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Proposed Hidden Quarry

Township of Guelph-Eramosa, Wellington County

Final Report

Air Quality Assessment

RWDI # 1201429
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SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI AIR Inc. (RWDI) was retained by James Dick Construction Limited (JDCL) to conduct an Air Quality Assessment for the Proposed Hidden Quarry (the quarry) located in the Township of Guelph-Eramosa, Wellington County (the Proposed Licensed Area), as shown on Figure 5.2. The purpose of this study was to assess the potential air quality impacts from the quarry and provide recommendations to ensure compliance with the applicable regulations and guidelines. This assessment conforms to that required by the MOE when applying for an Environmental Compliance Approval (ECA) (formally known as a Certificate of Approval) under Section 9 of the Ontario Environmental Protection Act, and therefore the following regulations and guidelines apply to the analysis:

- Ontario Regulation 419/05: Local Air Quality.
- Ministry of the Environment (MOE) Guideline A10: Procedure for Preparing an Emission Summary and Dispersion Modelling Report.
- MOE Guideline A11: Air Dispersion Modeling Guideline for Ontario.

This report is part of an application by the Proponent for a Class A, Category 2 license for quarry operations with excavation below the water table under the Aggregate Resources Act (ARA), as well as for planning amendments under local planning documents in accordance with the Provincial Policy Statement (PPS) and the Planning Act. This report is intended to be read in conjunction with the Site Plan (Stovel and Associates Inc., January 19, 2012) and other reports and technical studies submitted as part of JDCL's application. The Site Plan is also subject to the prescribed conditions noted in the Aggregate Resources Act of Ontario Provincial Standards.

The quarry operates with the processing capacity of 500 tonnes per hour and 700,000 tonnes per year of finished aggregate. The operations identified and modelled in this air quality analysis included site preparation, drilling, blasting, excavation, transportation, aggregate processing, shipping, and rehabilitation.

For the purposes of estimating emissions from the facility, a maximum operating scenario was considered. This scenario considered the above-water extraction phase, using the maximum processing and shipping rates that the facility could be expected to achieve. This scenario was used as the basis for the dispersion modelling analysis, which was conducted for 1-hour and 24-hour averaging times. Emission rates were determined through published emission factors.

The facility is located on Part of Lot 1, Concession 6, in the Township of Guelph-Eramosa, Ontario, and is surrounded by agricultural and rural industrial land uses under the Township of Guelph-Eramosa Zoning By-Law, and rural land uses under the Town of Milton Zoning By-Law. The local terrain is relatively flat, with low hills, and this was considered in the dispersion modelling analysis.

Noting the conservatisms in the analysis, RWDI believes that the predicted frequency of excursions is within acceptable levels, provided the following recommendations are implemented:

1. The quarry is limited to 12 hours of operation per day, from 7:00 am to 7:00 pm for site preparation, drilling, blasting, excavation, processing operations and rehabilitation activities, and 6:00 am to 6:00 pm for shipping operations.
2. The maximum processing rate of 6,000 tonnes per day is not exceeded.
3. Equipment-specific controls (tailpipe emission tiers, dust suppression, speed limits, etc.) listed in Appendix B of this report will be implemented;
4. An Environmental Compliance Approval under Section 9 of the Environmental Protection Act (EPA) will be obtained.
5. A Best Management Practices Plan will be developed and implemented.
6. The processing plant should be located approximately as shown in Figure 5.2B
7. Stripping of overburden should be limited to times when extraction, production and shipping activities are well below the estimated peak rate of 6,000 tonnes per day.

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1.1 PURPOSE AND SCOPE OF REPORT

RWDI AIR Inc. (RWDI) was retained by James Dick Construction Limited (JDCL) to conduct an Air Quality Assessment for the Proposed Hidden Quarry (the quarry) located in the Township of Guelph-Eramosa, Wellington County, as shown on Figure 5.2. The purpose of this study was to assess the potential air quality impacts from the quarry and provide recommendations to ensure compliance with the applicable regulations and guidelines. Two levels of assessment were performed:

- A compliance assessment that focused on emission sources that are subject to assessment when applying for an Environmental Compliance Approval (formally known as a Certificate of Approval) under Section 9 of the Ontario Environmental Protection Act; and,
- A comprehensive cumulative effects analysis that included all significant sources at the site and background pollutant levels.

The following regulations and guidelines were applied to the analysis:

- Ontario Regulation 419/05: Local Air Quality.
- Ministry of the Environment (MOE) Guideline A10: Procedure for Preparing an Emission Summary and Dispersion Modelling Report.
- MOE Guideline A11: Air Dispersion Modeling Guideline for Ontario.

For the cumulative effects analysis, the approach followed widely used practices for land use planning studies and environmental assessments in Ontario.

This report is part of an application by the Proponent for a Class A, Category 2 license for quarry operations with excavation below the water table under the Aggregate Resources Act (ARA), as well as for planning amendments under local planning documents in accordance with the Provincial Policy Statement (PPS) and the Planning Act. This report is intended to be read in conjunction with the Site Plan (Stovel and Associates Inc., January 19, 2012) and other reports and technical studies submitted as part of JDCL's application.

This air quality assessment consisted of the following tasks:

- Review of the Site Plan, operational plans and data;
- Estimate air quality emissions from on-site operations;
- Estimate background levels of relevant pollutants;
- Estimate potential air quality impacts based on dispersion modelling performed according to Ontario Regulation 419/05 requirements and MOE Guidelines;
- Model various air quality controls to obtain effective and practical control measures;
- Recommend appropriate air quality control measures.

1.2 DESCRIPTION OF PROCESSES AND NAICS CODE(S)

The Hidden Quarry is a proposed aggregate operation, to be operated under a Class A, Category 2 license (quarry operations with excavation below the water table) under the ARA.

Operations at the proposed quarry operation will be conducted in two distinct stages:

- The first stage occurs above water, and involves site preparation, above-water extraction of aggregate via front-end loader or excavator, transportation, processing, washing, stockpiling and shipping, with a processing capacity of 500 tonnes per hour and 700,000 tonnes per year.
- The second stage of operations occurs at and below the water table, and involves underwater drilling, blasting, and extraction of aggregate via dragline, dewatering, transportation, processing, washing, stockpiling and shipping, also with a processing capacity of 500 tonnes per hour and 700,000 tonnes per year.

Ancillary processes at the site include fuel storage for on-site vehicles and shipping and maintenance welding. The North American Industrial Classification System NAICS code for the facility is 212315, Dolostone Mining and Quarrying.

1.3 DESCRIPTION OF PRODUCTS AND RAW MATERIALS

The quarry will produce finished aggregate products for asphalt, ready-mix and road base applications. The raw material used by the quarry is dolostone obtained from the excavation operations. The initial phase of the quarry will involve extraction, processing and shipping of sand and gravel from above the dolostone formation.

Diesel fuel will be required for diesel-fired generating equipment.

1.4 PROCESS FLOW DIAGRAM

The typical process flow diagram for the processing plant is shown on Figure 1.4. It should be noted that at any time, the precise flow of material may change between different pieces of processing equipment, but the overall maximum processing rate remains constant.

1.5 OPERATING SCHEDULE

For purposes of this assessment, a full capacity, worst-case operating scenario was used as follows:

- Site preparation and rehabilitation activities occur from 7:00 am to 7:00 pm.
- Drilling, blasting, excavation and processing operations occur from 7:00 am to 7:00 pm; and,
- Shipping operations will occur from 6:00 am to 6:00 pm.
- The site will operate generally from April 1 to December 24.

2 Initial Identification of Sources and Contaminants

Table 2.1 provides the Sources and Contaminants Identification Table for the quarry operations. The term particulate matter (PM) refers to airborne dust and other particles less than 44 microns in diameter, which can remain suspended in the air over relatively long distances. PM is further divided into size fractions of interest, including total suspended particulate (TSP), suspended particulate matter with a diameter of less than 10 microns (PM_{10}), also known as inhalable PM, and suspended particulate matter with a diameter of less than 2.5 microns ($PM_{2.5}$), also known as respirable PM.

3 Contaminants and Sources Not Directly Assessed

3.1 CONTAMINANTS NOT DIRECTLY ASSESSED

The following are potential contaminants that were not directly assessed:

- Crystalline Silica;
- Trace metals; and,
- Combustion by-products other than oxides of nitrogen (NO_X) and PM.

3.1.1 RATIONALE FOR ASSESSMENT

3.1.1.1 Crystalline Silica

The quarry will process dolostone. Dolotsone dust consists of a mixture of calcium and magnesium carbonates, which do not have any specification limitations under the O. Reg. 419/05. Dolostone dust may include small amounts of other non-metallic materials introduced from other aggregates contained as anomalies in the rock. Of these materials, crystalline silica is of most interest with respect to air quality.

O Reg. 419/05 does not define a standard for crystalline silica by itself. However, the MOE does have a 24-hour guideline value for crystalline silica in PM_{10} of 5 µg/m³. This equates to 10% of the Interim Ambient Air Quality Criteria for PM_{10}. Therefore, if the silica concentration in the dolostone excavated and processed at the quarry is below 10%, the guideline value will also be met. Based upon the chemical analysis of the quarry, the average concentration of crystalline silica is well below the 10% threshold. Therefore crystalline silica is expected to be adequately represented by PM_{10}. To ensure this aspect of air quality standard is met, the silica content will be monitored as part of the normal chemical analysis of particulate matter at the site.

3.1.1.2 Trace Metals

With regard to trace metals and other possible contaminants contained within dust generated at a dolostone quarry operation, the MOE's guidance in its "Procedure for Preparing an Emission Summary and Dispersion Modelling Report, Version 3" was followed. Table 7-3 of the procedure document identifies non-metallic mineral mining and quarrying operations as sectors where metals in the fugitive particulate matter are generally not anticipated. Based on this guidance, trace metals were not assessed explicitly.

3.1.1.3 Combustion By-Products

With respect to emissions of combustion by-products from on-site mobile equipment and the drag-line, the principal contaminants of interest are typically nitrogen oxides (NOx), $PM_{2.5}$, PM_{10}, and TSP and these are used as surrogates for all products of combustion.

3.2 SOURCES NOT DIRECTLY ASSESSED IN CUMULATIVE EFFECTS ASSESSMENT

The following sources were not directly assessed:

- Overburden stripping and rehabilitation operations;
- Below water drilling and blasting operations;
- Extraction and stockpiling of shot rock from below water operations;
- Wash plant;
- Wind erosion of aggregate storage piles;
- On-site storage tanks and facilities used for fuelling on-site vehicles; and,

3.2.1 RATIONALE FOR ASSESSMENT

3.2.1.1 Emissions from Overburden Stripping & Rehabilitation

Removal and hauling of overburden is expected to occur only at times when extraction, production and shipping of aggregate are relatively low. The total on-site level of activity is expected to be lower than that during peak extraction, production and shipping. As such, peak extraction, production and shipping, with no coincident overburden removal represents the worst-case operating scenario to be assessed as required under Section 10 of O. Reg. 419/05. Removal of overburden does not represent the worst-case operating scenario and therefore was not assessed.

In addition, stripping of overburden normally involves material that has inherently high moisture content. A review of literature on continuous soil measurements, included in Appendix C, indicates that the 95th percentile low soil moisture level was 20% by volume (approximately 13% by mass). These values are from a study done in Illinois; however RWDI believes that the measurements provide a suitable surrogate for soils in south-western Ontario. Given the moist, organic, loam nature of the material, a review of the emission factors provided in U.S. EPA AP-42 Chapter 13.2.4: Aggregate Handling and Storage Piles for these activities suggest that with elevated moisture content (in this case greater than 13%), the potential emissions of particulate matter are insignificant compared to site-wide emissions during peak extraction, production and shipping.

3.2.1.2 Below-Water Blasting and Extraction Operations;

Once the initial above-water phase of the quarry is complete, blasting, extraction and temporary stockpiling (for initial dewatering) activities will be performed below water. As a result, emissions of particulate are considered to be insignificant, as they will be conducted in a saturated environment. Emissions from the dragline would consist of products of combustion from the on-board engine, which were included in the modelling of NOx emissions, but particulate emissions would not be significant as the material handled would be saturated with water. Combustion by-product emissions from the dragline were included in the assessment of nitrogen oxides.

3.2.1.3 Wash Plants

The wash plant and associated stackers are saturated with water, therefore are not considered to be significant sources of PM emissions.

3.2.1.4 Aggregate Storage Piles

Wind erosion from exposed pit faces and stockpile areas is relatively infrequent, occurring only when the wind is high and conditions are dry. Wind erosion begins to occur when the wind gusts exceed 15 to 20 km/h and becomes significant when the gusts exceed about 30 km/h. As discussed in Section 6.1.1, winds above 30 km/h occur less than 2% of the time during the summer. If surfaces are wet due to rainfall or other precipitation, then wind erosion will not occur. Overall, wind erosion is expected to occur less than 2% of time.

Furthermore, the aggregate produced at the quarry will be washed. As a result, emission of particulate matter due to wind erosion of aggregate storage piles is expected to be insignificant.

JDCL will also develop a Best Management Practice Plan (BMPP), which will serve as a guideline for dust management practices at the facility. As Section 7.4.1 of MOE Guideline A10 allows for the exclusion of stockpiles when a BMPP is in place, and given the washed nature of the aggregate, emissions from the aggregate stockpiles are expected to be insignificant.

3.2.1.5 On-Site Fuel Storage Tanks and Facilities Used for Fuelling On-Site Vehicles;

Table B-3 of MOE Guideline A10, Procedure for Preparing an ESDM Report, Version 2.0, July 2005, lists specific examples of sources that emit contaminants in negligible amounts. On-site storage tanks and facilities used for fuelling on-site vehicles are listed on Table B-3 and were deemed to be negligible for the purposes of this assessment.

3.3 SOURCES NOT DIRECTLY ASSESSED IN COMPLIANCE ASSESSMENT

3.3.1 SOURCES NOT ASSESSED

For the compliance assessment, several additional sources were not directly assessed. These sources include:

- Fugitive dust emissions from paved and unpaved internal haul roads;
- Fugitive dust emissions from unpaved internal haul roads;
- Haul truck and mobile equipment tailpipe emissions; and,
- Shipping truck tailpipe emissions.

3.3.2 RATIONALE FOR ASSESSMENT

3.3.2.1 Fugitive Dust Emissions from Paved and Unpaved Internal Haul Roads

JDCL will develop a Best Management Practice Plan, which will serve as a guideline for dust management practices at the facility. With the implementation of this plan, the facility is exempt from assessing particulate emissions from paved roadways, unpaved roadways, and aggregate storage piles located on-site, as per guidance in Section 7.4.1 of MOE Guideline A10.

3.3.2.2 Tailpipe Emissions from Trucks and Mobile Equipment

On-site mobile equipment contributes combustion by-product emissions but is not subject to the compliance assessment, as Section 5 of Regulation 419/05 states that "this Regulation does not apply to discharges of contaminants from motor vehicles". Motor vehicle engine exhaust emissions are addressed through federal regulations that have resulted in declining exhaust emissions over the past few decades and will result in continued declines in the coming years.

4 Operating Conditions, Emission Estimating and Data Quality

4.1 DESCRIPTION OF OPERATING CONDITIONS

Section 10 of O. Reg. 419/05 states that, for the purposes of an air quality assessment, an acceptable operating scenario to consider is one that would result, for a given contaminant, in the highest concentration of that contaminant at a point of impingement that the facility is capable of causing. To satisfy this requirement, a worst-case production scenario was developed for the quarry. This scenario, described in Section 1.2, and shown on Figure 1.4, represents the maximum processing and shipping rates that the facility could be expected to achieve.

As noted in Section 3.2.2.2, once the initial above-water stage of the quarry is complete, blasting, extraction and temporary stockpiling (for initial dewatering) activities will be performed below water. As a result, emissions of particulate matter from these activities are considered to be insignificant, as they will be conducted in a water-saturated environment. Therefore, the maximum operating scenario considered the maximum processing and shipping rates that the facility could be expected to achieve, including extraction, handling, hauling, processing and shipping of aggregate during above-water operations. The quarry operations were then broken down into three emission scenarios.

4.1.1 SCENARIO 1 – COMPLIANCE MODELLING

A compliance model run was performed to determine whether the quarry would be able to obtain an Environmental Compliance Approval. This scenario does not include fugitive dust from paved and unpaved haul routes, as well as tailpipe emissions from trucks and heavy equipment, as discussed in Section 3.3.

The option exists to use conveyors to move material from working face to the processing plant,

4.1.2 SCENARIO 2 – CUMULATIVE EFFECTS MODELLING – CONVEYORS FROM FACE

This scenario included fugitive dust and tail pipe emissions from mobile equipment at the site, and considers the use of conveyors for transporting raw material from the working face to the primary crusher.

As a conservative simplification, emissions from the transfer of the material onto the conveyor were represented by the same haul truck loading emission estimate of the third scenario, while emissions from the conveyor drop into the primary crusher are represented by the emission estimate from the third scenario for trucks dumping into the grizzly feeder at the primary crusher.

4.1.3 SCENARIO 3 – CUMULATIVE EFFECTS MODELLING – HAUL TRUCKS

This scenario includes fugitive dust and tail pipe emissions from mobile equipment at the site, and considers on-site haul trucks to transport raw material from the working face to the primary crusher.

4.2 EXPLANATION OF METHOD USED TO CALCULATE THE EMISSION RATE

Emission rates from sources included in this assessment were estimated using the methodologies discussed in the following sections. Information supporting these estimates is provided in Appendix B.

4.2.1 HAUL TRUCK LOADING AND DUMPING OPERATIONS

PM emissions from loading of haul trucks and dumping at the grizzly were estimated using emission factors from the U.S. EPA Compilation of Air Pollutant Emission Factors (AP-42) Chapter 13.2.4: Aggregate Handling and Storage Piles. A moisture value of 5% was used to reflect the high moisture content of material taken directly from the working face. This is consistent with RWDI's experience at sand and gravel operations in Southern Ontario.

The amount of aggregate material handled at any given location was assumed to be equivalent to the anticipated maximum hourly extraction rate for the site.

Truck loading and dumping emissions vary with wind speed, and were calculated on an hourly basis using the meteorological data set processed for use with the AERMOD dispersion model. For the purposes of the tables included in this report, a range of wind speeds were used to provide representative values for reporting purposes.

Appendix B provides a summary of the sources, emission factors, and control measures applied to each material handling source.

4.2.2 PROCESSING OPERATIONS

PM emissions from processing operations were estimated using emission factors from the U.S. EPA AP-42 Chapter 11.19.2: Crushed Stone Processing and Pulverized Mineral Processing. Processing operations at the quarry include crushing, screening, conveying and loading of trucks via front end loader.

For the primary and secondary crushers, AP-42 does not provide an emission factor for TPM emissions. Thus, the emission factor for tertiary crushing was used. This is considered to be a conservative assumption, since tertiary crushing involves crushing of smaller stone-sizes, which typically generates more dust than primary and secondary crushing.

The material being processed will have high inherent moisture content. Water sprays will be utilized for supplemental moisture if required. Therefore the “controlled” emission factors provided in AP-42 have been used.

Appendix B provides a summary of the sources, emission factors, and control measures applied to each processing source.

4.2.3 SHIPPING OPERATIONS

PM emissions from loading of shipping trucks were estimated using emission factors from AP-42 Chapter 13.2.4: Aggregate Handling and Storage Piles. The moisture values for the material handled were based on the mean values provided in Chapter 13.2.4 for limestone products.

The amount of aggregate material handled at each location was assumed to be equivalent to the production rate of the material stockpiled at that location. A supplemental control efficiency of 90% was applied to reflect the washed nature of the aggregate.

Truck loading emissions vary with wind speed, and were calculated on an hourly basis using the meteorological data set processed for use with the AERMOD dispersion model. For the purposes of the tables included in this report, a range of wind speeds were used to provide representative values for reporting purposes.

Appendix B provides a summary of the sources, emission factors, and control measures applied to each material handling source.

4.2.4 FUGITIVE DUST EMISSIONS FROM PAVED INTERNAL HAUL ROADS

Emission factors from Chapter 13.2.1 of AP-42 were used to predict the emission rates shipping truck traffic on the paved internal haul roads. These roads consist of a paved site entrance, a paved loop around the processing plant.

The paved section was estimated to have average silt loading of 1.2 g/m^2, which is lower than the mean value for quarry sites provided on Table 13.2.1-3 of AP-42. Past experience indicates that this is achievable on industrial paved roads using intensive flushing / sweeping programs.

Appendix B provides a summary of the sources, emission factors, and control measures applied to each internal haul road.

4.2.5 FUGITIVE DUST EMISSIONS FROM UNPAVED INTERNAL HAUL ROADS

Emission factors from Chapter 13.2.2 of AP-42 were used to predict the emission rates from quarry truck traffic on the unpaved internal haul roads. These roads consist of unpaved quarry truck haul routes between the working faces and the processing plant.

The silt loading values were based on values provided in AP-42, and is supported by studies done by RWDI at various sites across Ontario. The unpaved haul routes were estimated to have an average silt loading of approximately 8.3%.

In addition, watering of the unpaved haul routes, combined with a posted and monitored speed limit of 25 km/h, was estimated to provide 95% control of emissions compared to a dry haul route with no speed limit, based on information provided in AP-42 and in literature supporting AP-42. These values reflect the implementation of the Best Management Practices Plan.

Appendix B provides a summary of the sources, emission factors, and control measures applied to each internal haul road.

4.2.6 Diesel-Fired Drag Line Emissions

Emissions from the diesel-fired drag-line unit were estimated using emissions factors from Chapter 3.3 of AP-42: Gasoline and Diesel Industrial Engines. The drag-line engine is a 500 hp unit, and operates at a load factor of 53%, which accounts for the fact that the unit does not operate at maximum power output for an entire hour. The load factor is based on information contained in the supporting documentation for the U.S. EPA NONROAD emission model.[1]

4.2.7 TRUCK AND HEAVY EQUIPMENT TAILPIPE EMISSIONS

Emissions from the loaders and quarry haul trucks were estimated using Tier 3 emission limits from the U.S. EPA. New loaders and haul trucks already meet the Tier 3 standards, thus by the time operations at the proposed quarry commence, it is assumed that equipment at the site will comply with the Tier 3 standards. The loaders at the working face and at the plant are assumed to be similar to a Caterpillar 988, with a rated power output of 414 kW. The quarry haul trucks are assumed to be similar to a Caterpillar 770 class off-highway truck, with a rated power output of 381 kW. A load factor of 48% was applied to the loaders, while a load factor of 58% was applied to the quarry haul trucks. The load factors are representative values, based on information contained in the supporting documentation for the U.S. EPA NONROAD emission model.[1]

4.2.8 SHIPPING TRUCK TAILPIPE EMISSIONS

Tailpipe emissions from shipping trucks were estimated using short-haul truck emission factors from the U.S. EPA MOVES emission model. This model provides emissions on a gram per vehicle kilometer travelled basis. A shipping truck traffic volume of 13round trips (26 passes) per hour was used, which is consistent with the peak hour indicated in the Cole Engineering Draft Traffic Impact Study. The haul route length is based on the distance between the processing plant and various working faces in several locations within each operating phases.

4.3 SAMPLE CALCULATION FOR EACH METHOD

4.3.1 HAUL TRUCK LOADING AND DUMPING OPERATIONS

The equations from Chapter 13.2.4 are used to estimate potential emissions of material handling operations related to material handling at the working face during above-water extraction. For this sample calculation of TSP emissions, the appropriate particle size multiplier is 0.74. The moisture value was set at 5%, which is characteristic of material being taken directly from the working face. The hourly handling rate was assumed to be 500 tonnes per hour, which is equivalent to the maximum hourly production rate for the quarry. For this sample calculation, a sample wind speed of 5 m/s was chosen. Refer to Appendix B for a summary of emission rate calculations for material handling operations.

[1]."Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling" EPA-420-R-10-016, NR-005d, July 2010.

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4.3.1.1 Material Handling Emission Factor (HTL):

$$E = 0.0016k\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

E = emission factor (kilograms per metric tonne of material handled)

k = particle size multiplier (dimensionless).

U = average hourly wind speed (m/s)

M = material moisture content (%)

$$E = 0.0016*(0.74)\frac{\left(\frac{5}{2.2}\right)^{1.3}}{\left(\frac{5}{2}\right)^{1.4}} = 9.5*10^{-4}\frac{kg_{TSP}}{Mg_{overburden}}$$

4.3.1.2 Material Handling Emission Rate:

$$\left(500\frac{Mg_{aggregate}}{h}\right)\left(9.5\times10^{-4}\frac{kg_{TSP}}{Mg_{aggregate}}\right)\left(\frac{1000g}{kg}\right)\left(\frac{h}{3600s}\right) = 0.13\frac{g_{SPM}}{s}$$

4.3.2 PROCESSING OPERATIONS

The processing operation emission rates are dependent on the amount of material being handled as well as the control efficiency. Below is a sample calculation for the processing operations, reflective of typical operations. Refer to Appendix B for a summary of emission rate calculations for processing operations.

4.3.2.1 Screen Deck (SC1) Emission Rate

$$= \left(500\frac{Mg_{aggregate}}{hr}\right)\left(1.1*10^{-3}\frac{kg_{SPM}}{Mg_{aggregate}}\right)\left(1-\frac{90\%}{100\%}\right)\left(\frac{1000g}{kg}\right)\left(\frac{h}{3600s}\right) = 0.015\frac{g_{SPM}}{s}$$

4.3.3 SHIPPING OPERATIONS

The equations from Chapter 13.2.4 are used to estimate potential emissions of material handling operations related to shipping of finished aggregate. For this sample calculation of TSP emissions, the appropriate particle size multiplier is 0.74. The moisture value was set at 2.1%, which is the mean of the values presented in AP-42. The hourly handling rate was estimated to be 75 tonnes per hour at load-out area 1. For this sample calculation, a sample wind speed of 5 m/s was chosen. In addition, a supplemental control factor of 90% was applied to reflect the washed nature of the finished aggregate. Refer to Appendix B for a summary of emission rate calculations for material handling operations.

4.3.3.1 Material Handling Emission Factor (LOADOUT1):

$$E = 0.0016k\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

E = emission factor (kilograms per metric tonne of material handled)

k = particle size multiplier (dimensionless).

U = average hourly wind speed (m/s)

M = material moisture content (%)

$$E = 0.0016 * (0.74)\frac{\left(\frac{5}{2.2}\right)^{1.3}}{\left(\frac{2.1}{2}\right)^{1.4}} = 3.2 * 10^{-3}\,\frac{kg_{TSP}}{Mg_{aggregate}}$$

4.3.3.2 Material Handling Emission Rate:

$$\left(75\frac{Mg_{aggregate}}{h}\right)\left(3.2\times10^{-3}\,\frac{kg_{TSP}}{Mg_{aggregate}}\right)\left(\frac{1000g}{kg}\right)\left(\frac{h}{3600s}\right)\left(1-\frac{90\%}{100\%}\right) = 0.0067\,\frac{g_{SPM}}{s}$$

4.3.4 FUGITIVE DUST EMISSIONS FROM PAVED INTERNAL HAUL ROADS

Sample calculations of PM emissions from shipping traffic on the paved entrance ramp are proved below. Emissions for the paved shipping haul route around the processing plant were calculated analogously.

For the paved shipping truck route, the particle size multiplier (k), varies with aerodynamic particle size range, and for TSP, k = 3.23. As discussed in Section 4.2.4, the silt loading value was set at 1.2 g/m². This sample calculation reflects the average weight of empty and loaded trucks, with a vehicle weight of 33 tonnes (36 tons), a haul route length of approximately 75m, and the traffic volume of 13round trips (26 passes) per hour, which is consistent with the maximum hour indicated in the Cole Engineering Draft Traffic Impact Study.

4.3.4.1 Paved Haul Road Emission Factor (Shipping Trucks)

$$E = k(sL)^{0.91}(W)^{1.02}$$

E = emission factor (grams per vehicle kilometre travelled, or vkt)

k = particle size multiplier (dimensionless).

sL = road surface silt loading (g/m²)

W = average weight of the vehicles traveling the road (US short tons)

$$E = (3.23)(1.2)^{0.91}(36)^{1.02} = 147\frac{g_{SPM}}{vkt}$$

4.3.4.2 Paved Haul Road Emission Rate (Paved Entrance Ramp)

$$ER = \left(26\frac{vehicles}{hr}\right)(75m)\left(\frac{km}{1000m}\right)\left(147\frac{g_{SPM}}{vkt}\right)\left(\frac{hr}{3600s}\right) = 0.080\frac{g_{SPM}}{s}$$

4.3.5 FUGITIVE DUST EMISSIONS FROM UNPAVED INTERNAL HAUL ROADS

Sample calculations of PM emissions from the unpaved internal haul road between one of the working faces and the processing plant are proved below. Emissions from the unpaved haul roads between the other working faces and the processing plant were calculated analogously.

For the unpaved internal haul road, the particle size multiplier (k), varies with aerodynamic particle size range, and for suspended particulate matter, k = 4.9. As discussed in Section 4.2.5, the silt loading value was set at 8.3%. The vehicle weight in this case reflects empty and loaded quarry trucks travelling along the same haul routewith a vehicle weight of 49 tonnes (54 tons). The sample calculation provided below reflects quarry operations at the further point inPhase 1 from the processing plant, giving a haul route length of approximately 600m. The peak traffic volume was estimated to be 14 round trips (28passes) per hour, based on the hourly production rate and the haul truck payload capacity. Lastly, a 95% control was applied to the emission factor to account for the implementation of a Best Management Practices Plan, with speed limit reductions, regular watering of the haul route, and monitoring procedures.

4.3.5.1 Unpaved Haul Road Emission Factor (Quarry Trucks to SE Portable Plant)

$$E = 281.9k\left(\frac{s}{12}\right)^{0.7}\left(\frac{W}{3}\right)^{0.45}\left(1-\frac{CE}{100\%}\right)$$

E = emission factor (grams per vehicle kilometre travelled)

k = particle size multiplier (dimensionless).

s = road surface(s) silt material content (%)

W = average weight of the vehicles traveling the road (US short tons)

CE = emission control efficiency (%)

$$E = 281.9(4.9)\left(\frac{8.3}{12}\right)^{0.7}\left(\frac{54}{3}\right)^{0.45}\left(1-\frac{95\%}{100\%}\right) = 3918\frac{g}{vkt}$$

Unpaved Haul Road Emission Rate

$$\left(28\frac{Vehicles}{hr}\right)(600m)\left(\frac{1km}{1000m}\right)\left(3918\frac{g_{SPM}}{vkt}\right)\left(\frac{hr}{3600s}\right)\left(1-\frac{95\%}{100\%}\right)=0.91\frac{g_{SPM}}{s}$$

4.3.6 DIESEL-FIRED DRAG-LINE EMISSIONS

Sample calculations for this source are provided in Appendix B.

4.3.7 TRUCK AND HEAVY EQUIPMENT TAILPIPE EMISSIONS

Sample calculations for this source are provided in Appendix B.

4.3.8 SHIPPING TRUCK TAILPIPE EMISSIONS

Sample calculations for this source are provided in Appendix B.

4.4 ASSESSMENT OF DATA QUALITY FOR EACH EMISSION RATE

The assessment of data quality for each emission rate is provided on Table 5.1, and is generally based on the AP-42 data quality ratings. In general, the emission data quality ratings for the processing sources are equivalent to a “Marginal” rating as per Section 8.3 of MOE Guideline A10. The emission factors used, and the data quality rating assigned to those factors do reflect the best available data for these types of sources, and are accepted by the MOE for air quality assessments of this nature.

The calculated emission rates for material handling had a data quality rating of “C” for the operations at the working face and “B” for shipping operations. The “C” rating is applied due to the absence of site-specific moisture or silt data. This translates to an “Average” and “Above-Average” rating respectively, as per Section 8.3 of MOE Guideline A10.

The calculated emission rates for the unpaved haul routes had a data quality rating of “B”, while the calculated emission rates for the paved haul routes had a data quality rating of “A”. This translates to an “Above-Average” rating as per Section 8.3 of MOE Guideline A10.

The calculated emission rates for the drag line had a data quality rating of “D”, which translates to an “Marginal” rating as per Section 8.3 of MOE Guideline A10.

The calculated tailpipe emission rates for the heavy equipment and highway trucks have been assigned a data quality rating of “Above-Average” rating as they are based on the U.S. EPA NONROAD and MOVES models.

5 Source Summary Table and Property Plan

5.1 SOURCE SUMMARY TABLE

Table 5.1 in the Tables Section provides the Source Summary Table for the quarry.

5.2 SITE PLAN

Figure 5.2 provides an overview of operational areas and potential receptors at the quarry.

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6 Dispersion Modelling

Dispersion modelling for the facility was conducted using the estimated emission rates discussed in the preceding section in conjunction with the AERMOD dispersion model to predict concentrations of all contaminants at points of impingement along the property line and beyond. This modelling was conducted for the three scenarios described in Section 4.1.

Sources were modelled as a series of volume sources with parameters based on information obtained from the Site Plan and typical dimensions of processing equipment and vehicles used at other facilities of this nature. The modelled source parameters are consistent with guidance from the NSSGA[2]. Internal haul roads were modelled as adjacent volume sources, also in accordance with guidance from the National Sand Stone and Gravel Association and the U.S. EPA.

6.1 DISPERSION MODELLING INPUT SUMMARY TABLE

Table 6.1 in the Tables Section provides the Dispersion Modelling Input Summary Table for the facility. Additional information on specific elements of the modelling analysis is provided in the following sections.

6.1.1 METEOROLOGICAL CONDITIONS

Under O. Reg. 419/05 the MOE provides a series of pre-processed meteorological data sets for use in dispersion modelling assessments in Ontario. These data sets use surface observations and upper air data from airports that represent major geographical areas of Ontario. While these data sets are the MOE's preferred option for conducting dispersion modelling assessments, they do not necessarily reflect localized conditions, and therefore a discussion of the dispersion modelling data sets and a discussion of more localized meteorological conditions is provided here. For this assessment, the meteorological data from London shows good agreement with the local data, as discussed below.

The quarry is located in the Township of Eramosa and, therefore, the West Central Region meteorological data set is recommended by the MOE for use at this site. This includes surface(s) data from London, Ontario and upper air data from White Lake, Michigan. Within each region, the MOE provides alternative data sets with the choice of data set depending on the character of the terrain at the study site. The area surrounding the quarry is typically agricultural with some wooded areas and residences in the vicinity of the site. The default data set for "crops" was used based on the land use patterns surrounding the site, as this data set is expected to produce more conservative estimates.

To get information on wind climate at the study site, historical data reported by Environment Canada were examined for the Guelph Turfgrass Institute and the Region of Waterloo International Airport. Wind roses, and the relative location of these stations to the quarry, are shown on Figure 6.1.

Data from the Guelph Turfgrass Institute is not complete for the period of record, so data from the Region of Waterloo International Airport were used to determine the potential for wind erosion, and to characterize the wind climate for the area. Data from the Guelph Turfgrass Institute is useful however, in that it shows a general tendency towards lower average wind speeds than observed at the Region of

[2] "Modelling Fugitive Dust Sources", National Stone, Sand & Gravel Association, Alexandria, VA., 2004.

Waterloo International Airport, which in turn shows lower average wind speeds than observed at the London International Airport. This suggests that using the Region of Waterloo International Airport data to discuss the potential for wind erosion is conservative, and that using the data from London International Airport for the modelling assessment is also appropriate.

During the summer season, corresponding to the peak production period for the quarry, the wind most often comes from the west, west-northwest and northwest (about 26% of the time in total). Winds from the south through west-southwest are also relatively common (about 25% of the time). The least common winds are from south easterly and north easterly directions.

Strong winds (greater than 30 km/h) are predominantly from the west during the summer, but also come from the southwest, west-southwest and west-northwest. Altogether, winds above 30 km/h occur only 1.7% of the time during the summer.

6.1.2 AREA OF MODELLING COVERAGE

The area of modelling coverage was designed to meet the requirements outlined in O. Reg. 419/05, section 14. A multi-tiered receptor grid was developed with reference to Section 7.2 of the Air Dispersion Modelling Guideline for Ontario, Version 2.0, March, 2009; therefore, interval spacing was dependent on the receptor distance from on-site sources. Meteorological anomalies were removed as per Section 6.6 of MOE Guideline A11.

In addition, 18 discrete receptor locations were included in the assessment. These receptors represent residences near the quarry.

6.1.3 STACK HEIGHT FOR CERTAIN NEW SOURCES OF CONTAMINANT

On-site emissions are not routed through stacks; therefore, this section of Reg. 419/05 does not apply to this report.

6.1.4 TERRAIN DATA

Terrain information for the area surrounding the facility was obtained from the MOE Ontario Digital Elevation Model Data web site. The terrain data is based on the North American Datum 1983 (NAD83) horizontal reference datum. These data were run through the AERMAP terrain pre-processor to estimate base elevations for receptors and to help the model account for changes in elevation of the surrounding terrain. Base elevations for sources are based on information contained on the Site Plan and are assumed to be at the elevation of the first lift.

6.1.5 AVERAGING PERIODS USED

Ontario's regulation on Local Air Quality (Reg. 419/05) uses a phased approach to implementation of contaminant standards. Originally, the regulation had three schedules of standards, with the first two being applicable during interim phase-in periods (up to 2010 for Schedule 1 and 2010 to 2013 for Schedule 2, for most types of facilities). For this study, the fully phased-in contaminant standards (Schedule 3) have been used. The relevant averaging time for the Schedule 3 standard for TSP is 24-

hours. The relevant averaging times for the Schedule 3 standard for NO_x are 1-hour and 24-hours. PM10 and PM2.5 do not currently have standards in O. Reg. 419/05, but they do have air quality criteria that, like TSP, are based on an averaging time of 24 hours.

6.2 LAND USE ZONING DESIGNATION PLAN

The quarry is located on Part of Lot 1, Concession 6, in the Township of Guelph-Eramosa, in the County of Wellington. The property is bordered to the south by Highway 7, which forms the boundary between the Township of Guelph-Eramosa and the Town of Milton. The site is presently zoned Agricultural. The Proponent is filing applications for the appropriate Official Plan and Zoning By-Law Amendments. The neighbouring land uses include agricultural and rural industrial, under the Township of Guelph-Eramosa Zoning By-Law, and Rural under the Town of Milton Zoning By-Law.

6.3 CRITERIA

Table 6.3 in the Tables Section provides the criteria used in the compliance assessment and cumulative effects assessments.

6.4 AMBIENT CONCETRATIONS

The compliance assessment predicted the impact of the quarry emission sources at and beyond the property boundary of the facility. The comprehensive cumulative effects assessment went a step further and considered how predicted impacts from the quarry sources would combine with ambient air pollutant levels to produce an overall impact at sensitive off-site receptors. Pollutant concentrations in ambient air can be attributed to two distinct elements:

1. Non-Background (locally significant emissions sources): Emissions from large industrial sources, mobile sources, and other miscellaneous sources that result in acute spatial variation of in-air pollutant concentrations on a local scale (e.g., large combustion sources, industrial process emissions, major highways).
2. Miscellaneous other sources, including smaller industries; agricultural activities, residential and commercial sources; traffic on the local road network; rail traffic; and long-range transport of pollutants from other regions. These sources can be approximated by spatially uniform in-air pollutant concentrations on a local scale.

With respect to non-background sources, there are no such sources within 5 kilometres of the quarry. Therefore the primary contributors to the ambient air pollutant levels are the more ubiquitous sources, including vehicle traffic on Highway 7, rail traffic on the line to the north of the quarry, agricultural activities and emissions from residential and commercial sources in Rockwood and the surrounding areas. Long range transport of fine particulate ($PM_{2.5}$) also contributes to the ambient air pollutant levels.

Therefore, estimating the overall impact at sensitive off-site receptors required an estimate of background pollutant levels, which was based on historical monitoring data from a representative monitoring site. Although the monitoring site in Guelph is located in a more urbanized environment, with some non-background sources located within several kilometers of the monitor, this provides a more conservative estimate of ambient air pollutant levels. Given the proximity of the station to the quarry, and the conservativeness of the data, it is a suitable site for this assessment.

The cumulative effects assessment used a simplified approach to estimating the credible worst-case cumulative concentration at off-site locations. In this approach the maximum modelled contribution from quarry emission sources was added to an estimate of the maximum coincident background concentration. Consistent with widespread practice in Ontario, the 90th percentile level from the historical monitoring data was used to represent the maximum coincident background level. This excludes the upper 10thpercentile of background data, which are related to events that are unlikely to occur at the same time as the predicted maximum contribution from the quarry sources under worst-case weather conditions.

Background $PM_{2.5}$ levels were based on a 5-year average of the annual 90th percentile hourly concentration measured at the MOE monitoring station in Guelph (14.8 µg/m³). The Guelph monitoring station is located less than 15km upwind of the site, and as it is located in a more urban setting, it is expected to provide a more conservative estimate of background concentrations.

Background TSP was derived from the $PM_{2.5}$ data for Guelph, based on an estimated $PM_{2.5}$/ TSP ratio of 0.30. This value came from a published study of 500 monitoring sites in the US.[3] The resulting 90th percentile background concentration is 49 µg/m³.

Background PM_{10} was also derived from the $PM_{2.5}$ data for the Guelph, based on an estimated $PM_{2.5}$/ PM_{10} ratio of 0.54 from the study noted above. The resulting 90th percentile background concentration is 27 µg/m³.

Background O_3 concentrations were obtained from the MOE monitoring station in Guelph. A 5-year average of the annual 90th percentile hourly and daily concentrations was adopted.

NO_2 concentrations were not measured at the Guelph station prior to 2010, so data from the MOE monitoring station in Kitchener were used for the years prior to 2010. NO2 levels in Kitchener in 2010 were similar to but slightly higher than in Guelph, and therefore it is expected that using NO2 data from Kitchener will be conservative, and is therefore appropriate. The MOE does not provide 90th percentile values of the 24-hour average concentrations, therefore, as a conservative simplification, the 90th percentile 1-hour average concentration was used as the 24-hour value.

The data used in this assessment has been summarized on Table 6.4.

6.5 CONVERSION OF NOX TO NITROGEN DIOXIDE

NO_X in diesel exhaust is composed primarily of nitric oxide (NO) and nitrogen dioxide (NO_2). The composition of diesel exhaust shortly after combustion is dominated by nitric oxide (NO). However, once the exhaust is emitted to the atmosphere and begins to mix with outside air, some of the NO is oxidized in reactions with other pollutants (principally ground-level ozone, O_3) to produce NO_2.

[3]Ramona Lali, Michaela Kendall, Kazuhiko Ito, and George D. Thurston, "Estimation of historical annual PM2.5 exposures for health effects assessments ", Atmospheric Environment, Volume 38, Issue 31, October 2004, Pages 5217-5226

For the purposes of this assessment, the Ozone Limiting Method (OLM) was used to estimate the maximum short-term NO_2 concentrations resulting from emissions of NO_X. The 1-hour and 24-hr concentrations of NO_X predicted by AERMOD were compared to the average 90th percentile measured ambient ozone concentration for years 2006-2010 from the MOE ambient monitoring station in Guelph.

A factor of 0.10 was assumed for the thermal conversion of NO_X to NO_2 for combustion sources. If the remaining concentration of NO_X was less than the 90th percentile O_3 concentration, then it was assumed that 100% of the NO_X is converted to NO_2 according to the following equation:

$$\text{If } 0.9NO_X < O_3\text{, then } NO_2 = NO_X$$

However, if the concentration of NO_X is greater than the 90th percentile O_3 concentration, then O_3 is the limiting factor and the following relationship will be applied:

$$\text{If } 0.9NO_X > O_3\text{, then } NO_2 = 0.1NO_X + O_3$$

It should be noted that this method assumes that the peak NO_2 concentrations and elevated ozone concentrations occur simultaneously, which may be a conservative assumption. The OLM has gained acceptance by regulatory agencies in Ontario for the purpose of conducting environmental assessments.

6.6 FREQUENCY ANALYSIS

As part of the cumulative effects analysis, a frequency analysis was conducted to estimate the frequency of exceeding the relevant criteria at the identified receptor locations. The frequency analysis presents the number of predicted excursions above the relevant criteria at off-site receptors for the entire modelling period of 5 years. This can also be expressed as a percentage of time during the modelling period during which predicted concentrations are above the relevant criteria. This was conducted for both modelled scenarios, and with and without ambient background concentrations.

6.7 DISPERSION MODELLING INPUT AND OUTPUT FILES

Appendix A provides a CD with the AERMOD input, output and supporting files for both of the dispersion modelling scenarios assessed.

7 Emission Summary Table and Conclusions

7.1 EMISSION SUMMARY TABLE

Results from the dispersion modelling model run are summarized in Table 7.1A for the compliance assessment, Table 7.1B for the cumulative effects assessment (conveyor scenario), and 7.1C for the cumulative effects assessment (haul truck scenario). These tables summarize maximum predicted concentrations of each contaminant at the receptor locations identified on Figure 5.2.

7.2 COMPARISON OF MODELLED AND HISTORICAL EXCEEDANCE DATA

7.2.1 SECNARIO 1 – COMPLIANCE MODELLING

The results of the dispersion modelling analysis indicate that the facility is in compliance with the relevant criteria at the property line and at all receptor locations, with the exception of PM_{10} along the property line. Compliance with the PM_{10} criteria at the property line is not required to demonstrate compliance with the requirements of O. Reg. 419/05, and therefore the facility would be eligible to obtain an Environmental Compliance Approval for the proposed operations.

7.2.2 SCENARIO 2 – CUMULATIVE EFFECTS MODELLING – CONVEYORS FROM FACE

The results of the dispersion modelling analysis indicate that with the inclusion of background air quality data, predicted concentrations of NO_2 and $PM_{2.5}$ are below the relevant criteria at all receptors.

Predicted concentrations of TSP and PM_{10} exceed the relevant criteria at several locations, but the predicted frequency of excursions above the relevant criteria remains low, at 1.5% of the time at the most impacted receptor, and below 1% at all other locations.

7.2.3 SCENARIO 3 – CUMULATIVE EFFECTS MODELLING – HAUL TRUCKS

The results of the dispersion modelling analysis indicate that without the inclusion of background air quality data, predicted concentrations of NO_2 and $PM_{2.5}$ are below the relevant criteria at all receptors.

Predicted concentrations of TSP and PM_{10} exceed the relevant criteria at several locations, but the predicted frequency of excursions above the relevant criteria is higher than for Scenario 1, but remains low, at less than 2.7% of the time at the most impacted receptor and below 1.2% at all other locations.

7.3 CONCLUSIONS

This assessment includes several significant conservative modelling assumptions, which are important when considering the dispersion model predictions. These include:

- The maximum operating scenario is applied to every day during the operating season for the 5-year simulation period, resulting in a coincidence of maximum operations and worst-case weather conditions which, in reality, will be a rare occurrence; and,
- Assumption of dry weather every day of the 5-year simulation period.

Noting these conservatisms, RWDI believes that the predicted frequency of excursions from the dispersion modelling analysis is within acceptable levels, provided the following recommendations are implemented:

1. The quarry is limited to 12 hours of operation per day, from 7:00 am to 7:00 pm for site preparation, drilling, blasting, excavation, processing operations and rehabilitation activities, and 6:00 am to 6:00 pm for shipping operations.
2. The maximum processing rate of 6,000 tonnes per day is not exceeded.
3. Equipment-specific controls (tailpipe emission tiers, dust suppression, speed limits, etc.) listed in Appendix B of this report will be implemented;
4. An Environmental Compliance Approval under Section 9 of the Environmental Protection Act (EPA) will be obtained.
5. A Best Management Practices Plan will be developed and implemented.
6. The processing plant should be located approximately as shown in Figure 5.2B
7. Stripping of overburden should be limited to times when extraction, production and shipping activities are well below the estimated peak rate of 6,000 tonnes per day.

TABLES

2.1 Sources and Contaminant Identification Table

RWDI Project 1201429

Source Information			Expected Contaminants	Included in Modelling? (yes / no)	Significant? (yes / no)	Reference (optional)
Source ID (optional)	Source Description or Title	General Location				
STRIP	Overburden Stripping	Working Face	particulate matter	no	no	Section 3.2.2.1
			silica	no	no	Section 3.2.2.1
			trace metals	no	no	Section 3.2.2.1
			by-products of combustion	no	no	Section 3.2.2.1
DRILLING	Underwater Drilling	Working Face	particulate matter	no	no	Section 3.2.2.2
			silica	no	no	Section 3.2.2.2
			trace metals	no	no	Section 3.2.2.2
			by-products of combustion	no	no	Section 3.2.2.2
BLASTING	Underwater Blasting	Working Face	particulate matter	no	no	Section 3.2.2.2
			silica	no	no	Section 3.2.2.2
			trace metals	no	no	Section 3.2.2.2
			by-products of combustion (blast)	no	no	Section 3.2.2.2
DRAGLINE	Drag Line	Working Face	particulate matter	no	no	Section 3.2.2.2
			silica	no	no	Section 3.2.2.2
			trace metals	no	no	Section 3.2.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
LDR	Pit Loader	Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HTL	Haul Truck Loading at Working Face	Processing Plant	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
HR_P1_1	Haul Truck Route from P1_1	Phase 1 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P1_2	Haul Truck Route from P1_2	Phase 1 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P1_3	Haul Truck Route from P1_3	Phase 1 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P2_1	Haul Truck Route from P2_1	Phase 2 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P2_2	Haul Truck Route from P2_2	Phase 2 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3

2.1 Sources and Contaminant Identification Table

RWDI Project 1201429

Source Information			Expected Contaminants	Included in Modelling? (yes / no)	Significant? (yes / no)	Reference (optional)
Source ID (optional)	Source Description or Title	General Location				
HR_P2_3	Haul Truck Route from P2_3	Phase 2 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P3_1	Haul Truck Route from P3_1	Phase 3 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P3_2	Haul Truck Route from P3_2	Phase 3 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
HR_P3_3	Haul Truck Route from P3_3	Phase 3 Working Face	particulate matter	yes	yes	
			silica	no	no	Section 3.1.2.1
			trace metals	no	no	Section 3.1.2.2
			by-products of combustion	yes	yes	Section 3.1.2.3
GR1	Truck Dump at Grizzly	Processing Plant	particulate matter	yes	yes	
CR1	Primary Crusher	Processing Plant	particulate matter	yes	yes	
SC1	Screen	Processing Plant	particulate matter	yes	yes	
C01	Conveyor Transfer	Processing Plant	particulate matter	no	no	Section 3.2.2.3
ST01	Stacker	Processing Plant	particulate matter	no	no	Section 3.2.2.3
C02	Conveyor Transfer	Processing Plant	particulate matter	no	no	Section 3.2.2.3
ST02	Stacker	Processing Plant	particulate matter	no	no	Section 3.2.2.3
CR2	Secondary Crusher	Processing Plant	particulate matter	no	no	Section 3.2.2.3
SC2	Screen	Processing Plant	particulate matter	no	no	Section 3.2.2.3
C03	Conveyor Transfer	Processing Plant	particulate matter	no	no	Section 3.2.2.3
ST03	Stacker	Processing Plant	particulate matter	no	no	Section 3.2.2.3
C04	Conveyor Transfer	Processing Plant	particulate matter	no	no	Section 3.2.2.3
ST04	Stacker	Processing Plant	particulate matter	no	no	Section 3.2.2.3
STKPL01	Product Stockpile	Processing Plant	particulate matter	no	no	Section 3.2.2.4
STKPL02	Product Stockpile	Processing Plant	particulate matter	no	no	Section 3.2.2.4
STKPL03	Product Stockpile	Processing Plant	particulate matter	no	no	Section 3.2.2.4
STKPL04	Product Stockpile	Processing Plant	particulate matter	no	no	Section 3.2.2.4

2.1 Sources and Contaminant Identification Table

RWDI Project 1201429

Source Information			Expected Contaminants	Included in Modelling? (yes / no)	Significant? (yes / no)	Reference (optional)
Source ID (optional)	Source Description or Title	General Location				
PLANTPDR	Plant Loader	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
LOADOUT1	Loading Highway Trucks at Stockpiles	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
LOADOUT2	Loading Highway Trucks at Stockpiles	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
LOADOUT3	Loading Highway Trucks at Stockpiles	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
LOADOUT4	Loading Highway Trucks at Stockpiles	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
ENTRANCE	Shipping Truck Route (Entrance Ramp)	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
LOOP	Shipping Truck Route (Plant Loop)	Processing Plant	particulate matter	yes	yes	
			by-products of combustion	yes	yes	
REFUEL	On-site Fuel Storage	Processing Plant	volatile organic compounds	no	no	Section 3.2.2.5
REHAB	Rehabilitation Operations	Working Face	particulate matter	no	no	Section 3.2.2.1
			by-products of combustion	no	no	Section 3.2.2.1

Notes:

Revision Date: 2012-07-09
Prepared by: BGS

5.1 Source Summary Table (by source)

Source ID [1]	Source Type [1]	Source Description	Source Data								Emission Data							
			Stack Volumetric Flow Rate (Am³/s)	Stack Exit Gas Temp. (°C)	Stack Inner Diameter (m)	Stack Exit Velocity (m/s)	Stack Height Above Grade (m)	Stack Height Above Roof (m)	Source Coordinates X (m)	Source Coordinates Y (m)	Contaminant	CAS Number	Maximum Emission Rate (g/s)	Averaging Period (hours)	Emission Estimating Technique [2]	Sample Calculation Identifier	Emissions Data Quality [3]	% of Overall Emissions (%)
DL	Point	Drag Line (any Phase)	4	200	0.3	50	4	n/a			TSP	n/a	7.10E-02	1	EF	Appendix B	Marginal	3%
											PM10	n/a	7.10E-02	1	EF	Appendix B	Marginal	2%
											PM2.5	n/a	7.10E-02	1	EF	Appendix B	Marginal	13%
											NOx	10102-44-0	1.00E+00	1	EF	Appendix B	Marginal	45%
LDR	Line	Loader at Working Face (any Phase)	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.35E-01	1	EF	Section 4.3.5	Average	6%
											PM10	n/a	4.62E-02	1	EF	Section 4.3.5	Average	2%
											PM2.5	n/a	1.45E-02	1	EF	Section 4.3.5	Average	3%
											NOx	10102-44-0	2.20E-01	1	EF	Appendix B	Above-Average	10%
HTL	Volume	Haul Truck Loading at Working Face (any Phase)	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.30E-01	1	EF	Section 4.3.1	Average	6%
											PM10	n/a	6.30E-02	1	EF	Section 4.3.1	Average	2%
											PM2.5	n/a	9.50E-03	1	EF	Section 4.3.1	Average	2%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	4.94E-01	1	EF	Section 4.3.5	Average	22%
											PM10	n/a	1.67E-01	1	EF	Section 4.3.5	Average	6%
											PM2.5	n/a	5.00E-02	1	EF	Section 4.3.5	Average	9%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	8.37E-01	1	EF	Section 4.3.5	Average	37%
											PM10	n/a	2.28E-01	1	EF	Section 4.3.5	Average	8%
											PM2.5	n/a	2.36E-02	1	EF	Section 4.3.5	Average	4%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	9.51E-01	1	EF	Section 4.3.5	Average	42%
											PM10	n/a	2.61E+00	1	EF	Section 4.3.5	Average	87%
											PM2.5	n/a	3.86E-01	1	EF	Section 4.3.5	Average	72%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.26E+00	1	EF	Section 4.3.5	Average	56%
											PM10	n/a	3.47E-01	1	EF	Section 4.3.5	Average	12%
											PM2.5	n/a	3.47E-02	1	EF	Section 4.3.5	Average	7%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.14E+00	1	EF	Section 4.3.5	Average	51%
											PM10	n/a	3.14E-01	1	EF	Section 4.3.5	Average	10%
											PM2.5	n/a	3.14E-02	1	EF	Section 4.3.5	Average	6%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.26E+00	1	EF	Section 4.3.5	Average	56%
											PM10	n/a	3.47E-01	1	EF	Section 4.3.5	Average	12%
											PM2.5	n/a	3.47E-02	1	EF	Section 4.3.5	Average	7%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	3.42E-01	1	EF	Section 4.3.5	Average	15%
											PM10	n/a	8.67E-02	1	EF	Section 4.3.5	Average	3%
											PM2.5	n/a	8.67E-03	1	EF	Section 4.3.5	Average	2%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	4.33E-01	1	EF	Section 4.3.5	Average	19%
											PM10	n/a	1.13E-01	1	EF	Section 4.3.5	Average	4%
											PM2.5	n/a	1.13E-02	1	EF	Section 4.3.5	Average	2%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
HR_P1_1	Line	Haul Truck Route from P1_1	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	4.56E-01	1	EF	Section 4.3.5	Average	20%
											PM10	n/a	1.19E-01	1	EF	Section 4.3.5	Average	4%
											PM2.5	n/a	1.19E-02	1	EF	Section 4.3.5	Average	2%
											NOx	10102-44-0	7.40E-01	1	EF	Appendix B	Above-Average	33%
GR1	Volume	Truck Dump at Grizzly	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.30E-01	1	EF	Section 4.3.1	Average	6%
											PM10	n/a	6.30E-02	1	EF	Section 4.3.1	Average	2%
											PM2.5	n/a	9.50E-03	1	EF	Section 4.3.1	Average	2%
CR1	Volume	Primary Crusher	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	7.50E-02	1	EF	Section 4.3.2	Marginal	3%
											PM10	n/a	3.40E-02	1	EF	Section 4.3.2	Marginal	1%
											PM2.5	n/a	6.30E-03	1	EF	Section 4.3.2	Marginal	1%
SC1	Volume	Screen	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.50E-02	1	EF	Section 4.3.2	Marginal	0.7%
											PM10	n/a	5.30E-03	1	EF	Section 4.3.2	Marginal	0.2%
											PM2.5	n/a	3.50E-04	1	EF	Section 4.3.2	Marginal	0.07%

5.1 Source Summary Table (by source)

Source ID [1]	Source Type [1]	Source Description	Source Data								Emission Data							
			Stack Volumetric Flow Rate (Am^3/s)	Stack Exit Gas Temp. (°C)	Stack Inner Diameter (m)	Stack Exit Velocity (m/s)	Stack Height Above Grade (m)	Stack Height Above Roof (m)	Source Coordinates X (m)	Source Coordinates Y (m)	Contaminant	CAS Number	Maximum Emission Rate (g/s)	Averaging Period (hours)	Emission Estimating Technique [2]	Sample Calculation Identifier	Emissions Data Quality [3]	% of Overall Emissions (%)
PLANTPDR	Line	Plant Loader	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.10E-02	1	EF	Section 4.3.5	Average	0.5%
											PM10	n/a	1.10E-02	1	EF	Section 4.3.5	Average	0.4%
											PM2.5	n/a	1.10E-02	1	EF	Section 4.3.5	Average	2%
											NOx	10102-44-0	2.20E-01	1	EF	Appendix B	Above-Average	10%
LOADOUT1	Volume	Loading Highway Trucks at Stockpiles	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	6.70E-03	1	EF	Section 4.3.3	Above-Average	0.3%
											PM10	n/a	3.20E-03	1	EF	Section 4.3.3	Above-Average	0.1%
											PM2.5	n/a	4.80E-04	1	EF	Section 4.3.3	Above-Average	0.09%
LOADOUT2	Volume	Loading Highway Trucks at Stockpiles	n/a	n/a	n/a	n/a	n/a	n/a			TSP	10102-44-0	1.60E-02	1	EF	Section 4.3.3	Above-Average	0.7%
											PM10	n/a	7.40E-03	1	EF	Section 4.3.3	Above-Average	0.2%
											PM2.5	n/a	1.10E-03	1	EF	Section 4.3.3	Above-Average	0.2%
LOADOUT3	Volume	Loading Highway Trucks at Stockpiles	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	6.70E-03	1	EF	Section 4.3.3	Above-Average	0.3%
											PM10	10102-44-0	3.20E-03	1	EF	Section 4.3.3	Above-Average	0.1%
											PM2.5	n/a	4.80E-04	1	EF	Section 4.3.3	Above-Average	0.09%
LOADOUT4	Volume	Loading Highway Trucks at Stockpiles	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	1.60E-02	1	EF	Section 4.3.3	Above-Average	0.7%
											PM10	n/a	7.40E-03	1	EF	Section 4.3.3	Above-Average	0.2%
											PM2.5	10102-44-0	1.10E-03	1	EF	Section 4.3.3	Above-Average	0.2%
ENTRANCE	Line	Shipping Truck Route (Entrance Ramp)	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	8.09E-02	1	EF	Section 4.3.4	Above-Average	4%
											PM10	n/a	1.63E-02	1	EF	Section 4.3.4	Above-Average	0.5%
											PM2.5	n/a	4.50E-03	1	EF	Section 4.3.4	Above-Average	0.8%
											NOx	10102-44-0	1.40E-02	1	EF	Appendix B	Above-Average	0.6%
LOOP	Line	Shipping Truck Route (Plant Loop)	n/a	n/a	n/a	n/a	n/a	n/a			TSP	n/a	3.10E-01	1	EF	Section 4.3.4	Above-Average	14%
											PM10	n/a	6.28E-02	1	EF	Section 4.3.4	Above-Average	2%
											PM2.5	n/a	1.74E-02	1	EF	Section 4.3.4	Above-Average	3%
											NOx	10102-44-0	5.30E-02	1	EF	Appendix B	Above-Average	2%
Total	n/a	Total of all listed sources									TSP	n/a	2.26E+00					
											PM10	n/a	3.00E+00					
											PM2.5	n/a	5.33E-01					
											NOx	10102-44-0	2.25E+00					

Notes:
[1] Source ID, Source Type: should provide information on the modelling source type (e.g., Point, Area or Volume Source); the process source or sources within the modelling source (e.g., Process Line #1); and the stack or stacks within each process source.
[2] Emission Estimating Technique Short-Forms are V-ST (Validated Source Test), "ST" (Source Test), EF (Emission Factor), MB (Mass Balance), and EC (Engineering Calculation).
[3] Data Quality Categories: Highest; Above-Average; Average; and Marginal.

Revision Date: 2012-07-09
Prepared by: BGS

6.1 Dispersion Modelling Input Summary Table

RWDI Project 1201429

Relevant Section of the Regulation	Section Title	Description of How the Approved Dispersion Model was Used
Section 8	Negligible Sources	The following sources were determined to be negligible: Overburden stripping and rehabilitation operations; below water blasting operations; extraction and stockpiling of shot rock from below water operations; wash plant sources; wind erosion of aggregate storage piles; and, on-site storage tanks and facilities used for fuelling on-site vehicles.
Section 9	Same Structure Contamination	Same structure contamination was not applicable in this analysis, therefore Section 9 of O. Reg. 419/05 does not apply.
Section 10	Operating Conditions	Refer to Section 4.1 of the report. For the purposes of estimating emissions from the facility, a maximum processing scenario was examined, which considers the extraction, processing and shipping of aggregate at a maximum capacity of 500 metric tonnes per hour. The processing plant operations include crushing, screening, conveying and stockpiling of aggregate. Shipping operations includes the loading of processed aggregate into trucks.
Section 11	Source of Contaminant Emission Rates	Emission rates were obtained from AP-42 emission factors, U.S. EPA Tier 3 standards, and manufacturer specifications.
Section 12	Combined Effect of Assumptions for Operating Conditions and Emission Rates	Predcited concentrations were below the relevant crietria for the compliance assessment, therefore Section 12 of O. Reg. 419/05 does not apply.
Section 13	Meteorological Conditions	The quarry is located in the Township of Guelph-Eramosa and, therefore, the West Central Region meteorological data set is recommended by the MOE for use at this site. This includes surface(s) data from London, Ontario and upper air data from White Lake, Michigan. Within each region, the MOE provides alternative data sets with the choice of data set depending on the character of the terrain at the study site. The area surrounding the quarry is typically agricultural with some wooded areas and residences in the vicinity of the site. The default data set for “crops” was used based on the land use patterns surrounding the site, as this data set is expected to produce more conservative estimates.
Section 14	Area of Modelling Coverage	The area of modelling coverage was designed to meet the requirements outlined in O. Reg. 419/05, s 14. A multi-tiered receptor grid was developed with reference to Section 7.2 of the Air Dispersion Modelling Guideline for Ontario, Version 2.0, March 2009; therefore, interval spacing was dependent on the receptor distance from on-site sources. In addition, 18 discrete receptor locations were included in the assessment. These receptors represent residences near the quarry, and were modelled at both 1.5-metre and 4.5-metre heights above grade to reflect two-storey residences.
Section 15	Stack Height for Certain New Sources of Contaminant	All sources were modelled as volume sources, therefore Section 15 of O. Reg. 419/05 does not apply.
Section 16	Terrain Data	Terrain information for the area surrounding the facility was obtained from the MOE Ontario Digital Elevation Model Data web site. The terrain data is based on the North American Datum 1983 (NAD83) horizontal reference datum. These data were run through the AERMAP terrain pre-processor to estimate base elevations for receptors and to help the model account for changes in elevation of the surrounding terrain. Base elevations for sources are based on information contained on the Site Plan and are assumed to be at the elevation of the first lift.
Section 17	Averaging Periods	1-hour and 24-hour averaging periods were used in the assessment, consistent with the relevant criteria.

6.3 Relevant Air Quality Criteria

Assessment	Pollutant	CAS Number	Threshold (µg/m³)	Averaging Period	Source	Notes
Compliance	Total Suspended Particulate	n/a	120	24-hours	O. Reg. 419/05 Schedule 3	
	Nitrogen Oxides	10102-44-0	400	1-hour	O. Reg. 419/05 Schedule 3	
			200	24-hours	O. Reg. 419/05 Schedule 3	
Cumulative	Total Suspended Particulate	n/a	120	24-hours	Ontario Ambient Air Quality Criteria	[1]
	Suspended Particulate less than 10 µm in Diameter	n/a	50	24-hours	Interim Ontario Ambient Air Quality Criteria	[1]
	Suspended Particulate less than 2.5 µm in Diameter, without background	n/a	25	24-hours	Canada Wide Standard	
	Suspended Particulate less than 2.5 µm in Diameter, with background	n/a	30	24-hours	Canada Wide Standard	
	Nitrogen Oxides, converted to nitrogen dioxide	10102-44-0	400	1-hour	O. Reg. 419/05 Schedule 3	[2]
			200	24-hours	O. Reg. 419/05 Schedule 3	[2]

Note:
[1] The CWS reflects a 24-hour, 98th percentile ambient measurement annually, averaged over three consecutive years. For comparison purposes, it is treated as a 24-hour criteria;
[2] Converted to NO2 using the ozone-limiting method.

6.4 Ambient Air Quality Data

Year	90th Percentile Values				
	NO2		O3		PM2.5
	(ppb)	(µg/m³)	(ppb)	(µg/m³)	(µg/m³)
2006	22	91	46	95	16
2007	20	93	47	97	17
2008	19	93	47	97	15
2009	18	87	44	91	12
2010	14	95	48	99	14
Average	18.6	91.8	46.4	95.8	14.8

Notes:

All ozone and PM2.5 data from MOE Station 28028 Guelph

2010 NO2 data from MOE Station 28028 Guelph

2006-2009 NO2 data from MOE Station 26060 Kitchener

Conversion from ppb to µg/m³ based on 10ºC.

Table 7.1A: Emission Summary Table - Compliance Assessment

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827

Relevant Criteria:	TSP	120	µg/m³ Schedule 3 Standard
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
	NOx	400	µg/m³ Schedule 3 1-hour Standard
		200	µg/m³ Schedule 3 24-hour Standard

Receptor		UTM Coordinates		Contaminant	Avergaing Period	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria		
ID	Type	X	Y			P1	P2	P3	P1	P2	P3
		(m)	(m)		(hours)	(µg/m³)	(µg/m³)	(µg/m³)	(%)	(%)	(%)
MAX	Property Line	--	--	TSP	24	50	48	53	42%	40%	44%
				PM10	24	23	22	24	46%	44%	48%
				PM2.5	24	4	3	4	15%	14%	15%
				NOx	1	90	80	89	23%	20%	22%
					24	46	37	40	23%	18%	20%
R01	Residence	571,970	4,828,650	TSP	24	15	14	16	12%	12%	14%
				PM10	24	7	6	7	13%	13%	15%
				PM2.5	24	1	1	1	4%	4%	5%
				NOx	1	26	16	35	6%	4%	9%
					24	9	4	10	5%	2%	5%
R02	Residence	571,710	4,828,580	TSP	24	6	5	6	5%	4%	5%
				PM10	24	3	2	3	5%	5%	5%
				PM2.5	24	0.4	0.4	0.4	2%	1%	2%
				NOx	1	22	13	25	5%	3%	6%
					24	5	3	9	3%	2%	5%
R03	Residence	571,585	4,829,360	TSP	24	23	16	21	19%	13%	17%
				PM10	24	11	7	9	21%	14%	19%
				PM2.5	24	2	1	1	7%	5%	6%
				NOx	1	77	24	63	19%	6%	16%
					24	31	13	22	16%	6%	11%
R04	Residence	571,385	4,829,360	TSP	24	11	8	11	9%	7%	9%
				PM10	24	5	4	5	10%	7%	10%
				PM2.5	24	0.8	0.6	0.8	3%	2%	3%
				NOx	1	39	18	34	10%	5%	9%
					24	15	6	11	7%	3%	6%
R05	Residence	571,450	4,829,615	TSP	24	7	6	6	6%	5%	5%
				PM10	24	3	3	3	6%	6%	6%
				PM2.5	24	0.5	0.5	0.5	2%	2%	2%
				NOx	1	44	25	29	11%	6%	7%
					24	23	10	9	11%	5%	5%
R06	Residence	571,635	4,830,450	TSP	24	2	2	2	2%	2%	2%
				PM10	24	1	1	1	2%	2%	2%
				PM2.5	24	0.2	0.2	0.2	1%	1%	1%
				NOx	1	20	21	15	5%	5%	4%
					24	7	4	4	4%	2%	2%
R07	Residence	572,110	4,830,510	TSP	24	2	2	2	2%	2%	2%
				PM10	24	1	1	1	2%	2%	2%
				PM2.5	24	0.1	0.2	0.1	1%	1%	1%
				NOx	1	20	23	16	5%	6%	4%
					24	6	6	3	3%	3%	2%
R08	Residence	572,325	4,830,420	TSP	24	2	3	2	2%	2%	2%
				PM10	24	1	1	1	2%	2%	2%
				PM2.5	24	0.2	0.2	0.2	1%	1%	1%
				NOx	1	20	25	16	5%	6%	4%
					24	9	11	4	4%	5%	2%

Table 7.1A: Emission Summary Table - Compliance Assessment

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data	1827

Relevant Criteria:			
	TSP	120	µg/m³ Schedule 3 Standard
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
	NOx	400	µg/m³ Schedule 3 1-hour Standard
		200	µg/m³ Schedule 3 24-hour Standard

Receptor		UTM Coordinates		Contaminant	Avergaging Period	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria		
ID	Type	X	Y			P1	P2	P3	P1	P2	P3
		(m)	(m)		(hours)	(µg/m³)	(µg/m³)	(µg/m³)	(%)	(%)	(%)
R09	Residence	572,420	4,830,320	TSP	24	3	3	3	2%	2%	2%
				PM10	24	1	1	1	2%	3%	2%
				PM2.5	24	0.2	0.2	0.2	1%	1%	1%
				NOx	1	22	26	16	5%	7%	4%
					24	8	10	5	4%	5%	2%
R10	Residence	572,515	4,829,590	TSP	24	8	9	9	7%	7%	8%
				PM10	24	4	4	4	8%	8%	9%
				PM2.5	24	1	1	1	2%	3%	3%
				NOx	1	29	72	35	7%	18%	9%
					24	13	37	24	6%	18%	12%
R12	Residence	572,310	4,829,420	TSP	24	14	14	16	12%	12%	13%
				PM10	24	7	7	7	13%	13%	15%
				PM2.5	24	1	1	1	4%	4%	5%
				NOx	1	36	80	71	9%	20%	18%
					24	14	33	36	7%	16%	18%
R13	Residence	572,295	4,829,365	TSP	24	19	19	20	16%	16%	17%
				PM10	24	9	9	9	18%	18%	18%
				PM2.5	24	1	1	1	6%	6%	6%
				NOx	1	34	70	89	8%	18%	22%
					24	16	26	40	8%	13%	20%
R14	Residence	572,510	4,829,410	TSP	24	10	10	11	9%	8%	10%
				PM10	24	5	4	5	9%	9%	11%
				PM2.5	24	1	1	1	3%	3%	3%
				NOx	1	22	46	35	6%	11%	9%
					24	10	18	15	5%	9%	7%
R15	Residence	572,245	4,828,855	TSP	24	26	25	27	22%	21%	22%
				PM10	24	12	11	12	24%	23%	24%
				PM2.5	24	2	2	2	8%	7%	8%
				NOx	1	25	18	37	6%	5%	9%
					24	9	6	14	5%	3%	7%
R16	Residence	572,195	4,829,050	TSP	24	50	48	53	42%	40%	44%
				PM10	24	23	22	24	46%	44%	48%
				PM2.5	24	4	3	4	15%	14%	15%
				NOx	1	36	25	58	9%	6%	14%
					24	13	7	26	6%	3%	13%
R17	Residence	572,430	4,828,585	TSP	24	10	9	10	8%	8%	8%
				PM10	24	5	4	5	9%	9%	9%
				PM2.5	24	1	1	1	3%	3%	3%
				NOx	1	14	14	18	4%	3%	4%
					24	6	4	8	3%	2%	4%
R18	Residence	572,125	4,828,655	TSP	24	27	26	27	22%	22%	22%
				PM10	24	12	12	12	24%	24%	24%
				PM2.5	24	2	2	2	8%	8%	8%
				NOx	1	23	17	33	6%	4%	8%
					24	8	4	13	4%	2%	7%

Table 7.1A: Emission Summary Table - Compliance Assessment

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data: 1827

Relevant Criteria:			
	TSP	120	µg/m³ Schedule 3 Standard
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
	NOx	400	µg/m³ Schedule 3 1-hour Standard
		200	µg/m³ Schedule 3 24-hour Standard

Receptor		UTM Coordinates		Contaminant	Avergaing Period	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria		
ID	Type	X (m)	Y (m)		(hours)	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)
R19	Residence	571,645	4,829,520	TSP	24	12	9	8	10%	7%	7%
				PM10	24	5	4	4	11%	8%	7%
				PM2.5	24	1	1	1	3%	3%	2%
				NOx	1	90	31	50	23%	8%	12%
					24	46	15	14	23%	7%	7%

Notes:

Shaded values in bold indicate excursions above the relevant crtieria

Table 7.1B: Emission Summary Table - Conveyors from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³, 90th Percentile
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

Receptor		UTM Coordinates		Contaminant	Averaging	With No Background Concentration												With Additional Background Concentrations											
ID	Type	X	Y		Time	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria			Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria		
						P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
		(m)	(m)		(hours)	(µg/m³)	(µg/m³)	(µg/m³)	(%)	(%)	(%)							(µg/m³)	(µg/m³)	(µg/m³)	(%)	(%)	(%)						
R01	Residence	571,970	4,828,650	TSP	24	63	54	76	52%	45%	64%	0	0	0	0%	0%	0%	112	103	125	93%	85%	**105%**	0	0	**1**	0%	0%	**0.05%**
				PM10	24	19	15	24	37%	31%	47%	0	0	0	0%	0%	0%	46	42	51	91%	85%	**101%**	0	0	**1**	0%	0%	**0.05%**
				PM2.5	24	5	4	6	19%	14%	25%	0	0	0	0%	0%	0%	19	18	21	65%	61%	70%	0	0	0	0%	0%	0%
				NO2	1	117	126	128	29%	31%	32%	0	0	0	0%	0%	0%	209	218	220	52%	54%	55%	0	0	0	0%	0%	0%
					24	56	38	61	28%	19%	31%	0	0	0	0%	0%	0%	147	130	153	74%	65%	77%	0	0	0	0%	0%	0%
R02	Residence	571,710	4,828,580	TSP	24	23	16	22	19%	13%	18%	0	0	0	0%	0%	0%	72	65	71	60%	54%	59%	0	0	0	0%	0%	0%
				PM10	24	8	5	7	15%	10%	14%	0	0	0	0%	0%	0%	35	32	34	69%	64%	68%	0	0	0	0%	0%	0%
				PM2.5	24	2	1	2	8%	5%	8%	0	0	0	0%	0%	0%	17	16	17	56%	53%	56%	0	0	0	0%	0%	0%
				NO2	1	107	113	112	27%	28%	28%	0	0	0	0%	0%	0%	199	204	204	50%	51%	51%	0	0	0	0%	0%	0%
					24	11	10	13	5%	5%	7%	0	0	0	0%	0%	0%	102	101	105	51%	51%	52%	0	0	0	0%	0%	0%
R03	Residence	571,585	4,829,360	TSP	24	89	47	76	75%	39%	64%	0	0	0	0%	0%	0%	138	96	125	**115%**	80%	**104%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
				PM10	24	29	13	24	59%	27%	49%	0	0	0	0%	0%	0%	56	40	51	**113%**	81%	**103%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
				PM2.5	24	7	3	6	30%	13%	24%	0	0	0	0%	0%	0%	22	18	21	74%	61%	70%	0	0	0	0%	0%	0%
				NO2	1	161	115	152	40%	29%	38%	0	0	0	0%	0%	0%	253	207	243	63%	52%	61%	0	0	0	0%	0%	0%
					24	79	23	69	39%	11%	34%	0	0	0	0%	0%	0%	171	115	160	85%	57%	80%	0	0	0	0%	0%	0%
R04	Residence	571,385	4,829,360	TSP	24	46	29	43	38%	24%	36%	0	0	0	0%	0%	0%	95	78	92	79%	65%	77%	0	0	0	0%	0%	0%
				PM10	24	14	8	13	29%	16%	27%	0	0	0	0%	0%	0%	41	35	40	83%	70%	81%	0	0	0	0%	0%	0%
				PM2.5	24	4	3	4	16%	10%	15%	0	0	0	0%	0%	0%	19	17	19	63%	58%	62%	0	0	0	0%	0%	0%
				NO2	1	124	109	124	31%	27%	31%	0	0	0	0%	0%	0%	216	200	216	54%	50%	54%	0	0	0	0%	0%	0%
					24	26	15	30	13%	7%	15%	0	0	0	0%	0%	0%	118	106	122	59%	53%	61%	0	0	0	0%	0%	0%
R05	Residence	571,450	4,829,615	TSP	24	43	36	29	36%	30%	24%	0	0	0	0%	0%	0%	92	85	78	77%	71%	65%	0	0	0	0%	0%	0%
				PM10	24	15	13	9	30%	26%	17%	0	0	0	0%	0%	0%	42	40	36	84%	80%	71%	0	0	0	0%	0%	0%
				PM2.5	24	5	4	2	20%	17%	9%	0	0	0	0%	0%	0%	20	19	17	66%	63%	57%	0	0	0	0%	0%	0%
				NO2	1	122	109	118	30%	27%	30%	0	0	0	0%	0%	0%	213	201	210	53%	50%	52%	0	0	0	0%	0%	0%
					24	26	14	23	13%	7%	11%	0	0	0	0%	0%	0%	117	106	115	59%	53%	57%	0	0	0	0%	0%	0%
R06	Residence	571,635	4,830,450	TSP	24	12	13	8	10%	11%	7%	0	0	0	0%	0%	0%	61	62	57	51%	52%	48%	0	0	0	0%	0%	0%
				PM10	24	4	5	3	8%	9%	6%	0	0	0	0%	0%	0%	31	32	30	62%	63%	60%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	5%	6%	4%	0	0	0	0%	0%	0%	16	16	16	54%	54%	53%	0	0	0	0%	0%	0%
				NO2	1	105	104	104	26%	26%	26%	0	0	0	0%	0%	0%	197	195	196	49%	49%	49%	0	0	0	0%	0%	0%
					24	7	12	6	4%	6%	3%	0	0	0	0%	0%	0%	99	104	98	50%	52%	49%	0	0	0	0%	0%	0%
R07	Residence	572,110	4,830,510	TSP	24	10	17	10	9%	14%	8%	0	0	0	0%	0%	0%	59	66	59	50%	55%	49%	0	0	0	0%	0%	0%
				PM10	24	3	5	3	7%	11%	6%	0	0	0	0%	0%	0%	30	32	30	61%	65%	60%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	4%	6%	3%	0	0	0	0%	0%	0%	16	16	16	53%	54%	52%	0	0	0	0%	0%	0%
				NO2	1	104	110	109	26%	28%	27%	0	0	0	0%	0%	0%	196	202	200	49%	50%	50%	0	0	0	0%	0%	0%
					24	7	13	7	3%	6%	4%	0	0	0	0%	0%	0%	98	105	99	49%	52%	49%	0	0	0	0%	0%	0%
R08	Residence	572,325	4,830,420	TSP	24	13	14	11	11%	11%	9%	0	0	0	0%	0%	0%	62	63	60	52%	52%	50%	0	0	0	0%	0%	0%
				PM10	24	5	4	4	9%	9%	7%	0	0	0	0%	0%	0%	32	31	31	63%	63%	61%	0	0	0	0%	0%	0%
				PM2.5	24	2	1	1	6%	5%	4%	0	0	0	0%	0%	0%	16	16	16	54%	53%	52%	0	0	0	0%	0%	0%
				NO2	1	104	112	108	26%	28%	27%	0	0	0	0%	0%	0%	196	203	200	49%	51%	50%	0	0	0	0%	0%	0%
					24	8	10	7	4%	5%	3%	0	0	0	0%	0%	0%	99	102	99	50%	51%	49%	0	0	0	0%	0%	0%

Table 7.1B: Emission Summary Table - Conveyors from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³, 90th Percentile
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

Receptor		UTM Coordinates		Contaminant	Averaging	With No Background Concentration												With Additional Background Concentrations											
ID	Type	X	Y		Time	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria			Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria		
		(m)	(m)		(hours)	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3
R09	Residence	572,420	4,830,320	TSP	24	14	17	12	12%	14%	10%	0	0	0	0%	0%	0%	63	66	61	53%	55%	51%	0	0	0	0%	0%	0%
				PM10	24	4	5	4	9%	11%	8%	0	0	0	0%	0%	0%	31	32	31	63%	65%	62%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	5%	6%	4%	0	0	0	0%	0%	0%	16	16	16	54%	54%	53%	0	0	0	0%	0%	0%
				NO2	1	106	114	109	26%	28%	27%	0	0	0	0%	0%	0%	198	205	200	49%	51%	50%	0	0	0	0%	0%	0%
					24	8	11	8	4%	5%	4%	0	0	0	0%	0%	0%	99	103	100	50%	51%	50%	0	0	0	0%	0%	0%
R10	Residence	572,515	4,829,590	TSP	24	29	111	43	25%	92%	36%	0	0	0	0%	0%	0%	78	160	92	65%	**133%**	77%	0	**1**	0	0%	**0.05%**	0%
				PM10	24	9	40	14	18%	80%	27%	0	0	0	0%	0%	0%	36	67	41	72%	**134%**	81%	0	**2**	0	0%	**0.1%**	0%
				PM2.5	24	3	12	4	11%	50%	16%	0	0	0	0%	0%	0%	17	27	19	58%	91%	63%	0	0	0	0%	0%	0%
				NO2	1	114	139	118	28%	35%	29%	0	0	0	0%	0%	0%	205	231	209	51%	58%	52%	0	0	0	0%	0%	0%
					24	28	77	23	14%	39%	11%	0	0	0	0%	0%	0%	120	169	115	60%	84%	57%	0	0	0	0%	0%	0%
R12	Residence	572,310	4,829,420	TSP	24	46	96	62	38%	80%	51%	0	0	0	0%	0%	0%	95	145	111	79%	**121%**	92%	0	**4**	0	0%	**0%**	0%
				PM10	24	13	35	22	27%	70%	44%	0	0	0	0%	0%	0%	40	62	49	81%	**124%**	98%	0	**7**	0	0%	**0.4%**	0%
				PM2.5	24	3	11	7	14%	43%	28%	0	0	0	0%	0%	0%	18	26	22	61%	85%	72%	0	0	0	0%	0%	0%
				NO2	1	124	138	128	31%	35%	32%	0	0	0	0%	0%	0%	215	230	220	54%	58%	55%	0	0	0	0%	0%	0%
					24	34	102	49	17%	51%	24%	0	0	0	0%	0%	0%	125	194	141	63%	97%	70%	0	0	0	0%	0%	0%
R13	Residence	572,295	4,829,365	TSP	24	54	86	120	45%	72%	**100%**	0	0	**1**	0%	0%	**0%**	103	135	169	86%	**113%**	**141%**	0	**1**	**5**	0%	**0.05%**	**0.3%**
				PM10	24	16	31	43	32%	63%	86%	0	0	0	0%	0%	0%	43	58	70	86%	**117%**	**140%**	0	**2**	**8**	0%	**0.1%**	**0.4%**
				PM2.5	24	3	10	13	14%	38%	53%	0	0	0	0%	0%	0%	18	24	28	61%	81%	94%	0	0	0	0%	0%	0%
				NO2	1	134	137	141	34%	34%	35%	0	0	0	0%	0%	0%	226	229	233	57%	57%	58%	0	0	0	0%	0%	0%
					24	45	79	71	22%	40%	36%	0	0	0	0%	0%	0%	137	171	163	68%	86%	82%	0	0	0	0%	0%	0%
R14	Residence	572,510	4,829,410	TSP	24	27	37	34	23%	31%	29%	0	0	0	0%	0%	0%	76	86	83	64%	72%	69%	0	0	0	0%	0%	0%
				PM10	24	9	13	11	17%	27%	22%	0	0	0	0%	0%	0%	36	40	38	71%	81%	76%	0	0	0	0%	0%	0%
				PM2.5	24	2	4	3	7%	17%	14%	0	0	0	0%	0%	0%	17	19	18	56%	63%	61%	0	0	0	0%	0%	0%
				NO2	1	113	120	117	28%	30%	29%	0	0	0	0%	0%	0%	205	212	209	51%	53%	52%	0	0	0	0%	0%	0%
					24	20	24	25	10%	12%	13%	0	0	0	0%	0%	0%	112	116	117	56%	58%	58%	0	0	0	0%	0%	0%
R15	Residence	572,245	4,828,855	TSP	24	76	68	81	64%	57%	68%	0	0	0	0.0%	0%	0.0%	125	117	130	**104%**	98%	**108%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
				PM10	24	24	21	25	47%	41%	51%	0	0	0	0%	0%	0%	51	48	52	**101%**	95%	**105%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
				PM2.5	24	5	4	6	21%	18%	23%	0	0	0	0%	0%	0%	20	19	21	67%	64%	69%	0	0	0	0%	0%	0%
				NO2	1	130	122	126	32%	30%	31%	0	0	0	0%	0%	0%	221	214	218	55%	53%	54%	0	0	0	0%	0%	0%
					24	39	33	46	20%	17%	23%	0	0	0	0%	0%	0%	131	125	138	66%	63%	69%	0	0	0	0%	0%	0%
R16	Residence	572,195	4,829,050	TSP	24	140	129	164	**116%**	**108%**	**137%**	**2**	**1**	**6**	**0%**	**0%**	**0.3%**	189	178	213	**157%**	**149%**	**178%**	**18**	**14**	**28**	**1.0%**	**0.8%**	**1.5%**
				PM10	24	45	35	48	91%	71%	96%	0	0	0	0%	0%	0%	72	62	75	**145%**	**125%**	**150%**	**15**	**9**	**24**	**0.8%**	**0.5%**	**1.3%**
				PM2.5	24	10	8	12	41%	31%	47%	0	0	0	0%	0%	0%	25	23	27	83%	75%	88%	0	0	0	0%	0%	0%
				NO2	1	171	160	166	43%	40%	42%	0	0	0	0%	0%	0%	263	251	258	66%	63%	65%	0	0	0	0%	0%	0%
					24	93	75	103	47%	38%	52%	0	0	0	0%	0%	0%	185	167	195	93%	84%	97%	0	0	0	0%	0%	0%
R17	Residence	572,430	4,828,585	TSP	24	31	28	33	25%	23%	27%	0	0	0	0%	0%	0%	80	77	82	66%	64%	68%	0	0	0	0%	0%	0%
				PM10	24	9	8	10	19%	17%	20%	0	0	0	0%	0%	0%	36	35	37	73%	71%	74%	0	0	0	0%	0%	0%
				PM2.5	24	2	2	2	8%	7%	9%	0	0	0	0%	0%	0%	17	17	17	56%	55%	57%	0	0	0	0%	0%	0%
				NO2	1	111	107	109	28%	27%	27%	0	0	0	0%	0%	0%	203	198	201	51%	50%	50%	0	0	0	0%	0%	0%
					24	18	14	21	9%	7%	10%	0	0	0	0%	0%	0%	110	106	112	55%	53%	56%	0	0	0	0%	0%	0%

Table 7.1B: Emission Summary Table - Conveyors from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³, 90th Percentile
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

With No Background Concentration

Receptor ID	Receptor Type	UTM X (m)	UTM Y (m)	Contaminant	Averaging Time (hours)	Maximum Predicted 24-Hour Concentration P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	Percentage of Relevant Criteria P1 (%)	P2 (%)	P3 (%)	Number of Predicted Excursions Above Criteria over 5 Years P1	P2	P3	Frequency of Predicted Excursions Above Criteria P1	P2	P3
R18	Residence	572,125	4,828,655	TSP	24	75	72	82	62%	60%	68%	0	0	0	0%	0%	0%
				PM10	24	23	22	26	46%	44%	51%	0	0	0	0%	0%	0%
				PM2.5	24	5	5	6	21%	19%	24%	0	0	0	0%	0%	0%
				NO2	1	123	125	132	31%	31%	33%	0	0	0	0%	0%	0%
					24	45	39	49	23%	19%	25%	0	0	0	0%	0%	0%
R19	Residence	571,645	4,829,520	TSP	24	158	44	48	**132%**	37%	40%	**1**	0	0	**0%**	0%	0%
				PM10	24	56	16	15	**112%**	31%	29%	**1**	0	0	**0%**	0%	0%
				PM2.5	24	18	5	4	73%	20%	17%	0	0	0	0%	0%	0%
				NO2	1	145	112	125	36%	28%	31%	0	0	0	0%	0%	0%
					24	51	21	39	26%	10%	20%	0	0	0	0%	0%	0%

With Additional Background Concentrations

Receptor ID	Contaminant	Averaging Time (hours)	Maximum Predicted 24-Hour Concentration P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	Percentage of Relevant Criteria P1 (%)	P2 (%)	P3 (%)	Number of Predicted Excursions Above Criteria over 5 Years P1	P2	P3	Frequency of Predicted Excursions Above Criteria P1	P2	P3
R18	TSP	24	124	121	131	**103%**	**101%**	**109%**	**1**	**1**	**1**	**0.05%**	**0.05%**	**0.05%**
	PM10	24	50	49	53	**100%**	98%	**105%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
	PM2.5	24	20	20	21	67%	65%	69%	0	0	0	0%	0%	0%
	NO2	1	214	217	224	54%	54%	56%	0	0	0	0%	0%	0%
		24	137	130	141	69%	65%	70%	0	0	0	0%	0%	0%
R19	TSP	24	207	93	97	**173%**	77%	81%	**3**	0	0	**0.2%**	0%	0%
	PM10	24	83	43	42	**166%**	85%	83%	**4**	0	0	**0.2%**	0%	0%
	PM2.5	24	33	20	19	**110%**	66%	64%	**1**	0	0	**0.05%**	0%	0%
	NO2	1	237	204	217	59%	51%	54%	0	0	0	0%	0%	0%
		24	143	113	131	71%	56%	66%	0	0	0	0%	0%	0%

Notes:

Shaded values in bold indicate excursions above the relevant crtieria

Table 7.1C: Emission Summary Table - Haul Trucks from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

Receptor		UTM Coordinates		Contaminant	Averaging	With No Background Concentration												With Additional Background Concentrations											
ID	Type	X	Y		Time	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria			Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria		
		(m)	(m)		(hours)	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3
R01	Residence	571,970	4,828,650	TSP	24	99	94	99	83%	78%	82%	0	0	0	0%	0%	0%	148	143	148	**124%**	**119%**	**123%**	**2**	**1**	**3**	**0.1%**	**0.05%**	**0.2%**
				PM10	24	19	15	24	37%	31%	47%	0	0	0	0%	0%	0%	46	42	51	91%	85%	**101%**	0	0	**1**	0%	0%	**0.05%**
				PM2.5	24	5	4	6	19%	14%	25%	0	0	0	0%	0%	0%	19	18	21	65%	61%	70%	0	0	0	0%	0%	0%
				NO2	1	129	129	142	32%	32%	35%	0	0	0	0%	0%	0%	220	220	234	55%	55%	58%	0	0	0	0%	0%	0%
					24	74	42	79	37%	21%	39%	0	0	0	0%	0%	0%	165	134	170	83%	67%	85%	0	0	0	0%	0%	0%
R02	Residence	571,710	4,828,580	TSP	24	32	35	28	27%	29%	24%	0	0	0	0%	0%	0%	81	84	77	68%	70%	65%	0	0	0	0%	0%	0%
				PM10	24	8	5	8	15%	10%	15%	0	0	0	0%	0%	0%	35	32	35	69%	64%	69%	0	0	0	0%	0%	0%
				PM2.5	24	2	1	2	8%	5%	8%	0	0	0	0%	0%	0%	17	16	17	56%	53%	56%	0	0	0	0%	0%	0%
				NO2	1	112	116	124	28%	29%	31%	0	0	0	0%	0%	0%	204	208	216	51%	52%	54%	0	0	0	0%	0%	0%
					24	17	13	19	8%	7%	10%	0	0	0	0%	0%	0%	108	105	111	54%	53%	56%	0	0	0	0%	0%	0%
R03	Residence	571,585	4,829,360	TSP	24	153	125	133	**128%**	**104%**	**111%**	**1**	**1**	**1**	**0.05%**	**0.05%**	**0.05%**	202	174	182	**169%**	**145%**	**152%**	**11**	**4**	**5**	**0.6%**	**0.2%**	**0.3%**
				PM10	24	30	14	25	59%	27%	49%	0	0	0	0%	0%	0%	57	41	52	**113%**	81%	**103%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
				PM2.5	24	7	3	6	30%	13%	24%	0	0	0	0%	0%	0%	22	18	21	74%	61%	70%	0	0	0	0%	0%	0%
				NO2	1	192	122	175	48%	31%	44%	0	0	0	0%	0%	0%	283	214	267	71%	53%	67%	0	0	0	0%	0%	0%
					24	103	43	98	52%	21%	49%	0	0	0	0%	0%	0%	195	134	190	98%	67%	95%	0	0	0	0%	0%	0%
R04	Residence	571,385	4,829,360	TSP	24	64	69	59	53%	58%	49%	0	0	0	0%	0%	0%	113	118	108	94%	98%	90%	0	0	0	0%	0%	0%
				PM10	24	14	8	13	29%	16%	27%	0	0	0	0%	0%	0%	41	35	40	83%	70%	81%	0	0	0	0%	0%	0%
				PM2.5	24	4	3	4	16%	10%	15%	0	0	0	0%	0%	0%	19	17	19	63%	58%	62%	0	0	0	0%	0%	0%
				NO2	1	152	114	148	38%	28%	37%	0	0	0	0%	0%	0%	244	206	239	61%	51%	60%	0	0	0	0%	0%	0%
					24	37	23	41	19%	11%	21%	0	0	0	0%	0%	0%	129	115	133	64%	57%	66%	0	0	0	0%	0%	0%
R05	Residence	571,450	4,829,615	TSP	24	76	73	43	63%	61%	36%	0	0	0	0%	0%	0%	125	122	92	**104%**	**102%**	77%	**1**	**1**	0	**0.05%**	**0.05%**	0%
				PM10	24	15	13	13	30%	26%	27%	0	0	0	0%	0%	0%	42	40	40	84%	80%	81%	0	0	0	0%	0%	0%
				PM2.5	24	5	4	3	20%	17%	11%	0	0	0	0%	0%	0%	20	19	18	66%	63%	59%	0	0	0	0%	0%	0%
				NO2	1	137	112	130	34%	28%	33%	0	0	0	0%	0%	0%	229	204	222	57%	51%	55%	0	0	0	0%	0%	0%
					24	36	24	31	18%	12%	16%	0	0	0	0%	0%	0%	128	116	123	64%	58%	62%	0	0	0	0%	0%	0%
R06	Residence	571,635	4,830,450	TSP	24	26	33	13	22%	28%	11%	0	0	0	0%	0%	0%	75	82	62	63%	69%	52%	0	0	0	0%	0%	0%
				PM10	24	4	5	4	8%	9%	8%	0	0	0	0%	0%	0%	31	32	31	62%	63%	62%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	5%	6%	4%	0	0	0	0%	0%	0%	16	16	16	54%	54%	53%	0	0	0	0%	0%	0%
				NO2	1	113	108	109	28%	27%	27%	0	0	0	0%	0%	0%	205	200	201	51%	50%	50%	0	0	0	0%	0%	0%
					24	11	15	9	5%	7%	4%	0	0	0	0%	0%	0%	103	107	101	51%	53%	50%	0	0	0	0%	0%	0%
R07	Residence	572,110	4,830,510	TSP	24	27	46	17	23%	39%	14%	0	0	0	0%	0%	0%	76	95	66	64%	79%	55%	0	0	0	0%	0%	0%
				PM10	24	3	5	4	7%	11%	9%	0	0	0	0%	0%	0%	30	32	31	61%	65%	63%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	4%	6%	4%	0	0	0	0%	0%	0%	16	16	16	53%	54%	53%	0	0	0	0%	0%	0%
				NO2	1	116	122	116	29%	30%	29%	0	0	0	0%	0%	0%	208	213	208	52%	53%	52%	0	0	0	0%	0%	0%
					24	10	16	10	5%	8%	5%	0	0	0	0%	0%	0%	102	108	102	51%	54%	51%	0	0	0	0%	0%	0%
R08	Residence	572,325	4,830,420	TSP	24	24	39	18	20%	33%	15%	0	0	0	0%	0%	0%	73	88	67	60%	74%	55%	0	0	0	0%	0%	0%
				PM10	24	5	4	5	9%	9%	11%	0	0	0	0%	0%	0%	32	31	32	63%	63%	65%	0	0	0	0%	0%	0%
				PM2.5	24	2	1	1	6%	5%	5%	0	0	0	0%	0%	0%	16	16	16	54%	53%	54%	0	0	0	0%	0%	0%
				NO2	1	109	116	117	27%	29%	29%	0	0	0	0%	0%	0%	200	208	209	50%	52%	52%	0	0	0	0%	0%	0%
					24	11	15	11	5%	7%	5%	0	0	0	0%	0%	0%	103	106	102	51%	53%	51%	0	0	0	0%	0%	0%

Table 7.1C: Emission Summary Table - Haul Trucks from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

Receptor		UTM Coordinates		Contaminant	Averaging	With No Background Concentration												With Additional Background Concentrations											
ID	Type	X	Y		Time	Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria			Maximum Predicted 24-Hour Concentration			Percentage of Relevant Criteria			Number of Predicted Excursions Above Criteria over 5 Years			Frequency of Predicted Excursions Above Criteria		
		(m)	(m)		(hours)	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3	P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	P1 (%)	P2 (%)	P3 (%)	P1	P2	P3	P1	P2	P3
R09	Residence	572,420	4,830,320	TSP	24	24	40	19	20%	33%	16%	0	0	0	0%	0%	0%	73	89	68	61%	74%	56%	0	0	0	0%	0%	0%
				PM10	24	4	5	6	9%	11%	12%	0	0	0	0%	0%	0%	31	32	33	63%	65%	66%	0	0	0	0%	0%	0%
				PM2.5	24	1	2	1	5%	6%	5%	0	0	0	0%	0%	0%	16	16	16	54%	54%	54%	0	0	0	0%	0%	0%
				NO2	1	110	118	119	28%	30%	30%	0	0	0	0%	0%	0%	202	210	211	51%	52%	53%	0	0	0	0%	0%	0%
					24	10	17	13	5%	8%	7%	0	0	0	0%	0%	0%	101	108	105	51%	54%	52%	0	0	0	0%	0%	0%
R10	Residence	572,515	4,829,590	TSP	24	53	258	70	44%	215%	58%	0	2	0	0%	0.1%	0%	102	307	119	85%	256%	99%	0	20	0	0%	1.1%	0%
				PM10	24	9	40	22	18%	81%	44%	0	0	0	0%	0%	0%	36	67	49	72%	135%	98%	0	3	0	0%	0.2%	0%
				PM2.5	24	3	12	6	11%	50%	22%	0	0	0	0%	0%	0%	17	27	20	58%	91%	68%	0	0	0	0%	0%	0%
				NO2	1	116	168	140	29%	42%	35%	0	0	0	0%	0%	0%	208	259	232	52%	65%	58%	0	0	0	0%	0%	0%
					24	31	103	43	15%	52%	21%	0	0	0	0%	0%	0%	122	195	134	61%	98%	67%	0	0	0	0%	0%	0%
R12	Residence	572,310	4,829,420	TSP	24	82	146	101	69%	121%	85%	0	1	0	0%	0.05%	0%	131	195	150	109%	162%	125%	2	21	2	0.1%	1.1%	0.1%
				PM10	24	14	35	26	27%	70%	51%	0	0	0	0%	0%	0%	41	62	53	81%	124%	105%	0	7	4	0%	0.4%	0.2%
				PM2.5	24	3	11	7	14%	43%	29%	0	0	0	0%	0%	0%	18	26	22	61%	85%	73%	0	0	0	0%	0%	0%
				NO2	1	125	145	159	31%	36%	40%	0	0	0	0%	0%	0%	217	237	250	54%	59%	63%	0	0	0	0%	0%	0%
					24	41	103	68	21%	51%	34%	0	0	0	0%	0%	0%	133	195	160	66%	97%	80%	0	0	0	0%	0%	0%
R13	Residence	572,295	4,829,365	TSP	24	96	132	148	80%	110%	123%	0	1	1	0%	0.05%	0.05%	145	181	197	121%	151%	164%	6	16	20	0.3%	0.9%	1.1%
				PM10	24	16	31	52	32%	63%	103%	0	0	1	0%	0%	0.05%	43	58	79	86%	117%	157%	0	2	22	0%	0.1%	1.2%
				PM2.5	24	3	10	15	14%	38%	60%	0	0	0	0%	0%	0%	18	24	30	61%	81%	99%	0	0	0	0%	0%	0%
				NO2	1	141	142	167	35%	35%	42%	0	0	0	0%	0%	0%	233	233	259	58%	58%	65%	0	0	0	0%	0%	0%
					24	59	70	102	30%	35%	51%	0	0	0	0%	0%	0%	151	162	194	75%	81%	97%	0	0	0	0%	0%	0%
R14	Residence	572,510	4,829,410	TSP	24	60	80	50	50%	67%	42%	0	0	0	0%	0%	0%	109	129	99	90%	107%	82%	0	2	0	0%	0.1%	0%
				PM10	24	9	13	15	18%	27%	30%	0	0	0	0%	0%	0%	36	40	42	72%	81%	84%	0	0	0	0%	0%	0%
				PM2.5	24	2	4	4	8%	17%	16%	0	0	0	0%	0%	0%	17	19	19	56%	63%	62%	0	0	0	0%	0%	0%
				NO2	1	121	126	140	30%	32%	35%	0	0	0	0%	0%	0%	213	218	232	53%	55%	58%	0	0	0	0%	0%	0%
					24	26	31	36	13%	16%	18%	0	0	0	0%	0%	0%	118	123	128	59%	62%	64%	0	0	0	0%	0%	0%
R15	Residence	572,245	4,828,855	TSP	24	126	106	118	105%	88%	99%	1	0	0	0.05%	0%	0%	175	155	167	146%	129%	139%	4	4	1	0.2%	0.2%	0.05%
				PM10	24	24	21	28	48%	42%	57%	0	0	0	0%	0%	0%	51	48	55	102%	96%	111%	1	0	1	0.05%	0.0%	0.05%
				PM2.5	24	5	4	6	21%	18%	24%	0	0	0	0%	0%	0%	20	19	21	67%	64%	69%	0	0	0	0%	0%	0%
				NO2	1	153	137	147	38%	34%	37%	0	0	0	0%	0%	0%	245	229	239	61%	57%	60%	0	0	0	0%	0%	0%
					24	65	43	71	33%	21%	36%	0	0	0	0%	0%	0%	157	134	163	78%	67%	82%	0	0	0	0%	0%	0%
R16	Residence	572,195	4,829,050	TSP	24	209	190	216	174%	159%	180%	11	7	13	0.6%	0.4%	0.7%	258	239	265	215%	200%	221%	38	37	50	2.1%	2.0%	2.7%
				PM10	24	46	35	48	92%	71%	96%	0	0	0	0%	0%	0%	73	62	75	146%	125%	150%	15	9	26	0.8%	0.5%	1.4%
				PM2.5	24	10	8	12	41%	31%	47%	0	0	0	0%	0%	0%	25	23	27	84%	75%	89%	0	0	0	0%	0%	0%
				NO2	1	231	176	217	58%	44%	54%	0	0	0	0%	0%	0%	323	268	309	81%	67%	77%	0	0	0	0%	0%	0%
					24	104	94	106	52%	47%	53%	0	0	0	0%	0%	0%	196	186	198	98%	93%	99%	0	0	0	0%	0%	0%
R17	Residence	572,430	4,828,585	TSP	24	53	45	50	45%	38%	42%	0	0	0	0%	0%	0%	102	94	99	85%	79%	83%	0	0	0	0%	0%	0%
				PM10	24	9	9	12	19%	17%	24%	0	0	0	0%	0%	0%	36	36	39	73%	71%	78%	0	0	0	0%	0%	0%
				PM2.5	24	2	2	2	9%	7%	10%	0	0	0	0%	0%	0%	17	17	17	56%	56%	57%	0	0	0	0%	0%	0%
				NO2	1	124	114	119	31%	28%	30%	0	0	0	0%	0%	0%	216	205	210	54%	51%	53%	0	0	0	0%	0%	0%
					24	29	18	31	14%	9%	15%	0	0	0	0%	0%	0%	121	110	122	60%	55%	61%	0	0	0	0%	0%	0%

Table 7.1C: Emission Summary Table - Haul Trucks from Face to Plant

Modelled Values & Frequency of Excursions above the Relevant Criteria

Days of Valid Meteorological Data		1827	
Background Concentration	TSP	49	µg/m³
	PM10	27	µg/m³
	PM2.5	14.8	µg/m³
	NO2	91.8	µg/m³ (1-hour)
		91.8	µg/m³ (24-hour)
Relevant Criteria:	TSP	120	µg/m³ AAQC
	PM10	50	µg/m³ Interim AAQC
	PM2.5	25	µg/m³ Canada Wide Standard (without background)
		30	µg/m³ Canada Wide Standard (with background)
	NO2	400	µg/m³ 1-Hour AAQC
		200	µg/m³ 24-Hour AAQC

With No Background Concentration

Receptor ID	Receptor Type	UTM X (m)	UTM Y (m)	Contaminant	Averaging Time (hours)	Maximum Predicted 24-Hour Concentration P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	Percentage of Relevant Criteria P1 (%)	P2 (%)	P3 (%)	Number of Predicted Excursions Above Criteria over 5 Years P1	P2	P3	Frequency of Predicted Excursions Above Criteria P1	P2	P3
R18	Residence	572,125	4,828,655	TSP	24	179	171	130	**150%**	**142%**	**108%**	**1**	**1**	**1**	**0.05%**	**0.05%**	**0.05%**
				PM10	24	23	22	39	46%	44%	77%	0	0	0	0%	0%	0%
				PM2.5	24	5	5	8	21%	19%	32%	0	0	0	0%	0%	0%
				NO2	1	135	132	144	34%	33%	36%	0	0	0	0%	0%	0%
					24	72	60	81	36%	30%	40%	0	0	0	0%	0%	0%
R19	Residence	571,645	4,829,520	TSP	24	158	87	74	**132%**	73%	61%	**3**	0	0	**0.16%**	0%	0%
				PM10	24	56	16	18	**112%**	31%	36%	**1**	0	0	**0.05%**	0%	0%
				PM2.5	24	18	5	4	73%	20%	17%	0	0	0	0%	0%	0%
				NO2	1	158	128	142	39%	32%	36%	0	0	0	0%	0%	0%
					24	72	30	61	36%	15%	30%	0	0	0	0%	0%	0%

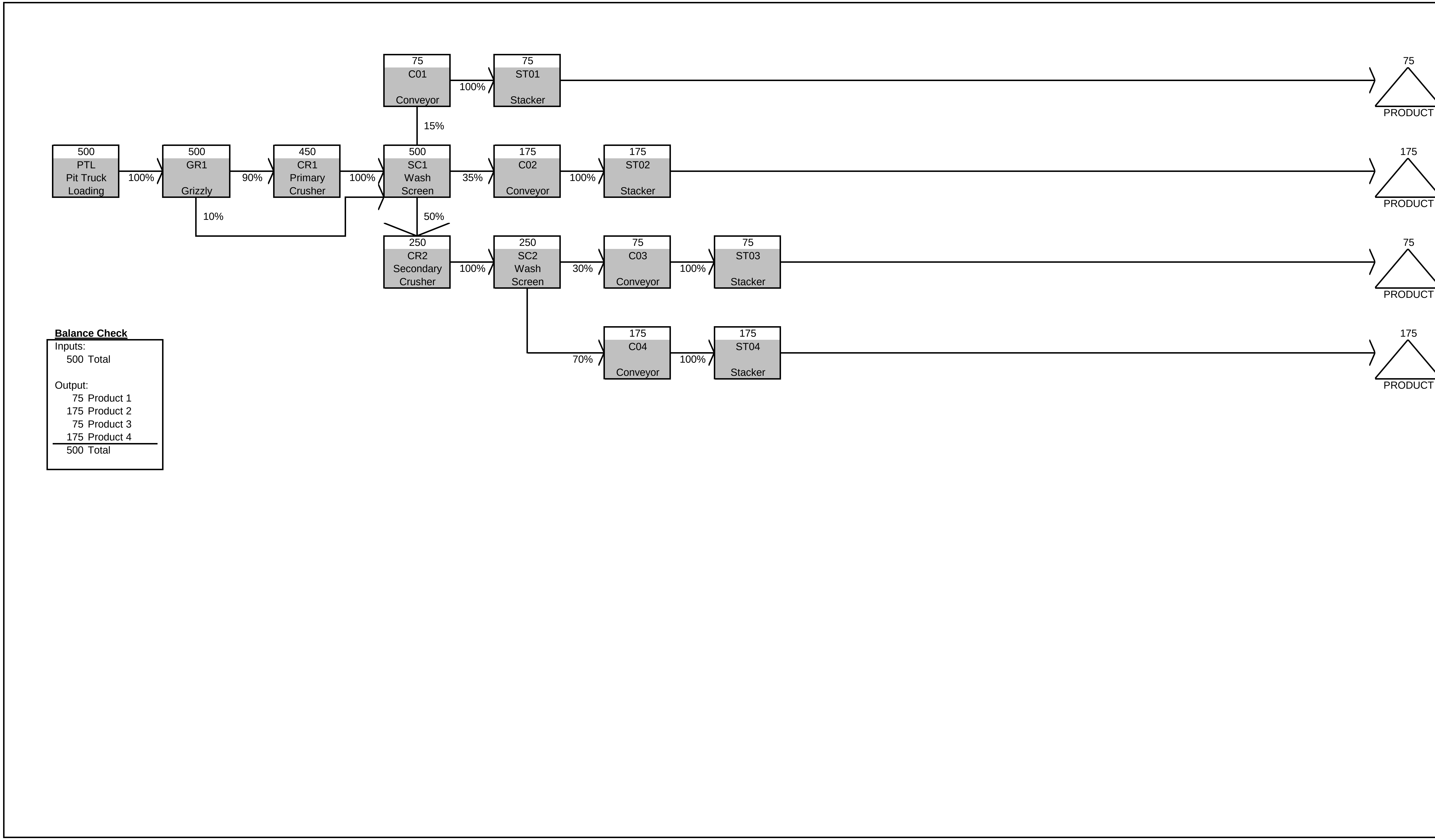
With Additional Background Concentrations

Receptor ID	Contaminant	Averaging Time (hours)	Maximum Predicted 24-Hour Concentration P1 (µg/m³)	P2 (µg/m³)	P3 (µg/m³)	Percentage of Relevant Criteria P1 (%)	P2 (%)	P3 (%)	Number of Predicted Excursions Above Criteria over 5 Years P1	P2	P3	Frequency of Predicted Excursions Above Criteria P1	P2	P3
R18	TSP	24	228	220	179	**190%**	**183%**	**149%**	**1**	**1**	**1**	**0.05%**	**0.05%**	**0.05%**
	PM10	24	50	49	66	**100%**	98%	**131%**	**1**	0	**1**	**0.05%**	0%	**0.05%**
	PM2.5	24	20	20	23	67%	65%	76%	0	0	0	0%	0%	0%
	NO2	1	227	224	236	57%	56%	59%	0	0	0	0%	0%	0%
		24	164	152	172	82%	76%	86%	0	0	0	0%	0%	0%
R19	TSP	24	207	136	123	**173%**	**114%**	**102%**	**13**	**4**	**1**	**0.7%**	**0.2%**	**0.05%**
	PM10	24	83	43	45	**166%**	85%	90%	**4**	0	0	**0.2%**	0%	0%
	PM2.5	24	33	20	19	**110%**	66%	64%	**1**	0	0	**0.05%**	0%	0%
	NO2	1	250	220	234	62%	55%	58%	0	0	0	0%	0%	0%
		24	164	122	153	82%	61%	76%	0	0	0	0%	0%	0%

Notes:

Shaded values in bold indicate excursions above the relevant crtieria

FIGURES



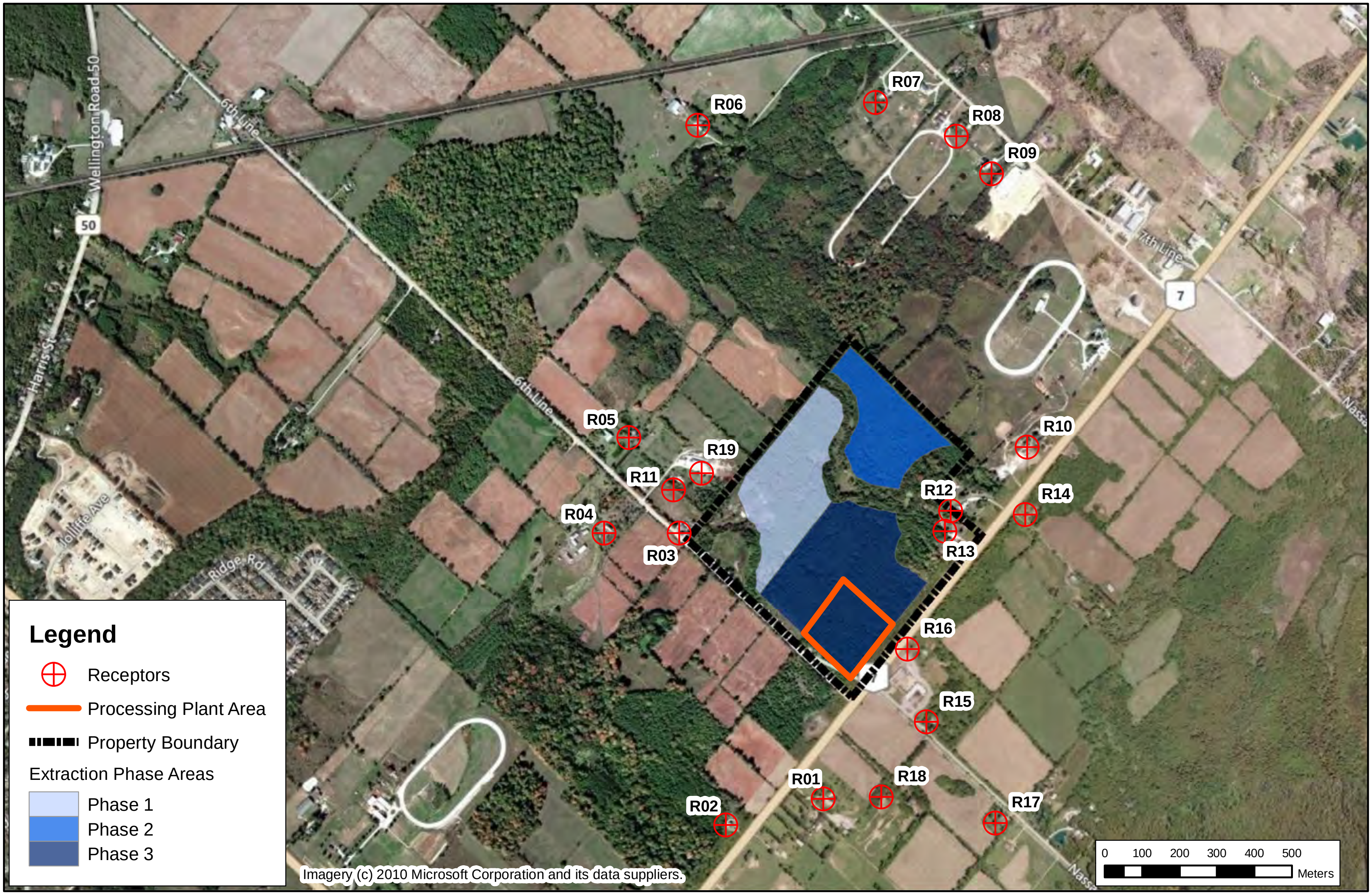
Process Flow Diagram

Hidden Quarry, Township of Guelph-Eramosa, Ontario

Project #1201429

Drawn by: BGS	Figure: **1.4**
Approx. Scale: not to scale	
Date Revised:	May 13, 2008

RWDI



Site Plan with Property Line and Receptor Locations
Showing Extraction Phases and Processing Area

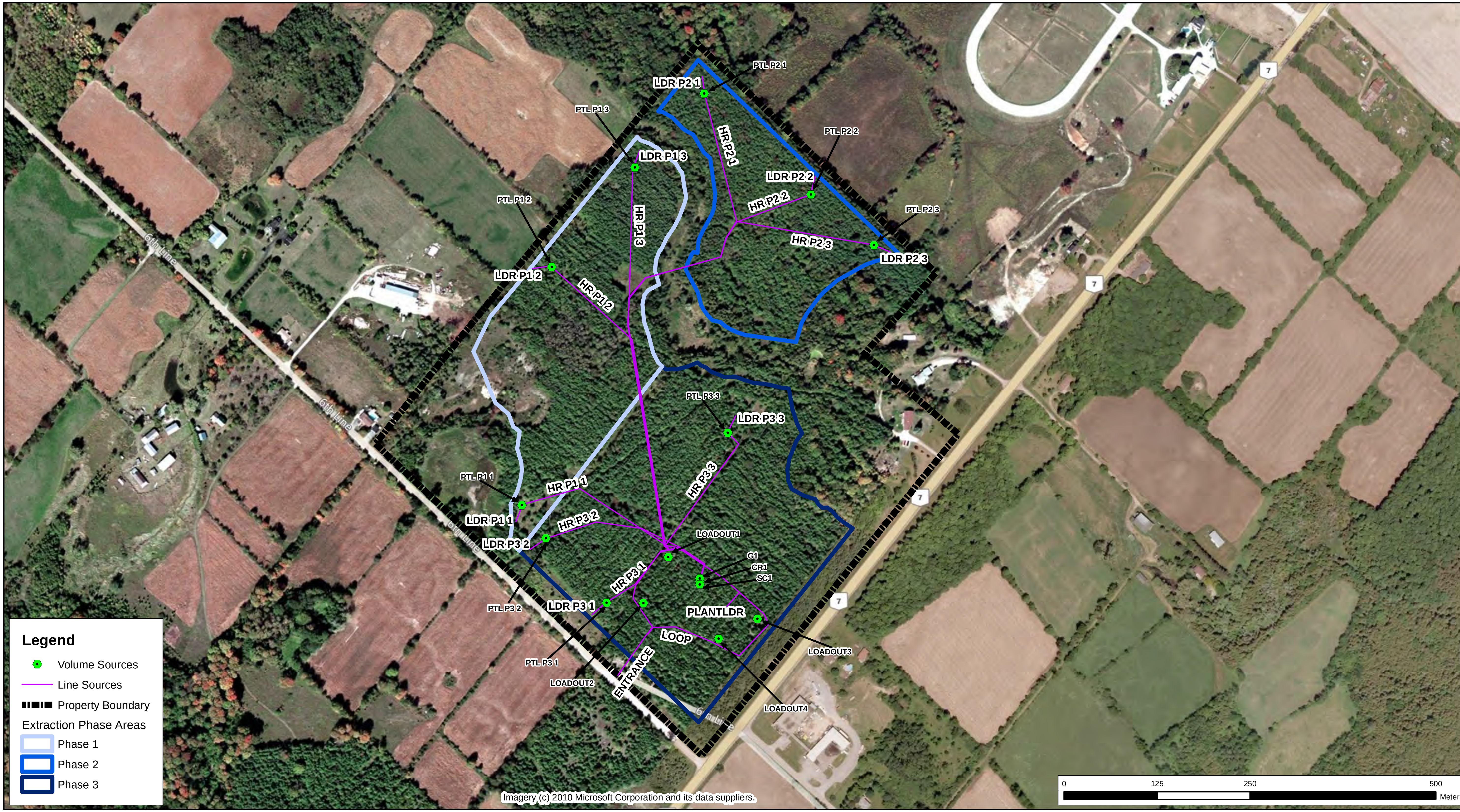
Hidden Quarry, Township of Guelph-Eramosa, Ontario

True North

Project #1201429

Drawn by: NBN	Fig: **5.2A**
Approx. Scale: 1:15,000	
Date Revised: Aug. 13, 2012	

RWDI



Site Plan Illustrating Air Quality Sources

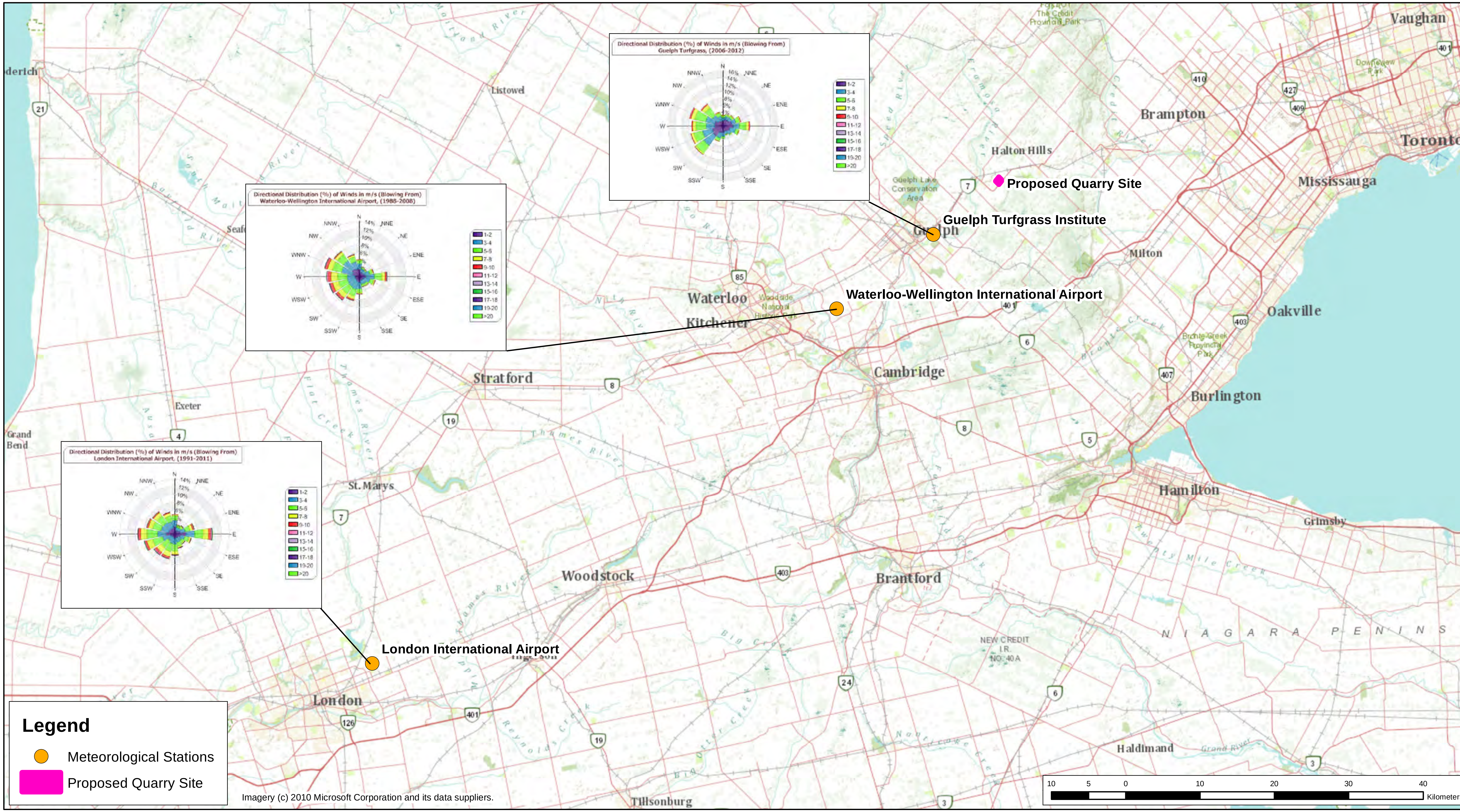
Hidden Quarry, Township of Guelph-Eramosa, Ontario

True North

Project #1201429

Drawn by: NBN	Fig: **5.2B**
Approx. Scale: 1:5,000	
Date Revised: Aug. 13, 2012	

RWDI



Local Wind Climate - Annual Wind Roses
for Waterloo-Wellington International Airport and the Guelph Turfgrass Institute

Hidden Quarry, Township of Guelph-Eramosa, Ontario

True North

Project #1201429

Drawn by: NBN	Fig: **6.1.1**
Approx. Scale:	1:500,000
Date Revised:	Aug. 13, 2012

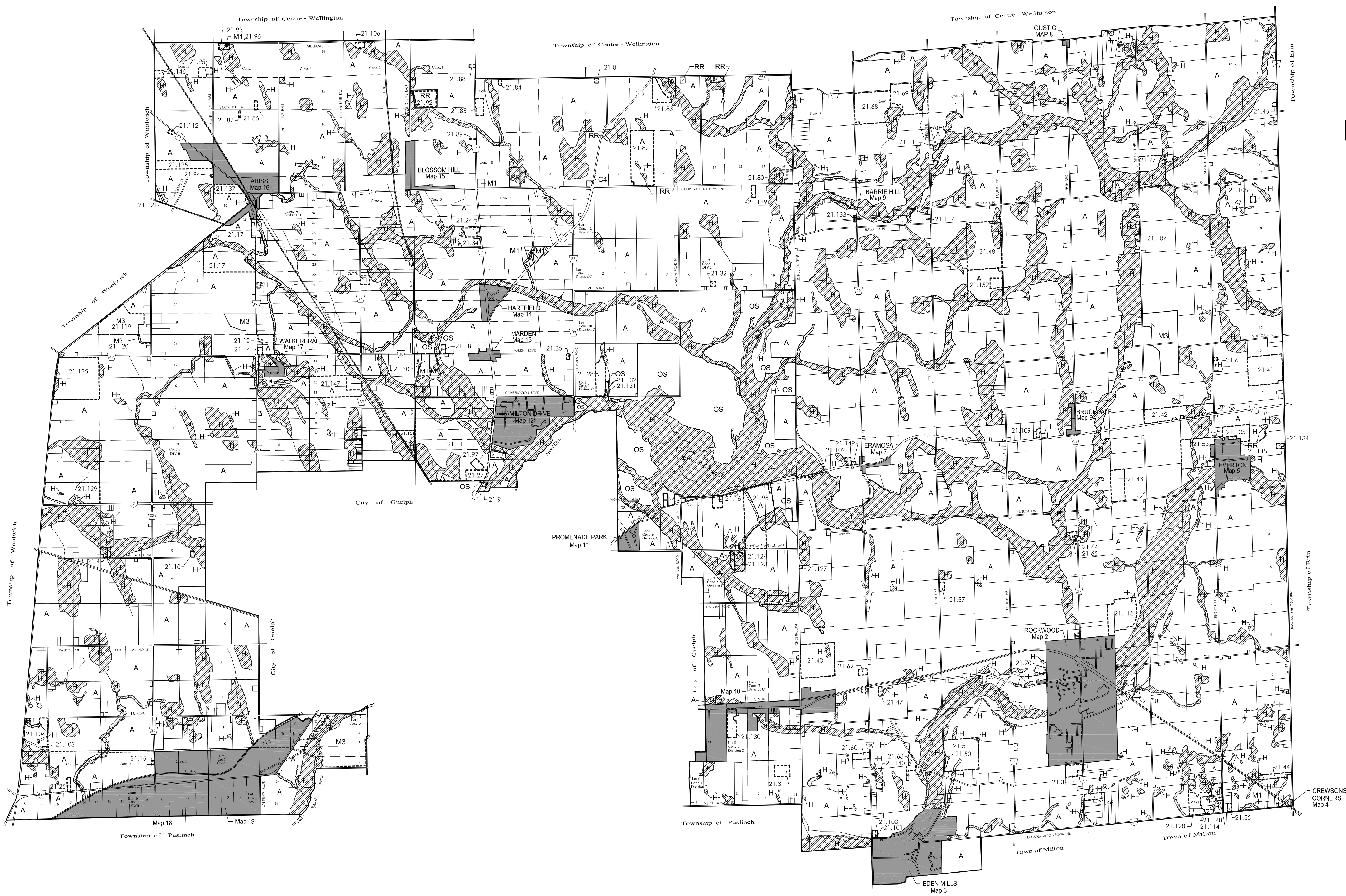
RWDI

FIGURE 6.2

TOWNSHIP OF GUELPH / ERAMOSA ZONING BY-LAW

Schedule "A" to By-law Number 57/1999

Map 1



LEGEND

- A Agricultural
- R1 Village Residential Low Density
- R2 Village Residential Medium Density
- RR Rural Residential
- C1 Village Commercial
- C2 Village Service Commercial
- C3 Hamlet Mixed Use
- C4 Highway Commercial
- I Institutional
- M1 Rural Industrial
- M2 Agricultural Business
- M3 Extractive Industrial
- M4 Disposal Industrial
- OS Open Space
- H Hazard
- 21.__ Special Provisions

NOTE: THIS SCHEDULE TO BE READ IN CONJUNCTION WITH APPLICABLE SECTIONS OF THE BY-LAW.

CONSOLIDATED TO DECEMBER 31,2009

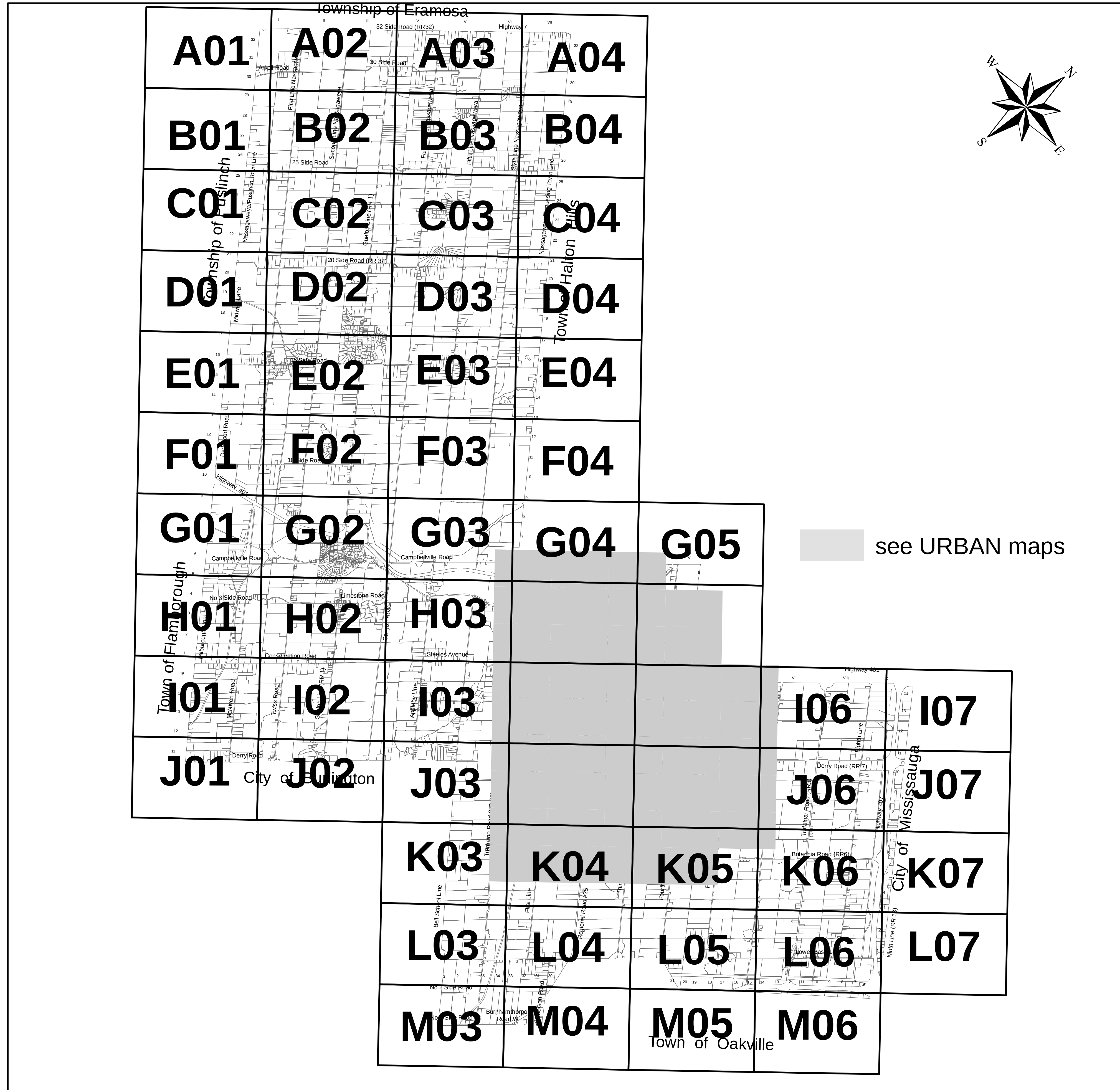
PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
MHBC PLANNING
200-540 BINGEMANS CENTRE DR. KITCHENER, ON. N2B 3X9
P: 519 576 3650 F: 519 576 0121
WWW.MHBCPLAN.COM

K:\9902\9902C-GUELPH-ERAMOSA-ZONING\SCHEDULES DECEMBER 2009\A-1.DWG L.H.B.

Town of Milton - Zoning By-Law 144-2003
RURAL AREA

Consolidated June 2009

Last Mapping Updates: July 19, 2010



DISCLAIMER:

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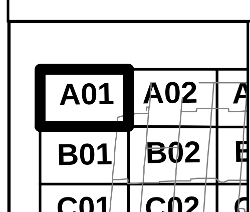
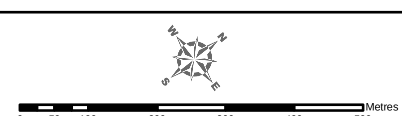
Further, these maps should be read in conjunction with the document "The Town of Milton Comprehensive Zoning By-law 144-2003", as amended from time to time.





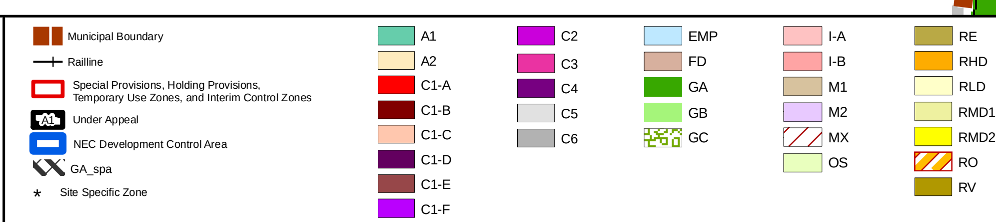
Sheet A01

Town of Milton - Zoning By-Law 144-2003

RURAL AREA

Consolidated June 2009

Date of Last Revision: July 19, 2010



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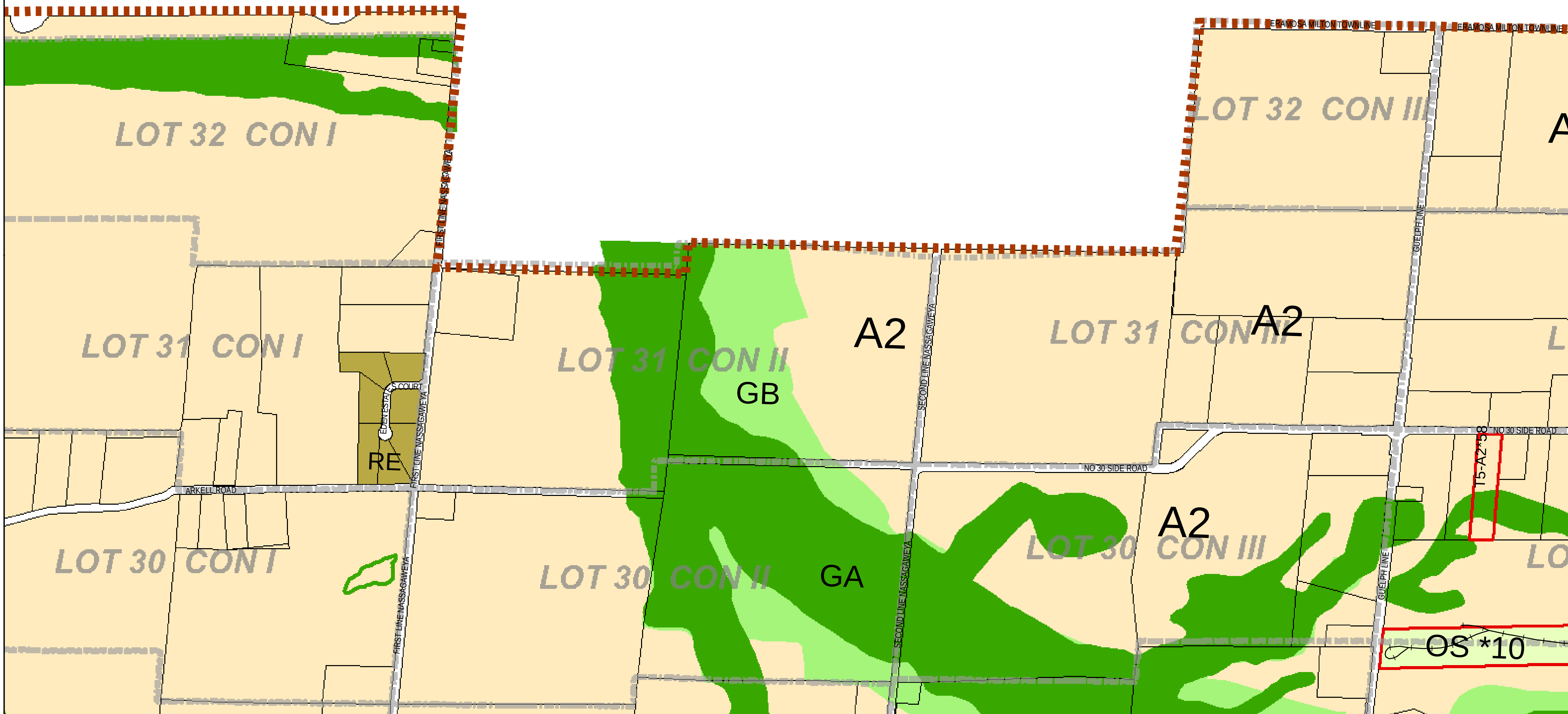

A01	A02	A03
B01	B02	B03
C01	C02	C03

Metres 0 50 100 200 300 400 500

Sheet A02

Town of Milton - Zoning By-Law 144-2003
RURAL AREA
Consolidated June 2009

Date of Last Revision: July 19, 2010

- Municipal Boundary
- Railline
- Special Provisions, Holding Provisions, Temporary Use Zones, and Interim Control Zones
- Under Appeal
- NEC Development Control Area
- GA_spa
- * Site Specific Zone

A1, A2, C1-A, C1-B, C1-C, C1-D, C1-E, C1-F, C2, C3, C4, C5, C6, EMP, FD, GA, GB, GC, I-A, I-B, M1, M2, MX, OS, RE, RHD, RLD, RMD1, RMD2, RO, RV

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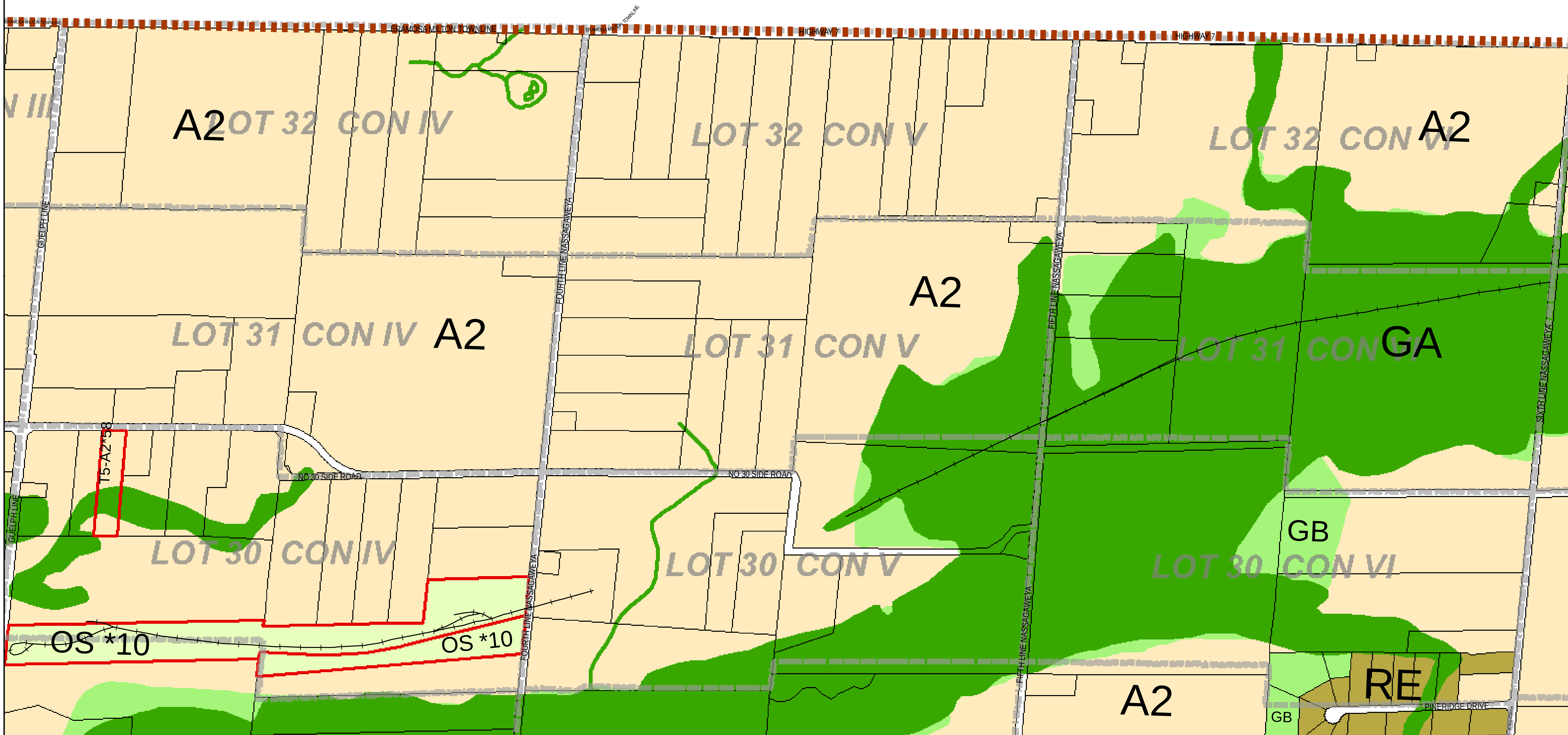

A02	A03	A04
B02	B03	B04
C02	C03	C04

0 50 100 200 300 400 500 Metres

Sheet A03

Town of Milton - Zoning By-Law 144-2003

RURAL AREA

Consolidated June 2009

Date of Last Revision: July 19, 2010

- Municipal Boundary
- Railline
- Special Provisions, Holding Provisions, Temporary Use Zones, and Interim Control Zones
- Under Appeal
- NEC Development Control Area
- GA_spa
- * Site Specific Zone

A1, A2, C1-A, C1-B, C1-C, C1-D, C1-E, C1-F, C2, C3, C4, C5, C6, EMP, FD, GA, GB, GC, I-A, I-B, M1, M2, MX, OS, RE, RHD, RLD, RMD1, RMD2, RO, RV

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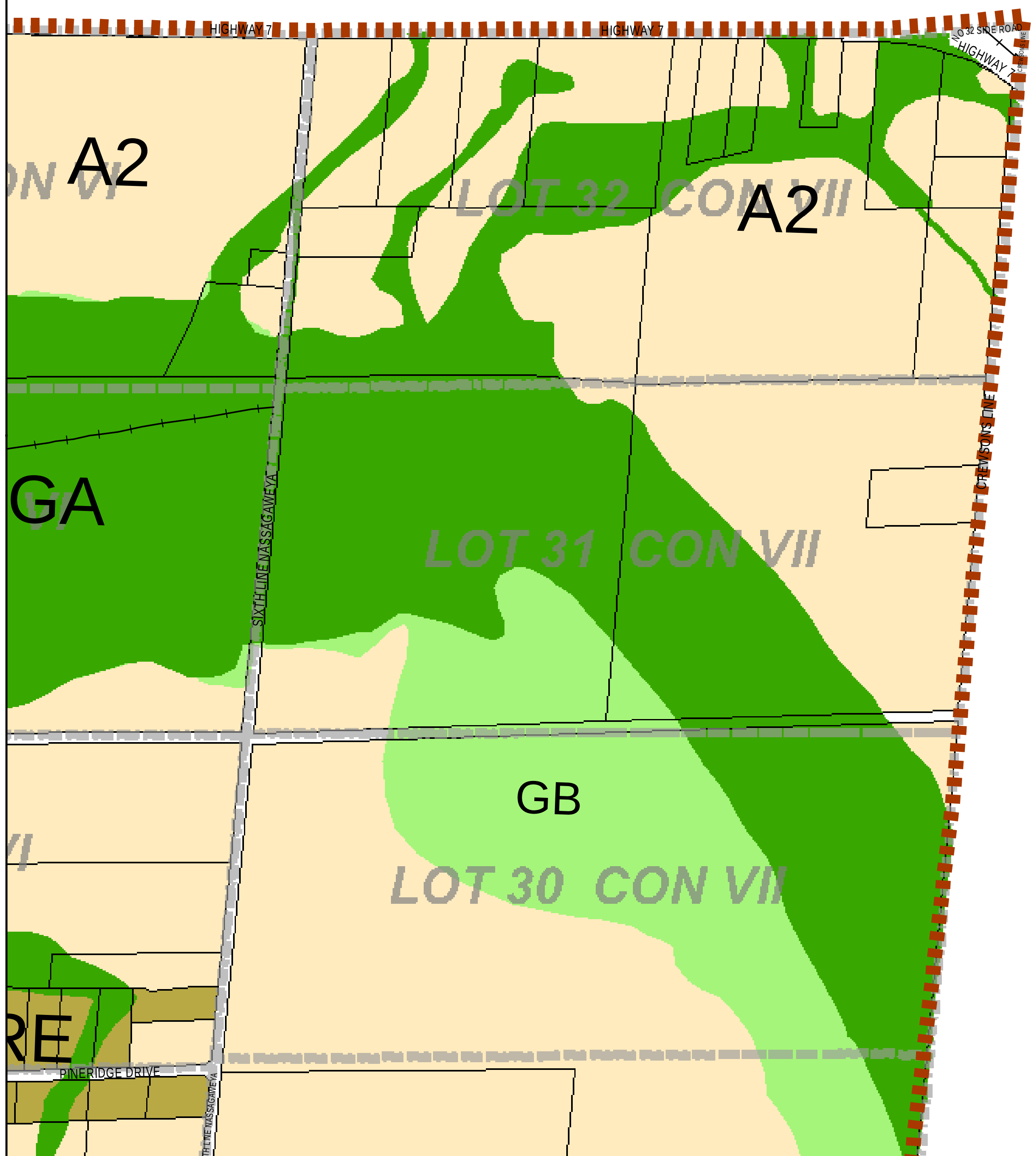

2	A03	**A04**
2	B03	B04
2	C03	C04

0 50 100 200 300 400 500 Metres

Sheet A04

Town of Milton - Zoning By-Law 144-2003

RURAL AREA

Consolidated June 2009

Date of Last Revision: July 19, 2010

- Municipal Boundary
- Railline
- Special Provisions, Holding Provisions, Temporary Use Zones, and Interim Control Zones
- A1 Under Appeal
- NEC Development Control Area
- GA_spa
- * Site Specific Zone

A1, A2, C1-A, C1-B, C1-C, C1-D, C1-E, C1-F, C2, C3, C4, C5, C6, EMP, FD, GA, GB, GC, I-A, I-B, M1, M2, MX, OS, RE, RHD, RLD, RMD1, RMD2, RO, RV

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APPENDIX A

APPENDIX B

CRUSHED STONE PROCESSING & PULVERIZED MINERAL PROCESSING - AP-42 Section 11.19.2.1 - See Appendix B4 for Input Parameters

ID	Description	TSP			
		AP-42 Factor (kg/Mg)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
CR1	Primary Crusher	6.0E-04	0.0750	0.075	E
SC1	Screen	1.1E-03	0.1528	0.015	E
C01	Conveyor Transfer Point	7.0E-05	0.0015		E
ST01	Stacker	7.0E-05	0.0015		E
C02	Conveyor Transfer Point	7.0E-05	0.0034		E
ST02	Stacker	7.0E-05	0.0034		E
CR2	Secondary Crusher	6.0E-04	0.0417		E
SC2	Screen	1.1E-03	0.0764		E
C03	Conveyor Transfer Point	7.0E-05	0.0015		E
ST03	Stacker	7.0E-05	0.0015		E
C04	Conveyor Transfer Point	7.0E-05	0.0034		E
ST04	Stacker	7.0E-05	0.0034		E

BULK MATERIAL HANDLING / TRANSFER EMISSIONS - AP-42 Section 13.2.4 - See Appendix B5 for Input Parameters

ID	Description	TSP												
		AP-42 Emission Factor (with controls if applicable)						Emission Rate (with controls if applicable)						Data Quality
		1 (kg/Mg)	3 (kg/Mg)	5 (kg/Mg)	9 (kg/Mg)	11 (kg/Mg)	13 (kg/Mg)	1 (g/s)	3 (g/s)	5 (g/s)	9 (g/s)	11 (g/s)	13 (g/s)	
HTL_P1_1	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P1_2	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P1_3	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P2_1	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P2_2	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P2_3	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P3_1	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P3_2	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
HTL_P3_3	Haul Truck Loading at Working Face	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
GR1	Truck Dump at Grizzly	1.2E-04	4.9E-04	9.5E-04	2.0E-03	2.7E-03	3.3E-03	1.6E-02	6.8E-02	1.3E-01	2.8E-01	3.7E-01	4.6E-01	C
LOADOUT1	Loading Highway Trucks at Stockpile 1	4.0E-05	1.7E-04	3.2E-04	6.9E-04	9.0E-04	1.1E-03	8.3E-04	3.4E-03	6.7E-03	1.4E-02	1.9E-02	2.3E-02	B
LOADOUT2	Loading Highway Trucks at Stockpile 1	4.0E-05	1.7E-04	3.2E-04	6.9E-04	9.0E-04	1.1E-03	1.9E-03	8.0E-03	1.6E-02	3.4E-02	4.4E-02	5.4E-02	B
LOADOUT3	Loading Highway Trucks at Stockpile 1	4.0E-05	1.7E-04	3.2E-04	6.9E-04	9.0E-04	1.1E-03	8.3E-04	3.4E-03	6.7E-03	1.4E-02	1.9E-02	2.3E-02	B
LOADOUT4	Loading Highway Trucks at Stockpile 1	4.0E-05	1.7E-04	3.2E-04	6.9E-04	9.0E-04	1.1E-03	1.9E-03	8.0E-03	1.6E-02	3.4E-02	4.4E-02	5.4E-02	B

UNPAVED ROAD SECTIONS - AP-42 Section 13.2.1 & PAVED ROAD SECTIONS - AP-42 Section 13.2.2 - See Appendix B6 for Input Parameters

ID	Description	TSP			
		AP-42 Factor (g/VKT)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
LDR	Loader at Working Face	3918	2.5E+00	0.12	
HR_P1_1	Haul Truck Traffic from Phase 1	3918	9.1E+00	0.46	
HR_P1_2	Haul Truck Traffic from Phase 1	3918	1.6E+01	0.80	
HR_P1_3	Haul Truck Traffic from Phase 1	3918	1.8E+01	0.91	
HR_P2_1	Haul Truck Traffic from Phase 2	3918	2.4E+01	1.22	
HR_P2_2	Haul Truck Traffic from Phase 2	3918	2.2E+01	1.10	
HR_P2_3	Haul Truck Traffic from Phase 2	3918	2.4E+01	1.22	
HR_P3_1	Haul Truck Traffic from Phase 3	3918	6.1E+00	0.30	
HR_P3_2	Haul Truck Traffic from Phase 3	3918	7.9E+00	0.40	
HR_P3_3	Haul Truck Traffic from Phase 3	3918	8.4E+00	0.42	
PLNTLDR	Plant Loader	3918	2.5E+00	0.12	
LOOP	Highway Truck Traffic	147	3.1E-01	0.31	
ENTRANCE	Highway Truck Traffic	147	8.0E-02	0.08	

Appendix B2: Summary of Fugitive Emissions - PM_{10}

Project #1201429

JDCL - Hidden Quarry

CRUSHED STONE PROCESSING & PULVERIZED MINERAL PROCESSING - AP-42 Section 11.19.2.1 - See Appendix B4 for Input Parameters

ID	Description	PM_{10} AP-42 Factor (kg/Mg)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
CR1	Primary Crusher	2.7E-04	3.4E-02	3.4E-02	E
SC1	Screen	3.8E-04	5.3E-02	5.3E-03	C
C01	Conveyor Transfer Point	2.3E-05	4.8E-04		D
ST01	Stacker	2.3E-05	4.8E-04		D
C02	Conveyor Transfer Point	2.3E-05	1.1E-03		D
ST02	Stacker	2.3E-05	1.1E-03		D
CR2	Secondary Crusher	2.7E-04	1.9E-02		E
SC2	Screen	3.8E-04	2.6E-02		C
C03	Conveyor Transfer Point	2.3E-05	4.8E-04		D
ST03	Stacker	2.3E-05	4.8E-04		D
C04	Conveyor Transfer Point	2.3E-05	1.1E-03		D
ST04	Stacker	2.3E-05	1.1E-03		D

BULK MATERIAL HANDLING / TRANSFER EMISSIONS - AP-42 Section 13.2.4 - See Appendix B5 for Input Parameters

ID	Description	PM_{10} AP-42 Emission Factor (with controls if applicable) 1 (kg/Mg)	3 (kg/Mg)	5 (kg/Mg)	9 (kg/Mg)	11 (kg/Mg)	13 (kg/Mg)	Emission Rate (with controls if applicable) 1 (g/s)	3 (g/s)	5 (g/s)	9 (g/s)	11 (g/s)	13 (g/s)	Data Quality
HTL_P1_1	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P1_2	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P1_3	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P2_1	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P2_2	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P2_3	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P3_1	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P3_2	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
HTL_P3_3	Haul Truck Loading at Working Face	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
GR1	Truck Dump at Grizzly	5.6E-05	2.3E-04	4.5E-04	9.7E-04	1.3E-03	1.6E-03	7.7E-03	3.2E-02	6.3E-02	1.3E-01	1.7E-01	2.2E-01	C
LOADOUT1	Loading Highway Trucks at Stockpile 1	1.9E-05	7.8E-05	1.5E-04	3.3E-04	4.2E-04	5.3E-04	3.9E-04	1.6E-03	3.2E-03	6.8E-03	8.8E-03	1.1E-02	B
LOADOUT2	Loading Highway Trucks at Stockpile 1	1.9E-05	7.8E-05	1.5E-04	3.3E-04	4.2E-04	5.3E-04	9.1E-04	3.8E-03	7.4E-03	1.6E-02	2.1E-02	2.6E-02	B
LOADOUT3	Loading Highway Trucks at Stockpile 1	1.9E-05	7.8E-05	1.5E-04	3.3E-04	4.2E-04	5.3E-04	3.9E-04	1.6E-03	3.2E-03	6.8E-03	8.8E-03	1.1E-02	B
LOADOUT4	Loading Highway Trucks at Stockpile 1	1.9E-05	7.8E-05	1.5E-04	3.3E-04	4.2E-04	5.3E-04	9.1E-04	3.8E-03	7.4E-03	1.6E-02	2.1E-02	2.6E-02	B

UNPAVED ROAD SECTIONS - AP-42 Section 13.2.1 & PAVED ROAD SECTIONS - AP-42 Section 13.2.2 - See Appendix B6 for Input Parameters

ID	Description	PM_{10} AP-42 Factor (g/VKT)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
LDR	Loader at Working Face	1114	7.0E-01	3.5E-02	
HR_P1_1	Haul Truck Traffic from Phase 1	1114	2.6E+00	1.3E-01	
HR_P1_2	Haul Truck Traffic from Phase 1	1114	4.5E+00	2.3E-01	
HR_P1_3	Haul Truck Traffic from Phase 1	1114	5.2E+00	2.6E-01	
HR_P2_1	Haul Truck Traffic from Phase 2	1114	6.9E+00	3.5E-01	
HR_P2_2	Haul Truck Traffic from Phase 2	1114	6.3E+00	3.1E-01	
HR_P2_3	Haul Truck Traffic from Phase 2	1114	6.9E+00	3.5E-01	
HR_P3_1	Haul Truck Traffic from Phase 3	1114	1.7E+00	8.7E-02	
HR_P3_2	Haul Truck Traffic from Phase 3	1114	2.3E+00	1.1E-01	
HR_P3_3	Haul Truck Traffic from Phase 3	1114	2.4E+00	1.2E-01	
PLNTLDR	Plant Loader	1114	7.0E-01	3.5E-02	
LOOP	Highway Truck Traffic	28	5.9E-02	5.9E-02	
ENTRANCE	Highway Truck Traffic	28	1.5E-02	1.5E-02	

Appendix B3: Summary of Fugitive Emissions - $PM_{2.5}$

Project #1201429

JDCL - Hidden Quarry

CRUSHED STONE PROCESSING & PULVERIZED MINERAL PROCESSING - AP-42 Section 11.19.2.1 - See Appendix B4 for Input Parameters

ID	Description	$PM_{2.5}$ AP-42 Factor (kg/Mg)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
CR1	Primary Crusher	5.0E-05	6.3E-03	6.3E-03	E
SC1	Screen	2.5E-05	3.5E-03	3.5E-04	E
C01	Conveyor Transfer Point	6.5E-06	1.4E-04		E
ST01	Stacker	6.5E-06	1.4E-04		E
C02	Conveyor Transfer Point	6.5E-06	3.2E-04		E
ST02	Stacker	6.5E-06	3.2E-04		E
CR2	Secondary Crusher	5.0E-05	3.5E-03		E
SC2	Screen	2.5E-05	1.7E-03		E
C03	Conveyor Transfer Point	6.5E-06	1.4E-04		E
ST03	Stacker	6.5E-06	1.4E-04		E
C04	Conveyor Transfer Point	6.5E-06	3.2E-04		E
ST04	Stacker	6.5E-06	3.2E-04		E

BULK MATERIAL HANDLING / TRANSFER EMISSIONS - AP-42 Section 13.2.4 - See Appendix B5 for Input Parameters

ID	Description	$PM_{2.5}$ AP-42 Emission Factor						Emission Rate						Data Quality
		1 (kg/Mg)	3 (kg/Mg)	5 (kg/Mg)	9 (kg/Mg)	11 (kg/Mg)	13 (kg/Mg)	1 (g/s)	3 (g/s)	5 (g/s)	9 (g/s)	11 (g/s)	13 (g/s)	
HTL_P1_1	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P1_2	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P1_3	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P2_1	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P2_2	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P2_3	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P3_1	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P3_2	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
HTL_P3_3	Haul Truck Loading at Working Face	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
GR1	Truck Dump at Grizzly	8.4E-06	3.5E-05	6.8E-05	1.5E-04	1.9E-04	2.4E-04	1.2E-03	4.9E-03	9.5E-03	2.0E-02	2.6E-02	3.3E-02	C
LOADOUT1	Loading Highway Trucks at Stockpile 1	2.8E-06	1.2E-05	2.3E-05	4.9E-05	6.4E-05	8.0E-05	5.9E-05	2.5E-04	4.8E-04	1.0E-03	1.3E-03	1.7E-03	B
LOADOUT2	Loading Highway Trucks at Stockpile 1	2.8E-06	1.2E-05	2.3E-05	4.9E-05	6.4E-05	8.0E-05	1.4E-04	5.8E-04	1.1E-03	2.4E-03	3.1E-03	3.9E-03	B
LOADOUT3	Loading Highway Trucks at Stockpile 1	2.8E-06	1.2E-05	2.3E-05	4.9E-05	6.4E-05	8.0E-05	5.9E-05	2.5E-04	4.8E-04	1.0E-03	1.3E-03	1.7E-03	B
LOADOUT4	Loading Highway Trucks at Stockpile 1	2.8E-06	1.2E-05	2.3E-05	4.9E-05	6.4E-05	8.0E-05	1.4E-04	5.8E-04	1.1E-03	2.4E-03	3.1E-03	3.9E-03	B

UNPAVED ROAD SECTIONS - AP-42 Section 13.2.1 & PAVED ROAD SECTIONS - AP-42 Section 13.2.2 - See Appendix B6 for Input Parameters

ID	Description	$PM_{2.5}$ AP-42 Factor (g/VKT)	Emission Rate (g/s)	Controlled Emission Rate (g/s)	Data Quality
LDR	Loader at Working Face	111	7.0E-02	3.5E-03	
HR_P1_1	Haul Truck Traffic from Phase 1	111	2.6E-01	1.3E-02	
HR_P1_2	Haul Truck Traffic from Phase 1	111	4.6E-01	2.3E-02	
HR_P1_3	Haul Truck Traffic from Phase 1	111	5.2E-01	2.6E-02	
HR_P2_1	Haul Truck Traffic from Phase 2	111	6.9E-01	3.5E-02	
HR_P2_2	Haul Truck Traffic from Phase 2	111	6.3E-01	3.1E-02	
HR_P2_3	Haul Truck Traffic from Phase 2	111	6.9E-01	3.5E-02	
HR_P3_1	Haul Truck Traffic from Phase 3	111	1.7E-01	8.7E-03	
HR_P3_2	Haul Truck Traffic from Phase 3	111	2.3E-01	1.1E-02	
HR_P3_3	Haul Truck Traffic from Phase 3	111	2.4E-01	1.2E-02	
PLNTLDR	Plant Loader	111	7.0E-02	3.5E-03	
LOOP	Highway Truck Traffic	7	1.4E-02	1.4E-02	
ENTRANCE	Highway Truck Traffic	6.8	3.7E-03	3.7E-03	

Appendix B4: Crushed Stone Processing & Pulverized Mineral Processing Emissions Spreadsheet

Project #1201429

JDCL - Hidden Quarry

Input Required
Calculated Value / Do Not Edit
Comment required
Table Heading (do not edit)

CRUSHED STONE PROCESSING & PULVERIZED MINERAL PROCESSING - AP-42 Section 11.19.2

ID [1]	Process Name / Description	AP-42 Process Description	Process Code [2]	Processing Rate			Control Efficiency Applied [4] (%)	Comments
				Hourly (Mg/h)	Daily (Mg/d)	Annual (Mg/a)		
CR1	Primary Crusher	Primary crushing (controlled)	6	450				
SC1	Screen	Screening (controlled)	2	500			90%	full enclosures
C01	Conveyor Transfer Point	Conveyor transfer point (controlled)	14	75			100%	wash plant, material is saturated
ST01	Stacker	Conveyor transfer point (controlled)	14	75			100%	wash plant, material is saturated
C02	Conveyor Transfer Point	Conveyor transfer point (controlled)	14	175			100%	wash plant, material is saturated
ST02	Stacker	Conveyor transfer point (controlled)	14	175			100%	wash plant, material is saturated
CR2	Secondary Crusher	Secondary crushing (controlled)	7	250			100%	wash plant, material is saturated
SC2	Screen	Screening (controlled)	2	250			100%	wash plant, material is saturated
C03	Conveyor Transfer Point	Conveyor transfer point (controlled)	14	75			100%	wash plant, material is saturated
ST03	Stacker	Conveyor transfer point (controlled)	14	75			100%	wash plant, material is saturated
C04	Conveyor Transfer Point	Conveyor transfer point (controlled)	14	175			100%	wash plant, material is saturated
ST04	Stacker	Conveyor transfer point (controlled)	14	175			100%	wash plant, material is saturated

[1] ID corresponds to process flow diagram for facility and / or material
[2] Process code used by spreadsheet to pull correct factor based on slected activity - does not require entry.
[3] Enter the control efficiency for each source - if no controls are applied, leave blank

Appendix B5: Bulk Material Handling Emissions Spreadsheet

Project #1201429

JDCL - Hidden Quarry

TRANSFER EMISSIONS - AP-42 Section 13.2.4

Average recorded hourly wind speed (m/s): 3.67 **[1]**

Drop operation emissions: $E = 0.0016\ k\ (U / 2.2)^{1.3} / (M / 2)^{1.4}$

E emission factor
k particle size multiplier (0.74, 0.35 and 0.053 for TSP, PM_{10} and $PM_{2.5}$)
U mean wind speed, meters per second (m/s)
M material moisture content (%)

Input Required
Calculated Value / Do Not Edit
Comment required
Table Heading (do not edit)

Handling Information [2]		Processing Rate			Site Data [3]				Controls	
ID [4]	Description	Hourly (Mg/h)	Daily (Mg/d)	Annual (Mg/y)	Site Specific Data? (y/n)	Silt Content (%)	Moisture Content (%)	Source Conditions Valid [5]	Control Efficiency Applied [6] (%)	Comments
HTL_P1_1	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P1_2	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P1_3	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P2_1	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P2_2	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P2_3	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P3_1	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P3_2	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
HTL_P3_3	Haul Truck Loading at Working Face	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
GR1	Truck Dump at Grizzly	500			n	3.9%	5.0%	moisture too high		higher moisture assumed for extracted material
LOADOUT1	Loading Highway Trucks at Stockpile 1	75			n	3.9%	2.1%	valid	90%	Washed stone
LOADOUT2	Loading Highway Trucks at Stockpile 1	175			n	3.9%	2.1%	valid	90%	Washed stone
LOADOUT3	Loading Highway Trucks at Stockpile 1	75			n	3.9%	2.1%	valid	90%	Washed stone
LOADOUT4	Loading Highway Trucks at Stockpile 1	175			n	3.9%	2.1%	valid	90%	Washed stone

[1] Obtained from local meteorological data set
[2] Enter specific information regarding sources and handling rates.
[3] Data from Table 13.2.4-1 in AP-42 unless otherwise specified.
[4] ID corresponds to process flow diagram for facility and / or material
[5] Relates to AP-42 Section 13.2.4-4
[6] Enter the control efficiency for each source - if no controls are applied, leave blank

Appendix B6: On-Site Mobile Equipment Emissions Input Data

Project #1201429

JDCL - Hidden Quarry

UNPAVED ROAD SECTIONS - AP-42 Section 13.2.2
PAVED ROAD SECTIONS - AP-42 Section 13.2.1

Paved Roads: $E = k\ (sL)^{0.91}\ (W)^{1.02}$
Unpaved Roads - Industrial: $E = 281.9\ k\ (s / 12)^{a}\ (W / 3)^{b}$
Unpaved Roads - Public: $E = 281.9\ k\ (s / 12)^{a}\ (S / 30)^{d} / (M / 0.5)^{c} - C$

E particulate emission factor (g/VKT)
k particle size multiplier (see below)
sL road surface silt loading (g/m²)
W average weight of the vehicles traveling the road (US short tons)
s surface material silt content (%)
C emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear
M surface material moisture content (%)
S mean vehicle speed (mph)
a,b,c,d constants (see below)

Input Required
Calculated Value / Do Not Edit
Comment required
Table Heading (do not edit)

ID [1]	Route	Traffic Passes Hourly (passes/h)	Traffic Passes Daily (passes/d)	Traffic Passes Annual (passes/a)	Segment Length [2] (m)	Paved? (y/n)	Is Roadway "industrial" or "public" [3]	Mean Vehicle Speed (km/h)	Mean Vehicle Speed (mph)	Average Vehicle Weight [4] (tons)	Surface Material Moisture Content [5] (%)	Surface Silt Content [6] (%)	Road Surface Silt Loading [7] (g/m²)	Control Efficiency Applied [8] (%)	Comments
LDR	Loader at Working Face	91			25	N	Industrial	25	16	54		8.3%		95%	Assumes Cat 988 Loader (11 tonne payload)
HR_P1_1	Haul Truck Traffic from Phase 1	28			300	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P1_2	Haul Truck Traffic from Phase 1	28			525	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P1_3	Haul Truck Traffic from Phase 1	28			600	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P2_1	Haul Truck Traffic from Phase 2	28			800	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P2_2	Haul Truck Traffic from Phase 2	28			725	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P2_3	Haul Truck Traffic from Phase 2	28			800	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P3_1	Haul Truck Traffic from Phase 3	28			200	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P3_2	Haul Truck Traffic from Phase 3	28			260	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
HR_P3_3	Haul Truck Traffic from Phase 3	28			275	N	Industrial	25	16	54		8.3%		95%	71 tonne GVW, 35 tonne payload (similar to Cat 770)
PLNTLDR	Plant Loader	91			25	N	Industrial	25	16	54		8.3%		95%	Assumes Cat 988 Loader (11 tonne payload)
LOOP	Highway Truck Traffic	13			575	Y	Industrial	25	16	36			1.2		5% tandems, 20% tri-axles, 50% tri-axle trailers, 25% tri-axle trains
ENTRANCE	Highway Truck Traffic	26			75	Y	Industrial	25	16	36			1.2		5% tandems, 20% tri-axles, 50% tri-axle trailers, 25% tri-axle trains

Constants for Mobile Emission Equations

Roadway Type	Contaminant	k	a	b	c	d	Quality
Paved Roads:	$PM_{2.5}$	0.15	-	-	-	-	-
	PM_{10}	0.62	-	-	-	-	-
	TSP	3.23	-	-	-	-	-
Unpaved Roads - Industrial:	$PM_{2.5}$	0.15	0.9	0.45	-	-	C
	PM_{10}	1.5	0.9	0.45	-	-	B
	TSP	4.9	0.7	0.45	-	-	B
Unpaved Roads - Public:	$PM_{2.5}$	0.18	1	-	0.2	0.5	C
	PM_{10}	1.8	1	-	0.2	0.5	B
	TSP	6	1	-	0.3	0.3	B

[1] Route ID numbers provided on site plan.
[2] Number of passes in a 1-hour period. For the all traffic except the shipping trucks, this value reflects travel in both directions.
[3] Publicly accessible and dominated by light vehicles, or industrial, and dominated by heavy vehicles.
[4] For the all traffic except the shipping trucks, the average weight reflects the average of the empty and loaded vehicle weight, for travel in both directions.
[5] Required only for publicly accessible unpaved roads. Data from Table 13.2.2-3 in AP-42 unless otherwise specified.
[6] Required only for unpaved roads (public and industrial). Data from Table 13.2.2-1 in AP-42 unless otherwise specified.
[7] Required only for industrial paved roads. Data from Table 13.2.1-2 or 13.2.1-3 in AP-42 unless otherwise specified.
[8] Enter the control efficiency for each source - if no controls are applied, leave blank
[9] Requires input of MOBILE 6 emission factors for exhaust, brake wear and tire wear - if no MOBILE 6 data is available, ignore this section.

Appendix B7: Summary of Combustion Exhaust Emissions

JDCL - Hidden Quarry

Vehicle Type	Gross Power Rating (kW)	Hourly Round Trips	Round Trip Length (m)	Load Factor (%)	Number of Vehicles	Emission Factor NOx (g/vkt)	Emission Factor NOx (g/kW-h)	Emission Factor PM2.5 (g/vkt)	Emission Factor PM2.5 (g/kW-h)	Emission Factor PM10 (g/vkt)	Emission Factor PM10 (g/kW-h)	Emission Factor TSP (g/vkt)	Emission Factor TSP (g/kW-h)	Emission Rate NOx (g/s)	Emission Rate PM2.5 (g/s)	Emission Rate PM10 (g/s)	Emission Rate TSP (g/s)	Comments
Drag Line	373	n/a	n/a	53%	1	--	18.8	--	1.3	--	1.3	--	1.3	1.0	0.071	0.071	0.071	Cat D379 Engine (500hp), emission factors from AP-42, Chapter 3.3
Pit Loader	414	46	n/a	48%	1	--	4.0	--	0.2	--	0.2	--	0.2	0.22	0.011	0.011	0.011	Based on Cat 988 Loader
Haul Truck	381	14	n/a	58%	3	--	4.0	--	0.2	--	0.2	--	0.2	0.74	0.037	0.037	0.037	Based on Cat 770
Plant Loader	414	46	n/a	48%	1	--	4.0	--	0.2	--	0.2	--	0.2	0.22	0.011	0.011	0.011	Based on Cat 988 Loader
Highway Truck - entrance ramp	n/a	13	150	n/a	13	25.4	--	1.55	--	1.91	--	1.91	--	0.014	0.00080	0.0010	0.0010	Based on average load per truck of 33 tonnes
Highway Truck - loop road	n/a	13	575	n/a	13	25.4	--	1.55	--	1.91	--	1.91	--	0.053	0.0032	0.0040	0.0040	Based on average load per truck of 33 tonnes

Emission factor from highway trucks based on 20 km/h speed while on site, and obtained from U.S. EPA MOVES model.
Loader and Haul Trucks assumed to be Tier 3 Compliant (new Cat 988 Loaders meet Tier 3). Emissions based on Tier 3 standards
Load Factors from "Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling", EPA-420-R-10-016, NR-005d, July 2010
TSP and PM2.5 Emissions assumed to be equal to PM10 emissions unless otherwise noted.

Sample Calculations

Drag Line TSP Emissions:

$$\frac{373\ \text{kW}}{} \times \frac{1.3\ \text{g}}{1\ \text{kW h}} \times \frac{53\%\ \text{Load}}{} \times \frac{1\ \text{h}}{3600\ \text{s}} = 0.071$$

Highway Truck TSP Emissions:

$$\frac{13\ \text{Vehicles}}{1\ \text{h}} \times \frac{150\ \text{m}}{} \times \frac{1.91\ \text{g}}{1\ \text{Veh. Km}} \times \frac{1\ \text{km}}{1000\ \text{m}} \times \frac{1\ \text{h}}{3600\ \text{s}} = 0.0010$$

APPENDIX C

A Soil Moisture Climatology of Illinois

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ABSTRACT

Ten years of soil moisture measurements (biweekly from March through September and monthly during winter) within the top 1 m of soil at 17 grass-covered sites across Illinois are analyzed to provide a climatology of soil moisture for this important Midwest agricultural region. Soil moisture measurements were obtained with neutron probes that were calibrated for each site. Measurement errors are dependent upon the volumetric water content with errors less than 20 percent when soil moisture is above 10 percent of soil volume. Single point errors in moisture measurements from the top 1 m of soil range from 6 percent to 13 percent when volumetric soil moisture is 30 percent of soil volume. The average depletion in moisture between winter and summer over the 10-year period for the top 2 m of soil in Illinois was 72.3 mm. Three-quarters of this decrease occurred above 0.5 m and only 5 percent occurred between the 1.0-m and 2.0-m depths. The average moisture decrease between winter and summer during a wet year (1985) and a drought year (1988) in the top 2 m of soil was 64 percent and 204 percent of the average for the 10-year period, respectively. Seasonal means in soil moisture averaged for the state show the effects of different seasons and soil types on soil moisture. In the winter and spring a latitudinal gradient exists with the wetter soils in the southern part of the state. During summer and autumn there is a longitudinal gradient with the wetter soils in the eastern half of the state. The longitudinal gradient is closely associated with the depth of loess deposits. A north to south latitudinal gradient of soil moisture variability for the summer season is also evident in the 10 yr of records. A comparison of time series of soil moisture from sites with differing soil texture shows that a silty loam soil holds 2 to 3 times more water in the top 1 m than a loamy sand soil. Time series of soil moisture indicate that seasonal variations in water in the top 1 m at a grass-covered site was 1 to 2 times greater than at an adjacent nonvegetated site.

1. Introduction

Provision of the best possible climate information to public and private users is dependent, first and foremost, on the acquisition of high-quality data. The usefulness of this information depends on the selection of the appropriate climatic factors to measure. In addition, the quality of climatic information benefits greatly from an understanding of temporal and spatial patterns and relationships in the historical data (Lamb et al. 1985).

Soil moisture is an important climatic factor for which high-quality data demanded by users, especially in the agribusiness sector, is not generally available (Wendland and Vogel 1986; Kunkel 1990). Cognizance of the moisture content of the upper portion of the soil profile is critical to the scheduling of field efforts by farmers and is an important input to the crop yield models that are used by grain and brokerage companies and their consultants. Surface water management decisions are also based on knowledge of soil moisture content, especially when conditions are extreme. In addition, further refinement of general circulation models for comprehending man-induced climate processes and their implications depends to a large extent upon a better understanding of temporal and spatial distributions of a number of surface parameters, including moisture in the upper layer of the earth's surface (Delworth and Manabe 1988).

The dearth of accurate and timely soil moisture information is a direct result of the expense and difficulty of obtaining high-quality soil moisture measurements at useful temporal and spatial scales. For this reason, most soil moisture information is output from computer models that are based on a limited number of soil moisture measurements at a few sites over one or two growing seasons (e.g., Ritchie 1972; Robinson and Hubbard 1990; Kunkel 1990). An exception to this generalization is the unique dataset of gravimetric soil moisture measurements from sites with natural cover throughout the Soviet Union (Vinnikov and Yeserkepova 1991). Accurate and nondestructive measurements of soil moisture require the use of expensive

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electronic equipment such as a neutron probe or time domain reflectometry systems.

Accurate representation of soil moisture is difficult because of its large temporal and spatial variability. The physical properties that determine the moisture storage characteristics of soil vary tremendously over short distances, both vertically throughout the upper portion of a soil profile and horizontally across the earth's surface among soil units. Precipitation and groundwater inputs to the upper soil and evapotranspiration and deep percolation outputs of water from the soil are also highly variable both through time and across space.

In response to the increasing demand for accurate and timely climate information at fine temporal and spatial resolution, the Illinois State Water Survey initiated the Illinois Climate Network (ICN) in 1981. The ICN provides measurements of solar radiation, soil temperature and moisture, screen height temperature and humidity, and wind speed and direction on a continuous or (in the case of soil moisture) frequent basis. Since that time, a neutron probe system has been used to measure soil water content at each ICN site at regular intervals throughout the year with a fine vertical resolution to a depth of 2 m. By 1983, soil water content was being measured at 15 locations across the state and two more sites were added in 1986 (Fig. 1).

The purpose of this study is to analyze the patterns and relationships contained within this soil moisture data. Although this Illinois record is only 10 yr long, it is the most comprehensive set of continuous soil moisture measurements available for an important Midwest agricultural region. Analysis of these historical data should improve utilization of year-to-date and now-only soil moisture information by agribusiness and surface water managers, and provide large-area measures of soil moisture variability that could help improve crop-yield and general circulation models.

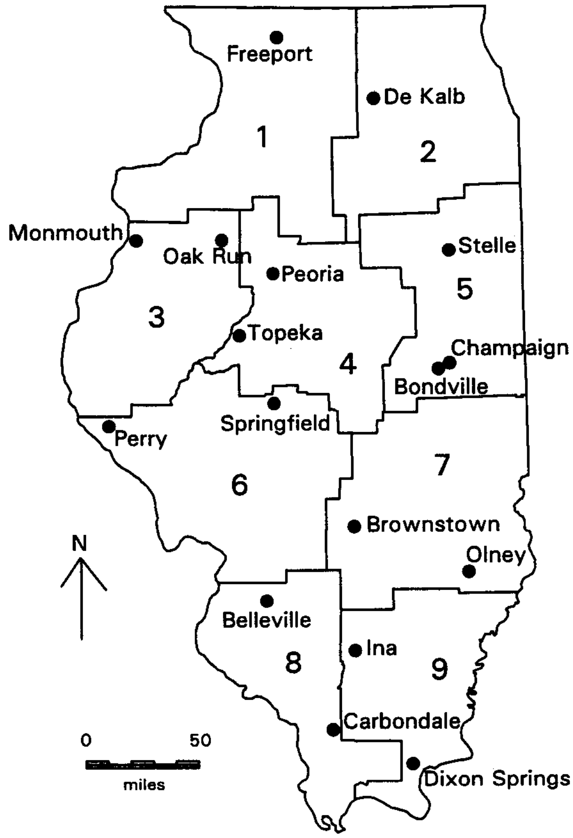


FIG. 1. Location of ICN soil moisture measurement sites throughout Illinois.

2. Data and methodology

The name, location, and beginning date of record for the ICN soil moisture measurement sites are provided in Table 1. The soils at each station (Table 2) are characteristic of the soils in the vicinity of the sites. With the exception of the Plainfield sand site at Topeka, the soil textures were predominately silty loam or silty clay loam.

Soil moisture was measured within grass plots using a Troxler[1] Neutron Depth Probe and a Troxler Neutron Surface Probe. Measurements were taken within 11 soil layers to a depth of 2 m; the first in the top 0.1 m of the profile, then every 0.2 m from a depth of 0.1 m through 1.9 m, and the last in the layer between 1.9 m and 2.0 m. Soil moisture in the top 0.1 m was measured with the surface neutron probe containing a neutron source and counter positioned parallel to the soil surface and covered by a heavy plastic shield. Neutrons from the surface probe are reflected to the counter from the top 0.1 to 0.15 m of soil. Soil moisture measurements from the soil layers below 0.1 m were obtained by lowering a neutron source and counter into a vertical, 0.058-m-diameter, aluminum tube permanently installed in the soil. The depth probe measures a spherical soil volume with a radius of 0.10 to 0.15 m.

Neutron probes use a source of high-energy neutrons and an electronic counter of low-energy neutrons to measure water content (Troxler Electronic Laboratories 1980). Collisions of high-energy neutrons preferentially with hydrogen nuclei from water molecules in the surrounding soil cause the high-energy neutrons to lose much of their energy and randomly reflect the lower-energy neutrons back to the counter. The counter records the number of low-energy neutrons reflected toward the access tube.

Because the mass of a neutron is similar to that of a hydrogen atom, hydrogen is the most effective element at slowing neutrons. Water and organic matter in the soil contain hydrogen atoms. Hydrogen atoms

[1] Reference to brand names or companies is made for information purposes only and does not imply endorsement of these companies or brands over any other company or brand.

TABLE 1. Name, location, and beginning date of record for Illinois soil moisture monitoring stations. The stations are listed in order from west to east and north to south across the state. Stations can be identified on the map in Fig. 1 by site name.

Site	County	Site code	Latitude (N)	Longitude (W)	Elevation (m)	Beginning of record
Freeport	Stephenson	FRE	42°14′	89°40′	265	15 Apr 1982
De Kalb	De Kalb	DEK	41°51′	88°51′	265	21 May 1981
Monmouth	Warren	MON	40°65′	90°41′	229	19 Jun 1981
Oak Run	Knox	OAK	40°58′	90°09′	265	1 Jun 1981
Peoria	Tazewell	ICC	40°42′	89°32′	207	25 Oct 1982
Stelle	Ford	STE	40°25′	89°19′	207	31 Mar 1986
Topeka	Mason	MTF	40°18′	89°54′	152	1 Jun 1981
Bondville	Champaign	BVL	40°03′	88°52′	213	19 Feb 1981
Champaign	Champaign	CMI	40°07′	88°14′	219	26 Jun 1986
Perry	Pike	ORR	39°48′	90°50′	206	6 May 1981
Springfield	Sangamon	LLC	39°31′	89°37′	177	22 Jul 1982
Brownstown	Fayette	BRW	38°57′	88°57′	177	30 Apr 1981
Olney	Richland	OLN	38°44′	88°06′	134	23 Jul 1982
Belleville	St. Clair	FRM	38°31′	89°53′	133	13 May 1982
Ina	Jefferson	RND	38°08′	88°55′	130	5 Aug 1982
Carbondale	Jackson	SIU	37°43′	89°14′	137	24 Nov 1982
Dixon Springs	Pope	DXG	37°27′	88°40′	165	29 Apr 1981

are also present as free ions that help determine the soil pH. Changes in organic matter and pH in soils usually occur gradually over many years. Consequently, there is generally a strong linear relationship between variations in soil water content and the neutron count ratio. The neutron count ratio is the number of slow neutrons reflected back to the counter from the soil divided by the number of slow neutrons reflected back to the counter from a dense plastic shield that serves as a standard. However, this relationship varies greatly among sites because of different soil pH and organic matter as well as other elements that slow neutrons. Therefore, the neutron probe counts should be calibrated to gravimetric measurements of soil moisture at each site.

Calibration of the neutron probe counts at each site was accomplished by taking soil cores on two occasions concurrent with neutron probe measurements. The cores were used to characterize the soil bulk density and volumetric water content of the sites and to establish the linear relationship between the neutron count ratio and soil water content. The first set of cores were taken as undisturbed samples when the soil was very dry during the summer drought of 1988 (Hollinger and Isard 1989). Three undisturbed samples from each site were used to determine the mass water content

TABLE 2. Soil series, family, texture, and total porosity in the top 1 m at the ICN sites.

Site	Series	Family	Texture	Total porosity (mm)
Freeport	Dubuque	fine silty, mixed, mesic Typic Hapludalfs	silt loam	523
De Kalb	Flanagan/Drummer	fine, montmorillonitic, mesic Aquic Argiudolls	silt loam	515
		fine silty, mixed, mesic Typic Haplaquolls	silt clay loam	
Monmouth	Muscatine	fine silty, mixed, mesic Aquic Hapludolls	silt loam	521
Oak Run	Rozetta	fine silty, mixed, mesic Typic Hapludalfs	silt loam	470
Peoria	Clinton	fine montmorillonitic, mesic Typic Hapludalfs	silt loam	445
Stelle	Monee	fine, illitic, mesic Mollic Ochraqualfs	silt loam	435
Topeka	Plainfield	mixed, mesic, Typic Udipsamments	loamy sand	446
Bondville	Flanagan/Elburn	fine montmorillonitic, mesic Aquic Argiudolls	silt loam	504
		fine silty, mixed, mesic Aquic Argiudolls	silt loam	
Champaign	Drummer	fine silty, mixed, mesic Typic Haplaquolls	silt clay loam	543
Perry	Clarkesdale	fine montmorillonitic, mesic Udollic Ochraqualfs	silt loam	544
Springfield	Ipava	fine, montmorillonitic, mesic Aquic Argiudolls	silt loam	499
Brownstown	Cisne	fine, montmorillonitic, Mollic Albaqualfs	silt loam	504
Olney	Bluford	fine, montmorillonitic, mesic Aeric Ochraqualfs	silt loam	417
Belleville	Weir	fine, montmorillonitic, mesic Typic Ochraqualfs	silt loam	474
Ina	Cisne	fine, montmorillonitic, mesic Mollic Albaqualfs	silt loam	467
Carbondale	Parke	fine silty, mixed mesic Ultic Hapludalfs	silt loam	491
Dixon Springs	Grantsburg	fine silty, mixed, mesic Typic Fragiudalfs	silt loam	486

and bulk density of the soil in each 0.2-m layer. Mass water content was determined by weighing the soil samples while they were wet, drying them in an oven at a temperature of 105°C for 24 h, and reweighing the dried samples. Bulk density was determined from the weight and volume of the soil sample prior to oven drying. Volumetric water content (usually expressed in percent as the volume of water/volume of soil, or equivalently in millimeters as the depth of water in a soil column of specified depth) and porosity of the samples (expressed in millimeters as 1.0 bulk density 2.65^{-1}) were computed from the mass water content and bulk density (Campbell 1985). Total porosity, considered equivalent to volumetric water content at saturation, was determined by summing the equivalent depth in millimeters of the pore space over the six layers composing the top 1 m of the soil (Table 2). A second set of soil samples were taken when the soil was wet in the spring of 1989. The mass water content of these samples were determined and volumetric water content computed using the bulk densities determined from the first set of soil cores. Measurements from the five layers between 0.10 and 1.0 m for both the dry and wet calibration datasets were used to establish the linear relationship between the neutron depth probe count ratio and volumetric water content for each ICN site. The methodology used to extract undisturbed soil samples for computing soil bulk density (Hollinger and Isard 1989) proved to be inaccurate for sandy soils. Therefore, the mean of the calibration coefficients from the other 16 ICN sites was used for the Topeka site. Because of the small number of measurements for the surface layer (two neutron counts and six volumetric water content determinations for each site), a single linear relationship between the neutron surface probe counts and volumetric water content was determined by combining the surface-layer data from all the ICN stations except Topeka.

An estimate of the error associated with a neutron probe volumetric water content measurement (E in millimeters of water) in a soil layer with thickness L is given by:

$$E = L\frac{[2.3SE^2 + (0.0163M + 0.1651)^2]^{1/2}}{100}, \quad (1)$$

where SE is the standard error of the calibration coefficient expressed in percent, 2.3 is the critical value of the t statistic at $\alpha = 0.05$ with $n = 8$, $(0.0163M + 0.1651)$ is the error associated with the neutron source as determined by the manufacturer, and M is the volumetric water content in percent (Troxler Electronic Laboratories 1980). When measurements from more than one soil layer are used to determine the volumetric water content of a soil column, the measurement error estimate (E_c, in percent of volumetric water content) is the sum of the estimates of errors for each layer normalized by the total column volumetric water content and is given by

$$E_c = 100(\sum_{i=1}^{n} M_i)^{-1}(\sum_{i=1}^{n} E_i^2)^{1/2}, \quad (2)$$

where the subscripts represent the soil layers.

Each site was visited twice each month (the week of the 15th and the week of the last day of the month) during the months of March through September, and once each month during the last week of October through February. After each visit, the neutron count ratios obtained using the surface and depth probes were converted to total volumetric water content.

3. Results and discussion

The calibration coefficients (intercepts and slopes) from the linear relationships between neutron probe count and volumetric water content, coefficients of determination, and standard errors of the estimates of volumetric water content are presented in Table 3. In general, the relationships between the neutron depth probe counts and volumetric soil moisture were strongest where variations in volumetric soil moisture between the dry and wet sets of calibration samples and variations of moisture with depth in the top 1 m of soil were greatest. For example, at Ina, close to the shore of Rend Lake, the soil was relatively moist throughout the entire profile to a depth of 2 m even when calibration samples were obtained during the 1988 drought. Consequently the slope coefficient and coefficient of determination for Ina are low. The last column in Table 3 gives the measurement uncertainty for a volumetric water content observation of 30 percent of the soil volume [equation (2)] in the top 1 m of soil at each site. The uncertainty of the soil moisture measurements range from 5.6 percent to 12.9 percent for a volumetric water content of 30 percent of soil volume. The largest error is associated with the Plainfield sand soil at the Topeka site, underscoring the importance of obtaining site-specific measurements of bulk density.

Figure 2 shows the uncertainty associated with volumetric moisture measurements ranging from 5 percent to 50 percent of saturation throughout the top 1 m of soil averaged for all ICN sites (middle curve). The top and bottom curves represent estimates of uncertainty in the soil moisture measurements at Topeka and Perry, the sites with the largest and smallest measurement uncertainties, respectively. Measurement uncertainty increases dramatically with decreasing soil moisture because it is represented as a percent of volumetric water content. Over 95 percent of the water content measurements at sites with silt loam or silt clay loam soils (all ICN sites except Topeka) were greater than 20 percent of soil volume (Fig. 3) and consequently measurement uncertainties were usually less than 20 percent of volumetric water content. For more than 70 percent of the observations, soil water content measurements exceeded 30 percent of the soil

TABLE 3. Calibration coefficients for each site and estimates of the point measurement uncertainty based on a 1-m soil profile with a volumetric water content of 30 percent.

Site	Calibration coefficients		r^2	Std. err.	Measurement uncertainty
	Intercept	Slope	(%)		(%)
Freeport	−0.16206	0.762097	92.8	2.34	7.36
De Kalb	−0.03685	0.539677	70.5	3.58	10.50
Monmouth	−0.05010	0.590620	92.7	2.04	6.65
Oak Run	−0.06019	0.616035	96.3	2.10	6.80
Peoria	−0.13530	0.750457	78.4	3.48	10.18
Stelle	−0.09686	0.643103	72.5	3.49	10.29
Topeka	0.00225	0.478336	70.5	4.49	12.90
Bondville	−0.03033	0.579987	92.2	2.31	7.30
Perry	−0.07104	0.640366	95.9	1.56	5.59
Springfield	0.07075	0.443391	64.1	2.47	7.69
Brownstown	−0.00507	0.500732	92.8	2.81	8.54
Olney	0.16534	0.252367	65.3	2.76	8.41
Belleville	−0.11607	0.727183	96.0	1.75	6.00
Ina	0.16074	0.284056	49.8	2.76	8.40
Carbondale	−0.00313	0.520645	91.3	3.32	9.85
Dixon Springs	−0.06713	0.624197	95.4	1.95	6.44
Surface Probe	0.00000	0.925660	72.2	4.50	10.37

volume and consequently measurement errors were less than 10 percent of the volumetric soil moisture.

The means of the three lowest soil moisture observations at each level in the top 1 m of soil at each station (Table 4) reveal the extent to which the soils in Illinois dry during summer droughts and provide an indication of maximum errors associated with the neutron probe soil moisture measurements. Soil moisture at Belleville reached a minimum of 1.0 percent of soil volume at the 0.1–0.3 m depth. In general, minimum soil moisture measurements at the ICN stations were greater than 20% of soil volume below a depth of 0.5 m. These minimum values compare favorably with the air dry volumetric water content values between 1 percent and 5 percent of porosity given by Campbell (1985) and the 5 percent, 10 percent, and 20 percent of porosity values for permanent wilting point listed by Hanks and Ashcroft (1986) for sand, loam, and silty clay loam, respectively.

Soil moisture in the upper 1 m of soil averaged for all stations is shown for 1981 through 1991 in Fig. 4. Precipitation between soil moisture observations averaged for the ICN sites is presented for comparison. It should be noted that the record is only representative of the state after the summer of 1982, by which time 13 of the 17 ICN sites were installed (Table 1). The maximum value of soil moisture during spring displays little interannual variation. Soil moisture exceeded 341 mm (70 percent of saturation) during each of the last 10 years in Illinois, reaching a maximum of 391 mm (80 percent of saturation) early in the spring of 1988.

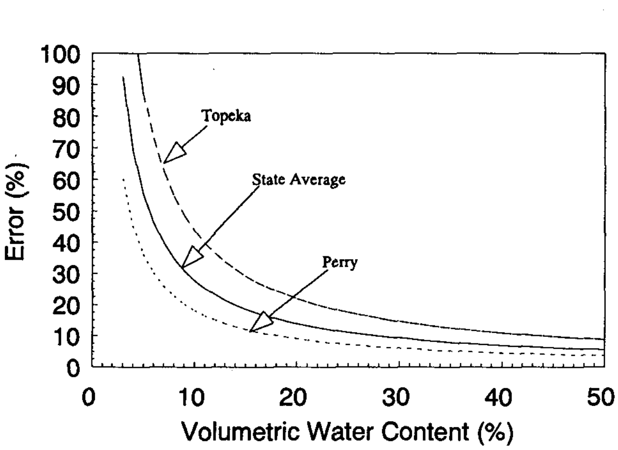


FIG. 2. Relationships between errors (percent) associated with soil moisture measurements and volumetric water content (percent of volume) of the soil.

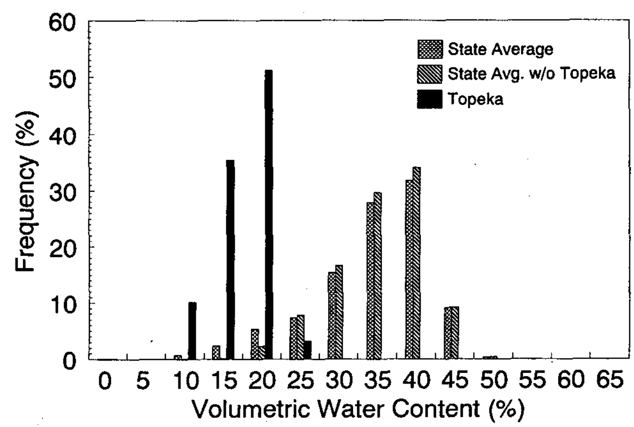


FIG. 3. Histogram showing percentage of soil moisture observations (frequency) by volumetric soil water content (percent of soil volume) averaged for all ICN sites, averaged for all ICN sites excluding Topeka, and for the Topeka station.

TABLE 4. Mean of the three driest soil observations in the top six soil layers at each of the Illinois soil moisture sites since January 1985. Soil moisture values are expressed as percent of soil volume.

	Soil layer					
Site	0–0.1 m	0.1–0.3 m	0.3–0.5 m	0.5–0.7 m	0.7–0.9 m	0.9–1.1 m
Freeport	10.9	6.0	8.0	10.6	18.2	25.1
De Kalb	13.8	7.2	18.7	24.0	24.5	26.8
Monmouth	12.5	11.4	14.5	17.0	19.7	25.1
Oak Run	6.5	4.0	14.9	27.5	27.2	32.0
Peoria	9.3	1.9	22.7	29.3	30.2	35.9
Stelle	14.6	11.5	22.1	21.8	21.8	21.9
Topeka	5.3	6.6	9.2	9.9	7.2	6.9
Bondville	11.4	12.6	18.2	27.1	23.6	28.1
Champaign	12.3	16.3	19.7	19.8	20.5	23.1
Perry	11.6	9.8	21.0	24.0	19.8	25.1
Springfield	11.9	23.3	28.6	32.0	28.3	31.0
Brownstown	8.3	6.4	10.3	26.1	26.6	29.8
Olney	7.2	21.4	24.9	32.0	30.3	29.5
Belleville	9.3	1.0	4.6	16.7	35.3	36.4
Ina	8.3	22.3	30.1	36.9	32.9	35.1
Carbondale	8.6	7.2	10.4	20.2	25.9	29.3
Dixon Springs	8.3	5.1	17.8	22.4	26.7	36.4
State average	10.0	10.2	17.4	23.4	24.6	28.1

Consequently, for the state as a whole, these data indicate that autumn, winter, and early spring precipitation is generally sufficient to recharge soil moisture in the top 1 m.

Inspection of Fig. 4 also reveals that there were four summer droughts (1983, 1984, 1988, and 1991) during the last 10 years, when on average, soil moisture decreased to below 279 mm (57 percent of saturation) in the top 1 m across Illinois. Soil moisture averaged across the state was lowest in mid-August 1983 (205 mm or 42 percent of saturation). In contrast, the dry conditions during the 1988 and 1991 summers tended to be more persistent. It should be noted that Wendland (1991) identified 1985, 1987, and 1988, but not 1983 and 1984 as drought years in Illinois on the basis of April to August precipitation (data from 1991 were not included in that study).

The annual cycle of moisture in the top 1 m of soil averaged for all ICN measurement sites is depicted in Fig. 5. The mean values and one standard deviation

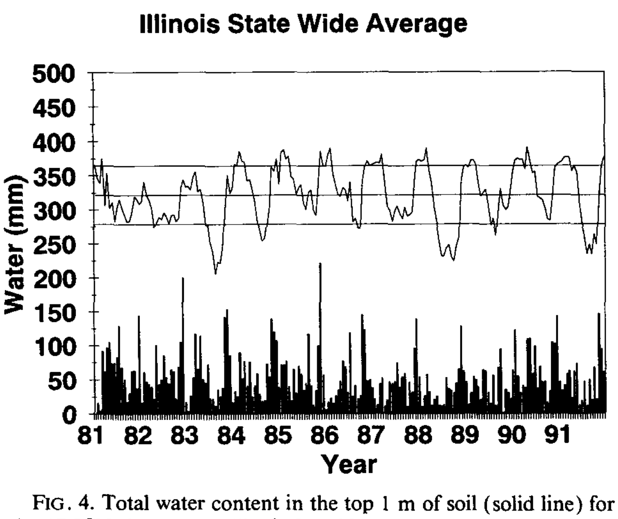


FIG. 4. Total water content in the top 1 m of soil (solid line) for the 17 ICN sites across Illinois for 1981–1992. The amount of precipitation for the periods between soil moisture measurements (usually 2 weeks) averaged for the same sites is presented for comparison (bars). The middle horizontal line represents 10-yr mean of all observations. The bottom horizontal line is the soil moisture level one standard deviation below the mean, and the top horizontal line is the soil moisture one standard deviation above the mean.

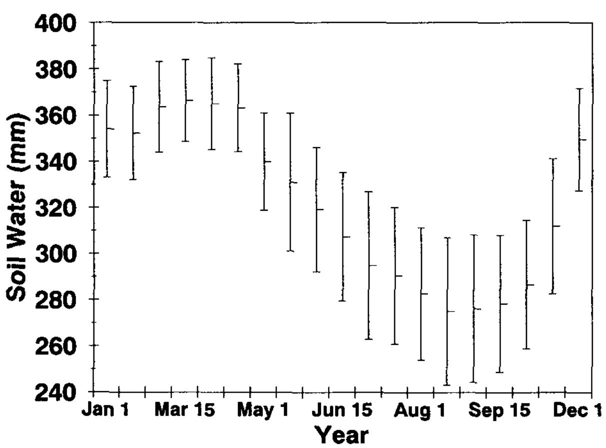


FIG. 5. Mean and standard deviation of soil moisture at each observation period. The mean and standard deviation of each period include all observations at the 17 stations between the start of record and December 1992.

TABLE 5. Mean soil moisture (mm) and changes in soil moisture between seasons (mm) for the 0–1.0-, 0–0.15-, 0.15–0.5-, 0.5–1.0-, 1.0–2.0-, and 0–2.0-m layers.

Layer (m)	Winter		Spring		Summer		Autumn	
	Mean	Change	Mean	Change	Mean	Change	Mean	Change
0–1.0	357.4	50.8	347.4	−10.0	288.1	−59.3	306.6	18.5
0–0.15	56.0	14.6	49.2	−6.8	33.6	−15.6	41.4	7.8
0.15–0.5	121.4	21.0	115.5	−5.9	89.7	−25.8	100.4	10.7
0.5–1.0	180.0	15.2	182.7	2.7	164.8	−17.9	164.8	0.0
1.0–2.0	346.9	9.4	353.9	7.0	343.5	−10.4	337.5	−6.0
0–2.0	704.3	60.2	701.3	−3.0	631.6	−69.7	644.1	12.5

(SD) above and below the mean were computed using all soil moisture observations for the ten-year measurement period. On average, soil moisture in the state is greatest in early spring (15 March) and lowest in late summer (15 August). Moisture begins to decline in the top 1 m of soil between mid-April and early May and begins to increase again in late September. The greatest recharge occurs during mid- to late autumn (October and November) and early winter (December). It is also clear that the variability of soil moisture conditions is twice as large in the summer (SD $\approx$ 30 mm) than during winter and early spring (SD $\approx$ 15 mm).

Volumetric soil moisture averaged for the ICN sites are shown in Table 5 for each season. Soil moisture is integrated over depths 0–1.0, 0–0.15, 0.15–0.50, 0.50–1.0, 1.0–2.0, and 0–2.0 m and the change in volumetric soil moisture from the previous season for each of the layers is given. Seasons are defined as winter (December–February), spring (March–May), summer (June–August), and autumn (September–November). The values are the average of three observations during winter, six each in spring and summer, and four during the autumn season for each year in the record. It should be noted that soil moisture averages for the 0–1.0- and 0–2.0-m layers are greater for the winter than for the spring season even though maximum soil moisture for these layers occurs on 15 March (Fig. 5).

The average soil moisture depletion between the winter and summer seasons for the top 2 m of soil was 72.7 mm (Table 5). Three-quarters of this decrease occurred in the top 0.5 m of the soil with approximately one-third of the desiccation above the 0.15-m depth. Less than 5 percent of the soil moisture change from winter to summer occurred below 1 m. Table 6 shows average volumetric soil moisture values for a wet year (1985) and a dry year (1988) in Illinois. The decrease in soil moisture between winter and summer for the top 2 m of soil was 49.5 and 147.3 mm for the wet and dry years, respectively. The decrease in soil moisture from summer to winter in the top 2 m of soil in 1985 was only 69 percent of the average change for the 10-year record. eight Seventy-eight percent of this decrease occurred in the top 0.5 m of the soil with approximately 30 percent of the desiccation above 0.15 m. Approximately 4 percent of the soil moisture change during this time period occurred below 1 m. During the 1988 drought, desiccation in the top 2 m of soil was 204 percent of the average change for the 10-year record. Only 64 percent of the change from winter to summer occurred in the top 0.5 m of the soil, with 22 percent of the desiccation above 0.15 m. Approximately 10 percent of the soil moisture decrease between winter and summer occurred below 1 m.

Tables 5 and 6 also demonstrate the seasonal lag in soil moisture storage in the deeper layers compared to the top 0.5 m of soil. Soil moisture in the layers 0–0.15 m and 0.15–0.50 m peaked during the winter, declined through spring and summer, and recharged in the autumn. Peak soil moisture conditions in the

TABLE 6. Mean seasonal soil moisture (mm) for seasons during a wet year (1985) and a drought year (1988) for the 0–1.0-, 0–0.15-, 0.15–0.5-, 0.5–1.0-, 1.0–2.0-, and 0–2.0-m layers.

Layer (m)	1985				1988			
	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn
0–1.0	370.5	359.3	322.9	328.6	372.3	340.4	239.5	267.3
0–0.15	56.1	49.6	41.5	42.2	55.3	44.5	22.3	34.9
0.15–0.5	127.5	119.2	103.7	106.7	128.3	111.7	67.5	84.9
0.5–1.0	186.9	190.5	177.7	179.7	188.7	184.2	149.7	147.5
1.0–2.0	365.0	374.3	363.1	359.7	361.7	364.6	347.2	333.3
0–2.0	735.5	733.6	686.0	688.3	734.0	705.0	586.7	600.6

layers 1.0–2.0 m occurred during the spring months, declined through the summer and autumn, and recharged during the winter. On average, there was little change in soil moisture in the layer 0.5–1.0 m between summer and autumn (Table 5) with soil moisture recharge beginning in autumn during the wet year (1985) and not until winter during the dry year (1988).

An accurate spatial representation of soil moisture (depth of water, water available for plants, and potential evapotranspiration) is difficult for large areas because it requires incorporation of the boundaries of soil units with different water holding capacities into the map. For example, inclusion of data from the Topeka site characterized by Plainfield loamy sand with low soil moisture content results in a "bull's-eye" in the west-central part of Illinois. All the other ICN sites are characterized by silty loam and silty clay loam soils (Table 2). The area of sandy soil surrounding Topeka is much smaller than the area within the bull's-eye on a contour map of mean soil moisture produced using SURFER® (Golden Software 1988). To avoid this problem, data from the Topeka site were removed from the analysis to more clearly show the spatial variations in soil water that are due to variations in sources and sinks of moisture (Fig. 6). Means for each station displayed in Fig. 6 are pooled over three (for winter), four (for autumn), and six (for spring and summer) observations per season for a period of 10 years.

In the winter and spring there is a latitudinal gradient in soil moisture with the northern soils being drier than the southern soils. This soil moisture gradient roughly corresponds to the precipitation gradient in Illinois (Wendland et al. 1992). During the summer and autumn there is a longitudinal soil moisture gradient in the western portion of the state. The decrease from east to west in soil moisture in western Illinois corresponds with an increase in the depth of loess deposits over the region (Fehrenbacher et al. 1984). The deep loess deposits are associated with a more uneven terrain, which likely causes greater runoff of precipitation during summer and autumn rain storms.

The standard deviation (mm) of moisture in the top 1 m of soil across Illinois and for the northern, central, and southern regions of the state are given for the four seasons of the year in Table 7. Data from the Topeka site were included in this table. Variability of soil moisture throughout the state is relatively low in winter and spring (SD $\approx$ 29 mm) with the highest values occurring in northern Illinois and the lowest values in the central portion of the state. The standard deviation of soil moisture range is 45 and 41 mm for the summer and autumn seasons, respectively. A statistically significant latitudinal gradient exists in soil moisture variability for the 10 summers of record, decreasing from north to south within Illinois. In contrast, the spatial variation in the standard deviation of moisture in the top 1 m of soil is very small for autumn.

TABLE 7. Standard deviation (mm) of moisture in the top 1 m of soil across Illinois and for the northern, central, and southern regions of the state for the seasons of the year. Number of observations given in parentheses.*

Season	North	Central	South	State
Winter	37.45^{a}	20.77^{b}	35.59^{a}	29.13
	(62)	(247)	(166)	(475)
Spring	34.85^{a}	25.15^{b}	28.90^{c}	28.74
	(131)	(782)	(349)	(1262)
Summer	51.97^{a}	45.96^{b}	40.61^{c}	45.01
	(136)	(550)	(365)	(1051)
Autumn	41.67^{a}	40.97^{a}	41.25^{a}	41.13
	(92)	(381)	(258)	(731)
Annual	42.92^{a}	36.59^{b}	36.77^{b}	37.50
	(421)	(1960)	(1138)	(3519)

* Differences between numbers with the same subscript for a season (row) are not statistically significant at α = 0.05 (F test).

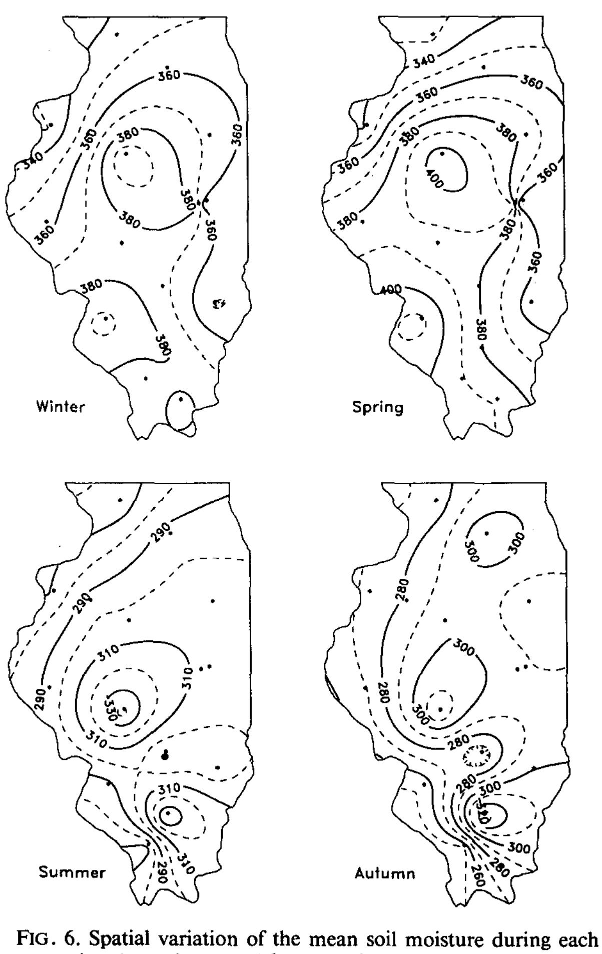


FIG. 6. Spatial variation of the mean soil moisture during each season using the entire record for all stations except Topeka (sandy soil). Maps were produced using SURFER® (Golden Software 1988). Data grids were constructed using the kriging procedure with grid size = 75 and nearest-neighbor search radius = 100 data units.

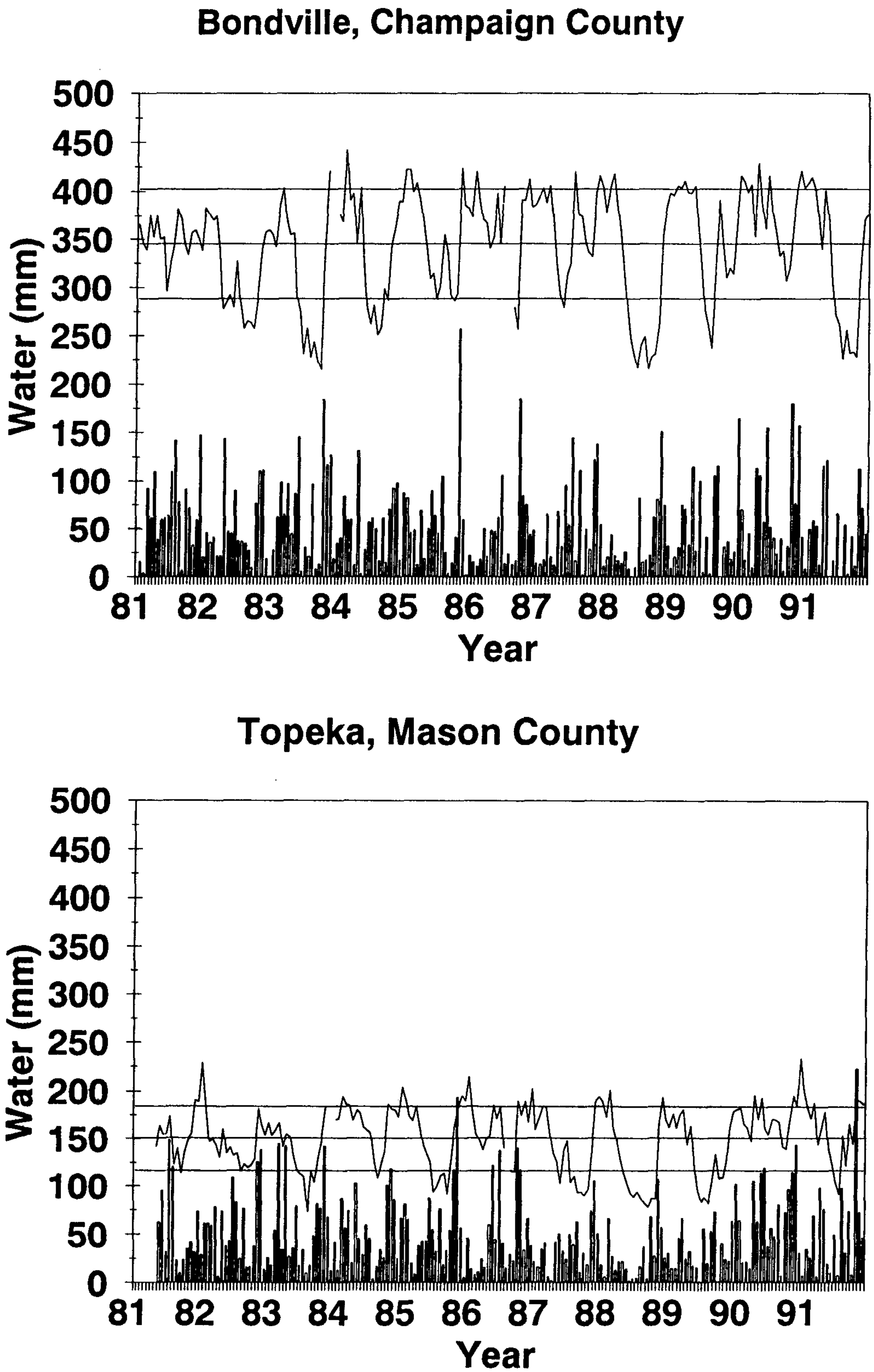
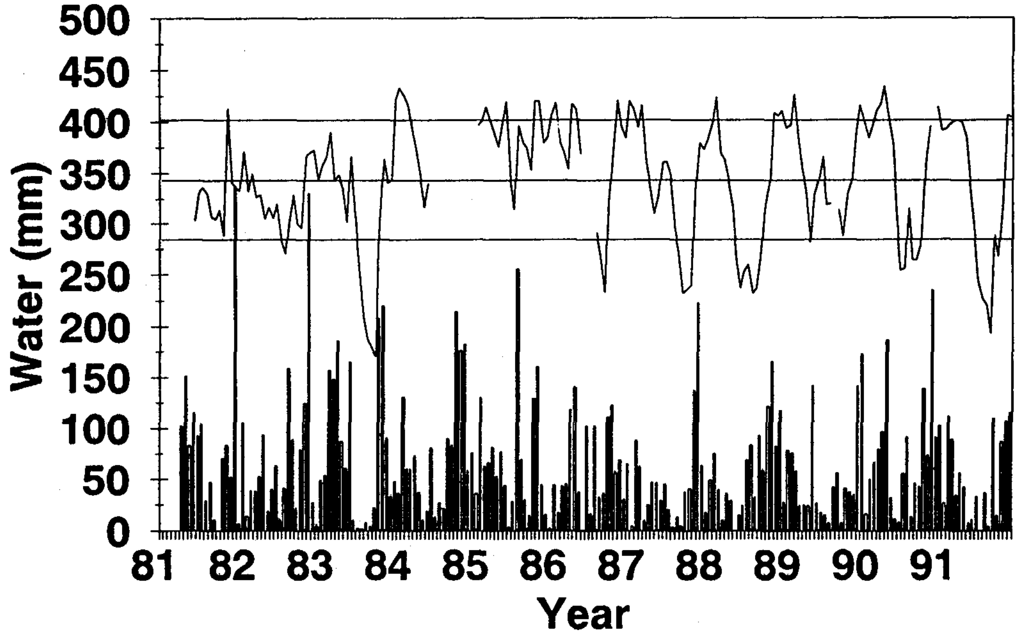


FIG. 7. Time series of soil moisture and precipitation observations for the Topeka (Plainfield loamy sand soil) and Bondville (poorly drained, silt-loam soil) ICN sites.

Dixon Springs, Pope County

Grass Covered



Dixon Springs, Pope County

Bare Soil

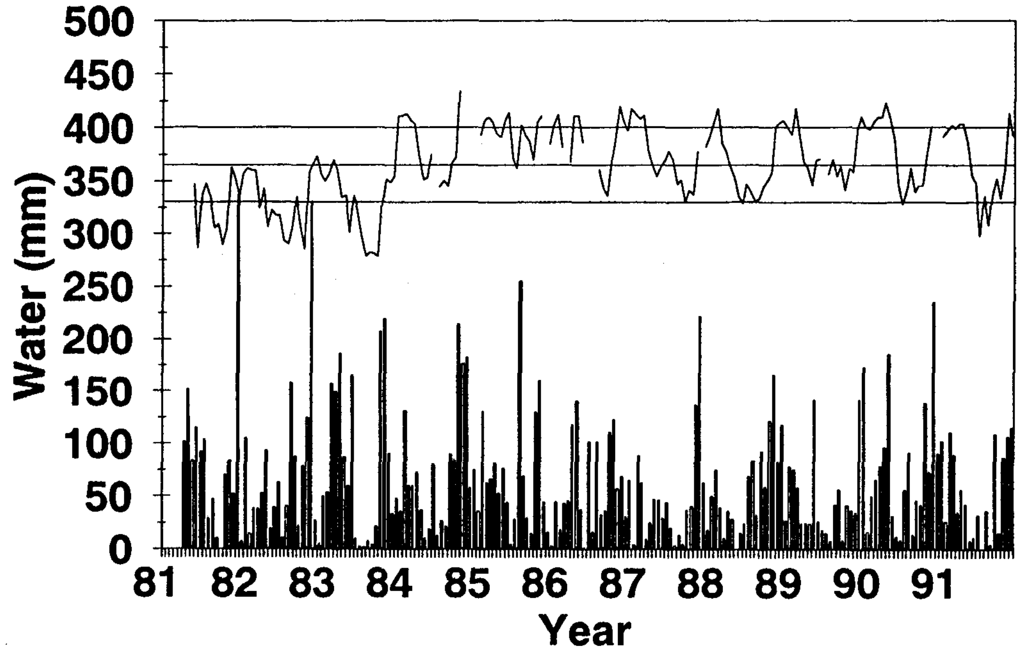


FIG. 8. Time series of soil moisture and precipitation observations for the grass-covered and bare soil sites at Dixon Springs.

As indicated above, the vast majority of soils in Illinois have silt–loam or silt–clay–loam textures. The most noticeable exceptions to this generalization are the soils along the Mississippi, Illinois, and Kankakee Rivers where loamy sands and sands occur. These sandy soils are characterized by very little soil structure, low organic matter, and relatively low porosity. An inspection of Fig. 7 allows comparison between the time series of soil moisture observations in the Plainfield loamy sand soil at Topeka in Mason County, and at Bondville in Champaign County, a site located on a poorly drained, silt–loam soil that is high in organic matter and without a natural dense layer in the top 2 m. Precipitation over the 10-year period at the two sites was similar. However, there was usually twice as much water in the top 1 m of soil at Bondville than at Topeka, most likely due to differences in soil texture and structure, which impact soil water retention. Differences in the response of soil moisture to individual large precipitation events at the two sites, however, are not readily apparent.

Time series of soil moisture and precipitation observations for adjacent grass-covered and bare soil sites at Dixon Springs are presented in Fig. 8. The range in moisture in the top 1 m of soil throughout the year at the vegetated site is 1 to 2 times greater than at the bare soil location. Although total porosity measurements for the two sites were similar, the vegetated site generally contains 50–75 mm more water in the top 1 m of soil during spring when soil moisture is greatest, than does the nonvegetated site. The soil at the nonvegetated site does not dry out as rapidly as the soil at the grass-covered site. As a result, even though soil moisture is greater at the vegetated than bare soil site during spring, desiccation is so much more rapid that there is usually a greater deficit of soil moisture at the vegetated than bare soil site during the summer. Because the deficit in summer is greater, soil moisture at the vegetated site responds more dramatically to summer precipitation events than at the bare site.

4. Summary

Ten years of neutron probe moisture measurements with fine vertical resolution in the top 1 m of the soil are analyzed to provide a climatology of soil moisture for Illinois. Soil moisture profile measurements have been obtained since 1982 at 15 grass-covered sites distributed throughout the state at a biweekly temporal resolution during the growing season and monthly during winter. Currently, there are 17 soil moisture monitoring sites in Illinois.

The neutron probes used to measure the soil moisture were calibrated to each of the stations. Measurement errors at the stations were dependent upon the volumetric soil moisture content of each soil layer. For the top 1 m of soil, measurement errors ranged from 6 percent to 13 percent when volumetric soil moisture was 30 percent of saturation. In Illinois, volumetric soil moisture was typically above 30 percent of saturation for most of the year.

The average depletion of soil moisture between winter and summer in the top 2 m of soil in Illinois is 72.7 mm. Three-quarters of this decrease occurred above 0.5 m and only 5 percent occurred between the 1.0- and 2.0-m depths. The average decrease between winter and summer during a wet year (1985) and a drought year (1988) in the top 2 m was 69 percent and 203 percent, respectively, of the average for the 10-year period. Seventy-eight percent of the decrease in the top 2 m of the soil occurred in the 0–0.5-m layer during the wet year while only 64 percent of the desiccation in the 2-m-deep soil column occurred in the same layer during the 1988 drought year.

Contour maps of mean moisture in the top 1 m of soil for the 10-year record show the spatial variation of soil moisture across the state by season. When data from the sandy soil at Topeka were not included in the analysis, a latitudinal gradient of soil moisture existed during the winter and spring with the wetter soils located in the southern part of the state. During the summer and autumn a decrease from east to west is evident with the drier soils in the western part of the state. The longitudinal gradient of soil moisture corresponds to the depth of loess deposits with the drier soils occurring in the region of the state with deep loess and uneven terrain.

Variations of soil moisture within each season over the 10-yr period were greater in the summer and autumn (SD $\approx$ 41 and 45 mm, respectively) than for winter and spring (SD $\approx$ 29 mm). In general, soil moisture in the northern portion of the state was more variable than in the southern parts of Illinois during spring and summer. The north to south latitudinal gradient of soil moisture variability for the summer season is statistically significant.

Time series of soil moisture and precipitation from sites with silty loam and loamy sand soils indicate the importance of soil texture on soil moisture conditions. Typically there was twice as much water in the top 1 m of the silt loam than loamy sand soil. Finally, time series of soil moisture show that seasonal variation in water in the top 1 m of soil at a grass-covered site was 1 to 2 times greater than at an adjacent nonvegetated site.

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