sources of VOCs are VOC-containing products used during the construction phase. These may include paints, coatings, and adhesives. VOCs may also be emitted from new building materials like carpets and wall coverings. As well, fuel may be stored on site during the excavation and construction phases. Airborne VOCs would likely be dissipated significantly, contributing to higher background levels but not affecting the school site in particular. Nevertheless, the expected high volume of use of such products may result in some elevated exposure at the school, depending on which products are used and the type of controls on their emissions. For example, low volatility paints and coatings will help reduce the amount of VOCs emitted into the air. Strict attention to enclosure of containers of fuel and solvents like paint thinners will also help reduce exposure.

3.10.3 Risk Assessment

Based on the criteria for Severity and Probability ratings set out in section 2.5, VOCs are considered to have medium risk for health and learning during the construction phase and low risk during other phases. Explanations and ratings for Health and Learning for each stage are provided in Table 3.9.

Table 3.9. Risk Rating for Exposure VOCs

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Possible effects on liver, kidney, blood, nervous system, respiratory systems. Most are reversible but some chronic effects are not	P1	Remote risk of release from contaminated soil or water, or vapour intrusion if JFPS foundation becomes damaged	Low
	Learning	S2	Annoyance, distraction due to odours	P1		Low
Excavation	Health	S3		P1	As above	Low
	Learning	S2	As above	P1		Low
Construction	Health	S3	As above	P3	Sources in building materials (e.g. paints, adhesives); vapours will dissipate over a wide area	Medium
	Learning	S2		P3		Medium
Finished Building	Health	S3	As above	P1	No source expected beyond normal conditions, e.g. cleaning products, some use of paints and adhesives	Low
	Learning	S2		P1		Low

3.11 Indoor Air Quality Comfort Factors

Indoor air quality (IAQ) comfort factors include thermal comfort (indoor temperature, relative humidity and air movement), contaminants in air (particulates, gases, vapours etc.) and freshness of air.

3.11.1 Potential Effects

Temperature - Health

Increases in the body's core temperature can result in discomfort as well as more serious health effects. Physical activity increases core body temperature, and therefore can increase the risk of developing heat illnesses during periods of hot weather.

Possible effects of excessive body core temperatures include the following heat-related illnesses [in order of increasing severity (due to steadily greater fluid loss)]:

Heat Rash: Itchy red bumps on the skin that result from blockage of sweat glands.

Heat Cramps: Brief, painful muscle spasms due to loss of salts and fluids from sweating. Heat cramps are painful but subside with fluid replacement.

Heat Exhaustion: Illness from depletion of water or salt in the body. Occurs primarily due to excessive sweating without fluid replacement during exposure to high levels of environmental heat or strenuous physical exercise. Symptoms can include intense thirst, weakness, discomfort, anxiety, dizziness, fainting, and headache, with a core body temperature of slightly below to somewhat above normal (between 37°C and 40°C) and cool, clammy skin (52).

Heat stroke: A total failure of the body to regulate core temperature due to central nervous system dysfunction from exposure to high environmental heat or strenuous physical exercise that can lead to delirium, loss of consciousness, convulsions, coma, permanent neurological damage or death. It should be considered a medical emergency and is characterized by hot, dry skin, and rectal (core) temperatures exceeding 40°C (52).

As children and adults appear to have a similar vulnerability to heat illness (53)(54), measures designed to protect adults will also protect children.

Thermal Comfort

Thermal sensation is a major contributor to perceptions of indoor air freshness and pleasantness. Six primary factors affect thermal comfort: core body temperature (based on activity level), clothing, air temperature, radiant heat sources (e.g. appliances, sunlight), air speed and relative humidity (55). Both the absolute temperature and the variation in temperature affect the comfort level. The human body can sense a temperature differential of as little as half a degree. Any variations exceeding about one (1) degree within a space creates discomfort. In general, the cooler areas are perceived to be more fresh and pleasant.

ASHRAE guidelines provide recommendations for ensuring the thermal comfort of sedentary or near-sedentary adults, such as office workers. While there is limited evidence in the scientific literature regarding children's comfort requirements, ASHRAE notes that these guidelines can be judiciously applied to children's comfort in classrooms (55). In buildings primarily cooled by the opening of windows, the ASHRAE guidelines suggest that temperatures are maintained within roughly a 5°C range to ensure the comfort of 90% of building occupants. During warmer weather, the recommended range starts at 21°C-26°C when the average monthly temperature is 20°C, and rises linearly to 26°C-31°C with increasing average monthly temperature values up to 33.5°C.

Although a range is given, most building occupants feel most comfortable at the mid-point of the ranges specified.

The Massachusetts Bureau of Environmental Health has published more conservative comfort guidelines for non-air-conditioned schools, suggesting that indoor air temperatures within schools be maintained at 70ºF to 78ºF (roughly 21°C – 25.5°C) throughout the year to ensure occupants' comfort (56). The program also recommends that measures be taken to increase thermal comfort of building occupants when the heat index or humidex (a measure of perceived temperature, taking into consideration the relative humidity) exceeds 88ºF (approximately 31°C).

Exceeding these temperature guidelines has been observed to cause children to become restless, become disobedient and act out, to be less alert, and to have difficulty concentrating (57,58). In adults, thermal discomfort lowers alertness, triggers complaints, causes distraction, reduces performance of mentally-challenging work and can worsen symptoms associated with sick building syndrome (59).

Temperature – Learning Impacts

The impact of elevated temperatures on student academic performance was well studied in the 1950s through early 1970s (60). Studies from that era demonstrated that students had reduced reading speed, reading comprehension and multiplication performance of up to 30% when exposed to temperatures of 27-30°C relative to their performance at 20°C (57,61). Studies also demonstrated a general performance advantage for students in air-conditioned environments, particularly when performing complex tasks(58). Recent studies have supported earlier work by Schoer and Saffran in 1973 (62) which indicated a reduction in academic performance with increases in indoor temperatures within the conservative Massachusetts comfort guideline range. Wargocki & Wyon (58) found that performance speed increased when temperatures decreased from 25 to 20 °C.

Freshness of air

Whether indoor air is perceived to be "fresh" by building occupants generally depends upon its overall similarity to outdoor air. The more indoor air deviates from outdoor air, the less fresh it is perceived to be, and the more complaints that are registered about the indoor building environment or indoor air quality. The concentration of carbon dioxide (CO_2) indoors is used as a proxy to evaluate whether adequate volumes of fresh outdoor air are being introduced into a building (63)(64)(65). Indoor CO_2 levels below 600 ppm are associated with few occupant complaints. The percentage of unhappy building occupants steadily increases with increasing CO_2 concentrations, with frequent complaints of symptoms, including headaches, fatigue, and eye and throat irritation, when the concentrations exceed 1,000 ppm.

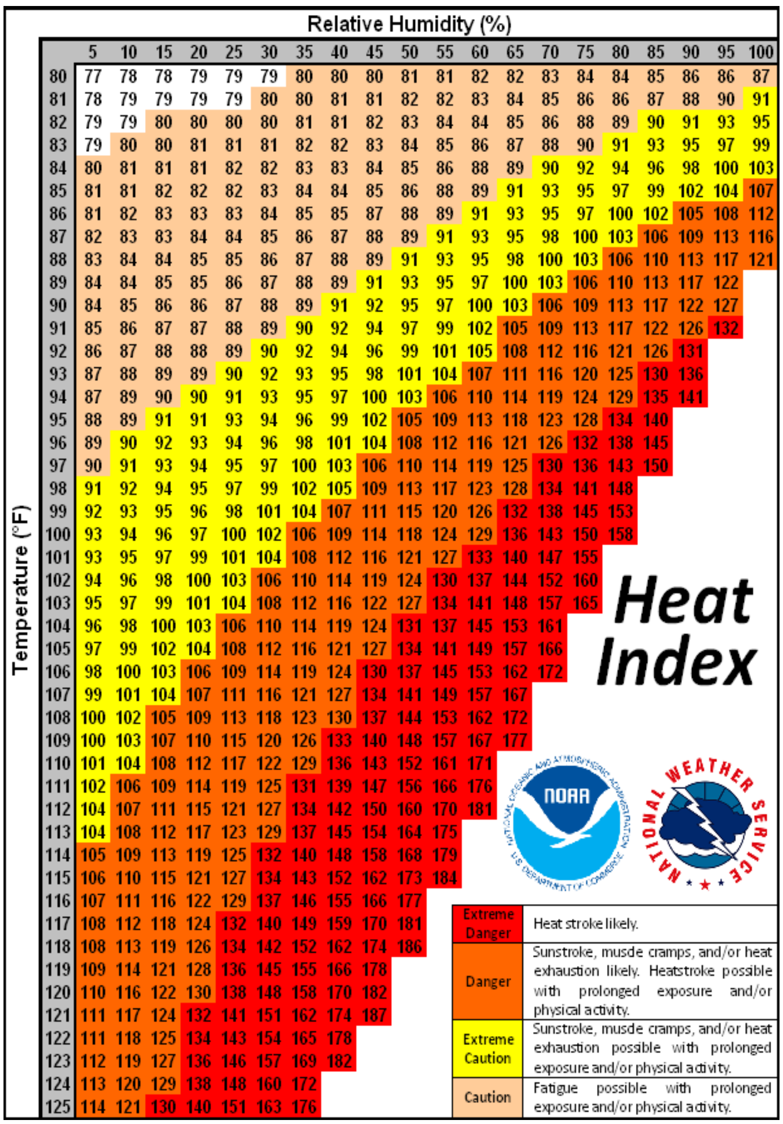
The Wargocki & Wyon study found that doubling the fresh air supply resulted in significant increases in students' speed performing simulated mathematical exercises in the classroom, but no significant effect upon the speed of performing language-based exercises.

3.11.2 Potential Exposure

Temperature – Health and Comfort

The US National Weather Service has developed the following chart (see Figure 3.2) indicating heat index values (in Fahrenheit) at which heat illnesses are more likely to occur. It can be seen from this chart that, depending on the humidity, caution is advised at temperatures above 26.6°C (80 °F), and more extreme warnings are provided for temperatures above 32.2°C (66).

Figure 3.2. Heat Index Ratings and Corresponding Ranges at Which Heat Illnesses are More Likely to Occur*



Relative Humidity (%) / Temperature (°F)

Temperature (°F)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
80	77	78	78	79	79	79	80	80	80	81	81	82	82	83	84	84	85	86	86	87
81	78	79	79	79	79	80	80	81	81	82	82	83	84	85	86	86	87	88	90	91
82	79	79	80	80	80	80	81	81	82	83	84	84	85	86	88	89	90	91	93	95
83	79	80	80	81	81	81	82	82	83	84	85	86	87	88	90	91	93	95	97	99
84	80	81	81	81	82	82	83	83	84	85	86	88	89	90	92	94	96	98	100	103
85	81	81	82	82	82	83	84	84	85	86	88	89	91	93	95	97	99	102	104	107
86	81	82	83	83	83	84	85	85	87	88	89	91	93	95	97	100	102	105	108	112
87	82	83	83	84	84	85	86	87	88	89	91	93	95	98	100	103	106	109	113	116
88	83	84	84	85	85	86	87	88	89	91	93	95	98	100	103	106	110	113	117	121
89	84	84	85	85	86	87	88	89	91	93	95	97	100	103	106	110	113	117	122	
90	84	85	86	86	87	88	89	91	92	95	97	100	103	106	109	113	117	122	127	
91	85	86	87	87	88	89	90	92	94	97	99	102	105	109	113	117	122	126	132	
92	86	87	88	88	89	90	92	94	96	99	101	105	108	112	116	121	126	131		
93	87	88	89	89	90	92	93	95	98	101	104	107	111	116	120	125	130	136		
94	87	89	90	90	91	93	95	97	100	103	106	110	114	119	124	129	135	141		
95	88	89	91	91	93	94	96	99	102	105	109	113	118	123	128	134	140			
96	89	90	92	93	94	96	98	101	104	108	112	116	121	126	132	138	145			
97	90	91	93	94	95	97	100	103	106	110	114	119	125	130	136	143	150			
98	91	92	94	95	97	99	102	105	109	113	117	123	128	134	141	148				
99	92	93	95	96	98	101	104	107	111	115	120	126	132	138	145	153				
100	93	94	96	97	100	102	106	109	114	118	124	129	136	143	150	158				
101	93	95	97	99	101	104	108	112	116	121	127	133	140	147	155					
102	94	96	98	100	103	106	110	114	119	124	130	137	144	152	160					
103	95	97	99	101	104	108	112	116	122	127	134	141	148	157	165					
104	96	98	100	103	106	110	114	119	124	131	137	145	153	161						
105	97	99	102	104	108	112	116	121	127	134	141	149	157	166						
106	98	100	103	106	109	114	119	124	130	137	145	153	162	172						
107	99	101	104	107	111	116	121	127	134	141	149	157	167							
108	100	102	105	109	113	118	123	130	137	144	153	162	172							
109	100	103	107	110	115	120	126	133	140	148	157	167	177							
110	101	104	108	112	117	122	129	136	143	152	161	171								
111	102	106	109	114	119	125	131	139	147	156	166	176								
112	104	107	111	115	121	127	134	142	150	160	170	181								
113	104	108	112	117	123	129	137	145	154	164	175									
114	105	109	113	119	125	132	140	148	158	168	179									
115	106	110	115	121	127	134	143	152	162	173	184									
116	107	111	116	122	129	137	146	155	166	177										
117	108	112	118	124	132	140	149	159	170	181										
118	108	113	119	126	134	142	152	162	174	186										
119	109	114	121	128	136	145	155	166	178											
120	110	116	122	130	138	148	158	170	182											
121	111	117	124	132	141	151	162	174	187											
122	111	118	125	134	143	154	165	178												
123	112	119	127	136	146	157	169	182												
124	113	120	129	138	148	160	172													
125	114	121	130	140	151	163	176													

Extreme Danger	Heat stroke likely.
Danger	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	Fatigue possible with prolonged exposure and/or physical activity.

*Note that temperatures are given in Fahrenheit

Buildings built prior to 1940 typically are configured to provide cooling via cross-ventilation (56). ECOH understands that John Fisher Public School does not have an air conditioning system. If windows are kept closed during hot weather to avoid noise and dust from the construction project, rooms will not be able to take advantage of this cross-ventilation, increasing the likelihood that temperatures will at times exceed guidelines and thereby pose a risk of adverse heat-related effects.

Freshness of air

Provision of fresh air during the construction is a concern because the JFPS does not have a central heating and cooling system which could filter incoming air. If windows are kept closed to prevent entrance of noise and dust from the construction project, the amount of fresh air may be reduced, thereby increasing the probability of concerns related to indoor air quality.

3.11.3 Risk Assessment

Based on the criteria for Severity and Probability ratings set out in section 2.5, indoor air quality comfort factors are considered a medium risk for learning and health during all construction phases (depending in part on weather conditions). Ratings for Health and Learning for each stage are provided in Table 3.10.

Table 3.10. Risk Rating Related to IAQ

<table>
<tr><th rowspan="2">Phase</th><th rowspan="2">Effects</th><th colspan="2">Severity</th><th colspan="2">Probability</th><th rowspan="2">Risk Rating</th></tr>
<tr><th>Severity Rating</th><th>Severity Rationale</th><th>Probability Rating</th><th>Probability Rationale</th></tr>
<tr><td rowspan="2">Demolition</td><td>Health</td><td>S2</td><td>Possibility of heat-related illness, reactions to lack of fresh air</td><td>P4</td><td rowspan="2">Increased heat in hot humid weather if windows must be kept closed due to dust and noise (if there is no air conditioning); lack of fresh air if windows kept closed because of noise and dust</td><td>Medium</td></tr>
<tr><td>Learning</td><td>S2</td><td>Distraction, irritability, adverse impacts on learning from increased heat</td><td>P4</td><td>Medium</td></tr>
<tr><td rowspan="2">Excavation</td><td>Health</td><td>S2</td><td rowspan="4">As above</td><td>P4</td><td rowspan="4">As above</td><td>Medium</td></tr>
<tr><td>Learning</td><td>S2</td><td>P4</td><td>Medium</td></tr>
<tr><td rowspan="2">Construction</td><td>Health</td><td>S2</td><td>P4</td><td>Medium</td></tr>
<tr><td>Learning</td><td>S2</td><td>P4</td><td>Medium</td></tr>
</table>

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Finished Building	Health	S2	As above	P1	No change from baseline conditions expected	Low
	Learning	S2		P1		Low

4. PHYSICAL HAZARDS

4.1 Noise

Noise is generally defined as unwanted sound. Sound is technically described in terms of the loudness (amplitude) and frequency (pitch) of the sound. The standard unit of measurement for sound is the decibel (dB). The human ear is not equally sensitive to sound at all frequencies. The "A-weighted scale," abbreviated dB(A), reflects the normal hearing sensitivity range of the human ear. On this scale, the range of human hearing extends from approximately 3 dB(A) to 140 dB(A).

4.1.1 Potential Effects

Noise sensitivity varies among different groups and is affected by differential physiological and psychosocial factors. Noise sensitivity refers to the internal states (physiological, psychological, and attitudinal) of any individual that influence reactivity to noise in general. Risk groups most often mentioned in the literature in relation to environmental noise are children, older people, the chronically ill and the hearing-impaired. Noise sensitive locations include residential, educational, health and religious structures, and recreational areas (67).

4.1.1.1 Auditory effects

To process sound, normal healthy "hair cells" in the inner ear transform vibration into nerve impulses and send messages to the brain. Prolonged exposures to sounds louder than 85 dB(A) cause trauma to the hair cells, resulting in hearing loss. Continuous exposure to hazardous levels of noise tend to affect high frequency receptors first. Noise induces hearing loss gradually, imperceptibly, and often painlessly. Often, the problem is not recognized early enough to provide protection. Further, it may not be recognized as a problem, but merely considered a normal consequence of ordinary exposure, and part of the environment and daily life.

Studies have shown that exposure to different types of noise from early childhood might have cumulative effects on hearing impairment in adulthood (68). Similar conclusions were also made by the European Union's Policy Interpretation Network on Children's Health and Environment (PINCHE) project (69).

4.1.1.2 Non-auditory health effects

The most investigated non-auditory health endpoints for noise exposure are perceived disturbance and annoyance, cognitive impairment (mainly in children), sleep disturbance, and cardiovascular health. Noise can pose a threat to a child's physical and psychological health, including learning and behavior.

Annoyance

Annoyance is an unpleasant mental state characterized by irritation and distraction from one's conscious thinking. It is a common response in a population exposed to environmental noise. This results from noise interfering with daily activities, feelings, thoughts, sleep, or rest, and might be accompanied by negative responses, such as anger, displeasure, exhaustion, and stress-related symptoms (70). Studies have shown the same pattern of noise annoyance for aircraft noise in school children (aged 9-11 years) as adults (71).

Speech Intelligibility

Studies (72) have demonstrated degraded speech recognition performance in children between the age 8-12 years with increases in the noise levels and reverberation. In addition, the ability of a child to understand speech is influenced by development of memory, attention and language skills.

There are other groups of children who may have difficulty understanding their teachers and their peers in the classroom. These may include children who are not being taught in their first language, children with disorders such as attention deficit/hyperactivity disorder, and children with speech and language difficulties. These children may be easily distracted in poor acoustic conditions and may have general problems in processing language, which may exacerbate learning difficulties.

Cardiovascular Diseases

Studies have indicated increased systolic blood pressure and heart rate in children exposed to noisy environments as compared to quieter surroundings. However, on chronic exposure to noisy conditions, a habituation effect develops in children. This was indicated by a study finding that children exposed to chronic noise had lower increase in blood pressure when exposed to acute noise and other stressors, compared to a control group accustomed to a quieter environment (73).

Physiological effects and quality of life

Noise as a stressor affects the neurological and endocrine regulatory system. In children, moderate noise exposure is associated with fatigue, headaches and higher cortisol levels indicative of a stress reaction (74). Similar results were reported by a Swedish study (75) in relation to noise levels between 59-87 dB(A) in classroom during the school day.

Cognitive development and academic performance

Acute and chronic noise exposure affects discrimination of speech and non-speech sounds. Diminished auditory processing can result in memory or attention deficits that hinder the normal processing of auditory signals (76). To study the environmental influences on student behavior and achievement, researchers compared reading scores between students in classrooms exposed to railway noise, and others in the same school in quieter classrooms. Students in the noisy classrooms had poorer performance, and were 3-4 months behind in reading ability compared to those in the quieter rooms (77).

The Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study (78) suggests that reading comprehension begins to fall below average at aircraft noise exposure greater than 55 dB(A). The study noted that as the association is linear, any reduction in aircraft noise exposure should improve reading comprehension.

Exposure to sounds above 50 dB(A) have been associated with learning difficulties in children (79) and decreased performance in the standard test scores for literacy, mathematics and science in children aged 7-11 years (80). Noise can reduce the clarity of a teacher's voice, and exposure to noise increases the time required for children to process information. A meta- analysis by the World Health Organization (WHO) (81) presents the exposure- response relationship between noise and cognitive impairment. The curve assumes that 100% of children exposed to noise at 95 dB(A) suffer from cognitive impairment and that no children are affected at an exposure level of 50 dB(A).

A health impact assessment was done by Golder Associates of the expansion of the Billy Bishop Toronto City Airport (BBTCA) for the City of Toronto (82). Noise modelling performed to measure the increased noise levels generated by expansion found that in the two schools closest to the BBTCA, levels were increased between 2-11 dB(A) above the WHO guidelines.

4.1.2 Potential Exposure

4.1.2.1 Recommended noise levels in a classroom

WHO guidelines on community noise state that the background level of noise in classrooms should not be more than 35 dB(A) and any levels above this can lead to decreased attention and social adaptability (83). The WHO guidelines further recommend that noise from external sources in outdoor playgrounds not exceed 55 dB(A).

Similar to the WHO guidelines, in 2002, the American National Standards Institute (ANSI) issued voluntary standard S12.60, "Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools," which calls for a maximum one hour average ambient noise level of 35 dB(A) in an unoccupied furnished classroom and includes recommendations for the required sound isolation between classrooms and adjacent spaces or the outdoors (84).

The Ontario Ministry of Environment's Environmental Noise Control Guidelines (NPC-300) recommend that indoor noise resulting from road traffic not exceed 45 dB(A) in schools and daycare centres.

Health Canada (85) advises that health impact endpoints be evaluated based on the change in the percentage of the population who become highly annoyed (%HA). It further suggests that mitigation should be proposed if the predicted change in %HA at a specific receptor is greater than 6.5% between project and baseline noise environments, or when the baseline-plus-project-related noise is more than 75 dB(A).

4.1.2.2 Noise levels during construction

As acknowledged by the developer, construction of the proposed project would result in increased ambient noise levels in and around the project area. A consultant's memo (86), attached to Deltera's Construction Mitigation Plan states that:

"Construction projects generate noise. Noise is created off site during shoring and excavation, by the equipment and associated activities. Noise is also generated off site during construction of the building structure, mainly associated with concrete pouring but also from such activities as pipe cutting, drilling, hammering and sawing. Once the cladding for the building has been installed, there is considerably less noise generated by construction that would affect surrounding properties."

As indicated by this consultant, the increase in the noise levels will fluctuate depending on the construction phase, equipment type and duration of use, distance between the noise source and receptor, and presence or absence of noise attenuation barriers (e.g., barriers erected on the project and existing buildings).

Available information is insufficient to project the anticipated noise levels at JFPS during the construction of the proposed building. Noise levels predicted for a project in a somewhat comparable situation in New York City may provide some idea of expected noise levels. As outlined in the New York court proceedings regarding Public School (PS) 163, the New York Department of Health found that the noise levels are loudest during excavation and foundation work, superstructure construction, and periods when two or more stages of construction overlapped (87). The increase in hourly noise levels during the loudest stages of construction were projected to range from 3.4 dB(A) to 17.5 dB(A), with absolute levels up to 77.2 dB(A).

Some examples of typical noise levels from various types of construction equipment are listed in Table 4.1. The table shows noise levels at distances of 50 feet (15.25 meters) from the construction noise source.

Table 4.1. Noise Levels at 50 Feet (15.25 meters) for Various Construction Equipment

Construction Equipment Noise Emission Levels (dBA)

Equipment List	CEQR & FTA Typical Noise Levels at 50 feet[1]	Quieter Equipment Noise Levels at 50 feet[2]	Noise Reduction with Path Controls[3]	Actual Noise Level at 50 feet
Acetylene Torch	73			73
Asphalt Spreaders	85			85
Backhoe	80			80
Bar Bender	80			80
Bobcat (Skid Steer)	80			80
Boring Jack Power	80			80
Cherry Picker	85			85
Compactor	80			80
Compressor	58			58
Concrete Pump	82			82
Concrete Trowel	85		10	75
Concrete Truck	85			85
Concrete Vibrator	76			76
Crab to Erect CW Panels	85	75		75
Crane	85		10	75
Crane (Tower Crane)	85		10	75
Delivery Truck	84			84
Drill Rig	84		10	74
Dump Truck	84			84
Excavator	85			85
Fuel Truck	84			84
Generator	82			82
Hand Tool	85	59		59
Hydraulic Break Ram	90		10	80
Hydraulic Hammer	73			73
Impact Wrench	85		10	75
Line Drill	84		10	74
Loader	80			80
Man Lift (Hoist)	85	75		75
Masonry Mixer	75			75
Pile driving Rig	85		10	75
Pile driver (vibratory)	95	85[4]	10	75
Pneumatic Tool	85		10	75
Pump	77			77
Rock Driller	85		10	75
Rubbish Carting Truck	78			78
Telehandler	85	74		74
Temp Electrical Plant	85	75		75
Tractor	84			84
Welder	73			73

Notes:
1. Sources: Table 22-1, Noise Emission Reference Level (A-weighted decibels with RMS "slow" time constant), CEQR, May 2010; Transit Noise and Vibration Impact Assessment, Federal Transit Administration (FTA), May 2006.
2. Sources and references for typical quieter equipment are provided in Appendix D-3-1.
3. Path controls include noise barriers, enclosures, acoustical panels, and curtains, whichever feasible and practical, and 10 dBA of reduction was assumed.
4. Typical equipment must meet the sound level standards specified in Subchapter 5 of the New York City Noise Control Code.

Table 4.2 shows an approximate prediction of noise exposures at 50 feet (15.25 meters) from the project, based on noise characteristics of equipment that may be used during different project phases. This prediction assumes that the equipment used emits the noise levels indicated in Table 4.1. These levels may be reduced through use of equipment with lower noise-emitting characteristics.

Table 4.2. Prediction of Cumulative Noise* at 50 Feet (15.25 Meters) from the Project Due to Equipment Used During Different Phases of a Construction Project

Phase of the Project	Examples of Equipment Used	Cumulative Noise Levels at 50 Feet (15.25 Meters) in dB(A)
Ground clearing including demolition and removal of existing structures, trees, rocks etc.	Excavators, bull dozers, loaders, Crawler loader	94
Excavation	Trenchers, Tractors, jackhammers, backhoes	89
Placing foundation and road beds	Concrete mixers, Concrete pumping trucks, tippers	77
Erection of structures	Cranes	84
Finishing, including filling, paving, grading and cleanup operations	Graders	89

* using formula $SPL_T = 10Xlog\left(\sum_{i=1}^{n} 10^{(SPL1/10)}\right)$

Noise Attenuation

The noise levels inside the school will be attenuated by building materials. Attenuation of sound by a building depends on sound barriers and the absorption of sound by the construction material. The Sound Transmission Class (STC) is a single-number rating of the general sound insulation capacity of various building elements. It is obtained by comparing the noise reduction performance of building elements at various frequencies against a standard noise reduction curve. The STC may be considered to approximately represent the amount by which sound levels are reduced in passing through a building element (88). The STC for a brick wall is approximately 42 dB(A) and for single pane windows is about 22 dB(A). Assuming a window-containing brick outer wall, application of STC values yields a very rough estimate suggesting that an outdoor noise level of 94 dB(A) would result in an indoor level of about 57 dB(A) with windows closed. To properly estimate indoor and outdoor noise levels during construction, much more information would be needed about noise-emitting characteristics of equipment, which pieces of equipment will be used at any given time, and sound barriers used on the construction site.

4.1.3 Risk Assessment

Based on the criteria for Severity and Probability Ratings set out in section 2.5, noise is considered to have high risk for health and learning during the demolition, excavation and construction phases. Ratings for Health and Learning for each stage are provided in Table 4.3.

Table 4.3. Risk Ratings for Exposure to Noise

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Hearing loss, cognitive and cardiovascular effects	P4	Noise-emitting characteristics of equipment; distance from school	High
	Learning	S3	Annoyance, disturbance, speech intelligibility	P4		High
Excavation	Health	S3	See above	P4	See above	High
	Learning	S3		P4		High
Construction	Health	S3	See above	P4	See above	High
	Learning	S3		P4		High
Finished Building	Health	NA	No anticipated source of high noise levels	NA	No anticipated source of high noise levels	NA
	Learning	NA		NA		NA

4.2 Vibration

Vibration is an oscillatory physical energy from an object which rapidly moves back and forth, up and down, or side to side and what we feel when that energy is transmitted to us. It is described in terms of frequency (the number of movements of the vibrating object per second) and amplitude/magnitude (the distance the object moves from the central point).

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with amplitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with amplitude/magnitude of each event being either constant or varying with time).

The body is affected by vibration when it is in contact with vibrating equipment. Segmental vibration occurs when exposure to a localized part of the body is contact with a vibrating object. For example, when a person operates hand-held equipment such as a chain saw or jackhammer, vibration can affect hands and arms. Such an exposure is called hand-arm vibration exposure. When vibration affects almost the entire body it is called whole-body vibration (WBV) exposure. For measuring the human response to vibration four factors need to be considered: magnitude of acceleration caused by the vibrating surface in m/sec2, frequency of vibration in Hz, direction of vibration (x, y or z) and the duration of exposure.

The unit of measurement commonly used when considering vibration effects on buildings is peak particle velocity (PPV) which is related to frequency and is a measurement of maximum ground particle movement speed, specified in inches per second (in/sec) or millimeters per second (mm/sec).

4.2.1 Potential Effects

4.2.1.1 Effect on Building Content and Structure

Vibration has the potential to affect both buildings and human health. Damage to buildings caused by vibration can affect the stability of the building structure, and indirectly affect health by allowing infiltration of hazards such as radon or VOCs, or by damaging building materials that may release asbestos fibres. These possibilities are addressed in section 4.3.

4.2.1.2 Human Response

Human perception of motion/acceleration in relation to the vibration levels are outlined in Table 4.4. (89). Perception does not always mean that the vibration levels will cause adverse health effects but perceived vibration may cause annoyance. The degree to which a person is annoyed depends in part on their activities at the time of the disturbance.

Table 4.4. Vibration and Human Perception of Motion*

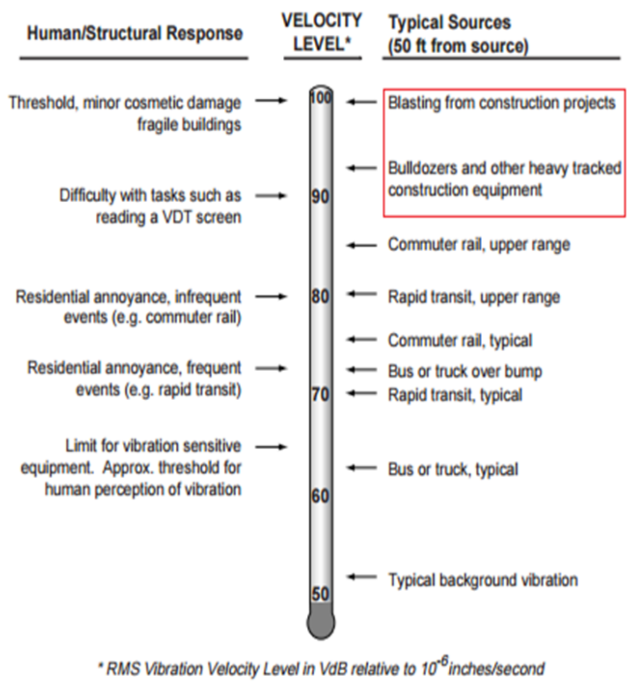
Approximate Vibration Level (mm/s)	Degree of Perception
0.10	Not felt
0.15	Threshold of perception
0.35	Barely noticeable
1.0	Noticeable
2.2	Easily noticeable

Approximate Vibration Level (mm/s)	Degree of Perception
6.0	Strongly noticeable

*Note: The approximate vibrations (in floors of buildings) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

Decibel notation can be used to express vibration velocity (this is different than the decibels used to express noise). The background vibration velocity in residential areas is usually 50 VdB (vibration decibels) or lower. Figure 4.1 illustrates typical vibration sources and the human and structural responses to them.

Figure 4.1. Vibration Sources, Structural and Human Response



Health effects

Health effects from vibration can be classified as acute (occurring shortly after exposure) or chronic (occurring a long time after exposure, or after prolonged exposure). Vibration affects the balance-regulating mechanisms in the internal ear which can lead to nausea, fatigue and vertigo. Vibration leads to involuntary muscular response and increased blood pressure leading to headache, chest pain and abdominal pain. Symptoms of acute exposure generally end within minutes or hours of when exposure stops. An increase in the magnitude of vibration leads to an increase in reported effects.

Epidemiological studies suggest that chronic exposure to WBV is associated with an increased risk for lower back pain(90)(91). Vibration exposure can produce hearing loss in the same way that noise exposure does – by over-stimulation of inner ear auditory hair cells. Chronic symptoms often persist for long periods (weeks, months, years) after exposure ends, and are usually permanent. Table 4.5 shows limits set by different standards to prevent health effects of vibration. It is not expected that vibration due to the construction project will exceed these limits.

Table 4.5. Limits for Human Exposure- Whole Body Vibration

ISO 2631 Part 1	Whole body vibration for standing person, primarily lumbar spine connected nervous system	0.63-1.2 m/sec^2 for 4 hours 0.42-0.80 m/sec^2 for 8 hours
European Union Human Vibration Directive 2002	Action Level Limit Value	0.5 m/sec^2 1.15 m/sec^2

4.2.2 Potential Exposure

Construction activity results in varying degrees of ground vibration depending on the equipment, methods and life cycle of the project. The vibration produced spreads through the ground and decreases with distance. In multi-story buildings, ground vibration from external sources tends to diminish with increasing height. The rate of decrease per floor is highly dependent on such factors as distance to the vibration source, the type of building structure and the plan area of each level of the building (91).The activities resulting in severe vibration are pavement breaking, general demolition, pile driving, compaction, excavation, dirt moving, jack hammering and movement of heavy tracked equipment.

Limits on allowable construction vibration are established under the Toronto Municipal Code (Table 4.6) (93). As part of its application for a demolition permit, the developer will be required to submit a Vibration Control Form. The Deltera Construction Mitigation Plan (25) states that all means and methods for performing project work will be evaluated for vibration impact to adjacent properties. A memo by a consultant to the developer (94) identifies JFPS as a vibration-sensitive receptor and notes that vibration can be created off-site during shoring and excavation. According to this memo, once shoring and excavation are complete, there is very little potential for vibration to be transmitted off site.

Table 4.6. Frequency and Maximum Allowable PPV for Construction Projects, Toronto Municipal Code

Frequency of vibration (Hz)	Vibration Peak Particle Velocity (mm/sec)
< 4	8
4-10	15
>10	25

Pile drivers are capable of producing vibrations exceeding 1.5 inches/second (roughly 38mm/sec) at a distance of 25 feet (8), exceeding even standards established for control of vibrations during explosive surface blasting associated with mining operations(95). However, Deltera's Construction Mitigation Plan (25) has indicated that pile drivers will not be used. Table 4.7, based on data from the US Federal Transit Administration (8), indicates that the next highest vibration potential from typical construction equipment is a vibratory roller, producing vibrations of roughly 0.2 inches/second (roughly 5mm/sec) at a distance of 25 feet (7.6 meters). The expected vibration at the JFPS would therefore be less than the 5mm/sec cutoff value in the Toronto Municipal Code for areas considered to be within the "zone of influence" of vibratory construction activities. The Toronto criterion for "Zone of Influence" is equivalent to the FTA's most stringent cutoff criteria of 0.2in/sec (~5mm/sec) for assessing the potential of structural damage during environment impact assessments. If vibration levels are below this limit, no structural damage to a facility is expected (8). Heavy, tracked construction equipment (e.g. excavators, bulldozers) may present a problem, however, if operated on city streets during transit to and from the building site. Typically, this type of equipment does not present a major vibration concern, as they are transported to sites on flatbed trucks, and then generally only moved for very short periods and on soft surfaces (e.g. loose soil). The developer's vibration study should indicate if bulldozers or equivalent heavy tracked equipment will be transported at any time not on a flatbed truck.

City of Toronto vibration control, By-law No. 514-20008 requires those applying for permits for construction or demolition to assess and, in some cases, monitor the potential vibration impact of the construction activities. The purpose is to avoid the potential for adverse vibration impact.

Table 4.7. Vibration Source Levels for Construction Equipment (Based on Measured Data by the US Federal Transport Administration)

Equipment		PPV at 25 ft (in/sec)	Approximate L_v† at 25 ft
Pile Driver (impact)	upper range	1.518	112
	typical	0.644	104
Pile Driver (sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.210	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

† RMS velocity in decibels (VdB) re 1 micro-inch/second

4.2.3 Risk Assessment

The risk to health increases with increasing exposure. The progress and severity of symptoms also depends on the magnitude, frequency, and direction of the vibration. Based on the potential harm on health and learning, the severity of risk is labelled as S2 and the probability of risk is P1 based on the predicted magnitude of vibration generated by construction equipment. Risk Ratings are provided in Table 4.8.

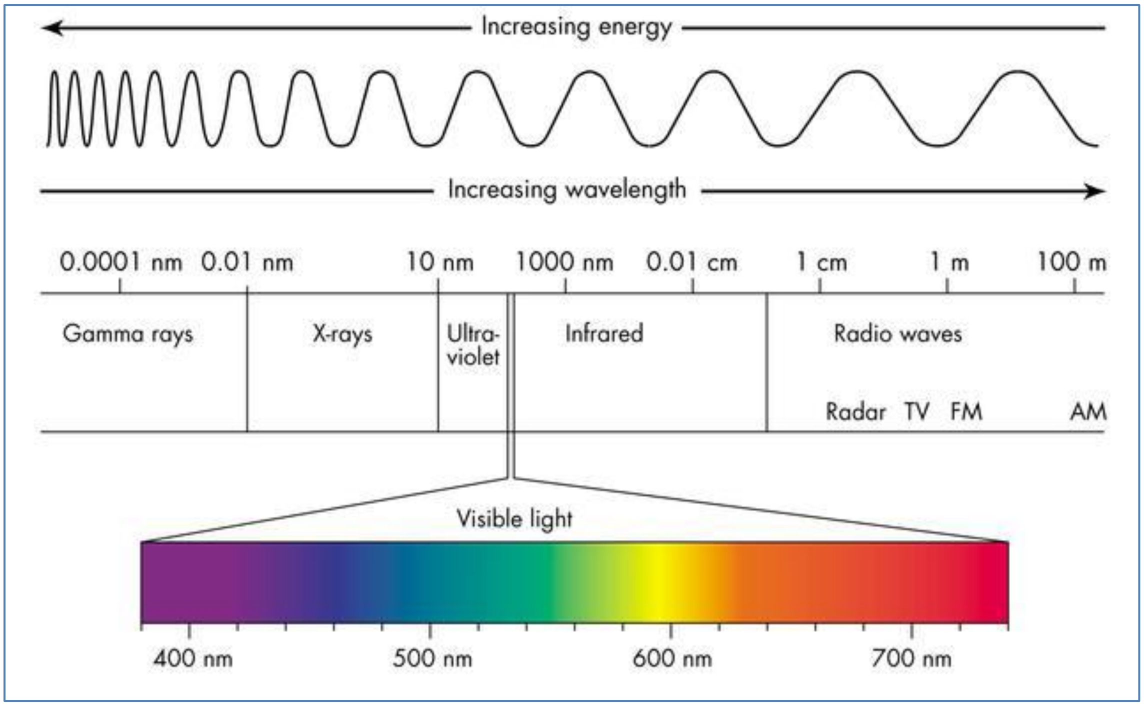
Table 4.8.: Risk Rating for Exposure to Vibration

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Acute effects like nausea, fatigue and vertigo	P1	Predicted vibration levels lower than the standards, assuming that heavy tracked equipment is transported by trucks	Low
	Learning	S2	Annoyance	P1		Low
Excavation	Health	S2	See Above	P1	See above	Low
	Learning	S2		P1		Low
Construction	Health	S2		P1		Low
	Learning	S2		P1		Low
Finished Building	Health	S2		P1		Low
	Learning	S2		P1		Low

4.3 Radiation

Radiation is energy emitted from and travelling away from a source. It can exist in the form of tiny fast-moving particles that have both mass and energy (particulate radiation) or waves of pure energy (electromagnetic radiation). As shown in Figure 4.2, the continuous spectrum of electromagnetic radiation is subdivided into specific types of radiation based upon their characteristic range of energy levels (which can also be reported as a range of frequencies or wavelengths).

Figure 4.2. The Electromagnetic Spectrum (96)



Most types of particulate radiation (e.g. alpha particles, beta particles, neutrons), and some high-energy types of electromagnetic radiation (e.g. X-rays, gamma rays, cosmic rays) have sufficient energy to remove electrons from atoms when either passing nearby or colliding with those atoms; such types of radiation are called "ionizing radiation". Electromagnetic radiation with lower energy levels (e.g. ultraviolet, visible and infrared light, microwaves, radio waves, etc.) cannot remove electrons from atoms, and is called "non-ionizing radiation".

During the proposed development at 30 Erskine Avenue, students' and adults' exposure to radiation might be increased as a result of exposure to nonionizing radiation from the arcs generated by welding equipment, and/or as a result of increased exposure to ionizing radiation from radon gas.

4.3.1 Radon

Radon is a naturally-occurring, tasteless, odourless, invisible radioactive gas. When this gas decays it emits particulate radiation, that like any other particulates can move around air and can be breathed in. It is present in all soil, water and air to some degree, with the highest radon levels occurring where soils or underlying bedrock are rich in uranium. As the soil is likely to be disturbed especially during excavation, Radon gas may be released into the atmosphere and can become an inhalation hazard. The factors influencing indoor radon levels are complex, and the only way to determine what they are is to perform radon measurements.

4.3.1.1 Potential Effects

Radioactive particles generated from radon decay are easily blocked by the skin without any evidence of skin cancer (97). However, when inhaled they can deposit in the lungs, directly exposing the sensitive interior surfaces of the lung to radioactive particles. The resulting absorption of radioactive particulate by the lung tissues increases the risk of developing lung cancer.

Most radon gas generated within soils escapes into the atmosphere, where it is diluted to low concentrations. All of us are therefore exposed to a low natural background level of radiation from radon in outdoor air. Indoors, radon can accumulate to higher levels (98).Testing must be performed to establish indoor concentrations, as it cannot be easily modelled.

There is no such thing as a completely safe level of exposure to radon, and there is no practical way to completely filter radon from the air we breathe. Even low-level exposure to radon can therefore result in a small increase to the risk of developing lung cancer. (99). In considering the risk presented by low-level radon exposure, however, it can be helpful to consider the parallels between low level exposure to radon and exposure to sunlight. There is no such thing as a “safe level” of exposure to sunlight either, since even one short exposure can theoretically lead to skin cancer, and yet there is no way to completely avoid exposure to sunlight and live a normal life.

While radon is the second-leading cause of lung cancer in Canada after smoking, estimated to cause 16% of diagnosed lung cancers (100), most lung cancers caused by radon actually occur in smokers or former smokers, as smoking increases the risk due to radon exposure by approximately 25 times (99).

Due to the size and shape of a child’s lungs, their faster breathing rate as compared to adults, and the relatively greater lifespan of a child, a child’s lifetime risk of developing lung cancer is likely somewhat greater than that of an adult (lifelong non-smoker) exposed to the same air containing the same concentrations of radon gas and for the same period of time.

4.3.1.2 Potential Exposure

Radon measurements were collected in four occupied locations at John Fisher Public School in January-February 1991(101), and the measured radon levels (roughly 3-30 Becquerels per cubic meter [Bq/m^3]) would be considered quite low for indoor building environments (low enough that any mitigation attempts would be unlikely to result in further reductions).

Increased exposure of staff and students to radon as a result of demolition or excavation work is unlikely. Vibration or settling of the school’s foundation resulting from demolition or excavation work could theoretically increase the potential for radon gas already present in the soil beneath the school to enter the school and accumulate to higher levels. This could occur due to increases in the size or number of cracks or openings in the school’s foundation, or through increases in the porosity and/or permeability of the soil. As the existing radon measurement results for John Fisher simply provide information on levels within the school in 1991, it is entirely possible that high concentrations of radon gas are present in the soil below the school, and either poor gas-permeability of the soil or a well-constructed, soil-vapour-resistant foundation prevented radon from accumulating within the school. Potential exposure to vibration and the allowable vibration on a construction project has been addressed in section 4.2.2.

Accelerations/PPV values for tracked bulldozers travelling on paved sections of asphalt (such as Erskine Avenue or the parking lot beside the building to be demolished) would be even higher. If a flatbed truck is not used to transport the bulldozers or equivalent heavy tracked equipment around the construction site at any time, this could generate sufficient vibration to damage the foundation and potentially result in increases in radon exposure. This issue is not explicitly addressed in Deltera's ConstructionMitigation Plan (25).

Seasonal changes in temperature and humidity are likely to exert a much more substantial impact (strain) on building walls. Such changes have a much greater ability to generate cracks than even construction vibrations occurring at levels perceivable to humans (102,103), and can result in hairline cracks in walls/foundations in the absence of construction vibration (103).

Finally, the probability of John Fisher Public School staff or students being exposed to elevated levels of radon that could be present in the structure(s) to be demolished at 30 Erskine Avenue is negligible. Research has shown that even air that contains extremely high levels of radon will be dispersed and diluted to levels equivalent to the natural background within a few metres of the source (104).

4.3.1.3 Risk Assessment

Based on the criteria for Severity and Probability ratings set out in section 2.5, radon is considered a medium risk for health and learning during the construction phases. Ratings for Health and Learning for each stage are provided in Table 4.9.

Table 4.9. Risk Rating for Exposure to Radon

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Lung Cancer	P2	Vibration could affect school foundation & increase entry potential of radon (if present in soil)	Medium
	Learning	S2	Anxiety, apprehension	P2		Medium
Excavation	Health	S3	See Above	P2	See above	Medium
	Learning	S2		P2		Medium
Construction	Health	S3	See Above	P1	See above	Medium
	Learning	S2		P2		Medium
Finished Building	Health		Not applicable		Not applicable	N/A
	Learning					N/A

4.3.2 Welding Radiation (Ultraviolet/ Visible/ Infrared)

Welding generates a full spectrum of light from infrared (IR) through visible light to ultra violet (UV) electromagnetic (EM) radiation. Infrared "light" is a type of electromagnetic (EM) radiation that is invisible to humans and is perceived as heat by humans. Visible light is the section of the EM spectrum visible to humans (corresponding to the "rainbow of colours", violet through red). Ultraviolet light is also invisible to humans and is the one of concern.

Generally-speaking, the intensity of UV radiation decreases significantly with increasing distance from the source.

4.3.2.1 Potential Effects

The eyes and skin can both suffer damage resulting from exposure to UV radiation. At close range, exposure to the intense UV radiation from a welding arc can cause skin reddening (erythema) or skin burns (essentially equivalent to a bad sun-burn) (105). Exposure to high levels of UV radiation can damage the cornea.

4.3.2.2 Potential Exposure

Welding is likely to take place during the construction phase of the project, and there is some possibility that thermal cutting may also take place during the demolition phase. Lyon et al. (106) calculated safe distances beyond which nearly all healthy (adult) workers may be repeatedly exposed without acute adverse health effects such as erythema and photokeratitis. This work was based on the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values for occupational exposures, which are intended for healthy adults. Ten (10) meters was the distance calculated to be acceptable for a 10-minute exposure to radiation from shielded metal (arc) welding.

Viewing of a welding arc through windows while inside the school should not present a hazard to adults or students, as normal window glass typically blocks 100% of UV-B and 50% of UV-A (107), and the closest wall of the school is located approximately 15 metres away from the property boundary. Therefore, the primary risk is associated with viewing welding arcs while outside (i.e. during recess and lunch, and before and after school).

Children under the age of 10 are at much greater risk for retinal injury due to significantly greater transmission of high-energy "blue" visible light, and UV radiation through the lens of their eyes than adults(107). Transmission of blue light through the lens of a ten year old has been reported to be twice that of a 45 year old (108), and the lens of a child has been shown to transmit as much as 80 times more light in a range centered around the 320nm wavelength (UV-A, which presents the greatest risk for retinal burns) (109). These studies suggest that the probability of a child's exposure to hazardous levels of welding radiation is substantially greater than that of an adult when both are located at an equivalent distance from the welding arc.

4.3.2.3 Risk Assessment

Based on the criteria for Severity and Probability Ratings set out in section 2.5, welding radiation is considered a low risk for learning and a medium risk for health during the construction phase. Risk ratings are provided in Table 4.10.

Table 4.10. Risk Rating for Exposure to Welding Radiation

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Retinal Burns, Damage to Cornea or Conjunctiva Photokeratitis	P2	Possibility of thermal cutting during demolition if unshielded, distance between students and cutting operation could be unsafe	Medium
	Learning	S1	No interference with learning expected	P2		Low
Excavation	Health		Not applicable		Not applicable: no welding anticipated during excavation	N/A
	Learning					N/A
Construction	Health	S3	Retinal Burns, Damage to Cornea or Conjunctiva Photokeratitis	P2	If unshielded, distance between students and welding/cutting arcs could be unsafe	Medium
	Learning	S1	No interference with learning expected	P2		Low
Finished Building	Health		Not applicable		Not applicable: no welding anticipated when building finished	N/A
	Learning					N/A

5. BIOLOGICAL HAZARDS

5.1 Pests/ Disease Vectors

The term “pests” generally refers to animals (including insects) that can present a “nuisance” to humans of varying magnitude because of their interaction with humans. When examined in the context of potential biological hazards, pests can be more narrowly defined as animals capable of causing adverse health effects in humans. The most common “pests” in this context are mosquitoes, rats and mice, raccoons, bats, birds, flies, fleas, ticks and mites. “Pests” often serve as vectors in the transmission of disease (i.e. transmit the disease from one host to another, such as animal-to-human or human-to-human), as well as parasites. Microbiological diseases originating from animal products (e.g. urine, feces, hair, feathers, etc.) are discussed in Section 5.2.

5.1.1 Potential Effects

Bites, particularly from larger animals can cause physical damage to the human body (skin punctures, tears, puncture wounds, etc.). Bites can directly cause infection due to disease agents transmitted at the time of biting, or result in subsequent infection by infectious agents that enter open wounds.

Animal bites can result in the transmission of bacterial, fungal, viral, prion-based, and parasitic diseases from animals to the bitten human. The most commonly acquired diseases from bites include:

- Rabies: A viral infection carried in humans and wild mammals, including most commonly in the urban environment: stray dogs, raccoons, skunks, foxes, coyotes, and bats. Treatment is readily available, but if not administered before symptoms appear, rabies is almost always fatal within a few weeks (110).
- West Nile Virus: A viral infection carried by mosquitoes that have fed on other infected animals (a wide variety of hosts exist)(111). In Canada, humans are most at risk between mid-July and early September (112).Infection typically results in a fever, and rarely, as a form of viral meningitis, and recovery typically takes around a week (113).

Other diseases associated with animal bite/contact include:

- Tularemia;
- Rat Bite Fever;
- Tick-Borne Relapsing Fever;
- Lyme Disease; and
- Ringworm (Dermatophytosis)

5.1.2 Potential Exposure

Pest animals in the building to be demolished may migrate to surrounding properties during demolition. During the construction phase, they may be attracted to the construction site by attractions like waste containers or food waste.

Items associated with construction work may collect pools of stagnant water that can encourage breeding of mosquitoes (114) which could become infected with West Nile virus. Based upon reported statistics, the probability of infection is quite low. For the years 2010 through 2015, Health Canada reported between 5 to 428 clinical cases of West Nile virus per year for the entire country. Less than 10 cases were reported in the Greater Toronto Area in 2016. The highest number of cases ever reported was in 2007, with 2215 cases (115). Fewer than 1% of people infected with the virus will develop severe symptoms or health effects, and children are not believed to be at greater risk for infection than adults (113).

The Deltera Construction Mitigation Plan (25) states that the constructor will develop pest management/rodent control procedures. The Plan includes a few of the measures that will be taken to control pests, including trash control. It does not, however, include many details about pest control procedures, such as those recommended by the Chartered Institute for Environmental Health (114).

5.1.3 Risk Assessment

Based on the criteria for Severity and Probability ratings set out in section 2.5, pests are considered a medium risk for health and learning during all project phases. Ratings for Health and Learning for each stage are provided in Table 5.1.

Table 5.1. Risk Ratings for Pests

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S3	Animal bite - injury, rabies & other diseases like rat bite fever Mosquito-borne diseases	P3	Possible release of pests from infestation or open sewers into surrounding buildings	Medium
	Learning	S2	Distraction, annoyance from pests	P3		Medium
Excavation	Health	S3	See above	P3	Increased potential for mosquito breeding grounds on construction sites Possible release of pests from infestation or open sewers into surrounding buildings	Medium
	Learning	S2		P3		Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Construction	Health	S3	See above	P3	See above	Medium
	Learning	S2		P3		Medium
Finished Building	Health	S3	See above	P3	Increased waste may encourage accumulation of pests which may migrate to neighboring property	Medium
	Learning	S2		P3		Medium

5.2 Microbial Organisms

Microbial organisms (microbes) are microscopic-scale organisms, such as fungi, bacteria and viruses. Microbes are found almost everywhere on earth in enormous numbers; one estimate made for the number of fungal spores alone that a human inhales each day is 60-60,000 (116). Construction and renovation projects create large amounts of dust or debris that may carry many microorganisms.

5.2.1 Potential Effects

Increased exposures of students or school staff to microorganisms as a result of the construction project could occur as a result of aerosolization (i.e. becoming airborne) of biological materials (e.g. feces, urine, hair, feathers, etc.) during demolition of buildings, or aerosolization of existing microbes in the soil during excavation. Examples include the following:

- Microalgae normally grow in water or soil and are aerosolized when there is disturbance of soil or dust (117). Studies have shown that microalgae are a cause of respiratory allergy in children (118).
- Fungal (mould) spores can cause a variety of health symptoms from allergic reaction (flu- like symptoms) to serious lung, skin and other infections that can have serious health impacts. (119). Aspergillosis - a common community-acquired pneumonia results from inhalation of spores of aspergillus due to exposure to construction sites or garden work.
- Histoplasmosis: This fungal disease is caused primarily by avian pathogens in bird droppings. It primarily affects a person’s lungs, with symptoms varying from mild to severe. Infections

have been reported among people who were peripheral to activities that caused aerosolization of spores. Two such incidents were reported following sweeping of a school yard (120).

Inhalation or skin contact with microorganisms can cause infection, mild to severe allergic reaction, and irritation. The majority of microbes have no effect on healthy individuals; however, specific species are known to be human pathogens, and people's individual sensitivity exposure to microbial organisms varies widely.

5.2.2 Potential Exposure

Dusts containing bacteria or fungal spores can be aerosolized during construction, excavation, or demolition. Such contaminated airborne dusts can cause infections in people near the work site, as reported in Indianapolis during the years 1978, 1980 and 1988.(120).

5.2.3 Risk Assessment

Based on the criteria for Severity and Probability Ratings set out in section 2.5, microbial agents are considered a medium risk for health and learning during all project phases. Ratings for Health and Learning for each stage are provided in Table 5.2.

Table 5.2. Risk Rating for Exposure to Microbial Organisms

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Respiratory allergies, skin infections, flu -like illness	P3	Possibility of biological material such as dried feces, hair, urine, feathers containing microbes may be present in building to be demolished; aerosolization of contaminated materials during demolition	Medium
	Learning	S2	Allergic responses can interfere with learning and teaching	P3		Medium
Excavation	Health	S2	See above	P3	Dust generated from excavation of soil containing microbial agents	Medium
	Learning	S2		P3		Medium
Constructio	Health	S2	See above	P2	Dust generated by construction activities may contain microbes – less	Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S2		P2	likely than in demolition and excavation phases	Medium
Finished Building	Health	S2	See above	P2	Waste from the building can pose a risk to the adjacent property	Medium
	Learning	S2		P2		Medium

6. SAFETY HAZARDS

6.1 Traffic

General traffic conditions on urban streets are characterized by speeds of 40-50 km/hr, variable traffic volumes, limited maneuvering space, frequent turns and cross movements, significant pedestrian movement, road restrictions and other obstructions.

Construction, maintenance, and utility operations in urban streets alter the general traffic conditions and include movement of construction workers, heavy construction equipment, vehicles, detours and road encroachments. Construction site activities slow down traffic and limit road use.

6.1.1 Potential Harm

Alteration of traffic due to construction work, presence of construction equipment near the school, and limited space may increase the risk of vehicle accidents and therefore pose a safety risk to pedestrians and drivers. Other hazards associated with increased traffic include noise and diesel emissions, which are addressed in sections 3.5 and 4.1.

6.1.2 Probability of Harm

Statistical data pertaining to accidents due to construction site traffic near schools is not available. However, taking into consideration that the school is near the busy Yonge and Erskine intersection and that Erskine Avenue is a two-lane road, there is a probability of increased traffic congestion due to construction of the proposed development. The Traffic Management Plan described in Deltera's Construction Mitigation Plan (25) addresses construction site entry and exit points for tractor trailer and concrete truck movement, but does not describe how heavy equipment (e.g. demolition equipment, drilling equipment, cranes) will access the site. It also does not identify the staging / parking area for construction vehicles, nor consider snow piling on the curb and streets during winters.

The drawing in the Traffic Management Plan does not indicate whether the proposed pedestrian walkway will extend the entire length along the sidewalk of the construction site, and whether the height of the covered pedestrian walkway will be high enough to allow construction vehicles to enter and exit the construction site. There is limited information about controls that may be implemented by the developer or details such as a tower crane assembly plan and number of construction vehicles.

Furthermore, the construction activity may give rise to external distractions, which have been noted as a cause of distracted driving, which has been shown to worsen drivers' abilities to react quickly to hazards (121)

After building completion, there is a possibility of increased traffic hazards due to increased traffic and turns from the non-signaled intersection of Erskine and Yonge.

6.1.3 Risk Assessment

In view of the uncertainties of traffic management, and the potential for considerable traffic congestion and the presence of construction vehicles on Erskine Avenue, the probability of adverse incidents related to traffic is rated P3, or possible, during demolition, excavation and construction phases. Based on the criteria for Severity and Probability Ratings set out in section 2.5, traffic is considered to have high risk for health and medium risk for learning during all these phases, as described in table 6.1.

Table 6.1. Risk Rating for Traffic Hazards

Table 6.1 Traffic and School Access Risk Rating		Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Driving distractions; safety hazards; possibility of severe injury or death	P3	High vehicle / equipment movement during demolition	High
	Learning	S2	Minimal distraction in classroom; distraction during outdoor activities	P3		Medium
Excavation	Health	S4	As above	P3	High vehicle volume during excavation	High
	Learning	S2		P3		Medium

Table 6.1 Traffic and School Access Risk Rating		Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Construction	Health	S4		P3	High vehicle / equipment movement due to construction material movement	High
	Learning	S2		P3		Medium
Finished Building	Health	S4	As above	P2	Traffic increase from new residents	Medium
	Learning	S2		P1		Low

6.2 Cranes

There are many types of cranes that are in operation at a construction site. Primarily cranes can be categorized into two broad types:

- **Mobile Cranes**: The cranes that are mounted either on a vehicle or mobile platform. These are designed to be easily transported to a site and used with different types of load and cargo with little or no setup or assembly.
- **Fixed Cranes**: Cranes whose main body doesn't move during operation.

Construction sites employ a combination of mobile and fixed cranes for material movement at construction projects. Cranes occupy varying spaces on a construction site depending on the type and nature of work they must perform. Construction projects in high density urban areas pose a challenge to positioning cranes in a manner that will ensure safe execution of the work activity.

Tower cranes are the most commonly used fixed cranes at construction sites and are anchored to the ground on a concrete slab. The base of the crane is attached to a mast which gives the crane its height. The mast is attached to the slewing unit consisting of a horizontal jib, operator's cabin, and counter weights. The slewing unit facilitates 360-degree rotation of the crane jib allowing it to have access to a cylindrical area. A hoist unit appended to the jib performs the lifting operations as guided by the crane operator. Tower cranes hoist and transport a variety of loads near and above people, working under crowded conditions, occasionally with overlapping work zones, and often under time, budget and labour constraints.

The use, operation and maintenance of cranes and their parts are regulated by Ontario Regulation 213/91. Cranes require regular maintenance and testing to ensure that they are in adequate condition, operated as designed, and in compliance with legal requirements. The applicable crane standards that are cited in Ontario Regulation 213/91are:

- CSA-Z248-04 (R2009) Code for Tower Cranes;
- Z150 Safety code on mobile cranes; and
- Z150.3-11 Safety code on articulating boom cranes.

6.2.1 Potential Harm

The toppling of a crane is perhaps the most catastrophic event that can occur on a construction site. While those most at risk from such an event are the crane operator and other workers, crane collapses are known to have damaged adjacent buildings (122), and killed or injured members of the public. Risk to adjacent sites depends on several factors, including positioning and configuration of the crane and its mast. In recent years, members of the public and occupants of nearby buildings were killed in dramatic crane collapses in New York City and San Francisco.

6.2.2 Probability of Harm

Calamities involving crane collapses, fatalities or serious injuries are widely reported, and several informal blogs are dedicated to reporting and tracking crane incidents. However, reliable data are insufficient to estimate the frequency or statistical probability of a crane collapse. Nevertheless, information and research are available on conditions more frequently associated with crane incidents, and factors that influence crane safety.

The Ontario Ministry of Labour (MOL) reports that between April 1, 2011 and May 31, 2016, three workers died and 12 workers were seriously injured in incidents involving mobile cranes at construction sites across Ontario (123). There were also 66 reported incidents involving minor injuries to workers or "close calls". The MOL further reported that in a “blitz” of construction sites in August and September 2016, inspectors issued 90 orders related to crane operation and hoisting.

A study of 125 crane-related fatalities that occurred between 1997 and 2003 in the United States analyzed the construction operations and crane types associated with fatal crane events (124). Table 6.1, reproduced from this study, indicates that the majority of the 125 fatal events occurred during crane mobilization, lifting/moving equipment, assembly and disassembly of cranes, erecting structural steel, demolition and pile driving activities. Table 6.3, also reproduced from the study, indicates that mobile cranes were involved in more fatal events than were tower cranes.

Table 6.2. Frequency of Crane Fatality Events by Construction Operation*

Code	Construction Operation	Frequency	Percent
37	Mobilization	39	31
37a	Lifting/moving equipment and materials	(30)	(24)
37b	Assembly/disassembly of cranes	(9)	(7.3)
12	Erecting structural steel	19	15
6	Demolition	15	12
40	Pile driving	12	10
58	Trenching, installing pipe	4	3.2
21	Forming	3	2.4
42	Placing bridge girders and beams	3	2.4
48	Pre-cast installation	3	2.4
11	Emplacing reinforcing steel	2	1.6
17	Exterior carpentry	2	1.6
25	Installing HVAC including piping, ductwork and other equipment	2	1.6
44	Pouring concrete piers and pylons	2	1.6
43	Pouring floor decks	2	1.6
03	Cleanup	1	0.8
09	Electrical Transmission and Distribution	1	0.8
10	Elevator, escalator installation	1	0.8
22	Forming for piers or pylons	1	0.8
24	Installing culverts and incidental drainage	1	0.8
26	Installing plumbing, lighting fixtures	1	0.8
33	Installing interior painting and decorating	1	0.8
23	Installing interior walls, ceilings, doors	1	0.8
24	Installing underground plumbing, conduit	1	0.8
34	Landscaping	1	0.8
36	Maintenance	1	0.8
41	Placing bridge deck	1	0.8
46	Pouring concrete foundations and walls	1	0.8
49	Roofing	1	0.8
53	Stripping and curing concrete	1	0.8
56	Temporary work	1	0.8

*Brackets indicate subset of numbers above; percent refers to the percent of the 125 fatal crane accidents studied that involved the indicated activity

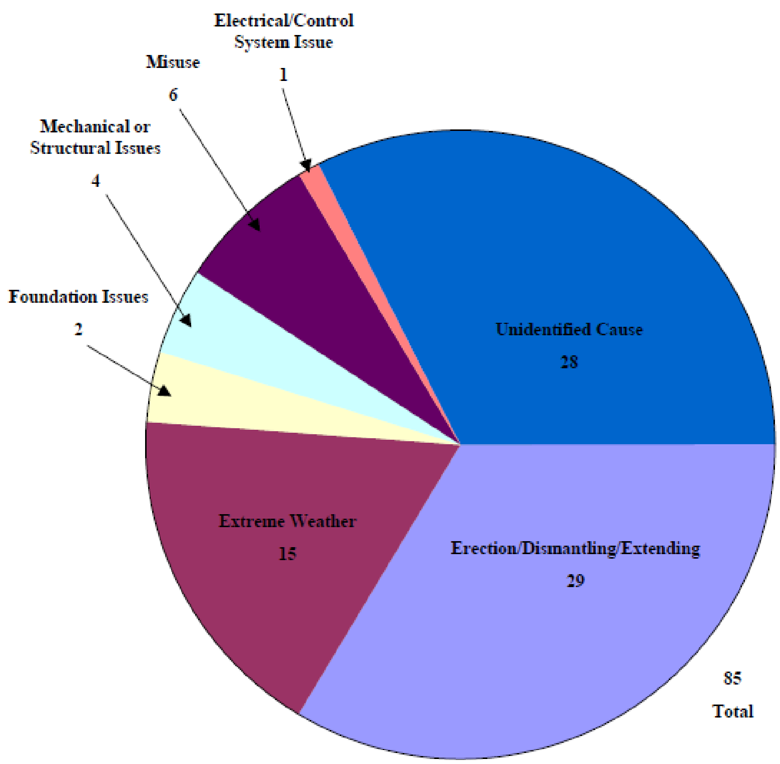
Table 6.3. Frequency of Crane Fatal Events by Crane Type*

Crane Type	Frequency	Percent
Mobile Crane with Lattice Boom	68	56.2
Crawler	(37)	(30.6)
Truck	(31)	(25.6)
Barge	(1)	(0.8)
Mobil Crane with Telescopic Boom	39	32.2
Crawler	(0)	(0)
Truck	(39)	(32.2)
Tower Crane	5	4.1
Bridge Crane	3	2.5
Container Crane	3	2.5
Jib Crane	3	2.5

***Brackets indicate subset of numbers above; percent refers to the percent of the 125 fatal crane accidents studied that involved the indicated crane type

A study was conducted by the UK Health and Safety Executive (HSE) of major incidents around the world involving the collapse of tower cranes between 1989 and 2009 (125). A total of 86 incidents involving the collapse or major structural failure of tower cranes were identified. The incidents were analysed and placed into seven categories as depicted in Figure 6.1.

Figure 6.1. Analysis of Underlying Causes of Tower Crane Accidents on Construction Sites



The study found that cranes manufactured by 14 different companies were involved in the 86 events, but did not find evidence that cranes by any, one manufacturer were more likely to be implicated in a crane incident.

The report refers to two crane related accidents that occurred in Toronto, Canada:

- A Pecco saddle jib tower crane collapsed on October 23, 2009 at a construction site in Toronto due to failure of the slewing ring bolts. This incident is categorized in the mechanical or structural fault group (See Figure 6.2) as referenced from the report.
- The jib of a Kroll luffing crane collapsed on April 12, 2007 in Toronto during a wind storm. The incident is categorized in the extreme weather group.

Figure 6.2. A Pecco Saddle Job Tower Crane Collapse on October 23,2009- Toronto (124)

A research study on “Identification and Analysis of Factors affecting safety on construction sites with tower cranes” (126) was conducted by interviewing safety and equipment managers of the top ten construction companies in Israel. The study identified 21 factors that affect safety on construction sites due to operation of tower cranes.

The most influential factors were (in order of importance):

- Operator proficiency;
- Site Safety Management;
- The company’s safety management and culture;
- Blind lifts (lifting a crane load while it is not fully visible). Blind lifts are rare for tower crane work and more common for mobile cranes;
- Signal person experience; and
- Wind speeds.

Other factors not listed in this study but known to cause crane accidents include ground stability, and improper assembly and disassembly of cranes.

6.2.3 Risk Assessment

References cited above indicate that events involving cranes or conditions that could lead to a crane calamity are not infrequent on construction sites. While the Deltera Construction Mitigation Plan (25) states that “safe work procedures [regarding cranes] will be requested and strictly adhered to”, it does not set out what these procedures will be. It also does not address placement of the crane in relation to JFPS. In view of this ambiguity and the evidence cited above, a catastrophic incident involving a crane is possible and assigned a Probability rating of P3 for the construction phase. The risk due to cranes is therefore rated as high during construction. Cranes are not expected to be present during demolition and excavation phases and of course no cranes will be in the vicinity when the building is finished. Hence there is no risk of a crane-related incident during demolition, excavation and finished phases. Risk ratings for crane hazards are given in Table 6.4.

Table 6.4. Risk Rating for Crane Hazards

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	NA	It is presumed that there are no cranes during demolition	NA	It is presumed that there are no cranes during demolition	NA
	Learning	NA		NA		NA
Excavation	Health	NA	It is presumed that there are no cranes during excavation	NA	It is presumed that there are no cranes during excavation	NA
	Learning	NA		NA		NA
Construction	Health	S4	Death or serious injury in the event of a crane collapse	P3	Details of construction safe work procedures are not available Experience shows crane accidents are possible at construction sites	High
	Learning	S4	Loss of concentration due to emergency responders, police, school closure due to accident	P3		High
Finished Building	Health	NA	Cranes are not present in the completed building	NA	Cranes are not present in the completed building	NA
	Learning	NA		NA		NA

6.3 Falling Objects

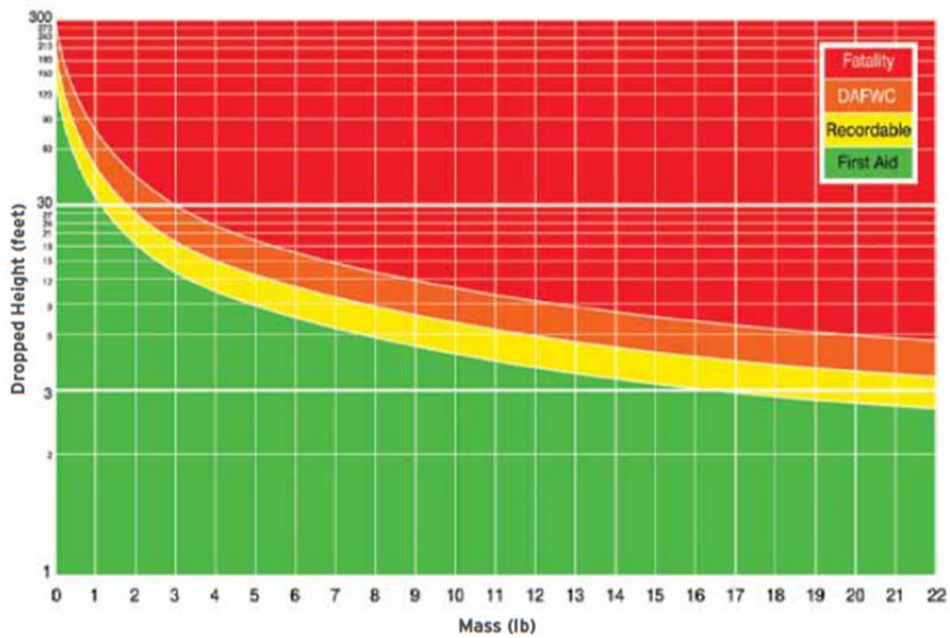
A construction project is a dynamic undertaking, with materials and objects continuously moved across the site and to different levels. Falling objects due to construction activities can pose a risk to people near the site. Scaffolding that is overloaded or inadequately tied to a building is vulnerable to collapse. Injuries and deaths to members of the public have resulted from failure of a structure, scaffolding or lifting equipment, inappropriate lifting and slinging practices, inadequate supports or supports not resting on level/firm ground, or incorrect estimation of the weight or center of gravity of a load. In high winds, equipment can collapse and objects can be blown significant distances. Risks relative to wind speed have been assessed by the City of Calgary, which has developed an Advanced Weather Forecasting System (127) to help manage risk of objects on construction sites becoming windborne.

6.3.1 Potential Harm

While free falling objects have a vertical descent and therefore are not likely to affect those outside the project site, objects travelling horizontally have the potential to strike people, material or buildings on adjacent properties. Health impact of horizontally displaced objects depends on the object's original height, forces other than gravity acting on it (most notably wind), and its density, size and shape. A scaffold collapse may have a horizontal as well as a vertical impact, depending on the scaffold height. Scaffolding that is overloaded or inadequately tied to a building is vulnerable to collapse. Potential injury is not only dependent on stability of the scaffolding itself, but also the construction materials kept on the scaffold such as bricks and tools. The severity of potential harm could be serious injury or even death and as such should be rated S4. There is no evidence in literature of any impacts of windblown articles or collapsed structures on learning per se, but emergency response or damage to the school may interrupt learning activities, and the risk of getting injured may restrict outdoor activities of JFPS students and staff.

Chevron (128) has developed a risk calculator that rates the risk of falling objects on construction projects, based on the object's height and mass. (See Figure 6.3.) This calculator suggests that very severe injuries or fatalities are possible from objects that may fall during the proposed project.

Figure 6.3. Severity of Injury from a Falling Object Based on Height of Fall and Mass of the Object



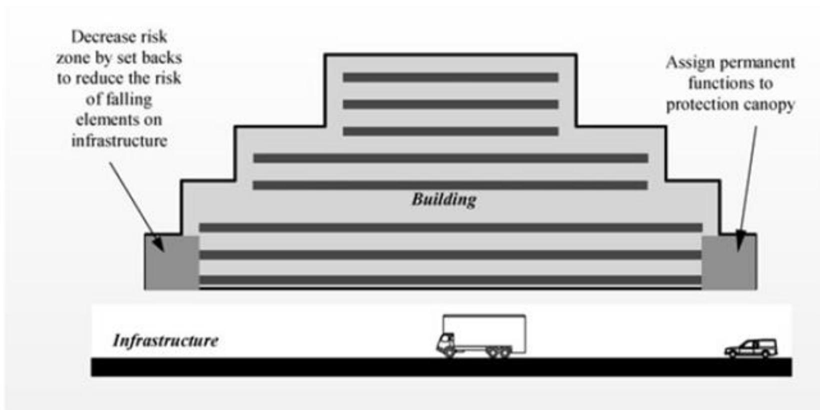
(DAFWC = days away from work case, i.e. lost time injury)

6.3.2 Probability of Harm

Every year several incidents of scaffold collapse are reported from all over the world. According to data from the US Occupational Safety and Health Administration (OSHA) 54 fatalities occurred in 2009 from scaffolding and staging. Seventy-two (72) percent of workers injured in scaffolding accidents, according to the US Bureau of Labor Statistics (BLS), claimed that the reason for their accident was the result of problems with planks or scaffold supports giving way, which led to injury or death (129). Slipping and being caught between falling objects were also common contributing causes to scaffolding accidents. High wind speeds have also been implicated in scaffolding collapses, such as an incident in Cardiff City Centre in the UK where 30 tonnes of scaffolding crashed from a multi-story building.

A paper published by Suddle indicates that buildings with a stepped ("set back") design are less likely to cause injury to third parties due to falling objects(130). (See Figure 6.4.) The proposed building design (131) indicates that the building is partially recessed (set back) above the third story, which may provide some protection from falling objects after the first three levels have been constructed. However, the proportional set back appears to be much less than that shown in Figure 6.4, so there remains a possibility of falling objects affecting the school site.

Figure 6.4. Set Back Design in Building Provides Protection from Falling Objects



6.3.3 Risk Assessment

In view of the references cited above, the probability of harm from falling or moving objects is rated P3 or possible during the demolition and construction phases. Risk is therefore rated high during these phases. Rationale for the ratings is given in Table 6.5.

Table 6.5. Risk Rating for Falling Objects

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	A large object that is windblown or horizontally displaced can strike a person or a part of the school (e.g. a glass window) causing serious injury or death	P3	Building demolition can create large objects that can be windblown or otherwise be horizontally displaced to land in JFPS premises/playgrounds etc.	High
	Learning	S3	Learning disrupted due to emergency response or school damage	P3		Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Excavation	Health	S4	As above	P2	Falling, moving objects not likely during excavation	Medium
	Learning	S3		P2		Medium
Construction	Health	S4	As above	P3	Construction objects may fall or be blown horizontally	High
	Learning	S3		P3		Medium
Finished Building	Health	S4	As above	P1	Displaced objects on balconies unlikely to reach JFPS	Low
	Learning	S3		P1		Low

6.4 Structural Stability and Water Table Impacts

There are many potential hazards arising out of excavation and trenching activities. Among the most serious are cave-ins. A cave-in or horizontal displacement of soil occurs when walls of an excavation collapse. Undisturbed soil remains in place by natural horizontal and vertical forces of the nearby soil. When soil is dug from the earth, the natural forces are no longer able to hold back the soil left behind. Without support, eventually the soil from the excavation moves downward and inward into the excavation under the force of gravity, resulting in a cave-in.

Another potential hazard related to excavation relates to impacts on the water table. An excavation may flood if the work is below the water table, near a watercourse bank or exposed to adverse weather conditions. Water accumulation may be caused by an excavation near a ground water source, in wet conditions or because of equipment that uses water for operation near the excavation site.

6.4.1 Potential Harm

As cave-ins can affect the stability of neighbouring structures, there is potential for damage to the JFPS building. Another source of instability is vibration, which is addressed in Section 4.2. It is possible that the JFPS site may also be affected by water damage if the excavation floods.

6.4.2 Probability of Harm

Constructors are required to have a professional engineer specify in writing the precautions to be taken to prevent damage to adjacent structures during excavation (132).The City of Toronto also requires a geotechnical study as part of the building application and oversees measures to protect adjacent buildings, as part of the building permit process. This includes oversight of water table issues. The Deltera Construction Mitigation Plan (25) includes erosion and sediment control measures.

6.4.3 Risk Assessment

Given the oversight of excavation and potential damage or flooding of adjacent buildings, the probability of damage to JFPS during demolition and excavation is considered remote. However, as the potential damage or injury, should it occur, could be severe, the overall rating for risk or level of concern is medium during the demolition and excavation phases. Rationale is given in Table 6.6.

Table 6.6. Risk Rating for Hazards Due to Structural Instability and Water Table Impacts

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Damage to building could cause severe injury	P1	Remote probability of impact on school, given oversight by City and Ministry of Labour	Medium
	Learning	S4	Damage to building could seriously disrupt school operations	P1		Medium
Excavation	Health	S3	As above	P1		Medium
	Learning	S4		P1		Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Construction	Health		Not applicable	P3	Not applicable	N/A
	Learning			P3		N/A
Finished Building	Health		Not applicable	P3	Not applicable	N/A
	Learning			P3		N/A

6.5 Fire and Explosion

Fires

Buildings face the greatest risk from fires during the construction phase. Combustion occurs when fuel, oxygen, heat and a chemical chain reaction synchronize to cause a fire.

The leading causes of fire in buildings under construction or demolition are incendiary or suspicious events including smoking, open flames from hot work, embers, electrical equipment, static discharges, striking underground pipelines, motor vehicle crashes, arson and heating equipment.

Explosions

An explosion is a rapid increase in volume and release of energy usually accompanied by generation of high temperatures and release of gases. Explosions are characterized by fragmentation and dispersion of projectiles, which have a potential to cause damage in areas outside the perimeter of the construction site. Explosions on construction sites may occur due to various reasons including ignition of gas cylinders, pressurized container explosions, inadvertently striking utility gas lines, chemical explosions, accumulated hazardous atmospheres in confined spaces, and electrical explosions.

6.5.1 Potential Harm

Fire and explosions have the potential to damage adjacent buildings and seriously injure people in the vicinity.

6.5.2 Probability of Harm

An examination of US Bureau of Labour statistics (133) revealed that a total of 361 deaths due to 313 fire or explosion incidents on construction projects in the United States were reported to the Bureau from 1992 to 2003. Forty-five percent of the deaths were due to chemical explosions and 27% due to fires. The remainder were due to pressurized container explosions and arc flashes. While these numbers are low compared to the number of construction projects in the United States, anecdotal reports indicate a serious concern about fire and explosion risks on construction sites. The Canadian Wood Council, in a Guide on Construction Fire Safety,(134) cites the following risk factors for construction fires:

- Proximity of combustible materials to ignition sources (e.g. electrical equipment and hot work such as welding);
- Lack of completion of any built-in fire-safety systems such as sprinklers;
- Absence of doors, finished walls and other separations that may slow fire spread; and
- Potential site security issues.

6.5.3 Risk Assessment

As a Fire Safety Plan was not included in the Deltera Construction Mitigation Plan (25), there is little specific information on which to base an assessment of probability of fire risk for this project. However, experience suggests that fires on construction sites or conditions that may cause them are not infrequent. Therefore, the probability of a fire at this project is rated as possible (P3) during excavation and construction phases. As the severity of harm could be catastrophic (S4), this results in an overall risk rating of high for health and learning during the excavation and construction phases. Ratings and rationales are given in Table 6.7.

Table 6.7. Risk Rating for Fire and Explosion Hazards

<table>
<tr><th rowspan="2">Phase</th><th rowspan="2">Effects</th><th colspan="2">Severity</th><th colspan="2">Probability</th><th rowspan="2">Risk Rating</th></tr>
<tr><th>Severity Rating</th><th>Severity Rationale</th><th>Probability Rating</th><th>Probability Rationale</th></tr>
<tr><td rowspan="2">Demolition</td><td>Health</td><td>S4</td><td>Serious injury may result from major fire or explosion</td><td>P2</td><td rowspan="2">Presence of combustible materials</td><td>Medium</td></tr>
<tr><td>Learning</td><td>S4</td><td>Major damage to school may occur</td><td>P2</td><td>Medium</td></tr>
</table>

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Excavation	Health	S4	As above	P3	Presence of combustible materials, striking underground utilities during excavation	High
	Learning	S4		P3		High
Construction	Health	S4		P3	Presence of combustible materials, pressurized gases, sources of ignition, electrical equipment	High
	Learning	S4		P3		High
Finished Building	Health	S4		P2	Routine risks of high rise fires	Medium
	Learning	S4		P2		Medium

6.6 Electrical

Electricity consumed at a construction site can be obtained from the grid, from battery banks, or from portable generators of varying capacity. Construction equipment is known to cause electrical accidents due to contact with overhead or underground power lines. Electricity is known to be a common source of fires in buildings. Fires of electrical origin can be caused in several ways:

- Leakage of current due to inadequate or damaged electrical insulation;
- Overheating of electrical equipment due to overloading of conductors;
- Overheating of flammable materials too close to electrical equipment;
- Ignition of flammable vapour by electrical equipment which is not operating normally; and
- Ignition of flammable atmosphere by static electricity

6.6.1 Potential Harm

Electricity can kill or severely injure people and cause damage to property. There are three types of electrical hazards: electric shock, electric arc and electric fires.

An electric shock results in a convulsive response by the nervous system to the passage of electricity through part of the body. Electric arc blasts produce burns resulting from radiated heat or from molten or hot metal fragments. Sometimes fatal injuries, burns or serious fires may result from an arcing incident.

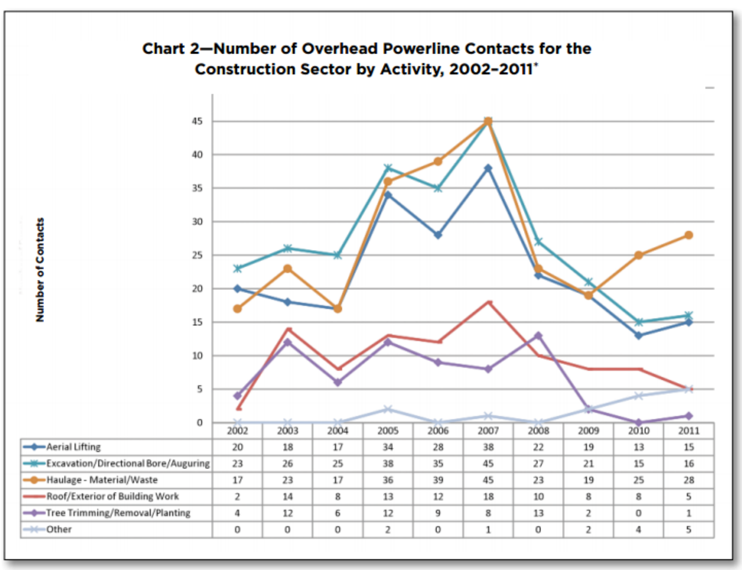
All types of electrical hazards have some potential to affect the public near a construction site.

6.6.2 Probability of Harm

Statistics show that 70 percent of the critical injuries and fatalities from powerline contacts occur on construction sites. The Ontario Electrical Safety Authority (ESA) has found that the most common causes of powerline hazards are lack of awareness and improper procedures. The ESA graph in Figure 6.5 indicates that aerial lifting activities resulted in 224 incidents of contact with overhead power lines between 2002-2011 and that 272 incidents were attributed to hauling materials and waste. Roof /exterior of building work activities contributed to 98 incidents during the reported period.

Whereas there is significant probability of harm to the construction workers and people with access to the construction site, there is little evidence of electricity-related harm to neighboring facilities or occupants. However, if construction equipment such as a crane or excavator contacts an electrical powerline, the electrical current could pass through the equipment into the ground creating a potential difference across the surface. This could present a hazard of a step potential, which could put people on the ground in the vicinity at risk. Another risk is loss of power to the school in the event of a power outage.

Figure 6.5. Number of Overhead Powerline Contacts in Construction Sector



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Aerial Lifting	20	18	17	34	28	38	22	19	13	15
Excavation/Directional Bore/Auguring	23	26	25	38	35	45	27	21	15	16
Haulage - Material/Waste	17	23	17	36	39	45	23	19	25	28
Roof/Exterior of Building Work	2	14	8	13	12	18	10	8	8	5
Tree Trimming/Removal/Planting	4	12	6	12	9	8	13	2	0	1
Other	0	0	0	2	0	1	0	2	4	5

Source: ESA records

6.6.3 Risk Assessment

The harm caused by a possible electrocution results in a severity rating of S4 (health) for electrical hazards. Based on the references cited above, the probability of such an occurrence is rated as P3 or possible during excavation and construction phases. As a result, risk of electrical hazards for this project is judged to be high (for health) during the excavation and construction phases, as shown in Table 6.8.

Table 6.8. Risk Rating for Electrical Hazards

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Electrical shock may cause severe injury or death	P1	Remote likelihood of electrical hazard during demolition	Medium
	Learning	S2	Electrical outage will disrupt learning; disruption due to emergency response	P1		Low
Excavation	Health	S4	As above	P3	Possible that contact could be made between construction equipment and overhead line, resulting in risk of step potential electrical shock	High
	Learning	S2		P3		Medium
Construction	Health	S4	As above	P3	As above	High
	Learning	S2		P3		Medium
Finished	Health	S4	As above	P1	No unusual source of electrical hazards	Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
	Learning	S2		P1		Low

6.7 Utilities

Densely populated urban areas have many utility lines buried underground. Underground utilities may include lines for telecommunication, electricity distribution, natural gas, steam lines, cable television, fiber optics, traffic lights, street lights, storm drains, water mains and waste water pipes. Construction activities such as excavation, drilling and trenching have a potential to strike and cause damage to underground utilities. Damage to underground utilities pose several hazards depending on the type of utility, location and extent of damage caused. Damage to underground utilities also result in interruption in services and cause downtime for business or operations.

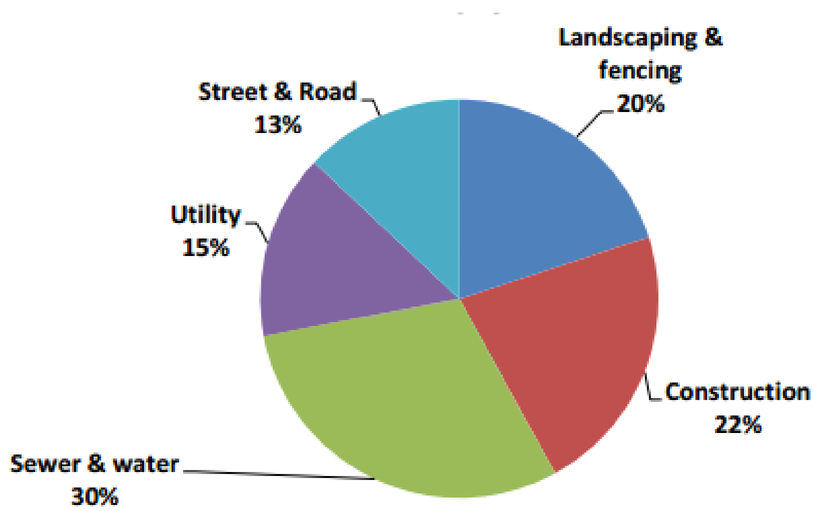
6.7.1 Potential Harm

Underground utilities such as buried gas, electrical power lines and water or sewage pipes present a serious risk of fire, explosion, electrical shock and flooding. Breaks in buried services endanger the life and safety not only of workers but also the general public.

6.7.2 Probability of Harm

A December 2014 report of the Standing Senate Committee on Energy, the Environment and Natural Resources states that the risk of damage to buried infrastructure by uncontrolled excavation is a daily public safety concern across Canada and that construction projects are one of the leading causes of such damage. During 2011-2012, 7,264 damage incidents to buried infrastructure were reported in Ontario, Quebec and British Columbia. Of these, construction projects contributed to 22% of damages to underground utilities (135). (See Figure 6.6.) In 40% of reported incidents, the excavator failed to make a locate request and 41% were due to poor excavation practices. Another cause of these incidents was insufficient line locating practices.

Figure: 6.6. Percentage of Utilities Damage Based on Nature of Work, British Columbia, Ontario and Quebec, 2011-2012



6.7.3 Risk Assessment

Section 8.3 of the Deltera Construction Mitigation Plan (25) describes procedures regarding underground Utilities/Locates. It in part states that "Locates identifying any underground utilities (e.g. gas lines, hydro vaults, etc.) will be obtained prior to the commencement of any excavating, digging, etc. Locates will be obtained on a monthly basis, prior to the date of expiration. Where underground utilities are identified within the working area, adequate precautions will be taken, including but not limited to, the development and implementation of safe work procedures and worker training". Details of the safe work procedures, worker training and description of adequate precautions are not provided.

Because damaging a gas line or high voltage can have catastrophic impacts, it has been assigned a severity rating of S4. In view of Deltera's Construction Mitigation Plan (25) and oversight by the City and Ministry of Labour, the probability is rated as improbable, or P2, as shown in Table 6.9, resulting in a risk rating of Medium. This risk is applicable only to the excavation phase.

Table 6.9. Risk Rating for Utilities Hazards

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health		Not applicable		Not applicable	N/A
	Learning					N/A
Excavation	Health	S4	Severe injury in event of a gas line strike	P2	Improbable that a utility line would be disrupted, in view of Construction Mitigation Plan and oversight by City	Medium
	Learning	S3	Disruption of learning if utilities disrupted	P2		Medium
Construction	Health		Not applicable		Not applicable	N/A
	Learning					N/A
Finished Building	Health		Not applicable		Not applicable	N/A
	Learning					N/A

6.8 Access to Site/ School

Access to the construction site by children, or conversely, access to the school site by people present on the construction site, could result in safety issues affecting children and security issues for the school. Potential harm includes the risk of injury to children accessing the construction site. Similarly, intruders entering the school can pose a risk to staff and students.

While the severity of such a hazard could be catastrophic (S4), the probability is considered remote (P1). The Deltera Construction Mitigation Plan (25) emphasizes the barriers that will be constructed and states that remote monitoring may be provided. Risk is therefore judged to be medium during all phases, as set out in Table 6.10.

Table 6.10. Risk Rating for Access to Site/School Hazards

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S4	Severe injury possible if child should access site	P1	Remote likelihood of access by children to site. Remote likelihood of intrusion into school above baseline levels	Medium
	Learning	S4	Serious consequences possible if intruder should access school	P1		Medium
Excavation	Health	S4	As above	P1	As above	Medium
	Learning	S4		P1		Medium
Construction	Health	S4	As above	P1	As above	Medium
	Learning	S4		P1		Medium
Finished Building	Health	S4	As above	P1	Remote likelihood of intrusion into school	Medium
	Learning	S4		P1		Medium

7. PSYCHOSOCIAL HAZARDS

A psychosocial hazard is any hazard that affects mental well-being or mental health. Hazards considered in relation to this risk assessment include stress and effects on learning related to physical conditions such as noise, lighting and limitations on outdoor activities (e.g. recess).

7.1 Stress

A stress response begins with the perception of threat or danger in the environment. Stress is a complex psychobiological process with biological, emotional, mental, and behavioral consequences, all of which influence one another. A person's response to stress may have physical effects by overwhelming a person's coping mechanisms and affecting ability to function in a healthy and safe manner (136). Psychosocial stress can lead to illness by causing acute and chronic changes in the functioning of body systems.

Systems in the brain regulate neural and hormonal responses to stress. In the event of constant stimulation the response mechanisms can cause adverse health effects (137). Studies have investigated how different ways of coping with stress can lead to different health outcomes. For example, active coping (trying to deal with the stressor instead of avoiding it) is associated with cardiovascular responses such as a rise in blood pressure (138).

In the present risk assessment, students, the principal of the school, teachers and parents may be at risk of psychosocial stress due to changes related to the construction project. Indicators of stress responses related to construction activity were found in animal studies that showed doubling of the stress hormones in response to nearby construction (139).

Conditions related to construction that may augment stress include:

- Annoyance due to noise, vibration, odours and dust (140);
- Increased traffic;
- The need for increased vigilance over children playing near the construction zone;
- Possible emergencies;
- Disruptions in normal routines; and
- The need for increased surveillance of school site conditions, e.g. related to security, structural damage.

The burden of responsibility for maintaining a safe and healthy school environment would fall largely on the school principal and staff, making them particularly likely to experience stress related to this project. Children also may be particularly vulnerable to stressors that affect them in a sensitive development period. Some research has indicated that children under the age of 6 years are developmentally less capable of adapting to change in their surroundings (141).

7.2 The Learning Environment

Learning is a product of the complex interaction between the environment, system, teaching processes, communications and student services. A change in any of these could disrupt the learning process. As discussed in Section 3.5 (Indoor Air Quality), poor indoor environmental conditions can adversely affect students' learning performance (60) (142). Section 4.1 discussed the adverse effects of noise on learning. Below we consider potential effects of lighting and limitations on outdoor activities (e.g. recess).

7.2.1 Lighting

Studies have shown that classroom lighting plays a particularly critical role in student performance (143). There is evidence that physiological disorders may occur in the human system if the human skin does not receive some exposure to solar radiation, either direct or diffused, for long periods of time. Lack of sunlight can cause a Vitamin D deficiency resulting in weakened body defenses and an aggravation of chronic diseases (144).The nonvisual retinal responses to light also mediate several neuroendocrine hormonal functions that regulate such mechanisms as melatonin secretion, pubescence, ovulation, and a wide variety of daily rhythms.

A report on daylight in schools and human performance (145), covering more than 21,000 students in three school districts in the US states of California, Washington and Colorado, indicated that students with the most classroom daylight progressed faster on math and reading tests than students who learned in environments that received the least amount of natural light. Laboratory studies have indicated that bright light exposure induced higher feelings of alertness and vitality, faster responses in sustained attention tasks and higher physiological arousal (146).

Predictions of shadow projections of the finished building were made by the project architects for different times of day and seasons of the year (147). The shadowing diagrams indicate that while JFPS would be in shadow during parts of the school day, this is partly due to shadow from other buildings and not from the proposed project. The proposed project would shade the school increasingly after 3 pm. Though this might not greatly affect the sunlight received by school students, it could affect the day care children who are present in the school into the late afternoon and early evening.

7.2.2 Limitations on Outdoor Activities Such as Recess

Exposure to a number of hazards discussed in this report, most particularly noise and dust, will be more severe outdoors than indoors. Due to these hazards or safety concerns, school staff may feel it necessary at times to reduce children’s time outdoors.

The US Center for Disease Control (CDC) (148) has recommended that children participate in at least 60 minutes of physical activity daily. The National Association for Sports and Physical Education (149) recommends that elementary school children have at least one 20-minute recess period per day. Physical activity during recess has been shown to improve mental and physical health outcomes such as lower anxiety levels, improved attention and improved cardiovascular health. If children’s time outdoors is reduced due to construction-related conditions such as safety issues or elevated noise and dust levels, this may have adverse effects through reduced time for recess and outdoor physical activities.

7.3 Risk Assessment

Based on the criteria for Severity and Probability ratings set out in section 2.5, psychosocial issues are considered a medium risk for health and learning during the demolition, excavation and construction phases. Ratings for Health and Learning for each stage are provided in Table 7.1.

Table 7.1. Risk Rating for Psychosocial Hazards

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Demolition	Health	S2	Health effects on the hormonal balance mechanisms due to stress, response to noise, traffic, and other hazards	P3	Stressors associated with hazards and conditions present during demolition, excavation and construction phases; safety concerns or higher exposure to hazards such as noise and dust outdoors, which may limit outdoor activities such as recess	Medium
	Learning	S2	Coping strategies, stress response affecting learning and teaching; reduced time outdoors, with decrease in benefits from recess and other outdoor activities	P3		Medium
Excavation	Health	S2	As above	P3	As above	Medium
	Learning	S2		P3		Medium
Construction	Health	S2	As above	P3	As above, plus additional shade late in day	Medium
	Learning	S2	Above, plus shade effects	P3		Medium

Phase	Effects	Severity		Probability		Risk Rating
		Severity Rating	Severity Rationale	Probability Rating	Probability Rationale	
Finished Building	Health	S2	Shade effects	P1	Some additional shade after school hours	Low
	Learning	S2		P1		Low

8. RISK MANAGEMENT STANDARDS AND GUIDELINES

The risks documented in this report can be mitigated through a variety of control measures. Government authorities apply various guidelines, standards and laws to require developers to adopt risk mitigation measures. This section provides an overview of such guidelines or laws applicable in Toronto, and then reviews several approaches taken by other authorities or in other jurisdictions.

It has been noted that children are more sensitive than adults to many of the hazards assessed in this report. Therefore, standards applied to protecting the public from construction risks should be designed to protect children. Unlike occupational standards, which are designed to protect adult workers, environmental and public protection standards are designed to protect the general public, including children. Although occupational standards in some cases also protect the public, environmental and public protection standards should take precedence where they provide a greater degree of protection.

8.1 Requirements in Toronto and Ontario

8.1.1 City of Toronto

Developers must apply to the City of Toronto for demolition and building permits, which must be approved by Toronto Buildings. Requirements for demolition and construction are set out in the Toronto Municipal Code, *Chapter 363, Building Construction and Demolition.* (150) This Code specifies information that is or may be required from the developer before a permit is approved. Provisions are set out requiring a geotechnical report, and a vibration report and vibration control form. Other information to be submitted with a demolition permit application includes:

- The method of demolition and whether the method for handling air and dust emissions, recognizing on-site sources, complies with sections 6 and 11 of Regulation 346 (151) (replaced by 419/05, Air Pollution Regulation) made under the *Environmental Protection Act*, R.S.O. 1990, c. E.19 (152).

- The presence on site of any hazardous materials, including PCBs, fluid storage tanks and WHMIS controlled products.

Toronto Buildings refers demolition applications to Toronto Public Health (TPH) for comment. TPH requires that information submitted with a demolition permit application include a Designated Substance Survey and a dust control plan. TPH requires adherence to its Approved Recommendations, Demolition and Excavation Dust Control,(153)which set out measures to be taken to ensure that dust from demolition and excavation does not migrate beyond the project's property line.

Toronto's noise bylaw (Toronto Municipal Code, Chapter 591) (154) limits construction noise between the hours of 7:00 am and 7:00 pm on weekdays (with other requirements for weekends and holidays). It does not limit construction noise during school hours.

Other provisions of the Toronto Municipal Code address construction hazards related to ground water and utility lines. Chapter 681 of the Code addresses sewers and establishes requirements to ensure that sewers are not damaged due to construction. Depending on the findings of the geotechnical report required under Chapter 363, the developer may be required to take measures to prevent impacts related to the water table(150).

The constructor must also identify the presence of utility lines (gas, water, electricity) and take measures to prevent damaging them.

8.1.2 Province of Ontario

8.1.2.1 Air Quality Requirements

The Ontario Ministry of the Environment and Energy (MOEE) establishes Ambient Air Quality Criteria (AAQC) (155)which, as explained on the MOEE web site:

"is a desirable concentration of a contaminant in air, based on protection against adverse effects on health or the environment. The term 'ambient' is used to reflect general air quality independent of location or source of a contaminant. AAQCs are most commonly used in environmental assessments, special studies using ambient air monitoring data, assessment of general air quality in a community and annual reporting on air quality across the province."

As explained, the AAQC are not limits for emissions from a particular source. Source emissions are regulated under the Ontario Regulation on Air Pollution, Regulation 419/05, which replaced Regulation 346, referred to in the Toronto Municipal Code quoted above. Sections 6 and 11 of Regulation 346 are replaced by Section 45 and 49 of Regulation 419/05 which state(156):

"45. No person shall cause or permit to be caused the emission of any air contaminant to such extent or degree as may,

a) cause discomfort to persons; cause loss of enjoyment of normal use of property; interfere with normal conduct of business; or cause damage to property.

49. Except for heat, sound, vibration or radiation, no person shall,

a) construct, alter, demolish, drill, blast, crush or screen anything or cause or permit the construction, alteration, demolition, drilling, blasting, crushing or screening of anything so that a contaminant is carried beyond the limits of the property on which the construction, alteration, demolition, drilling, blasting, crushing or screening is being carried out; or sandblast or permit the sandblasting of anything so that a contaminant is emitted into the air, to an extent or degree greater than that which would result if every step necessary to control the emission of the contaminant were implemented."

As implied by these provisions, the regulation does not stipulate quantitative limits on emission of air pollutants from construction activities, but requires that measures be taken to control emissions.

8.1.2.2 Noise Requirements

As quoted above, Section 49 of Regulation 419/05 specifically excludes sound (noise), as well as vibration, radiation and heat from limitations on emissions from construction.

Environmental Noise Guideline - Stationary and Transportation Sources - Approval and Planning (NPC-300) (157) provides reference noise limits and the applicable time periods for various types of indoor spaces like schools, day care centers, and residences. The guidelines state that the noise between 07:00 am and 11:00 pm for school and daycare centers from road traffic sources should not exceed 45 dB(A). The specified indoor sound level limits are maxima and apply to the indicated indoor spaces with windows and doors closed. The noise limits do not apply to construction-related noise and account for road traffic noise only.

Noise Regulation (O. Reg. 381/15)(158) under the Occupational Health and Safety Act (OHSA) extends noise protection requirements to all Ontario workplaces including construction projects and schools. The regulation requires that every employer shall ensure that no worker is exposed to a sound level greater than a time-weighted average exposure limit of 85 dB(A) measured over an 8-hour work day.

Employers must comply with this limit following the "hierarchy of controls", which emphasizes the use of engineering controls and work practices to protect workers.

8.1.2.3 Worker Health and Safety Requirements

The Ontario Occupational Health and Safety Act and regulations establish a variety of requirements to protect worker health and safety on construction sites(159). While these apply primarily to those working on the site, they also serve to protect others near the project. Compliance is enforced by the Ontario Ministry of Labour.

8.2 Other Jurisdictions

Requirements for mitigating hazards to the public from construction sites have been established in several jurisdictions. Good examples described in this section are Calgary's program to address construction safety hazards, and New York's requirements regarding environmental hazards. Also described are some relevant US federal and state requirements and guidelines.

8.2.1 Calgary

The City of Calgary requires a Public Protection Site Safety Plan (160) as part of the building permits and site review process. Components of the plan relate to safety issues such as falling or moving objects, cranes, and vehicles. To implement this initiative, Calgary created a Safety Response Unit to respond to public concerns. Resources created to support this program include On-Site Construction Safety Best Practices (161) For buildings of five stories or more in certain areas, Calgary requires that constructors use the Advanced Weather Forecasting System (127) so they can take appropriate action in response to weather conditions. As part of this system, Calgary provides a guideline showing the risk of moving/falling objects in relation to wind speed.

8.2.2 New York City

The City of New York has established detailed requirements for mitigation of noise and air contaminants from construction projects. In conjunction with the New York City Noise Code(162), the City introduced construction noise rules that require construction projects to establish noise mitigation plans. The rules provide for specific requirements to be included in the noise mitigation plan, including limits on emissions of noise levels from specified equipment, and control measures that must be implemented.

The City has also established Rules Pertaining to the Prevention of the Emission of Dust from Construction Related Activities. These rules establish specific requirements regarding dust suppression methods, primarily through wetting, that must be applied on construction sites.

8.2.3 US Standards

The United States Environmental Protection Agency (EPA) establishes National Ambient Air Quality Standards and requires individual states to implement State Implementation Plans (SIPs) to achieve the standards (163). The six criteria pollutants as defined by the U.S. Environmental Protection Agency (EPA) are carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. As part of their SIPs, states institute requirements for environmental controls on construction projects.

The EPA also issues regulations limiting diesel emissions from heavy equipment. Some states, such as Massachusetts, are requiring retrofit of diesel equipment to meet the standards (164). California has introduced regulations limiting emissions form off-road diesel equipment (165). Guidance material issued by Massachusetts and California shows how substantial reductions in diesel emissions can be achieved by retrofitting equipment.

8.3 Voluntary Standards

In addition to requirements set by regulation or enforced by government authorities, there are a number of voluntary standards and guidelines for controlling health and safety hazards from construction projects. These include the following.

ANSI ANSI/ASSE A10.34-2001 (R2012) Protection of the Public on or Adjacent to Construction Sites(166)

This standard recommends elements and activities on construction projects to provide protection for the public. It states that a project constructor should develop a public hazard control plan and sets out general expectations for plan provisions to minimize the impact of the hazards addressed in this assessment.

Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) IAQ (Indoor Air Quality) Guidelines for Occupied Buildings Under Construction (167)

While this guideline is intended to apply to construction projects at the same site as an occupied building, it includes measures that may be applicable to construction at an adjacent site. It includes guidelines regarding ventilation, use of low VOC products, and dust suppression measures.

Standards Council of Canada, Code of Practice for Safety in Demolition of Structures, S350-M1980 (R2003) (168)

This Standard outlines the safety precautions to be observed and procedures to be used before, during, and after demolition operations to provide for the safety of the public, workers, and property.

ChemInfo, prepared for Environment Canada, Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" (2005) (169)

This Guideline recommends development of a site-specific Environmental Management Plan before any construction or demolition activities are begun. It outlines a variety of dust suppression and other control measures that should be included in the plan to minimize emissions of airborne contaminants.

9. RECOMMENDATIONS

To conduct the proposed Phase II risk assessment, more specific information is needed from the developer about demolition, excavation and construction plans, and projected conditions.

Following are recommendations for information and studies that the TDSB should ask the City to require from the developer. In some cases, the City will routinely require this information, or the Deltera Construction Mitigation Plan (25) has stated that the constructor will provide the information. The TDSB should further recommend that the City review this information and determine that the developer's plans will protect JFPS occupants before a demolition or building permit is issued.

1. Designated Substance Assessment and assessment of any other hazardous material or mould in building to be demolished;
2. Soil sampling information for site, including lead, other metals, VOCs;
3. Demolition method;
4. Health and Safety procedures;
5. Public Protection Site Safety Plan;
6. Dust and diesel emissions modelling study;

7. Specific dust prevention and control measures and proof that those measures are effective in controlling dust levels to ambient background levels at the school boundry;
8. Measures to control emissions from parking garage of finished building;
9. Confirmation that emissions from all diesel and combustion equipment meets Canadian and Ontario standards;
10. Noise modelling study to show that noise levels do not exceed ambient background noise levels on school property for each phase of the project;
11. Noise Mitigation Plan;
12. Vibration modelling study and vibration control plan, with study of impact of vibration on JFPS building;
13. Confirmation that no project vehicles use asbestos-containing brake pads;
14. Excavation plan (showing how JFPS will be protected);
15. Pest Control Plan;
16. Boom length of tower crane; overhang over school site;
17. Lift plan;
18. Road safety, transport and access plan for construction vehicles and other equipment;
19. Traffic routes and parking details for construction and workers' vehicles;
20. Staging area;
21. Site fire safety plan;
22. Specific plans for safety netting and other measures to protect against falling objects; and
23. Exact location of covered walkway; how this will allow construction vehicles and equipment to enter site.

Where there are uncertainties about exposure to hazards, monitoring should be conducted during the project phases to ensure that controls are satisfactory. Table 9.1 sets out the recommendations for information to be requested from the developer for each hazard to carry out a site specific risk assessment (Phase 2), and recommended monitoring to ensure that mitigation is achieved.

Table 9.1. Recommendations for Information to be Requested and Monitoring Measures

Hazard	Information to be Requested from Developer/Constructor	Monitoring
General	– Designated Substance Assessments, other hazardous material in building to be demolished – Soil sampling information for site (lead, other metals, VOCs) – Demolition method – Health and Safety procedures – Public Protection Site Safety Plan consistent with City of Calgary requirements and the ANSI Standard on protection of the public	
Asbestos	– See Vibration: relevance to stability of ACM in school Confirmation that no project vehicles will use asbestos-containing brake pads	– Monitor condition of ACM in school during project – Air monitoring in school

Hazard	Information to be Requested from Developer/Constructor	Monitoring
Lead	– Soil tests for lead – Whether any lead- containing materials remain in the building to be demolished	– Air and wipe sampling during demolition and excavation
Particulates (dust) and diesel emissions Combustion equipment emissions	– Dust and diesel emissions modelling study; – Specific dust control measures, consistent with Toronto Department of Public health and the NYC Code for Dust Prevention – Measures to control emissions from parking garage of finished building – Confirmation that emissions from all diesel and combustion equipment meets Canadian, Ontario and US EPA standards	– PM10 and total suspended particulate (TSP)
Indoor air quality		– Monitor IAQ conditions
Noise	– Noise modelling study to determine noise levels at site border for each phase of the project – Noise Mitigation Plan consistent with the New York City (NYC) Administrative Code	– Monitor noise levels during all building phases
Vibration	– Vibration modelling study – Vibration control plan – Study of impact of vibration on JFPS building	– Monitor damage to school during all phases
Radon	– See Vibration: relevance to integrity of foundation and cracks to prevent radon infiltration	– Monitor damage to school, e.g. cracks in basement – Radon monitoring: baseline and during excavation
Biological hazards	– Pest Control Plan	– Mould and bacterial assessment if there is evidence of infestation.
Cranes, hoists, lifts	– Boom length of tower crane; overhang over school site – Lift plan	
Traffic	– Road safety, transport and access plan for construction vehicles and other equipment – Traffic routes and parking details for construction and workers' vehicles – Staging area	
Fire	– Site fire safety plan	
Structural stability	– Plan for protecting JFPS during excavation	
Falling objects	– Specific plans for safety netting and other measures to protect against falling objects. – Exact location of covered walkway; how this will allow construction vehicles and equipment to enter site	

10. CONCLUSION

This Phase 1 risk assessment has examined hazards that might reasonably be assumed to pose a risk to health, safety or learning due to the construction project proposed for the 18-30 Erskine Avenue site adjacent to John Fisher Public School. Each hazard has been assessed for risks to health/safety and learning for each of four stages of the project. A summary of health and learning risk ratings for each hazard for each stage is provided in Table 10.1.

While we have taken into account the Deltera Construction Mitigation Plan (25) and other proposal documents, specific details regarding the site and construction plans were insufficient to carry out a site-specific reliable risk assessment.

Table 9.1 lists additional information that should be requested from the developer, along with recommended hazard monitoring during the project.

ECOH appreciates the opportunity to be of service to TDSB in conducting this Phase 1 risk assessment.

Table 10.1: Health and Learning Risk Ratings		Potential Risk - Health				Potential Risk - Learning			
		Stage				Stage			
	Hazard	Demolition	Excavation	Construction	Finished Building	Demolition	Excavation	Construction	Finished Building
Chemical Hazards	Asbestos	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Lead	Medium	Medium	Low	NA	Low	Low	Low	NA
	Respirable Crystalline Silica	Medium	Medium	Medium	Low	Low	Low	Low	Low
	Diesel exhaust	High	High	Medium	Low	Medium	Medium	Medium	Low
	Crustal Dust	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Nitrous oxides (Nox)	High	High	Medium	Low	Medium	Medium	Medium	Low
	Sulphur Oxides (SOx)	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
	Volatile Organic Compounds (VOCs)	Low	Low	Medium	Low	Low	Low	Medium	Low
	Asphalt fumes	NA	NA	Medium	NA	NA	NA	Medium	NA
	Indoor Air Quality	Medium	Medium	Medium	Low	Medium	Medium	Medium	Low
Physical Hazards	Noise	High	High	High	NA	High	High	High	NA
	Vibration	Low	Low	Low	Low	Low	Low	Low	Low
	Welding Radiation	Medium	NA	Medium	NA	Low	NA	Low	NA
	Radon	Medium	Medium	Medium	NA	Medium	Medium	Medium	NA
Biological Hazards	Pests (excluding microbes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
	Microbes	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Safety Hazards	Traffic	High	High	High	Medium	Medium	Medium	Medium	Low
	Falling Objects	High	Medium	High	Low	Medium	Medium	Medium	Low
	Cranes	NA	NA	High	NA	NA	NA	High	NA
	Structural Stability & Water Table	Medium	Medium	NA	NA	Medium	Medium	NA	NA
	Fire and Explosion	Medium	High	High	Medium	Medium	High	High	Medium
	Utilities	NA	Medium	NA	NA	NA	Medium	NA	NA
	Electrical	Medium	High	High	Medium	Low	Medium	Medium	Low
	Access to site	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Psychosocial Hazards		Medium	Medium	Medium	Low	Medium	Medium	Medium	Low

10. STATEMENT OF LIMITATIONS

This risk assessment comprised a review of hazards associated with construction of the tower at 18 Erskine Avenue that may pose a risk to occupants of John Fisher Public School at 40 Erskine Avenue. In conducting this assessment, ECOH has exercised a degree of thoroughness and competence that is consistent with the environmental, health and safety profession.

ECOH is a consulting company with experience in conducting environmental, health and safety risk assessments for public and private sector organizations. Consultants who contributed to this assessment hold the following professional qualifications: Professional Engineer, Certified Industrial Hygienist, Registered Occupational Hygienist, Medical Doctor, Professional Geoscientist (Ltd.), Qualified Person for Risk Assessment. The external party consulted (Intrinsik) has qualifications in toxicology and environmental health.

ECOH, to the best of its knowledge, considers the information presented to be reliable and the opinions expressed to be consistent with professional standards. ECOH cannot, however, guarantee the completeness or accuracy of information supplied to ECOH by third parties.

ECOH is an environmental, health and safety consulting company, and as such does not intend any results or conclusions presented in this report to be construed as legal advice. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. ECOH accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions based on this report.

ECOH appreciates the opportunity to be of service to TDSB in conducting this Phase II risk assessment.

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REFERENCES

1. CCOHS. Risk Assessment : OSH Answers [Internet]. 2006 [cited 2017 Feb 2]. Available from: http://www.ccohs.ca/oshanswers/hsprograms/risk_assessment.html

2. CSA Z1002-12 Occupational Health and Safety- Hazard Identification Risk Assessment and Control. CSA Group, Z1002-12 2012 p. 58.

3. Smith J, Riley P. ANSI Z10 Risk assessment. 2005.

4. World Health Organization. Training for the Health Sector - Children are not Little Adults [Internet]. 2008 [cited 2017 Jan 24]. Available from: http://www.who.int/ceh/capacity/Children_are_not_little_adults.pdf

5. Columbia University School of Nursing. Emergency - Incidents Affecting Children - Differences between Children & Adults [Internet]. 2005 [cited 2017 Jan 11]. Available from: http://ccnmtl.columbia.edu/projects/eprep/children/partidx_06_01.html

6. World Health Organization. Training for the Health Sector - Children and Chemicals [Internet]. World Health Organization; 2011. Available from: http://www.who.int/ceh/capacity/chemicals.pdf

7. US EPA. EPA - Asbestos - Protect Your Family [Internet]. Available from: https://www.epa.gov/asbestos/protect-your-family

8. Federal Transit Administration. Transit Noise and Vibration Impact Assessment [Internet]. Washington, D.C.; 2006 [cited 2017 Jan 23]. Available from: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FTA_Noise_and_Vibration_Manual.pdf

9. ON MOL. Alert: Asbestos Hazard in Vehicle Brake Repair [Internet]. Government of Ontario, Ministry of Labour; 2013 [cited 2017 Feb 2]. Available from: https://www.labour.gov.on.ca/english/hs/pubs/alerts/i34.php

10. Health Canada. Final Human Health State of the Science Report on Lead. 2013.

11. ON MOL. Introduction: Silica On Construction Projects. OMOL [Internet]. 2011;(April):2–3. Available from: www.labour.gov.on.ca/english/hs/pubs/silica/gl_silica_1.php

12. International Agency for Research on Cancer. Silica Dust, Crystalline, In the Form of Quartz or Cristobalite. 2010;355–405.

13. Normohammadi M, Kakooei H, Omidi L, Yari S, Alimi R. Risk Assessment of Exposure to Silica Dust in Building Demolition Sites. Saf Health Work [Internet]. 2016;7(3):251–5. Available from: http://dx.doi.org/10.1016/j.shaw.2015.12.006

14. OSHA. Crystalline Silica Exposure - Health Hazard Information. OSHA [Internet]. 2002; Available from: www.osha.gov/OshDoc/data_General_Facts/crystalline-factsheet.pdf

15. Stacey P, Thorpe A, Roberts P. Levels of respirable dust and respirable crystalline silica at construction sites RR878 Levels of respirable dust and respirable crystalline silica at construction sites. Vol. RR878, Health and Safety Executive. 2011.

16. Beaudry C, Lavoué J, Sauvé J-F, Bégin D, Senhaji Rhazi M, Perrault G, et al. Occupational Exposure to Silica in Construction Workers: A Literature-Based Exposure Database. J Occup Environ Hyg [Internet]. 2013;10(2):71–7. Available from: http://dx.doi.org/10.1080/15459624.2012.747399

17. Flanagan ME, Seixas N, Becker P, Takacs B, Camp J. Silica exposure on construction sites:

results of an exposure monitoring data compilation project. J Occup Environ Hyg [Internet]. 2006;3(3):144–52. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16464818

18. Agency USEP. Health Assessment Document For Diesel Engine Exhaust [Internet]. Environmental Protection. 2002 [cited 2017 Feb 2]. Available from: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060#area

19. Office of Environmental Health Hazard Assessment (OEHHA). Health Effects of Diesel Exhaust. Exposure [Internet]. 2001; Available from: oehha.ca.gov/media/downloads/calenviroscreen/indicators/diesel4-02.pdf

20. Lewis MP. Estimating fuel use and emission rates of nonroad diesel construction equipment performing representative duty cycles. 2009.

21. Health Canada. Human Health Risk Assessment for Diesel Exhaust. 2016;2016–7. Available from: www.canada.ca/en/health-canada/services/publications/healthy-living/human-health-risk-assessment-diesel-exhaust-summary.html

22. EPA. Health assessment Document for Diesel Engine Exhaust. 2002.

23. Ahn C, Pan W, Lee S, Pena-Mora F. Enhanced estimation of air emissions from construction operations based on discrete-event simulation. In: Proceedings of the International Conference on Computing in Civil and Building Engineering [Internet]. 2010. p. 1–2. Available from: www.engineering.nottingham.ac.uk/icccbe/proceedings/pdf/pf119.pdf

24. Heidari B, Marr LC. Real-time emissions from construction equipment compared with model predictions. J Air Waste Manage Assoc [Internet]. 2015;65(2):115–25. Available from: http://www.tandfonline.com/doi/abs/10.1080/10962247.2014.978485#.VMscI2iG-k8

25. Deltera. Construction Mitigation Plan 18 Erskine 18 Erskine Avenue, Toronto, Ontario M4P 1Y2 Prepared by: 18 Erskine Holdings Inc. & Deltera Contracting Inc. Toronto, Ontario; 2017.

26. USEPA. Particle Pollution and Your Health. USEPA [Internet]. 2003;(September):2. Available from: http://www.airnow.gov/index.cfm?action=pubs.index

27. Van der Bruggen CO, Stams GJ, Bögels SM. Research review: the relation between child and parent anxiety and parental control: a meta-analytic review. J Child Psychol Psychiatry [Internet]. 2008 Dec [cited 2017 Jan 27];49(12):1257–69. Available from: http://doi.wiley.com/10.1111/j.1469-7610.2008.01898.x

28. Li H, Fang CHY, Shi W, Gurusamy S, Li S, Krishnan MN, et al. Toxicology Letters, Size and site dependent biological hazard potential of particulate matters collected from different heights at the vicinity of a building construction. Toxicol Lett [Internet]. 2015;238(3):20–9. Available from: http://dx.doi.org/10.1016/j.toxlet.2015.08.002

29. Geneva L. IARC: Outdoor air pollution a leading environmental cause of cancer deaths. 2013.

30. Dorevitch S, Demirtas H, Perksy VW, Erdal S, Conroy L, Schoonover T, et al. Demolition of high-rise public housing increases particulate matter air pollution in communities of high-risk asthmatics. J Air Waste Manag Assoc. 2006;56(7):1022–32.

31. Service PH. Nitrogen Oxides (nitric oxide , nitrogen dioxide , etc .). Div Toxicol [Internet]. 2002;9:43–4. Available from: http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=69

32. Bakke B, Ulvestad B, Stewart P, Eduard W. Cumulative exposure to dust and gases as determinants of lung function decline in tunnel construction workers. Occup Environ Med. 2004 Mar;61(3):262–9.

33. Bakke B, Stewart P, Ulvestad B, Eduard W. Dust and gas exposure in tunnel construction work. AIHAJ. 62(4):457–65.

34. Canada E and CC. Sulphur Oxides - SOx. 2017;2123. Available from: www.ec.gc.ca/air/default.asp?lang=En&n=BBB2123F-1

35. ATSDR. Tox: FAQ Sulfur Dioxide CAS #7446-09-5 [Internet]. ATSDR - Public Health Statement. 1999. Available from: http://www.atsdr.cdc.gov/toxfaqs/tfacts116.pdf

36. ATSDR. Public Health Statement - Sulfur Dioxide CAS # 7446-09-5. ATSDR - Public Heal Statement [Internet]. 1998;(December):7. Available from: https://www.atsdr.cdc.gov/ToxProfiles/tp116-c1-b.pdf

37. Vehicle Emissions in B.C. - Statistics [Internet]. [cited 2017 Feb 7]. Available from: http://www.bcairquality.ca/topics/vehicle-emissions-stats.html

38. Ann Butler M, Burr G, David Dankovic C, Alan Lunsford R, Miller A, Nguyen M, et al. Health effects of occupational exposure to Asphalt [Internet]. Cincinati, OH; 2000 [cited 2017 Jan 24]. Available from: https://www.cdc.gov/niosh/docs/2001-110/pdfs/2001-110.pdf

39. WorkSafeBC. Risk Advisory - Asphalt fume exposure during road construction. 2016.

40. Wess JA, Olsen LD, Haring Sweeney M. Concise International Chemical Assessment Document 59 - Asphalt (Bitumen) [Internet]. World Health Organization Geneva. Geneva: World Health Organization; 2004 [cited 2017 Jan 24]. Available from: http://www.who.int/ipcs/publications/cicad/cicad59.pdf

41. International Agency for Research on Cancer. Occupational exposures to bitumens and their emissions [Internet]. Lyon, France; 2011 [cited 2017 Jan 24]. Available from: https://www.iarc.fr/en/media-centre/iarcnews/pdf/IARC_Bitumen_Eng.pdf

42. American Conference of Governmental Industrial Hygienists. 2016 TLVs and BEIs - Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH: ACGIH; 2016.

43. National Institute for Occupational Safety and Health. Asphalt Fume Exposures During the Application of Hot Asphalt to Roofs - Current Practices for Reducing Exposures. Cincinnati, OH; 2003.

44. Lampi MA, El-Alawi YS, McConkey BJ, Huang XD, Dixon DG, Greenberg BM. Occurrence and toxicity of photomodified polycyclic aromatic hydrocarbon mixtures Present in Contaminated Sediements. Environ Toxicol Risk Assess. 2000;10:211–21.

45. Lynch RM, Kipen H. Building-related illness and employee lost time following application of hot asphalt roof: a call for prevention. Toxicol Ind Health [Internet]. 1998 [cited 2017 Jan 24];14(6):857–68. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9891916

46. Agency for Toxic Substances and Disease Registry. Toxicological Profile for Polycyclic Aromatic Hydrocarbons [Internet]. Atlanta, GA; 1995 [cited 2017 Jan 24]. Available from: https://www.atsdr.cdc.gov/toxprofiles/tp69.pdf

47. US EPA. EPA - IAQ - Volatile Organic Compounds Impact Indoor Air Quality [Internet]. 2016. Available from: https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality

48. Nurmatov UB, Tagiyeva N, Semple S, Devereux G, Sheikh A. Volatile organic compounds and risk of asthma and allergy: A systematic review. Eur Respir Rev [Internet]. 2015;24(135):92–101.

Available from: http://dx.doi.org/10.1183/09059180.00000714

49. Cipolla M, Bruzzone M, Stagnaro E, Ceppi M, Izzotti A, Culotta C, et al. Health Issues of Primary School Students Residing in Proximity of an Oil Terminal with Environmental Exposure to Volatile Organic Compounds. Biomed Res Int [Internet]. 2016;2016(Article ID 4574138). Available from: http://dx.doi.org/10.1155/2016/4574138%0AResearch

50. Jia C, Batterman S, Godwin C. VOCs in industrial, urban and suburban neighborhoods, Part 1: Indoor and outdoor concentrations, variation, and risk drivers. Atmos Environ. 2008;42(9):2083–100.

51. Connecticut Department of Health. Vapor Intrusion of VOCs Evaluating the Risks to Buildings in Your Town. Environ Occup Heal Assess Progr. 2012;(8):1–7.

52. Bouchama A, Knochel JP. Heat Stroke. N Engl J Med. 2002;346(25):1978–88.

53. Rowland T. Thermoregulation during exercise in the heat in children: old concepts revisited. J Appl Physiol [Internet]. 2008 Aug 1 [cited 2017 Jan 25];105(2):718–24. Available from: http://jap.physiology.org/cgi/doi/10.1152/japplphysiol.01196.2007

54. Gabriela T. Leites, Giovani S. Cunha1, Joyce Obeid1, Boguslaw Wilk1, Flavia Meyer, Brian W. Timmons. Thermoregulation in boys and men exercising at the same heat production per unit body mass. Eur J Appl Physiol. 2016;116:1411–9.

55. American Society for Heating Refrigeration and Air Conditioning Engineers. Thermal Environmental Conditions for Human Occupancy - ANSI/ASHRAE Standard 55-2010. 2010.

56. Massachusetts Bureau of Environmental Health. Methods for Increasing Comfort in Non-Air-Conditioned Schools [Internet]. 2007. Available from: https://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0ahUKEwie8bns9t7RAhWIyyYKHXmwCoMQFggeMAE&url=http%3A%2F%2Fwww.mass.gov%2Feohhs%2Fdocs%2Fdph%2Fenvironmental%2Fiaq%2Fcomfort-non-ac-school.doc&usg=AFQjCNGCrgLraNTZ2jvDEvX3R724

57. Holmberg I, Wyon DP. Systematic observation of classroom behaviour during moderate heat stress. Proc CIB Symp "Thermal Comf Moderate Heat Stress. 1972;37.

58. Wargocki P, Wyon DP. The Effects of Moderately Raised Classroom Temperatures and Classroom Ventilation Rate on the Performance of Schoolwork by Children (RP-1257). HVAC&R Res MARCH. 2007;13(2).

59. Wyon DP, Wargocki P. Room temperature effects on office work. In: Creating the Productive Environment. 2nd ed. London: Taylor & Francis; 2006. p. 181–92.

60. Mendell MJ, Heath GA. Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Indoor Air. 2004;15:27–52.

61. Wyon BP. Studies of Children under Imposed Noise and Heat Stress. Ergonomics. 1970;13(5):598–612.

62. Schoer L, Shaffran J. A Combined Evaluation of Three Separate Research Projects on the Effects of Thermal Environment on Learning and Performance. ASHRAE Trans [Internet]. 1973 [cited 2017 Jan 26];79:97–108. Available from: http://www.techstreet.com/standards/ch-2266-a-combined-evaluation-of-three-separate-research-projects-on-the-effects-of-thermal-environment-on-learning-and-performance?product_id=1857647

63. National Research Council of Canada - Institute for Research in Construction. COPE Project

Research Reports. Ottawa; 2003.

64. Charles K, Readon J, Magee R. Indoor air quality and thermal comfort in open-plan offices. Institute for Research in Construction Construction Technology Update. 2005.

65. American Society for Heating Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE Standard 62.1-2010: Ventilation for Acceptable Indoor Air Quality, Appendix C. Atlanta, GA; 2010.

66. National Weather Service. Heat Safety Home Page - Heat Index [Internet]. National Oceanic and Atmospheric Administration; 2017 [cited 2017 Jan 26]. Available from: http://www.nws.noaa.gov/om/heat/heat_index.shtml

67. FAA Advisory Circular 91-36D [Internet]. [cited 2017 Feb 1]. Available from: http://airportnoiselaw.org/ac91-36.html

68. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, et al. Auditory and non-auditory effects of noise on health. Lancet [Internet]. 2014 Apr [cited 2017 Feb 1];383(9925):1325–32. Available from: http://linkinghub.elsevier.com/retrieve/pii/S014067361361613X

69. Bistrup ML, Babisch W, Stansfeld S, Sulkowski W. PINCHE’s policy recommendations on noise: How to prevent noise from adversely affecting children. Acta Paediatr [Internet]. 2006 Oct 1 [cited 2017 Feb 1];95(0):31–5. Available from: http://doi.wiley.com/10.1080/08035250600885951

70. Öhrström E, Skånberg A, Svensson H, Gidlöf-Gunnarsson A. Effects of road traffic noise and the benefit of access to quietness. J Sound Vib [Internet]. 2006 Aug [cited 2017 Feb 1];295(1–2):40–59. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0022460X06000927

71. Elise E. M. M. van Kempen, Irene van Kamp, Rebecca K. Stellato and IL-B and MMH and MEN. Children’s annoyance reactions to aircraft and road traffi. J Acoust Soc Am [Internet]. 2009 [cited 2017 Feb 1];125(2). Available from: http://ur9ep9bn4s.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info%3Aofi%2Fenc%3AUTF-8&rfr_id=info%3Asid%2Fsummon.serialssolutions.com&rft_val_fmt=info%3Aofi%2Ffmt%3Akev%3Amtx%3Ajournal&rft.genre=article&rft.atitle=Children%27s+annoyance+reac

72. Neuman AC, Wroblewski M, Hajicek J, Rubinstein A. Combined Effects of Noise and Reverberation on Speech Recognition Performance of Normal-Hearing Children and Adults. Ear Hear [Internet]. 2010 Jun [cited 2017 Jan 31];31(3):336–44. Available from: http://content.wkhealth.com/linkback/openurl?sid=WKPTLP:landingpage&an=00003446-201006000-00004

73. Lepore SJ, Shejwal B, Kim BH, Evans GW. Associations between chronic community noise exposure and blood pressure at rest and during acute noise and non-noise stressors among urban school children in India. Int J Environ Res Public Health [Internet]. 2010 Sep [cited 2017 Feb 1];7(9):3457–66. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20948935

74. Lilian Corra. Children and Noise- Children's Health and the Environment. World Health Organization. 2009. p. 50.

75. Wålinder R, Gunnarsson K, Runeson R, Smedje G. Physiological and psychological stress reactions in relation to classroom noise. Source Scand J Work Environ Heal Scand J Work Environ Heal This [Internet]. 2007 [cited 2017 Jan 26];33(4):260–6. Available from: http://www.jstor.org/stable/40967652

76. Hollander C. The effects of aircraft noise on the auditory language processing abilites of english

first language primary school learners. 2011.

77. Bronzaft AL. The effect of elevated train noise on reading ability: Followup report. J Acoust Soc Am [Internet]. 1980 Nov [cited 2017 Jan 31];68(S1):S91–S91. Available from: http://asa.scitation.org/doi/10.1121/1.2004995

78. Clark C, Martin R, Kempen E Van, Alfred T, Head J, Davies H. Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: The RANCH project. Noise Heal. 2006;8(30).

79. Kaltenbach M, Maschke C, Klinke R. Health consequences of aircraft noise. Dtsch Arztebl Int [Internet]. 2008 Aug [cited 2017 Feb 1];105(31–32):548–56. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19593397

80. Shield BM, Dockrell JE. The effects of environmental and classroom noise on the academic attainments of primary school children. J Acoust Soc Am [Internet]. 2008 Jan [cited 2017 Feb 1];123(1):133–44. Available from: http://asa.scitation.org/doi/10.1121/1.2812596

81. Burden of Disease from Environmental Noise World Health Organization Regional Office for Europe Burden of disease from environmental noise. [cited 2017 Feb 1]; Available from: www.euro.who.int

82. Mckeown D. Health Impact Assessment Proposed Expansion to Billy Bishop Toronto City Airport HIA for proposed expansion of Billy Bishop Toronto City Airport. 2013;

83. Birgitta Berglund , Thomas Lindvall DHS. Guidelines for Community Noise - World Health Organization. World Health Organization; 1999.

84. ANSI. Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools Acoustical Society of America. 2002.

85. Health Canada. Useful Information for Environmental Assessments. 2010.

86. Brian Chapnik HGC Engineering. CMP Consultants Comments on Construction Noise Activity. Electronic Memorandum. 2017.

87. Community Free Democrats. City Council Hearing on Bill to Limit Construction Noise Near Schools. 2016;10–2. Available from: cfdnyc.org/june?25?city?council?hearing?on?bill?to?limit?construction?noise?near?schools/

88. Noise Manual (Revised 5th Edition) - 9.4.3.4 Acoustical Enclosures - Knovel [Internet]. [cited 2017 Feb 13]. Available from: https://app.knovel.com/web/view/swf/show.v/rcid:kpNMRE0001/cid:kt00B7LRA2/viewerType:pdf/root_slug:noise-manual-revised?cid=kt00B7LRA2&page=78&b-toc-cid=kpNMRE0001&b-toc-root-slug=noise-manual-revised&b-toc-url-slug=noise-control-engineering&b-toc-title=N

89. Vibration: Northern Expressway Environemntal Report.

90. Lings S, Leboeuf-Yde C. Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. Int Arch Occup Environ Health [Internet]. 2000 Jun 16 [cited 2017 Jan 26];73(5):290–7. Available from: http://link.springer.com/10.1007/s004200000118

91. Seidel H. On the Relationship between Whole-body Vibration Exposure and Spinal Health Risk. Ind Health. 2005;43:361–77.

92. Environment Department. Assessing vibration: a technical guideline. 2006.

93. City of Toronto. Vibration Study Terms of Reference [Internet]. Toronto: Toronto Planning; 2010 [cited 2017 Jan 23]. p. 2. Available from: http://www1.toronto.ca/static_files/CityPlanning/PDF/vibration.pdf

94. Brian Chapnik HGC Engineering. CMP Consultant Comments on Construction Vibration. Electronic Memorandum. 2017.

95. Rosenthal MF, Morlock GL. Blasting Guidance Manual [Internet]. Office of Surface Mining Reclamation and Enforcement - US Dept. of the Interior; 1987 [cited 2017 Jan 27]. Available from: https://www.osmre.gov/lrg/docs/directive315.pdf

96. Astronomy of Stars, Galaxies, and the Cosmos [Internet]. [cited 2017 Feb 8]. Available from: http://physics.highpoint.edu/~atitus/courses/phy1050/content.php?content=47

97. Charles MW. Radon exposure of the skin: I. Biological effects. J Radiol Prot [Internet]. 2007 Sep 1 [cited 2017 Jan 26];27(3):231–52. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17768326

98. Health Canada, CMHC. Radon - A Guide for Canadian Homeowners. Health Canada; 2007.

99. World Health Organization. WHO Handbook on Indoor Radon - A Public Health Perspective [Internet]. Zeeb J, Shannoun F, editors. Geneva: World Health Organization; 2009 [cited 2017 Jan 27]. Available from: http://apps.who.int/iris/bitstream/10665/44149/1/9789241547673_eng.pdf

100. Health Canada. Cross-Canada Survey of Radon Concentrations in Homes - Final Report [Internet]. Ottawa, Ontario: Health Canada; 2012 [cited 2017 Jan 27]. Available from: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/radiation/radon/survey-sondage-eng.pdf

101. Canadian Institute for Radiation Safety. Radon in Schools - A Report Prepared for the Public Schools Boards in Metropolitan Toronto. Toronto, Ontario; 1991.

102. Dowding CH, Marron D, Baillot R. Response of Historic Structure to Long-Term Environmental and Construction Vibration Effects. In: 7th FMGM 2007 [Internet]. Reston, VA: American Society of Civil Engineers; 2007 [cited 2017 Jan 23]. p. 1–13. Available from: http://ascelibrary.org/doi/abs/10.1061/40940%28307%2917

103. Johnson AP, Hannen WR, Zuccari F. Vibration Limits for Historic Buildings and Art Collections. J Preserv Technol. 2015;46(1):66–74.

104. Health Canada. Environmental and Workplace Health -Summary Report on Active Soil Depressurization (ASD) Field Study [Internet]. Summary Report on Active Soil Depressurization (ASD) Field Study. 2017 [cited 2017 Jan 11]. p. 1–6. Available from: http://www.hc?sc.gc.ca/ewh?semt/radiation/radon/active?soil?depressurisation?2016?depressurisation?active?sol?eng.php

105. Burgess WA. Welding. In: Recognition of Health Hazards in Industry - A Review of Materials & Processes. 2nd ed. New York: John Wiley & Sons Inc.; 1995. p. 167–204.

106. Lyon TL, Marshall WJ, Sliney DH, Krial NP, Del Valle PF. Evaluation of the Potential Hazards from Actinic Ultraviolet Radiation Generated by Electric Welding and Cutting Arcs, December 1975 - September 1976. [Internet]. Aberdeen, MD: Army Environmental Hygiene Agency; 1976 [cited 2017 Jan 26]. Available from: http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA033768

107. American Academy of Pediatrics Committee on Environmental Health. Ultraviolet Light: A Hazard to Children. Am Acad Pediatr [Internet]. 1999;104(2):328–33. Available from:

http://pediatrics.aappublications.org/cgi/doi/10.1542/peds.104.2.328

108. Turner PL, Mainster MA. Circadian photoreception: Ageing and the eye's important role in systemic health. Br J Opthamology [Internet]. 2008;92:1439–44. Available from: http://bjo.bmj.com/cgi/content/full/92/11/1439%5Cnhttp://bjo.bmj.com/cgi/content/full/92/11/1439#BIBL%5Cnhttp://bjo.bmj.com/cgi/eletter-submit/92/11/1439%5Cnhttp://

109. Boettner EA, Wolter JR. Transmission of the Ocular Media. Invest Ophthalmol Vis Sci [Internet]. 1962;1(6):776–83. Available from: http://www.iovs.org/content/1/6/776.abstract

110. Public Health Agency of Canada. Rabies Virus [Internet]. 2011 [cited 2017 Jan 27]. Available from: http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/rab-eng.php

111. Public Health Agency of Canada. West Nile Virus [Internet]. 2011 [cited 2017 Jan 27]. Available from: http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/wnv-vno-eng.php

112. Health Canada. Risks of West Nile virus [Internet]. 2015 [cited 2017 Jan 27]. Available from: https://www.canada.ca/en/public-health/services/diseases/west-nile-virus/risks-west-nile-virus.html

113. Health Canada. Symptoms of West Nile virus [Internet]. 2015 [cited 2017 Jan 27]. Available from: https://www.canada.ca/en/public-health/services/diseases/west-nile-virus/symptoms-west-nile-virus.html

114. Chartered Institute of Environmental Health. Pest minimisation Best practice for the construction industry. Natl Pest Advis Panel [Internet]. Available from: www.cieh-npap.org

115. Health Canada. Surveillance of West Nile virus [Internet]. 2016 [cited 2017 Jan 27]. Available from: https://www.canada.ca/en/public-health/services/diseases/west-nile-virus/surveillance-west-nile-virus.html

116. Reponen T, Hyvärinen A, Ruuskanen J, Raunemaa T, Nevalainen A. Comparison of concentrations and size distributions of fungal spores in buildings with and without mould problems. J Aerosol Sci. 1994;25(8):1595–603.

117. Sharma R, Khokhar MK, Jat RL, Khandelwal SK. Role of algae and cyanobacteria in sustainable agriculture system. Wudpecker J Agric Res [Internet]. 2012;1(October):381–8. Available from: http://www.wudpeckerresearchjournals.org

118. Reponen T, Lockey J, Bernstein DI, Vesper SJ, Levin L, Khurana Hershey GK, et al. Infant origins of childhood asthma associated with specific molds. J Allergy Clin Immunol [Internet]. 2012;130(3):639–644.e5. Available from: http://dx.doi.org/10.1016/j.jaci.2012.05.030

119. CDC-Centres for Disease Control and Prevention. Information for Healthcare Professionals about Blastomycosis. CDC - Centres Dis Control Prev. 2013;46(12).

120. S. Lenhart, M. Schafer, M. Singal RH. Histoplasmosis: Protecting Workers at Risk. CDC - Centres for Disease Control and Prevention. 2004.

121. IAPA. Accident Prevention e - News February 2007. 2007 ENEWS FEB [Internet]. 2007;9–11. Available from: http://www.iapa.ca/main/apmag/2007_enews_feb.aspx

122. Crane Tips in Ontario. Crane Accidents Crane Tips in Ontario. 2013;(May):4–6. Available from: http://www.craneaccidents.com/2013/05/report/crane?tips?in?ontario

123. Blitz Results: Mobile Cranes and Material Hoisting 2016 | Ministry of Labour. Ministry of Labour, Government of Ontario; 2016.

124. Beavers JE, Moore JR, Rinehart R, Schriver WR. Crane-Related Fatalities in the Construction Industry. J Constr Eng Manag. 2006;132(9):901–10.

125. RR 820 Tower crane incidents worldwide, Health and Safety Executive - Publication Index | NBS [Internet]. [cited 2017 Feb 8]. Available from: https://www.thenbs.com/PublicationIndex/documents/details?Pub=HSE&DocId=297372

126. Shapira A, Simcha M. Identification and Analysis of Factors Affecting Safety on Construction Sites with Tower Cranes. J Constr Eng Manag. 2009;135(4):307–18.

127. The City of Calgary Advanced Weather Forecasting System (AWFS) [Internet]. p. 1. Available from: http://www.calgary.ca/_layouts/cocis/DirectDownload.aspx?target=http%3A%2F%2Fwww.calgary.ca%2FPDA%2Fpd%2FDocuments%2FInspections%2FAWFS-wind-speed-and-risk.pdf&noredirect=1&sf=1

128. Chevron. Handbook Best practice Dropped Object Management abbreviations / terms. Chevron Handbook. Covington Los Angeles: Chevron U.S.A. Inc.; 22 p.

129. Safety and Health Topics | Scaffolding | Occupational Safety and Health Administration [Internet]. [cited 2017 Feb 13]. Available from: https://www.osha.gov/SLTC/scaffolding/

130. Suddle S. The risk management of third parties during construction in multifunctional Urban locations. Risk Anal. 2009;29(7):1024–40.

131. Kirkor Architects & Planners. Residential Development Drawings 18-30 Erskine Ave. Toronto, Ontario; 2016.

132. Excavation Hazards [Internet]. ON MOL. 2015. Available from: https://www.labour.gov.on.ca/english/hs/sawo/pubs/fs_trenches.php

133. Mccann M. Fire and Explosion p Deaths in Construction. Philadelphia; 2007.

134. Buildings L. Construction Site Fire Safety. Ottawa, Ontario; 2015. 51 p.

135. Canadin Common Ground Alliance [Internet]. 2010. Available from: http://www.canadiancga.com/page-776157/3116126

136. Gee GC, Payne-Sturges DC. Environmental health disparities: a framework integrating psychosocial and environmental concepts. Environ Health Perspect [Internet]. 2004 Dec [cited 2017 Jan 25];112(17):1645–53. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15579407

137. McEwen BS, Gianaros PJ. Central role of the brain in stress and adaptation: Links to socioeconomic status, health, and disease. Ann N Y Acad Sci [Internet]. 2010 Feb [cited 2017 Jan 27];1186(1):190–222. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20201874

138. Suzuki S, Kumano H, Sakano Y. Effects of effort and distress coping processes on psychophysiological and psychological stress responses. Int J Psychophysiol. 2003;47(2):117–28.

139. Raff H, Bruder ED, Cullinan WE, Ziegler DR, Cohen EP. Effect of animal facility construction on basal hypothalamic-pituitary-adrenal and renin-aldosterone activity in the rat. Endocrinology [Internet]. 2011 Apr [cited 2017 Jan 27];152(4):1218–21. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21248141

140. Wong-McSweeney D, Woodcock J, Waddington D, Peris E, Koziel Z, Moorhouse A, et al. Effect of Attitudinal, Situational and Demographic Factors on Annoyance Due to Environmental Vibration and Noise from Construction of a Light Rapid Transit System. Int J Environ Res Public

Health [Internet]. 2016 Dec 14 [cited 2017 Jan 25];13(12). Available from: http://www.ncbi.nlm.nih.gov/pubmed/27983662

141. Stress and Young Children. ERIC Digest. [Internet]. [cited 2017 Jan 27]. Available from: http://www.ericdigests.org/2003-4/stress.html

142. Schneider M. National Clearinghouse for Educational Facilities. Building. 2002;75(October):2–19.

143. Phillips RW. Educational Facility Age and the Academic Achievement and Attendance of Upper Elementary School Students. [Internet]. 1997 [cited 2017 Jan 30]. Available from: http://www.ncef.org/content/educational-facility-age-and-academic-achievement-and-attendance-upper-elementary-school

144. Hathaway WE. Effects of School Lighting on Physical Development and School Performance. Source J Educ Res J Educ Res This [Internet]. 1995 [cited 2017 Jan 26];88(4):228–42. Available from: http://www.jstor.org/stable/27541979

145. California Board for Energy Efficiency. Daylighting in Schools An Investigation into the Relationship Between Daylighting and Human Performance Condensed Report. 1999.

146. Smolders KCHJ. Daytime light exposure : effects and preferences. 2013.

147. Kirkor Architects & Planners. Sun Shadow Study (March/September) 18-30 Erskine Ave, Toronto. 2016.

148. CDC-Centres for Disease Control and Prevention. Arenaviridae. CDC - Centres Dis Control Prev. 2013;(June):2.

149. Recess for Elementary School Students Council on Physical Education for Children A Position Paper from the National Association for Sport and Physical Education. 2005;Shephard.

150. City of Toronto. Toronto Municipal Code Chapter 363; Building Construction and Demolition. 2014 p. 1–4.

151. General-Air Pollution [Internet]. R.R.O. 1990, Reg. 346 2005. Available from: https://www.ontario.ca/laws/regulation/900346

152. Environmental Protection Act, R.S.O. 1990, c. E.19 [Internet]. 2016. Available from: https://www.ontario.ca/laws/statute/90e19

153. Toronto Public Health. Toronto Public Health Healthy Environments City of Toronto Approved Recommendations Demolition and Excavation Dust Control. Toronto Public Heal. :1.

154. City of Toronto. Toronto Municpal Code Chapter 591, Noise. 2009 p. 1–29.

155. Standards Development Branch Ontario Ministry of the Environment. Ontario's Ambient Air Quality Criteria. 2012.

156. O. Reg. 419/05: Air Pollution-Local Air Quality [Internet]. 2016. Available from: https://www.ontario.ca/laws/regulation/050419

157. MOE. Environmental Noise Guideline Stationary and Transportation Sources – Approval and Planning Publication NPC-300. Publication NPC-300. 2013.

158. O. Reg. 381/15: Noise [Internet]. 2016. Available from: https://www.ontario.ca/laws/regulation/150381

159. Construction Industry | Occupational Safety and Health Administration [Internet]. [cited 2017 Feb

13]. Available from: https://www.osha.gov/doc/index.html

160. City of Calgary. Calgary construction and public safety. 2016;1–8. Available from: http://www.calgary.ca/PDA/pd/Pages/Inspections/Safety?Response?Unit?initiatives.aspx?redirect=/constructionsafety

161. Sullivan GP, Pugh R, Melendez a P, Hunt WD. Residential Construction Site Safety Best Practices Guide. Can Home Build Assoc Calgary Reg [Internet]. 2015;2(June):215. Available from: http://www.doaj.org/bpguide/

162. A Guide To New York City 's Noise Code. Government Information and Services for NYC 2016.

163. US EPA. NAAQS Table: Criteria Air Pollutants [Internet]. 2016. Available from: https://www.epa.gov/criteria-air-pollutants/naaqs-table

164. Energy and Environmental Affairs. Reducing Air Emissions from Diesel Construction Engines [Internet]. 2008. Available from: http://www.mass.gov/eea/agencies/massdep/water/wastewater/reducing-air-emissions-from-diesel-construction-engines.html

165. Agency CEP. In-Use Off-Road Diesel-Fueled Fleets Regulation [Internet]. 2007. Available from: https://www.arb.ca.gov/msprog/ordiesel/ordiesel.htm

166. Rich GH, Gibson L, Rich J. ANSI/ASSE A10.34-2001 (R2012) Protection of the Public on or Adjacent to Construction Sites. Am Natl Stand Institute, Inc. 2012;(July):32.

167. Mele B. SMACNA's IAQ for Occupied Buildings Under Construction. In: 16th Annual Technical Conference Rocky Mountain Section AIHA/ASSE. 2010. p. 1–24.

168. Code NB, Demolition S. CSA Standard S350-1980 Safety in Demolition of Structures. 1980;

169. Cheminfo Services Inc. Best Practices for the Reduction of Air Emissions From Construction and Demolition Activities. 2005.