ODOURS, AESTHETICS & SOCIO-ECONOMIC ASPECTS OF HAMILTON-WENTWORTH'S AIR QUALITY

Prepared by

Aesthetic, Odours and Economic Workgroup
Hamilton-Wentworth Air Quality Initiative

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The Aesthetic, Odour and Economics Workgroup report is one of four Workgroup reports prepared for the HAQI. The other three reports cover human health, environment and transportation issues. In addition, a Summary Report integrates the findings of the four technical reports. The primary authors of those reports and other key supplementary reports are listed in Appendix A.

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Odours, Aesthetics & Socio-economic Aspects of Hamilton-Wentworth's Air Quality

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1 INTRODUCTION

There is evidence that air quality is perceived as a serious problem in Hamilton-Wentworth. A recent article (Chatelaine, 1996) showed the results of a study which ranked Hamilton a poor 20th among 25 cities on overall air and water quality. Windsor was rated worst overall. In a recent survey conducted in Burlington, respondents referred to the bad smell of Hamilton's air while driving across the Burlington Skyway (The Hamilton Spectator, March 8, 1996).

It is difficult to measure the possible effects of air pollution in social and economic terms. For example, how many people don't relocate to Hamilton because of these negative perceptions? Do these attitudes affect the willingness of the public to use Hamilton International Airport? Do perceptions of poor air quality in a neighbourhood cause property values to decline?

Aesthetic aspects and odours are equally difficult to measure. Studies suggest that people tend to rely on their senses (smell, sight) rather than hard data as indicators of air quality in their community. For many of us, reduced visibility (smog and haze), unpleasant odours (rotten egg smells near industries), and visible particles of black soot on lawn furniture are evidence of poor air quality. Also, people have different levels of tolerance for these indicators. An odour that one person can hardly detect may be highly irritating to another.

1.1 The Aesthetics, Odours, and Economics Workgroup

The Aesthetics, Odours, and Economics (AOE) Workgroup consists of individuals from a variety of backgrounds (Regional Municipality of Hamilton-Wentworth, Ontario Ministry of Environment and Energy, private industry, citizen groups, and McMaster University) who are concerned about the socio-economic aspects of Hamilton's air quality.

The AOE Workgroup was formed early in 1996 with the following objectives:

- to determine public perception of air quality problems in Hamilton-Wentworth;
- to characterize non-health related air quality problems (e.g. odours, smoke and property damage, black fallout) using available complaint and monitoring data; and
- to determine the socio-economic effects from existing air quality data in Hamilton-Wentworth

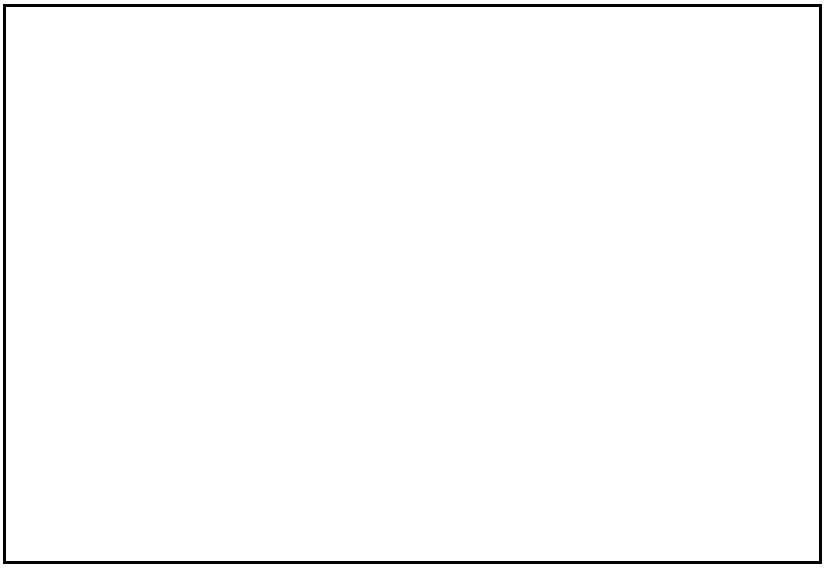
The AOE Workgroup also provided support in the development of two surveys. One survey, conducted by the Regional Health Department of Hamilton-Wentworth, examined the attitudes and perceptions of residents of a neighbourhood in Hamilton to black fallout. The second survey, conducted by McMaster University, surveyed a sample of Hamilton-Wentworth citizens to investigate the attitudes and values that residents of Hamilton-Wentworth place on different attributes of air quality. The results of these surveys are presented in sections 5 and 7.

1.2 Community Involvement in Air Quality Issues

The residents have shown a long standing interest in air quality issues. Several community groups have been formed and are active in air quality issues, including: the Beach Boulevard Preservation Committee, the Homeside Environmental Committee, and the Community Action Parkdale East. The Beach Boulevard Preservation Committee is an overall community interest group with many issues and functions. They have a specific interest in air quality and how it impacts quality of life. The Homeside Environmental Committee was formed to address the impacts of black fallout in the northeast end of the City of Hamilton. Through the efforts of this Committee, political will was focused on air quality which led to the formation of the City of Hamilton Air Quality Stakeholder Committee. Community Action Parkdale East focuses on the impacts of the operation of the Sewage Treatment Plant (mostly odour problems). This 200-member neighbourhood environmental group was formed to address environmental issues affecting the area between Parkdale Avenue and Nash Road, north of King Street. They are involved in providing air quality information to the Region of Hamilton-Wentworth on incinerator operations and local industrial emissions.

2 HOW DOES HAMILTON'S AIR QUALITY COMPARE TO OTHER CITIES?

Figures 1, 2, and 3 compare the ambient air concentration of selected air pollutants in three parts of Hamilton - the industrial zone, downtown, and the mountain - to four other Ontario cities. The pollutants included sulphur dioxide, inhalable particulates (PM_{10}), total reduced sulphur compounds (TRS), ozone, lead and suspended particulates. In most cases, downtown Hamilton and the mountain are about the same or better on average than the downtowns of Toronto, St.Catharines, Sudbury and Windsor. The Hamilton industrial zone levels are generally higher, and combined with the historical record of much higher pollution levels from over 25 years ago, this seems to have coloured the current perception of Hamilton’s overall air quality. Odours due to TRS probably play a role in this. TRS is almost entirely industrially related, and is not measured in most other communities (including Toronto and St.Catharines in these examples), unless an industrial source exists.



3 INDICATORS OF AIR QUALITY

Most people tend to depend their senses (sight, smell) to determine the quality of the environment. According to one study (Mukherjee, 1993), the most important indicators of air quality are odour (24%) and black fallout (15%). Visible air pollution (smog, particulate, smoke, and coloured plume) and health effects (such as the number of visits to the doctor) also indicate poor air quality according to public studies.

3.1 Odours

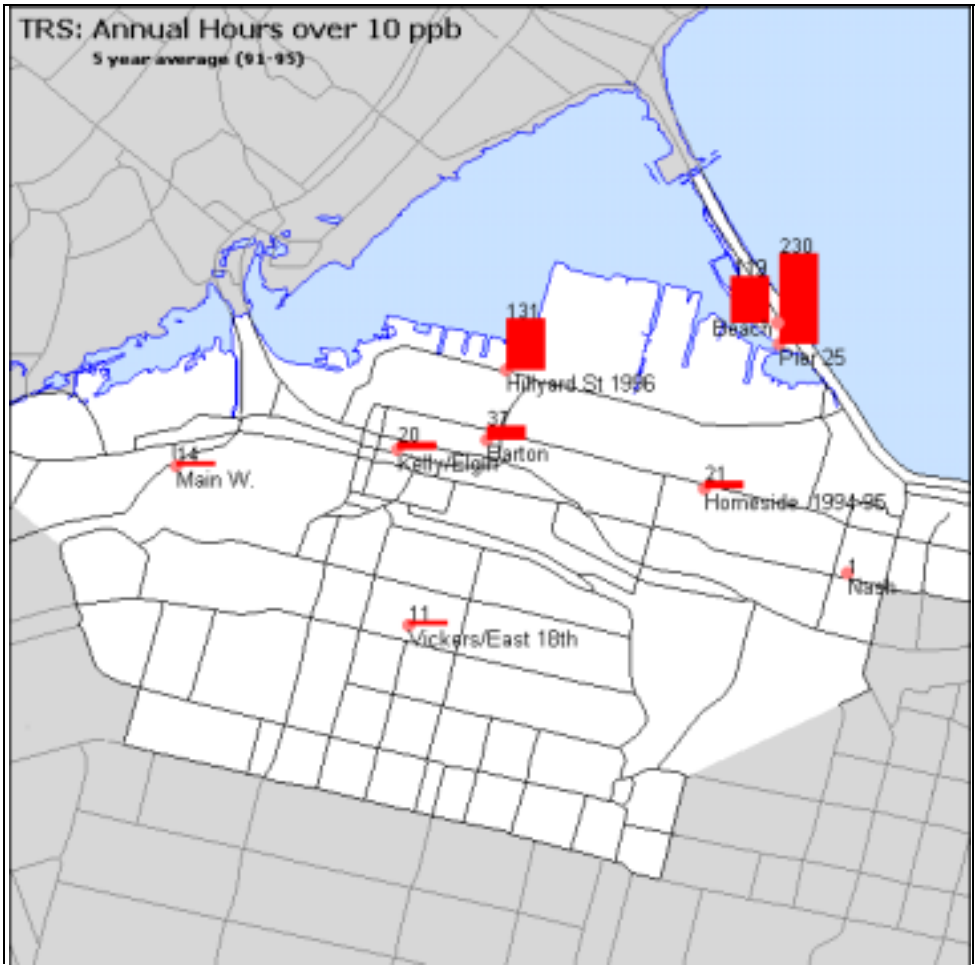
There are several main groups of odorous compounds: volatile organic compounds (VOCs), reduced sulphur compounds (e.g. hydrogen sulphide), ammonia and amines. Operations that commonly cause odours include: iron and steel production, oil refineries, foundries, rendering and food processing, landfills, and paint and printing operations. These pollutants can also react with other pollutants to create odorous by-products. Odour is typically caused by a mixture of compounds, which is why odour is often so difficult to describe.

The impact an odour has on a community depends on the intensity, volume of odorous gas, atmospheric conditions, and the amount of dispersion between the emission source and those affected by the odour.

Ambient Data

Total Reduced Sulphur Compounds

Sulphur type odours (e.g., rotten egg smell) are monitored primarily with Total Reduced Sulphur Compound (TRS) continuous analyzers. Monitors have been situated at eight locations in Hamilton during the 1990s. Figure 4 indicates the spatial variation and the number of hourly readings that the hydrogen sulphide (H_2S) odour threshold of 10 parts per billion was exceeded annually. Sites close to the steel mills to the east and west measure substantially more odours than the rest of the city. Since TRS sources at the mills are low lying (not tall stacks), concentrations of TRS decline rapidly with distance from the source. The elevated concentration levels on the Beach Strip have been shown to come mainly from Dofasco, and the elevated levels at the Hillyard Street site (just west of Stelco) are due primarily to Stelco. Areas just to the south are less affected because winds rarely come from the north. The mountain, east, and west ends are only slightly affected, because of their distance from the sources.



Volatile Organic Compounds

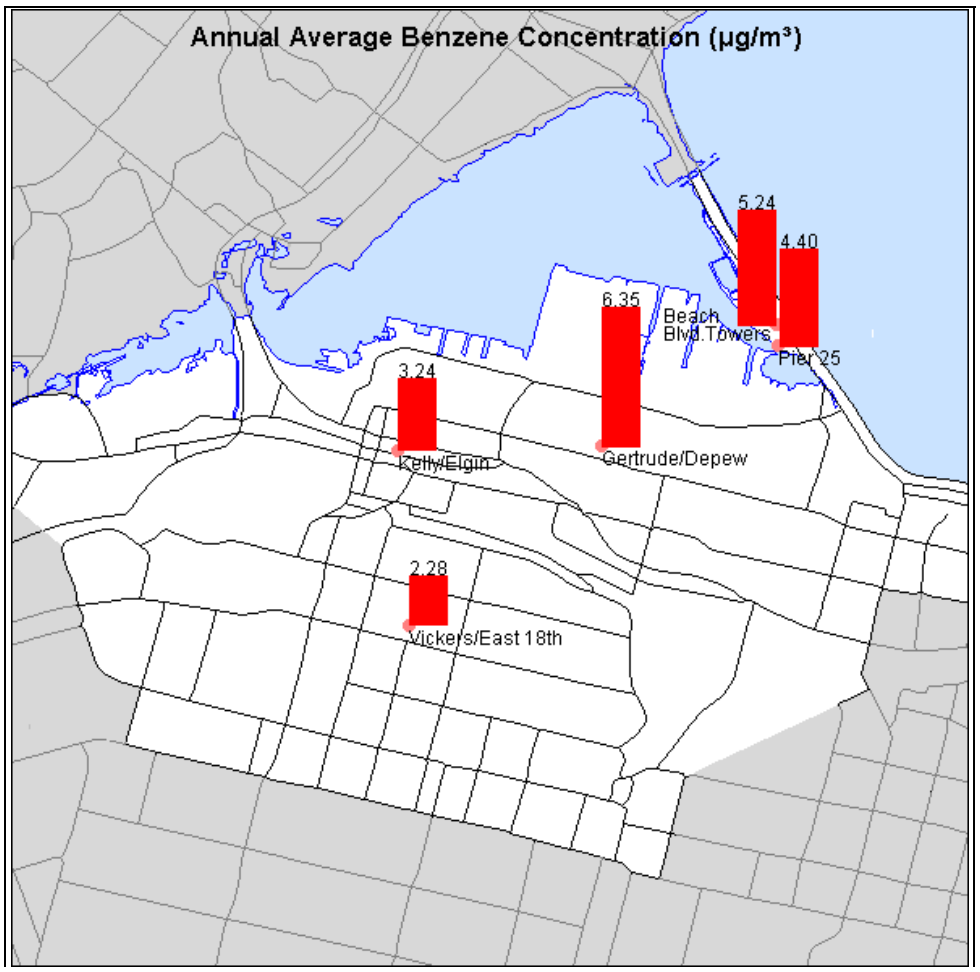
Volatile organic compounds (VOCs) have been measured at five sampling sites in the 1990s. Most VOCs measured appear to be related to vehicle emissions. However, VOCs such as benzene and naphthalene come from industrial sources - specifically, from coke ovens. Figure 5 shows how concentrations of benzene vary across the city. Although there is no scientific measure of odour in Hamilton, it is reasonable to assume that high benzene levels in the industrial area will also be accompanied by high levels of other odorous pollutants.

Complaints about Odour

Studies (Pengelly et. al., 1996) show that the community regards odour as one of the indicator of air quality. According to data compiled by the Ministry of Environment and Energy (MOEE), odour is responsible for the most public complaints. Many variables affect complaint data. For example, the intensity of odours varies with industry location, size, and type, production practices, season, temperature, humidity, time of day, and wind speed and direction. Some odorous compounds attach themselves to dust, concentrating and prolonging their offensiveness.

There is also a strong psychological aspect to air pollution odours. Human reactions to industrial odours are influenced by personal preferences, opinions, experiences, and olfactory system sensitivity. Tolerance is higher if the source of the odour is understood or if people believe they can do something about it. People react as much to the context as to the odour itself. Finally, habituation to an odour can occur over time. If people have grown accustomed to an odour, they are less likely to complain.

Industrial odours can adversely affect people's outlook and their physical and mental health. People who complain about odours often express concern for the welfare of exposed children, declines in property values, and increases in insects and rodents. Many are concerned about possible health effects of odours. They reason that if one can smell the air, it must be very polluted. Further details on complaints, including odours, are provided in section 4.



3.2 Visibility

Visibility is often defined as the distance at which an object (for example, a mountain or tall building) can just be seen. Reduced visibility is often a regional phenomenon that is caused by the presence of pollutants such as fine particles, sulphates and nitrates. People are also concerned over visible emissions from smoke stacks, even if there are no visibility restrictions. For example, visible black smoke from stack emissions are often indicative of poor operation of an industrial process, which may lead to increased public awareness of poor air quality. However, these emissions by themselves may not necessarily contribute to a significant reduction in visibility across the local area or region.

Visibility is recorded at the Hamilton International Airport in Mount Hope and the Canada Centre for Inland Waters (CCIW) in Burlington. Visibility is influenced by pollutants such as fine particles (PM_{10} and $PM_{2.5}$), sulphates, nitrates and ammonium compounds. Figure 6 is an example of the relationship between $PM_{2.5}$ and visibility observations (24 hour averages) in Hamilton. The data shows visibility decreases as levels of pollutants increase. The visibility readings are recorded up to a upper range of 15 kilometers at this site (CCIW), therefore, there are no readings above 15 kilometers.

What causes reduced visibility?

In Hamilton, reduced visibility can occur under several different scenarios. First, temperature inversions in the spring and fall can create pollution build-ups. Warmer air above a cool ground layer acts as a cap, preventing the cool air from rising. Pollution accumulates near the top of this boundary layer, resulting in a reddish-brown layer of air pollution. The reddish brown colour is caused by nitrogen dioxide, a product of fuel burning by industry and vehicles. In Hamilton, the colour may also be partly due to iron oxide particulate. The visibility of this layer depends on the time of day, the angle of view and whether the sun is shining.

Below this layer, the overall pollution load can also reduce visibility and provide condensation nuclei favorable for the production of dense fog from moist air over the lake. In Hamilton, the pollution particles near the ground act as condensation nuclei which can combine with moist air over Lake Ontario to produce a fog (Hung and Liaw, 1981).

Finally, long range transport of pollutants from the United States and other areas upwind of Hamilton-Wentworth can create region-wide visibility reductions, particularly during the summer. During elevated ozone episodes on hot sunny days, ozone is often accompanied by fine particulates and acid aerosols. These particles, comprised mostly of sulfates, nitrates, carbonates, and some organic compounds, are formed when gaseous pollutants react chemically in the atmosphere. They form a white haze which can restrict visibility (U.S. EPA, 1977). Regional haze caused by human emissions can cover large areas and may be transported long distances.

3.3 Black Fallout

Black fallout is solid particles of air pollution, comprised largely of carbon, which occur in a variety of sizes. Visible dust particles are generally greater than 50 micrometers in size. Potential sources of black fallout in Hamilton include: inefficient industrial combustion, the steel-making industry, vehicle emissions, poorly operated home and industrial heating systems, wood burning, carbon black manufacturing and waste incineration.

Black fallout has become a major concern in parts of Hamilton in recent years; likely because it is highly visible (see the Perception Survey in Section 5). Complaints of black soot on lawn furniture, vehicles and buildings are common.

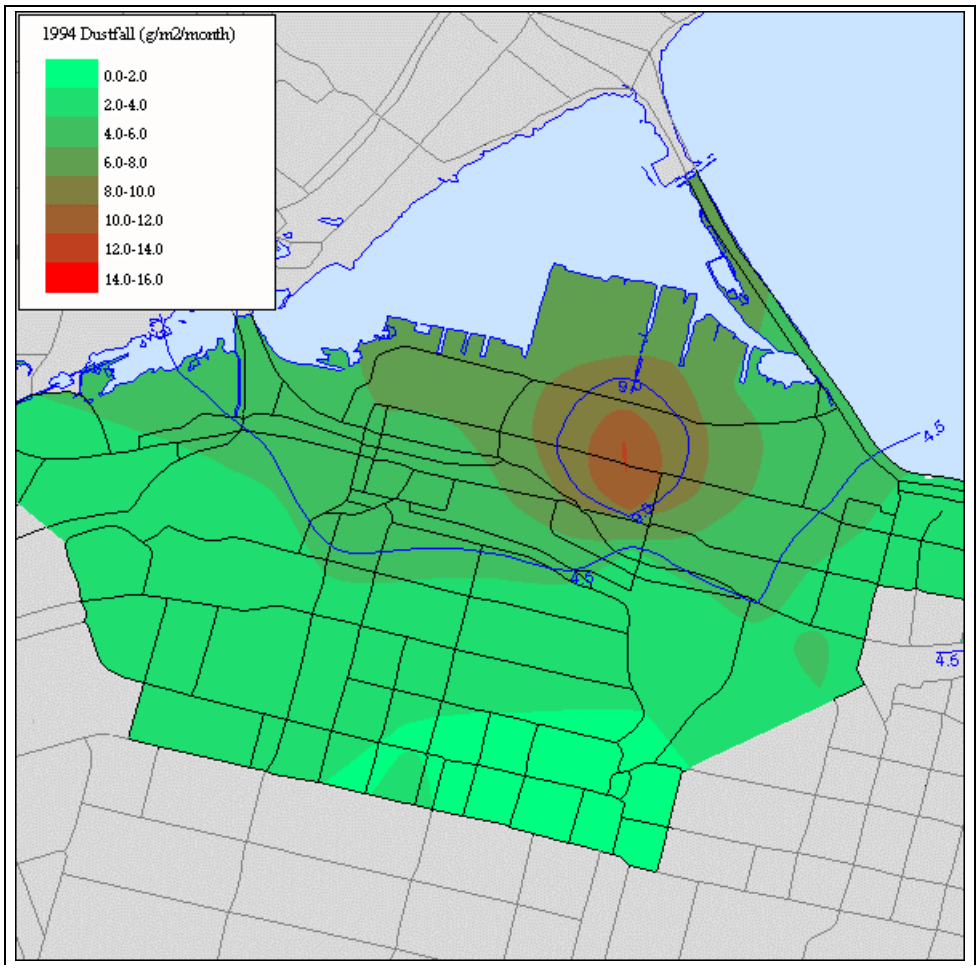
Ambient Data

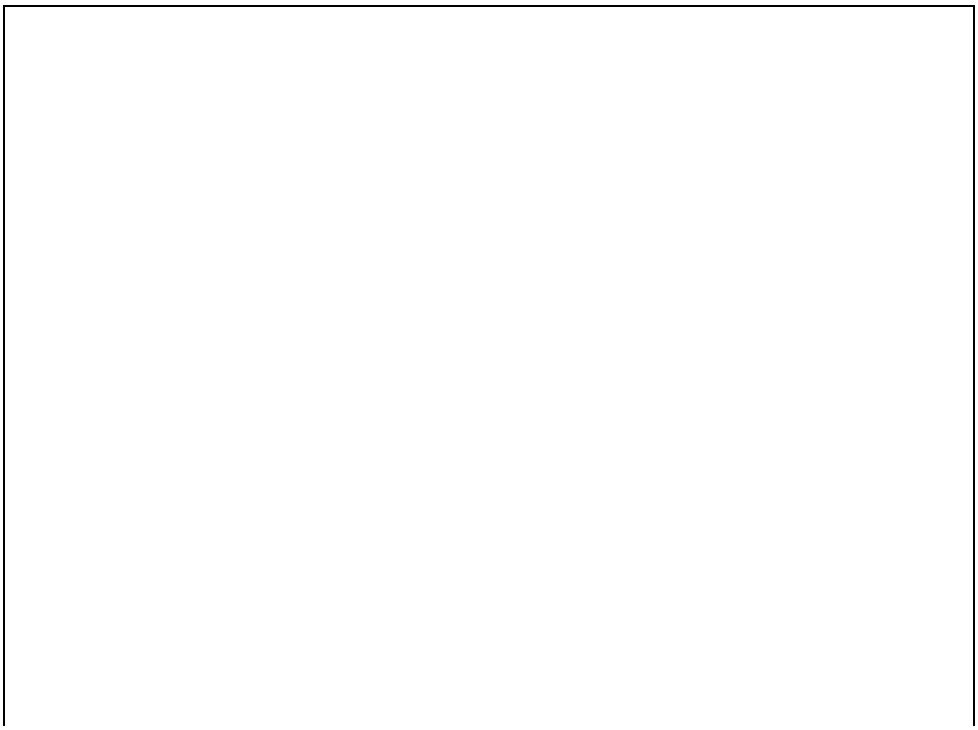
Black fallout is a component of general heavy dust. These particles tend to fall out of the air by gravity, and, due to their size, settle relatively close to the sources. Figure 7 displays the dustfall data. The annual objective for dustfall is 4.5 grams/m^2/month and this level is exceeded in the lower city in the vicinity of the industrial zone. In the centre of the industrial zone, the average level of particles measured is more than twice this objective. Under certain conditions, the dust particles can occasionally travel further afield.

These problems currently still exist despite major reductions in industrial particulate emissions and corresponding reductions in the measured dust levels. Figure 8 shows the downward trend of dustfall. The readings across the city began to improve in the 1980s, long after emission improvements had already taken place at the major industries. This lag could be due to a variety of factors, including improved fugitive dust control from stockpiles and roadways, as well as bringing smaller industrial sources under better control. Other measures included the banning of apartment incinerators in 1989.

4 COMPLAINTS

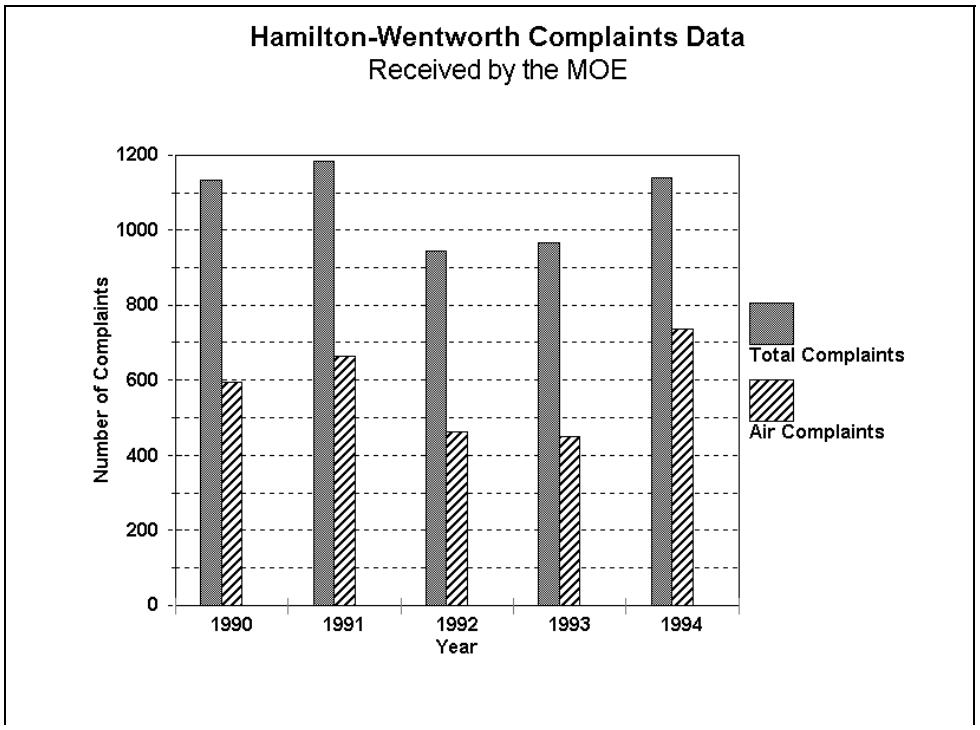
The Ontario Ministry of Environment and Energy (MOEE) receives many public complaints about the aesthetic effects of air pollution, such as bad odours, dust fall and soiling. The number of complaints in Hamilton-Wentworth ranged from 945 to 1139 over the years 1990 to 1994, with somewhat lower number in 1992 and 1993. The number and percentage of complaints on air quality was highest in 1994, likely due to community efforts to draw attention to air quality problems (which led to the formation of the Black Fallout Committee). The trends for the complaints over the years are presented in Figure 9.

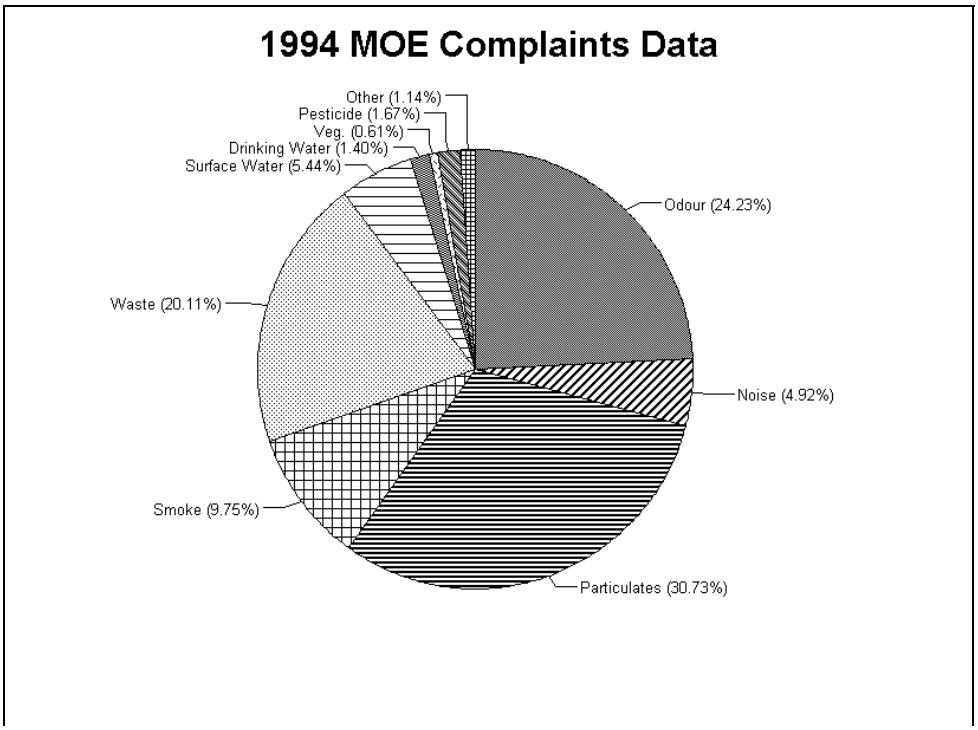


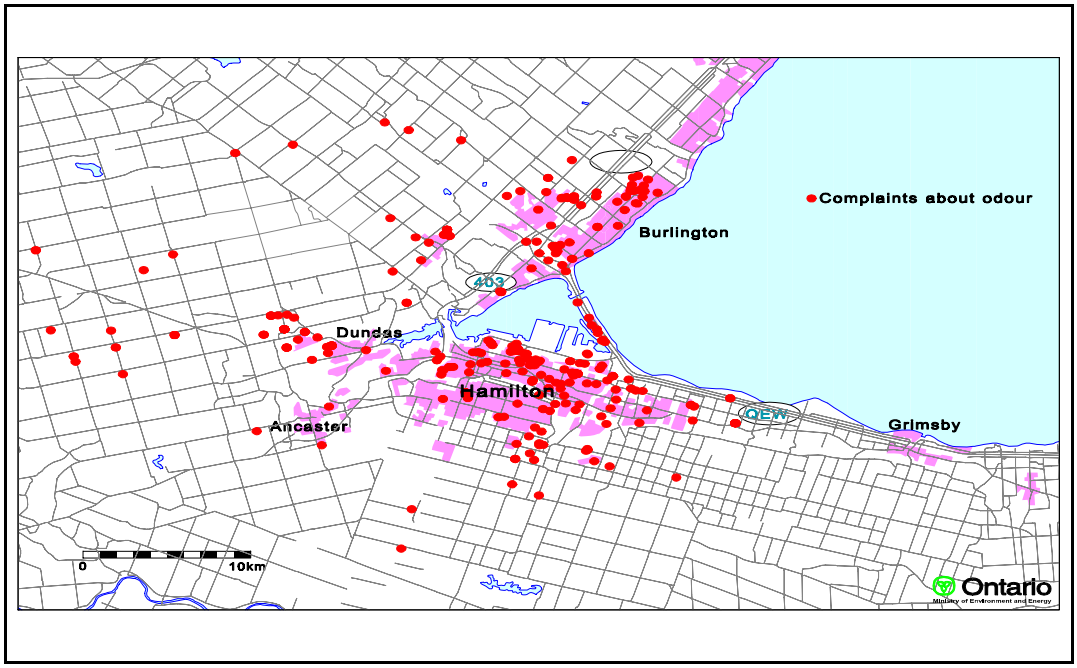


Sixty-five percent (65%) of these complaints were related to air pollution such as dust, odours and smoke. A more detailed breakdown of the complaint categories are shown in Figure 10. Similar patterns of air pollution complaints are registered in other parts of the province, with 47% related to air pollution in northern Ontario, 51% in southeastern Ontario, and 64% in Toronto area. In the eastern and central parts of Ontario, the air pollution complaints are lower at 31%.

The spatial distribution of odour complaints received in 1994 is shown in Figure 11. These data show a higher proportion of complaints around the industrial/urban areas of Hamilton.


Hamilton-Wentworth Complaints Data
Received by the MOE
Number of Complaints
1200
1000
800
600
400
200
0
1990
1991
1992
1993
1994
Year
Total Complaints
Air Complaints


1994 MOE Complaints Data
Other (1.14%)
Pesticide (1.67%)
Veg. (0.61%)
Drinking Water (1.40%)
Surface Water (5.44%)
Odour (24.23%)
Waste (20.11%)
Noise (4.92%)
Smoke (9.75%)
Particulates (30.73%)



4.1 Complaints Handling By Companies

Most large companies in Hamilton-Wentworth have a specific protocol for handling complaints. This usually involves maintaining a log which records the time, duration, and nature of the incident that may have caused the complaint. Smaller companies usually do not keep records of complaints, but they may respond to them.

Companies will generally respond to a complaint, depending on its nature. They may investigate to determine if they are truly responsible. If there has been property damage (soiling, for example), they may clean the exterior of the house or issue a car wash chit.

Generally, companies in the Hamilton area do not inform the MOEE of complaints they have received. When an abatement officer responds to a public complaint that can be traced to an individual corporation, that company will often try to amend the problem if it does not involve any major process changes.

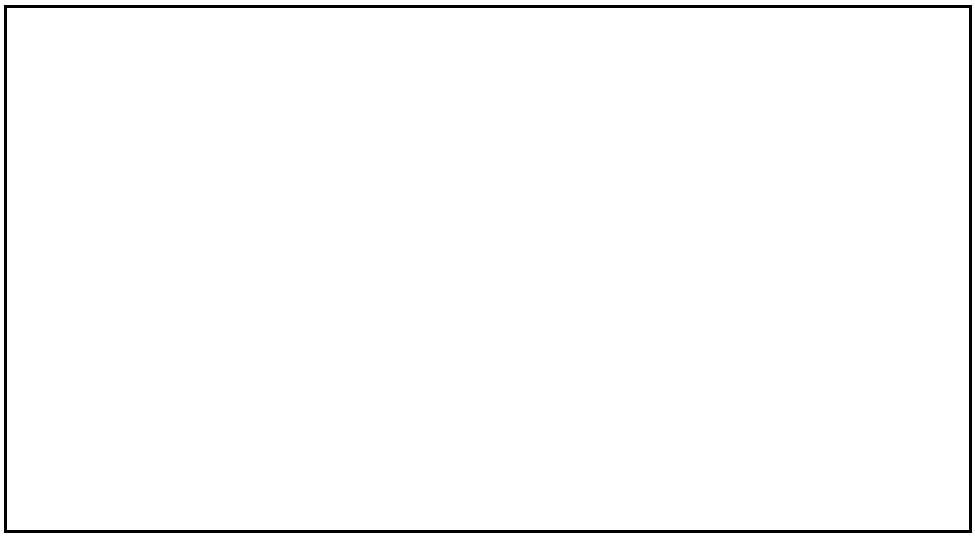
4.2 Complaints and Actual Ambient Air Measurements

A commonly asked question is whether the number of complaints increases when MOEE ambient air monitoring data show there are high levels of pollution. The AOE Workgroup examined complaint records and the relevant measurement data to determine potential correlations. Complaints about black fallout were compared to actual dustfall measurements in three areas where dustfall complaints are most frequent: Greensville (Flamborough), central Hamilton, and the Hamilton Beach Strip. The number of monthly complaints from each area was compared with a composite average of the data from MOEE dustfall monitoring stations for each month from 1991 to 1995 (Figure 12).

There appeared to be no correlation between dustfall complaints and actual measurements. This also seemed to be the case with odours. For example, the Beach Strip area had the greatest odour problems, as determined by TRS monitoring stations. However, complaints about odour were surprisingly few and rarely coincided with elevated odour measurements at the monitoring stations.

4.3 Why Are Measurements Not Good Indicators of Complaints?

There may be several reasons for the discrepancy between measured levels of pollutants and complaints. There are many factors which influence whether people will complain, including



sensitivity of the individual and the influence of community groups. As people are repeatedly exposed to air pollution, they may become habituated to odour and visibility impacts and are less likely to complain. Others may feel that authorities would not take action to address their complaints. They do not lodge complaints because they feel there is no use in doing so. People who do not hesitate to complaint may lodge a complaint at very low pollutants levels, while others fail to lodge a formal complaint, even though they are affected.

It is also possible that very localized cases of high odour or dustfall may not be close enough to MOEE monitoring stations to be recorded. Similarly, very short odour and dustfall events (e.g., minutes or seconds) may not be detected in the hourly, daily, or monthly time frames used in the MOEE's monitoring procedures, yet are detected by the public.

Historically, some complaints have been directed to a number of interested authorities (MOEE, Region of Hamilton-Wentworth, industry, City of Hamilton) for action. This means the MOEE complaints database may not have all the complaints in the region.

Although complaints data provide a general indication of public dissatisfaction with air quality, the limitations should be considered when developing policies based on these data.

5 PERCEPTION OF BLACK FALLOUT

Residents of Hamilton are subjected to airborne industrial pollution daily. Some residential areas, especially those located close to industry, have greater exposure to pollution. Often, odour and visible pollution (black fallout and haze) lead people to believe that air pollution levels in their neighbourhood pose a threat to their health.

One such area is the Homeside neighbourhood, located in the northeast end of the City of Hamilton. Prior to 1993, residents of Homeside began to notice an increase in a black soot-like substance on their properties. Through community awareness and persistence, the Homeside Environmental Committee was formed, consisting of members of the neighbourhood, MOEE officials, City of Hamilton politicians, and representatives from the Regional Public Health Department. The Committee was formed to address residents' concerns about pollution and black soot.

As a result, the Homeside Community Environment Project Workgroup was formed to investigate the impacts of black soot on the Homeside neighbourhood. The Workgroup, with members from the Regional Public Health Department and McMaster University, investigated the psychosocial impacts of black soot on residents of the north end of Hamilton. They gathered information on public perceptions of black soot, air pollution, and health.

A telephone survey was conducted in November, 1996. To determine the extent of the black soot nuisance, the survey area extended beyond the Homeside neighbourhood. The survey area was bounded by Hamilton Harbour (and the Hamilton beach area) to the north, Red Hill Creek to the east, Main Street East and Queenston Road to the south, and Wentworth Street North to the west.

Using census tract information and City of Hamilton maps, all households in the study area were identified. Using random numbers, a sample of 600 households were selected. After compiling a list of household telephone numbers, the survey was conducted by Institute for Social Research (ISR) at York University, providing 402 responses. Details of the survey may be found in Elliot et. al. (1997). A summary of the findings is provided in the following sections.

5.1 Perception Survey Results

When residents of north end Hamilton were asked what they liked most about the area they lived, 34% of all respondents reported access to amenities such as shopping, schools and recreational services, 21% reported quiet characteristics of the area and 19% reported feeling of friendliness/sense of community. When asked what they disliked about the area, 25% reported nothing, pollution was second with 11% and factories was third with 7%. Almost one-quarter of respondents mentioned industrial pollution when they were asked what would they change about their area.

In the area of pollution concerns, it is evident that air pollution is a major concern for the residents, with moderate or extreme concerns reported by 90% for industrial smoke stacks, 85% for air pollution (all types), 91% for black soot, 81% for traffic exhaust, 87% for water and 76% for soil. Concerns about air pollution was significantly related to education level. Respondents who

completed high school were more likely to report concerns about air pollution, black soot and odour in their neighbourhood.

Data were also collected about respiratory health and medication use as well as smoking status. One-third of respondents reported that they or someone in their household currently have asthma as diagnosed by a doctor. Of these, 75% reported regular use of a puffer or inhaler. Further, 17% reported they or someone in their household currently have emphysema, chronic bronchitis or a persistent cough, as diagnosed by a doctor. The Ontario Health Survey results indicated asthma rates of 4.5% and Pengelly et al. (1993) reported emphysema and bronchitis rates of 3.1% for all age groups within Hamilton Region. Comparable rates for the North Hamilton survey are 15% and 7% respectively. However, North Hamilton survey results should not be compared directly to Ontario Health survey results since the questions were not asked in the same manner in both surveys. In addition, the confidence limits around these rates would suggest that the Hamilton survey may not be that different than the Ontario Survey results.

With respect to effects on daily lives, respondents were allowed five mentions of how air pollution have affected their daily lives. Respiratory health effects was highest ranked with 39% (first mentions), followed by lifestyle disruptions (e.g., staying indoors, closing windows) and other physical effects (e.g., headaches).

When asked the same question about black soot, respondents mentioned lifestyle disruptions most frequently (74%), followed by psychosocial effects (13%), respiratory health (9%) and other physical health (4%). Although most respondents mentioned lifestyle disruptions as the effect of black soot on their daily lives, nevertheless, 50% of the respondents also considered black soot to be a health related problem. From these data, it appears that the residents of North Hamilton may have a broader definition of health, and/or they perceive links between lifestyle issues and health effects.

For odour, psychosocial effects (e.g., neighborhood stigma, worry about health) was mentioned first most frequently (31%), followed by respiratory health (27%) and lifestyle disruption (24%).
In terms of actions taken by the respondents, 11% of respondents have telephoned, written or spoken to politicians, government or industrial representatives about air pollution over the last two years. However, a somewhat higher percentage (28%) considered moving out of the neighborhood because of the black soot and about half of them had taken steps toward making a move (e.g., looking for new home, putting house up for sale). Of those who had expressed concerns about black soot, 64% believed it was the producers who should be responsible for getting rid of the black soot, while another 32% felt government should be responsible. However, respondents did not identify any particular level of government that was responsible for the black soot (e.g., only 6 of 79 mentioned MOEE).

5.2 Conclusions of the Perception Survey

Elliot et. al. (1997) concluded the residents of north Hamilton experienced relatively high levels of concern about air pollution, industrial stack smoke and black soot. Levels of concern for air pollution was much higher than other types of pollution such as water and soil.

6 SOCIO-ECONOMICS OF AIR POLLUTION

Air pollution affects the community by lowering the quality of life and our ability to attract new business and employment to Hamilton. Air pollution can lower or eliminate scenic views, affecting the ability of Hamilton to attract tourists, special events, and conventions.

Approaches to Studying Socio-Economic Aspects

There are several approaches to studying the socio-economic aspects of air pollution. One type of study attempts to correlate air pollution levels with various demographic groups (e.g. disadvantaged groups with low income or low education). This type of study has not been conducted in Hamilton-Wentworth, therefore, studies in other areas were examined. In the United States, studies suggest that low income groups are likely to be exposed to elevated levels of certain pollutants. Analysis of criteria air pollutant levels between 1970 and 1984 showed air quality had improved significantly and there was a diminishing relationship between low income and living in polluted areas (Korc, 1996). However, results from a case study of New York and Philadelphia showed that communities with higher ground level ozone levels (downwind of ozone precursor sources) had a greater proportion of upper income households (Liu, 1996). The results appear to be mixed in studies on the relationship between low income and living in polluted areas.

Another type of study examines the population characteristics around landfill or hazardous waste facilities. Locally undesirable land uses may drive the wealthy away by making the neighbourhood an unpleasant place in which to live, attracting the poor and thus driving down market property values (Liu, 1996). This theory was supported by a Houston study which examined changes in socio-economic characteristics after a hazardous waste facility was sited in the area. However, other studies on commercial hazardous waste facility expansions do not support this conclusion. These studies suggest the reasons for siting hazardous waste facilities are more likely to be influenced by the willingness of the community to oppose the siting of the facility.

In some activity specific operations (e.g. landfills), the social impacts have often focused on the potential of that activity to create airborne contaminants (odour and dust) which can disrupt the daily activities of the community, lead to loss of enjoyment of property, or affect general quality of life.

7 VALUING AIR QUALITY IN HAMILTON-WENTWORTH

As noted earlier, polluted air can increase short and long term health risks, create unpleasant odours, soil people's houses and backyards, and reduce visibility. In developing a plan to improve Hamilton-Wentworth's air quality, it is important to know which aspects of air quality are most important to Hamilton-Wentworth's residents. In addition, in evaluating any policy that would reduce air pollution, it is useful to compare the policy’s costs to its benefits expressed in monetary units. Therefore, a survey was conducted by Dr. Andrew Muller and Alan Diener of McMaster University in order to address these issues (Muller and Diener, 1997). The objective of this study was to

ascertain both the overall, and the relative, importance placed by the residents of Hamilton-Wentworth on four specific attributes of air quality (health effects, bad odour, black fallout and poor visibility) and to assess their willingness to pay for well defined changes in these attributes. (See Muller and Diener, 1997, for a more detailed report of the survey)

7.1 Methods

The survey was administered by mail in February, 1997, and was sent out to 1908 households within the Region of Hamilton-Wentworth randomly chosen from the December 1995 tax assessment rolls. The survey was broken into several sections (Muller and Diener, 1997). The first section attempted to determine attitudes towards environmental quality as a social issue, as well as attitudes about the specific effects of air pollution (health effects, odours, black fallout, and visibility). Questions pertaining to general experiences with these effects was also included in this section. In the next section, the survey used a recently developed survey method designed to determine a respondent's willingness to pay for improved air quality, known as a choice experiment. In this section, respondents were asked to rank a number of scenarios presenting different levels of health effects, bad odours, black fallout, and visibility. Each scenario proposed a change in property taxes or rental payment which might be necessary to improve air quality. From these rankings, it was possible to determine which characteristics of poor air quality were most important to Hamilton-Wentworth residents and how much they were willing to pay to improve them. In the final section, respondents were asked general demographic questions. Feedback from a number of HAQI participants and faculty of McMaster University was helpful in the design of the questionnaire.

The stated-preference choice experiment (CE) approach is a recently developed alternative to contingent valuation (CV). While both of these methods can be used to elicit people's willingness to pay for improvements in air quality resulting from a public project or policy, the CE may avoid many of the difficulties of contingent valuation studies. Choice experiments allow us to value bundles of attributes and to assess the tradeoffs amongst the attributes that individuals may be willing to make. In a CE, the status quo and a number of alternatives are described by their attributes. Respondents then rank the alternatives from most preferred to least preferred. Whereas, in a typical contingent valuation survey respondents are asked to consider a scenario describing the potential benefits of a hypothetical policy. They are then asked how much they would be willing to pay for that policy to be implemented. One of the drawbacks of the contingent valuation method is that no clear method exists to evaluate changes in the individual components of a bundle of goods or attributes.

7.2 Choice Experiment Scenarios

The attributes employed in the questionnaire included health effects, defined as hospital admissions due to cardio-respiratory diseases and increased mortality, number of days of black fallout, number of days of bad odour and number of days of poor visibility, all on a monthly basis. It was decided to use three levels of each attribute. The middle level of each attribute was based upon the current estimated level of occurrence. The other two levels were based on a one-third reduction and a one-third increase of the current levels. In order to assess willingness to pay, a fifth attribute, a monthly

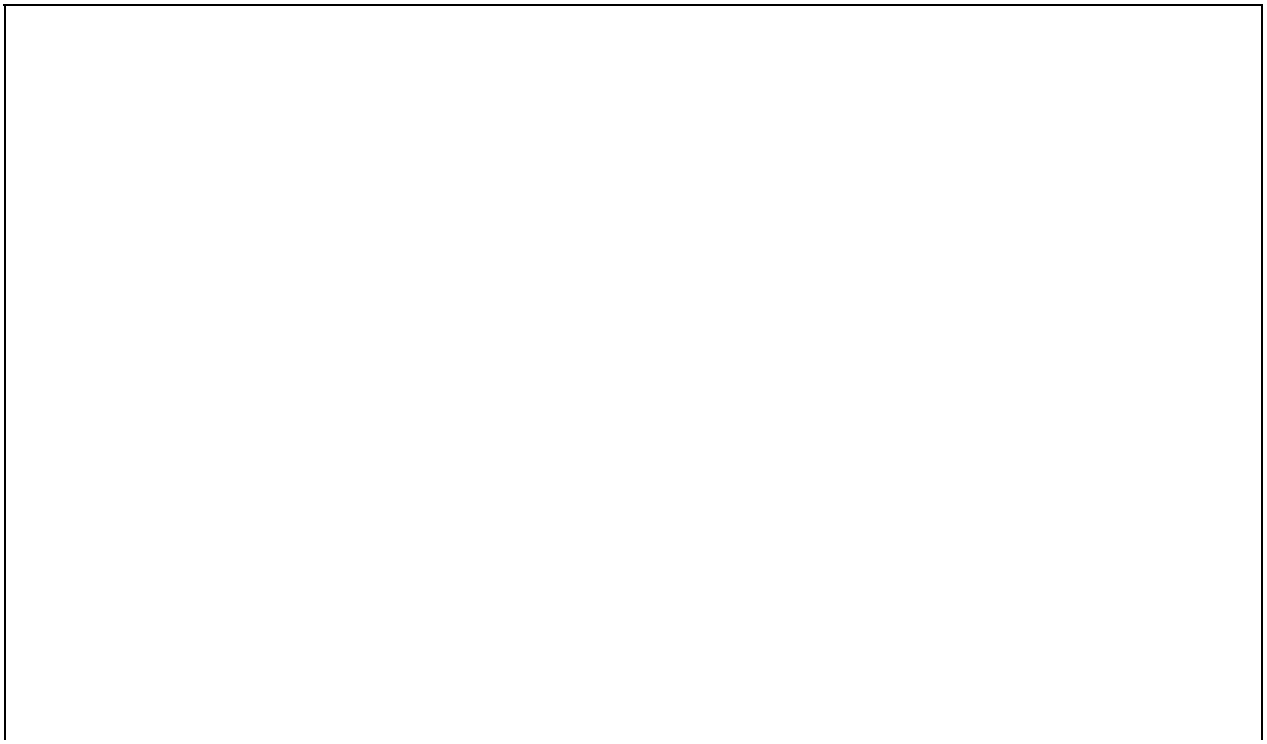
change in property taxes or rental payments was used. Each alternative specified either an increase, a decrease, or no change in monthly property taxes or rental payments.

7.3 Results

Of the 1,908 surveys mailed out, 259 were eventually removed from the sample primarily because the recipients had moved. A total of 515 completed surveys were returned by March 19, 1977, resulting in a response rate of 31%. Of the total number of returned questionnaires 188 of the respondents were able to complete the rankings task without committing any violation of consistency conditions. These respondents were of a younger average age, higher income, and higher educational attainment. In addition, those who chose to return the survey may have had particularly strong concerns about of air quality. It is important to note that selection bias may have prevented this sample from being entirely representative of the region of Hamilton-Wentworth. All these factors may have biased the results.

General Attitudes towards Air Quality

Air quality in Hamilton-Wentworth is perceived to be poor. The majority of the respondents (58%) thought the air quality in their neighbourhood was somewhat worse or much worse than the rest of Southern Ontario. Only 15% of the respondents thought that air quality in their neighbourhood was better than the rest of Southern Ontario (see Figure 13). The majority of the respondents were either very concerned or extremely concerned about each of the four air quality attributes (See Figure 13). Respondents were most concerned with health effects, with 81% of the respondents reporting they were very concerned or extremely concerned. Concerns for the remaining attributes were also high, with 70%, 58% and 56% of respondents reporting they were very concerned or extremely concerned about black fallout, bad odour and poor visibility, respectively (Figure 14).



Willingness to Pay Results

Using the respondents' first choices in the ranking of the choice sets, willingness to pay for a one-third improvement in each of the attributes was calculated. Table 1 provides the preferred estimates of willingness to pay for improvements in air quality based on the responses of the 188 respondents that committed no consistency violations. The estimated model implies that respondents were willing to pay approximately $40 per month to decrease the number of hospital admissions for cardio-respiratory diseases from 18 to 12 per month and decrease the number of extra deaths from 2 per month to one per month, $13 per month to decrease the number of days with black fallout per month from 3 to 2, $13 per month to decrease the number of monthly bad odour days from 4 to 3; and $15 in order to lower the number of monthly poor visibility days from 3 to 2 per month. Although as might be expected, respondents valued improvements in health most highly. These estimates also imply that respondents also place substantial value on reducing the nuisance and aesthetic effects of air pollution.

Table 1: Willingness to Pay (WTP) for Air Quality Improvements

Attribute	WTP ($/month)	Normalized Index

		(Health=100)
Health	$39.60	100
Black fallout	$12.80	33
Bad odour	$13.10	33
Poor Visibility	$14.50	38

7.4 Conclusion of Valuing Air Quality in Hamilton-Wentworth Study

Residents of Hamilton-Wentworth are generally concerned about the effects of air quality, particularly about the health effects. Most respondents believe that the air quality in the Region is somewhat worse than the rest of Southern Ontario. Respondents consistently rated health effects as their most serious concern. Respondents also placed substantial concerns on poor visibility, bad odours and black fallout. The ranking of attributes by willingness to pay is consistent with the rankings obtained in the general attitudes section of the survey (questions 2-5 and question 21). Respondents appeared to be willing to pay between $13 and $40 for a one-third improvement in each of the attributes. The data set developed as a result of the survey is now available for further research.

8 MONETARY VALUATION OF HEALTH EFFECTS IN HAMILTON-WENTWORTH

Human health effects, including premature mortality, cardiac and respiratory hospital admissions and cancer cases, associated with current levels of air pollution in Hamilton-Wentworth region were estimated by the Human Health Working Group (HHWG) of HAQI (HAQI, 1997a). Monetary value estimates associated with these health effects are presented in this section.

Estimates produced in this section complement the contingent valuation survey results of Muller and Diener (1997) which are discussed in section 7. Muller and Diener obtained willingness-to-pay (WTP) values for a postulated 33% reduction in bad odours, poor visibility and human health effects that are associated with air pollution. The contingent valuation survey technique employed by Muller and Diener is intended to produce value estimates for public goods (benefits) where no markets or market values are available (e.g., improved visibility, reduced odours, reduced anxiety about health effects). This method involves the administration of carefully designed questionnaires and statistical analysis of survey results. WTP values derived from contingent value surveys also tend to be contentious.

However, in the case of human health, prices and costs derived from markets and market forces are available for mortality and morbidity (i.e, illness) effects. The minimum amount that people are willing to pay to gain reduced health risks can be inferred from health care costs, lost wages, reduced productivity and from wage differentials among jobs associated with different risks. The estimation procedure that utilizes these market values is called the *cost-of-illness (COI)* approach.

While COI values represent relatively robust and non-controversial estimates of the value of heath effects, COI estimates do not reflect the total welfare gain or loss associated with death or illness. Other non-priced consequences of illness and death (e.g. pain and suffering, WTP to avoid illness and death, adverse effects on family members) imply that true WTP values associated with health effects are higher than COI estimates. Hagler-Bailly (1996) found that the WTP/COI ratios ranged from 1.3 to 2.4 for morbidity effects. Thus, they propose an adjustment factor of 2.0 to derive WTP values from COI estimates. For non-fatal cancer cases, a lower adjustment factor of 1.5 is suggested because of the relatively high cancer treatment costs.[1]

Consequently, these adjustment factors were used to estimate equivalent *willingness-to-pay* values for morbidity effects associated with prevailing air pollutant levels in Hamilton-Wentworth. The WTP values associated with changes in mortality risks are based on wage-risk studies. If all of the mortality and morbidity effects were avoided or eliminated, the values of these effects would approximate the WTP value people would attribute to the benefit of health effect reductions.

Per incident "central" value estimates for each health effect are shown in Table 2 as well as estimates generated by the HHWG. The estimated *total* monetary value associated with the human health effects in Hamilton-Wentworth at current levels of air pollution is summarized in the last column of Table 2. The total annual monetary value of $860.8 million excludes mortality estimates for carbon monoxide (CO) and nitrogen oxides (NO_X) because the HHWG had a low level of confidence in these particular estimates. As previously mentioned, the *total* monetary value can be viewed as representing the maximum willingness-to-pay to avoid or eliminate these health risks. Consequently, these values can be used as a benchmark for comparisons against the cost of emission reduction measures or scenarios.

Over 75% ($653.6 million) of the aggregate monetary value is attributed toPM_{10} and sulphates, with SO_2 accounting for almost 19% ($160.2 million). The remaining 5.5% is distributed amongst the other four contaminants, with ozone accounting for 5.1%. Consequently, these results suggest that future efforts and resources should be devoted first to achieving reductions in fine particulates (i.e., sulphates), followed by reductions in sulphur dioxide.

These WTP estimates also demonstrate the degree to which premature mortality is the most highly valued of all health consequences. In addition, as the severity of the health effect increases, the incidence declines and the monetary value rises.

The monetary value estimates presented in this section only encompass reductions in those health effects for which estimates were provided by the HHWG. The estimates exclude other adverse health effects associated with fine particulate emissions such as airway obstructive diseases, emergency room visits, asthma symptom days, restricted activity days, acute respiratory symptom

[1] For the health effects examined in this section, the unadjusted COI information used by Haglar-Bailly was collected from Canadian sources.

days, and child bronchitis cases. Therefore, the estimates provided here may understate the value that people ascribe to reducing air pollution.

Table 2: Estimated Monetary Value Associated with the Human Health Effects of Air Pollution in Hamilton-Wentworth

Health Effects	Central Estimate of WTP Values[1] *($/incident)*	Estimate of Health Effects *(Incidences per year)*	Total WTP Value of Health Effects *($/year)*
Mortality	4000000	163[a]	856000000
Cancer Case	2600000	<1[d]	<2,600,000
Cardiac Hospital Admission	8400	208[b]	1729400
Respiratory Hospital Admission	6500	93[c]	604500
Total	not applicable	not applicable	860933900

1 per incident equivalent WTP monetary values from Hagler Bailly (1996).
a "medium" confidence estimate. Based on fine particulates, ozone, sulphur dioxide.
b "high" confidence estimate. Based on fine particulates, carbon monoxide.
c "high" confidence estimate. Based on ozone, sulphur dioxide, nitrogen oxide.
d average estimate based on both "fatal" and "non-fatal" cancer cases caused by air toxics.

As previously mentioned, these results complement the estimates in section 7. This breakdown by pollutant and health effect allows HAQI members and Ministry of Environment and Energy (MOEE) staff to prioritize contaminants (i.e., in terms of reductions) for policy and strategic purposes. Disaggregation also permits a detailed and informed benefit-cost analysis.

The WTP estimates produced in this section should not be added to the Muller and Diener WTP estimates as there would be double-counting. The two sets of estimates may be viewed as indicators of the range of WTP values of reducing health effects from air pollution. The estimates presented in this section may be the higher end of the range.

9 CONCLUSIONS AND RECOMMENDATIONS

The overall conclusions and recommendations of the AOE Workgroup are as follows.

9.1 Conclusions

The major conclusions of the AOE Workgroup are as follows.

1. Most people in Hamilton believe that the air quality in the Region is somewhat worse than the rest of Southern Ontario

2. People are generally concerned about the effects of air quality, particularly about health effects. Aesthetic impacts such as black fallout and odour are also important.

3. Residents of Hamilton-Wentworth consistently rated health effects as their most serious concern. Residents also placed substantial concerns over black fallout, bad odours and poor visibility. Survey results show the respondents appear to be willing to pay between $13 and $40 per month for a one-third improvement in each of these air quality attributes.

4. In most cases, there is little correlation between pollution levels (e.g., dust fall, reduced sulphur compounds) and the number of complaints. This is likely the result of confounding factors which influence the likelihood of an individual to complain.

5. The findings of the North Hamilton Survey indicated the residents of north Hamilton experience relatively high levels of concerns about air pollution, industrial stack smoke and black soot. Levels of reported concern about air pollution were much higher than for other types of pollution (water, soil); however, intensity of concern was high across all types of pollution.

6. The relationship of air pollution and various social/economic parameters (e.g., income level, house prices) have not been investigated as part of this evaluation. The literature cites a number of different methods for examining this relationship, but, the results have showed mixed relationship between pollution levels and social/economic parameters.

7. The total monetary values of health effects in Hamilton-Wentworth due to current air quality levels is approximately $860 million per year.

Information Gaps

A number of information gaps were identified by the AOE Workgroup during the course of the study. These information gaps include:

1. The costs of air pollution mitigation are not available for the Hamilton-Wentworth region; and

2. There is a no information currently on the social/economic costs of air pollution aesthetic and environmental impacts currently in Hamilton-Wentworth.

9.2 Recommendations

The AOE workgroup recommends the continuation of the work begun in this phase of the HAQI. The main aspects of future activities are identified below.

1. Monetary values of health benefits and willingness to pay for improvements have been developed by the AOE Workgroup. However, air pollution control strategies and cost have not been evaluated for improving Hamilton-Wentworth's air quality. It is recommended that an analysis of air pollution control strategies should be conducted to explore alternatives to the current regulatory programs. The analysis should:

   - identify and consult with critical stakeholders (e..g, industries, public, McMaster University, Regional Municipality, MOEE) needed to develop a comprehensive air pollution control strategy;
   - identify/obtain missing information/data (e.g., mitigation options, costs) in support of the analysis;
   - identify and evaluate mitigation measures/actions/strategies that will lead to improvements in air quality in Hamilton-Wentworth;
   - identify programs/regulations/strategies/instruments to implement mitigation measures;
   - estimate emission reductions and costs of mitigation measures;
   - refine health and other economic benefits of mitigation; and
   - recommend a set of cost-effective measures for improving air quality.

2. Analysis of the data from the two surveys (Perception of Black Fallout, and Valuing Air Quality) should be continued. In particular:

   - the spatial analysis of the economic valuation survey should be undertaken to explore the differences in general attitudes and willingness to pay across Hamilton-Wentworth;
   - the North Hamilton survey team should continue the bivariate and multivariate analysis of the data to investigate the determinants of concern, effects and actions related to air pollution; and
   - the North Hamilton survey team should analyze the chronic respiratory disease data to allow for a comparison with other published data.

3. In view of the importance of aesthetic aspects of air quality and of its adverse impacts on the quality of life in Hamilton-Wentworth, which have been identified in this report, the AOE recommends that some model of active air quality management in Hamilton-Wentworth be implemented to ensure measured improvements in air quality on an ongoing basis. The following models should be explored to determine the best option for Hamilton-Wentworth.

- Wherever possible, employ Community Liaison Committees to work toward solutions of site or source specific odour problems. These Committees could help establish or expand on current local committees to increase communication between the public and industry.

- Utilize stakeholder approaches to establish public accountability for the resolution of odour or aesthetic issues since these may not fall within the MOEE mandate for regulatory intervention.

- Establish a standard for community and industry interaction to deal with issues of restitution, compensation, or direct industry support of community initiatives.

- Form an industrial society[2] of key industries to perform self-monitoring, set emission improvements and targets, and provide accountability to each other and the community.

4. Community odour initiatives are recently developed techniques to promote direct public access to odour control information, technologies, and solutions. Community odour initiatives typically bring together a diverse group of people. These citizen groups can identify problems and issues, evaluate alternative policy and technical solutions, and develop consensus on the best course of action. They also serve as a "watchdog" to ensure that industries are abiding by clean air standards for emissions.

   For example, in 1991, the Lambton Industrial Society's (LIS) odour panel assessed industrial area odours in Sarnia, Ontario. This may have been the first of the modern community odour initiatives (Ortech, 1992). As a result, odour complaints are now likely to be directed to LIS for remedial action (Munro, 1996).

5. Formal complaints are important ways for residents to express their concerns to the responsible parties. A large number of complaints in Hamilton is related to black fallout, odour and dust; however, this is likely an underestimate of the number of people who are actually concerned about these problems. Interpretation of the complaints data is further complicated by variations in sensitivities of people. The MOEE has been the primary authority responsible for responding and handling complaints in the past; however, the systems can be improved

[2] The Hamilton Environment Industry Association was formed in the summer of 1997 to address some these issues.

and made more efficient if the complainants are better informed and the complaints/responses are coordinated. The residents of Hamilton-Wentworth does consider black fallout, odour and dust to be important, and an effective complaint/ response procedure would be beneficial to the residents of Hamilton.

It is recommended that HAQI (or its replacement) continue to work with stakeholders such as the local community groups, industries and various levels of government to establish a meaningful and coordinated complaints handling procedure, along with a program for educating prospective complainants. This coordinated complaints procedure needs to be advertised to the public so that consistency and accurate records can be attained. All companies, whether large or small, should record complaints and provide them to a central authority, which does not necessarily have to be the MOEE.

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APPENDIX A

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