Borough Council of King's Lynn and West Norfolk

King's Lynn Docks

Detailed Assessment

July 2016

Move Forward with Confidence

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Document Control Sheet

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Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area. For local authorities that have identified areas where there is a potential risk of exceedence of Air Quality Strategy (AQS) objectives, a Detailed Assessment (DA) is required.

In recent years, the Borough Council of King's Lynn and West Norfolk have observed exceedences of both the annual mean and 24 hour mean Air Quality Objectives (AQOs) for PM_{10} at the King's Lynn docks. Additionally, the Council have received a number of complaints from local residence and business owners in relation to dust soiling of property and visible dust plumes. The Council therefore commissioned Bureau Veritas UK Ltd (BV) to undertake a study which confirms the source and location emitting the particulates in the dock area to assess the necessity to declare an Air Quality Management Area (AQMA) in relation to PM_{10} emissions.

The following main objectives were assessed:

- Analysis of shipping activity at the docks in relation to monitored meteorological and PM_{10} monitored data, to establish links between activity at the docks and periods of elevated pollutant concentrations;
- Analysis of complaints logs collected by the Council to ascertain likely PM_{10}/dust sources linked to monitored PM_{10} concentrations;
- Undertaking of unitary emissions modelling to ascertain the area which is likely to be affected by PM_{10} emissions from the docks;
- Review of current best practice for vessel berthing and unloading techniques which may be used in a subsequent air quality/dust management plan; and
- To put forward conclusions and recommendations as to the extent of any proposed AQMA and necessary future monitoring.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments as set out in the latest guidance and tools provided by Defra for air quality assessment (LAQM.TG(09)[1]) have been used.

Following the conclusions reached in section 10 the following recommendations are provided to the Council as outcomes of this study:

- As PM_{10} concentrations have been shown to be below the AQS objective for both the annual and 24-hour means at three locations around the dock periphery for 2012, 2013 and 2014, it is not considered necessary to declare an AQMA;
- Any new developments in or close to the dock areas should give consideration to Measure 1 of the Council's Air Quality Action Plan (AQAP)[2] which states that: *"Consideration of Air Quality Impacts when providing comments on planning applications within an AQMA or where an AQMA could be impacted or created."* This is particularly pertinent as whilst this study does not recommend the declaration of an

[1] Local Air Quality Management Technical Guidance LAQM.TG(09). February 2009. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

[2] Borough Council of King's Lynn and West Norfolk – Air Quality Action Plan – Making King's Lynn a cleaner, more environmentally friendly place to live, work and visit. – 2015

AQMA at the docks presently, this conclusion could be changed should sensitive receptors be introduced at the dock area in future; and

- Analysis of the complaints and shipping data support the assumption that the processing of woodchip at the docks resulted in complaints. Although it is understood that the operator is now no longer present at the docks, should complaints occur again from receptors within the dock area, these are best dealt with by building a case for statutory nuisance. If a statutory nuisance case is established it may be necessary for an air quality/dust management plan to be developed in collaboration with ABP.

1 Introduction

1.1 Scope of Assessment

The Borough Council of King's Lynn & West Norfolk covers approximately 550 square miles (142,877 hectares) and is essentially rural in nature. The Borough includes the two market towns of King's Lynn and Downham Market, the Victorian coastal town of Hunstanton, and more than one hundred villages of varying sizes. The Borough is located about 100 miles north of London and stretches from the north Norfolk coast, along the eastern side of The Wash, through the Marshland, Fens and Brecks to the borders of Lincolnshire, Cambridgeshire and Suffolk. The Borough is the tenth largest district council area in England and Wales. In 2010, the population of King's Lynn & West Norfolk was estimated at approximately 143,631.

King's Lynn is an important settlement, where major transport routes converge, including a trunk road (A47) and three principal roads (A10, A17 and A134); a direct, electrified rail service to London and Cambridge; an extensive system of inland navigable waterways; and sea links to northern and eastern Europe. The town lies some forty miles from the other regional centres of Cambridge, Norwich and Peterborough.

The main source of air pollution in the Borough is road traffic emissions, notably along the A148 (London Road / Gaywood Road / Wootton Road) going through King's Lynn town centre. Other pollution sources, including commercial, industrial and domestic sources, also make a contribution to background pollution concentrations.

Two AQMAs have been declared in King's Lynn where exceedences of the annual mean Air Quality Strategy (AQS) objective for NO_2 were identified, mainly due to traffic congestion.

In recent years, the Council have observed exceedences of both the annual mean and 24 hour mean Air Quality Objectives (AQOs) for PM_{10} at the King's Lynn docks. Additionally, the Council have received a number of complaints from local residence and business owners in relation to dust soiling of property and visible dust plumes. The Council have therefore commissioned Bureau Veritas UK Ltd (BV) to undertake a study which confirms the source and location emitting the particulates in the dock area to assess the necessity to declare an Air Quality Management Area (AQMA) in relation to PM_{10} emissions. The area considered as part of this study is illustrated in Figure 1.1.

The docks are operated by Associated British Ports (ABP), and handle around 500,000 tonnes of cargo a year, including agricultural and forest products, chemicals, steel and other metals. The three docks; the tidal Riverside Quay, Alexandra Dock and Bentinck Dock, can accommodate vessels up to 140 metres in length. The docks cover an area of 97 acres and include the 25,000 tonne capacity Alexandra Grain Silo complex.

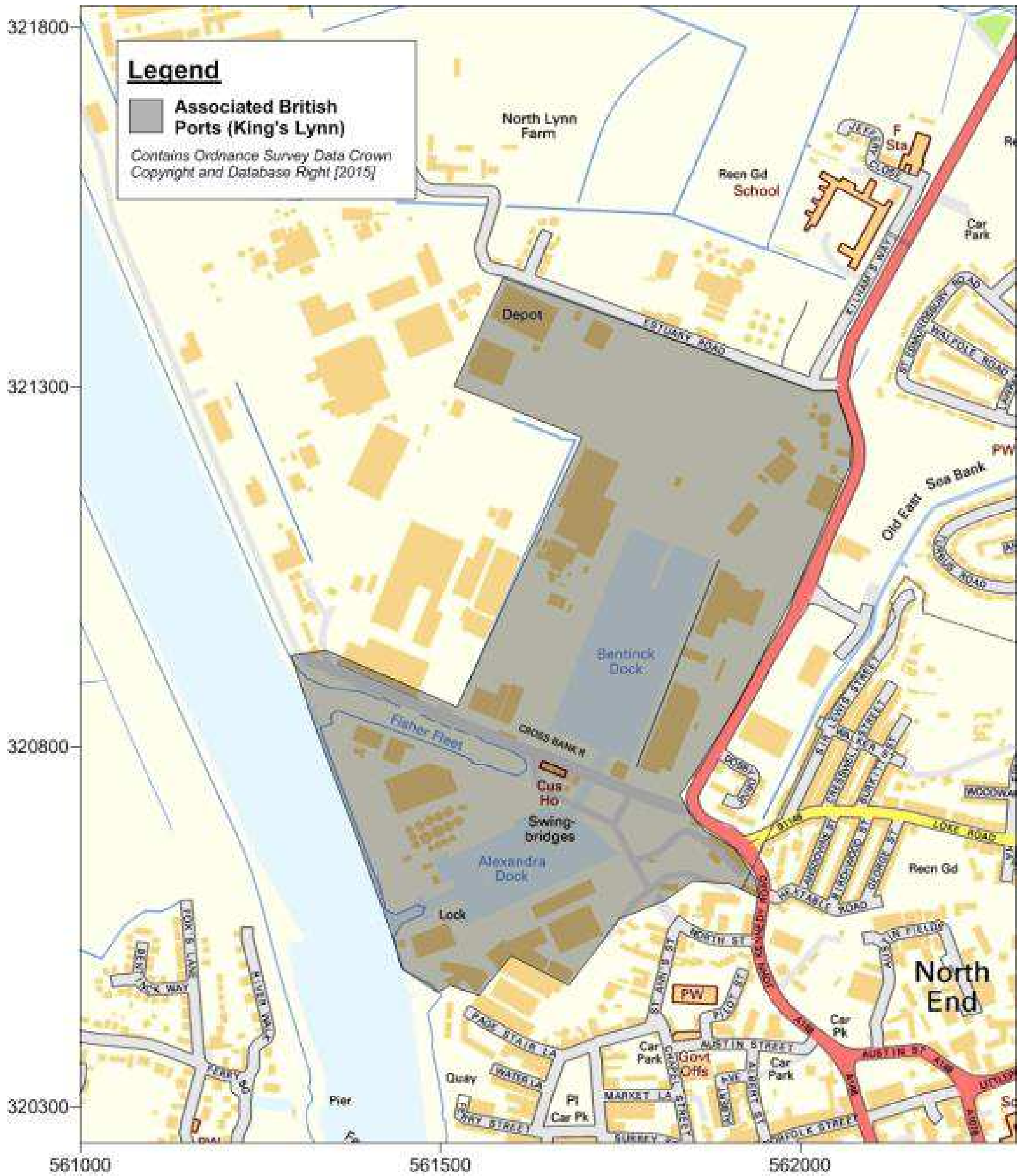
The following are the main objectives of the assessment:

- Analysis of shipping activity (through logs) at the docks in relation to monitored meteorological and pollutant concentration data, to establish links between activity at the docks and periods of elevated pollutant concentrations;
- Analysis of complaints logs collected by the Council to ascertain likely PM_{10}/dust sources linked to monitored PM_{10} concentrations;
- Undertaking of unitary emissions modelling to ascertain the area which is likely to be affected by PM_{10} emissions from the docks;
- Review of current best practice for vessel berthing and unloading techniques which may be used in a subsequent air quality/dust management plan; and

- To put forward conclusions and recommendations as to the extent of any proposed AQMA and necessary future monitoring.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments as set out in the latest guidance and tools provided by Defra for air quality assessment (LAQM.TG(09)[3]) have been used.

Figure 1.1 – Study Area



[3] Local Air Quality Management Technical Guidance LAQM.TG(09). February 2009. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future pollutant concentrations can be assessed in relation to the national air quality standards and objectives established by Government. The Air Quality Strategy[4] (AQS) provides the over-arching strategic framework for air quality management in the UK and contains national air quality standards and objectives established by the UK Government and Devolved Administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from Limit Values prescribed in the EU Directives transposed into national legislation by Member States.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The CAFE Directive[5] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[6]. The Directive introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement of these standards.

The Air Quality Standards (England) Regulations[7] 2010 came into force on 11 June 2010 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the new CAFE Directive.

The objectives for ten pollutants – benzene (C_6H_6), 1,3-butadiene (C_4H_6), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter - PM_{10} and $PM_{2.5}$, ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs), have been prescribed within the AQS[4].

The EU Limit Values are considered to apply everywhere with the exception of the carriageway and central reservation of roads and any location where the public do not have access (e.g. industrial sites). The AQS objectives apply at locations outside buildings or other natural or man-made structures above or below ground, where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period. Typically these include residential properties and schools/care homes for long-term (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives.

This assessment focuses on PM_{10} as this is the pollutant of most concern around the area of the docks. Exceedences of both the annual mean and 24 hour mean air quality objectives were observed in 2011 at the Page Stair Lane Monitor. Additionally, the Council have received a number of complaints in relation to dust and particulate matter emissions due to operations at the docks. The AQS objectives for PM_{10} are presented in Table 2.1.

Table 2.1 – Relevant AQS Objectives for the Assessed Pollutants in England

Pollutant	AQS Objective	Concentration Measured as:	Date for Achievement
Particles (PM_{10}) (gravimetric)	50 µg/m³ not to be exceeded more than 35 times per year	24-hour mean	31 December 2004
	40 µg/m³	Annual mean	31 December 2004

[4] Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

[5] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[6] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons in ambient air.

[7] The Air Quality Standards Regulations (England) 2010, Statutory Instrument No 1001, The Stationary Office Limited.

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995 places a statutory duty on local authorities to periodically Review and Assess the current and future air quality within their area, and determine whether they are likely to meet the AQS objectives set down by Government for a number of pollutants – a process known a Local Air Quality Management (LAQM). The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, carbon monoxide, lead, nitrogen dioxide, sulphur dioxide and particulate matter.

Where the results of the Review and Assessment process highlight that problems in the attainment of health-based objectives for air quality will arise, the authority is required to declare an Air Quality Management Area (AQMA) – a geographic area defined by high concentrations of pollution and exceedences of health-based standards.

Where an authority has declared an AQMA, and development is proposed to take place either within or near the declared area, further deterioration to air quality resulting from a proposed development can be a potential barrier to gaining consent for the development proposal. Similarly, where a development would lead to an increase of the population within an AQMA, the protection of residents against the adverse long-term impacts of exposure to existing poor air quality can provide the barrier to consent. As such, following an increased number of declarations across the UK, it has become standard practice for planning authorities to require an air quality assessment to be carried out for a proposed development (even where the size and nature of the development indicates that a formal Environmental Impact Assessment (EIA) is not required).

One of the objectives of the LAQM regime is for local authorities to enhance integration of air quality into the planning process. Current LAQM Policy Guidance[8] clearly recognises land-use planning as having a significant role in terms of reducing population exposure to elevated pollutant concentrations. Generally, the decisions made on land-use allocation can play a major role in improving the health of the population, particularly at sensitive locations – such as schools, hospitals and dense residential areas.

[8] LAQM Policy Guidance LAQM.PG(09) - February 2009. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

3 Review of Air Quality Monitoring Undertaken by the Council

3.1 Local Air Quality Management

Between 1999 and 2003, the Borough Council of King's Lynn & West Norfolk undertook its First Round of Review and Assessment of air quality, which concluded that PM_{10} and NO_2 concentrations were likely to exceed the AQS objectives at a number of locations in King's Lynn. As a result, the Council declared two AQMAs, one in South Quay (for PM_{10}) in April 2002, and another one in Railway Road (for NO_2) in November 2003. The South Quay AQMA was revoked in June 2006 following the effective implementation of an AQAP for the area.

During the Second Round of Review and Assessment the 2004 Progress Report recommended proceeding to a Detailed Assessment for NO_2, following new monitored exceedences of the annual mean objective outside the AQMA in King's Lynn. The resulting Detailed Assessment, in 2005, confirmed that exceedences were likely to occur at several sites outside the AQMA, and as a result, made the recommendation to extend the AQMA to encompass properties along Railway Road, Blackfriars Road and London Road.

The Third Round of Review and Assessment concluded that the AQS objectives for benzene, 1,3-butadiene, carbon monoxide, lead, PM_{10} and sulphur dioxide were still being met and that no further assessment was required for these pollutants. The report also recommended (following the conclusions of the Detailed Assessment 2005) that monitoring of NO_2 be continued in the Borough to validate the proposal to extend the Railway Road AQMA in King's Lynn. The Council approved a variation order in February 2007 to extend the AQMA, to include all of Railway Road, Austin Street, Blackfriars Road, St James Road and London Road.

The Progress Report carried out in 2007 confirmed that NO_2 concentrations were still exceeding the objective at the majority of the monitoring sites in the AQMA; justifying its extension. It also concluded that a Detailed Assessment for NO_2 in Wisbech was not required, as monitoring results were below the AQS objective. However, new available NO_2 monitoring results showed an exceedence of the objective at the 'Wootton Road 2' diffusion tube in the Gaywood Clock area of King's Lynn. This site is located about 1km east of the extended AQMA in the town centre; therefore, it was recommended that a Detailed Assessment be carried out in this area.

The Detailed Assessment, which also included the Further Assessment (a part of the assessment regime now removed from the process) of the Railway Road AQMA, was completed in 2008. The report concluded that a new AQMA in the Gaywood Clock area was required, as both updated monitoring data and predicted NO_2 concentrations confirmed that the AQS annual mean objective was likely to be exceeded. The new AQMA was declared in April 2009, for an area encompassing properties at the junction of Wootton Road, Gayton Road and Lynn Road. The Further Assessment confirmed that the extended Railway Road AQMA in King's Lynn Town Centre was still valid and should remain, as both monitoring and modelling confirmed exceedences of the AQS objective.

The 2009 Updating and Screening Assessment (USA) took into consideration changes to the Technical Guidance LAQM.TG(09) and concluded that although exceedences of NO_2 were still recorded in the Borough, these were confined to the existing AQMAs. Pollutant concentrations outside the AQMAs met the objectives and no Detailed Assessment was required. The Further Assessment of the Gaywood Clock AQMA was completed in July 2010. The report confirmed the need for the AQMA as both monitoring and modelled concentrations still exceeded the NO_2 annual mean objective.

The 2010 and 2011 Annual Progress Reports concluded that no new Detailed Assessment were required as there were no new exceedences recorded outside the existing AQMAs.

The 2012 Updating and Screening Assessment found that a Detailed Assessment was required in the Page Stair Lane area due to potential exceedences of the annual mean and 24-hour mean with regards to PM_{10}. During 2011 particulate monitoring was completed in this area using an Osiris instrument, an indicative method of monitoring only.

The 2012 USA also identified two new developments on Hardwick Road, a new Tesco Superstore and Sainsbury Superstore, which modelling had predicted to increase NO_2 concentrations on Hardwick Road. Both applications had highway improvements as part of the application and developments. It was advised that the Borough Council of King's Lynn and West Norfolk continue to monitor at this location in order to assess the impact of the development.

The 2013 Progress Report found no exceedences of the NO_2 objectives outside of existing AQMAs. The monitoring site at Hardwick Road showed that the annual mean NO_2 concentrations were generally reducing (based on the 2012 and 2013 diffusion tube results, both of which were below 2011 levels). From this data it would appear that the Tesco and Sainsbury developments have not led to increases in NO_2 concentrations as predicted.

The 2014 Progress Report found no exceedences of the NO_2 objectives outside of the existing AQMAs. At Southgates Park, the concentrations showed an increasing trend in 2012 and 2013. The 2013 results from Gaywood also showed an increase from 2012 and were very close to the annual mean objective. The majority of diffusion tube sites in 2013 showed an increase from 2012 concentrations; however the 2013 concentrations were still lower than those in 2011.

With reference to $PM_{10,}$ monitoring, it was found that the objectives were met at the Tapered Element Oscillating Microbalance (TEOM) monitoring stations. Indicative Osiris monitoring at four locations through the year also showed compliance with the annual mean and 24-hour mean objectives in 2013. The Council continued to undertake PM_{10} monitoring at relevant receptors in the areas of Stoke Ferry and Page Stair Lane, King's Lynn, using a Defra approved method to confirm existing concentrations, and so ascertain the necessity to proceed to a Detailed Assessment in these areas.

The 2015 USA found that there were two NO_2 diffusion tube locations where the annual mean NO_2 objective was exceeded, one of which was inside the existing Town Centre AQMA. The other site was located at the Bus Station monitoring location. This site is not relevant of public exposure with regards to the annual mean NO_2 objective.

With regard to PM_{10} monitoring, the 2015 USA reported that that the annual mean and the 24-hour mean PM_{10} objectives continued to be met at both the North Lynn TEOM monitoring location and all four Osiris sites.

A number of planning applications were reviewed as part of the 2015 USA, none of which were considered to require any further assessment in relation to air quality impacts.

3.2 Review of Particulate Monitoring undertaken by the Council

3.2.1 Particulate Monitoring Data

The Council undertook continuous particulate monitoring at five sites in 2014. Three of these (Estuary Road (ER), North Lynn (NL) and Page Stair Lane (PSL)) are located close to the study area. The remaining two sites, the urban background site at St Michaels C of E Primary School and the Industrial site at Stoke Ferry, are located approximately 2.5km and 23km south respectively.

All pollutant monitoring data has been supplied by the Council made available through the Norfolk Air Quality Website[9].

[9] Norfolk Air Quality Website - http://www.norfolkairquality.net/

Table 3.1 provides the annual mean PM_{10} concentrations recorded at each of the three sites close to the docks area from 2011 to 2014. Monitoring commenced at Page Stair Lane in 2011 and at North Lynn and Estuary Road in 2013.

Table 3.1 – Annual Mean PM_{10} concentrations at monitoring locations close to docks area

Site ID	Site Name	Site Type	OS Grid Ref	Instrument	Annual Mean PM_{10} Concentration (µg/m^3)			
					2011	2012	2013	2014
NL	North Lynn, Edward Benefer Way, off St Edmundsbury Road	Near Road	562086, 321325	TEOM	-	-	23.2	17.8
PSL	Page Stair Lane	Industrial	561527, 320437	Osiris	**42**	23	20	19.1
ER	Estuary Road	Industrial	561593, 321466	Osiris	-	-	18	16.4
Concentrations in **bold** show an exceedence of the annual mean 40µg/m^3 AQS Objective								

Figure 3.1 – Chart showing annual mean PM_{10} concentrations at locations close to docks area

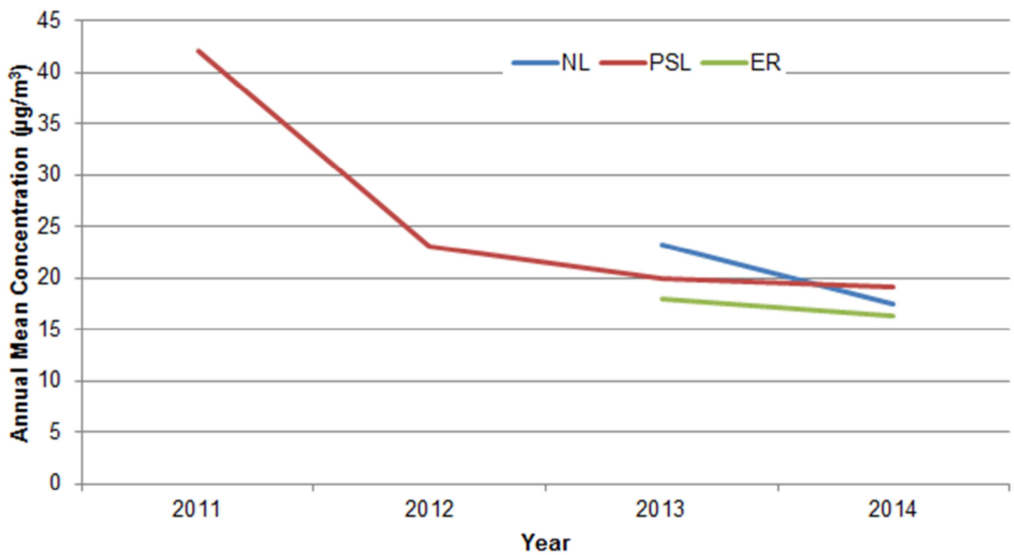


Table 3.2 – 24 hour Mean PM_{10} concentrations at monitoring locations close to docks area

Site ID	Site Name	Site Type	OS Grid Ref	Instrument	Number of exceedences of 50µg/m^3 24 hour Mean*			
					2011	2012	2013	2014
NL	North Lynn, Edward Benefer Way, off St Edmundsbury Road	Near Road	562086, 321325	TEOM	-	-	1	4
PSL	Page Stair Lane	Industrial	561527, 320437	Osiris	**78**	16	6	7
ER	Estuary Road	Industrial	561593, 321466	Osiris	-	-	1	2
Concentrations in **bold** show an exceedence of the 35 allowed exceedences of the 24 hour mean AQS Objective								

Table 3.1 shows that the 40µg/m^3 annual mean AQS objective for PM_{10} was achieved at North Lynn and Estuary Road for all years shown, and at Page Stair Lane for all years except 2011. Figure 3.1 illustrates that annual mean PM_{10} concentrations are observed to decrease at all sites with each subsequent year.

The 24 hour mean AQS objective for PM_{10} was achieved at all three sites for all years with the exception of Page Stair Lane in 2011 as shown in Table 3.2. 78 exceedences of the 50µg/m^3 limit were recorded at Page Stair Lane in 2011, more than double the 35 allowed exceedences.

The values presented in Table 3.1 and Table 3.2 are those values presented in the Council's 2015 USA. Data for the TEOM analyser have been corrected using the Volatile Correction Model (VCM)[10] corrected and data for the Osiris analysers have been corrected using a gravimetric factor of 1.3 by AQDM who conduct the data management for the Council.

TEOM analysers are widely used by local authorities to support LAQM work. However, the outcome of the equivalence study means that TEOM analysers cannot strictly be used to measure PM_{10} concentrations for comparison with the air quality objectives.

The UK government and the Devolved Administrations recognise that many local authorities have invested considerable resources in TEOM analysers, and it may not be practicable to replace these instruments in the short term. It is therefore considered appropriate that TEOM analysers should remain suitable for use for the purpose of LAQM, but wherever possible the data collected should be adjusted using the VCM rather than the use of a simple 1.3 multiplication factor.

TEOM instruments are suitable for Detailed Assessments but the data should be corrected using the VCM Model wherever possible. For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

Osiris analysers are portable instruments which use a light scattering method to measure ambient concentration of fine particles. They are considered suitable for use in Review and Assessment, but not for Detailed Assessments. Data from the Osiris monitors have been used in this assessment for indicative purposes only.

Where further analysis, later in this report, has been undertaken using data from the three monitoring sites, all data from the TEOM analyser has been corrected using the VCM and all data from Osiris analysers have been corrected using a gravimetric factor of 1.3.

Figure 3.2 illustrates the location of the three monitoring sites relative to the dock area.

[10] Volatile Correction Model – Used to correct TEOM measurements for the loss of volatile components of particulate matter that occur due to the high sampling temperatures employed by this instrument.

Figure 3.2 – PM_{10} monitoring locations close to the dock area

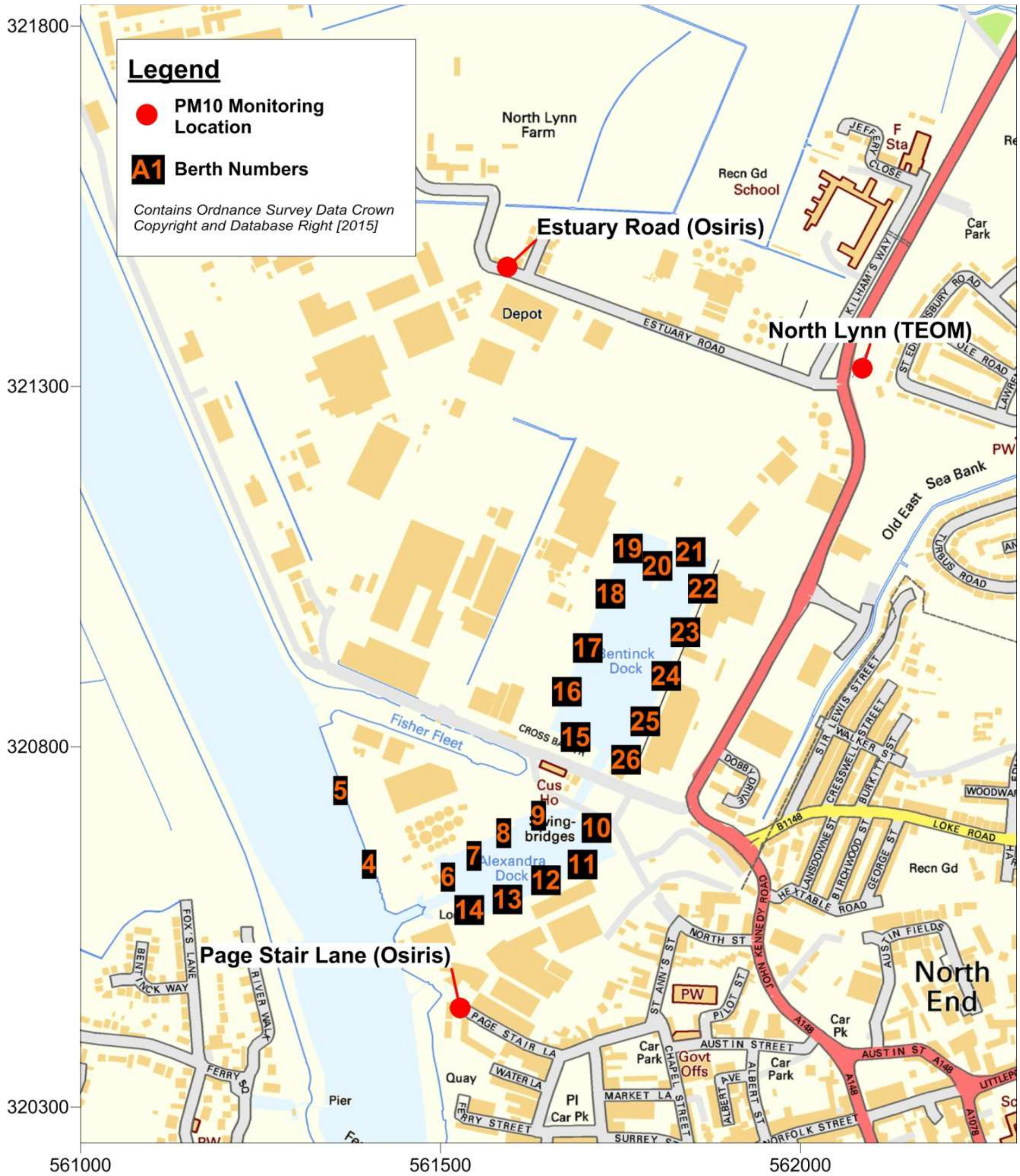


Figure 3.3 provides a plot of the 24 hour mean PM_{10} against Julian Day number recorded at Page Stair Lane to illustrate seasonal variation and variation between different years. It can be seen that the 24 hour mean in 2011 showed greater variation and higher concentrations than all other years with several peaks over 100µg/m^3. The highest 24 hour mean occurs on 20 April (Julian Day Number 111), with a concentration of 248.7µg/m^3, almost five times the 24 hour mean AQS objective. For all other years (2012 – 2015) there has not been any 24 hour means greater than 100µg/m^3. Elevated concentrations are observed to occur in 2012 between Julian Day Numbers 60 to 95, and 125 to 180, but not to the same magnitude as in 2011.

There is no obvious seasonal trend in the 24 hour PM_{10} concentrations, although there does seem to be slightly elevated concentrations between Julian Days 30 to 120 and 240 to 330.

Figure 3.3 – 24 hour Mean PM_{10} concentrations recorded at Page Stair Lane

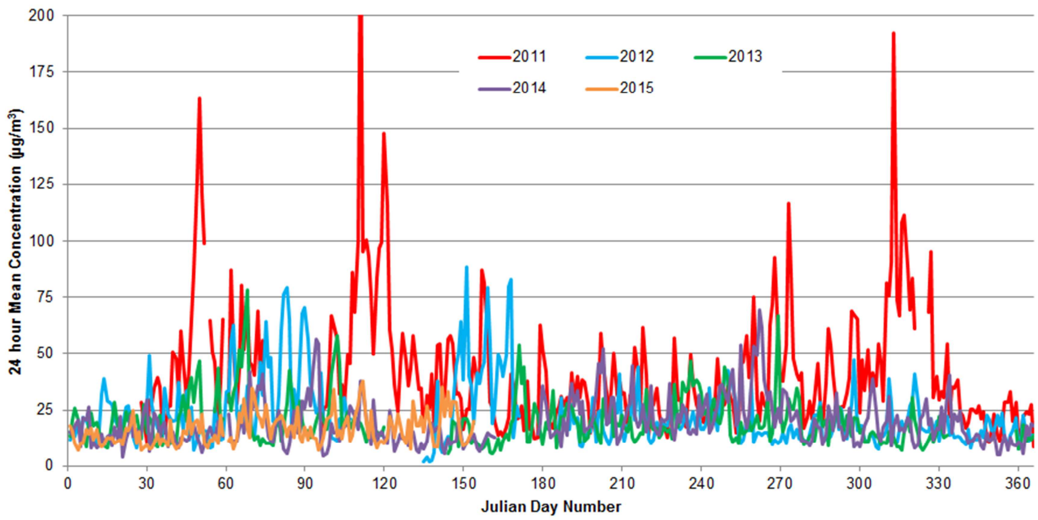


Figure 3.4 provides a plot of the 24 hour mean PM_{10} against Julian Day number recorded at Estuary Road. There are a small number of peaks greater than the 50µg/m^3 AQS objective all except one of which occur between Julian days 70 and 100. Although the annual mean PM_{10} concentration has decreased for each year monitored up until 2014, several elevated PM_{10} periods have already occurred in 2015 and so it is possible that the 2015 annual mean, available at the end of the year, will reverse this trend.

Similar to the observed seasonal variation at Page Stair Lane there seems to be a slight increase in concentrations through the spring, Julian days 30 to 120.

Figure 3.4 – 24 hour Mean PM_{10} concentrations recorded at Estuary Road

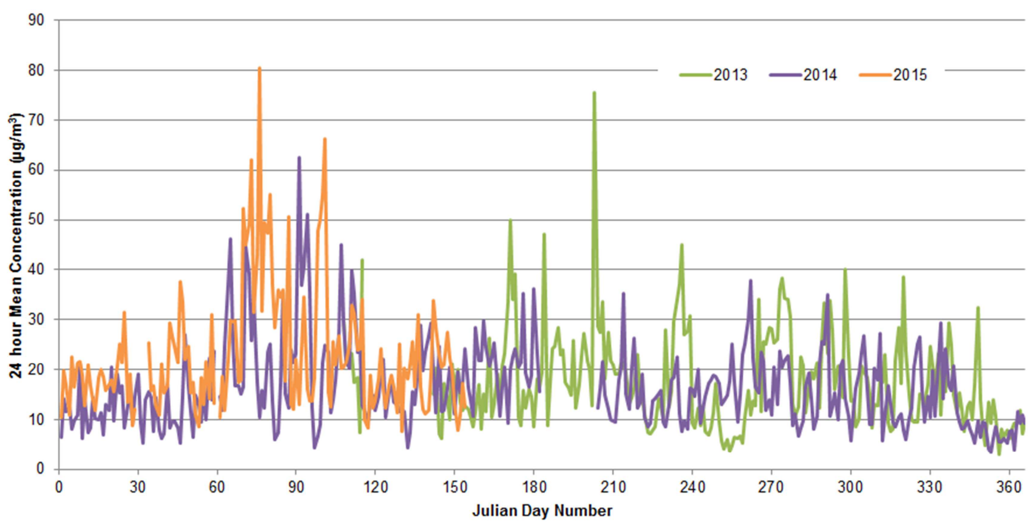
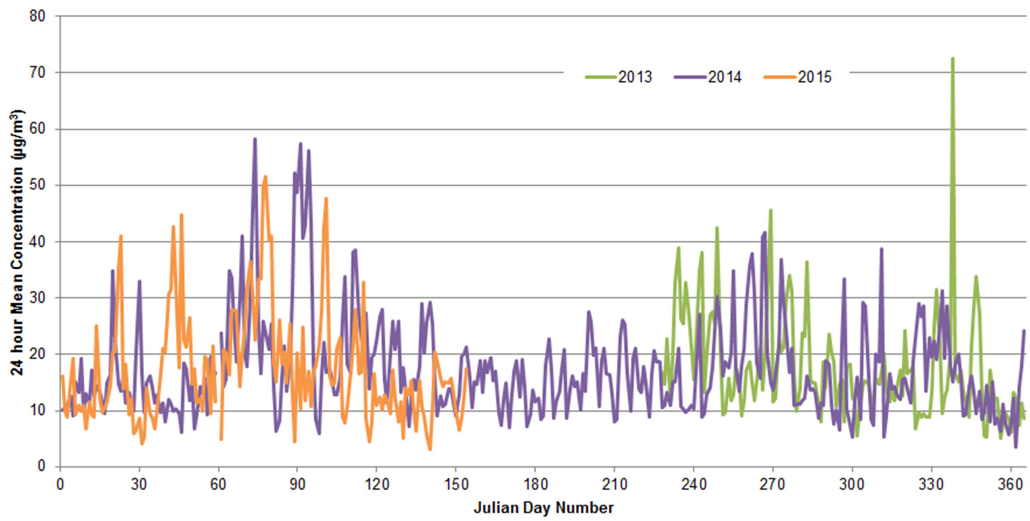


Figure 3.5 provides a plot of the 24 hour mean PM_{10} against Julian Day number recorded at North Lynn. There are a small number of peaks greater than the 50µg/m^3 AQS objective, all except one of which occurs between Julian days 70 and 100. Although the annual mean PM_{10} concentration has decreased for each year monitored up until 2014, several elevated PM_{10} periods have already

occurred in 2015 and so it is possible that the 2015 annual mean, available at the end of the year, will reverse this trend.

Similar to the observed seasonal variation at Page Stair Lane and Estuary Road, there seems to be a slight increase in concentrations through the spring, Julian days 30 to 120.

Figure 3.5 – 24 hour Mean PM_{10} concentrations recorded at North Lynn



3.2.2 Meteorological Data

In addition to collecting PM_{10} concentration data, the Osiris monitors at Page Stair Lane and Estuary Road also collected meteorological data, specifically wind speed and direction. All meteorological data has been supplied by the Council made available through the Norfolk Air Quality Website[9]. It has been assumed the correct QA/QC procedures have been applied to the data prior to its publication online.

Figure 3.6 below shows annual wind roses relating to meteorological data collected at Page Stair Lane. Despite collection of PM_{10} concentrations data at Page Stair Lane commencing in 2011, collection of metrological data did not commence until 2013 and hence wind roses prior to this are not shown. The 2015 wind rose has been produced using data from 1st January 2015 to 2nd June 2015 to give an indication of 2015 meteorological conditions.

Figure 3.6 – Annual Wind roses for Page Stair Lane 2013 to 2015

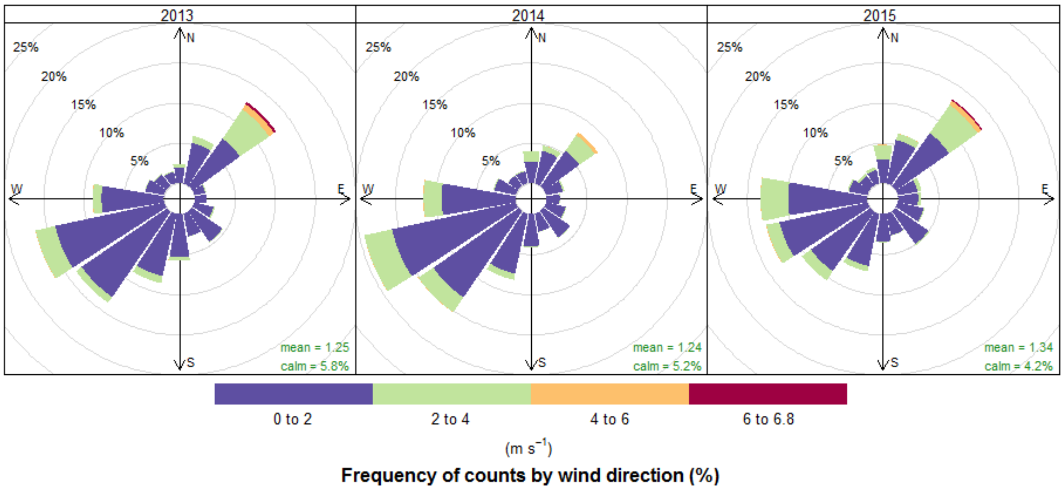


Figure 3.6 illustrates that at Page Stair Lane the predominant wind directions are from the south-south west to the west in all three years. There is also a noticeable portion in all three years from the north east; this portion also seems to correlate with higher wind speeds.

Figure 3.7 below shows annual wind roses relating to meteorological data collected at Estuary Road. Collection of both, PM_{10} concentration data and metrological data commenced in 2013. The 2015 wind rose has been produced using data from 1st January 2015 to 2nd June 2015 to give an indication of 2015 meteorological conditions.

Figure 3.7 – Annual Wind roses for Estuary Road 2013 to 2015

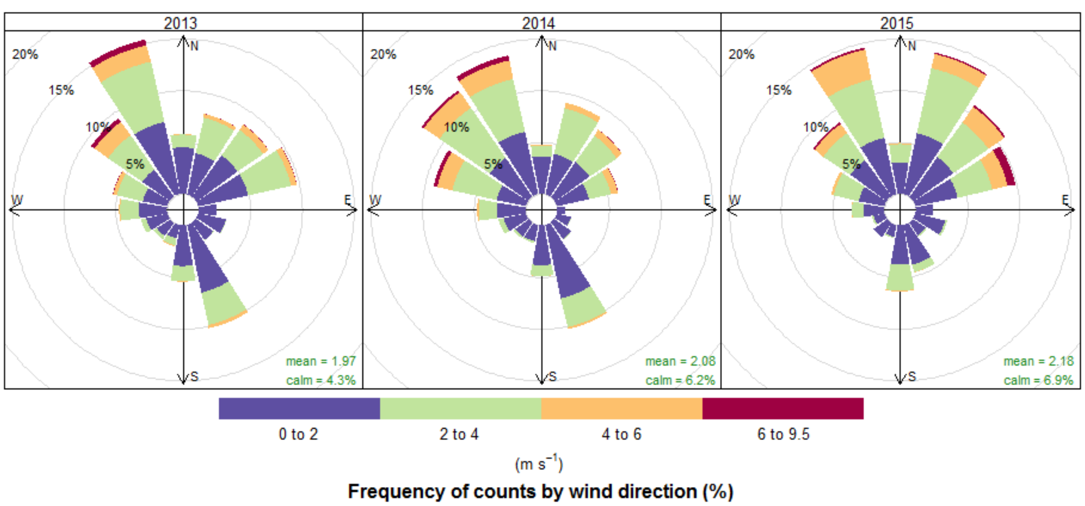


Figure 3.7 illustrates that at Estuary Road the predominant wind directions are from the north west to the east-north-east in all three years. There is also a noticeable portion from the south to south-south-east.

The meteorological data at Estuary Road does not correlate to that collected at Page Stair Lane despite the two sites being located only 1.0km apart. In addition to the wind direction at the two sites not showing a correlation, wind speeds at the two sites do not correlate either. Wind speeds are greater than 2m/s for a far greater proportion of time at Estuary Road than at Page Stair Lane.

Figure 3.8 and Figure 3.9 show the locations of the Page Stair Lane and Estuary Road monitors respectively. At Page Stair Lane the monitor is surrounded by buildings on all sides which are higher than the monitoring equipment whereas at Estuary Road the monitoring equipment is located in a far more open environment.

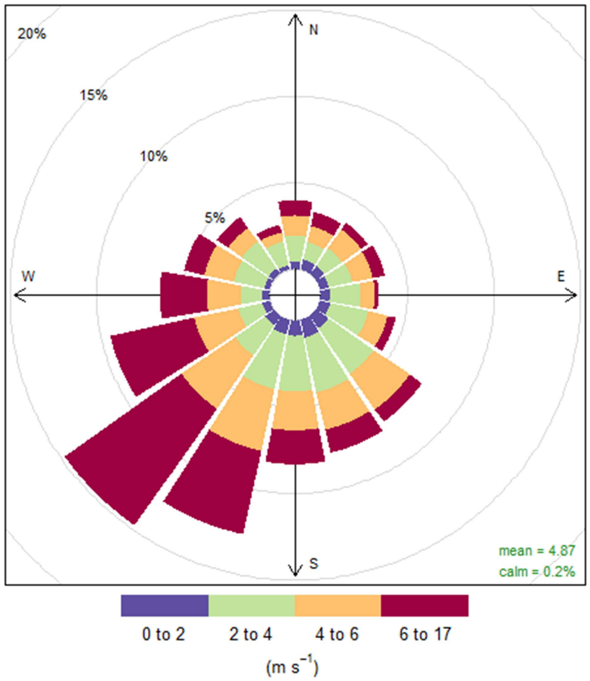
Figure 3.8 – Page Stair Lane Osiris Monitor – Site Context

Figure 3.9 – Estuary Road Osiris Monitor – Site Context

In order to ascertain the correct prevailing meteorological conditions between the two sites the meteorological data from both sites has been compared against data collected at Marham meteorological station located approximately 16km to the south east of the docks. Figure 3.10

illustrates a wind rose for data collected at Marham meteorological station in 2011. The data presented in Figure 3.10 shows more similarity to that presented for Page Stair Lane in Figure 3.6 than that for Estuary Road, with the prevailing wind direction being from the south west.

Figure 3.10 – Annual Wind roses for Marham 2011

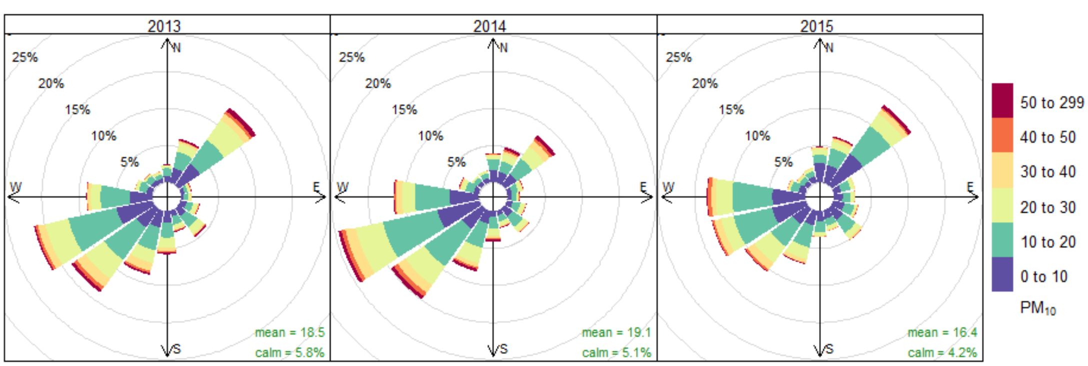


Frequency of counts by wind direction (%)

It has therefore been assumed that the metrological data collected at Page Stair Lane is more representative of prevailing meteorological conditions in King's Lynn, despite the sites sheltered location.

PM_{10} concentration data can be combined with the wind roses to produce pollutant roses. This gives an indication of where a pollutant source is likely to be located relative to the monitoring location. Figure 3.11 illustrates pollutant roses for Page Stair Lane for years 2013 to 2015.

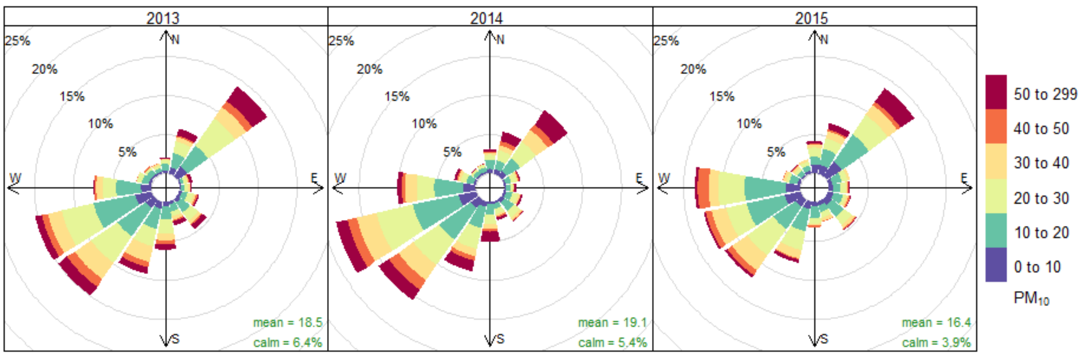
Figure 3.11 – PM_{10} Pollutant roses for Page Stair Lane - 2013 to 2015 (µg/m^3)



Frequency of counts by wind direction (%)

Figure 3.11 illustrates that the elevated concentrations of PM_{10} seem to emanate from all directions, although as they make up on a small portion of the data set it is difficult to distinguish which direction elevated PM_{10} concentrations emanate from. It is possible to emphasize the directions where elevated concentrations are contributing to increased PM_{10} concentrations by varying the length of the rose sector in proportion to the contribution of the PM_{10} concentration annual mean as a percentage. Figure 3.12 illustrates this for the Page Stair Lane dataset.

Figure 3.12 – PM_{10} Pollutant roses showing the proportion of contribution to the mean, for Page Stair Lane - 2013 to 2015 (µg/m^3)

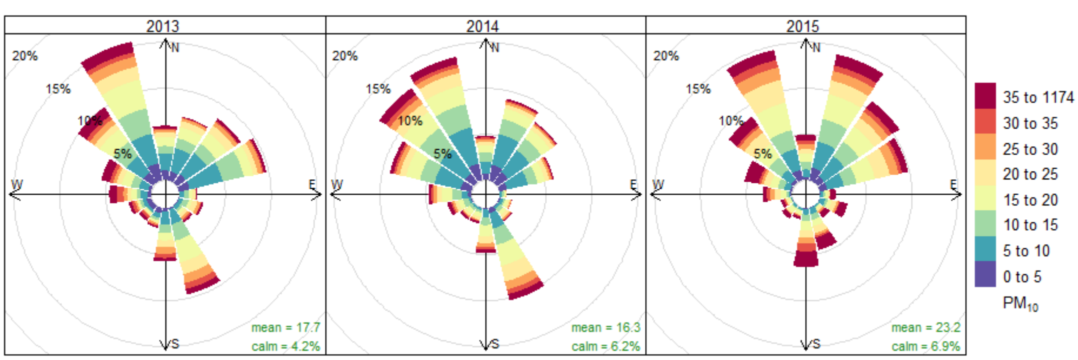


Proportion contribution to the mean (%)

The pollutant roses, as shown in Figure 3.12, show a noticeable contribution to the mean occurring in periods of wind from the northeast for all three years, this is illustrated by the large red area of the northeast sector. The data for 2013 and 2014 shows a significant contribution to the mean from the south-westerly directions as well. This is not the case for 2015 data however.

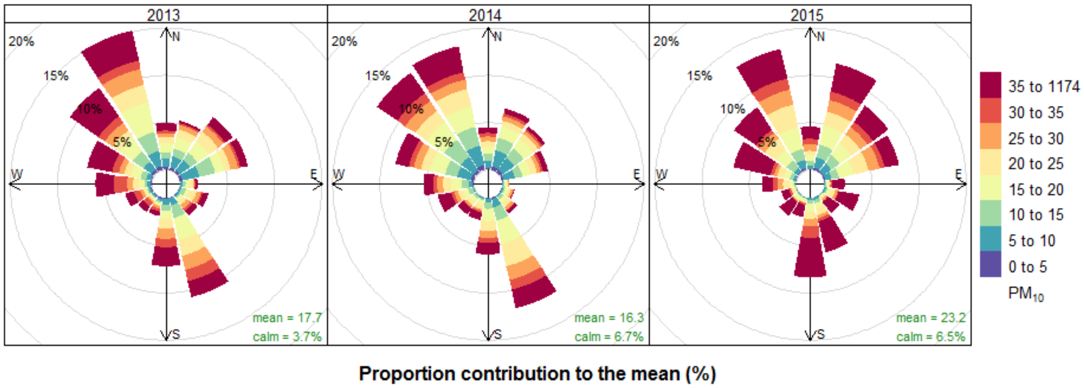
Figure 3.13 and Figure 3.14 provide pollutant roses, and pollutant roses showing the proportion of contribution to the mean respectively for Estuary Road. The pollutant roses show noticeable elevated PM_{10} contributions from the southerly and north-westerly directions for 2013 and 2014. The pollutant roses for 2015 additionally show elevated contributions from a north-easterly direction additionally. The dock area is located immediately south of the Estuary Road Monitor and so it is likely the elevated concentrations from the southern directions are emanating from the docks. The area to the north west of the Estuary Road monitor is made up of agriculture to the north and industrial to the west. The industrial area includes the large DOW Chemical Company site.

Figure 3.13 – PM_{10} Pollutant roses for Estuary Road - 2013 to 2015 (µg/m^3)



Frequency of counts by wind direction (%)

Figure 3.14 – PM_{10} Pollutant roses showing the proportion of contribution to the mean, for Estuary Road - 2013 to 2015 (µg/m^3)



As previously mentioned, collection of meteorological data was only undertaken at Page Stair Lane and Estuary Road. To enable pollutant roses to be produced for the North Lynn site, meteorological data from the Page Stair Lane site has been combined with the monitoring data from the North Lynn site. Meteorological data from Page Stair Lane was chosen as, following comparison with data collected at Marham meteorological station, it was found to be more representative of prevailing meteorological conditions.

Figure 3.15 – PM_{10} Pollutant roses for North Lynn using meteorological data from Page Stair Lane - 2013 to 2015 (µg/m^3)

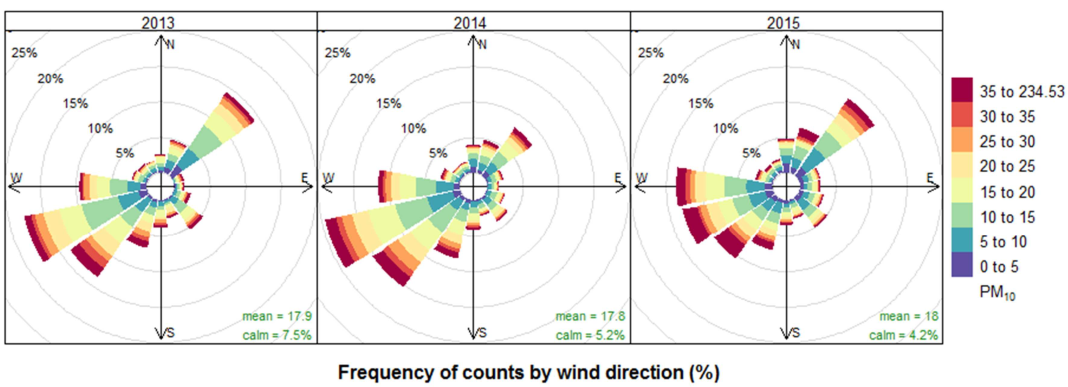
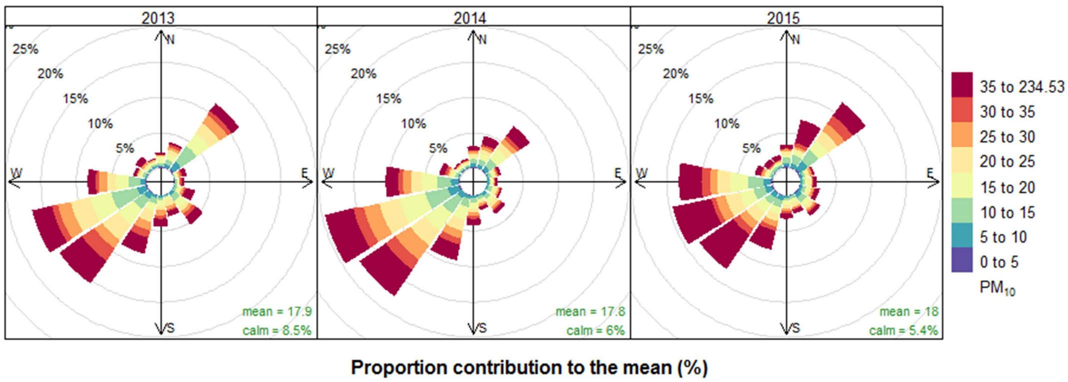


Figure 3.15 and Figure 3.16 provide pollutant roses, and pollutant roses showing the proportion of contribution to the mean respectively for North Lynn using meteorological data from Page Stair Lane. The pollutant roses show noticeable elevated PM_{10} contributions from the south-westerly and directions for all years. The dock area is located immediately south and west of the North Lynn Monitor and so it is likely the elevated concentrations from the south-westerly directions are emanating from the docks.

Figure 3.16 – PM_{10} Pollutant roses showing the proportion of contribution to the mean, for North Lynn using meteorological data from Page Stair Lane - 2013 to 2015 (µg/m^3)



4 Vessel Movement Data

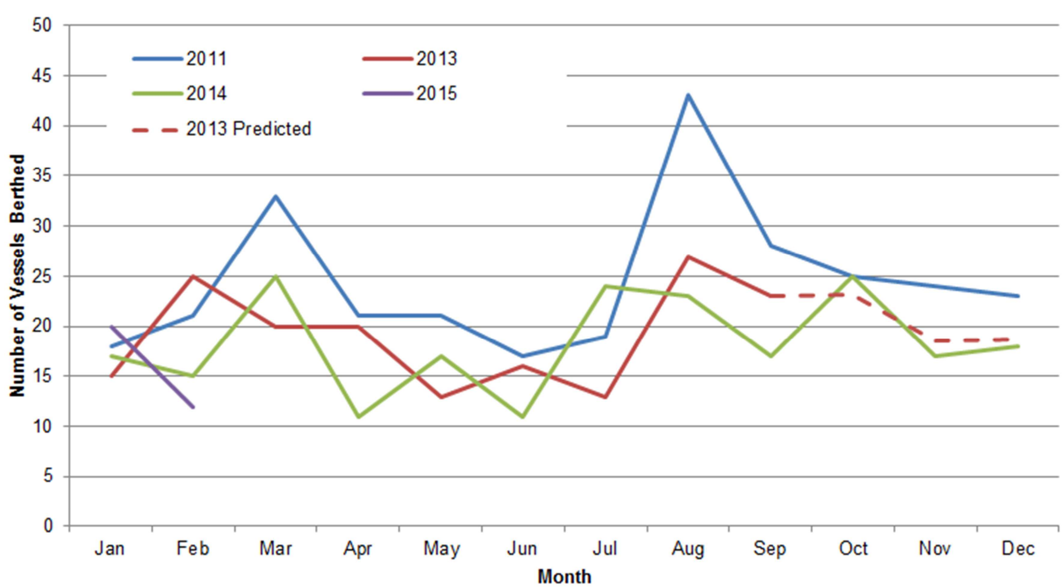
Details of vessel movements at the docks have been provided by the Council, covering movements from 2011 to 2015. The logs provided information relating to the vessel arriving and leaving time, where the vessel berthed in the docks and what cargo was loaded or unloaded. A summary of vessel data is shown in Table 4.1.

Table 4.1 – Summary of Vessel Data from King's Lynn Docks

Year	Earliest Date of Vessel Arrival in Year	Latest Date of Vessel Arrival in Year	Number of Vessels	Tonnes of Cargo Processed
2011	06/01/2011	31/12/2011	293	579,188
2012	-	-	-	-
2013	04/01/2013	07/10/2013	178	344,094
2014	01/01/2014	31/12/2014	220	479,332
2015	01/01/2015	20/02/2015	33	52,466

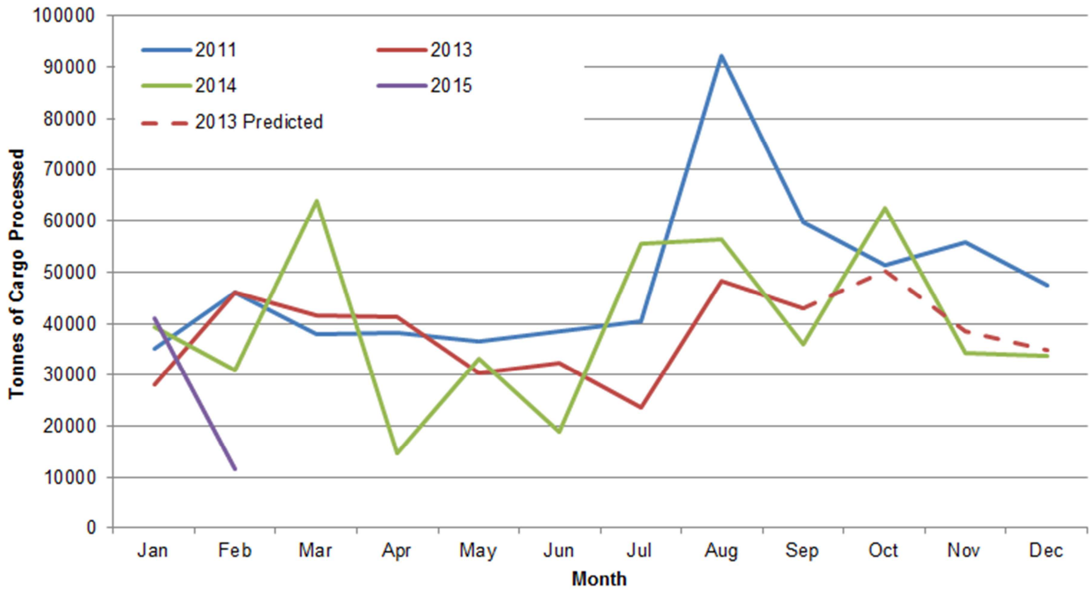
Review of the data in Table 4.1 reveals a number of gaps in the data. The most notable gap is the lack of data for the year 2012. Additionally, data for 2013 covers the year only until 7th October 2013 and data for the year 2015 only until 20th February 2015. Figure 4.1 shows a monthly breakdown of the number of vessels berthing at the docks. A prediction of the last three months of 2013 has been made based on the ratio of the number of vessel berthed in this period in 2014 and 2011 against the total for the rest of 2013. This cannot be done for 2015 as data is only present for 2 months. The chart illustrates that the largest number of vessels berthed in 2011 and that numbers were similar for 2013 and 2014. Figure 4.1 also shows a peak in vessel numbers in March and then through late summer and autumn (August to October).

Figure 4.1 – Chart showing number of Vessels per month at the docks



The amount of Cargo processed at the dock area is obviously loosely proportional to the number of vessels entering the docks. Figure 4.2 shows a monthly breakdown of the total tonnes of cargo processed at the docks. A prediction of the last three months of 2013 has been made based on the ratio of the tonnes of cargo processed in this period in 2014 and 2011 against the total for the rest of 2013. This cannot be done for 2015 as not enough data is only present. The chart illustrates that greatest amount of cargo was processed at the docks during 2011, including over 90,000 tonnes in August 2011.

Figure 4.2 – Chart showing tonnes of cargo processed at the docks per month

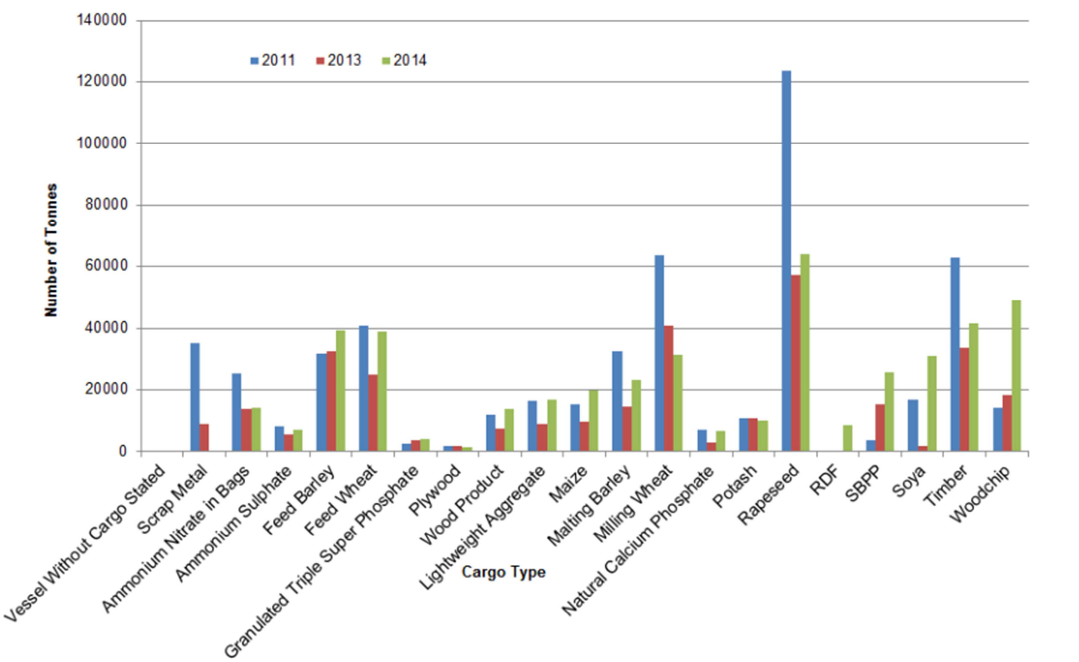


As well as the tonnage of the vessels, the type of cargo was also provided in the data. Appendix 2 contains a Table of the tonnage of each type of cargo discharged or loaded at the docks in each year.

Figure 4.3 shows the amount of each type of cargo in tonnes processed at the docks for 2011, 2013 and 2014 for cargo types where more than five shipments were processed. It is worth noting that the 2013 data only covers the period from 1st January 2013 to 7th October 2013. Figure 4.3 shows that the cargo with most tonnes processed at the docks for all three years was Rapeseed, with over 247,000 tonnes processed at the docks over the three years, this accounted for 19% of all cargo by weight processed.

The tonnage processed of most cargo types showed a decrease as time progressed or stayed at approximately the same level. The exception to this was woodchip for which there was 14,000 tonnes processed in 2011, 18,000 in 2013 and 49,000 in 2014.

Figure 4.3 – Chart showing the type of cargo processed at the docks quantified by tonnage



5 Complaints Data

The Council have received complaints from four different locations/complainants in relation to dust emissions from the docks. These have been summarised in Table 5.1.

Table 5.1 – Summary of Complaints data collected at the docks

Complaint Date	Complaint Location	Complaint Details
11/08/2003	[redacted] Trinity Quay, Page Stair Lane	Dust problems 2-3wks, has to clean TV screen 2xday, duvet cover today
21/09/2009	[redacted] Trinity Quay, Page Stair Lane	Dust at weekend
20/04/2011	Street Record, Page Stair Lane	Air Pollution and Odours
04/09/2013	Bentinck Dock, PE30 2HB	Complaints regarding moving of recycled wood with no dust suppression. Complainant described dust as 'really bad'. Council attended and found that although water jet was now being used, substantial deposited dust was present on cars. Operators spoke to who informed Council Officer that a second water sprayer would be in use shortly.
15/12/2013	Bentinck Dock, PE30 2HB	Dust from Ship unloading, it began raining before it became an issue.
24/02/2014	Bentinck Dock, PE30 2HB	Unloading at the docks, very dry and dusty. Beginning to settle on cars. Complainant said she can feel the dust in her throat when she walks across [redacted]) yard. No dust suppression taking place.
25/02/2014	Bentinck Dock, PE30 2HB	Complainant details that dust has been bad all week due to, wagons coming and going, and a lot of dust from ship loading. Council visit requested due to concerns around health (sore throats and eyes etc).

Complaint Date	Complaint Location	Complaint Details
25/04/2014	Bentinck Dock, PE30 2HB	[redacted] shredded wood being loaded since the previous day - very dusty cargo, due to prolonged spell of dry weather. Council officer observed that - generally not dusty - 80% of all grabs being dropped below cargo doors level minimising dust. However the loading shovel manoeuvring stock pile towards grabs is causing some dust - not excessive but dust observed. Water suppression not occurring but was due to start.
30/05/2014	Bentinck Dock, PE30 2HB	Complaints about dust from trucks pushing woodchip stockpiles. People working outside and are complaining about being affected by the dust. No dust suppression.
30/05/2014	Bentinck Dock, PE30 2HB	Vessel ([redacted] being loaded on dock nearest [redacted]. Dry shredded wood from stockpile. Grab shovel being used to load and also arrange stockpile before lifting some loads. Shovel is being lowered into hold before being released. Dust being emitted while material is moved around stockpile. Dust seen settled on cars parked at [redacted] [redacted] HGV pulled up with full load of wood chip. JCB being used with flat plate to push stockpile towards shovel. This Action created a visible dust cloud of brown dust. Wind SSE. JCB also being used in hold to flatten load. Also creating dust. [redacted] HGV emptied load by pushing (with ram?) from inside body, this also added to dust cloud. [redacted] employee who works in the yard for [redacted] and often is around loading area detailed that he is affected regularly by dust. He has noticed an effect on his breathing, he has phlegm all the time. He has been to his doctor who gave treatment and then sent him for tests. [redacted] said that a driver had told him that the customer had requested finer shredded wood so this has made it dustier. This particular load had been going on since last night. [redacted] advised to call when it is dusty to build evidence base. Council Officer spoke to supervisor for [redacted] and was advised that they only had about 30 minutes loading to do now. Council officer advised the use of water spray as there is visible dust cloud from the stockpile and this is causing a problem for people working here.
07/08/2014	Bentinck Dock, PE30 2HB	Complaint from [redacted] Dust been bad since around 8am. Loading further down but material being moved with dumper truck near [redacted].
07/08/2014	Bentinck Dock, PE30 2HB	[redacted] are loading biomass with no abatement and dropping from height [redacted] have advised them on correct procedure. They were also told at liaison group. Complainant noted that there is some abatement on the ship loading however the stockpile nearest to [redacted] and has no abatement at present. Still dusty and affecting them.
13/08/2014	Bentinck Dock, PE30 2HB	Complaint from [redacted] Loading with no water jets, very dusty and close to our offices. Complainant report getting fed up with reporting it every time' [redacted] stated that they thought it would not be a problem due to wind direction. However, they would now start using dust suppression.
24/10/2014	Bentinck Dock, PE30 2HB	Complaint from [redacted]. The dust was very bad again. Council Officer attended. The spray curtain was operational dust was being generated by the movement/stockpiling of the biomass. The stockpile of biomass was a lot taller than the height of the spray curtain. Complainant informed that this was the second day of the biomass movement and that they were getting very concerned about the dust as people were starting to get coughs which they associated with the dust. They also complained about their eyes stinging. Complainant reported that the curtain had not been activated until at least half an hour after they started, and that yesterday they hadn't put it on until an hour after they started moving the biomass and then at the end of the day they had done some more shifting around without it being on at all. Officer observed wagon to be blocking spray curtain, Officer also observed that a lot of dust was coming through and by the time they got to the stockpile their eyes were stinging from the dust. The biomass stockpile included chipboard, fibreboard, treated wood and painted wood. Findings discussed with [redacted] Offices.
30/10/2014	Bentinck Dock, PE30 2HB	Complaints call from [redacted] due to Loading on Wednesday, dust suppression was effective (used water/mist). Thursday measures not for effective (due to change in wind direction).
06/11/2014	Bentinck Dock, PE30 2HB	Reports that someone has been moving stockpile today and it has been very dusty without dust suppression. Water suppression was be used earlier but not at a point material was being moved. Reports of cars parked at [redacted] being covered in dust.
03/12/2014	[redacted] Coastguard Cottages, Crossbank Road	Council Officer spoke to [redacted] to discuss. Dust from loading of ships at the Bentinck docks from 10.00 to 16.00hrs on Sunday. No water suppressor being used. Biomass being used was not very effective. Possible [redacted] operation. Drop height in ship was above sides of ship. Visibility was poor due to level of dust in air. Problem when HGV tip biomass on to pile. [redacted] lives [redacted], Crossbank Road. Cars covered in dust on regular basis, windows sills covered in dust [redacted] has spoken to [redacted] port Manager

Complaint Date	Complaint Location	Complaint Details
17/12/2014	[redacted] Coastguard Cottages, Crossbank Road	Complainant [redacted]. Says he may need longer than 14 days to keep a diary as he's affected a lot of the time. Complainant detailed that piles of chippings can be seen 'combusting' in warm weather giving off noxious vapour.
02/01/2015	[redacted] Coastguard Cottages, Crossbank Road	Loading taking place with no water dust suppression.
07/01/2015	[redacted] Coastguard Cottages, Crossbank Road	The dust is still a problem. Loading at the weekend with no dust suppression. Concern that the piles are self-combusting, the emissions are unknown but the complainant details that they cause stinging to the eyes and throat.
23/02/2015	[redacted] Coastguard Cottages, Crossbank Road	Complainant detailed that activities on Saturday were very dusty. From the Cross Bank Road all the way to his house was covered in dust. He and his wife had sore throats from the dust.
25/02/2015	[redacted] Coastguard Cottages, Crossbank Road	Council Officer asked Complainant to keep a diary of complaints. Complainant refused stating it was a waste of time.

As shown in Table 5.1 although the complaints records cover the period from August 2003 to February 2015 the majority of the complaints have been recorded since September 2013. The complaints have been lodged by four different sources located in three different areas as is illustrated in Figure 5.1. It can be seen that the complaints sources do not overlap in time with complaints occurring at Page Stair Lane from 2003 to 2011, at Bentinck Dock from September 2013 to November 2014 and at Coastguard Cottages from December 2014 to February 2015.

The complaints records from complaints at Page Stair Lane contain only limited detail, additionally two of the three records occurred before the Page Stair Lane monitor was commissioned. Analysis of these complaints will therefore be limited.

The complaints records at Bentinck Dock have been collected from employees at a company who operate a builder's merchants yard on the west side of the Bentinck Dock. The complaints records are quite detailed observing that although dust suppression equipment is present at the docks it is not always used. The complaints imply that the dust is due to movements of biomass burner fuel and woodchip. Health impacts of the dust are reported, relating to people's eyes stinging and people having trouble breathing and suffering sore throats.

Figure 5.1 – Location of complaints in the dock area

The complaints from the resident at Coastguard Cottages show a similar characteristics to those recorded at Bentinck Dock with the addition of the observation that piles of biomass fuel are smoking in the hot weather. The final complaint gives the impression the complainant has given up on complaining, refusing to keep a complaints diary, stating that it is a waste of time.

6 Site Visit

A visit to King's Lynn docks was undertaken on the 21st July 2015 in order to gain context for the layout of the docks and witness activities being undertaken on a typical day. The following individuals were in attendance at the site visit:

- Jamie Clayton (Bureau Veritas);
- Fabia Pollard (Borough Council of King's Lynn and West Norfolk); and
- Jacqueline Murfitt (Borough Council of King's Lynn and West Norfolk).

Figure 6.1 illustrates the route taken around the docks on during the site visit. A number of photos which were taken during the site visit are illustrated in Appendix 3.

Figure 6.1 – Route undertaken during site visit showing locations of site photographs

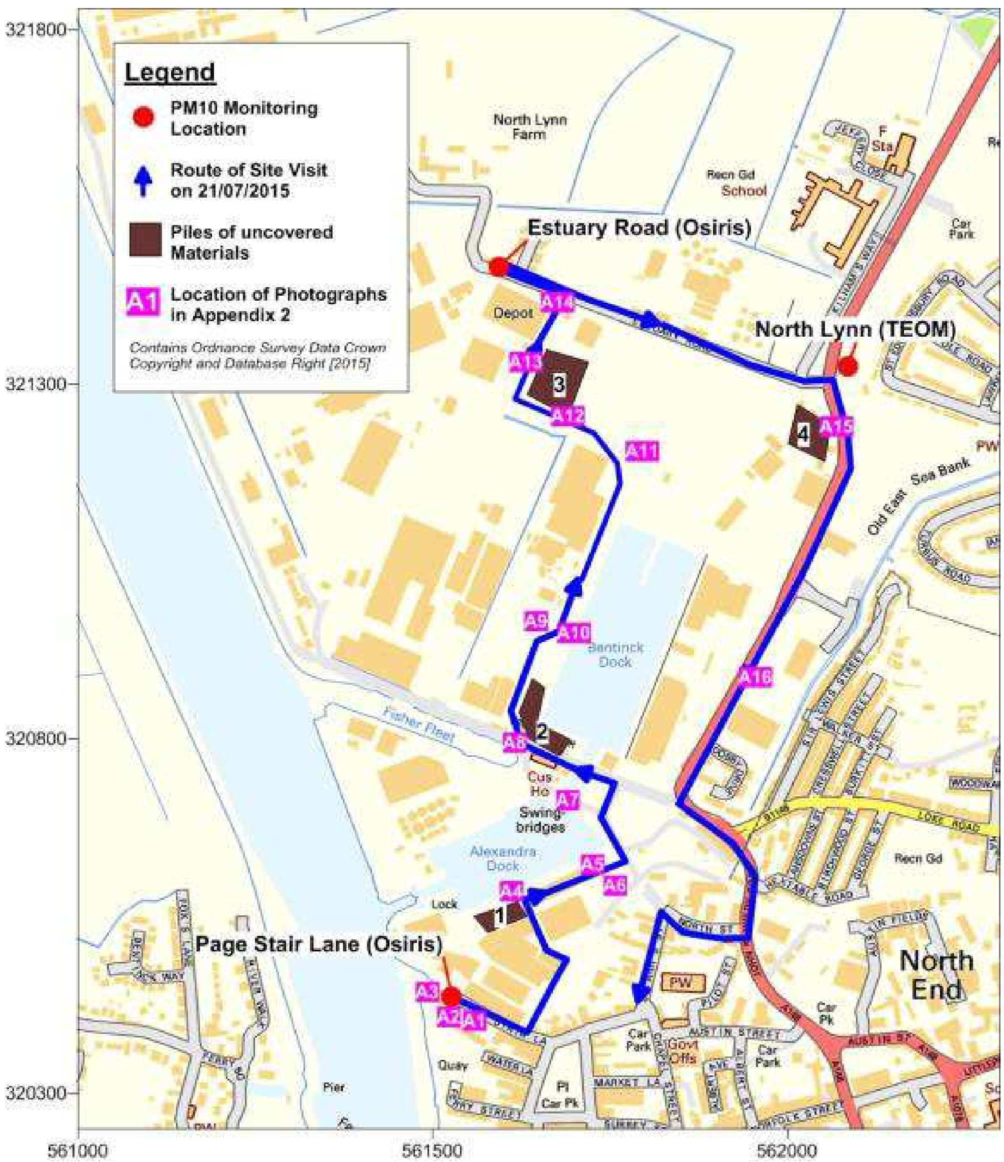


Table 6.1 shows the meteorological and PM_{10} concentration data recorded at the three monitoring locations during the site visit on the 21st July 2015. The three sites show good agreement in PM_{10} concentration with all three sites being 21µg/m^3 to 23µg/m^3 as an hourly average. This is well below the PM_{10} annual mean AQS objective of 40µg/m^3. The PM_{10} concentration recorded during the site visit is slightly above the annual average PM_{10} concentrations recorded at the three sites in 2014.

The wind speed recorded at both sites is below 5 m/s and so would be classed as a light breeze / gentle breeze according to the Beaufort scale. The wind speed recorded at Estuary Road is notably higher than that recorded at Page Stair Lane this may be due to the building surrounding the Page Stair Lane site shielding some of the wind from the monitor. The wind direction data between the two sites do not show agreement.

Table 6.1 – Data recorded at the three monitoring sites during the site visit on 21st July 2015

Time	Estuary Road			Page Stair Lane			North Lynn
	PM_{10} (µg/m^3)	Wind Direction (º)	Wind Speed (m/s)	PM_{10} (µg/m^3)	Wind Direction (º)	Wind Speed (m/s)	PM_{10} (µg/m^3)
10:00	21	15	2.3	25	265	1.5	21.3
10:15	18	30	2.4	22	5	1.5	
10:30	20	20	2.1	22	270	1.8	
10:45	29	330	2.9	22	335	1.6	
11:00	26	25	2.6	22	270	1.6	21.3
11:15	23	30	2.8	21	0	1.8	
11:30	19	30	2.5	21	275	1.7	
11:45	17	30	2.3	21	0	1.8	

6.1 Observations during Site Visit

The site visit began at the Page Stair Lane Osiris monitoring location, Figure A1 and Figure A2 (Appendix 3) provide context of the location. The area immediately to the south of the monitoring location is residential from which there have been complaints of dust/PM_{10}. Figure A3 shows the view looking north along the River Great Ouse towards berth numbers 4 and 5 (Figure 3.2). The Council employer present observed that vessels discharging or loading at berth 4 and 5 had in the past caused complaints by the residents in properties on Page Stair Lane.

Upon entering the dock area, the route progressed to the south side of Alexandra dock. Large piles of loose material were observed at the side of the dock as shown in Figure A4 and located at pile 1 in Figure 6.1. The Council employee present observed that these were piles of lightweight aggregate, the piles were uncovered and dust could be seen being whipped up on the side of the piles.

The route continued along the side of the Alexandra Dock to the south east corner, to an area where a large amount of treated timber was being stored both indoors and outdoors. Figure A5 shows the view north across the dock with piles of timber wrapped in polythene, Figure A6 shows the view south, large amounts of timber can be seen both wrapped and unwrapped. Residential receptors on St Ann's Fort can be seen in the background with a separation distance from the site of around 10 metres.

Figure A7 provides a view west across Alexandra dock taken from the point of the channel that joins it to Bentinck Dock. Continuing along cross banks road large piles of uncovered scrap metal and Woodchip were present pile 2 on Figure 6.1, as shown in Figure A8 and Figure A10.

Continuing round to the west side of Bentinck Dock a ship was observed to be unloading during the time of the site visit, as can be seen in Figure A9.

North of the dock, where the photograph in Figure A11 was taken, a pile of what appeared to be woodchip was located in the north east corner of the dock site. The Council employee present stated that the amount of material stockpiled in the northeast corner of the site was now greatly reduced from the level which it had been at, and that the level had previously been twice as high as the concrete bund which lines the sites northeast corner.

Following the site road round to the location where Figure A12 was taken is a large open storage area. Large piles of uncovered loose materials were present, as can be seen in Figure A12, the amount of material being stored far exceeded the amount that the concrete bunds were designed to hold. This was evidenced by the piles being significantly higher than the bunds to that point that material had spilt out around the bunds and had even ruptured the bund in some places.

Continuing north along the site road to where it meets Estuary Road Figure A13 shows the dust abatement equipment installed at M&S (Softwood) Ltd. Figure A14 shows the view west along Estuary Road. The site visit then continued first along Estuary Road to the point of the Estuary Road monitor before heading back along Estuary Road and on to Edward Benefer Way. Figure A15 is taken at the northeast corner of the docks site from Edward Benefer Way. Figure A16 is taken from Edward Benefer way opposite the large grain silo facing the receptors to the south east of the docks. The residential receptors beyond the retail units are located approximately 100m from the dock boundary.

7 Analysis of Data Sources

7.1 Comparison of Vessel Data to PM_{10} Concentration Data

The section will attempt to establish if there is a relationship between the recorded PM_{10} concentration at the three monitoring sites and the vessel logs recorded at the docks. Although it is accepted that stockpiles of materials remain onsite after vessels have departed it has been assumed that the most substantial movement of materials would occur when loading and discharging the vessels. The recorded PM_{10} concentrations during periods which vessels are in the dock area have therefore been compared to periods when there are no vessels in the docks to try to establish a link between vessels being present and elevated PM_{10} concentrations.

As the vessel data provided has gaps the PM_{10} concentration data has only been used for periods when vessel data has been provided. Table 7.1 provides a summary of the vessel data provided and the proportion of time it is therefore considered that vessels are present in the docks and not present in the docks.

Table 7.1 – Percentage of Time Vessels are present in the Docks

Start Data	End Date	Total Hours	Percentage of Time		
			No vessels in Dock	One or More Vessels in Dock	Two or More Vessels in Dock
1st Jan 2011	1st Jan 2012	8,760	23.3	76.7	51.2
1st Jan 2013	9th Oct 2013	6,744	23.9	76.1	43.6
1st Jan 2014	1st Jan 2015	8,760	33.5	66.5	40.5
1st Jan 2015	23rd Feb 2015	1,272	23.3	76.7	37.2

The table shows that vessels are present in the docks over two thirds of the time for all years and three quarters of the time for 2011, 2013 and 2015. Although therefore it is more than likely that at any given time that there will be a vessel in the docks, there is still a substantial amount of time when there are no vessels in dock for the purpose of comparison. The table also shows the percentage of time two or more vessels in dock. This is notably higher for 2011, this agrees with the data presented in Section 4, which found that 2011 had more vessels visiting the docks than any other year.

Table 7.2 provides the average PM_{10} concentrations recorded at the three monitoring locations at the docks for all periods, periods when at least one vessel is in dock and periods when no vessels are in dock. The PM_{10} concentrations have assumed the same periods as so given in Table 7.1 to account for gaps in the vessel data provided.

Table 7.2 shows that apart from at PM_{10} concentrations recorded at Page Stair Lane in 2011 and Estuary Road in 2013, the PM_{10} concentration was higher during periods that vessels were present in the docks than when no vessel were present in the docks. This is most notable at the North Lynn monitor in 2013 when the PM_{10} concentration was 2.4µg/m^3 higher when vessels were present in the docks.

Table 7.2 – Average PM_{10} Concentration during periods when Vessels are in Dock and not in Dock

Year	PM_{10} Concentration ($\mu g/m^3$)		
	NL	PSL	ER
Concentration during all periods			
2011[c]	-	42.5	-
2013[a]	21.6	21.0	18.7
2014[c]	17.8	19.1	16.4
2015[b]	16.8	13.0	18.7
Concentration during periods of vessels in dock			
2011[c]		42.4	
2013[a]	22.0	21.3	18.7
2014 [c]	18.3	19.4	16.6
2015[b]	17.2	13.3	18.8
Concentration during periods no vessels in dock			
2011[c]	-	42.6	-
2013[a]	19.5	19.9	18.9
2014[c]	16.7	18.6	16.0
2015[b]	15.5	12.0	18.2
Difference in PM_{10} between periods vessels are in dock and periods no vessels are in dock			
2011[c]	-	0.2	-
2013[a]	-2.4	-1.4	0.3
2014[c]	-1.5	-0.7	-0.6
2015[b]	-1.6	-1.3	-0.6

[a] Data covers period from 01/01/2013 to 09/10/2013 only.
[b] Data covers period from 01/01/2015 to 23/02/2015 only.
[c] Data covers full year

7.2 Comparison of Vessel Data to Complaints Data

The section will attempt to establish if there is a relationship between the complaints data detailed in section 5 and the vessel logs recorded at the docks.

Figure 7.1 shows the number of vessels visiting the docks each month plotted alongside the complaints logs. Where gaps is the shipping data are present (the last two months of 2013 and the entirety of 2012) complaint data has been omitted also, to enable a fair comparison.

There is not an obvious correlation between the number of vessels being processed each month and the number of complaints. The number of complaints increases in frequency from February 2014 onwards. This does not correlate with a noticeable change in the number of vessels being processed at the docks each month. During 2011 a larger number of vessels were processed at the docks than in 2013 or 2014, however only a single complaint was logged.

Figure 7.1 – Chart showing the number of vessels processed at the docks each month alongside the number of complaints logged each month

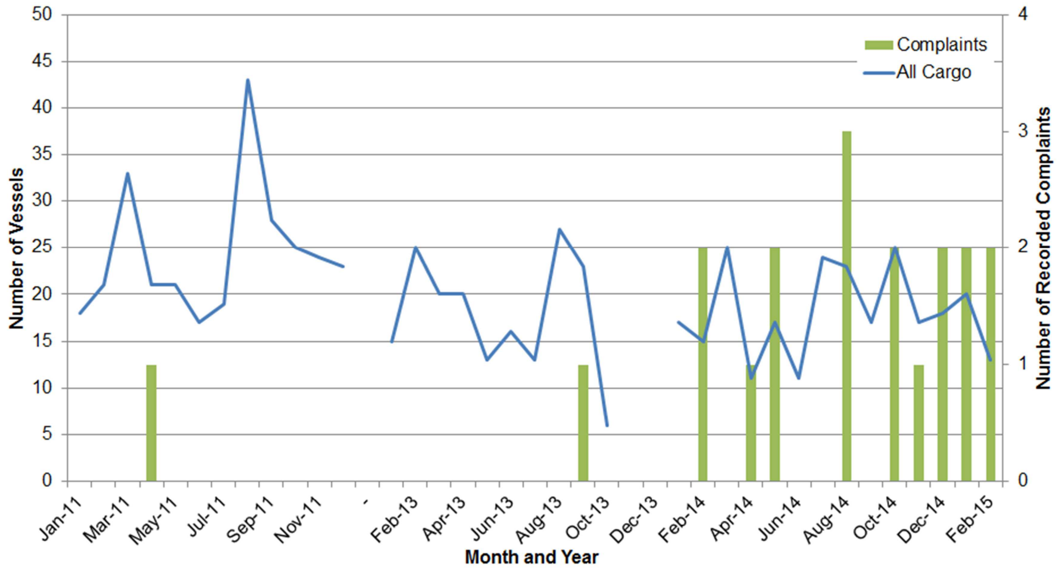
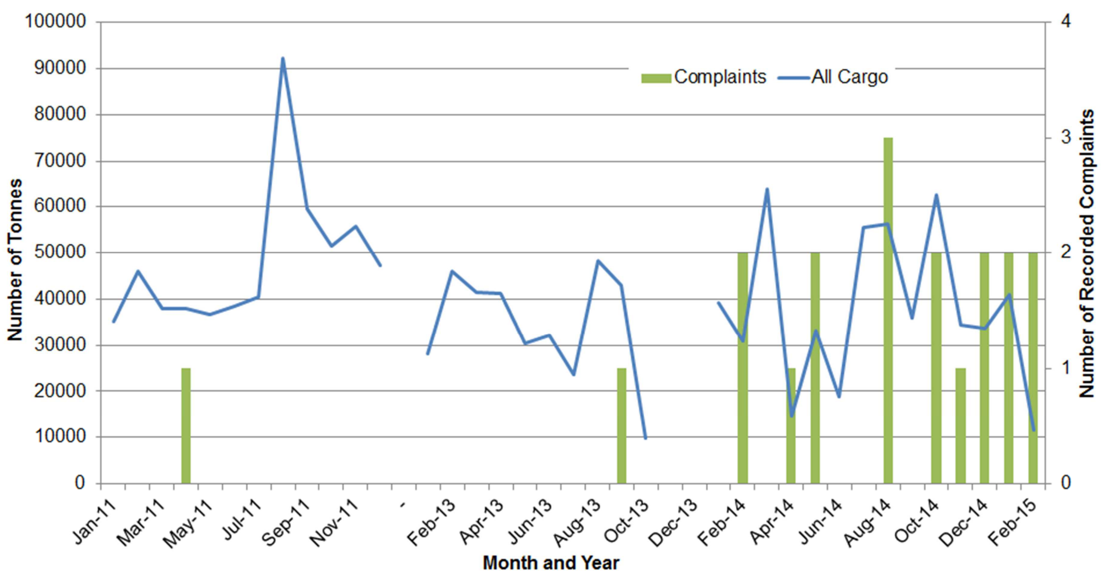


Figure 7.2 shows the number of tonnes of cargo processed at the docks each month plotted alongside the complaints logs. As with the number of vessels data, there is not an obvious correlation between the tonnes of cargo processed each month and the number of complaints. The number of complaints increases in frequency from February 2014 onwards. This does not correlate with a noticeable change in the number of tonnes of cargo being processed at the docks each month.

Figure 7.2 – Chart showing the tonnes of cargo processed at the docks each month alongside the number of complaints logged each month



Anecdotal evidence from the complaint data as detailed in Table 5.1, implies that the dusty periods relate to the load/unloading of woodchip. Figure 7.3 therefore shows the number of vessels processed each month with woodchip as a cargo alongside the complaint data. Prior to February 2014 there does not appear to be any obvious correlation between the number of vessels and the number of complaints. However, from February 2014 onwards complaint data correlates well to the months when woodchip was processed at the docks.

In July 2014 and September 2014 no vessels carrying woodchip were processed at the docks, during these months no complaints were recorded. In August 2014 three complaints were recorded at the docks which corresponded to four vessels with a cargo of woodchip being processed.

Figure 7.3 – Chart showing the number of vessels with woodchip as a cargo processed at the docks alongside the number of complaints logged each month

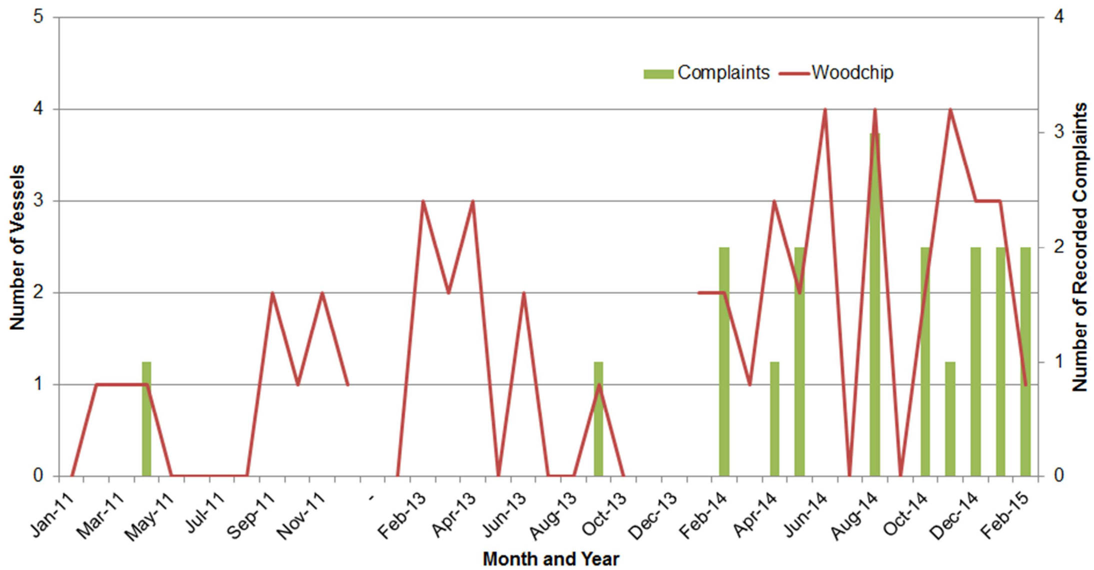


Table 7.3 shows details of the vessels in the docks during the complaint periods. Where a vessel cargo included woodchip the vessel data and complaint have been shaded orange. Table 7.3 shows an obvious correlation between vessels processing woodchip and periods of complaints. Of the 15 complaint periods when vessel data is available, 10 occur during periods when a vessel processing woodchip is in the dock area. 67% of complaints therefore occurred during a period when a vessel processing woodchip was in the dock area.

Table 7.3 – Table showing details of Vessels in the docks during complaint periods

Date	Complaint Location	Berth	Cargo
20/04/2011	Street Record, Page Stair Lane	5	RAPESEED
		4	FEED WHEAT
		15	WOODCHIP
		12/13	-
04/09/2013	Bentinck Dock, PE30 2HB	25	DURUM WHEAT
		13	FEED BARLEY
		4/5	TIMBER
		16/23	RAPESEED
		17	WOODCHIP
		13	RDF
24/02/2014	Bentinck Dock, PE30 2HB	4/5	GTSP
25/02/2014	Bentinck Dock, PE30 2HB	4/5	GTSP
		13	SBPP
25/04/2014	Bentinck Dock, PE30 2HB	11 17	TIMBER/WOODCHIP
30/05/2014	Bentinck Dock, PE30 2HB	17	WOODCHIP
		4/5	BAG AMMONIUM NITRATE
07/08/2014	Bentinck Dock, PE30 2HB	25 23	SOYA/RAPESEED
		4/5	RAPESEED
		16	WOODCHIP
13/08/2014	Bentinck Dock, PE30 2HB	4	FEED WHEAT
		25	NCP
		11	TIMBER
		23	MILLING WHEAT
		17	WOODCHIP
		5	FEED BARLEY
24/10/2014	Bentinck Dock, PE30 2HB	23	FEED BARLEY
		25	CAN
		4	FEED WHEAT
30/10/2014	Bentinck Dock, PE30 2HB	5	BAG AMMONIUM NITRATE
		25	NPK
		17	WOODCHIP
		23	MALTING BARLEY
06/11/2014	Bentinck Dock, PE30 2HB	5	SBPP
		25	SOYA
		13	-
		4	FEED WHEAT
03/12/2014	[redacted] Coastguard Cottages, Crossbank Road	17	WOODCHIP
		13	SBPP
		17	WOODCHIP
		23	MALTING BARLEY
		12	-
17/12/2014	[redacted] Coastguard Cottages, Crossbank Road	4	SBPP
		23	MILLING WHEAT
		5/4	FEED BARLEY
02/01/2015	[redacted] Coastguard Cottages, Crossbank Road	15	WOODCHIP
		5	MALTING BARLEY
07/01/2015	[redacted] Coastguard Cottages, Crossbank Road	4/5	MAIZE
		4	TIMBER
		23/13	MALT
		15	WOODCHIP
		4	SOYA

Table 7.4 provides the number of loads of each of the different types of cargo processed during complaint periods. Woodchip, in total accounts for 11 of the 50 vessels present during complaint

periods. Woodchip therefore accounts for 22% of the cargo during complaint periods, the next most frequent cargo during complaint periods are Timber, Feed Barley, Feed Wheat and SBPP, each of which accounted for 4 of the 50 vessels during complaint periods, only 8%.

Table 7.4 – Types of Cargo during complaint periods

Cargo	Vessels During Complaint Periods
-	3
BAG AMMONIUM NITRATE	2
CAN	1
DURUM WHEAT	1
FEED BARLEY	4
FEED WHEAT	4
GTSP	1
TIMBER/WOODCHIP	1
MAIZE	1
MALT	1
MALTING BARLEY	3
MILLING WHEAT	2
NCP	1
NPK	1
RAPESEED	3
RDF	1
SBPP	4
SOYA	2
SOYA/RAPESEED	1
TIMBER	3
WOODCHIP	10
Total	**50**

8 Unitary Emissions Modelling

8.1 Model Inputs

To gain an appreciation of how far particulates are likely to travel from a source, unitary emissions modelling has been undertaken using ADMS 5. In the absence of any emission rates for sources at the site the modelling represents only an indication of the likely proportional drop off with distance in PM_{10} from a fugitive area source, i.e. an uncovered pile of loose material. Table 8.1 details the model inputs that were assumed for the source.

Table 8.1 – ADMS 5 Model Input Parameters

	Model Parameter
Source Type	Area
Height (m)	0
Vertical Velocity (m/s)	0.1
Temperature	Ambient
PM_{10} Emission Rate (g/s)	0.1
Area of source (m^2)	4

To account for different meteorological conditions the model was ran using the R91 meteorological file provided with ADMS 5. The R91 meteorological file assumes data equivalent to the seven Pasquill-Gifford atmospheric stability classes A-G[11], as detailed in Table 8.2. This will ensure the model results cover a range of climatic conditions from extremely stable to extremely unstable.

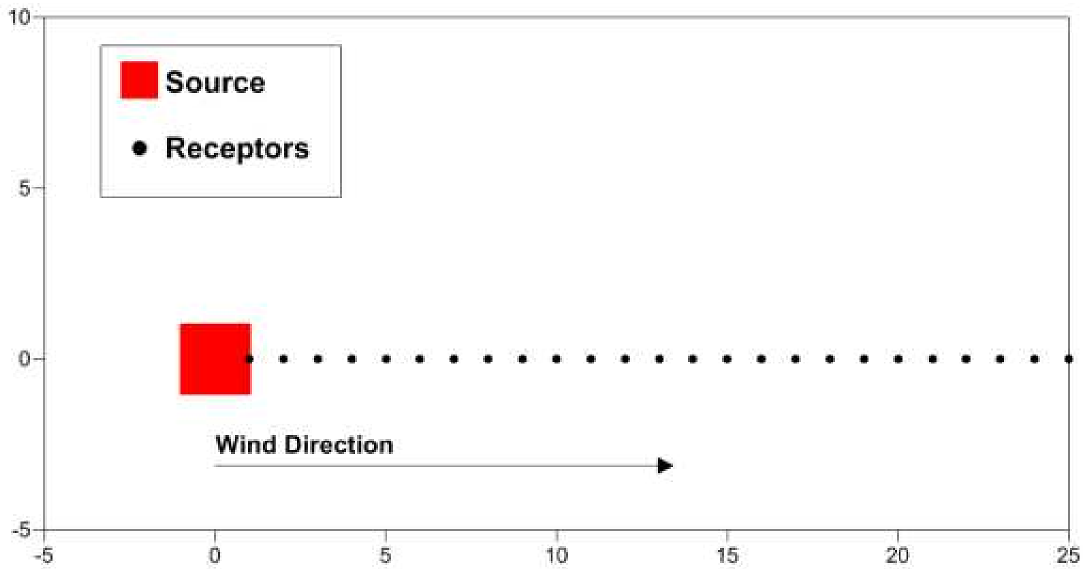
Table 8.2 – Pasquill-Gifford atmospheric stability classes

Stability Class	Description of Conditions
A	Extremely Unstable
B	Moderately Unstable
C	Slightly Unstable
D	Neutral
E	Slightly Stable
F	Moderately Stable
G	Extremely Stable

The wind direction was assumed to be from the west for all stability classes. Receptors were therefore placed to the east of the source at regular intervals so the proportion reduction in concentration could be observed with increasing distance from the source. Receptors were placed up to 1000m from the source, receptors up to 25m from the source are illustrated in Figure 8.1.

[11] A Recommended Pasquill-Gifford Stability Classification Method for Safety Basis Atmospheric Dispersion Modeling at SRS (2012) http://sti.srs.gov/fulltext/SRNL-STI-2012-00055.pdf

Figure 8.1 – Unitary Emissions Modelling setup



Although the model will output a predicted PM_{10} concentration in µg/m^3, due to the assumptions that have been made (size of the source, PM_{10} emission rate and meteorological conditions) the results can only be used to give an indication of the proportional drop of in concentration with distance rather than make a prediction of concentration at a specific receptor location. Results have therefore been expressed as a percentage of the concentration predicted at the source location.

8.2 Modelled Results

Figure 8.2 shows the results of the unitary dispersion modelling for the eight Pasquill-Gifford atmospheric stability classes for receptors from the source up to 1000m away. In order to illustrate the decrease in the percentage with distance the scale on both of the chart axis is shown logarithmically.

As expected the percentage of the concentration decreases more rapidly for meteorological data representing the more unstable conditions, this is most notable for classes A and B. Classes C to G show a lot closer alignment although do show a less rapid reduction in concentration with increased stability. Class D represents neutral conditions and therefore provides moderate conditions for dispersion. The equation of the line of best fit for Class D has been calculated based on a power relationship as follows.

$$y = 712.46x^{-1.582}$$

Where x = Distance from source and y = percentage of concentration at source.

The line of best fit matches the Class D results well from a distance above around 5m from the source. Less than 5m from the source the line of best fit is observed to overestimate the percentage of the concentration.

Figure 8.2 – Logarithmic chart showing reduction in PM_{10} against distance from the source for the eight Pasquill-Gifford atmospheric stability classes

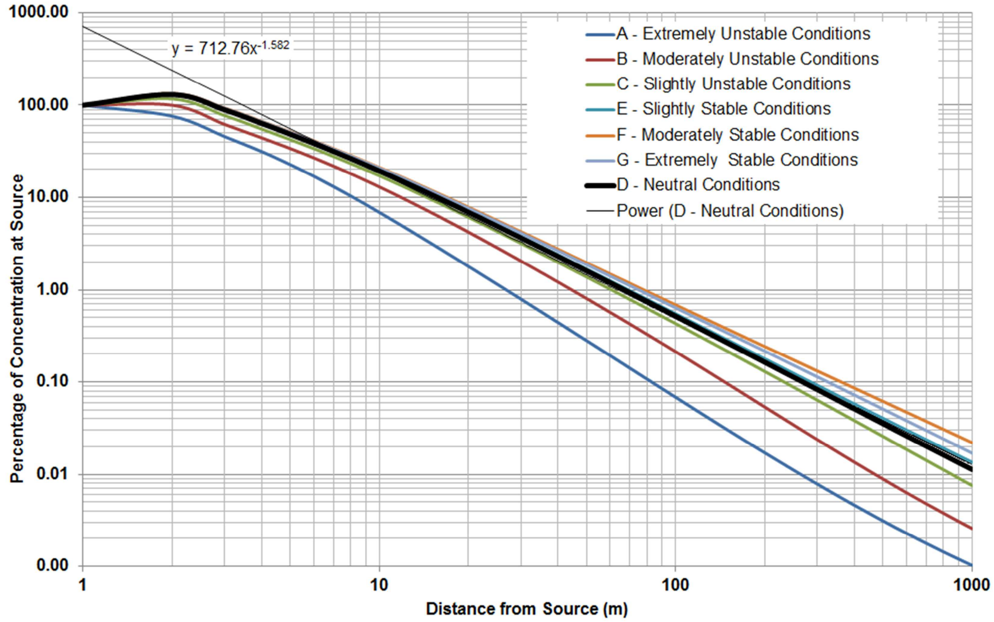
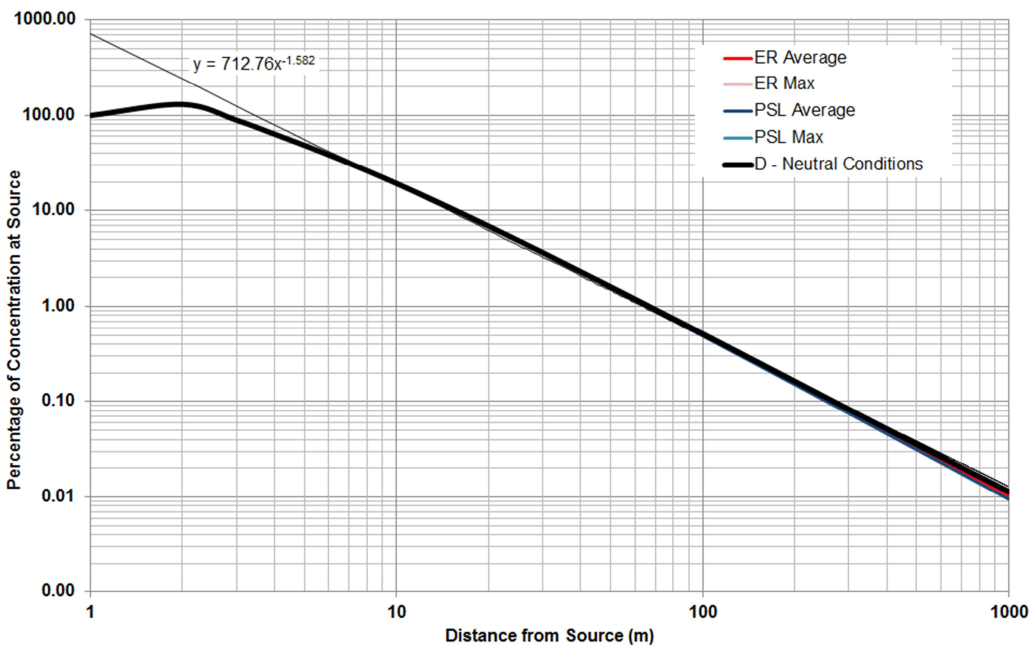


Figure 8.2 shows the results of the unitary dispersion modelling assuming Class D (Neutral Conditions) of the Pasquill-Gifford atmospheric classes but also considering meteorological data from the Page Stair Lane (PSL) and Estuary Road (ER) monitoring locations. Model runs have been undertaken assuming the maximum recorded wind speed at the two monitors and the average recorded wind speed at the two monitors.

Figure 8.3 – Logarithmic chart showing reduction in PM_{10} against distance from the source for Pasquill-Gifford atmospheric stability class D (neutral) and using wind speed data collected from monitoring locations.



As can be seen in Figure 8.3 there is very little difference between the results for Class D (Neutral Conditions) and results assuming wind speed recorded at the local monitors. For the purpose of providing an indication of PM_{10} concentration decrease with distance from the source the Class D conditions have been assumed. Table 8.3 therefore provides a prediction of the percentage of the concentration at the pollutant source at various distances from the source. These have been calculated assuming the trend line equation as shown on Figure 8.2 and Figure 8.3.

The table includes an example assuming a recorded concentration at the source of 50µg/m^3. The modelling does not include any background concentration, for the purpose of this example this has therefore been assumed to be 20µg/m^3. The concentration for the source at the source is therefore 30µg/m^3.

Table 8.3 – Percentage of Concentration at Source of PM_{10}

Distance from Source (m)	Percentage of Concentration at Source	Concentration Example (µg/m^3) (Background concentration assumed to be 20µg/m^3)
0	100.0%	50.0
5	55.9%	36.8
10	18.7%	25.6
20	6.2%	21.9
50	1.5%	20.4
100	0.5%	20.1
200	0.2%	20.0

The percentage of the concentration decreases rapidly with distance; at 50m distance from the source only 1.5% of the concentration at the source would be present. It is worth noting that it is also assumed the wind direction is blowing from source to receptor and so actual wind conditions may reduce this further.

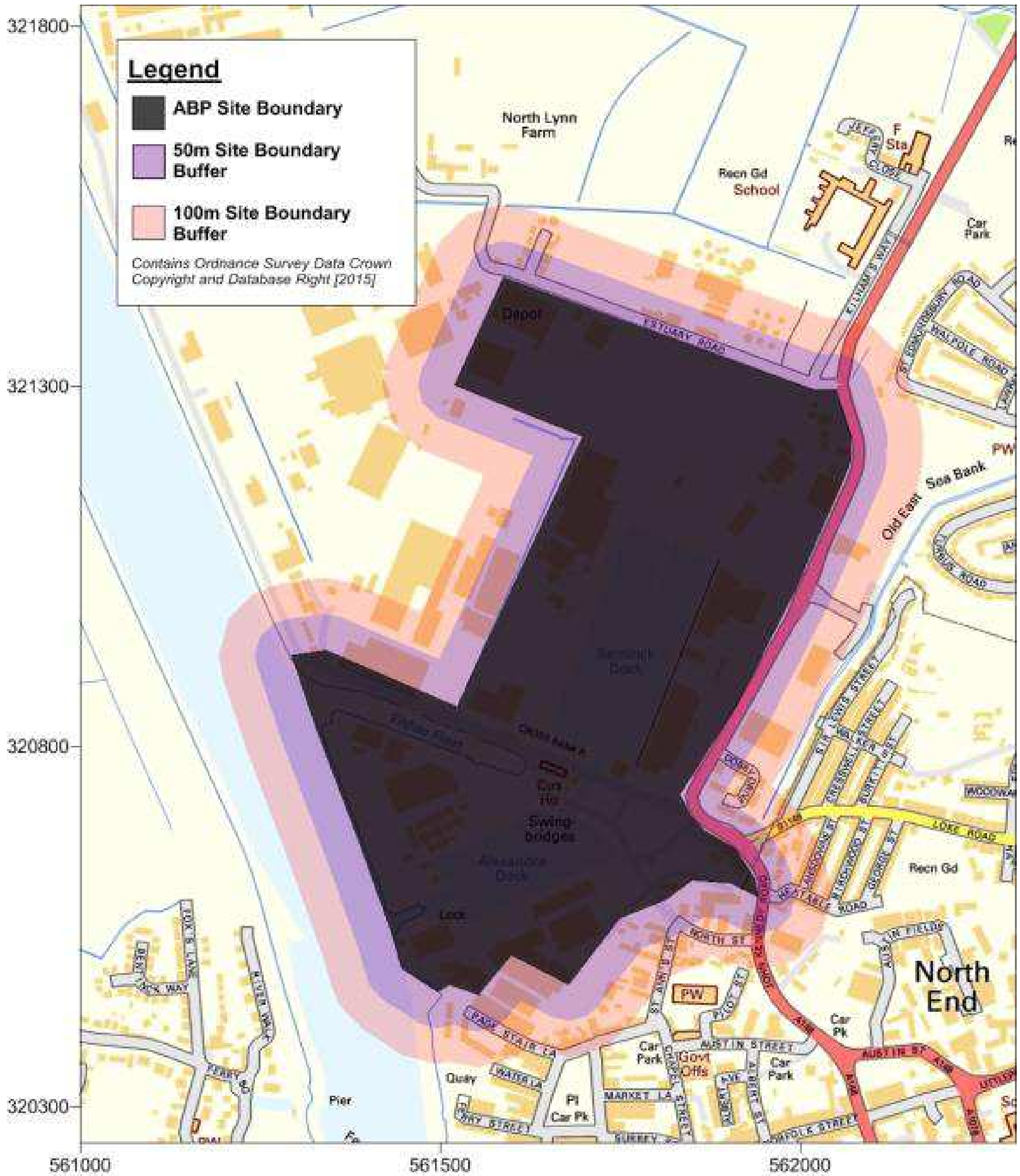
Figure 8.4 shows the site boundary at the docks with buffers at 50m and 100m from the dock area boundary, assuming the results of the modelling the PM_{10} concentration at the extent of these buffers would be expected to be 1.5% and 0.5% of the process contribution concentration at the source respectively.

As can be seen in Figure 8.4 these buffers cover a large number of residential receptors. These receptors are mainly situated on Estuary Road to the North and around the southeast corner of the dock area. Most of the dust producing activities at the docks do not take place around the edge of the site but would be undertaken at the edge of the docks. This increased separation distance would mean that the dust concentrations would hopefully be further depleted before reaching residential receptors.

This separation distance may also explain as to why despite a number of complaints occurring at the docks in relation to dust and particulates the recorded PM_{10} concentrations at the three monitors remain well below the air quality objectives. It is possible if that if monitoring were undertaken within the dock area, such as at the dock side, that significantly higher PM_{10} concentrations would be recorded.

Should concentrations within the dock area be above the 40µg/m^3 annual mean PM_{10} AQO due to operations at the docks and new relevant exposure be introduced (e.g. a new residential development), this may necessitate the declaration of an AQMA and the development of an associated AQAP.

Figure 8.4 – ABP site boundary showing 50m and 100m buffers



9 Best Practice Particulate Suppression Measures at Ports

The controlling of dust/PM_{10} emitting activities at ports can be regulated by a number of different means, dependant as to what receptors are being affected and the activities being undertaken. This section outlines a number of documents which provide advice on dust/PM_{10} suppression measures or examples of dust suppression techniques at other ports.

9.1 A quick guide to health and safety in ports (The Health and Safety Executive)

The Health and Safety Executive has produced "A quick guide to health and safety in ports"[12] which details the following in relation to dusty cargoes:

Typical cargoes in UK ports include grain, soya, animal foodstuffs, fishmeal, ores, coal and coke, cement, biomass, superphosphate and other fertilisers.

Typical risks from dusty cargoes

During handling these can give off large quantities of dust. In some cases, eg coal and aggregates, the dust is simply small particles of the material itself. In other cases, eg grains and pulses, the dust may include contaminants such as bacteria and fungi.

Different dusts have different effects on health, but the most important effects of dusty cargoes are on the lungs. The chronic effects are often permanent and disabling.

How you can reduce the risks from dusty cargoes

Where possible, you should prevent a person's exposure to hazardous dust. If it is not possible to prevent exposure, you should adequately control their exposure to the dust. Some ways to control exposure include:

- *restrict staff entry to dusty areas;*
- *use totally enclosed, continuous handling systems – these usually provide the best control and should be used whenever reasonably practicable;*
- *suppress dust with sprays of water or other binding agents;*
- *ensure all equipment used to reduce dust exposure is properly maintained;*
- *design tasks to reduce the amount of dust generated;*
- *provide suitable dust-filtration systems to the cabs of all new loading shovels used to handle dusty cargoes;*
- *provide respiratory protective equipment (RPE) – this should be suitable for its purpose, maintained and compatible with other protective equipment worn; and*
- *where appropriate, provide health surveillance for workers.*

Which laws apply?

Control of Substances Hazardous to Health Regulations 2002 (COSHH)

[12] Health and Safety Executive - A quick guide to health and safety in ports - http://www.hse.gov.uk/pubns/indg446.pdf

The "quick guide to health and safety in ports" provides guidance on dust suppression techniques relative to health and safety, although does not provide any sort of compliance regime to be adhered to.

9.2 Guidance on the assessment of dust from demolition and construction (IAQM)

In addition to being a health and safety concern, fugitive particulates can also be an annoyance due to dust soiling on property. The Institute of Air Quality Management (IAQM) has produced the Guidance on the assessment of dust from demolition and construction (2014)[13]. The guidance, although designed for use on construction sites, provides detailed list of mitigation measure to aid fugitive dust management. Some of these measures are specific to construction sites and so will not be relevant to port activities; however some measures would provide practical dust suppression techniques which could be applied at ports. Such measures include:

- With respect to communications:
    - Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.
    - Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.
    - Develop and implement a Dust Management Plan (DMP), which may include measures to control other emissions, approved by the Local Authority. The level of detail will depend on the risk, and should include as a minimum the highly recommended measures in this document. The desirable measures should be included as appropriate for the site. The DMP may include monitoring of dust deposition, dust flux, real time PM_{10} continuous monitoring and/or visual inspections.
- With respect to site management:
    - Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.
    - Make the complaints log available to the local authority when asked.
    - Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.
- With respect to monitoring:
    - Carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the local authority when asked.
    - Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.
- With respect to preparing and maintaining the site:
    - Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site.

[13] IAQM - Guidance on the assessment of dust from demolition and construction (2014)

- Fully enclose site or specific operations where there is a high potential for dust production and the site is actives for an extensive period.
- Avoid site runoff of water or mud.
- Keep site fencing, barriers and scaffolding clean using wet methods.
- Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below.
- Cover, seed or fence stockpiles to prevent wind whipping.

▪ With respect to operating vehicle/machinery:

- Ensure all vehicles switch off engines when stationary - no idling vehicles.
- Impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate).

▪ With respect to operations:

- Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.
- Use enclosed chutes and conveyors and covered skips.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.
- Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.

▪ With respect to waste management

- Avoid bonfires and burning of waste materials.

▪ With respect to construction materials

- Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.
- Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.
- For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust.

9.3 Port of Immingham – Master Plan 2010 – 2030 (Associated British Ports)

The Port of Immingham is the UK's largest port in terms of tonnage handled, benefiting from its prime deep-water location on the River Humber, the UK's busiest trading estuary. In July 2007, during the process of reviewing national ports policy, the Government recommended that the major UK ports produce master plans, and consult on them, to help coordinate future planning. Subsequent master plan guidance published in 2008 by the Department for Transport (DfT) indicated that such plans should be produced by major ports (defined as those handling at least 1 million tonnes) to:

- Clarify their strategic plans for the medium to long-term;
- Assist local and regional planning bodies and transport network providers in preparing and revising their development strategies; and
- Inform port users, employees and local communities of expected development over the coming years.

In September 2012 ABP therefore published the Port of Immingham Master Plan 2010 – 2030[14]. The plan was prepared with the following key goals in mind:

- The need to continue to attract investment and create jobs;
- The need to promote environmental and economic sustainability; and
- The need to support the community that depends on the Port.

The plan features a section on air quality from paragraphs 9.52 to 9.63. In reference to managing air quality at the port the plan details measures split between physical tools and management tools. Physical tools detailed in the plan include the following:

- Water suppression – it has long been recognised that the spraying of water can prevent dust becoming airborne, both by making the cargo wetter and by placing water cannons 'downwind' of bulk handling operations so that the water droplets capture dust particles. In its most basic form, water suppression takes the form of a spray set up on the quayside;
- Advanced water suppression systems – this more targeted approach includes special spray bars mounted on hoppers and conveyors, a computer-controlled rain cannon system, spray bars on terminal boundaries and mobile water tankers spraying water around and on stockpiles;
- Wheelwashes – located at the exits of all terminals and areas containing permitted processes, these use sprays to wash the wheels of lorries exiting the site;
- Road sweepers – a fleet of mechanical sweepers is used to keep roads and quays clean by wet brush sweeping. Dust deposited on roads can be re-suspended by passing traffic: wet sweeping removes this source of dust emission;
- Physical barriers – these are located around terminals and include measures such as netting, earth bunds and steel cladding;
- Dust monitors – a number of PM_{10} dust monitors are located around the Port to evaluate on-going trends and specific incidents;
- Mechanical efficiencies – at Humber International Terminal for example, conveyor systems, two cargo stacking/reclaiming pieces of plant and two automatic rail-loading bunkers are used to increase the speed of cargo handling while reducing its environmental implications: and
- Polymer crusting – some of the bulk handlers on the estate use spray polymer coatings on their stockpiles which dry to form an impermeable crust.

With regard to management tools the following are detailed:

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[14] Associated British Ports – Port of Immingham : Master Plan 2010 – 2030 (2012).

- Encouraging and sharing good practice among the Port community, such as working bulk stockpiles on the leeward side of the wind, limiting the heights of stockpiles to levels that allow water suppression and distributing weather forecasts (including predicted wind strengths and directions);
- Working closely with regulators;
- Collaborating with North East Lincolnshire Council on its Air Quality Action Plan;
- Quarterly Environmental Forum meetings with regulatory authorities and port users; and
- Constant on-going review of the operational impact of bulk cargoes. Under extreme circumstances, when it appears there really is no way to effectively manage dust emissions to air, ABP will refuse permission to bring cargo into the Port.

In addition to operational measures to reduce air quality/dust impacts the master plan also details a community engagement project undertaken by ABP employees with a local primary school. The project involved planting the first batch of what will become the biggest tree planting exercise in the history of the Port. Each child planted two tree saplings along a purpose built bund, which will grow into a foliage screen which will benefit both the Port and the town of Immingham. The trees will improve the visual impact of the area and will also help with dust suppression.

9.4 Other Information Sources

The following is a list of potentially useful links/case studies found when researching information relating to dust suppression in relation to ports. The list is not limited to examples in the UK and so legislation governing some of the examples may differ from those governing the docks at King's Lynn.

- Careful Costing Key to Effective Dust Control – Port Strategy (June 2005). http://www.portstrategy.com/news101/port-operations/cargo-handling/careful_costing_key_to_effective_dust_control
- European Sea Port Organisation (ESPO) and Ecoports – Top Environmental Priorities of European Ports for 2013. http://www.ecoports.com/templates/frontend/blue/images/pdf/Analysis_of_top_environmental_priorities_2013.pdf
- ESPO Green Guide: Towards Excellence in port environmental management and sustainability (2012). http://www.ecoports.com/templates/frontend/blue/images/pdf/espo_green%20guide_october%202012_final.pdf
- Port Technology: Tried and tested systems to control fugitive dust (Edition 47). https://www.porttechnology.org/journal_archive/edition_47/
- SR 520 Evergreen Point Floating Bridge and Landings Project - Fugitive Dust Prevention and Control Plan, prepared for Washington State Department of Transportation (2012). http://www.wsdot.wa.gov/NR/rdonlyres/34D9BCF6-3417-4C8C-8B89-977AFABBE95F/0/FBL_FugitiveDust.pdf
- Guttridge Bulk Materials Handling - Case study: Installation of dust suppression equipment at a port loading facility. https://www.guttridge.com/eu/en/dsh-case-study

- Managing and monitoring fugitive dust emissions – GreenPort (June 2009). http://www.greenport.com/news101/Regulation-and-Policy/managing-and-monitoring-fugitive-dust-emissions

10 Conclusions

10.1 Conclusions relating LAQM and AQS Objectives

Analysis of the data provided in section 3.2 reveals that both the annual mean and 24-hour mean AQS objectives for PM_{10} have not been breached at any of the three monitoring sites (North Lynn, Estuary Road and Page Stair Lane) since 2011. Annual mean PM_{10} concentrations have shown a decreasing trend each year at all three monitoring sites. Annual mean PM_{10} concentrations in 2014 at all three monitoring locations were less than half the 40µg/m^3 AQS objective. The number of exceedences of the 50µg/m^3 24-hour mean AQS objective has remained below the 35 allowed exceedences at all three monitoring locations since 2012. Of the three monitoring locations the most exceedences of the 50µg/m^3 24-hour mean AQS objective recorded each year were at Page Stair Lane, which recorded 16, 6 and 7 exceedences in years 2012, 2013 and 2014 respectively.

The monitoring locations represent likely PM_{10} exposure at the periphery of the docks where residential receptors are located. Guidance from the UK Government and Devolved Administrations makes clear that exceedences of the health based objectives should be assessed at outdoor locations where members of the general public are regularly present over the averaging time of the objective. LAQM TG(09) provides examples of where the AQS objectives should apply.

Following the descriptions in LAQM TG(09) it is considered that both the annual mean and 24-hour mean objectives apply at residential receptors at the periphery of the docks. Several of the complaints detailed in section 5 are from a business located on the docks. This business is far closer to areas of particulate producing activities than the residential receptors at the periphery of the docks. It is possible that were particulate monitoring undertaken at these business locations that breaches of the annual mean or 24-hour mean AQS objectives would occur. However, as per the descriptions in LAQM TG(09) it is not considered that either the annual or 24-hour mean AQS objectives apply at these commercial locations.

It is likely that in some areas of the docks exceedences of the 24-hour mean AQS objectives will occur. Should exceedences occur and new relevant exposure be introduced (e.g. a new residential development), this may necessitate the declaration of an AQMA and the development of an associated AQAP.

As PM_{10} concentrations have been shown to be below the AQS objective for both the annual and 24-hour means at the three monitoring locations around the dock periphery for 2012, 2013 and 2014, it is not considered necessary to declare an AQMA in relation to PM_{10}.

10.2 Conclusions relating to Meteorological and Pollutant Monitoring Data

In addition to collecting PM_{10} concentration data, the Osiris monitors at Page Stair Lane and Estuary Road also collected meteorological data, specifically wind speed and direction. As shown in Figure 3.6 and Figure 3.7, the meteorological data at Estuary Road does not correlate to that collected at Page Stair Lane, despite the two sites being located only 1.0km apart. In addition to the wind direction at the two sites not showing a correlation, wind speeds at the two sites do not correlate either. Wind speeds are greater than 2m/s for a far greater proportion of time at Estuary Road than at Page Stair Lane.

Meteorological data from both sites was compared against 2011 meteorological data collected at the Marham meteorological station located approximately 16km to the southeast of the docks. The prevailing wind direction at Page Stair Lane, from the southwest, was found to be similar to that recorded at Marham. It was therefore concluded that meteorological data recorded at Page Stair Lane was likely to be more representative of prevailing conditions at the docks than that recorded at Estuary Road.

Figure 3.11 to Figure 3.16 provide pollutant roses utilising PM_{10} concentration data in combination with meteorological data. The pollutant roses support the assumption that a significant portion of elevated PM_{10} concentrations at the monitoring locations emanate from the direction of the docks.

However, a portion of elevated PM_{10} concentrations are also observed to emanate from the north of the Estuary Road and North Lynn sites. The area to the immediate east and north of the North Lynn monitor is residential although further to the north east is the North Lynn Industrial Estate. The North Lynn Industrial Estate includes a range of industries from Network Waste Solutions - Waste Management Services to Bush Tyres - Tyre Shop which may emit PM_{10} as a consequence of site activities.

10.3 Conclusions relating to Vessel Data and Pollutant Monitoring Data

Section 7.1 attempts to establish if there is a relationship between the recorded PM_{10} concentration at the three monitoring sites and the vessel logs recorded at the docks. Although it is accepted that stockpiles of materials remain onsite after vessels have departed it has been assumed that the most substantial movement of materials would occur when loading and discharging the vessels. The recorded PM_{10} concentrations during periods which vessels are in the dock area have therefore been compared to periods when there are no vessels in the docks to try to establish a link between vessels being present and elevated PM_{10} concentrations.

Table 7.2 shows that apart from at PM_{10} concentrations recorded at Page Stair Lane in 2011 and Estuary Road in 2013, the PM_{10} concentration was higher during periods that vessels were present in the docks than when no vessel were present in the docks. This is most notable at the North Lynn monitor in 2013 when the PM_{10} concentration was 2.4µg/m^3 higher when vessels were present in the docks.

This supports the assumption that vessel activities at the docks can effect PM_{10} concentrations at the three monitoring locations.

10.4 Conclusions relating to Vessel Data and Complaints Logs

As shown in section 7.2 there is a correlation between complaints periods and processing of woodchip loads at the docks. In addition to the complaints themselves referencing woodchip to be a dust issue, the complaints detail mitigation measures which may be available, but are not always utilised. The complaints also name a specific problem operator within the dock area.

As discussed above it is not possible to regulate activities at the docks by declaring an AQMA through the LAQM regime. It is therefore considered that the most appropriate way for the Council to take action against any problem operator at the docks is to gather evidence relating to a case of statutory nuisance. Statutory nuisance works on the basis that a significant adverse impact on a resident/community of business results in those affected having to adjust their normal behaviour pattern when nuisance arises, which may result in removal of amenity (i.e. use of the area), or may stop them from enjoying the use (where use in itself continues).

The council are now aware that the operator which was processing woodchip at the docks is no longer operating at the docks, it is therefore hoped complaints will cease.

It is not known if ABP provides operators at the docks with any guidance as to best practice measures for suppression of particulates, or if any regime is in place should operators not comply. The complaints allude to dust mitigating equipment being available to operators but not always being utilised.

It may therefore be beneficial for an air quality/dust management plan to be developed covering the docks with a section detailing how potentially dusty cargoes should be loaded/unloaded. Operators could then be bound to adhere to the air quality/dust management plan as part of their agreement to operate at the docks.

10.5 Conclusions relating to Site Visit

A visit to King's Lynn docks was undertaken on the 21st July 2015 in order to gain context for the layout of the docks and witness activities being undertaken on a typical day as detailed in section 6.

Recorded monitoring data for the period of the site visit showed good agreement between the monitoring locations at the periphery of the docks with all three monitoring sites recording an hourly average between 21µg/m^3 to 23µg/m^3. The following observations were noted during the site visit.

- Council employee present on the site visit noted that in previous years' operators discharging and loading at berth numbers 4 and 5 had caused complaints by residents on Page Stair Lane
- Large Piles of uncovered loose material were present at various points around the dock area. Wind whip of these piles was observed.
- Uncovered material being stored to the north of the site in bunded storage areas exceeds the amount the bunds were designed to contain. This is evidenced by material being significantly higher than the bunds and causing the bunds to rupture in places.

10.6 Conclusions relating to Unitary Emissions Modelling

To gain an appreciation of how far particulates are likely to travel from a source, unitary emissions modelling has been undertaken using ADMS 5 as detailed in section 8. To account for different meteorological conditions the model was ran assuming data equivalent to the seven Pasquill-Gifford atmospheric stability classes.

As expected the percentage of the particulate concentration was shown to decreases more rapidly for meteorological data representing the more unstable conditions, than conditions with increased stability. A power relationship was calculated for neutral meteorological conditions as follows:

$$y = 712.46x^{-1.582}$$

Where x = Distance from source and y = percentage of concentration at source.

The percentage of the concentration decreases rapidly with distance; at 50m distance from the source only 1.5% of the concentration at the source would be present. It is worth noting that it is also assumed the wind direction is blowing from source to receptor and so actual wind conditions may reduce this further.

As can be seen in Figure 8.4 a large number of residential receptors are located within 50m of the docks boundary. These receptors are mainly situated on Estuary Road to the North and around the southeast corner of the dock area. Most of the dust producing activities at the docks does not take place around the edge of the site but would be undertaken at the edge of the docks. This increased separation distance would mean that the dust concentrations would hopefully be further depleted before reaching residential receptors.

This separation distance may also explain as to why despite a number of complaints occurring at the docks themselves, in relation to dust and particulates, the recorded PM_{10} concentrations at the three monitors remain well below the AQS objectives. It is possible if that if monitoring were undertaken within the dock area, such as at the dock side, that noticeably higher PM_{10} concentrations would be recorded.

The results of the unitary emissions modelling align with the particulate monitoring at the periphery of the docks. It appears that residential receptors are sufficiently far enough away from the particulate emitting activities on site that they are not significantly affected by them.

The modelling therefore supports the conclusion that it is not considered necessary to declare an AQMA, in relation to PM_{10} covering the dock area. However, as it is likely that in some areas of the docks exceedences of PM_{10} AQS objectives will occur, if new relevant exposure were to be introduced (e.g. a new residential development), this may necessitate the declaration of an AQMA and the development of an associated AQAP.

11 Recommendations

Following the conclusions reached in section 10 the following recommendations are provided to the council as outcomes of this study:

- As PM_{10} concentrations have been shown to be below the AQS objective for both the annual and 24-hour means at three locations around the dock periphery for 2012, 2013 and 2014, it is not considered necessary to declare an AQMA;

- Any new developments in or close to the dock areas should give consideration to Measure 1 of the Council's Air Quality Action Plan (AQAP)[15] which states that: *"Consideration of Air Quality Impacts when providing comments on planning applications within an AQMA or where an AQMA could be impacted or created."* This is particularly pertinent as whilst this study does not recommend the declaration of an AQMA at the docks presently, this conclusion could be changed should sensitive receptors be introduced at the dock area in future; and

- Analysis of the complaints and shipping data support the assumption that the processing of woodchip at the docks resulted in complaints. Although it is understood that the operator is now no longer present at the docks, should complaints occur again from receptors within the dock area, these are best dealt with by building a case for statutory nuisance. If a statutory nuisance case is established it may be necessary for an air quality/dust management plan to be developed in collaboration with ABP.

[15] Borough Council of King's Lynn and West Norfolk – Air Quality Action Plan – Making King's Lynn a cleaner, more environmentally friendly place to live, work and visit. – 2015

Appendices

Appendix 1 – Background to Air Quality

Particulate Matter (PM_{10})

Particulate matter is a mixture of solid and liquid particles suspended in the air. There are a number of ways in which airborne PM may be categorised. The most widely used categorisation is based on the size of particles such as $PM_{2.5}$, particles of aerodynamic diameter less than 2.5µm (micrometre = 10^{-6} metre), and PM_{10}, particles of aerodynamic diameter less than 10µm. Generically, particulate residing in low altitude air is referred to as Total Suspended Particulate (TSP) and comprises coarse and fine material including dust.

Particulate matter comprises a wide range of materials arising from a variety of sources. Examples of anthropogenic sources are carbon (C) particles from incomplete combustion, bonfire ash, recondensed metallic vapours and secondary particles (or aerosols) formed by chemical reactions in the atmosphere. As well as being emitted directly from combustion sources, man-made particles can arise from mining, quarrying, demolition and construction operations, from brake and tyre wear in motor vehicles and from road dust resuspension from moving traffic or strong winds. Natural sources of PM include wind-blown sand and dust, forest fires, sea salt and biological particles such as pollen and fungal spores.

The health impacts from PM depend upon size and chemical composition of the particles. For the purposes of the AQS objectives, PM_{10} or $PM_{2.5}$ is solely defined on size rather than chemical composition. This enables a uniform method of measurement and comparison. The short and long-term exposure to PM has been associated with increased risk of lung and heart diseases. PM may also carry surface-absorbed carcinogenic compounds. Smaller PM have a greater likelihood of penetrating the respiratory tract and reaching the lung to blood interface and causing the above adverse health effects.

In the UK, emissions of PM_{10} have declined significantly since 1980, and were estimated to be 114kt (kilotonne) in 2010[16]. Residential / public electricity and heat production and road transport are the largest sources of PM_{10} emissions. The road transport sector contributed 22% (25kt) of PM_{10} emissions in 2010. The main source within road transport is brake and tyre wear.

It is important to note that these estimates only refer to primary emissions, that is, the emissions directly resulting from sources and processes and do not include secondary particles. These secondary particles, which result from the interaction of various gaseous components in the air such as ammonia (NH_3), sulphur dioxide (SO_2) and NO_x, can come from further a field and impact on the air quality in the UK and vice versa.

Similarly to PM_{10}, emissions of $PM_{2.5}$ have declined since 1970, and were estimated to be 67kt in 2010, which makes over 58% of PM_{10} emissions. In 2010, the road transport sector emitted 28% (18kt) of the total $PM_{2.5}$ emissions in the UK.

[16] National Atmospheric Emissions Inventory (NAEI) Summary Emission Estimate Datasets 2010. March 2012

Appendix 2 – Vessel Data

Table A1 – Yearly Cargo Type expressed as tonnage

Cargo Type	Number of Vessels				
	2011	2013[a]	2014	2015[b]	Total
Vessel Without Cargo Stated	-	-	-	-	-
Scrap Metal	35,090	8,975	-	-	44,065
Ammonium Nitrate in Bags (Fertiliser)	25,324	13,927	14,164	3,306	56,721
Ammonium Sulphate (Fertiliser)	8,394	5,483	7,026	-	20,904
Calcined Magnesite (Livestock Feed)	800	2,000	2,200	-	5,000
Calcium Ammonium Nitrate (Fertiliser)	2,989	4,223	5,489	-	12,702
RDF(Fertiliser)	-	-	8,750	-	8,750
Durum Wheat	-	2,197	-	-	2,197
Feed Barley	31,944	32,452	39,419	-	103,815
Feed Beans	8,700	1,171	1,516	-	11,387
Feed Peas	-	5,420	-	-	5,420
Feed Wheat	40,819	25,194	39,020	4,882	109,915
Granulated Asphalt	7,976	2,500	-	-	10,475
Green Peas	-	1,171	2,773	3,894	7,838
Granulated Triple Super Phosphate (Fertiliser)	2,554	3,537	3,986	1,126	11,203
Hardboard	-	324	-	-	324
Plywood	1,803	1,894	1,469	759	5,924
Laminated Lumber	11,778	7,652	13,874	759	34,063
HC Beans	8,260	-	-	-	8,260
Lightweight Aggregate	16,487	8,950	16,995	-	42,431
Linseed	-	-	1,122	-	1,122
Maize	15,159	9,727	19,813	3,980	48,679
Malt	-	-	-	5,628	5,628
Malting Barley	32,691	14,561	23,088	3,161	73,501
Milling Wheat	63,760	40,913	31,593	1,622	137,888
Monopile	-	-	80	-	80
Natural Calcium Phosphate (Fertiliser)	7,076	3,040	6,674	-	16,790
NPK (Fertiliser)	4,436	2,839	6,613	-	13,888
Oats	-	-	2,520	-	2,520
PDV Salts	-	-	2,468	-	2,468
Potash	10,747	11,011	10,197	1,309	33,265
PROJECT (TANKS)	142	-	-	-	142
Rapeseed	123,638	57,370	64,013	2,729	247,750
RDF (Refuse-derived fuel)	6,603	6,357	7,010	-	19,970
SBPP（Sugar Beet Pulp Pellets)	3,689	15,356	25,809	6,491	51,345
Soya	16,763	2,001	31,176	3,501	53,441
Timber	62,982	33,586	41,665	2,629	140,862
TSP (Cleaner)	2,214	-	-	-	2,214
UREA (Fertiliser)	5,780	2,113	-	-	7,893
Woodchip	14,155	18,311	49,193	6,691	88,351

[a] 2013 figures cover period from 04/01/2013 to 07/10/2013
[b] 2015 figures cover period from 01/01/2015 to 20/02/2015

Appendix 3 – Site Visit Photographs

Figure A1 – Pags Stair Lane facing south-west

Figure A2 – Page Stair Lane facing south east

Figure A3 – River Great Ouse near Page Stair Lane facing north

Figure A4 – At the southwest corner of Alexandra Dock facing north

Figure A5 – At southeast corner of Alexandra Dock facing north

Figure A6 – At southeast corner of Alexandra Dock facing south

Figure A7 – At eastern extent of Alexandra Dock facing east

Figure A8 – At Cross Banks Road near Bentinck Dock facing north

Figure A9 – On the western side of Bentinck Dock facing east

Figure A10 – On the western side of Bentinck Dock facing south

Figure A11 – North of Bentinck Dock facing northeast Bentinck Dock towards piles of loose material

Figure A12 – Piles of loose material, northwest of Bentinck Dock

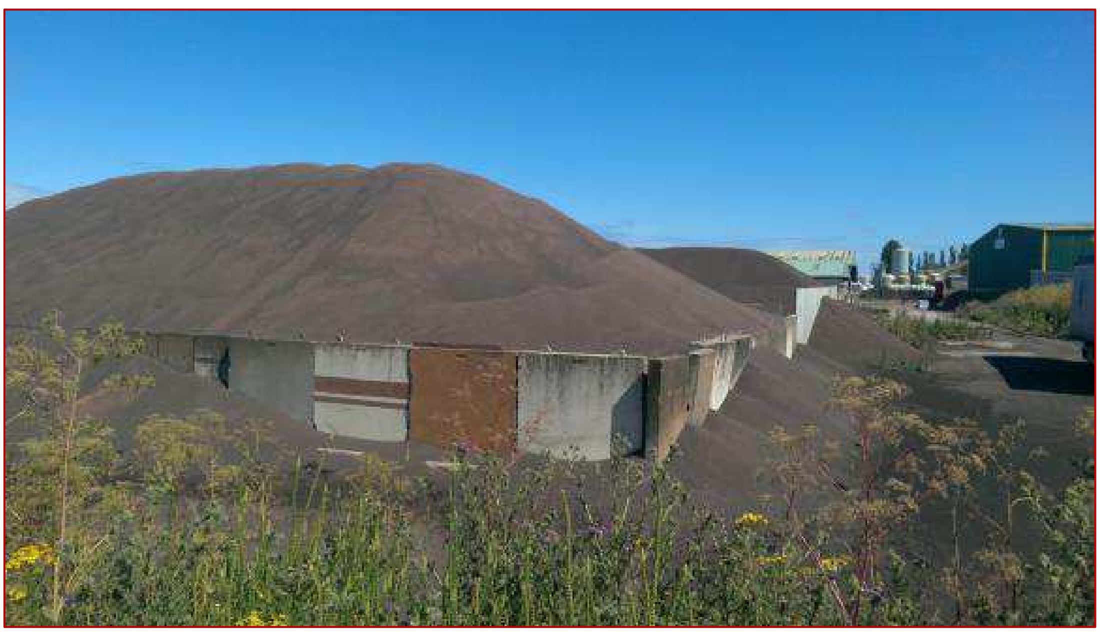

Figure A13 – Dust suppression equipment in the northwest corner of the dock area

Figure A14 – Estuary Road at the northwest corner of the site facing west

Figure A15 – Edward Benefer Way at northeast corner of the dock area facing west

Figure A16 – Edward Benefer Way facing east away from the dock area