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Davies & Irwin Inc.

A STUDY OF CUMULATIVE AIR QUALITY IMPACTS FROM AGGREGATE OPERATIONS 7TH LINE, ORO TOWNSHIP

Report 92-175

January 7, 1992

Submitted to:

CATTANACH HINDSON SUTTON & HALL
BARRISTERS AND SOLICITORS
MARKHAM, ONTARIO

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1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. studied the future air quality impact of six sand and gravel facilities located along the 7th Line in Oro Township. Three of the facilities currently have phases in progress (Seely & Arnill, Allan G. Cook, and the Township of Oro), and the other three are proposed (James Dick, Sarjeant, and Alfa). The authors reviewed aerial photographs and site plans, and one of the authors visited the site on December 12, 1991. Based on this information, they identified the locations most likely to experience an adverse cumulative impact from operations at the six sand and gravel facilities. They then subjected these locations to an analysis of predicted impact. This report presents the results and conclusions of the analysis.

2. BACKGROUND

The greatest potential air quality concern at sand and gravel operations is dust. Exhaust pipe emissions from vehicles and equipment on site are also a source of contaminants, but previous analyses by RWDI of busy roadways indicate that provincial criteria for exhaust pollutants are met within a relatively short distance from the roadway (on the order of 10m).

Dust emissions can be a nuisance, infiltrating residences through open windows, soiling cars and siding, and affecting visibility along roadways. There is little risk of adverse effects on human health from dust, except in the case of continual exposure to high concentrations of very fine dust. The available information on dust effects suggests that there is also little risk of adverse effects to vegetation or wildlife, except in the case of continual, heavy dust loadings.

Fortunately, most of the dust produced at sand and gravel operations can be controlled. The greatest persistent source of dust is equipment traffic on unpaved roads. Establishing a good road base and watering the surface daily during dry conditions can all but eliminate the dust emissions. Various chemical suppressants are available that enhance the effect of the watering.

Material processing (loading, crushing, screening and stockpiling) are also persistent sources of dust during dry conditions. Common solutions, where needed, are water sprays or various types of dust collection systems.

Finally, wind erosion is an important source of dust during strong winds. While equipment traffic and material processing produce a very fine dust, wind erosion will cause both fine dust and coarser, sand-sized particles to become airborne. At a typical site, where the surrounding area consists of trees or low vegetation, the sand-sized particles quickly settle and are trapped in the vegetation, leaving the fine dust particles to carry on. Thus, only the fine dust travels a significant distance beyond the site. Only in cases where residences were situated immediately adjacent to an area of exposed sand have there been significant problems with the sand-sized particles.

Wind erosion is significant only on surfaces that have a high content of sand and silt-sized particles. This includes stockpiles of sand and granular materials, traffic areas and areas of sand and silt in the excavation face. Stockpiles of clear stone experience little or no erosion. Typical control measures for wind erosion, where needed, include wind fences or other windbreaks, proper orientation of the excavation and stockpiles with respect to the prevailing winds, interim stabilization of inactive areas, and minimization of exposed surfaces of sand and silt. Water sprays, chemical stabilization of the surfaces and covers for the stockpiles have been used in some industries.

3. SITE VISIT AND SITE PLAN REVIEW

Based on a visit to the site and review of available information on the aggregate operations, the authors concluded that the following locations had the greatest possibility of an adverse impact: the residence on the Gauldie/Murray property; the residence on the Bolton property; and the residence on the Norman property. All of these residences are along the 7th Line.

The Bolton and Gauldie/Murray properties have the potential to be affected if dust emissions occur in the James Dick, Sarjeant or Cook site during southerly to southeasterly winds, which occur relatively frequently in the area. The residences are well exposed with respect to these gravel operations, having relatively few trees in between. There is not likely to be much additional effect from the Alfa site during southeasterly winds, since it is over a kilometre away, and there is a 150m wide forested buffer area adjacent to it that would filter out the majority of any dust emissions.

The Norman residence has the potential to be affected if dust emissions occur in the eastern portion of the James Dick site during northwesterly winds, or if dust emissions occur in the Sarjeant or Cook site during northerly winds. It may also be affected if emissions occur in the eastern portion of the Alfa site during southerly winds. There is not likely to be any additional effect from the Seely & Arnill site during southerly winds, since it is nearly a kilometre away and there is a 200m wide forested buffer area adjacent to it that would filter out the majority of any dust emissions.

There are other residences in the area, along County Road 11 and the 6th Line, but in general, they are separated from the nearest existing or proposed aggregate operation by a well-treed buffer zone. On the most open part of the James Dick property adjacent to the 6th Line, an extensive number of conifers have been planted which are likely to provide a good screen for dust emissions by the time operations move into that area. In any case, the potential for an impact along the 6th Line exists only during easterly and northeasterly winds which are relatively infrequent.

Based on these observations, the authors selected the Norman, Bolton and Gauldie/Murray Residences for analysis of future impacts from dust emissions at the aggregate operations. The next step was to identify the dust sources and their likely locations at each aggregate operation.

The intent was to examine the arrangement of sources that will have the greatest potential to produce a negative impact at the selected residences. At the James Dick site, the worst case is with the operations taking place in the eastern portion of the site (Stage 1). At the Alfa site, it is with the operations taking place in the northeast portion of the site (Stage 4). At the Sarjeant and Cook sites, the worst case is with the operations taking place in the western portion of the site (Area I and Area III at the Sarjeant site).

The sources of dust at each aggregate operation, selected for the analysis, are as follows:

- truck traffic along the 7th Line;
- client truck traffic on internal haul routes;
- loader traffic;

- loading of customer trucks;
- loading into the hopper at a crusher or screen;
- crushing;
- screening;
- stockpiling;
- wind erosion.

These are the principal dust sources.

4. CLIMATE

The climatic parameters examined in this study were wind, precipitation and thermal stability. These parameters all play a role in the emission and dispersion of dust. Atmospheric stability falls into three broad categories: convective or unstable; neutral; and stable (inversion). Unstable conditions are generally associated with calm winds and intense solar radiation. Stable conditions are generally associated with calm winds and nighttime radiative cooling of the earth's surface. Neutral stability is the most common case, and is generally associated with typical levels of solar radiation and moderate to high winds.

For the most part, the source of climatic information for this study was the Environment Canada weather station at Muskoka Airport. This is the nearest station to the study area that has long term, hourly wind records. Some information was also available for Barrie Airport, but the data were intermittent and covered a limited number of years. The frequency distribution of wind direction is shown in Figure 1. The dashed inner ring in the graph represents a 10% frequency of occurrence, and the solid outer ring represents a 20% frequency of occurrence. The tick marks on the outer ring represent the cardinal compass directions. The size of each pie wedge in the graphs indicates the frequency of occurrence of a wind direction. For example, the pie wedge for the west direction extends just beyond the 10% ring, to about 10.5%, indicating that westerly winds occur about 10.5% of the time.

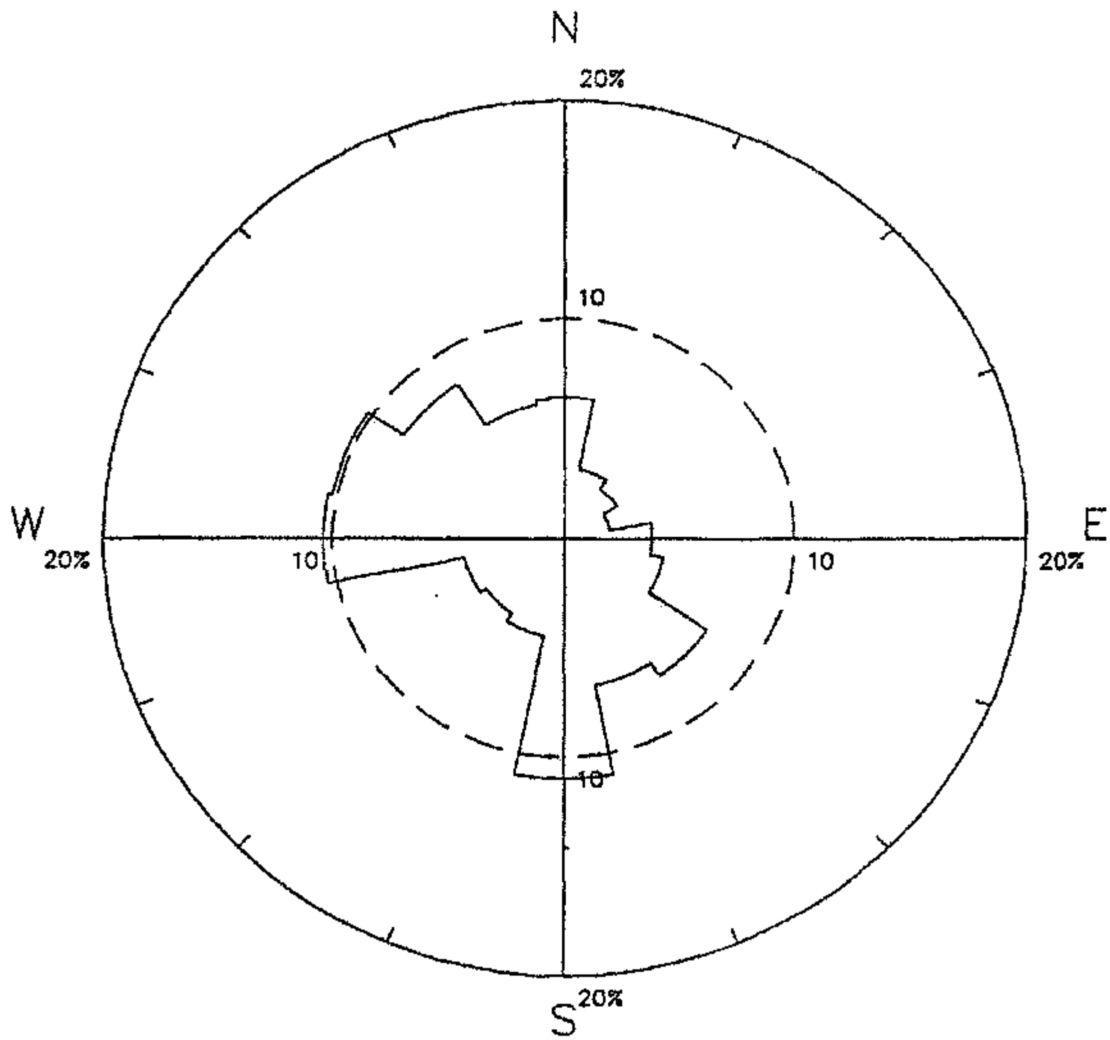

Figure 1 Wind Frequency Distribution, Muskoka, Ontario, 1955-1980

The precipitation parameter of greatest interest was the average number of days per year with measurable precipitation. Environment Canada data were available for two stations in Orillia. At one station, the value was 139 days, and at the other, the value was 143 days. At Barrie, the value was 138 days, and at Midhurst, the value was 139 days. The average of the four stations was 140 days. Data on atmospheric stability were provided by Environment Canada for Muskoka Airport, in the form of a Stability Array analysis (STAR).

5. CRITERIA

Dust from sand and gravel operations is covered by general regulations dealing with air contaminants. Regulation 308 of the Environmental Protection Act for Ontario prohibits the release of contaminants to a degree that may cause discomfort to persons, loss of enjoyment of normal use of property, interference with normal conduct of business or damage to property. As a gauge for determining whether such effects may or may not occur, Regulation 296 sets forth threshold concentrations for various types of airborne contaminants. The provincial Ministry of the Environment also has other tentative guidelines and criteria used for this purpose.

Regulation 308 also sets forth explicit standards for a source's contribution to the concentration of airborne contaminants at a point of impingement. The term point of impingement is not explicitly defined in the regulation, but in general practice, is taken to be any off-property location where and excursion above the standard may have a detrimental effect. In the case of dust emissions, for which the limiting effects associated with the standards are soiling and reduction of visibility, points of impingement would tend to include residences and busy roadways where impaired visibility might be a concern. Exhaust pipe emissions from motor vehicles are exempt from Regulation 308.

In addition to the regulations, the Ministry of the Environment has established a guideline for approval of pit and quarry operations (February, 1990). This guideline states that, when performing Regulation 308 point of impingement calculations for the purposes of obtaining a certificate of approval, only crushing and screening equipment need be evaluated. Stockpiles and roadways are not considered as sources of emission for this purpose. However, the guideline goes on to state that visible emissions and soiling from any part of the operation are not acceptable off property, and the air quality criteria of Regulation 296 must be met at all times.

Table 1 Provincial Criteria

	Total Suspended Particulate Matter		Dustfall	
Criterion	120	60	7.0	4.6
Units	$\mu g/m^3$	$\mu g/m^3$	$g/m^2/mo.$	$g/m^2/mo.$
Averaging Time	24 hours	annual	1 month	annual
Limiting Effect	visibility	visibility	soiling	soiling

The ambient air quality criteria that were considered in the present study to gauge the proposed sand and gravel operations are shown in Table 1. There are two regulated contaminants related to dust emissions: total suspended particulate matter and dustfall. The former refers to particles small enough to remain suspended in the atmosphere over long periods of time and which, when present in large concentrations, can affect visibility. The latter refers to particles large enough to settle at an appreciable rate leaving a dust film on surfaces.

The criteria for suspended particulate consist of threshold concentrations, expressed as micrograms of contaminant per cubic metre of air ($\mu g/m^3$). A microgram is one millionth of a gram. There are two criteria: one for the yearly average concentration, and the other for the 24-hour peak concentration. The value of the latter is approximately twice that of the former. In essence, this means that occasional peaks as high as twice the average value are acceptable.

The criteria for dustfall consist of threshold deposition rates, expressed as grams per square metre per month ($g/m^2/mo.$). Once again, there are two criteria - one for the yearly average deposition rate, and the other for the monthly peak - and the value of the peak is approximately twice that for the average.

6. BACKGROUND DUST

To get an idea of normal background dust levels in the study area, 24-hour suspended particulate concentrations measured by the Ontario Ministry of the Environment at nearby locations were examined. The following data sets were examined:

Orillia	1977 - 1989
Fenelon Falls	1978
Barrie	1982 - 1990
Keswick	1986 - 1990

Provincial monitoring sites tend to be located near identified sources of particulate matter (e.g., an industrial site). Therefore, the data from these sites are likely to overestimate background dust levels for the present case, in which there are no significant dust sources in the immediate surroundings of the study area. The median value for these data was 34 $\mu g/m^3$. The 30-percentile value was 26 $\mu g/m^3$ (i.e. 30% of the readings were less than 26 $\mu g/m^3$), and the 70-percentile value was 45 $\mu g/m^3$. In the analysis presented here, the median value of 34 $\mu g/m^3$ was adopted as the best estimate of typical background levels in the vicinity of the study site.

7. ANALYTICAL METHODS

The analysis of predicted dust impacts consisted of two main steps: calculation of dust emission rates for the various sources; and modelling of atmospheric dispersion processes. The results consisted of predicted levels of total suspended particulate matter (TSP) and dustfall at the Norman, Bolton and Gauldie/Murray Residences.

Dust emissions from vehicle traffic and processing equipment depend on a variety of factors, such as the moisture and particle characteristics of the material, the types of vehicles, the vehicle speed and the material handling rates. A reasonable general estimate of emission rates in dry conditions can be obtained from data published by the U.S. Environmental Protection Agency (EPA). Information was taken from Compilation of Air Pollutant Emission Factors (AP-42), Volume I, Stationary Point and Area Sources, fourth edition, published in 1985. This document provided formulas for calculating dust emission rates from traffic, loading, crushing, screening and stockpiling.

Dust emissions from wind erosion are highly dependent on the physical characteristics of the surface being eroded, the magnitude of the wind and the exposure of the surface to the wind. Wind erosion will cause both fine dust and sand-sized particles to become airborne, but the fine particles are of greatest importance, since they can travel much farther off site. One of the best compilations of field data on fine dust emissions from wind erosion is by W. G. Nickling and J. A. Gillies in a document entitled "Emission of Fine-Grained Particulates From Desert Soils" (in Paleoclimatology and Paleometeorology: Modern and Past Patterns of Global Atmospheric Transport, 1989, Kluwer Academic Publishers). Their data are for desert soils and are representative of extremely dry conditions, such as seldom occur in Ontario. Thus, the data represent worst case conditions.

Nickling and Gillies investigated a variety of soils and developed an equation that gives a reasonable estimate of dust emission rate for all of them. The equation gives the dust emission rate per unit area of exposed surface as a function of the wind drag force on the surface. This equation was used in the present analysis.

The formulas used to estimate emission rates required several input parameters. These parameters are shown in Table 2. Dust emission rates from vehicle traffic were calculated for two scenarios: the licensed maximum traffic rate; and the probable maximum traffic rate.

Atmospheric dispersion processes were modelled using the Fugitive Dust Model (FDM), a numerical model that was developed specifically to study dust emissions from industrial sites. The model is based on an approximate solution of the atmospheric advection-diffusion equations. The result is a standard gas dispersion model with corrections to account for particulate settling and deposition. The model also has other features that facilitate the modelling of dust sources. Details of the FDM model can be found in the User's Guide for the Fugitive Dust Model, published by the U.S. Environmental Protection Agency.

Table 2 Input Parameters for Emission Rate Calculations

1. Typical Aggregate Truck

- Empty Weight	= 18 tonnes
- Capacity	= 35.5 tonnes
- Mean Speed on Internal Roads	= 20 km/h
- No. of Wheels	= 22

2. Typical Front-End Loader

- Empty Weight	= 22 tonnes
- Capacity	= 3.8 cubic metres (6.5 tonnes)
- Mean Travel Speed	= 5 km/h
- Material Free-fall Distance During Load-out to Trucks	= 2 m

3. Processing

- Crushing Rate	= 300 tonnes/h
- Screening Rate	= 300 tonnes/h
- Stockpiling Rate	= 300 tonnes/h
- Free-fall Distance from End of Conveyor to Stockpile	= 3 m

4. Materials

- Silt Content of Processed Material	= 8 %
- Moisture Content	= 3.4 %
- Silt Content on Haul Roads	= 6%
- Area Subjected to Wind Erosion:	
at Face -	= 0.25 Hectares
at Processing Area -	= 1.1 Hectares

Table 2 (Continued) Input Parameters for Emission Rate Calculations

	Twp. of Oro	Cook	Sarjeant	James Dick	Alfa	Seely & Arnill	Total
1. Peak Hour, Summer, Traffic based on Maximum Licensed Extraction							
Trucks/h	2	18	15	20	15	34	104
Tonnes/h	71	639	533	710	533	1207	3692
2. Peak Hour, Summer, Traffic Based on Probable Maximum Extraction							
Trucks/h	1	9	8	10	8	17	52
Tonnes/h	36	320	266	355	266	604	1846

The FDM required information on the layout of the dust sources and the residences (receptors) where the dust impact was to be computed. Exhibit 1 (fold-out map at the back of the report) shows the scenarios that were modelled. Scenario A is the probable worst-case alignment of sources with respect to potential impacts at the Bolton and Gauldie/Murray residences. Scenario B is the probable worst-case alignment with respect to potential impacts at the Norman Residence. The layout shown in Exhibit 1 was based on information contained in the operational plans for each aggregate site. The FDM was run both with and without control measures in place. This is discussed further in the next section.

The FDM also required meteorological information as input. Three meteorological cases were analyzed: worst-case, annual average and mid-summer (July) average. For each residence being studied, the worst case data were computed for wind blowing directly from the sources to the residence, and for a range of wind speeds. The annual and mid-summer average were computed using wind frequency data partitioned by atmospheric stability (STAR data).

The FDM model uses dispersion coefficients which depend on the thermal stability of the atmosphere and the character of the surrounding terrain. For the worst-case runs, the dispersion coefficients were chosen to represent neutral stability and surroundings that consist mainly of wooded terrain (Pasquill-Gifford stability C was used for this purpose). The explanation for the use of neutral stability is as follows. Dust emissions tend to be maximized during conditions of extreme dryness. The atmospheric stability in such cases tends to be either neutral or unstable, but neutral stability leads to higher downwind dust concentrations. For the annual and mid-summer average runs, the default dispersion coefficients were used, which cover all possible stabilities and are representative of flat, open terrain. Because the default values apply to open terrain, they will tend to overestimate dust levels in the present case. This choice was adopted for simplicity. Table 3 summarizes the cases that were modelled.

The FDM provided 1-hour concentrations of suspended particulate matter and dustfall. In order to compare with the provincial criteria, the results were scaled to the appropriate averaging times and combined with background data. The worst-case suspended particulate values were converted to 24-hour values by applying a factor of 0.5. This factor accounts for the fact that operations at the aggregates sites typically occur for no more than 12-hours per day, and that wind erosion events seldom endure for longer than 12 hours at a stretch. The annual and monthly average values were further factored to account for the fact that a typical aggregate

Table 3 Scenarios Analyzed

1. Worst-Case

Year:	2000
Source:	James Dick, Sarjeant, Cook, Alfa
Traffic:	(a) licensed maximum (b) probable maximum
Wind Angles:	S, SE, WSW, W, WNW, NW, N, NE, ENE, E, ESE, SE
Wind Speeds:	1 to 12 m/s
Stability:	Neutral
Residences:	Norman, Bolton, Gauldie/Murray

2. Annual and July Average

Year:	2000
Source:	James Dick, Sarjeant, Cook, Alfa
Traffic:	(a) licensed maximum (b) probable maximum
Wind Angles:	STAR wind frequency data
Wind Speeds:	STAR wind frequency data
Stability:	STAR wind frequency data
Residences:	Norman, Bolton, Gauldie/Murray

facility operates for only about 250 days out of the year, and that there are about 140 days per year when dust emissions will be suppressed by precipitation.

8. RESULTS

Table 4 shows the emission rate estimates for the uncontrolled case that were used in the analysis. The controlled case is discussed later in this section. The emission rates for some of the processing operations (loading and stockpiling) and wind erosion are dependent on wind speed. For these sources, therefore, the table shows emission rates for two wind speeds: a typical speed of 3 m/s (10 km/h), and a fairly high speed of 11 m/s (40 km/h). In the actual analysis, wind speeds ranging between 1 and 12 m/s were examined.

It is clear from Table 4 that vehicle traffic produces by far the highest dust emission rates at all sites, with the exception of wind erosion at high wind speeds. The emissions from traffic on the internal roads are spread along the entire length of the unpaved, internal road at each site. Those for traffic on the 7th line are spread mainly between County Road 11 and the entrance to the Cook site.

Table 4 Emission Rate Estimates

PROCESSING EMISSION RATES (kg/h) -

Wind Speed:	3 m/s	11 m/s
Loader Activity	4	6
Crushing	3	3
Screening	2	2
Stacking	0	1
Wind Erosion	0	51

TRAFFIC EMISSION RATES (kg/h) -

	Licensed Maximum		Probable Maximum	
Scenario:	A	B	A	B
(a) Internal Roads:				
Cook	50	28	25	14
James Dick	117	117	58	58
Alfa	30	n/a	14	n/a
Sarjeant	34	42	16	21
(b) 7th Line:				
Cook	40	40	20	20
James Dick	33	33	17	17
Alfa	18	n/a	9	n/a
Sarjeant	28	28	13	13

Table 5 summarizes the results of the FDM runs. It is clear from the data for the uncontrolled cases that control measures are needed. The greatest attention is needed in the vicinity of the Norman residence, but some measure of control is also needed in the vicinity of the Bolton and Gauldie/Murray residences.

Table 5 Analysis Results

	Licensed Max. Traffic:		Probable Max. Traffic:		
	No Ctrl.	Ctrl.	No Ctrl.	Ctrl.	Provincial Criterion
1. Peak 24-hour TSP (µg/m³)					
Gauldie/Murray	289	84	174	75	120
Bolton	443	132	269	131	120
Norman	923	171	481	111	120
2. Annual Average TSP (µg/m³)					
Gauldie/Murray	54	39	46	38	60
Bolton	73	44	57	42	60
Norman	236	75	147	60	60
3. Average TSP for July (µg/m³)					
Gauldie/Murray	46	37	41	36	N/A
Bolton	58	40	48	39	N/A
Norman	243	75	150	61	N/A
4. Annual Average Dustfall (g/m²/month)					
Gauldie/Murray	3.0	2.2	2.6	2.2	4.6
Bolton	4.1	3.5	3.2	2.4	4.6
Norman	12.8	4.3	8.2	3.5	4.6
5. Average Dustfall for July (g/m²/month)					
Gauldie/Murray	3.0	2.0	2.2	2.0	7.0
Bolton	3	2.3	2.7	2.2	7.0
Norman	14.0	4.4	8.7	3.6	7.0

With no control measures in place, the predicted peak 24-hour concentration of TSP (total suspended particulate matter) exceeds the provincial criterion in both the licensed maximum traffic case and the probable maximum case. The predicted annual average concentration meets the provincial criterion at the Gauldie/Murray residence, but exceeds it at the Norman residence. At the Bolton residence, it meets the criterion in the probable maximum traffic case but exceeds it somewhat in the licensed maximum case. The predicted dustfall values meet the provincial criterion at the Bolton and Gauldie/Murray residences but not at the Norman residence.

Table 4 showed that the largest predicted source of dust emissions in the uncontrolled case is truck traffic on internal haul roads. This is consistent with the authors' observations at numerous sand and gravel operations. In the vicinity of the Norman residence, traffic on the 7th Line is also a significant source of dust. The concession road will be paved, but if it is not kept clean, dust will be generated by traffic on the pavement. In addition, dust can be generated whenever a vehicle inadvertently travels partly on the unpaved shoulder.

Site Plans: Internal Road Paving

The recommended control measure for unpaved internal haul roads is regular watering (at least once per day during dry conditions with heavy traffic). Calcium chloride or other approved additives could be used to enhance the effect of the water. For the 7th Line, the recommended approach is to pave the access road at each site from the 7th line to the scale house. In this way, gravel tracked onto the pavement from unpaved areas will tend to be contained on site, leaving the 7th Line relatively clean. The access road would have to be cleaned regularly (at least once per day during dry periods with heavy traffic). It is also advisable to treat the shoulders with calcium chloride along the 7th line, between County Road 11 and the Cook entrance. Routine treatments about twice per year, as are commonly done by municipalities in their industrial parks, would suffice. These treatments would mitigate dust emissions produced when vehicles occasionally travel partly on the shoulder.

The effect of watering was analyzed using a formula contained in <u>Control of Open Fugitive Dust Sources</u>, published by the U.S. EPA (EPA-450/3-88-008). A once-per-day soaking of the unpaved haul roads with 5 litres/m^2 was estimated to reduce dust emissions for the peak traffic volume by approximately 85%. At this rate, a typical 10,000 litre water truck can water about 700m of roadway in a single pass. A twice per day watering with 2.5 litres/m^2 would achieve a similar effect, or perhaps slightly better effect than the once-per-day treatment.

The reduction in dust emissions along the 7th Line due to paving and cleaning the access roads, and routine treatment of the shoulders was estimated from information on paved industrial roads contained in Compilation of Air Pollutant Emission Factors (AP-42), Volume I, Stationary Point and Area Sources, published by the U.S. EPA. The estimated reduction was 85%.

The controlled cases in Table 5, therefore, are with an 85% reduction in dust emissions from vehicle traffic. The predicted TSP and dustfall values for the probable maximum traffic case meet the provincial criteria at all three residences, with the exception of peak 24-hour TSP at the Bolton Residence. The exception is associated with wind erosion when the wind is from ENE at speeds in excess of 10 m/s. However, the basis for the peak 24-hour TSP values shown in Table 5 is a day with a steady wind throughout the hours of operation, and the likelihood of a such an event with winds from ENE in excess of 10 m/s is less than once every 7 years. The likelihood that it coincides with dry conditions is even smaller. Thus, the predicted excursion at the Bolton residence in the controlled case is an unlikely scenario and, as such, is not considered to be a concern.

In the case of the licensed maximum traffic, the predicted TSP levels continue to exceed the criteria at the Norman and Bolton residences. Thus, if the probable maximum traffic rate is ever exceeded, then the watering rate may have to be increased, particularly at the James Dick site.

9. CONCLUSIONS

The analysis conducted in this study indicates that the combined impact of dust emissions from the proposed sand and gravel operations along the 7th Line in Oro Township can be kept within provincial criteria, but measures will be needed to mitigate dust from truck traffic. The recommended measures are as follows:

1. Watering at a minimum rate of 5 litres/m^2/day on unpaved haul roads when shipping operations are taking place and the conditions are dry. This recommendation is intended for the James Dick, Sarjeant, Cook and Alfa sites.

2. Paving of the site access roads from the 7th Line to the scale house at each site.

3. Regular cleaning of the paved access road at each site when shipping operations are taking place (at least once per day during dry weather).

4. Routine (twice per year) treatment of the shoulders on 7th Line with calcium chloride or other approved dust suppressant between the Cook entrance and County Road 11.

In addition to the above measures for traffic dust, it is suggested that crushing of extremely dry materials be avoided. The material will generally have sufficient moisture if it is fed directly from the extraction face to the crusher, without being temporarily stockpiled for prolonged periods of time.

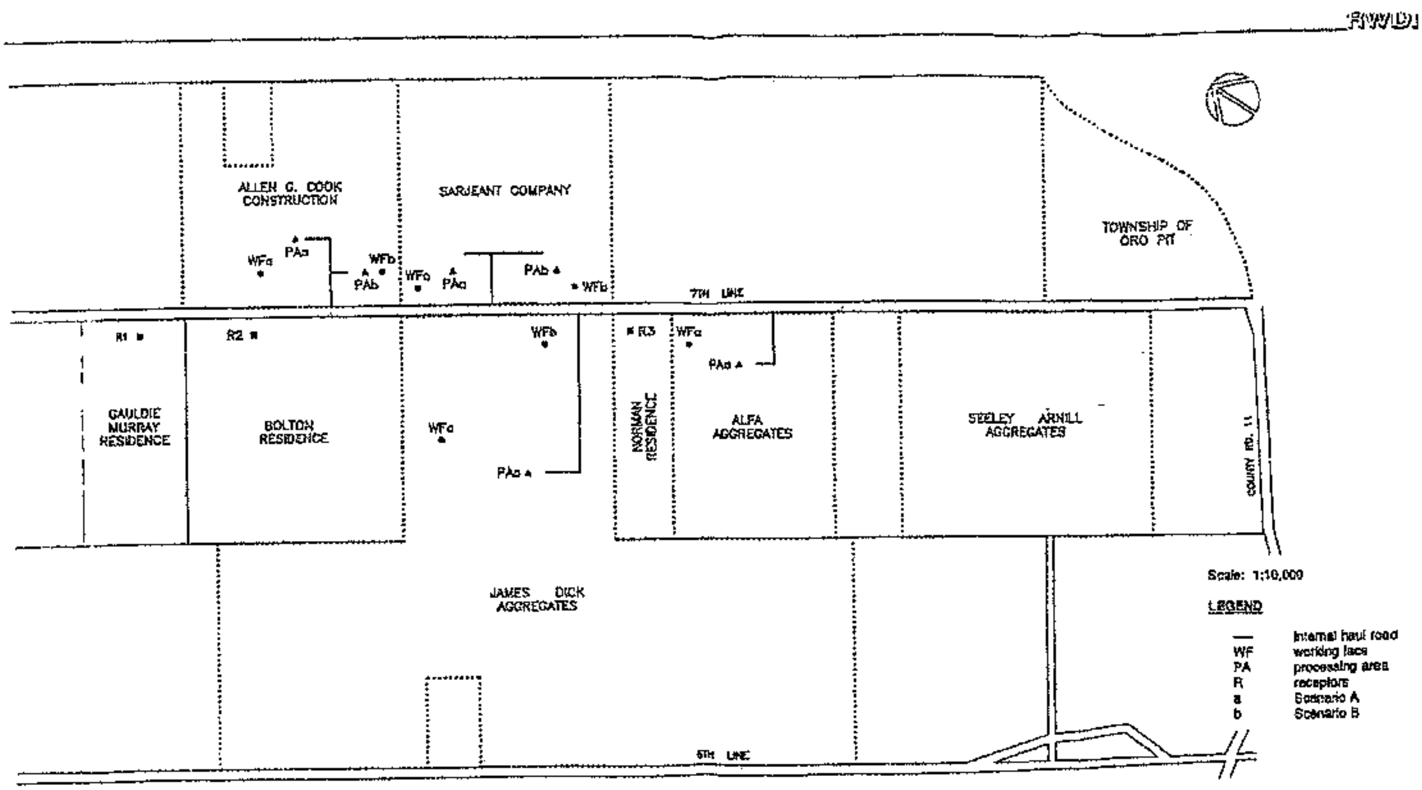

Exhibit 1: Site Plan Showing Sources and Receptors

7th Line, Oro Gravel Pits #2-175-11