Report on Turnkey Osiris Particle Results at the Halkett Place and Howard Davis Park Sites in Jersey for 2014

Environmental Health

Contents

Executive Summary

The main air quality issue in Jersey relates to the impact of traffic on local air quality. Vehicle exhausts produce particles (also known as particulate matter PM) as part of the combustion process and diesels produce more particles as the fuel contains more carbon bonds. Particles are measured depending on their size and number ie PM_{10} and $PM_{2.5}$ are particles with an aerodynamic diameter of 10 and 2.5 microns respectively and have well documented health effects. Particles can be from anthropogenic sources ie man-made from vehicle exhausts, tyres, and brakes, domestic heating, bonfires, and emissions from industry for example the energy from waste plant, commercial activities or from natural sources such as sea salt, wind-blown soil and sand. As pollution control technology in vehicles improves (such as particle traps and catalytic converters) particles from exhausts reduces and particles from tyres and brakes become the dominant sources. It is hoped in the future the advent of electric vehicles will remove a significant proportion of particles in the atmosphere.

Particle levels are compared to the limits set out in the European Union and UK legislation. Jersey's Air Quality Strategy 2013 limits are based on those in the UK Air Quality Standards Regulations 2007. They permit 35 mean daily exceedances of average daily figures of 50µg/m^3 (PM_{10}) per year which should have been achieved by the end of 2005. There were 17 exceedances at the Market/Halkett place site and 9 exceedances at Howard Davis Park however the EU & UK limits need updating. Both sites therefore complied with the EU and UK limits. The Regulations also set a mean annual limits: PM_{10} of 40 µg/m^3 and $PM_{2.5}$ of 25ug/m3. The PM_{10} mean annual level was 27.2 µg/m^3 $PM_{2.5}$ annual average level was 9.77 µg/m^3 so both comply with the annual 2005 Air Quality guideline.

PM_{10} concentrations in Jersey are broadly similar to those found in comparable urban areas in the UK. The level at the Market site is broadly what would be expected at a roadside location in the UK and the Howard Davis Park site levels are typical of an urban background location.

The exceedances tended to occur in the spring, autumn and winter months. The weather at these times is characterised by longer nights, clear skies, relatively dry air and conditions which can result in temperature inversions (i.e. an increase in temperature with height), which results in the trapping of moisture and pollutants in the surface air layer.

Jersey's local air quality management has recently been reported on by the UK consultancy Ricardo - AEA Technology. They have produced the document Air Quality Monitoring in Jersey 2012[26] which summarises all the monitoring and results to date. This is available at www.go.je

Further long term research should be carried out to assess levels of PM_{10}/$PM_{2.5}$ in Jersey associated with traffic numbers, its mix, and speed and meteorological conditions to establish trends and assess compliance. This forms part of the Air Quality Strategy and Project Plan.

Other recommendations to improve air quality could include the following:

- Compulsory, periodic testing of vehicle emissions (MOT)

- Park and Ride schemes in St Helier
- Parking (including charges and on street parking restrictions)
- Urban bus schemes
- Vehicle scrappage subsidies
- Vehicle access limits
- Variable tax on engine size and age
- Pedestrianisation
- Alternative fuels
- Safe to school routes
- Traffic management
- Incentives to use hybrids /electric vehicles
- Setting up sufficient charging points throughout Jersey
- Banning burning of dirty coal
- Reducing emissions at the port/airport

Improvements in air quality are generally made through discussion, advice and persuasion as there is no specific air quality legislation in Jersey.

It is hoped that as part of implementing Climate change measures levels of air pollution will reduce.

1.0 Introduction

1.1 Background

This report describes an air quality monitoring programme measuring particles (also known as particulate matter PM) carried out on the Island of Jersey in 2014. This is the 13th consecutive year in which an annual monitoring programme has been carried out; the first undertaken in 2002. It compares the data from Jersey with relevant air quality limit values, objectives and guidelines as well as data from previous years' monitoring programmes.

This ongoing monitoring programme has provided a long-term dataset of particle pollutant concentrations. The pollutants measured are particles which can be differentiated by size:

- TSPs Total Suspended particles
- PM_{10} particles are defined as having an average particle size of 10 microns in diameter (10 millionths of a metre),
- $PM_{2.5}$ particles are defined as having an average particle size of 2.5 microns in diameter
- $PM_{1.0}$ particles are defined as having an average particle size of 1 micron in diameter)

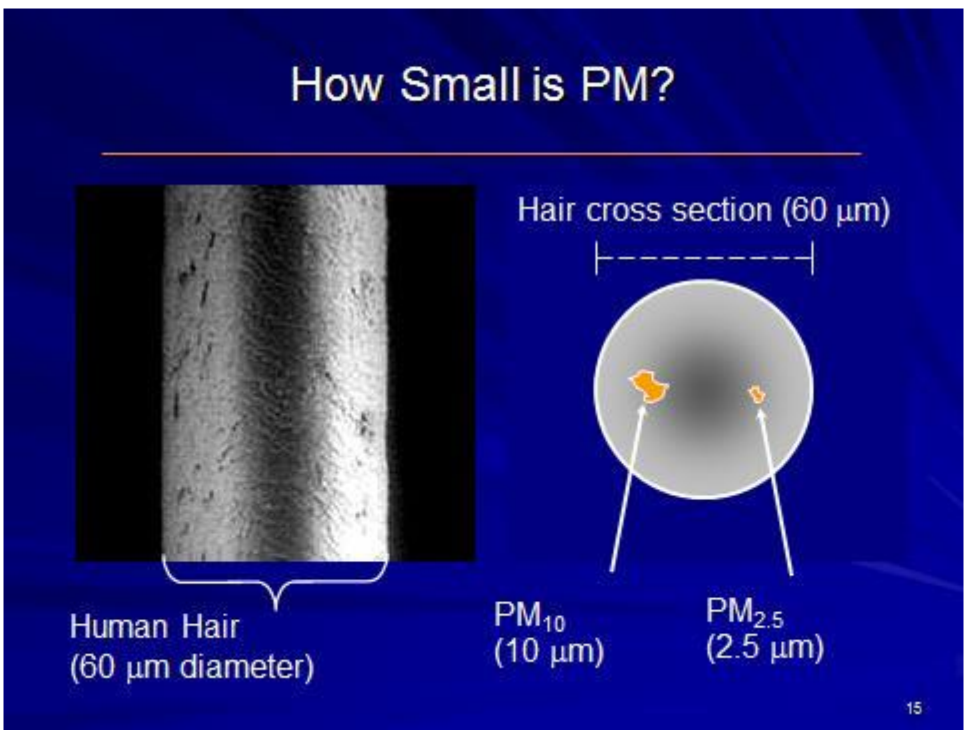


Figure 1: How small is Particulate matter (PM)

People who live, work, or attend school near major roads appear to have an increased incidence and severity of health problems that may be related to air pollution from roadway traffic.

Health effects that have been associated with proximity to roads include asthma onset and aggravation, cardiovascular disease, reduced lung function, impaired lung development in children, pre-term and low-birthweight infants, childhood leukemia, and premature death. Further information on the health effects can be found in Appendix 1.

Particles can originate from man-made and natural sources. They can be differentiated in a number of ways:

1. Size of particle for example coarse 2.5 microns – 10, fine <2.5 (traffic emissions of concern tend to be PM10 and below), see Figure 1 above.
2. Source location for example immediate local, urban background or regional including distant sources.
3. Main source categories for example traffic, industry, domestic and natural.
4. Main source types for example re-suspended dusts, tyre wear, fugitive dusts, traffic exhaust emissions, stockpiles, quarries and construction.
5. Typical contribution to annual mean concentrations.

Anthropogenic (Man-made):

a. Vehicular transport particularly diesels
b. Domestic heating: coal, wood, oil and less contribution from gas
c. The energy from waste plant
d. Oil fired power station although a significant amount of power comes from the French undersea link.
e. Construction and quarrying
f. Bonfires

Natural: Non- anthropogenic

a. Sea salt and sand
b. Wind-blown soil
c. Volcanoes
d. Dust storms
e. Water vapour

The report also compares the number of PM 10 exceedances of the air quality objective (50$\mu g/m^3$ as a daily mean which allows 35 exceedances per year) for the historic sites from 2002 – 2007 (Southampton Hotel, Weighbridge and Bellozanne valley) and the number of exceedances for the Market and Havre Des Pas /Howard Davis Park sites for the years 2006 - 2014. Traffic emissions including particles form a corridor of pollution with cyclists, vehicle users and pedestrians being exposed. Particles levels will reduce with distance from busy roads. There are lots of variables such as wind speed, temperature, reactions in the atmosphere, type of vehicles, speed and volume that will influence this reduction. Further information on sources of particles can be found in Appendix 4.

1.2 Objective

The 2014 monitoring is the continuation of a survey that has been carried out since 2002. This report is the latest in a series of annual reports. The objective, as in previous years, was to monitor at a site where particle pollutant concentrations were expected to be high, the public are exposed and compare these with a background location. The monitoring sites consist of an urban roadside and a rural background site.

1.3 Details of the Monitoring Programme

Two Turnkey Osiris Particle Monitors (OSIRIS: Optical Scattering Instantaneous Respirable Dust Indication System) were purchased in 1999 and 2002. These were replaced with two new Turnkey Osiris units in October 2008 costing £6,000 each. They are designed to continuously monitor particle levels: Total Suspended Particles (TSPs), PM_{10} $PM_{2.5}$ and $PM_{1.0}$. The Osiris units are set up to provide 15-minute running average levels to give good information on pollutant levels over time in micrograms /m3 ($\mu g/m^{3)}$. The locations of the two sites in St Helier are:

1. an urban roadside site at Jersey Market measuring traffic emissions from Halkett Place approximately 2 m from Halkett Place, GPS coordinates 49.184679 -2.104641
2. a background site at Howard Davis Park, St Clements Road approximately 15m from St Clements Road, GPS coordinates 49.179854 -2.09837

This report presents the results of the 13^{th} consecutive year of monitoring and covers the period January 2014 to December 2014. The particle monitoring discussed in this report also forms part of a wider Air Quality monitoring strategy which includes Nitrogen Dioxide (NO_2) passive diffusion tubes, Volatile Organic compound (VOC) passive diffusion tubes[6] measuring Benzene, Toluene, Ethylene, and Xylene (BTEX) sited around the island, and a Nitrogen Dioxide real time chemiluminescent analyser, also sited at Jersey's market which measures NO_2 from traffic on Halkett Place. These reports are available at www.gov.je Unfortunately the traffic data for Halkett Place was not available in the 2014. This prevented determining the correlation between traffic numbers, speed and air pollution levels.

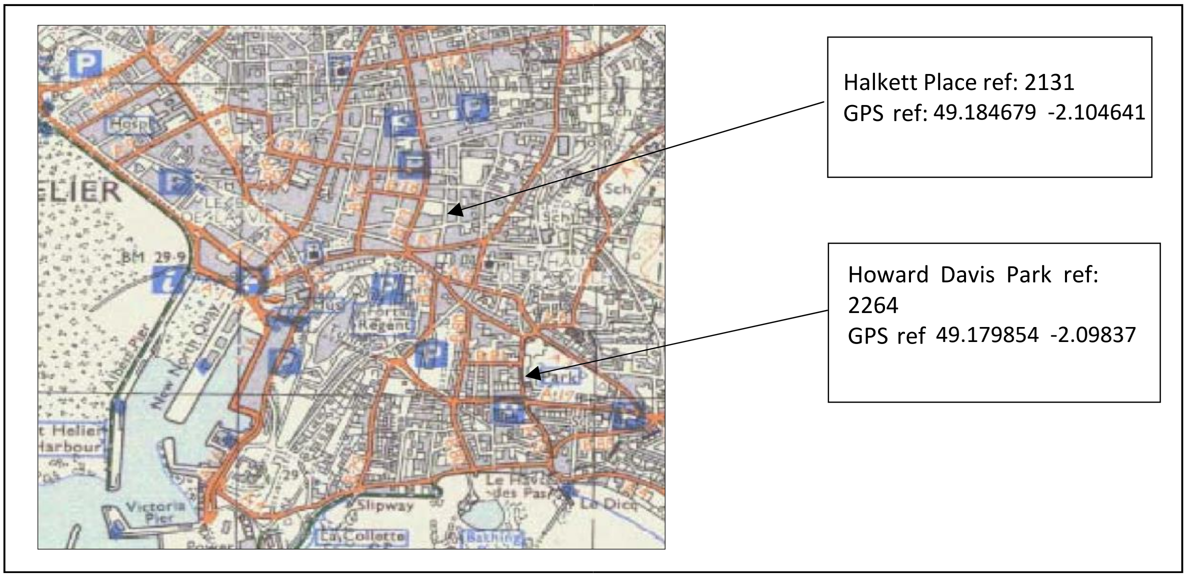


Figure 2: The sampling sites in St Helier town centre[11]

1.4 The particle monitoring equipment

The Osiris units (Optical Scattering Instantaneous Respirable Dust Indication System) are investigational instruments that fulfils the dual role of a portable instrument or permanent installation. A pump draws in air which is analysed by the unit for particulate content, which is then recorded to internal memory.

The instrument is housed in a sturdy die cast metal box with internal rechargeable battery and requires an external power source for long term monitoring. Data is recorded in respect of PM_{10}, $PM_{2.5}$, $PM_{1.0}$ and Total Suspended Particles (TSP) as 15-minute averages for the monitoring periods. Air Quality software program AirQWeb allows the data to be analysed, graphed, the settings on the units to be changed.

The instrument measures and records the concentration of airborne particles using a proprietary laser (nephelometer). An internal pump continuously draws an air sample through the nephelometer which analyses the light scattered by individual particles as they pass through a laser beam. These same particles are then collected on the reference filter. The nephelometer's dedicated microprocessor can analyse the individual particles even if there are millions of them per litre. This allows the size fractions to be determined at concentrations up to several milligrams/m^3. The accuracy of the units is =/- 10%, and they are sent annually to the UK for calibration and service.

It should be noted that the Turnkey Osiris units are not EU type approved as per the reference method specified in the Air Quality Standards Regulations 2007 *i.e.* EN 12341: 1998 "Air Quality — Field Test Procedure to Demonstrate Reference Equivalence of Sampling Methods for the PM_{10} fraction of particulate matter".

This is relevant because it means the data from the Osiris units provided is indicative only. The Osiris units are less accurate than the gravimetric type units used in monitoring stations throughout the UK and the European Union. More information on the OSIRIS units can be found in Appendix 2.

The EU type approved measurement principle is based on the collection on a glass fibre filter of the PM_{10} fraction of ambient particulate matter and the gravimetric mass determination. The Osiris units use a laser to count and size the particles. The units provide a useful screening tool to determine if more detailed measurement is required.

The original modems were replaced in 2013 by routers connected to an 'always open' 3G connection which enables the Osiris data to be displayed in real time. The daily PM_{10} results are available at the following three websites [Air quality monitoring (gov.je)](), https://www.airqweb.co.uk/ and http://jerseyair.ricardo-aea.com/index.php?site_id=JERS

Photograph 1: The Turnkey Osiris Unit

The Osiris units are also fitted with a circular GFA Whatman 25mm filter, which traps particles and allows them to be subsequently analysed. The filters are changed every 3 months and analysis allows the weight of particles to be determined and this can help in assessing the accuracy of the Osiris. Analysis of the filters was not carried out in 2014 due to financial constraints.

1.6 Monitoring Equipment locations:

The Osiris unit sited at the central market is approximately 4m above the pavement and approximately 2m from the road of Halkett Place (see the photograph 2 below). This road is used by up to 6,000 vehicles per day with up to 650 vehicles during rush hour periods. The peak hours are around 7.00 - 9.00 am and between 12.00 pm and 5.00pm each day. Halkett place doesn't have a defined afternoon rush hour and is more characterised by shoppers looking for parking and drivers cutting through St Helier to head east or west. Previous work has shown that particle levels follow traffic numbers, vehicle composition and speed closely. There is a definite increase in particles in the morning rush hour up to lunchtimes as delivery vehicles servicing the market leave their engines running outside the market. Some vehicles have to leave engines running for example refrigerated lorries and refuse vehicles. Signs are sited in this area to remind drivers to switch engines off when stationary.

The site is also a busy pedestrian area in the heart of St Heliers shopping centre. The unit is co-located with a NOx chemiluminescent analyser and 3 external diffusion tubes. Results from the NOx equipment is the subject of a separate report[26].

Photograph 2: The Position of the Osiris Unit Ref 2131 at the Central Market, Halkett Place, St Helier

This Osiris unit in Howard Davis Park was relocated from Havre des Pas on the 17th December 2011. It is specifically located in order to measure particles from a site not directly affected by traffic emissions (see photograph 3 below). The nearest road is St Clements Road, approx 15 metres away. The site is 300 m from the coast, so the particle levels will be affected by sea salt and sand particles when the wind is from the south and south east/ west, which can give elevated readings.

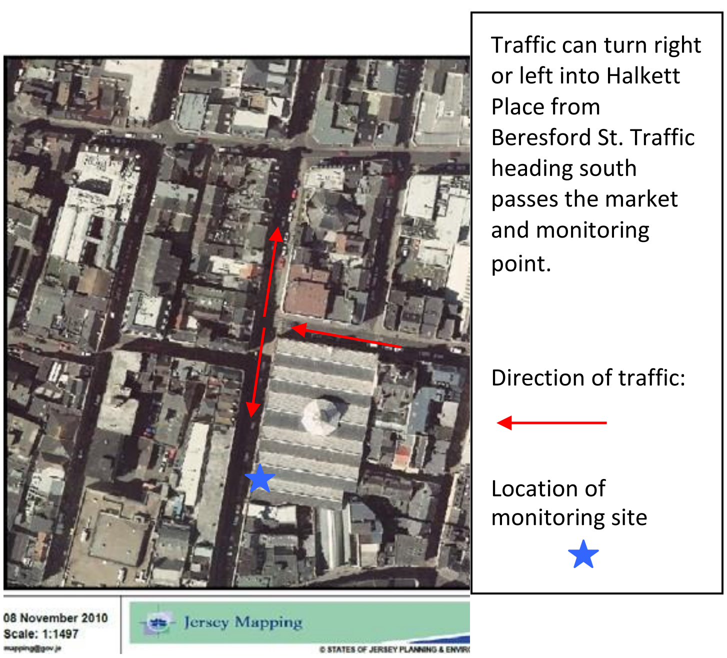
However, this is less significant as it was when sited at Havre des Pas which is within metres of the beach. The site is within a park used by the public, so gives an indication of background particle exposure levels from non-man made sources such as pollen, sand and sea salt. It is possible to determine the approximate percentage contribution of natural particles. Studies in

New Zealand have determined the concentration of sea salt in certain weather conditions to be as high as 28%.

Photograph 3: Position of the Osiris unit at Howard Davis Park

1.7 Impact of Traffic flow

Particle levels at the market site have reduced since the road layout changed in this area. Traffic can now turn right heading northerly along Halkett Place, thereby avoiding the area by the monitor. The provision of two speed bumps/pedestrian crossings on Beresford Street has led to an increase in traffic congestion on Beresford Street, however it has improved traffic movement along Halkett Place. (See photograph 4 below)



Photograph 4: Map showing the direction vehicles travel at the market site on Halkett Place[16]

2.0 Results

The number of days on which the daily average PM_{10} figure exceeded 50µg/m^3 for both sites is shown in Table 1 below.

Site	Days data obtained	PM_{10} Exceedances (>50µg/m^3) (max 35 exceedances)	PM_{10} annual mean (40 µg/m^3)	$PM_{2.5}$ annual mean (target) 2020 (25µg/m^3)
Howard Davis Park *	340 (93%)	9	16.77 µg/m^3	7.09 µg/m^3
Halkett St/Market	333 (91%)	17	27.2 µg/m^3	9.77 µg/m^3

Table 1. Number of daily PM_{10} exceedances and annual means at both sites (*background site)

Table 1 above shows

1. the number of days/percentages the units operated.
2. the number of days there were PM_{10} exceedances.
3. The PM_{10} and $PM_{2.5}$ annual means (µg/m^3)

2.1 Data capture:

An annual data capture rate of 85% or greater for ratified data is recommended in the Defra Technical Guidance LAQM TG(16) 6 in order to assess annual data sets against long term targets.

2.2 Exceedances:

There were 17 exceedances at the market /Halkett Place site and 9 at the Howard Davis Park site of the EU health limit of 50 µg/m^3 as a 24 hour average. The EU Directive allows 35 exceedances per year so both sites were within this.

The exceedances occurred in March, August and September in 2014 which is interesting as poor air quality tends to occur in the winter months.

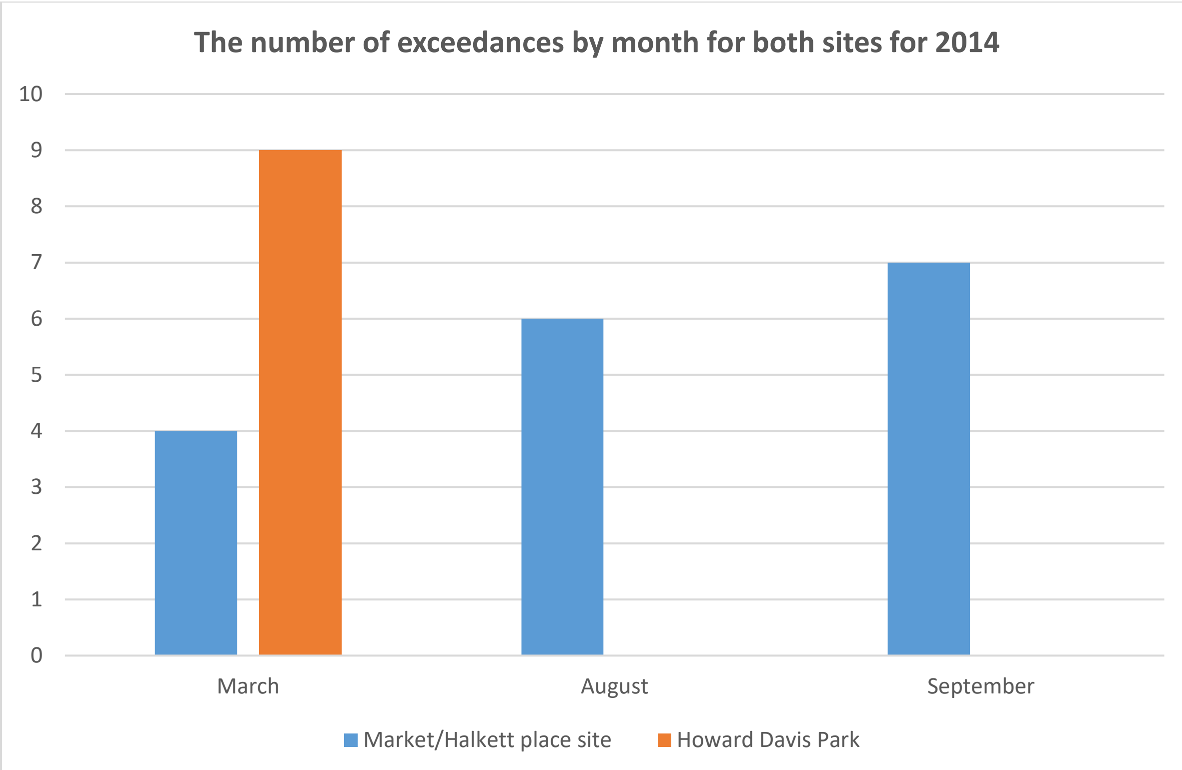


Figure 3 The exceedances by month for both sites for 2014

Figures 4 and 5 below show the 24-hour average particle levels for 2014 at both sites with the exceedances. As expected the concentrations are greater for Halkett Place due to traffic emissions. Traffic heads south past the market looking for parking or is cutting through St Helier heading east or west and there are a number of delivery vehicles servicing the market each day.

The peak hours are around 7.00 - 9.00 am and between 12.00 pm and 5.00pm each day. Previous work has shown that particle levels follow traffic numbers, vehicle composition and speed closely. Levels increase at certain times in the morning as the refuse lorry parks close to the unit with its engine running to allow the euro-bins to be emptied and ferry speed food delivery lorries keep their engines running to maintain the chilled or frozen temperatures.

The levels are lower at Howard Davis Park as expected and indicate background particle levels associated with non-traffic emissions. The exceedances at Howard Davis Park were likely to be due to non-anthropogenic sources such as sea salt, biological sources or occasional petrol or diesel emissions as the Osiris unit is sited on the roof above the gardener’s office and equipment storage shed.

Figure 4. PM_{10} and $PM_{2.5}$ 24 hour averages for 2014 at Halkett Place, Market site showing the 50 µg/m^3 and 25 µg/m^3 EU health limit. There were 15 exceedances at Halkett Place.

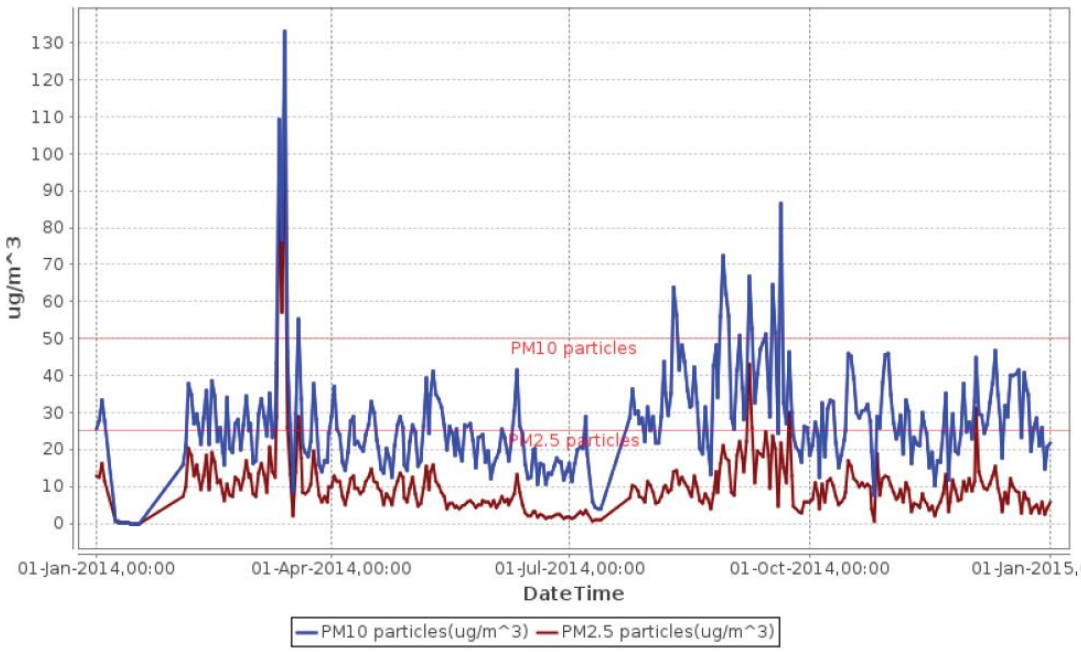
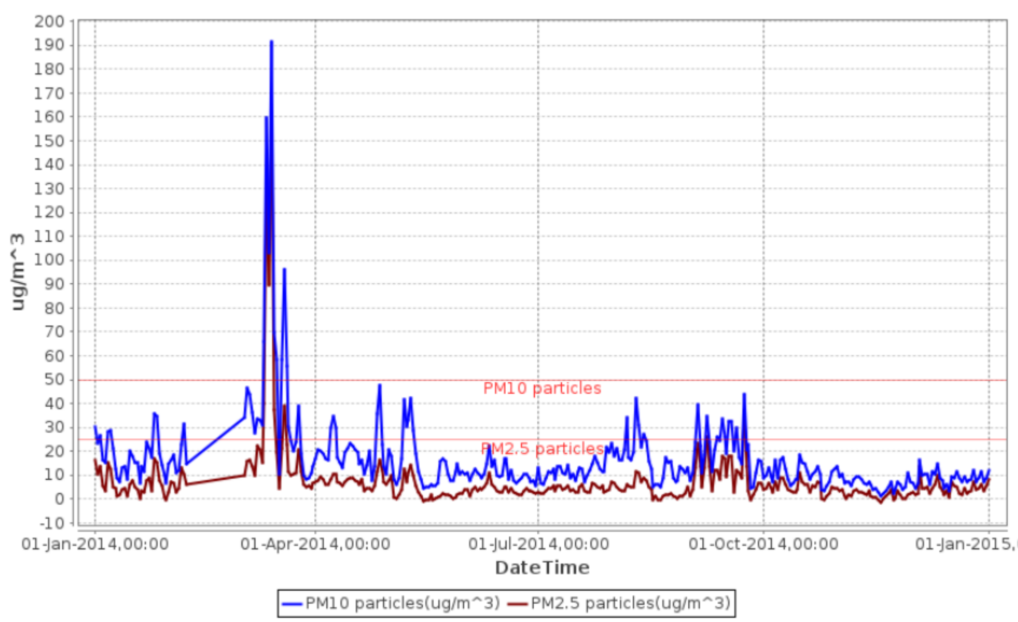


Figure 5. PM_{10} and 25 µg/m^3 24-hour average levels for 2014 at Howard Davis Park site showing the 50 µg/m^3 and 25 µg/m^3 EU health limits.



2.3 Comparison with EU, UK, WHO Health limits

Particles PM	Limit	UK Air Quality Standards Regulations 2010
PM10 µg/m3	Annual mean	40
	24 Hour mean	50 (35 exceedances/yr)
PM2.5 µg/m3	Annual	25
	24 Hour mean	N/A

The PM_{10} and $PM_{2.5}$ annual levels were both below the 24-hour health limit of 50 µg/m3 (35 exceedances/yr) and the annual health limits of 40 and 25 µg/m^3 respectively.

EU standards Directive 2008/50/EU

Pollutant	Concentration µg/m3	Averaging period	Legal nature
PM10	50 40	24 Hour Annual	met by 01/01/05 (35 exceedances / yr) met by 01/01/05
PM2.5	25 20	Annual Annual	met by 01/01/10 met by 01/01/15
PM2.5	20 (AEI) (Average exposure index)	Based on 3 year average	Legally binding in 2015 (Averages 2013 - 15)
PM2.5 Exposure Reduction target	Percentage reduction* + all measures to reach 18 µg/m3 (AEI)	Based on 3 year average	Reduction to be attained where possible by 2020 determined on the basis of the value of the exposure indicator in 2010

*Depending on the value of AEI in 2010, a percentage reduction requirement achieve 18 µg/m3 by 2020.
0,10,15, or 20%) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate
measures need to be taken to achieve 18 µg/m3 by 2020

The PM_{10} and $PM_{2.5}$ annual levels were both below the 24-hour health limit of 50 µg/m3 (35 exceedances/yr) and the annual health limits of 40 µg/m3 and 25 µg/m3 (to be achieved by 2010) and 20 µg/m^3 (to be achieved by 2015) respectively.

Table 6. Air quality guideline and interim targets for PM: annual mean

Annual mean level	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	Basis for the selected level
WHO interim target 1 (IT-1)	70	35	These levels are estimated to be associated with about 15% higher long-term mortality than at AQG levels.
WHO interim target 2 (IT-2)	50	25	In addition to other health benefits, these levels lower risk of premature mortality by approximately 6% (2–11%) compared to IT-1.
WHO interim target 3 (IT-3)	30	15	In addition to other health benefits, these levels reduce mortality risk by approximately another 6% (2–11%) compared to IT-2 levels.
WHO air quality guidelines (AQG)	20	10	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to $PM_{2.5}$ in the ACS study *(323)*. The use of the $PM_{2.5}$ guideline is preferred.

The PM_{10} and $PM_{2.5}$ annual levels were both below WHO interim targets 1 – 3 however the Halkett Place / market site PM_{10} annual level did not meet the WHO Air Quality annual guideline of 20 µg/m3.

2.4 Influences on air quality

Another major influence on particle levels is weather conditions. This is discussed in more detail in Appendix 5. There is a correlation between traffic composition, volumes, speed and particulate pollution. Levels increase on still days when dispersion is poor. Also, with fronts coming across the island this can influence the contribution of non man-made particles. An example of this is shown in Figure 6, which shows historical data from the year 2000 demonstrates the increase in particle levels as traffic numbers increase. The graph shows how particles increase as traffic numbers increase at around 07.00 and during the afternoon and stay relatively high as traffic hunts for parking and cuts through central St Helier heading West or East.

Research findings indicate that roads generally influence air quality within a few hundred meters, about 100 – 200m downwind from the vicinity of heavily travelled roads or along pollution corridors with significant traffic. This distance will vary by location and time of day or year, prevailing meteorology, topography, nearby land use, traffic patterns, as well as the individual pollutant. $PM_{2.5}$, which is more homogeneous regionally due to its longer atmospheric lifetime and diversity of (urban, rural and regional) sources.

Emissions can be elevated near busy roads and arise from multiple vehicle-related processes, including tailpipe exhaust, evaporation of fuel, brake and tyre wear, and dust kicked up from traffic. Certain wind and terrain conditions, certain times of the day, including rush hours can result in elevated concentrations of air pollution near the road and air pollutants traveling further from the road. The presence of walls, buildings and vegetation also has an impact on pollutant dispersion.

Generally, the more traffic, the higher the emissions; however, certain activities like congestion, stop-and-go movement or high-speed operations can increase emissions of certain pollutants. Both heavy-duty vehicles and light-duty petrol vehicles emit a range of pollutants. However, their contributions to different types of compounds are not the same. Per vehicle, heavy-duty diesel vehicles can emit more of certain pollutants (e.g., NOx and PM) and contribute disproportionately to the emissions from all motor vehicles. Petrol passenger cars generally emit more of other pollutants (e.g., CO, and benzene, a volatile organic compound (VOC)).

The Halkett place monitoring site is close to the Halkett Place market entrance and is influenced by delivery and refuse vehicles. They park by the entrance to the market and need to leave engines running to allow hydraulics to lift the bins and keep food chilled or frozen. Other delivery vehicles leave engines running in cold weather to allow drivers to keep conditions warm in the cab. Signs are sited in this area to remind drivers to switch off engines. This has an impact on particle levels and there are spikes at certain times during the morning. The afternoon rush hour is less noticeable.

Interpretation of data can be an imprecise science; however, it is often the case that episodes of poor air quality coincide with autumn and winter weather. When there are still days dispersion is poor and pollutants are able to accumulate locally, particularly in areas such as Halkett Place, where the streets have a 'canyon' effect. However, several exceedances occurred in the summer. This may be due to calm conditions minimising dilution and dispersion. Wind travelling from the west over three storey buildings will result in eddying effects pushing pollutants down reducing dilution and dispersion. A percentage of PM will be from off island during easterly winds. These conditions are likely to bring secondary particles from Europe.

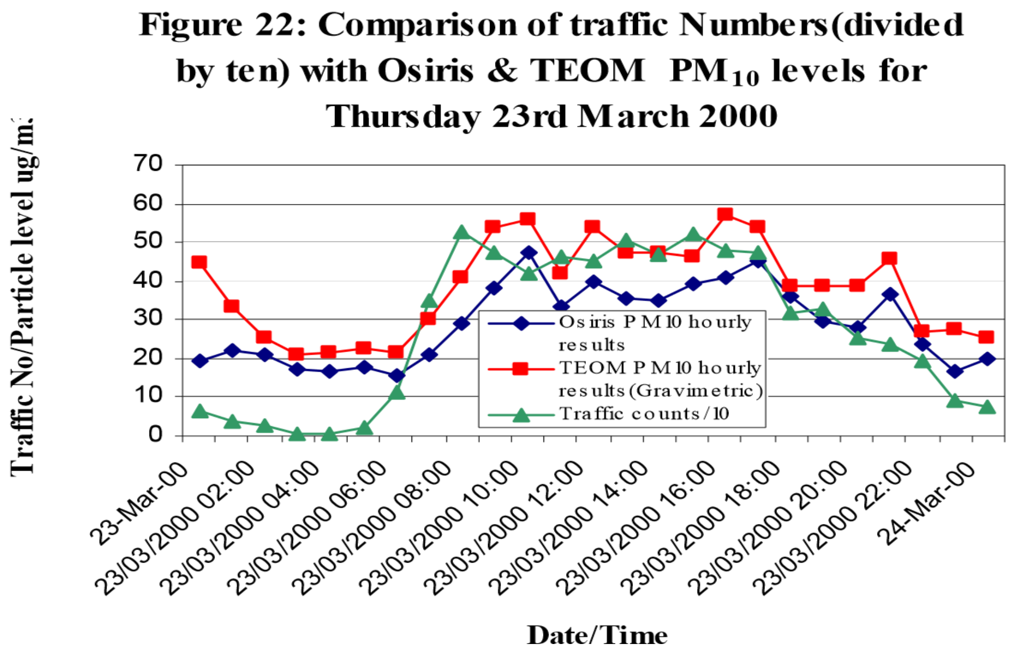


Figure 6. Correlation of particle levels with traffic density (year 2000 historical data). The Tapered elliptical oscillating microbalance (TEOM) is the EU type approved equipment which is more accurate than the Osiris unit.

2.5 Pollution categories

In the UK most air pollution information services use the index and colour coded banding system approved by the *Committee on Medical Effects of Air Pollution Episodes* (COMEAP). The system uses 1-10 index divided into four bands to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index:

- **1-3** (Low)
- **4-6** (Moderate)
- **7-9** (High)
- **10** (Very High)

Table 2 below shows the number of days where average PM_{10} levels met 4 standard categories of pollution level in 2014.

Levels were low at both sites for much of the year but higher levels were observed, particularly at the Halkett place site. This included 3 incidents of high air pollution and 5 incidents of very high air pollution. It is not known why the level was so high on these days. Appendix 3 provides explanation of the terms low moderate high and very high air pollution.

Air Pollution Bandings:	24 Hour mean	Market	Howard Davis Park
Low Air Pollution:	<50 µg/m^3	333	331
Moderate Air Pollution:	50 - 74 µg/m^3	13	5
High Air Pollution:	75 - 99 µg/m^3	2	1
Very High Air Pollution:	>= 100 µg/m^3	2	3

Table 2. Daily mean readings shown as the number of days where PM_{10} fell into four discreet categories.

2.6 Comparisons with previous years

Figure 7 below presents that the number of exceedances of the air quality objective of 50µg/m^3 as daily mean (which allows 35 exceedances per year) for the following historic sites:

- 2002 – 2007 Southampton Hotel, Weighbridge and Bellozanne valley and
- 2004 – 2014 Market and Havre Des Pas /Howard Davis Park sites.

Monitoring at the Southampton Hotel site was carried due to the large of traffic movements in this area as it is close to the bus station. The Bellozanne site was chosen to monitor traffic using the incinerator which has now been closed. The Havre Des Pas site was chosen to monitor traffic using the new energy from waste site.

There was a large number of exceedances for the Havre Des Pas site in 2007 and 2008 (44 and 38) which may be due in part to wind-blown salt and sand particles. This was confirmed by the analysis of the unit's filter. The number of exceedances for 2009 and 2010 for both sites dropped compared to 2007 and 2008. However, part of this can be explained because the unit at Havre Des Pas only captured 70% of the annual data. There were issues with the market unit reading low in July and August 2010. Care needs to be taken in direct comparison as the measurement periods varied. The trend at the market is an increasing number of exceedances, albeit below the 35 allowable per year. In 2014 the exceedances were 17 at the Market and 9 at Howard Davis Park. Data collection was high in this year around 93%. The number of exceedances at the Halkett place site has increased slightly compared to 2013 but are reduced compared to 2011 and 2012. Exceedances are likely to be due to traffic congestion and delivery vehicles elevating emissions coupled with meteorological conditions.

Further information on the effect of meteorological conditions on particles levels can be found in Appendix 5.

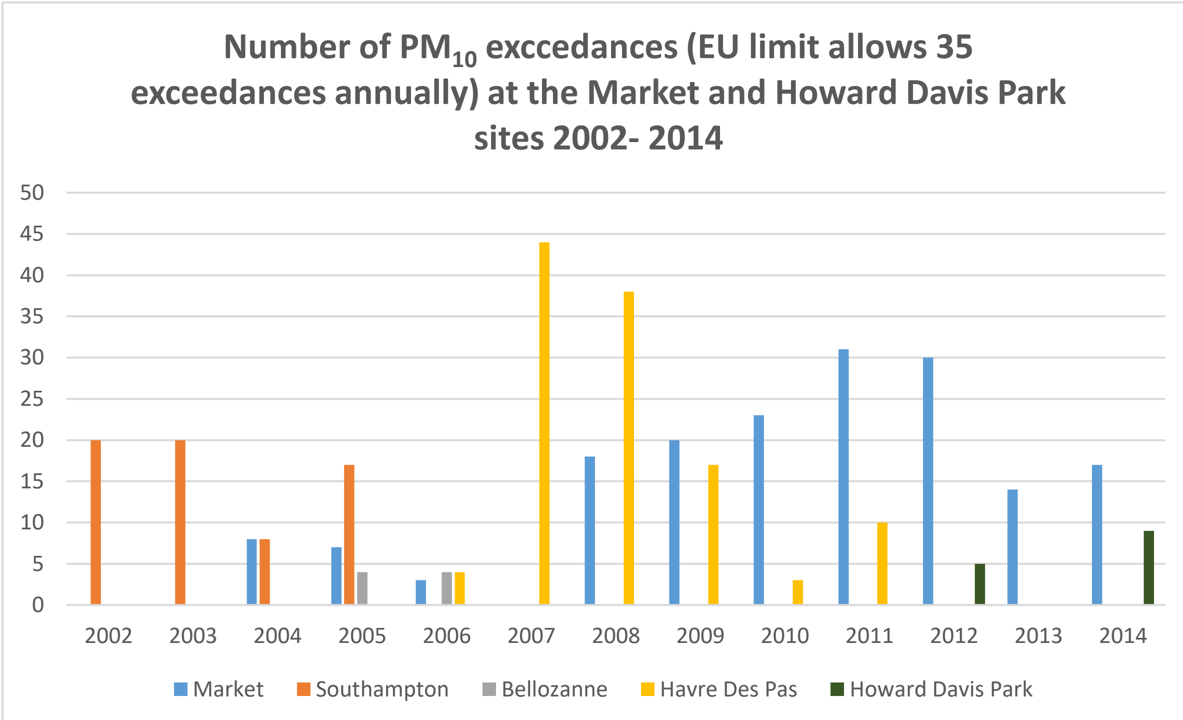


Figure 7. The number of days on which the daily average PM_{10} figure exceeded $50 \mu g/m^3$ at the Market and Howard Davis Park and historic sites from 2002 - 2014.

3.0 Jersey and the European Union (EU)

Although not legally binding in Jersey, the States has agreed to work towards the European Union Directive objectives[20]. The 2008 Ambient Air Quality Directive (2008/50/EC) and four associated Daughter Directives set standards and target dates for reducing concentrations of fine particles, which together with coarser particles known as PM_{10} were already subject to legislation. Under the new Directive, Member States are required to reduce exposure to $PM_{2.5}$ in urban areas by an average of 20% by 2020 based on 2010 levels. It obliges them to bring exposure levels below 20 micrograms/m^3 by 2015. Throughout their territory Member States were bound to achieve the $PM_{2.5}$ limit value set at 25 micrograms/m^3. This value must be achieved by 2015 or, where possible, 2010. Jersey has achieved this $PM_{2.5}$ limit.

4.0 Improvements in particle levels in Jersey

Air quality should improve as the benefits of improved engine design Euro 3/4 are seen. Further road changes as part of the St Helier Life program and general town centre improvements have assisted in improving air quality. The States of Jersey Air Quality Report, 2012, the Air Quality Strategy 2013, the Air quality Action Plan 2012 and the TTS Sustainable Traffic and Transport Plan 2011 all raise the profile of air pollution and suggest measures needed to reduce it.[23]

The States of Jersey Island Plan 2011 addresses the issue of transport, noting that the level of car ownership on the island is very high and predicted to increase by 5-10% between 2009 and 2014. With this increased ownership will come increased use and increased pollution, particularly in traffic hotspots and during peak periods. It further notes that 'Jersey needs to adopt a cultural change in travel behaviour before significant reductions in car use are apparent and that will take time'.

Jersey Electricity now imports in excess of 90% of its power from EDF (France), compared with just 45% in 1990, (the year in which the Kyoto Treaty was signed). This has led to Jersey Electricity being virtually the sole driver of the Island's reduction in carbon emissions - a reduction of one third since 1990 despite a 50% increase in overall energy consumption[23].

Pollution, including particles, from the old Bellozanne Incinerator has ceased as the new La Collette Energy from Waste plant is now operational. This uses the latest pollution control technology to minimise harmful emissions. Emissions are monitored in real time and are available in report form from the Transport & Technical Services Department. Work is under way to make these reports available on line.

CT Plus (Liberty Bus) took over the running of the island bus service in 2012 and operates a fleet of new buses, which operate to high emission standards. Other options available are to move towards gaseous fuels such as the vehicles operated by Jersey Gas, which emit no particles at all. The availability of bio-diesel in Jersey could also lead to a reduction in pollutant emissions. The States has also leased ten electric cars for use by staff and is committed to the promotion and use of electric vehicles.

Other measures to improve air quality include:

- The installation of two new cremators which comply as far as practicable with the UK Environmental Protection Act 1990 Process Guidance note 5(02)/12
- New Building Byelaw Part L to improve insulation in domestic properties improving reducing fuel consumption by improving the thermal insulation of new build properties.
- The growth in the use of solar panels, wind generators and ground and air source heat pumps will reduce the reliance on traditional fossil fuels; thereby reducing particle emissions from domestic premises.
- In April 2013, the Transport and Technical Services Department updated the Sustainable Transport policy (STP) which sets out to minimise the environmental impact of our travel and encourage Islanders to make convenient, sustainable and healthy travel choices.
- Liberty Bus have increased the peak hour capacity on routes into St Helier and improved access to remote areas. The intention is that this should result in a reduction in the use of private cars, however the proposed reduction in road traffic of 15% by 2015 has not been achieved, despite an increase in bus usage.
- The Island Plan promotes Sustainable Development, Travel & Transport (reducing the need to travel & car dependency) and aims to protect the Environment.[25]
- Environmental Health is leading on Jersey’s Air Quality Strategy in conjunction with the Environment Department and Department of Transport and Technical Services (TTS). As part of this process the Air Quality Strategy and Action Plan have been produced which detail the specific actions required, Departments responsible and the time limits.

5.0 Conclusions

1. Particle monitoring is undertaken at the Central Market on Halkett Place and at Howard Davis Park, St Helier. The units measure particles in real time (*i.e.* Total Suspended Particles (TSP) and particles of a mean aerodynamic diameter of 10 microns (PM_{10}), 2.5 microns ($PM_{2.5}$) and 1 micron ($PM_{1.0}$) provide data as 15 minute averages. The data is displayed in real time on the States of Jersey website Air quality monitoring (gov.je).

2. There were 17 exceedances at the Market site and 9 at Howard Davis Park of the 50 ug/m3 particle levels as a 24-hour average, both sites did not contravene the EU directive limit which allows a maximum of 35 exceedances per year. Exceedances are likely to be due to traffic congestion and delivery vehicles servicing the market elevating emissions coupled with and/or meteorological conditions. Data collection was relatively high in this year around 93%.

3. The $PM_{2.5}$ data was also below the EU and UK health limits.

4. Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. The risk of serious illness is likely to be small but prolonged exposure, over many years, may lead to chronic health effects.

5. PM_{10} concentrations in Jersey are broadly similar to those found in comparable urban areas in the UK. Levels at the Market site are broadly what would be expected at a roadside location in the UK and the Howard Davis Park site levels are typical of an urban background location.

6. Particle levels from other sources, such as the power station, have reduced with the use of the undersea cable links to France (ie up to 97% of electricity used in Jersey originates from France).

7. The main source of particles in Jersey is from road traffic. Levels of particles are also influenced by sea salt and sand due to the close proximity of the sea.

8. It is difficult to determine if particle levels in Jersey are getting worse over time. There are episodes of poor air quality on canyon type streets subject to congestion. This is also influenced by the time of year and weather conditions.

6.0 Recommendations

1. Further long-term research should be carried out to assess levels of $PM_{10}/PM_{2.5}$ in Jersey associated with traffic numbers, its mix, and speed and meteorological conditions to establish trends and assess compliance with the European Union Daughter Directive objectives. This forms part of the Air Quality Strategy and Project Plan.

2. Monitoring could involve the use of EU type approved measurement equipment to be meaningful and allow direct comparison with the UK. This would also allow a bias adjustment figure to be determined to increase the accuracy of the Osiris results.

3. Work is needed in conjunction with other stakeholders to implement the recommendations in the Jersey's Air Quality Action plan and Air Quality Strategy.

4. It is recommended dose sampling is carried out to assess actual exposure to air pollution whilst driving, cycling and walking.

5. It is recommended that source apportionment is assessed to determine the percentage contribution of sea salt. This could allow a bias adjustment to be added to particle results to increase the accuracy of particles associated with traffic emissions.

Other recommendations to improve air quality could include the following:

- Compulsory, periodic testing of vehicle emissions (MOT)
- Park and Ride schemes in St Helier
- Parking (including reduced charges for low emission vehicles)
- Urban bus schemes
- Vehicle scrappage subsidies
- Vehicle access limits
- Variable tax on engine size and age
- Pedestrianisation
- Safe routes to schools
- Alternative fuels
- Traffic management
- Incentives to use hybrids /electric vehicles
- Setting up electricity charging points throughout Jersey
- Banning or phasing out dirty fuels such as coal

Appendix 1: Air quality, particles and health

Poor air quality reduces life expectancy in the UK by an average of seven to eight months, with equivalent health costs estimated to be up to £20 billion a year. Improvements between 1990 and 2001 have helped avoid an estimated 4,200 premature deaths a year, and 3,500 hospital admissions a year. A major component of air pollution comes from particles which can be directly emitted or formed in the atmosphere when gaseous pollutants such as sulphur dioxide and nitrogen oxides react to form fine particles.

Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. The Expert Panel on Air Quality Standards (now part of Department of Health's Committee on the Medical Effects of Air Pollutants) concluded that particulate air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. EPAQS also believes that any risk of lung cancer from the concentrations found in the streets of the UK is likely to be exceedingly small. However prolonged exposure (eg 20-30 years) to respirable particles which are likely to be combined with Polycyclic Aromatic Hydrocarbons (PAH's) originating from unburnt or partially burnt fuel, is likely to be carcinogenic[4]. The impact of road traffic on local air quality is the foremost air quality issue in Jersey.

Particles or particulate matter (PM) are principally the products of combustion from space heating, power generation or from motor vehicle traffic. Pollutants from these sources may not only prove a problem in the immediate vicinity of these sources but can travel long distances. It is estimated that road transport (i.e. combustion of petrol and diesel, brake and tyre wear) is responsible for up to 70% of air pollutants in UK urban areas.[18]

Not all sources of measurable particles are man-made. Wind-blown soils, salt and sand inevitably contribute significantly to the overall figures obtained and it can be difficult to differentiate between these natural sources and the products of combustion which are likely to have more of a negative effect on health. At a previous monitoring site at Havre des Pas, there were a large number of exceedances in 2007 and 2008 (44 and 38) which may be due in part to salt and sand particles. This was confirmed by analysis of the Osiris filter.

The UK Air Quality Strategy aims to reduce the reduced life expectancy impact to five months by 2020. It should be remembered that health effects do not relate solely to the direct impacts of air pollution. By encouraging the use of non-motorised means of transport, such as cycling and walking, as a means of reducing local emissions of pollutants, measures in air quality action plans can help directly improve the health and fitness of local populations. In turn, this may also help individuals to be more resilient to direct ill-effects from air pollution.

The July 2007 UK Air Quality Strategy acknowledged that there will often be co-benefits for air quality and climate change where certain positive measures are taken. Furthermore in the light of current Government policy, it is particularly important that climate change and air quality policies are cohesive. For example, there will be situations where policies to reduce greenhouse gas emissions will have benefits for air quality, and vice-versa. Conversely there may be situations where actions and policies do not necessarily achieve these win-win situations.

Technology used to reduce greenhouse gas emissions should always be used in the right circumstances, and not in an area where such technology will impact on the ability of the States of Jersey to pursue the achievement of local air quality objectives.[3] All measures should be given careful consideration to ensure that the benefits for local air quality and climate change are maximised wherever they can be. Where practicable, synergistic policies beneficial to both air quality and climate change should be pursued.[4]

Recent research suggests that ultrafine particles associated with sulphur containing diesel emissions are believed to be hazardous to health and there are no international threshold values[5]. (Some combustion processes can lead to discharges of a large amount of very small particles with a diameter less than 100 nm (nanometre = a billionth of a metre)). Such particles can be drawn deep into soft lung tissue from where they can transfer directly into the bloodstream.

Pollutant	**Health effects at very high levels**
Nitrogen Dioxide, Sulphur Dioxide, Ozone	These gases irritate the airways of the lungs, increasing the symptoms of those suffering from lung diseases
Particles	Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung diseases
Carbon Monoxide	This gas prevents the uptake of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease

Table 3. Some common pollutants and their principal effects on health.

Poor air quality also impacts on the environment, harming ecosystems and biodiversity. Measures to tackle air quality, such as speed restrictions, may also have a beneficial impact on noise pollution, and vice-versa[3].

The States of Jersey Strategic Plan 2006-2011 contains a commitment to improving air quality with a move towards adopting international air quality standards. This was followed up by scrutiny of the Air Quality function in June 2008. Following on from this the UK consultancy AEA Technology first produced an Air Quality Report in 2009 which brings together air pollution data since 1997 and also considers the cumulative impacts of the developments on the Waterfront eg Castle Quay, Esplanade Quarter and the Energy from Waste plant. This report is available on the States website[6]. Subsequent Reports have been produced annually with the latest for data obtained in 2013[13] .

The Transport and Technical Services Department (TTS) produced Jersey's second Sustainable Transport Plan in 2010[24] (updated in 2013) which promotes making greener travel choices.

Jersey's 2011 Island Plan aims through better design to provide pedestrian, and cycle ways for new developments.

Jersey has also signed up to a number of Conventions and Protocols on Air Quality:

1. The convention on Long Range Transboundary Air Pollution- The 1999 Gothenburg Protocol to abate acidification, eutrophication and ground level ozone. The Convention on Long Range Transboundary Air Pollution aims to promote full exchange of information and consultation on long range trans-boundary air pollution and to promote research and monitoring. The Protocol sets emission ceilings for 2010 for four pollutants: sulphur, NOx, VOCs and ammonia.

2. The Convention on Long Range Transboundary Air Pollution – The 1998 Aarus Protocol on Heavy Metals aims to promote full exchange of information and consultation on long range trans-boundary air pollution and to promote research and monitoring. It targets three particularly harmful metals: cadmium, lead and mercury. According to one of the basic obligations, parties will have to reduce their emissions for these three metals below their 1990 levels (or an alternative year between 1985 and 1995). The Protocol aims to cut emissions from a number of industrial sources, such as the iron and steel and nonferrous metal industries and combustion processes, including power generation, road transport and waste incineration.

Particles in the atmosphere originate from a wide variety of sources. They take the form of dust; smoke or very small liquid or solid particles called aerosols. Particles may be either emitted directly into the atmosphere (*i.e.* primary particles) or formed subsequently by chemical reactions (*i.e.* secondary particles). PM_{10} particles are broadly composed of primary combustion derived carbonaceous particles *e.g.* ultrafines, secondary particles from atmospheric chemistry (*e.g.* ammonium nitrate), wind-blown natural minerals *e.g.* soil and salt or biological *e.g.* spores and bacteria and metals. (See Appendix 3)

Studies have shown that most of the inflammation in the lungs could be explained by the mass of particles inhaled; however mass could not account for all of the variability in the data. It is believed the presence of metals such as iron, zinc, lead and nickel in PM_{10} have the best association with inflammation out of all of the compositional measurements analysed. Primary particulate content of PM_{10} was also positively associated with inflammation.[7]

The Committee on the Medical Effects of Air Pollutants have previously provided advice on how the mortality effects of particulate air pollution can be quantified. Their recommendation was based on the link between levels of fine particulate air pollution (PM2.5) and deaths found in a large population study undertaken in the US. Since that time, a number of other studies have been undertaken. Some of these were in the UK or elsewhere in Europe.

There is good evidence that $PM_{2.5}$ plays a causal role in shortening life. Nonetheless, sources of pollutants (such as traffic) tend to emit a range of different pollutants. This makes it difficult, in population studies, to disentangle the effects of individual pollutants from each other.

Therefore, it is likely that the coefficient linking $PM_{2.5}$ concentrations with an increased risk of death reflects the effect of both $PM_{2.5}$ and also, to some extent, of other pollutants such as other size fractions of PM, nitrogen dioxide (NO_2) and other components of the air pollution mixture.

In April 2013, the UK Supreme Court, for the first time recognized that the government had failed to meet European air pollution limits. This may lead to punitive fines by the European Commission and to increased traffic control in some cities, including limiting entry by cars and Heavy Goods Vehicles.

Emissions from mainland Europe may also make a significant contribution to secondary particles in Jersey. The UK Airborne Particles Expert Group's findings suggest that in a typical year with typical meteorology, about 15% of the UK's total annual average PM_{10} concentrations (about 50% of secondary particles) are derived from mainland Europe. In years of higher frequency of easterly winds, with large movements of air from mainland Europe, emissions in mainland Europe account for a considerably higher proportion of PM_{10} concentrations, particularly in south and east England. No work has been carried out to try and establish the contribution of secondary particles originating from Europe affecting Jersey.[8]

Research has shown significant associations between $PM_{2.5}$ and elevated risks for cardiopulmonary and lung cancer mortality. A study in California in 2002 found that each 10 microgram per-cubic-meter increase in long-term average $PM_{2.5}$ concentrations was associated with approximately a 4% increased risk of death from all natural causes, a 6% increased risk of death from cardiopulmonary disease, and an 8% increased risk of death from lung cancer. Associations were also found with sulphur-containing air pollution but not other gaseous pollutants. On the other hand, measures of coarse particles were not consistently associated with mortality.[9]

Appendix 2: The Turnkey Osiris Particle Monitor

The Osiris (Optical Scattering Instantaneous Respirable Dust Indication System) is an investigational instrument that fulfils the dual role of a portable instrument or permanent installation. A pump draws in air which is analysed by the unit for particulate content, which is then recorded to internal memory. The accuracy of the units is =/- 10%, and they are sent annually to the UK for calibration and service.

The instrument is housed in a sturdy die cast metal box with internal rechargeable battery and requires an external power source for long term monitoring. Data is recorded in respect of PM_{10}, $PM_{2.5}$, $PM_{1.0}$ and Total Suspended Particles (TSP) as 15-minute averages for the monitoring periods. Up until mid-2013, each 24-hour period was saved in a folder for downloading manually by modem to a computer where further analysis of the data could take place. An Air Quality software program allows the data to be graphed and copied into Microsoft Excel for further analysis.

The instrument measures and records the concentration of airborne particles using a proprietary laser (nephelometer). An internal pump continuously draws an air sample through the nephelometer which analyses the light scattered by individual particles as they pass through a laser beam. These same particles are then collected on the reference filter. The nephelometer's dedicated microprocessor can analyse the individual particles even if there are millions of them per litre. This allows the size fractions to be determined at concentrations up to several milligrams/m^3.

The light scattered by the individual particles is converted into an electrical signal which is proportional to the size of the particle. A unique feature of the Turnkey nephelometer is that only light scattered through very narrow angles 10 degrees or less is measured. At this narrow angle the amount of light scattered is virtually the same for say black diesel or white limestone particles of the same size. That is, it doesn't depend on the material composition of the particle. On the other hand, the easier to measure right angle 90° scatter used by some earlier scattering instruments is highly dependent on material composition with white particles apparently scattering much more light than black ones of the same size.

The light scattered by airborne particles can be thought of as consisting of three components. Light reflected from the surface of the particle, light refracted through the particle and light which is diffracted from its original path by the presence of the particle. The intensity of the light scattered by reflection or refraction strongly depends on the type of particle. Thus a white limestone particle will reflect much more light than a black diesel fume particle of the same size. On the other hand, the diffracted component depends only on the size of the particle and is independent of its material composition.

For irregularly shaped particles, light, which is reflected and refracted, tends to be scattered over all possible directions. The diffracted component, however, tends to be scattered only through very small angles. For example, for a 5 micron diameter particle, 90% of the diffracted light is scattered by less than 10 degrees from the original direction of the light beam.

The intensity of the light pulse is therefore an indicator of particle size, from this the microprocessor is able to calculate the expected mass of the particle. It assumes the material density of the particle is 1.5 grams per cc, which for most airborne dusts is a good approximation but the mass calibration factor can be adjusted to compensate for different material types.

Having evaluated the mass of the particle, the microprocessor then evaluates the likely chance of deposition of the particle according to the sampling convention being used (PM_{10}, thoracic, and so on) as shown in figure 19 below. Thus, for the thoracic convention a 6 micron particle has an 80.5% chance of deposition, hence only this percentage of its evaluated mass is accumulated.

Osiris Particle Monitors use a heated inlet (at 50°C) to evaporate water vapour particles which would otherwise result in inaccurately high readings. However, it is now accepted that evaporation of volatiles/particles also occurs; resulting in lower than expected results. Research has suggested that in the case of the TEOM particle monitor, that such results should be increased by up to 30% to allow for this potential inaccuracy. However, there are uncertainties as to whether 30% is appropriate to the Osiris units in and will vary on the geographical area.

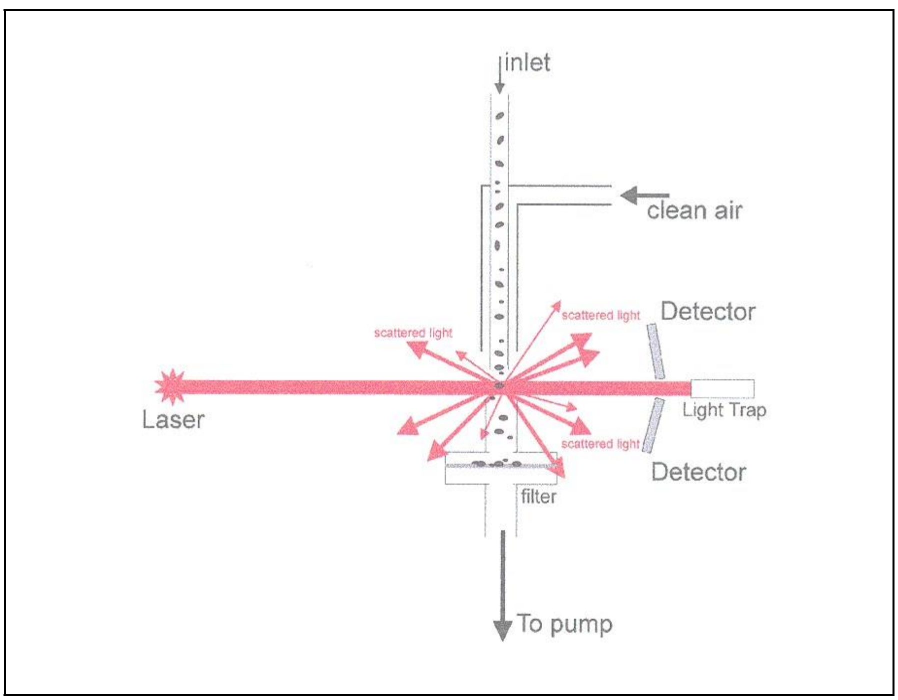
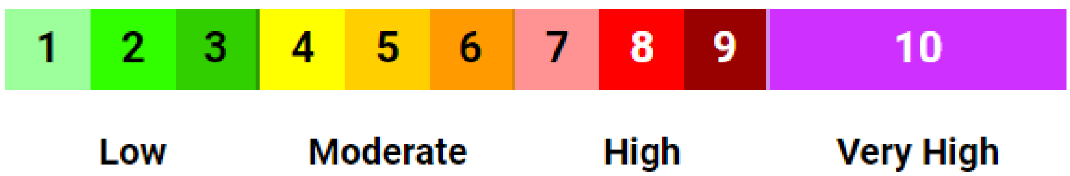


Figure 8: The Osiris particle monitor

Appendix 3: Air Pollution Information Service - Index and Bands

In the UK most air pollution information services use the index and banding system approved by the *Committee on Medical Effects of Air Pollution Episodes* (COMEAP). The system uses 1-10 index divided into four bands to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index:

- **1-3** (Low)
- **4-6** (Moderate)
- **7-9** (High)
- **10** (Very High)



The overall air pollution index for a site or region is calculated from the highest concentration of five pollutants:

- Nitrogen Dioxide
- Sulphur Dioxide
- Ozone
- Carbon Monoxide
- Particles < 10µm (PM10)

Air Pollution Forecasts

Air Quality Forecasts are issued on a regional basis for three different area types:

- In towns and cities near busy roads
- Elsewhere in towns and cities
- In rural areas

Forecasts are based on the prediction of air pollution index for the worst-case of the five pollutants listed above, for each region.

Health Advice

Latest studies report that:

When air pollution is LOW (1-3) effects are unlikely to be noticed even by those who are sensitive to air pollution.

When air pollution is MODERATE (4-6) sensitive people may notice mild effects but these are unlikely to need action.

When air pollution is HIGH (7-9) sensitive people may notice significant effects and may need to take action.

When air pollution is VERY HIGH (10) effects on sensitive people, described for HIGH pollution, may worsen.

Air pollution can cause short-term health effects to sensitive individuals (people who suffer from heart disease or lung diseases, including asthma). Effects on sensitive people can be reduced by spending less time outdoors. 'Reliever' inhalers should lessen effects on asthma sufferers.

More details on effects, including long-term, are available in a free leaflet *Air Pollution - what it means for your health*[28], which is available from the gov.uk website.

Banding	Index	Health Descriptor
Low	1, 2, or 3	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
Moderate	4, 5, or 6	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	7, 8, or 9	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Table 3. Air Pollution Bandings and Index and the Impact on the health of People who are Sensitive to Air Pollutio

Appendix 4: Sources of Particles

Box 8.1: Approximate contributions to PM_{10} concentrations (2002)

Type of particle	Source location	Main source categories	Main source types	Typical contribution to annual mean concentration ($\mu g/m^3$ gravi.)
Coarse 2.5-10µm	Immediate local (very close)	Traffic	resuspended dusts tyre wear	1 - 6
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 5
	Urban background	Traffic	resuspended dusts tyre wear	1 - 2
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 2
	Regional (including distant sources)	Natural	resuspended dust/soil sea salt biological	2 - 3 1 - 2 1
Fine <2.5µm	Immediate local (very close)	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable
		Domestic	coal combustion	variable
	Urban background	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable, up to 8
		Domestic	coal combustion	variable, up to 8
	Regional (including distant sources)	Secondary	power stations industrial processes vehicles	4 - 8
		Primary (Imported)	power stations vehiclesw industrial processes	1 - 2
		Natural	sea salt	<1

Researchers in New Zealand found that natural sources of PM_{10} accounted for 23% and 59% of total PM_{10} respectively at two sites on days when pollution levels were recorded as high. Salt from sea spray contributed approximately 28% of the PM_{10} and a further 31% was from windblown soil [31].

Appendix 5: Jersey's meteorological conditions and the importance of weather and Air Quality

Jersey's meteorological conditions

Jersey's prevailing wind directions are south-westerly, westerly or north-westerly. It is generally accepted that the strength of prevailing winds plays a key role in preventing conditions that allow air pollution to increase. As Jersey is an Island it should be less likely to suffer from chronic air pollution episodes than inland UK towns. The following charts in Figure 8 display graphically the wind directions gathered from 30 years of data from between 1971 and 2000. The prevailing wind can be clearly seen to be from a Westerly quadrant, although north-easterlies and southerlies are also not uncommon.

Seasonal variations are quite noticeable, but the influence of westerlies is clear throughout the year. The effect of this is that relatively clean air is most frequently blown in from over the Atlantic rather than from the direction of urban European centres which are more likely to contain a pollutant element.

Many of the streets in St. Helier are 'canyon' type streets which means that air pollution can take longer to disperse and may be less affected by wind speed and direction than a more open site.

The relationship between meteorological conditions and particle levels is not entirely clear. As wind speed increases particle levels are generally reduced. The monitor at the Market site is in a street canyon which may reduce the dispersion and dilution of particles. As wind passes over the top of the buildings an eddying effect can occur which causes circular dispersion[9]. In dry conditions wind may also re-suspend particles increasing levels. Also increased wind speed suspends sea salt and sand particles which can be moved inland causing elevated results.

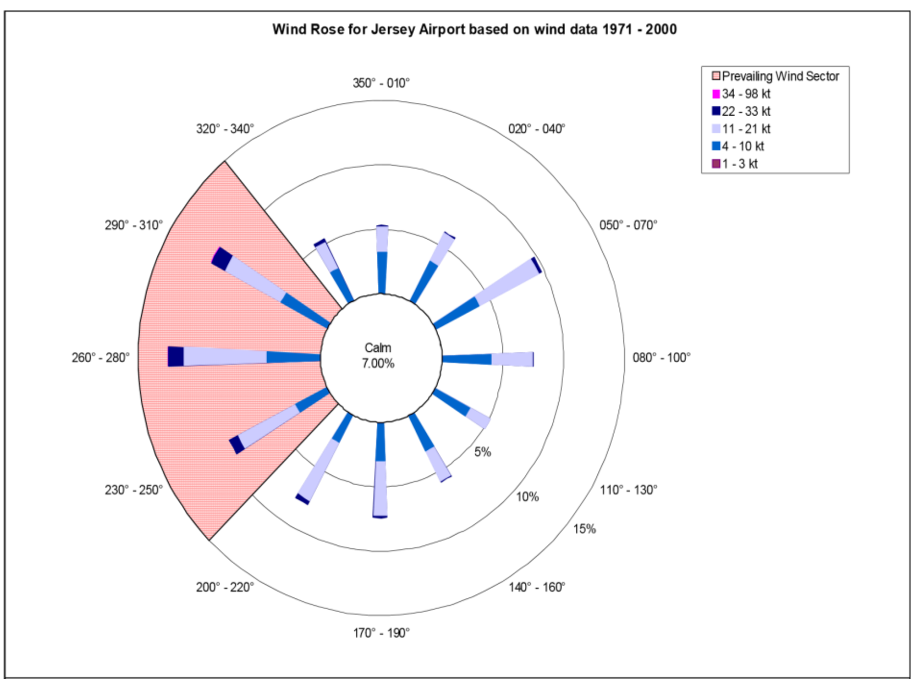
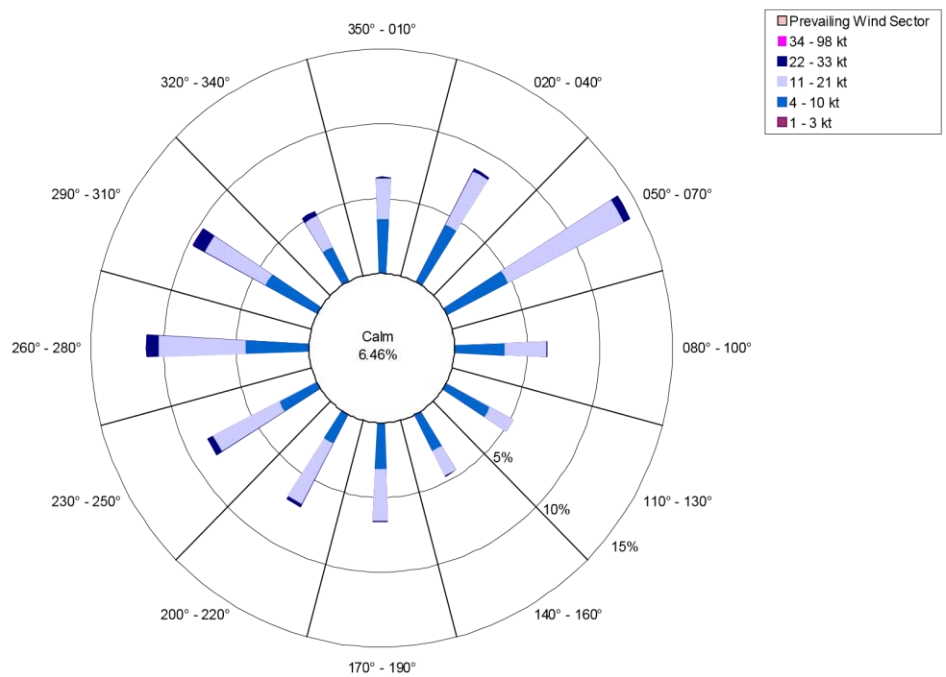
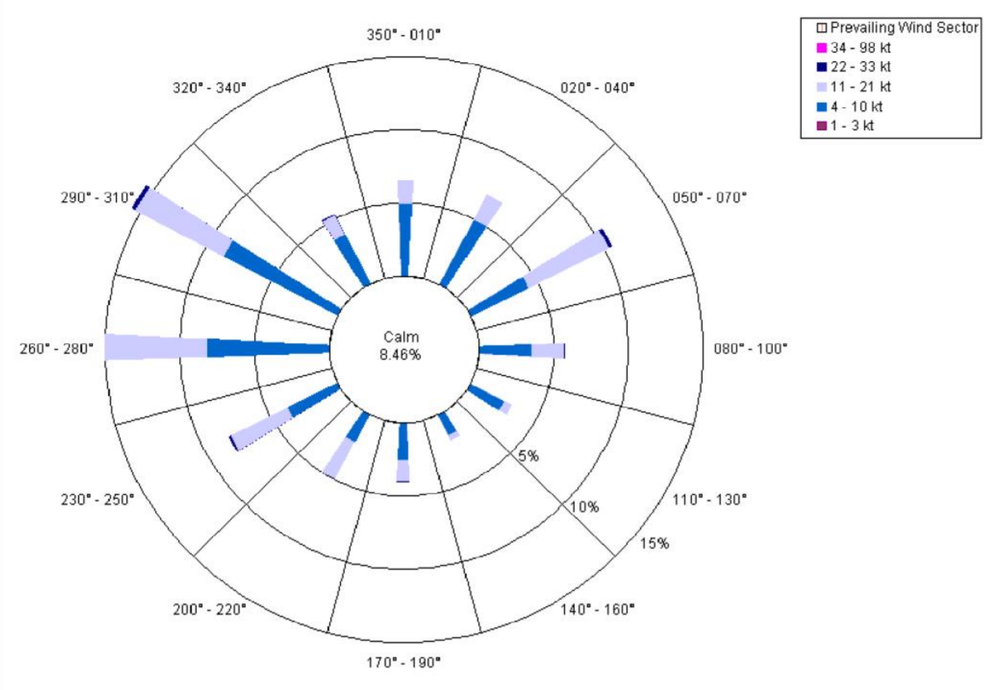


Figure 8. Wind rose for the airport. Data taken from 1971 to 2000 inclusive. Note the prevailing winds are from the westerly quadrant. *(Courtesy of Jersey Meteorological Department)*

Spring - Wind Rose for Jersey Airport based on wind data 1971 - 2000

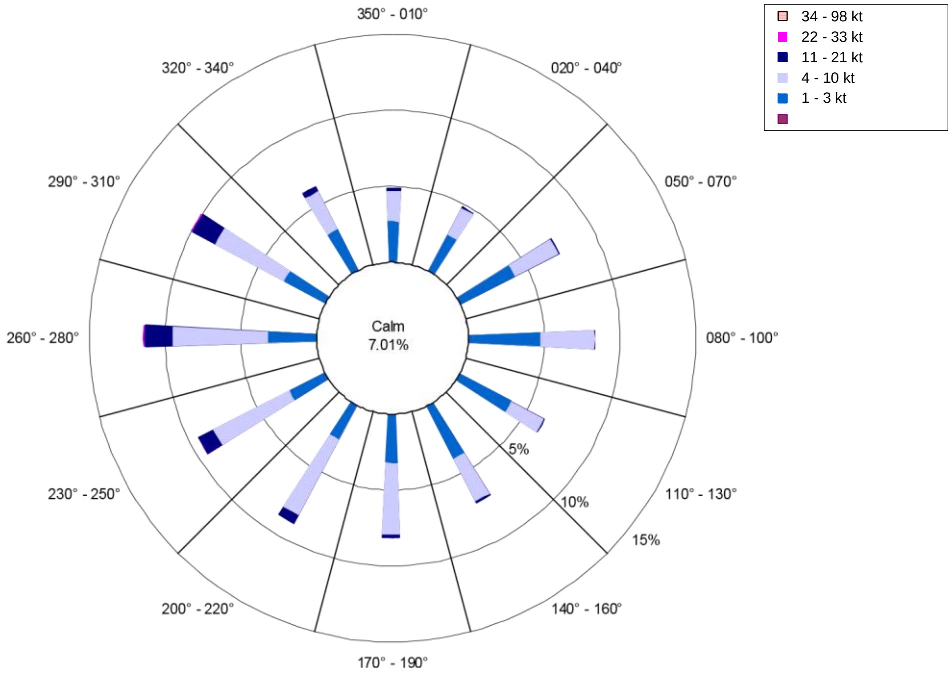


Summer - Wind Rose for Jersey Airport based on wind data 1971 - 2000



Autumn - Wind Rose for Jersey Airport based on wind data 1971 - 2000

Prevailing Wind Sector



Winter - Wind Rose for Jersey Airport based on wind data 1971 - 2000

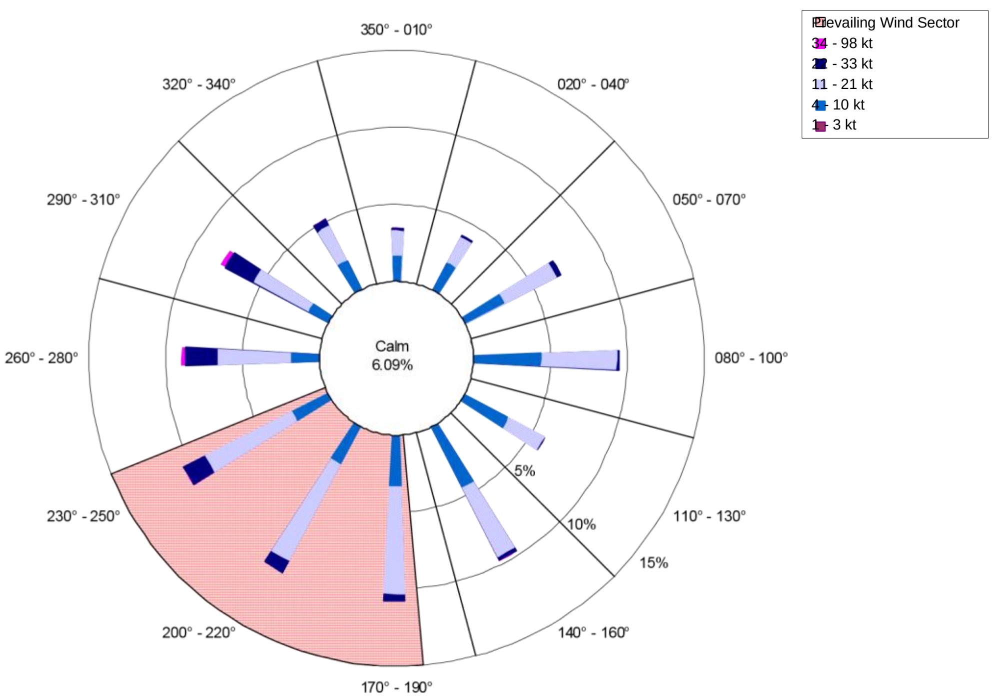


Figure 9. Wind roses for each of the four seasons at the airport. Data taken from 1971 to 2000 inclusive (wind speed in knots). *(Courtesy of Jersey Meteorological Department)*

The eventual fate of most pollutants emitted to atmosphere is chiefly governed by the weather. Wind speed and direction are crucial, as is the stability of the atmosphere as this will govern how well the pollutant mixes in with cleaner air. A further important feature of the lowest levels of the atmosphere is the boundary layer. This effectively 'caps' the atmosphere by impeding the upward movement of pollutants. Therefore, the volume of air available to mix and dilute the pollutant is governed by the height of the boundary layer. When the boundary layer height (BLH) is low there is a less available clean air and so higher pollution concentrations are likely. The BLH varies with climatic conditions, with the lowest BLH typically occurring in still, cold conditions, such as cloudless winter nights, and highest BLH normally occurs at midday in summer. Thus, the BLH can vary on a diurnal as well as an annual cycle.

Once in the atmosphere the released pollutant is free to interact with other pollutants and will sometimes form secondary pollutants (e.g. ozone). These secondary pollutants can be formed through a variety of chemical reactions and/or by the action of incident sunlight. The speed of these reactions will depend on the temperature, humidity, amount of sunlight, and wind speeds.

Different pollutants stay in the atmosphere for different lengths of time (i.e. they have different atmospheric residence times) depending on a range of factors. Their eventual removal from the atmosphere occurs as a result of quite complex deposition processes.

Some pollutants can be entrained within the processes of cloud formation and then removed from the atmosphere in falling rain. Alternatively, these pollutants may be washed out of the atmosphere by rain falling and literally knocking them out of the atmosphere. Both of these processes are known as "wet deposition".

Those pollutants that are not wet deposited can be dry deposited due to gravitational settling as the pollutant comes into contact with the ground, by reaction on surfaces, or through take up by living organisms. The rate at which this happens is governed by characteristics of the pollutant, the ground surface or organism type and the weather.

For example, plants form an important mechanism for removing ground level ozone from the atmosphere, but the rate at which they do so is influences by temperature, humidity, soil moisture, wind speed and so on. Examples of the influence of weather conditions on typical air quality include:

- There is a diluting effect of wind speed: at London Hillingdon, an approximate halving of NO_X concentrations with a doubling of wind speed from 5 to10 m.s-1 has been shown.
- $PM_{2.5}$ decreases when wind speed increases due to dilution but PM coarse increases with wind speed due to re-suspension. These effects show the different sources of PM components.
- Daily maximum ozone concentration is highly sensitive to temperature, particularly where this rises above around 24-25°. At Lullington Heath in Sussex, between 1993 and 1998, a rise from 25-30° typically produced a rise in ozone peak of around 60 µg.m-3, compared to 13 µg.m-3 for a 10-15° rise (Anderson *et al*. (2001).
- Precipitation can reduce particulate matter concentrations dramatically, although other weather factors such as wind speed are also correlated with rainfall.

- Around a 6 ug.m-3 difference in PM_{10} has been observed in Edinburgh between days with no rainfall and those with >20mm rainfall.

Glossary

1. $\mu g\ m^{-3}$ Micrograms per cubic metre.

2. Expert Panel on Air Quality Standards (EPAQs): The Expert Panel on Air Quality Standards (EPAQS) was set up in 1991 to provide independent advice on air quality issues, in particular the levels of pollution at which no or minimal health effects are likely to occur. It has now been merged into the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP)

3. Polycyclic aromatic hydrocarbons (PAH's) are chemical compounds that consist of fused aromatic rings. PAH's occur in oil, coal, and tar deposits, and are produced as byproducts of fuel burning (whether fossil fuel or biomass). As a pollutant, they are of concern because some compounds have been identified as carcinogenic, mutagenic and teratogenic.

4. AEA Ricardo: is an energy and climate change consultancy delivering technical advice, policy support and project and programme management services.

5. The Airborne Particles Expert Group (APEG) studied particles and their source apportionment *i.e.* primary and secondary particles and the proportion of emissions from Europe and UK. They have now merged into the Air Quality Expert Group (AQEG).

6. GSM Modem for sending and receiving data, SMS text messages, GPRS data over the GSM wireless network

7. Turnkey's Air Q 32 Software: allows officers from Health Protection to use a computer and dial up modem at Le Bas Centre and download data from the two Osiris units remotely. The dial up method has now been replaced by an automated system which uses the 3G telephone network.

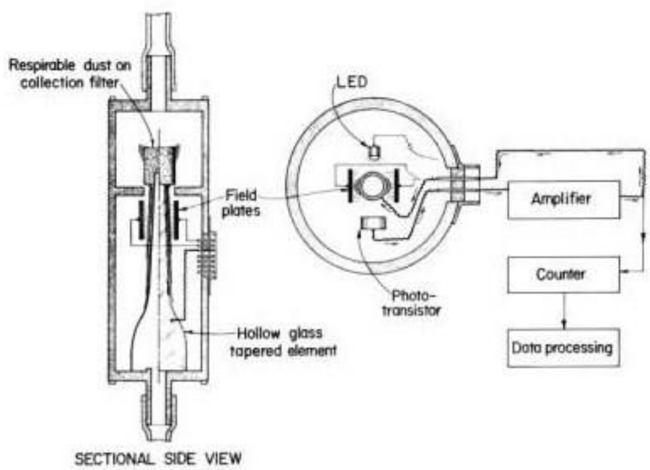
8. Scanning Electron Microscopy (SEN)
   A very widely used technique to study surface topography. A high energy (typically 10keV) electron beam is scanned across the surface. The incident electrons cause low energy secondary electrons to be generated, and some escape from the surface. The secondary electrons emitted from the sample are detected by attracting them onto a phosphour screen. This screen will glow and the intensity of the light is measured with a photomultiplier.

9. Energy Dispersive X Ray analysis
   This technique is used in conjunction with SEM and is not a surface science technique. An electron beam strikes the surface of a conducting sample.

The energy of the beam is typically in the range 10-20keV. This causes X-rays to be emitted from the material. The energy of the X-rays emitted depend on the material under examination.

10. Tapered Element Oscillating Microbalance)TEOM)

A TEOM detector consists of a substrate (usually a filter cartridge) placed on the end of a hollow tapered tube. The other end of the tube is fixed rigidly to a base. The tube with the filter on the free end is oscillated in a clamped-free mode at its resonant frequency. This frequency depends on the physical characteristics of the tube and the mass on its free end. A particle laden air steam is drawn through the filter where the particles deposit and then through the hollow tube. As particles deposit, the mass of the filter cartridge increases and the frequency of the system decreases. By accurately measuring the frequency change, the accumulated mass is measured. Combining this accumulated mass with the volume of air drawn through the system during the same time period yields the particle mass concentration.



11. Euro 2/3: European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in EU member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

12. Bio-diesel: refers to a vegetable oil- or animal fat-based diesel fuel consisting of longchain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow)) with an alcohol. Environmental benefits include reductions in greenhouse gas emissions, deforestation, pollution and the rate of biodegradation

References

1 Air Quality Strategy for England, Scotland, Wales and Northern Ireland.
http://webarchive.nationalarchives.gov.uk/20130123162956/http://www.defra.gov.uk/environment/quality/air/air-quality/air-quality-publications/

2 Cycling weekly magazine February 2009

3. UK Bio-energy Strategy
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48337/5142-bioenergy-strategy-.pdf

4 Air Quality Expert Group report on air quality and climate change

5 www.projektcleanair.dk/Målinger-CPH/documents/Partiklerengelsk.pdf

6 States of Jersey Air Quality Strategy and Action Plan (2013)
http://www.statesassembly.gov.je/AssemblyReports/2013/R.049-2013.pdf

7 Adverse Health Effects of Particulate Air Pollution V. Stone, J.H. Lightbody, L. Hibbs, C.L.Tran, M. Heal, and K. Donaldson. Napier University, University of Edinburgh

8 Report: Particles a problem or not in St Helier 2001 - A M Irving

9 http://www.arb.ca.gov/research/health/healthup/may02.pdf

10 Reports on the Turnkey Osiris Particle monitors results for Jersey 2002 – 2011

11 Jersey's Official OS Leisure Map 1:25000 States of Jersey Planning and Environment Department

12 The relationship between the European transfer reference methods

13 Air Quality monitoring in Jersey; Diffusion Tube surveys 2002 - 2012 AEA
http://www.gov.je/Environment/ProtectingEnvironment/Air/Pages/AirQuality.aspx

14 The Air Quality Standards Regulations 2007
http://www.opsi.gov.uk/si/si2007/uksi_20070064_en_1

15 EU Daughter Directive 99/30/EC.

16 Jersey Mapping Software: Digimap

17 2008/50/EC (2008) On ambient air quality and cleaner air for Europe

18 AEA Technology report Ref Brian Stacey Analysis of Particulate matter (dust) on filter using SEM and EDX April 2008

19 Air Quality Management issue 170 page 9 National Audit Office Briefing, Rob Bell

20 An Air Quality Strategy for Jersey, April 2003. NETCEN

21 EU Directive 96/62/EC on Ambient Air Quality Assessment and Management (The Air Quality Framework Directive)

22 Air Quality Monitoring St Helier February to March 2000 NETCEN

23 http://www.jec.co.uk/environment.aspx

24 Transport and Technical Services (2011) Jersey's Sustainable Transport Policy - Making Greener Travel Choices.

25 Draft (2009) Island Plan White Paper consultation

26 Ricardo-AEA (2012) Air Quality Monitoring in Jersey 2012.

27 http://www.gov.je/Environment/ProtectingEnvironment/Air/Pages/AirQuality.aspx

28 Air pollution – What it means for your health
http://archive.defra.gov.uk/environment/quality/air/airquality/publications/airpoll/documents/airpollution_leaflet.pdf