

## APPENDIX F

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### AIR QUALITY EVALUATION



Air Quality Evaluation  
for the  
New Wyecroft Road Transit Facility  
Oakville, Ontario

A Report Prepared for

Giffels Associates Limited  
TORONTO ONTARIO

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## 1.0 Introduction

Giffels Associates Limited/ IBI Group has been retained by Oakville Transit to undertake an Environmental Assessment (EA) for the New Wyecroft Road Transit Facility proposed at 430 Wyecroft Road in the Town of Oakville, Region of Halton. In turn, Giffels Associates Limited/ IBI Group retained A.J. Chandler & Associates Ltd. to prepare an air quality evaluation of the project to serve as a required component of the EA process. The purpose of this report is to review any potential air quality impacts from the proposed site on the surrounding area.

Oakville Transit [OT] currently operates a bus storage facility at 480 Wyecroft Road in Oakville about 300 m west of the proposed site. The capacity of that facility is 85 buses, and there is insufficient space on that site to allow the expansion of the facility to accommodate the 225 buses planned for the new facility. The initial build will provide sufficient indoor storage for 176 buses along with 2 service lanes, a bypass lane, 17 maintenance bays, an inspection pit and the necessary parts storage space and offices in a single building. The storage facilities will be designed to be expanded 17 m to the west and the maintenance bays expanded about 25% to the south.

The air quality evaluation that follows considers the emissions of products of combustion from both the buses operating on the site and the heating equipment needed to maintain space temperatures in the building. Since no detailed design has been completed details of the position and configuration of the heating and exhaust equipment are very general. Assumptions are made concerning the emission rate for oxides of nitrogen from the facility and the means by which these releases would occur. Given the existing level of detail, the emissions have been modelled using the Ontario Regulation 346 models. During detail design stack location and configuration should be evaluated with a more refined model as described by O.Reg. 419. Oxides of nitrogen, or  $\text{NO}_x$  is the contaminant of interest in this report.  $\text{NO}_x$  is the combustion product most likely to approach the air quality standard levels because diesel engines have the potential to emit significant amounts of  $\text{NO}_x$  and the standard for this contaminant is relatively stringent compared to those for other combustion products.

### 1.1 The Proposal

The proposed Wyecroft Road facility is planned for new site on the south side of Wyecroft Road between the 4<sup>th</sup> Line and Dorval Road. The site is approximately 64,000 m<sup>2</sup> in area, being about 275 m deep from Wyecroft and approximately 240 m across. The site design calls for staff parking on the east side of the facility. All site access is from Wyecroft Road. The facility will provide overnight storage inside the building for up to 225 buses. In addition, 21 or more maintenance service bays and service lanes for fuelling and cleaning will be provided inside the building. Buses returning daily will pass through the count down lane prior to being stored inside the building. Out of service vehicles will be housed in the maintenance bays while being serviced.

## 1.2 The Study Area

The new Wyecroft site is bounded on the north by Wyecroft Road a municipal 2 lane roadway. Wyecroft extends from 4<sup>th</sup> Line to the west to Kerr Street to the east and continues west as South Service Road. To the north of Wyecroft the land is zoned commercial industrial up to the South Service Road which borders the Queen Elizabeth Way [QEW]. The area between 4<sup>th</sup> Line and Dorval Road, south to Speers Road is occupied by industrial and commercial establishments. Residential areas are south of Speers Road approximately 600 m from the proposed site, and 500 m north of the site on the north side of the North Service Road and the commercial facilities that front on that road. A rail line paralleling the QEW is located to the south of the property along the rear of the commercial buildings along Speers Road.

## 1.3 Existing Air Quality

In Ontario, air quality is monitored and records are reported by the Ministry of the Environment on an annual basis. The latest annual report, that for 2007, is available on the MOE's website<sup>1</sup>. That report provides data on both the source of atmospheric contaminants and the levels recorded at 43 sites across the province. The only site located in Oakville is at 8<sup>th</sup> Line and Glenashton Drive which is designated as the Halton Reservoir site. This is approximately 5.3 km north east of the site in the middle of what is largely a residential area. The monitoring station is on higher ground being above the old Iroquois Lake shoreline, and the nearest part of the QEW is approximately 2.3 km southeast of the monitoring site. On the south side of the QEW is the Ford Motor Company manufacturing facility, one of the biggest industrial sources in the area.

In general transportation sources, private vehicles, trucks, buses, trains and planes account for a large percentage of the contaminants monitored at most monitoring stations. For carbon monoxide emissions from transportation sources account for 84% of the provincial releases, 20% of fine particulate matter emissions, 35% of volatile organic compounds that are a contributor to smog. For NO<sub>x</sub> it is estimated that road vehicles account for 27% of emissions and other transportation 38% for a total of 65% of the emissions. In cities the emission contribution from traffic can be higher than the provincial average because the concentration of vehicles tends to be higher. For instance, in Toronto<sup>2</sup> road vehicles account for 69% of NO<sub>x</sub>; 85% of CO; 38% of PM<sub>10</sub> and 16% of PM<sub>2.5</sub> emissions. Mobile sources, including on and off road vehicles, aircraft, rail and marine traffic accounts for 87% of the NO<sub>x</sub> emissions in Vancouver and 97% of the CO emissions<sup>3</sup>. The Vancouver report suggests that despite improvements in emission controls for vehicles the increase in vehicle numbers is leading to increases in overall emission levels.

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<sup>1</sup> <http://www.ene.gov.on.ca/publications/6930e.pdf>

<sup>2</sup> Toronto Public Health, 2007. Air Pollution Burden of Illness from Traffic in Toronto. Problems and Solutions. November. Available at <http://www.toronto.ca/health/hphe>

<sup>3</sup> Environmental Assessment Certificate Application for the Richmond-Airport-Vancouver Rapid Transit Project. December, 2004. Available at [http://www.eao.gov.bc.ca/epic/output/html/deploy/epic\\_document\\_208\\_19461.html](http://www.eao.gov.bc.ca/epic/output/html/deploy/epic_document_208_19461.html)

Before leaving sources and their impact on monitoring data, those monitoring stations located relatively close to major traffic arteries typically report higher NO<sub>x</sub> concentrations for the 90%, mean, and maximum 1 hour and 24 hour averages. Examples include Toronto West adjacent to the 401; Toronto North around a busy transportation hub with GO, Viva, and TTC bus services connecting at the top of the Yonge Street subway line and surrounded by commuter parking lots; and the Burlington site which is within 300 m of the QEW near the Burlington Skyway.

The Ontario Ambient Air Quality Criteria<sup>4</sup> for compounds includes criterion for nitrogen oxides but offers some direction about the nature of this compound and how it should be handled in models:

“Emissions of nitrogen oxides, NO<sub>x</sub>, are defined to be the sum of nitrogen dioxide, NO<sub>2</sub>, and nitric oxide, NO. Emissions of NO<sub>x</sub> consist mainly of NO with some NO<sub>2</sub>. In ambient air, NO converts to NO<sub>2</sub>. NO<sub>2</sub> has adverse effects at much lower concentrations than NO. Recognizing these factors, the standard for nitrogen oxides is based on the health effects of NO<sub>2</sub>.

In the case of Environmental Assessments, requiring emission modelling, nitrogen oxides are expressed as nitrogen dioxide and an amount (or concentration) of nitrogen oxides shall be calculated in accordance with the formula presented in O. Reg. 419:

$A = (B \times 1.53) + C$ , where,

A = the amount (or concentration) of nitrogen oxides,

B = the amount (or concentration) of nitric oxide,

C = the amount (or concentration) of nitrogen dioxide

In the case of air quality assessments (e.g. annual air quality reports and special study reports) NO<sub>2</sub>, not NO<sub>x</sub>, is the reference contaminant. NO<sub>x</sub> AAQCs with 1-hour and 24-hour averaging times should only be compared to monitored nitrogen dioxide NO<sub>2</sub> data.”

In the case of this study, considering NO<sub>x</sub> emissions from the combustion equipment on site, be it buses or heating equipment, the emissions are expressed as NO<sub>x</sub> and no data is provided on the NO or NO<sub>2</sub> present in the emissions. No correction has to be included in the modelling inputs for NO<sub>x</sub>. Note that O.Reg. 419 contains Schedule 3 which provides 1 hour and 24 hour average concentration criteria for NO<sub>x</sub> that are to be applied to certain types of facilities at some time in the future. These provide another point of reference for modelling results.

Monitoring data from the Oakville station are available in the 2007 Air Quality in Ontario report. The data presented includes percentile data for NO, NO<sub>2</sub> and NO<sub>x</sub> as well as the mean, and maxima for 1 and 24 hour periods. The data are summarized in the table on the next page with conversions from ppm to ug/m<sup>3</sup> determined at 20°C.

The data represent 8620 hourly readings taken at the Oakville station in 2007. The percentile values represent the values that the percentage of the data were below during that year. For instance, 70% of all the NO<sub>2</sub> data recorded were at 16 ppb or less. Since modelling results are typically presented as concentration in ug/m<sup>3</sup> the data are presented in those units in the second part of the table. The criterion

<sup>4</sup>

<http://www.ene.gov.on.ca/publications/6570e-chem.pdf>

Table Summarizing Ambient NO<sub>x</sub> Data from the Oakville Monitoring Location

|                 | Percentiles [ppb]                |     |     |     |     |     | Mean [ppb]           | Maximum [ppb]                |       |
|-----------------|----------------------------------|-----|-----|-----|-----|-----|----------------------|------------------------------|-------|
|                 | 10%                              | 30% | 50% | 70% | 90% | 99% |                      | 1 Hr                         | 24 Hr |
| NO              | 0                                | 1   | 1   | 2   | 8   | 47  | 3.9                  | 146                          | 34    |
| NO <sub>2</sub> | 3                                | 6   | 10  | 16  | 28  | 46  | 13.0                 | 58                           | 51    |
| NO <sub>x</sub> | 4                                | 7   | 11  | 18  | 37  | 85  | 16.9                 | 194                          | 83    |
|                 | Percentiles [ug/m <sup>3</sup> ] |     |     |     |     |     | [ug/m <sup>3</sup> ] | Maximum [ug/m <sup>3</sup> ] |       |
|                 | 10%                              | 30% | 50% | 70% | 90% | 99% |                      | 1 Hr                         | 24 Hr |
| NO              | 0                                | 1.2 | 1.2 | 2.5 | 10  | 59  | 4.9                  | 182                          | 42    |
| NO <sub>2</sub> | 6                                | 11  | 19  | 31  | 53  | 88  | 25                   | 111                          | 97    |
| NO <sub>x</sub> | 8                                | 13  | 21  | 34  | 71  | 162 | 32                   | 371                          | 159   |

values for NO<sub>2</sub> in the ambient air quality criteria document is 200 ppb for 1 hour and 100 ppb for 24 hours, since the maxima reported for these two periods were less than 60 ppb in 2007 in Oakville, there was no time when the levels exceeded the criterion.

This monitoring location cannot be said to be representative of the immediate area around the proposed facility as it is some distance away from the project site in an area that looks to be largely residential. Air quality in the immediate study area would be expected to be similar to that of the Burlington location which is dominated by emissions from vehicular sources. The Burlington NO data are 1.04 to 1.23 times higher than Oakville with the exception of the 24 hour maximum which was slightly higher at the Oakville station. The NO<sub>2</sub> data in Burlington is anywhere from 1.7 to 2.65 times higher than Oakville and the NO<sub>x</sub> data are 1.4 to 1.6 times higher in Burlington.

The QEW is likely to dominate all sources in the vicinity of the Site. The existing Wyecroft Transit facility is not equipped with elevated stacks, and the highest concentrations from that facility will be found close to the building, regardless of whether an advanced dispersion model or the Regulation 346 model is used to model the emissions. Given the relatively narrow zone of influence of the existing facility, with a smaller building and fewer vehicles, it is not considered in this report. It will however be included in the second round of the assessment to be completed when the new facility engineering is underway. At that time comparisons can be made and incremental levels determined for the new facility compared to the existing one.

Typically, to meet the intent of O.Reg. 419, any modelling results are compared to the point of impingement values determined from air dispersion modelling of the on-site sources. Unless the sources are arranged to allow the plumes from the stacks to readily disperse in the atmosphere, ie. the stack is 1.5 times the building height, large, low, rectangular facilities will have POI values that are highest in the immediate vicinity of the sources. The new facility will initially be approximately double the size of the existing facility, and ultimately it will house 3 times the vehicles, albeit the newer buses will have lower the specific vehicle emission rates.

## 2.0 The Proposed Facility

### 2.1 Physical Arrangement

As noted in the Introduction, the construction of the new Wyecroft Road facility will provide space to store 176 buses overnight and to maintain portions of Oakville Transit's fleet. The proposal calls for 16 lanes of storage that will accommodate 176 buses, 11 to a lane, in the garage portion of the new building. Eventually the capacity will be expanded by adding an additional 4 lanes of storage. To the east of the storage garage a maintenance area will be constructed. This area will measure approximately 51 x 150 m aligned north south. The maintenance building will be approximately 9 m high with the garage area being 6.53 m high. An office space measuring 70.5 x 36 m with a 5.1 m roof height will be on the north side of the maintenance portion of the building. Exhaust fans and roof top equipment could be mounted on all roofs.

### 2.2 Heating and Ventilating Requirements

The maintenance building will be heated and ventilated with heat recovery direct gas-fired rooftop, heating and ventilation units (AHU). Each AHU will typically have a supply side sized for 90% of the unit exhaust capacity, and an exhaust side sized for winter operation. In order to achieve that, the supply side will include an air filter sized for maximum air flow, a supply fan, and a gas burner sized for the total supply air flow. The exhaust side includes an exhaust fan sized for 90% of the supply air flow, a 30% air filter and a heat recovery device (heat pipe) for winter operation. Any filters on these pieces of equipment are intended to trap particulate matter but will have no effect on gaseous contaminants released in the buildings.

In the summer months, the AHU units will provide outdoor air for heat relief to reduce worker heat stress. The AHU supply fan will provide 100% fresh air to the space. Exhaust will be accomplished by the AHUs themselves plus local exhaust and roof mounted exhaust fans. The balance of exhaust (for summer heat relief or containment building flushing) in such facilities is typically realized by individual exhaust fans actuated by inside temperature and carbon monoxide (CO), or oxides of nitrogen (NO<sub>x</sub>) sensors. The AHU's exhaust fans in combination with operating process exhaust (considered for air balance purposes to be 50% in operation) and roof exhaust fans in summer will maintain a negative pressure inside the space of a minimum 10% to a maximum of 20%.

The exhaust fans would operate under automatic control based on temperature control and on monitoring carbon monoxide CO and NO<sub>x</sub>. One temperature sensor and two concentration sensors for each type of gas are provided for each AHU, and an average value is used from each signal. In the event of a communications or sensor failure, the system will operate only on the good sensor. Using heat recovery, the amount of exhaust air through AHUs is constant and therefore the amount of heating demand during low use periods is considerably reduced, maintaining in the same time:

CO control set point: 35 ppm  
NO<sub>2</sub> control set point: 3 ppm  
Space set point temperature, winter : 18°C

By using heat recovery units and avoiding re-circulation, both objectives, air quality and energy savings, can be met without compromising of inside air quality.

At this time the conceptual design calls for the following heating and ventilating equipment to be installed in the buildings:

- Bus Storage portion
  - 10 AHU at 20,000 cfm;
  - 8 exhaust fans at 5,000 cfm;
- Service lanes
  - 1 AHU at 20,000 cfm;
- Office space on north side of building
  - 4 Rooftop AHU/AC at 4,000 cfm.
- Maintenance area
  - 4 AHU at 20,000 cfm;
  - 4 exhaust fans at 4,000 cfm;
  - 6 tail pipe exhausts 2,400 cfm;
- Office/Storage area
  - 3 exhaust fans at 1,500 cfm;
  - 1 AHU at 20,000 cfm;
  - 1 Rooftop AHU/AC at 4,000 cfm.

Each service bay of the maintenance garage will be provided with a 150mm and a 100 mm tailpipe exhaust system, to minimize vehicle emissions in the work space (local tailpipe exhaust: 6 systems considered). These systems would typically operate continuously on a day schedule.

The offices in both the garage and maintenance buildings will be served by gas heated, electrical cooled rooftop AC unit. Each system operates as a single zone.

## 2.3 Emission Estimates

The major combustion emission sources on the site are related to the products of combustion of natural gas used for heating the building and diesel engine exhaust associated with the buses. The main products of combustion of hydrocarbons are carbon dioxide and water vapour, however incomplete combustion typically gives rise to traces of carbon monoxide and non-methane hydrocarbons. The other compound created during combustion is oxides of nitrogen[NO<sub>x</sub>] created when the nitrogen in the fuel and the air used for combustion are oxidized. Since NO<sub>x</sub> emissions are generally related to flame temperature, they can be expected to be higher from the diesel engines operating at high rpm than from natural gas combustion in the direct fired makeup air heaters. Furthermore, direct fired heaters

discharge their combustion products into the space so their combustion temperatures are very low compared to most systems.

When assessing the acceptability of new industrial sources in the province, the Ministry of the Environment’s Environmental Assessment and Approvals Branch utilizes air dispersion models to predict the impact of the new facility. The Branch employs a point of impingement standard for NO<sub>x</sub> of 500 ug/m<sup>3</sup> making this the most stringent criteria for acceptance of typical combustion gas emissions. Carbon monoxide POI values are 6,000 ug/m<sup>3</sup>. No standard exists for CO<sub>2</sub> point of impingement values. Thus NO<sub>x</sub> has been designated as the contaminant of concern for this study. In short, if the standards for NO<sub>x</sub> can be met, the standards for CO will also be satisfied.

A further assessment of emissions and impacts will be conducted when the HVAC and ventilation systems in the building have been designed and specific details of the stacks and operations on site have been determined. At that time all combustion contaminants will be examined and miscellaneous activities in the maintenance areas of the building will be included in the assessment.

### 2.3.1 Heating Equipment Emissions

Typically emission estimates for the heating systems in a facility are based upon the fuel consumption. That is, the input capacity of the heating system is used to estimate the worst case emission rate. Emissions factors, the quantity of a contaminant released per unit energy released in the combustion process, for gas fired appliances are provided by the US EPA’s AP-42 document<sup>5</sup>. For NO<sub>x</sub>, the emission factor for large wall fired boilers with low NO<sub>x</sub> burners was applied. This value, 0.14 lb/MMBtu, is higher than the residential gas fired furnace value of 0.092 lb/MMBtu but is midway between the lowest levels and the highest levels reported in the document. This was considered a reasonable estimate for an emission factor.

Table 1 Air Handling Unit Description

| Building Portion | Number Required | Individual Performance Specifications |                  |  |                                     |
|------------------|-----------------|---------------------------------------|------------------|--|-------------------------------------|
|                  |                 | Maximum Flow [cfm]                    | Input [MMBtu/hr] | NO <sub>x</sub> Emission Factor [lb/MMBtu] | NO <sub>x</sub> Emission Rate [g/s] |
| Storage          | 10              | 20,000                                | 3.00             | 0.14                                       | 0.053                               |
| Maintenance      | 4               | 20,000                                | 3.00             | 0.14                                       | 0.053                               |
| Service Lanes    | 1               | 20,000                                | 3.00             | 0.14                                       | 0.053                               |
| Parts            | 1               | 20,000                                | 3.00             | 0.14                                       | 0.053                               |
| AC Units         | 5               | 4,000                                 | 0.30             | 0.14                                       | 0.005                               |

<sup>5</sup> US EPA AP-42, Chapter 1.4 Natural Gas Combustion, July 1998. Available at <http://www.epa.gov/ttn/chieff/ap42/ch01/final/c01s04.pdf>

To convert the emission factor to an emission rate in mass/unit time, as required for mathematically modelling dispersion, it is necessary to utilize the input of the Air Handling units.

Realistically, the AHU heaters will not run at the full rated capacity all the time. The fans are capable of operating over a wide flow range, with the burner firing rate being adjusted correspondingly to achieve the required performance. In the summer no additional heat would be required. For the sake of this assessment, no adjustment was included, the full emission rate was assumed to be applicable at any time. When detailed model calculations are completed after the engineering design is available, consideration of adjusted emission factors, at least based upon seasons, will be undertaken.

### 2.3.2 Vehicle Exhaust

Diesel engines release products of combustion during operation. The quantity of contaminants released is a function of the load on the diesel engine and thus the fuel feed rate during operation. Typically diesel engine emission factors are expressed as g/bhp-hr, that is an emission rate that is a function of the horsepower being generated by the engine at any time. Such an emission factor suggests that emissions would vary directly as the load on the engine.

There is only limited data on idling emissions from diesel vehicles, and even more limited data on emissions during cold start periods. It is known that NO<sub>x</sub> emissions from internal combustion engines are affected by temperature in the combustion chamber<sup>6</sup> and many idling studies are done only after the engine had reached operating temperatures. The main contaminants that are measured in most studies are the regulated species, CO, PM, and NO<sub>x</sub>. McCormick<sup>7</sup> notes that there was little difference between emission results for engines hot started, or cold started at 10°C. Since the buses in this study will be stored inside, the cold start engine temperatures will likely be in this range, and it can be assumed that the emissions in the published literature will be representative.

McCormick's data was collected from engines installed in buses, unlikely some of the emission data in the literature which comes from engine dynamometer testing of stripped engines, and thus requires adjustment to the real world. McCormick's testing was done within 20 minutes of the vehicle being tested on a chassis dynamometer, meaning that any auxiliary equipment typically used on buses would have been operational for the testing. The data collected by the authors produced an average of 2.015 g NO<sub>x</sub>/minute during idling. The details provided in the paper include the manufacturing year of the engine along with its manufacturer and specifications. Since individual data for idle emissions is available by engine it is possible to determine the emission rate for each engine as a percentage of the anticipated maximum emission rate that the engine was certified to meet. The latter is based upon regulatory limit for engines of that year of manufacture. The average idle emission rate as a function of allowable emissions was 7.62%. The average is 0.5% higher than the average for the four 1997 engines tested. These engines, Cummins ISB 5.9 L engines are more typical of those installed in newer buses and

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<sup>6</sup> Internal Combustion Engine Fundamentals, Heywood, J.B. Published by McGraw-Hill Ltd. OISSBN:978-0-07-028637-5. 1988.

<sup>7</sup> McCormick, R.L., M.S. Graboski, T.L. Alleman, J. Yanowitz, 2000. Idle Emissions from Heavy-Duty Diesel and Natural Gas Vehicles at High Altitude. JAWMA 50:1992-1998

this suggests that newer engines produce less emissions at idle than some older engines.

Data from operating coaches, inter-city or tour buses or those with a baggage compartment under the passenger seating area, is presented in a report prepared for the American Bus Association in conjunction with US DOE, US EPA and US FHWA<sup>8</sup>. On-board continuous emission monitors were used for these tests of 6 different vehicles. Two different tests were conducted, one with no air conditioning loads and the other with simulated air conditioning loads. The simulated situation involved operating the engines as high idle speeds, 900-1000 rpm versus normal idle at 600-700 rpm for 20 minute test periods. The testing was completed on each bus in triplicate. The data shows that without the air conditioning operating, emission rates from the 6 engines varied from 1.85 - 5.48 g NO<sub>x</sub> per minute. The levels rose to 2.53 - 8.03 g NO<sub>x</sub> per minute at high idle. There was variability in the emissions from different engines. A 1999 DDCS60 engine had the highest emissions under both operating conditions and the emissions from the newer buses equipped with CAT C13 engines were about 50% of the 1997 DDC S60 engine levels. Being coach engines, rather than those used in urban buses, it is likely that the engines in this study are larger than those in the McCormick study. Without knowledge of the rated horsepower of these engines it is not possible to determine if the specific emissions were similar to those in the McCormick paper.

Several other literature results were found, but these are expressed as averages from truck fleets. This average is assumed to be a representative number for all the engines operating in the sector regardless of age, mileage, manufacturer, or power rating. In a Texas study<sup>9</sup> emission rates are reported for trucks from extended idle periods with no specific definition of extra equipment or operating situation. A US EPA study quoted in the Texas report suggests that the fleet average emission rate is 2.4 g NO<sub>x</sub> per minute. The Texas report also referencences a study that used on-board measurements on HDDV (trucks) and produced an average emission rate of 2.87 g NO<sub>x</sub> per minute. As explained in the Texas report, the authors of the on-board testing report suggest that there was variability in emissions depending upon the origin of the vehicle, be it New York state, Pennsylvania or California. The averages for California registered trucks was the lowest. The Texas study also reports that the range of truck idle emissions noted by Lambert et al. was 1.33 to 5.4 g NO<sub>x</sub> per minute depending upon engine loads. The Texas study concluded the review by selecting the US EPA value, 2.4 g NO<sub>x</sub> per minute for their calculations.

In a subsequent US EPA publication<sup>10</sup> the Agency reduced the fleet average emission factor to 2.25 g NO<sub>x</sub>

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<sup>8</sup> M.J. Bradley and Associates, Inc., 2006. Commercial Bus Emissions Characterization & Idle Reduction Idle & Urban Cycle Test Results. A report prepared for the U.S. Federal Highway Administration (FHWA), the Environmental Protection Agency, the Department of Energy, and the American Bus Association (ABA). [http://www.buses.org/files/download/motorcoach\\_idling\\_study.pdf](http://www.buses.org/files/download/motorcoach_idling_study.pdf)

<sup>9</sup> Texas Transportation Institute, Texas A&M University, 2003. Heavy-duty Diesel Vehicle (HDDV) Idling Activity and Emissions Study : Phase 1 - Study Design and Estimation of Magnitude of Problem. A study sponsored by Texas Commission on Environmental Quality. [http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/mob/HDDV\\_Idle\\_Activity\\_and\\_EI\\_Phase1-tti.pdf](http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/mob/HDDV_Idle_Activity_and_EI_Phase1-tti.pdf)

<sup>10</sup> US EPA, 2004. Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity. A report prepared for Transportation and Regional Programs Division Office of Transportation and Air Quality and Air Quality Strategies and Standards Division Office of Air Quality Planning and Standards. EPA420-B-04-001 January. <http://www.epa.gov/smartway/documents/420b04001.pdf>

/minute. This number reflects long term averages for HDDV trucks, and incorporates allowances for special auxiliary equipment, including refrigeration systems etc.. While not stated, HDDV trucks are likely to have larger capacity engines than those typically used on transit buses.

Part of the supporting work for some Californian legislation was a staff report which included an appendix that specifically looked at idling emissions, and included buses in the list of sources<sup>11</sup>. The report suggest that the buses included are tour or urban buses, not transit vehicles. California distinguishes between these types of vehicles. The fleet average for all HDDV diesel vehicles in California in 2005 was 1.48 g NO<sub>x</sub> per minute.

Given all the data available, the emissions data from the McCormick would appear to provide a representative value for this study. The McCormick data is shown in Table 2.

Table 2 Summary of Bus Idling Data from McCormick et al.

| VMY   | HP  | EmissionRate |         | Idle Emissions |        | % of Maximum |
|---|-----|--------------|---------|----------------|--------|--------------|
|   |     | [g/HP-hr]    | [g/hr]  | [g/minute]     | [g/hr] |              |
| 1993  | 250 | 6            | 1500    | 1.979          | 118.74 | 7.92         |
| 1993  | 250 | 6            | 1500    | 2.109          | 126.54 | 8.44         |
| 1991  | 330 | 6            | 1980    | 2.165          | 129.9  | 6.56         |
| 1991  | 330 | 6            | 1980    | 2.406          | 144.36 | 7.29         |
| 1987  | 370 | 6            | 2220    | 2.738          | 164.28 | 7.40         |
| 1987  | 370 | 6            | 2220    | 2.767          | 166.02 | 7.48         |
| 1998  | 430 | 4            | 1720    | 2.698          | 161.88 | 9.41         |
| 1998  | 430 | 4            | 1720    | 2.352          | 141.12 | 8.20         |
| 1997  | 175 | 6            | 1050    | 1.147          | 68.82  | 6.55         |
| 1997  | 175 | 6            | 1050    | 1.030          | 61.8   | 5.89         |
| 1997  | 175 | 6            | 1050    | 1.743          | 104.58 | 9.96         |
| 1997  | 175 | 6            | 1050    | 1.051          | 63.06  | 6.01         |
| Average   |     | 5.67         | 1586.67 | 2.015          | 120.93 | 7.62         |
| Average NO <sub>x</sub> Emission Rate at Idling [g/s] |     |              |         |                |        | 0.03         |

<sup>11</sup> California Air Resources Board, 2004. Appendix F Motor Vehicles Idling Emission Estimates, Staff Report: Initial Statement of Reasons for Proposed Rulemaking Airborne Toxic Control Measure to Limit Diesel-fueled Commercial Motor Vehicle Idling <http://www.arb.ca.gov/regact/idling/isor.pdf>

The basic idling emission data, provided in grams per minute, appears to show a relationship to the power of the engine, larger engines produce more emissions. This is in line with the emission factor expression of g/HP-hr. The problem is, how does one translate the idling emission data to the conventional emission factor so it can be used for the Oakville fleet?

NO<sub>x</sub> emissions from diesel bus engines have decreased over the last 10 years in response to regulatory reductions in the allowable emissions promulgated by the US EPA. Engines manufactured prior to 1998 were designed to operate with a not to exceed NO<sub>x</sub> emission rate of 6 g/bhp-hr. Engines for the 1998 to 2001 model years were restricted to 4 g/bhp-hr while those manufactured after 2002 had to meet a limit of 2.5 g/bhp-hr. US EPA regulations require the industry to lower emissions from on-road diesel engines to 0.2 g/bhp-hr by 2010. The 2010 regulations included a transition period, that required manufacturers to start producing low NO<sub>x</sub> engines starting in 2007. Fifty percent of all engines had to meet the 2010 standard starting in 2007 and thus the effective emission rate for engines from 2007 to the end of 2009 is 1.2 g/bhp-hr.

Table 2 uses the regulatory emission level for the year of manufacture to determine the emission rate at full horsepower, and then computes the percentage that the idling emissions were of the full power emissions. The average over all the engines tested is 7.6%. Taking this average and applying it to the full power emission estimate based upon the vehicle manufacture year of the buses in the fleet and the regulated emission level for that year provides an estimate of the rate of emissions for any particular engine year. Since emissions are expressed in g/bhp-hour, the calculation must assume a power rating for all the equipment in the fleet as well.

Oakville Transit provided a list of existing equipment which is summarized in Table 3a), but HP was not listed. For the purposes of estimating idling emissions, the full power emissions were assumed to be generated from a 300 HP diesel engine. This is the typical size of engine offered for urban buses by Cummins in the ISB, ISC and ISL model engines. Using the regulated value and the horsepower, the weight averaged full power emissions for the fleet was determined by multiplying the number of vehicles by the emission rate, and dividing the sum of this for the full fleet by the 86 vehicles currently being operated. That value was then adjusted for the idling emissions percentage to develop the hourly emissions for the average vehicle operated in the facility on a gram per second emission rate.

The Oakville Transit fleet list shows that as of July 2009, they expect delivery of 11 new buses. It is presumed that these will replace the oldest vehicles in the fleet since industry practice is to extensively overhaul vehicles every 7 years and replace the vehicle when it is due for the 3<sup>rd</sup> major overhaul. Thus, in 2011, Table 3b), when the new facility is opened, the fleet mix will no longer include the oldest vehicles in Table 3a), they will be replaced this year. The number of 2007-2009 vehicles thus increases and the balance of the fleet is assumed to be new vehicles added for 2011 and built to the 2010 emission specification. The procedures in the preceding paragraph were used to estimate average emissions for the 2011 fleet.

While there is little information to estimate the situation for 2025, it has been presumed that the 20 year old vehicles have been replaced and the emission standard of all replacement and additional vehicles reflect the 2010 emission standard, Table 3c), where the calculations are repeated with a new fleet mix.

Clearly, as the older vehicles are replaced the average emission rate in g/s at idle in the facility decreases.

Clearly, with a gram per second emission rate, operating time on site will influence total emissions. Information from Oakville Transit<sup>12</sup> suggests that the operators are allowed 10 minutes to have their vehicles on the road after they clock in to work. This is the time management suggest is needed for drivers to obtain their assignment from the starter, walk to the vehicle, perform a circle check and then ensure that the brakes are up to pressure before leaving the garage. It is imperative that the vehicle is comfortable and safe to operate. The McCormick data was collected from buses operating in normal mode, so one assumes they represent the types of emissions from buses in the Wyecroft garage. As a very conservative estimate, the 10 minute period from the time the driver clocks in until he leaves the site is assumed to be idling time. In reality this could be as little as 3 minutes, the recommended maximum warm-up period for diesel engines.

Assuming that the majority of the time a bus is on site it's engine is idling with the estimated emission rate shown in Table 3. Power output will increase when the bus is accelerating on site, but since this is expected to be only a minor portion of the time engines operate on site it was disregarded.

While the average bus can be assumed to operate for 10 minutes before leaving the garage, and have the emission rate shown in Table 3 when warming up on site, it is necessary to determine how many vehicles might be operating at the same time.

To determine how many buses might be operating on site at any time the existing bus schedules were used as a basis to project activities at the new facility. Departure and arrival data for the buses by time of day<sup>13</sup> are summarized in Table 4. These data were based upon data provided by Oakville Transit. They reflect the movement of the existing 85 buses that are housed at the existing facility. These data, summarized in Table 4, show movements either in or out in each one hour period of the day. Assuming that the basic activity level will remain the same, the impact of more vehicles stored on site in 2011 can be assessed by increasing the movement data by factors related to number of vehicles projected to be stored on site. There are round off errors introduced into the table by the process so leaving and returning numbers do not match.

While the vehicle movements show the split between arrivals and departures, they are not directly related to site emissions because the actual operating time for vehicles on site are not included. To establish emission rates, some assumptions must be made about the number of vehicles operating at any time. This is a function of the number of vehicles leaving or arriving at site at any time, and how long their engines run when they are on site.

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<sup>12</sup> Personal Communication, 2009. Richard Preyde, Manager of Fleet and Maintenance, Oakville Transit

<sup>13</sup> Giffels Associates Limited, 2009. New Wyecroft Road Transit Facility, Transportation Impact Study. A report to Oakville Transit.

Table 3 Summary of Oakville Transit Vehicle Fleet by Year

a) Existing June 2009

| Vehicle Manufactured Year   | Emission Rate Standard [g/HP-hr] | Number of Vehicles | Total Emission Rate [g/HP-hr] |
|---|----------------------------------|--------------------|-------------------------------|
| pre-1998  | 6                                | 19                 | 114                           |
| pre-2004  | 4                                | 18                 | 72                            |
| 2004-07   | 2.5                              | 29                 | 72.5                          |
| 2007-10   | 1.2                              | 20                 | 24                            |
| Total   |                                  | 86                 | 282.5                         |
| Weighted Average Emission [g/HP-hr]   |                                  |                    | 3.28                          |
| Average Assumed HP for Fleet  |                                  |                    | 300                           |
| Estimated Maximum NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle]          |                                  |                    | 985.47                        |
| Estimated Idling NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle] 7.6% max. |                                  |                    | 75.09                         |
| Estimated Emission Rate for Modelling [g/s/vehicle operating]                                       |                                  |                    | 0.021                         |

b) Anticipated 2011 Opening (176 vehicles total)

| Vehicle Manufactured Year   | Emission Rate Standard [g/HP-hr] | Number of Vehicles | Total Emission Rate [g/HP-hr] |
|---|----------------------------------|--------------------|-------------------------------|
| pre-1998  | 6                                | 8                  | 48                            |
| pre-2004  | 4                                | 18                 | 72                            |
| 2004-07   | 2.5                              | 29                 | 72.5                          |
| 2007-10   | 1.2                              | 31                 | 37.2                          |
| 2010  | 0.2                              | 90                 | 18                            |
| Total   |                                  | 176                | 247.7                         |
| Weighted Average Emission [g/HP-hr]   |                                  |                    | 1.41                          |
| Average Assumed HP for Fleet  |                                  |                    | 300                           |
| Estimated Maximum NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle]          |                                  |                    | 422.22                        |
| Estimated Idling NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle] 7.6% max. |                                  |                    | 32.17                         |
| Estimated Emission Rate for Modelling [g/s/vehicle operating]                                       |                                  |                    | 0.009                         |

b) Anticipated 2025 Opening (225 vehicles total)

| Vehicle Manufactured Year   | Emission Rate Standard [g/HP-hr] | Number of Vehicles | Total Emission Rate [g/HP-hr] |
|---|----------------------------------|--------------------|-------------------------------|
| 2004-07   | 2.5                              | 29                 | 72.5                          |
| 2007-10   | 1.2                              | 31                 | 37.2                          |
| 2010  | 0.2                              | 165                | 33                            |
| Total   |                                  | 225                | 142.7                         |
| Weighted Average Emission [g/HP-hr]   |                                  |                    | 0.63                          |
| Average Assumed HP for Fleet  |                                  |                    | 300                           |
| Estimated Maximum NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle]          |                                  |                    | 190.27                        |
| Estimated Idling NO <sub>x</sub> Emission Rate for Average Engine in Fleet [g/hr/vehicle] 7.6% max. |                                  |                    | 14.50                         |
| Estimated Emission Rate for Modelling [g/s/vehicle operating]                                       |                                  |                    | 0.004                         |

Table 4 Summary of Vehicle Movements - Wycroft Facility by Year

| Time   | Leaving | Returning | Time          | Leaving | Returning | Time          | Leaving | Returning |
|--|---------|-----------|---------------|---------|-----------|---------------|---------|-----------|
| <b>Existing Conditions (2009 - 85 Buses)</b> |         |           |               |         |           |               |         |           |
| 5:00 - 6:00                                  | 21      | 0         | 12:00 - 13:00 | 0       | 2         | 19:00 - 20:00 | 0       | 25        |
| 6:00 - 7:00                                  | 36      | 0         | 13:00 - 14:00 | 3       | 0         | 20:00 - 21:00 | 0       | 7         |
| 7:00 - 8:00                                  | 3       | 2         | 14:00 - 15:00 | 18      | 3         | 21:00 - 22:00 | 4       | 7         |
| 8:00 - 9:00                                  | 4       | 16        | 15:00 - 16:00 | 9       | 16        | 22:00 - 23:00 | 0       | 3         |
| 9:00 - 10:00                                 | 5       | 5         | 16:00 - 17:00 | 20      | 5         | 23:00 - 24:00 | 0       | 3         |
| 10:00 - 11:00                                | 2       | 2         | 17:00 - 18:00 | 5       | 3         | 0:00 - 1:00   | 0       | 8         |
| 11:00 - 12:00                                | 0       | 3         | 18:00 - 19:00 | 0       | 16        | 1:00 - 2:00   | 0       | 0         |
|  |         |           |               |         |           | 2:00 - 3:00   |         | 4         |
|  |         |           |               |         |           | <b>Totals</b> | 130     | 130       |
| <b>2011 Conditions (176 Buses)</b>           |         |           |               |         |           |               |         |           |
| 5:00 - 6:00                                  | 43      | 0         | 12:00 - 13:00 | 0       | 4         | 19:00 - 20:00 | 0       | 51        |
| 6:00 - 7:00                                  | 74      | 0         | 13:00 - 14:00 | 6       | 0         | 20:00 - 21:00 | 0       | 14        |
| 7:00 - 8:00                                  | 6       | 4         | 14:00 - 15:00 | 37      | 6         | 21:00 - 22:00 | 8       | 14        |
| 8:00 - 9:00                                  | 8       | 33        | 15:00 - 16:00 | 18      | 33        | 22:00 - 23:00 | 0       | 6         |
| 9:00 - 10:00                                 | 10      | 10        | 16:00 - 17:00 | 41      | 10        | 23:00 - 24:00 | 0       | 6         |
| 10:00 - 11:00                                | 4       | 4         | 17:00 - 18:00 | 10      | 6         | 0:00 - 1:00   | 0       | 16        |
| 11:00 - 12:00                                | 0       | 6         | 18:00 - 19:00 | 0       | 33        | 1:00 - 2:00   | 0       | 0         |
|  |         |           |               |         |           | 2:00 - 3:00   | 0       | 8         |
|  |         |           |               |         |           | <b>Totals</b> | 265     | 264       |
| <b>2025 Conditions (225 Buses)</b>           |         |           |               |         |           |               |         |           |
| 5:00 - 6:00                                  | 54      | 0         | 12:00 - 13:00 | 0       | 5         | 19:00 - 20:00 | 0       | 64        |
| 6:00 - 7:00                                  | 93      | 0         | 13:00 - 14:00 | 7       | 0         | 20:00 - 21:00 | 0       | 17        |
| 7:00 - 8:00                                  | 7       | 5         | 14:00 - 15:00 | 46      | 7         | 21:00 - 22:00 | 10      | 17        |
| 8:00 - 9:00                                  | 10      | 41        | 15:00 - 16:00 | 22      | 41        | 22:00 - 23:00 | 0       | 7         |
| 9:00 - 10:00                                 | 12      | 12        | 16:00 - 17:00 | 52      | 12        | 23:00 - 24:00 | 0       | 7         |
| 10:00 - 11:00                                | 5       | 5         | 17:00 - 18:00 | 12      | 7         | 0:00 - 1:00   | 0       | 20        |
| 11:00 - 12:00                                | 0       | 7         | 18:00 - 19:00 | 0       | 41        | 1:00 - 2:00   | 0       | 0         |
|  |         |           |               |         |           | 2:00 - 3:00   | 0       | 10        |
|  |         |           |               |         |           | <b>Totals</b> | 330     | 325       |

As noted earlier, operators have 10 minutes to start their vehicles, perform circle checks and leave the storage facility. For this study, it was assumed that any bus movement on site would involve 10 minutes of idling as a worst case condition, regardless of whether it was arriving or leaving site. The actual emission rate used for the modelling must however recognize that all the buses entering or leaving the site in a given time period will not be moving at the same time. Indeed, the operating data from other facilities suggests that during the busiest morning hour the buses leave with almost equal frequency during any given period.

The model provides a 30 minute average point of impingement calculation, thus the most appropriate way to consider the data is to look at each 30 minute period, or one half the hourly circulation to determine the total movements in any 30 minute period. Taking the 2011 situation, shown in Table 4, there are 74 vehicles leaving site in the highest traffic period. If one assumes that each bus idles for 10 minutes and they are equally distributed throughout the hour, a total of 740 minutes of bus operation occur on site in the hour, or an average of 12.33 vehicles would be operating at any time during the hour. This would imply that the average emission rate for 2011 of 0.009 g/s/vehicle the average emissions during the half hour would be  $12.33 \times 0.009 = 0.11$  g/s. In 2025, this emission rate would be  $15.5 \times 0.004 = 0.062$  g/s reflecting more vehicles but a lower average emission rate.

Returning vehicles will also influence the total emissions on site, however not to the same extent. A review of the data in Table 4 shows that the combined hourly traffic movements for any hour in the day are less than the early morning movements each day.

Since the service lanes used for cleaning and refuelling of vehicles are typically operated only at night, buses returning during the day are assumed to arrive at site and be directed to a parking location. Again, it can be assumed that 5 minutes is required to park each vehicle as a reasonable worst case. Since the maximum number of returns in any hour is less than the number of vehicles leaving in the early morning, this activity does not have to be modelled at this time, but can be incorporated into the later evaluation when it is completed.

At the end of use for the day vehicles need to be cleaned and refuelled before being stored. These activities take place in the service lanes. There are 2 lanes for cleaning the buses when they return. Each lane has the capacity to handle 3 vehicles at a time. It can be assumed that all buses will be staged awaiting attention in this manner. While the exact operating routine is not known, typically about 7 minutes are required to service any given vehicle. Thus 27 buses can be assumed to be serviced each hour in each lane. It was assumed that the buses being serviced were idling during servicing. Thus a total of 6 vehicles would be idling inside the building at any time. After servicing they are driven to the storage area. The transfer time from the service lanes to shutdown in storage was not modelled as during this period buses would be moving into and out of service lanes and the overall emissions are unlikely to be significantly higher. The buses idling in the service lanes in 2011 would emit a total of 0.054 g/s of NO<sub>x</sub> whereas this number would drop to 0.024 g/s in 2025. Both these are lower emission rates than those of the worst case hour discussed above.

Servicing operations in the maintenance bay provide additional emissions based upon the time of the day since the reflect engines operating in service bays and the movement of bus into those bays. The

building will be equipped with specialized exhaust fans that will enable direct connection of the exhaust of the bus to the fans. This will reduce emissions into the building during servicing. The exhaust fans are listed in the previous section. With 17 bays and 6 fans, the fans were sized to handle the exhaust from 3 vehicles operating at any time. Emissions from these fans would be assumed to be the average emission rate for 1100 rpm operation for 30 minutes. Data in the literature suggests that an increase in the idling speed will influence emission rates. NO<sub>x</sub> emissions are reported to increase by 86% if the engine speed is doubled. Assuming that the average fleet idling rate is as shown in Table 3, the rates ascribed to the maintenance activities will be 1.86 times the base emission rate. For 2011 the maximum emission rate would thus be 0.05 g/s NO<sub>x</sub> per fan {0.009 g/s/vehicle x 1.86 high RPM x 3 vehicles}. For 2025 this would be 0.022 g/s NO<sub>x</sub> total.

Buses need to move in and out of the service bays. There are 17 bays and if it is assumed that each repair takes 2 hours, the turnover in the bays would be 4 per shift if the full complement of mechanics are on duty. With 17 bays, each servicing 4 vehicles over the 8 hour period 68 vehicles enter and 68 leave the facility. This amounts to 17 movements per hour on the average. Assuming each movement takes about 5 minutes an average of 1.4 vehicles would be moving at any time. Assuming an emission rate equal to half the maximum vehicle rate shown in Table 3, 0.117 g/s for 2011, the total emission rate for movement would be  $0.117 \times 0.5 \times 1.4 = 0.082$  g/s. It is assumed that the maintenance staff are evenly distributed through the 3 shifts and the emission values for the maintenance area will not vary by shift.

Modelling the emissions from the building was done on the basis of the total emission rate in the buildings at any given time. Since the early morning hour had the most vehicular traffic leaving/entering the site, this traffic volume was used as the basis for the storage emissions. It was assumed that maintenance traffic, buses into and out of the maintenance area, and maintenance related exhaust emissions, were constant at all times of the day and night and thus should be added to the highest hour of storage emissions. At this maximum hour, there would be no activity in the Service Lanes, so no contribution was included for this source category. During the detailed evaluation, when emissions will be allowed to vary on an hourly basis, this will be included. Without details of the exhaust equipment, ie. stack characteristics, the modelling assumed the sources could be treated with the virtual source portion of the O.Reg. 346 model. Again, more detailed modelling will be done at a later date.

### 3.0 Modelling Procedures

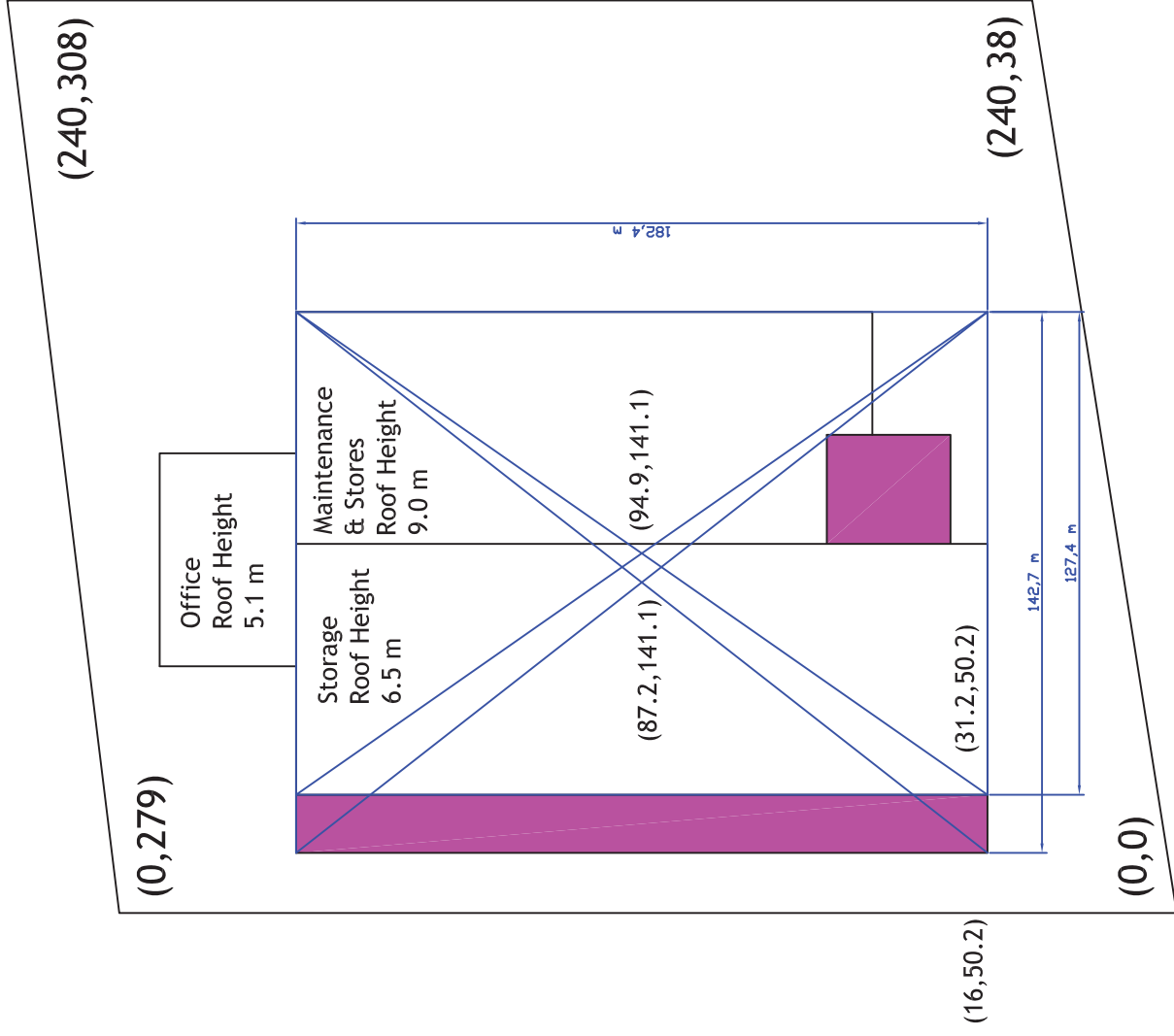
The effects of emissions on local air quality can be assessed by modelling the movement of the emissions from a source to any receptor located around the source. This movement varies as a function of the temperature and velocity of the gases leaving the source, the height of the source and the wind conditions at the time. For sources associated with a building, the physical location and elevation are fixed, although the emission rate, temperature and velocity can vary with amount of fuel being burned in the equipment. When buses are being warmed up in the storage facility the exhaust system closest to the operating vehicles will have higher emission rates than those further away. Weather conditions: wind speeds, wind direction, the amount of solar energy hitting the earth's surface and even precipitation events, vary continuously and further add to the dispersion of contaminants released on the site. Were all these factors well characterised for the site, advanced dispersion models could be used to predict the impacts from the emissions. However, without details on the exhaust configurations this assessment uses a preliminary level of analysis to ascertain the local impacts of the facility.

The model treats the emissions as coming from the wind oriented center of the building. The plan area of the building and a representative roof height data were used to establish the emission characteristics for the model. The details are shown in Figure 1.

A summary of the maximum emission rate from the building is provided in Table 5.

For this evaluation the maximum emission rate was used. This assumes that the heating systems were operating during the early morning hours when the storage emissions are at their maximum rate, the maintenance operation was operating at the typical level outlined in the previous chapter, and given the hour, that the service lanes were not in operation.

Heating emissions from the facility are related to the amount of natural gas burned, that is the firing rate of the makeup air heaters. Since the firing rate is a function of the differential temperature rise required to bring ambient air to indoor temperature levels, one would expect it would vary as the outside temperature, but this was not considered.



Expansion Areas

Figure 1  
 New Wyncroft Transit Facility  
 Oakville Transit  
 Modelling Site Plan

Table 5 Emission Rates from the New Wycroft Transit Facility

| Building Heating Systems                                      |         |               |          |             |               |          |
|---|---------|---------------|----------|-------------|---------------|----------|
| Building & Function   | Storage |               |          | Maintenance |               |          |
|   | Storage | Service Lane  | Heating  | Service     | Parts         | Heating  |
| Capacity [MMBtu/hr]   | 3       | 3             | 0.3      | 3           | 3             | 0.3      |
| Number  | 10      | 1             | 4        | 4           | 1             | 1        |
| Total Input [MMBtu/hr]  | 30      | 3             | 1.2      | 12          | 3             | 0.3      |
| Emission Rate [g/s]   | 0.53    | 0.05          | 0.02     | 0.21        | 0.05          | 0.01     |
| Building Totals [g/s]   |         |               | 0.60     |             |               | 0.27     |
| Maximum Number of Vehicles Operating in Buildings at Any Time |         |               |          |             |               |          |
| Building Exhaust  | 2011    |               |          | 2025        |               |          |
|   | Storage | Emission      | Emission | Storage     | Emission      | Emission |
|   |         | [g/s/vehicle] | [g/s]    |             | [g/s/vehicle] | [g/s]    |
| Storage Morning   | 12.33   | 0.009         | 0.111    | 15.5        | 0.004         | 0.062    |
| Maintenance Traffic   | 1.4     | 0.059         | 0.082    | 1.4         | 0.026         | 0.036    |
| Vehicle Exhaust (2 fans)                                      | 6       | 0.017         | 0.100    | 6           | 0.007         | 0.045    |
| Summary of Emissions [g/s]                                    |         |               |          |             |               |          |
| Year  | 2011    | 2025          |          |             |               |          |
| Heating   | 0.873   | 0.873         |          |             |               |          |
| Vehicles  | 0.294   | 0.143         |          |             |               |          |
| TOTAL   | 1.17    | 1.02          |          |             |               |          |

## 4.0 Modelling Results

The 2011 emissions listed in Table 5 were modelled with the MAXGLC portion of the Reg. 346 model package. This provides an estimate of the maximum concentration at locations on the property boundary and off site. The output of the model is a 30 minute average concentration. Such values can be compared to the point of impingement standards, 500 ug/m<sup>3</sup> for NO<sub>x</sub>, commonly used to ascertain the acceptability of new sources in Ontario.

The origin of the site, 0,0, was established at the south west corner of the property. The source was defined as a virtual source oriented with the long dimension N-S and comprised of a rectangular structure that covered the storage and maintenance portions of the building, but not the office structure. The building dimensions, shown in Figure 1 were used for the virtual source. The building height used for the model was 6.5 m, which provides a more conservative estimate of the point of impingement values than would be obtained by using the higher roof height of the maintenance portion of the building.

The results of the modelling are summarized in Table 6.

Table 6 Summary of Maximum 2011 NO<sub>x</sub> Point of Impingement Values [ug/m<sup>3</sup>]

| Location              | NO <sub>x</sub> | Coordinates | POI NO <sub>x</sub> Limit |
|-----------------------|-----------------|-------------|---------------------------|
| Maximum Property Line | 168             | 9615        | 500                       |
| Maximum Off Property  | 168             | 94.1,14.8   | 500                       |

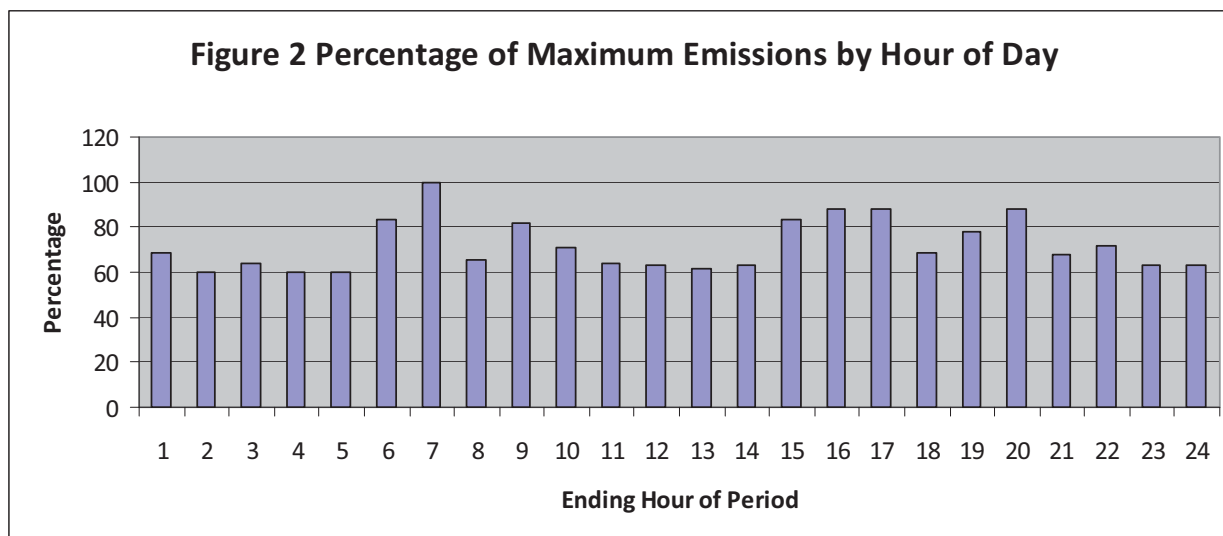
The results show the highest concentrations to occur along the southern property line. This is not surprising since the algorithm provides higher estimated concentrations along the axis that has the narrower building dimension. Furthermore, the southern property line is nearer to the wind oriented centre of the building used in the algorithm than is the northern property line.

The results represent an estimate for the 2011 situation. The ultimate buildout of the site in 2025 has lower emission and thus the results would be expected to be proportionally lower than the 2011 values. Moreover, when the building is enlarged the width is increased by approximately 15 m and the wind oriented centre of the building will shift to the west by about 7.5 m. This would shift the coordinates of the maximum POI. More importantly, the increased width will effectively move the virtual origin of the emissions further from the southern boundary resulting in an additional lowering of the point of impingement estimates. Given the concentrations listed in Table 6, and these influences, it was considered unnecessary to model the 2025 situation.

The MoE has suggested that another criteria be used during air quality assessments, a comparison of the 24 hour average POI value to the 24 hour criteria for NO<sub>2</sub> after incorporating the 90% value for the local monitoring data. As can be seen by Figure 2, the hourly emission rate is less than the maximum rate in

the early morning period when vehicles are leaving the site. Excluding the hour ending at 7 am, the average emissions in any hour of the day is 71% of the maximum.

If the emission rate for the 24 hours was equal, it is accepted that to calculate the 24 hour average value



you take the half hour value and multiply it by  $(0.5/24)^{0.28}$  or 0.3383. This would suggest that the maximum would be  $57 \text{ ug/m}^3$ . Adding in the background, based upon the Burlington 90% value for  $\text{NO}_2$   $59 \text{ ug/m}^3$ , the total is  $116 \text{ ug/m}^3$ . The AAQC for  $\text{NO}_2$  is  $191 \text{ ug/m}^3$ . Thus, as a first estimate, albeit likely high, the facility will result in doubling of the existing 24 hour level of  $\text{NO}_2$  in the vicinity of the facility, but that value will be about 61% of the AAQC.

The results show, that for the assumptions included in this report, the predicted concentrations around the site are below the 24 hour standard. Furthermore, the maximum 30 minute  $\text{NO}_x$  value will be about 34% of the applicable POI standard. The facility would thus be considered acceptable.

This evaluation will be revisited when the detailed stack information is available to allow hourly modelling of emissions and prediction of the maximum 24 hour value for  $\text{NO}_2$ .

When undertaking such an evaluation there are a number of conditions that can give rise to unrealistic predictions of the impacts of a facility. Most critical is the emission rate data employed. If the estimated emissions are too low, the results will fail to be representative. Conversely if the estimated emissions are too high, the model will over predict the impacts. Establishing an accurate emission rate is thus a major component of determining reliable predictions of impacts.

In this study, the emission values for all the combustion sources are considered above average in quality and should not be exceeded. Typically building heating equipment will not operate simultaneously yet the model assumed it does. Heating equipment emissions would represent the maximum that would be expected.

The emission factor for the bus engines is comprised of a number of factors, many of which can be

considered conservative, ie. should result in higher predicted emission rates. The regulatory emission levels for engines from different years of manufacturer were applied to determine a weighted average emission rate for all the engines involved. Some vehicles might have newer engines, but this was not taken into account. Individual engine power ratings were not available however a value of 300 HP was chosen for the average engine size. Many of the newer vehicles on the list are equipped with the Cummins ISL engine which has a 280 HP output when used in 40' buses, typical of the majority of the Oakville fleet. The maximum power New Flyer list on their web site for the ISL is 330 HP but a 10% increase in the power level, would represent less than 4% increase in the overall emissions, and not change the conclusions above.

Idling NO<sub>x</sub> emission estimates were based upon published emission data. The average emission rate was expressed as a percentage of anticipated maximum emission rate for the tested engines and this value was applied to the 300 HP average emission factor representing the Oakville fleet. The idling emission factors were assumed to apply for the full time the driver has to sign in and leave the site, 10 minutes. It has been suggested that this is much more than the ideal of 3 minutes before the vehicle moves. The concern is to have sufficient time for the brake air pressure to come up to operating levels.

The biggest impact on idling bus emissions is the length of time the buses run during the morning warm up period. It was assumed that in any hour the buses leaving the site were warmed for 10 minutes prior to departure. Moreover, it was assumed that the vehicles leaving the site do so in a uniform manner, rather than having large numbers of vehicles leaving at one point in the hour and none operating during other parts of the hour. Keeping in mind that the predicted concentrations are for 30 minute periods, it was assumed that an average emission rate could be obtained by taking the total number of buses, multiplying by the number of minutes they were idling and dividing that by 60 minutes to get the average number of buses operating at any time. Idling emissions would decrease by 70% if the idling time were reduced to 3 minutes.

Since the building design criteria suggest that the temperature inside will be minimum of 18°C there should be no reason for engines to idle more than the time required to pressurize the brake lines.

## 5.0 Conclusions and Recommendations

While the results of the preliminary modelling suggest that the maximum 1 hour average predicted NO<sub>x</sub> values on and near the property are well below the standard for NO<sub>x</sub> used by the MOE to evaluate new stationary sources, the results should be considered as preliminary. The results are associated with specific activities on site and an emission arrangement that accounts for all the emissions, but does not address the specific configuration of stacks and vents. The emissions and impacts should be re-evaluated when the facility's detail engineering design is completed and the equipment is identified.

That said, the source terms used in the model should be considered to be conservative as discussed in the previous chapter. There are a number of factors that need to be examined by Oakville Transit to determine if they reflect the way the facility will operate. The major source activity, bus warming in the winter months, should be examined to determine if the duration can be shortened as any reduction in the number of buses operating at any time on the site will reduce the emissions and hence the impacts. Furthermore, since the impacts are directly related to the buses, every attempt should be made to ensure the rapid replacement of older buses in the fleet to lower emissions. Both reduced emissions and reduced operating times will lessen the potential impacts from the facility.

To ensure that the model is not under predicting impacts at other times of the day, the operating regime of buses on the site, whether they are being warmed in the morning, cleaned when they return to site, or serviced on site, should be confirmed and specific guidelines developed by Oakville Transit. Should these differ greatly from those assumed in this evaluation, the modelling should be repeated to determine if the changes will result in increased impacts.

The engineers charged with the design of the facility need to consider several factors too. The exhaust configuration for all process exhaust systems that ventilate the various operating spaces in the building should be arranged to provide a vertical discharge. Velocities should be kept as high as practical. These exhausts should be in stacks that terminate some distance above the highest point on the building to ensure good dispersion. These systems should also ensure that air is not re-entrained into the fresh air supply ducts for the building as this could affect workers on site. It should be remembered that all measures that increase dispersion in the atmosphere will lower the predicted concentration estimates.