# AIR QUALITY

# Ship emissions study

## Proposed Richards Bay Harbour Expansion

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| Issue/revision | First submission |
| Job number | 12/023 |
| Date | June 2014 |
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# 1. INTRODUCTION

Kijani Green Energy (Pty) Ltd (Kijani) was approached by Aecom (Pty) Ltd to provide specialist air quality input into the Environmental Impact Assessment (EIA) of the proposed expansion of the terminals at the Port of Richards Bay, KwaZulu-Natal.

Kijani is a specialist air quality consultancy with extensive experience in the provision of specialist input into mining related EIAs in South Africa. All relevant staff are fully trained in all aspects of air quality analysis and modelling and are competent to undertake such work in a professional and timely manner. Kijani works under the auspices of Aecom in this matter.

Furthermore, Kijani hereby declares their independence on this matter, in keeping with the requirements of specialist professionals as outlined by the National Environmental Management Act (NEMA), 107 of 1998.

# 2. METHODOLOGY AND ASSUMPTIONS

A baseline study in which dust and the current environmental status quo as pertains to air quality was conducted in March 2013. This report should be read in conjunction with that one. A potential emissions source that was identified in that study was the pollution that could be expected to be added to the Richards Bay airshed by the increase in shipping that would result from the harbour expansion. This report tackles that aspect of this development.

Emissions to air from ships engines include a wide range of substances typically associated with the burning of fuel. This study focusses on the three most common, namely nitrogen dioxide, particulates and sulphur dioxide ($SO_2$).

## 2.1 Meteorological data

Following discussions with the South African Weather Services (SAWS), the nearest available hourly sequential dataset was identified as being that of Richards Bay Airport for the year 2011. This is considered to be a reasonable proxy for the region’s climate.

### 2.2 Pollutants

Emissions for shipping are typically considered to me made up of five key pollutants: $NO_x$, $SO_2$, unburned hydrocarbons, particulate matter and $CO_2$. Emissions vary by engine type, size of vessel and activity (at sea (or cruising), in port (includes time spent hoteling, loading and unloading) and manoeuvring).

Irrespective of ship category (container, passenger ferry etc.), the installed engine type on board a ship and the fuel used largely dictates the ship's emission. For the purposes of this study, all ships were assumed to be dry bulk carriers with diesel engines and emission factors for 'in port' and 'manoeuvring' activities were considered (Entec, 2002).

## 3. PROJECT DESCRIPTION

### 3.1 Overview

In terms of increased ship capacity, the proposed expansion programme of the Port of Richards Bay entails the following:

- Construction of 2 new Panamax shipping berths at the 600 series berths, with associated dredging of a channel to a depth of 14m and 800m turning circle;
- Extension of the Finger Jetty (800 series berths) with 2 new Capesize Coal shipping berths.

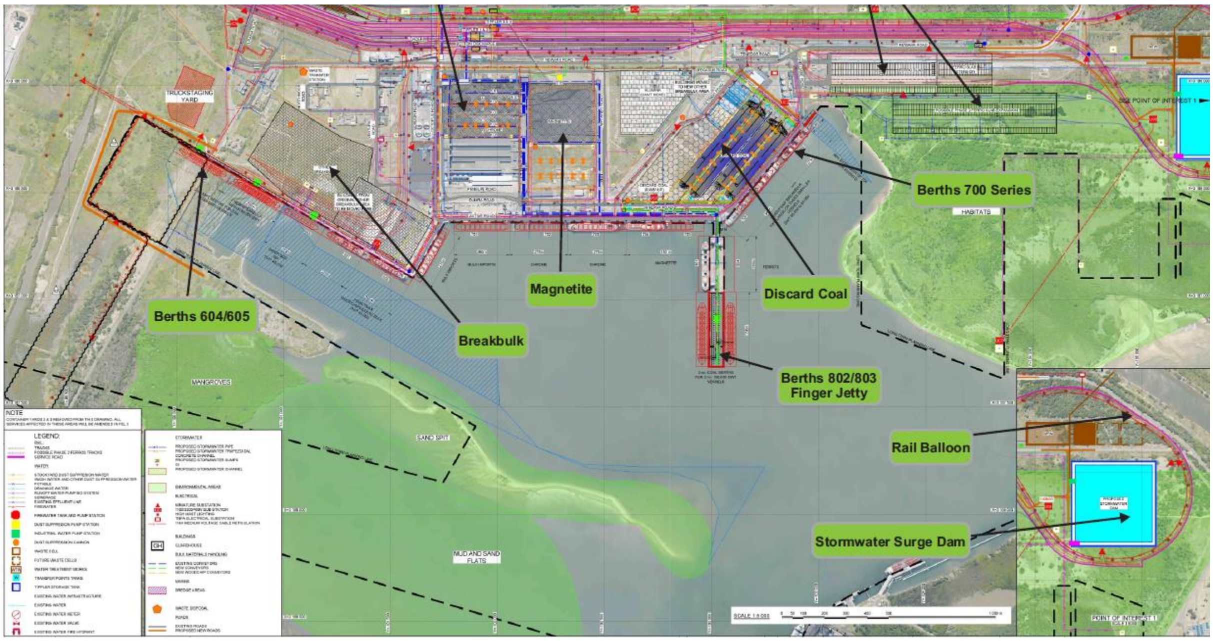


Figure 1: Proposed new berths: 604/605 in the east and 802/803 on the extended finger jetty.

## 3.2 Legislative framework

The project is situated on the hot, wet and humid KwaZulu-Natal coast, in the uThungulu district municipality and the uMhlathuze local municipality. The harbour is situated ona large lagoon at the mouth of the Umhlatuze River into the Indian Ocean. The town of Richards Bay has built up around the harbour which is a large bulk terminal, providing services to both solid and liquid bulk carriers.

The National Ambient Air Quality Standards were published in *The Government Gazette*, Vol 534, 24 December 2009. Proposed guidelines for $PM_{10}$ and $SO_2$ are outlined below:

Table 1: National ambient air quality standards for sulphur dioxide ($SO_2$)

| Averaging period | Concentration | Frequency of exceedence | Compliance date |
|---|---|---|---|
| 10 minutes | 500 µg/m$^3$ | 526 | Immediate |
| 1 hour | 350 µg/m$^3$ | 88 | Immediate |
| 24 hours | 125 µg/m$^3$ | 4 | Immediate |
| 1 year | 50 µg/m$^3$ | 0 | Immediate |
| The reference method for analysis of sulphur dioxide shall be ISO 6767 | | | |

Table 2: National ambient air quality standards for nitrogen dioxide ($NO_2$)

| Averaging period | Concentration | Frequency of exceedence | Compliance date |
|---|---|---|---|
| 1 hour | 200 µg/m$^3$ | 88 | Immediate |
| 1 year | 40 µg/m$^3$ | 0 | Immediate |
| The reference method for analysis of nitrogen dioxide shall be ISO 7996 | | | |

Table 3: National ambient air quality standards for particulate matter ($PM_{10}$)

| Averaging period | Concentration | Frequency of exceedence | Compliance date |
|---|---|---|---|
| 24 hours | 120 µg/m$^3$ | 4 | Immediate |
| 24 hours | 75 µg/m$^3$ | 4 | 1 January 2015 |
| 1 year | 50 µg/m$^3$ | 0 | Immediate |
| 1 year | 40 µg/m$^3$ | 0 | 1 January 2015 |
| The reference method for analysis of nitrogen dioxide shall be ISO 7996 | | | |

### 3.2.1 Air emissions licence

The port has a valid Air Emissions Licence (AEL) number UDM/11-12/AEL0005/1 in the name of Transnet Port Terminal, valid until 21 March 2017. The requirement for an AEL is triggered by listed activity number 14, Category 5, sub-category 5.1: Storage and Handling of ore and coal. The licence is issued by the uThungulu District Municipality.

The projections listed in the AEL indicate a steady increase in activity over the coming years, with a commensurate increase in potential emissions.

Listed emissions sources include infrastructure associated with the handling and loading of ore and coal (storage piles, conveyors etc.) and emission mitigation is limited to the monitoring and mitigation of dust. The proposed port expansions require an amendment to this AEL.

The scope of this particular study concerns the emissions directly associated with the expected increase in ship traffic and as such, has no direct bearing on the status of the AEL, which will be addressed separately.

### 3.2.2 Complaints register

Two complaints registers are maintained for the port, a public complaints register and an internal incidents register.

The public complaints register was made available for the period from October 2009 to August of 2012. It is not known whether this constitutes a complete record for 2012. Complaints were overwhelmingly related to dust, usually as a result of poor housekeeping or spills. However, just short of 10% of complaints generated were related to emissions from shipping.

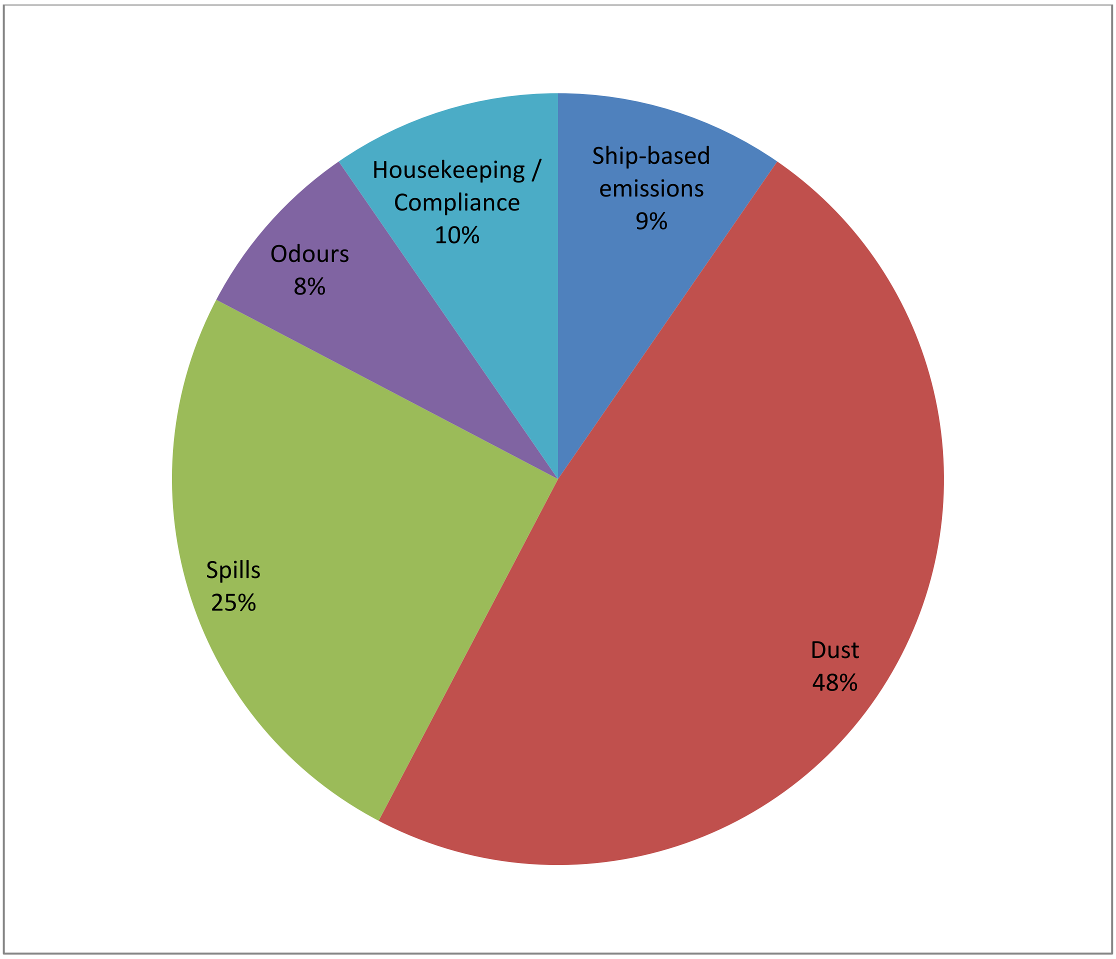


Figure 2: Breakdown of public environmental complaints for the Transnet Port Terminal, Oct 2009 to August 2012 (Richards Bay Ports Authority, 2009-2012).

### 3.3 Climate description and qualitative baseline assessment

A long term weather dataset was identified for the Richards Bay airport (SAWS, 2013). Following comparison to the Arboretum weather station situated at Harbour West (RBCAA, 2012), the South African Weather Services (SAWS) dataset was selected as an acceptable proxy for the study area (RBCAA, 2012).

### 3.3.1 Wind

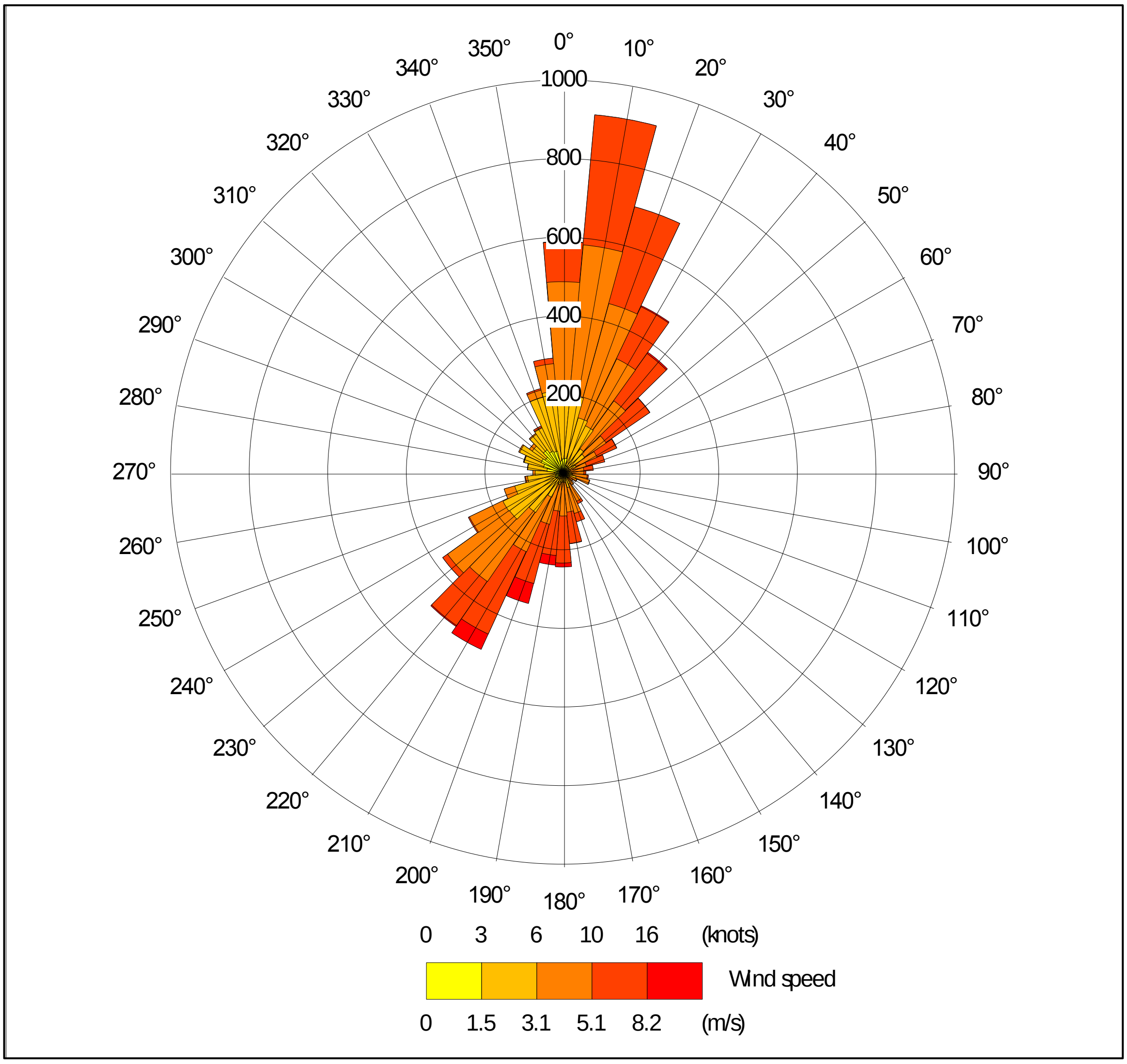


Figure 3: Annual wind rose for Richards Bay, KwaZulu-Natal Province, South Africa (SAWS, 2011)

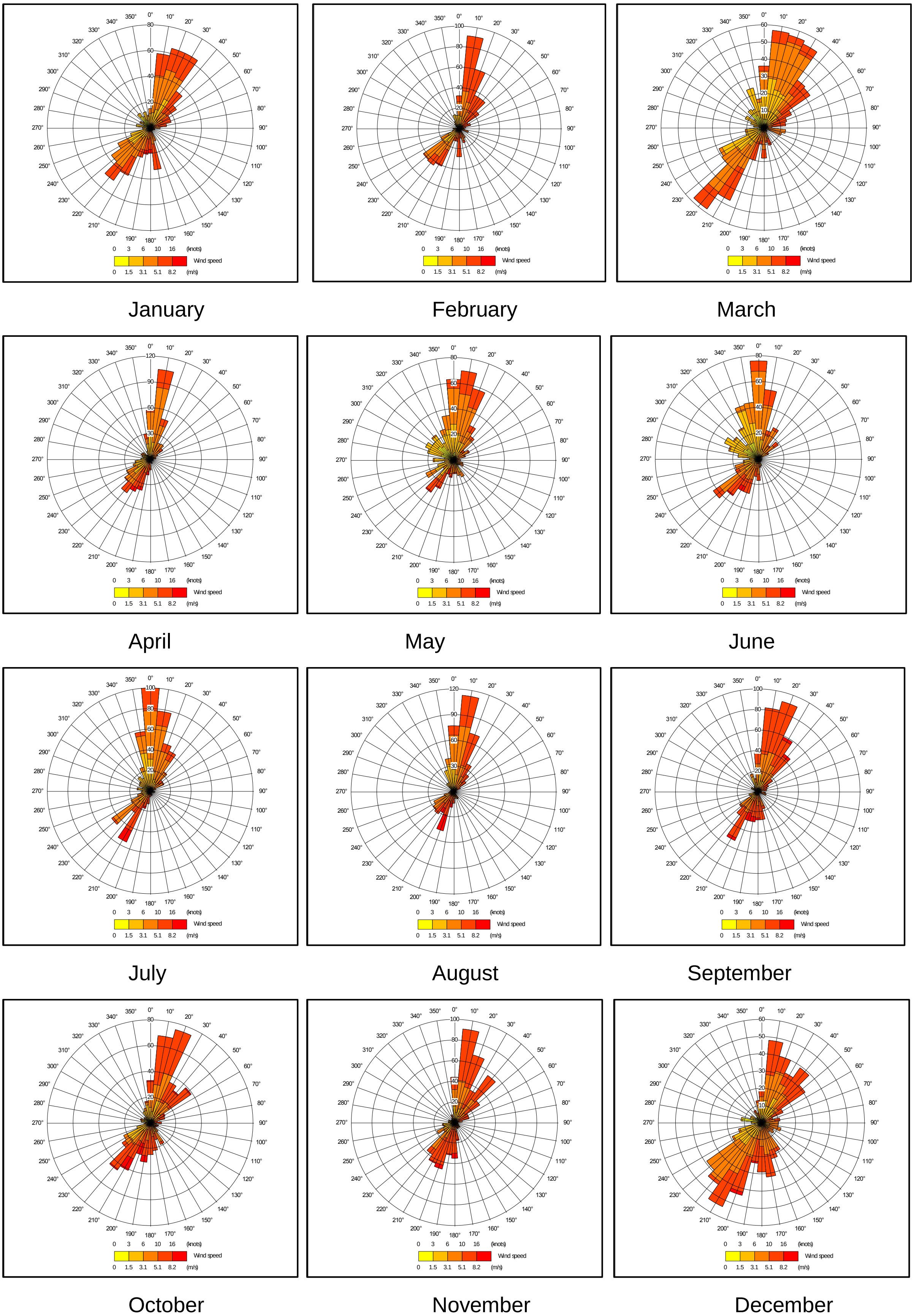


Figure 4: Monthly wind roses for Richards Bay, KwaZulu-Natal Province, South Africa (SAWS, 2011)

The prevailing winds are from the north and north northeast, with an occasional southerly component, strengthening in mid-summer. As a result, any dispersion from the site is likely to vary with the passage of weather systems up the coast but will be primarily to the south of the site.

### 4.1.1 Precipitation

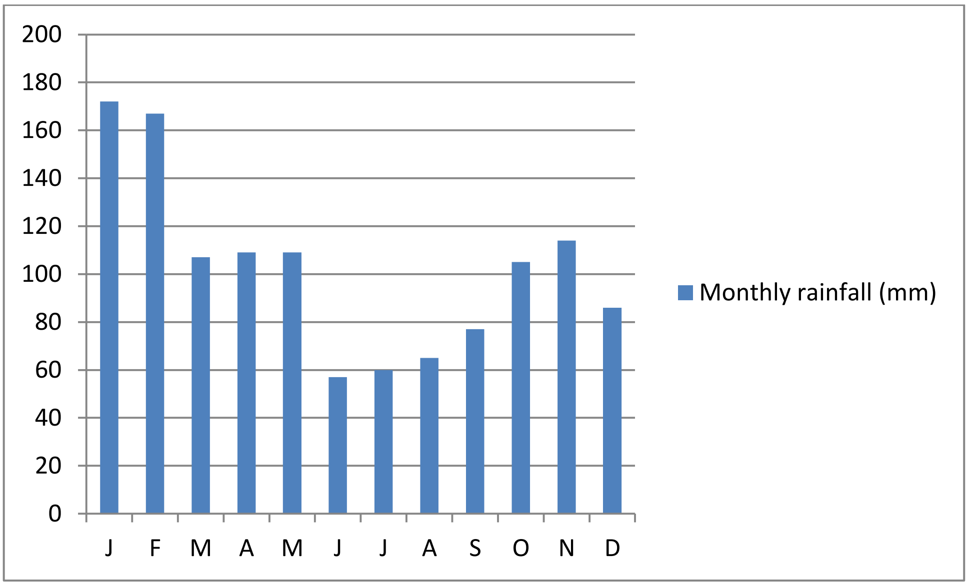


Figure 5: Average monthly rainfall figures for Richards Bay, KwaZulu-Natal Province, South Africa (SAWS, 1961-1990) (mm per month)

The site is on the northeast coast of South Africa, in an area known for its warm, moist sub-tropical climate. The region is known colloquially as the KwaZulu-Natal north coast. This region is characterised by regular, year round rain and spells of very hot and humid weather. The annual average rainfall for the region is just over 1200 mm per year (approximately twice the rain received by Johannesburg). Rain peaks in late to mid-summer, in January and February, but the region is also likely to receive rain all year round.

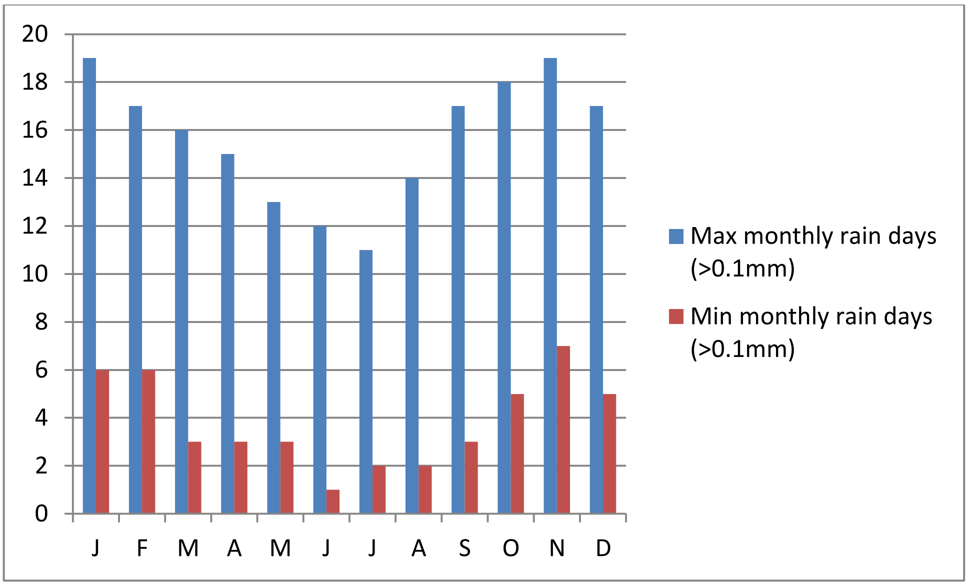


Figure 6: Average monthly rain days (days where precipitation exceeds 0.1mm) for Richards Bay, KwaZulu-Natal Province, South Africa (SAWS, 1961-1990) (number of days per month)

The region is characterised by consistently good rainfall, with even the driest winter months receiving at least one day of rain. In summer, rain can be an almost daily occurrence.

### 4.1.2 Temperature

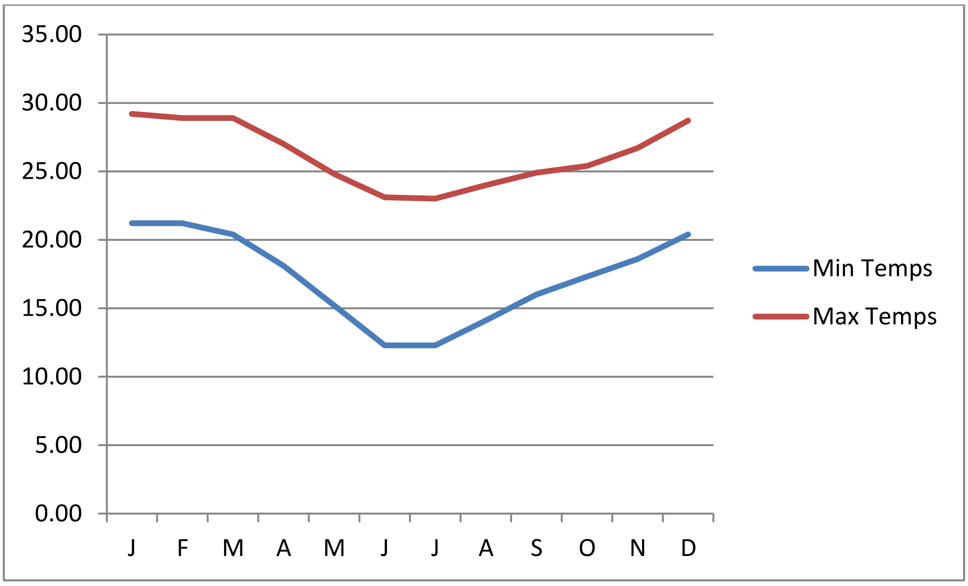


Figure 7: Average daily minimum and maximum temperatures for Richards Bay, KwaZulu-Natal Province, South Africa (SAWS, 1961-1990) (°C)

The climate is consistently warm and moist, with minimum temperatures seldom, if ever dropping below the 10 degree mark. The area experiences hot conditions during the summer, with the warmest period in December and January, when maximum temperatures average close to 30°C . Winters are mild with daytime temperatures reaching into the mid-twenties on most days and overnight temperatures never dropping below freezing. Despite it being nominally the dry season, winter remains consistently wet with occasional rain.

## 4.2 Sulphur dioxide ($SO_2$)

An $SO_2$ study was undertaken for Richards Bay town which included $SO_2$ monitoring at Bayside (see Figure 11 above). $SO_2$ levels for this site were registered as between 45% and 58% (around 60 µg/m$^3$) of NEMAQA guidelines for all time periods.


Figure 8: Approximate location of Bayside $SO_2$ monitoring site (red triangle) (RBCAA, 2012).

## 5. DISPERSION MODELLING OF INCREASED SHIPS' EMISSIONS

Potential emission modelling is undertaken using Cambridge Environmental Research Consultants (CERC)'s latest generation model, the Atmospheric Dispersion Modelling System (ADMS 5). Input data is a combination of estimates generated using the Entec *Quantification of ship emissions* (2002). Ship fuel use data as well as the approximate dimensions of ships' funnels (0.8m diameter by 55m height (Panamax) and 60m height (Capesize)) is estimated using Alderton's *Lloyd's Practical Shipping Guides: Port Management and Operations* (2000).

Meteorological data is sourced from the South African Weather Services (SAWS).

### 5.1.1 Emission factors

When modelling emissions from a site where real data is not available, it is possible to estimate the emissions that will be generated by using a series of equations to determine the likely emission of each process. These are called emission factors. An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant.

The emission factors used for this study were taken from the Entec *Quantification of ship emissions* (2002). The emission factors contained therein are mostly based on those developed by Entec in a study on shipping in European waters but are equally applicable to this project, given the international nature of Panamax and Capesize craft. South Africa has yet to develop its own set of emission factors.

A broad overview of potential emissions likely to be emitted can be obtained through the use of the general equation:

$$E_{kpy,i} = [A * OpHrs] * EF_i * [1 - (CE_i/100)]$$

where:

Ekpy,i = emission rate of pollutant i, kg/yr

A = activity rate, tonnes of fuel burnt/h

OpHrs = operating hours, h/yr

$EF_i$ = uncontrolled emission factor of pollutant i, kg/t

$CE_i$ = overall control efficiency for pollutant i, %

The bulk of the shipping activity in the harbour is likely to be in the form of stationary ships being loaded or offloaded, or hoteling. The breakdown of likely ship activity per visit is estimated as per Table 4 below (Alderton, 2000).

Table 4: Expected activity rates for dry-bulk ships at Richards Bay harbour.

| | Manoeuvring | Loading | Hoteling | Total |
|---|---|---|---|---|
| Average time in port for Richards Bay (hours) | 1 | 72 | 22 | 95 |

The expected increase in shipping is determined by assuming that the berths are used constantly at capacity. With an average turnaround time of 95 hours (likely an underestimation), the capacity of the harbour is expected to increase by approximately 368 ships per year, or a little more than one ship per day. Taking the forecast increase in capacity (36mtpa by 2040), this would mean an average ship load of a little under 100 000t, well within the 150 000t typically carried by a Capesize vessel. Average fuel use is estimated at 44 tons per day (Alderton, 2000). This is likely to be an overestimation, including, as it does, the fuel typically burnt while out at sea. However, Entec (2002) are explicit that there are ship emissions associated with loading, offloading and hoteling. Manoeuvring includes the addition above current levels of one additional ship movement in or out of the harbour per day, averaged over 24 hours. All of this serves to attempt to maximise the potential emissions and so to model a worst case scenario with the harbour operating at its maximum capacity.

Thus, the following emissions can be anticipated:

Table 5: Estimated emissions per activity

| Operation / Activity | $NO_x$ | $SO_2$ | $PM_{10}$ |
|---|---|---|---|
| Stationary (hoteling / loading, offloading) (g/s) | 8.5 | 6.9 | 1.4 |
| Manoeuvring (g/m/s) | 0.008 | 0.007 | 0.001 |

Background data for $SO_2$ is available but the model has been run to determine the possible additional contribution of shipping to local air quality and so baseline pollutants were not included in the model. Thus, the plots below should be seen as the amount of additional pollution that is expected in the air, as a result of the increase in shipping. To this end, exceedences of just 25% of the recommended standards were determined, to address the potential for cumulative emissions pushing the area's pollution load over the national standards.

# 6. RESULTS

## 6.1 Sulphur dioxide

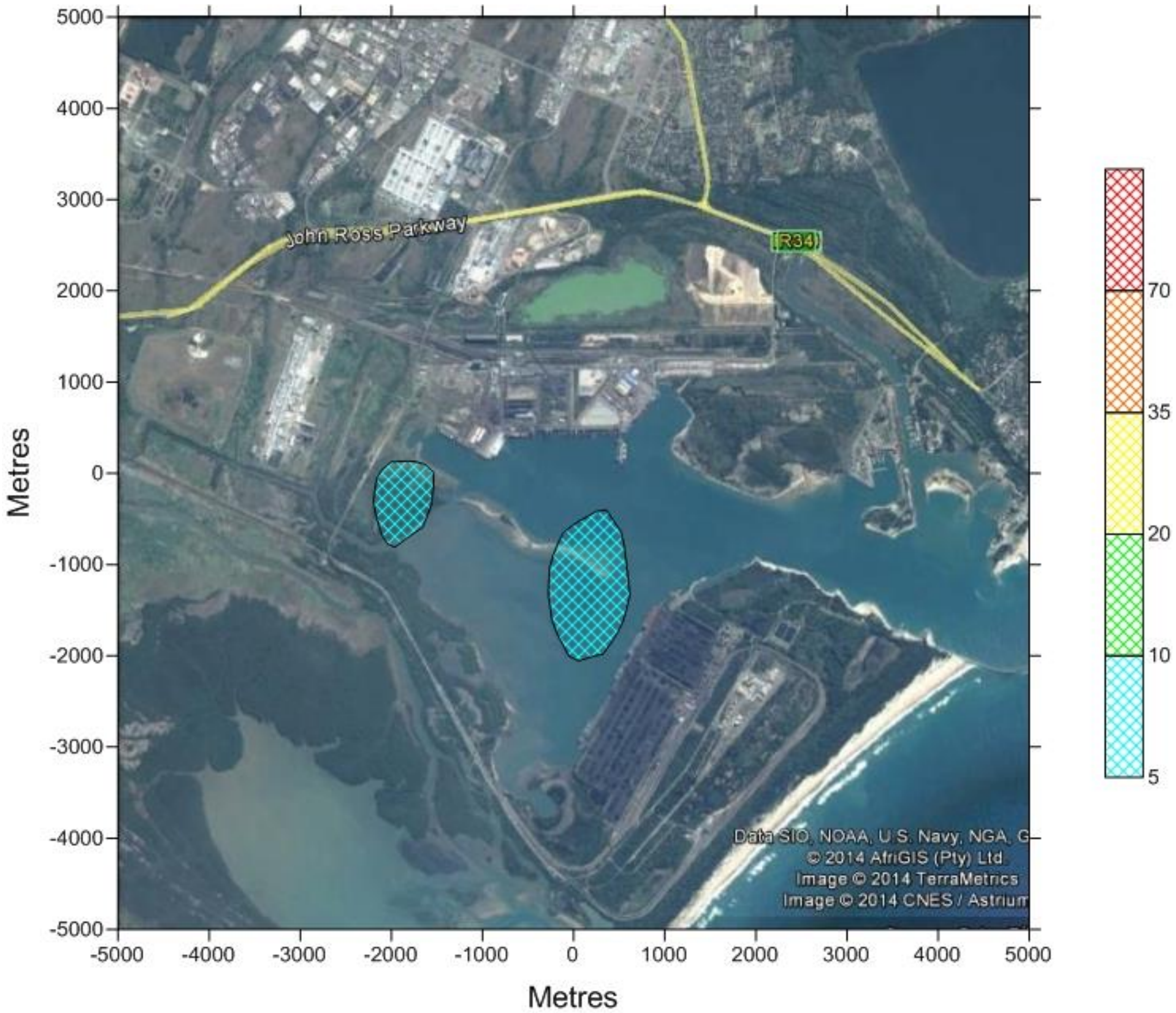


Figure 9: Modelled representation of $SO_2$ dispersion from proposed increased in shipping. Long term averages, 1 hour averaging period, levels indicated in µg/m$^3$

The expected increase in local average $SO_2$ levels as a result of the increase in shipping is marginal and the effect is unlikely to be felt outside of the harbour.

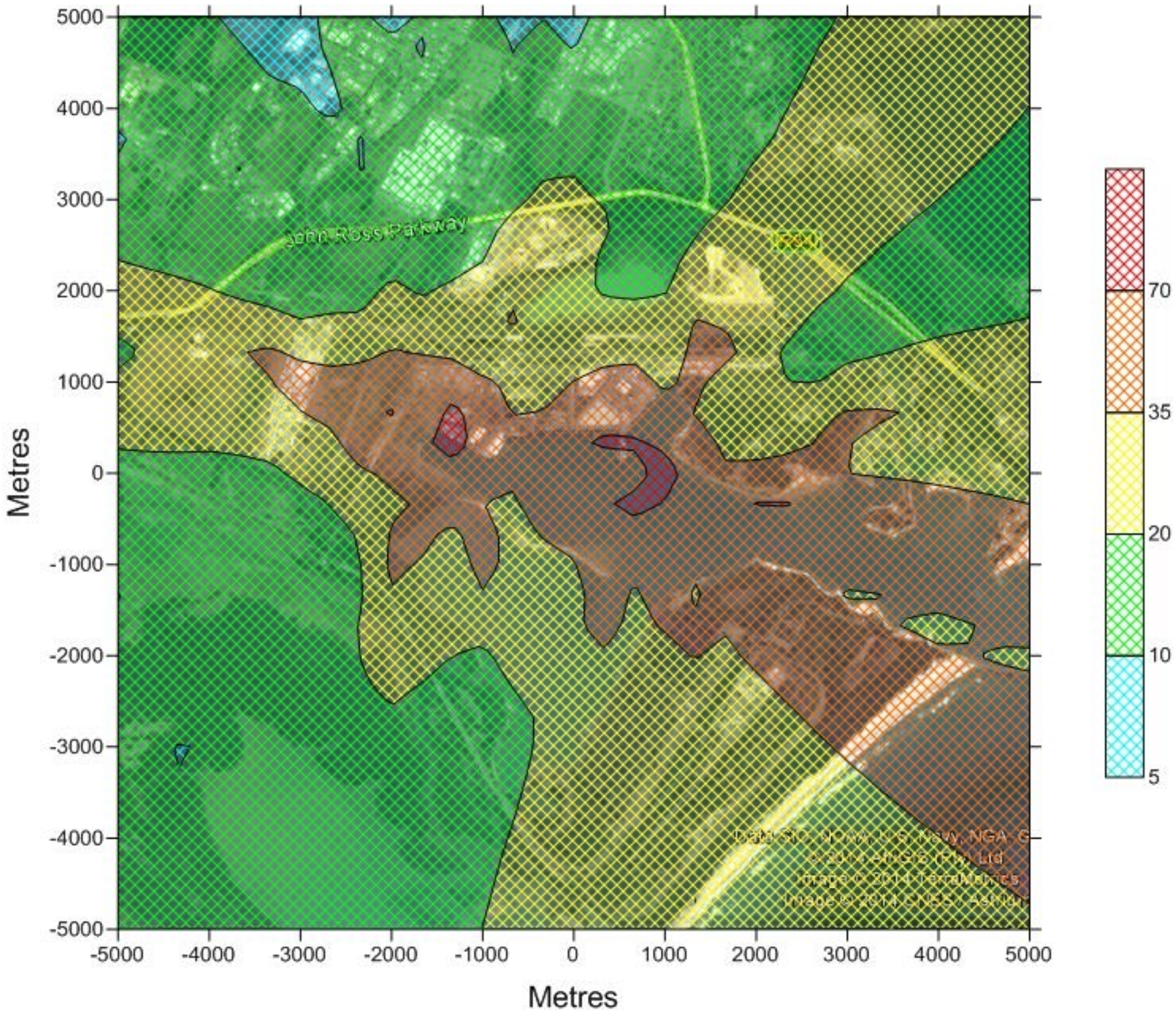


Figure 10: Modelled representation of $SO_2$ dispersion from proposed increased in shipping. 100$^{th}$ percentile, 24 hour averaging period, levels indicated in µg/m$^3$

The 100$^{th}$ percentile plot (Figure 10 above) represents the highest modelled value for each point that was achieved through the model run. In essence, it shows the single worst incidence of pollution that can be expected. Again, the bulk of increases in $SO_2$ remain within the confines of the harbour, with ships manoeuvring in and out of the harbour mouth resulting in periodic spikes in pollution along that path. Occasional exceedences of the 70 µg/m$^3$ may be experienced adjacent to the berths although this is still well short of the 500 µg/m$^3$ which would constitute an infringement.

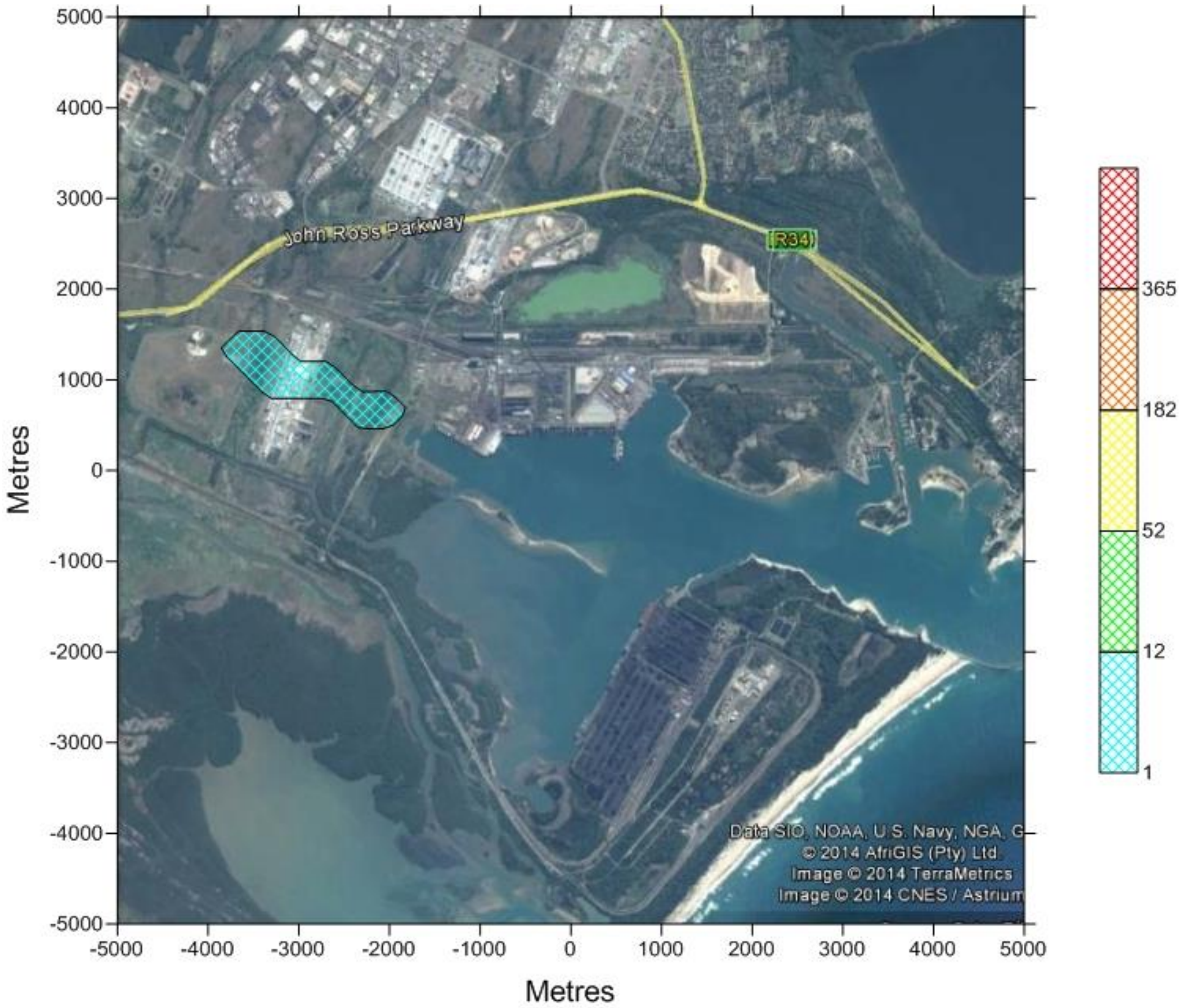


Figure 11: Modelled representation of incidences of ambient $SO_2$ levels (24 hour average) from the proposed increased in shipping exceeding the 31.75 µg/m$^3$ level (25% of ambient standard).

Figure 11 indicates the number of times that the 31.75 µg/m$^3$ level (25% of ambient standard) was exceeded in the year of the model run. In this case, this level was exceeded less than once a month, with exceedences most likely to happen to the west of the harbour.

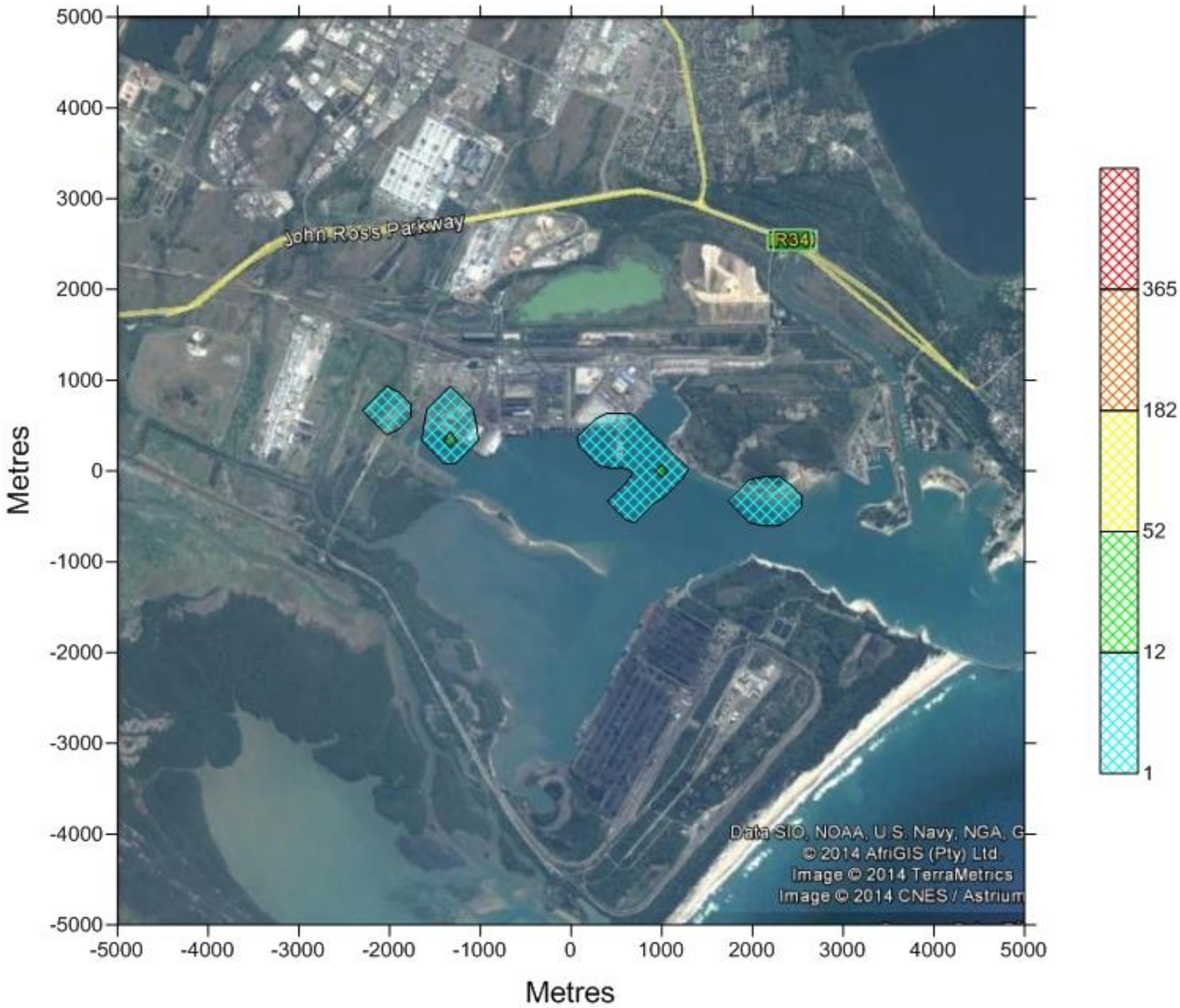


Figure 12: Modelled representation of incidences of ambient $SO_2$ levels (1 hour average) from the proposed increased in shipping exceeding the 87.5 µg/m$^3$ level (25% of ambient standard).

Figure 12 indicates the number of times that the 87.5 µg/m$^3$ level (25% of 1 hour average ambient standard) was exceeded in the year of the model run. In this case, this level was exceeded less than once a month, with exceedences most likely to happen in the vicinity of the new berths. Monthly exceedences could be expected in the immediate vicinity of the ships.

## 6.2 Particulate matter

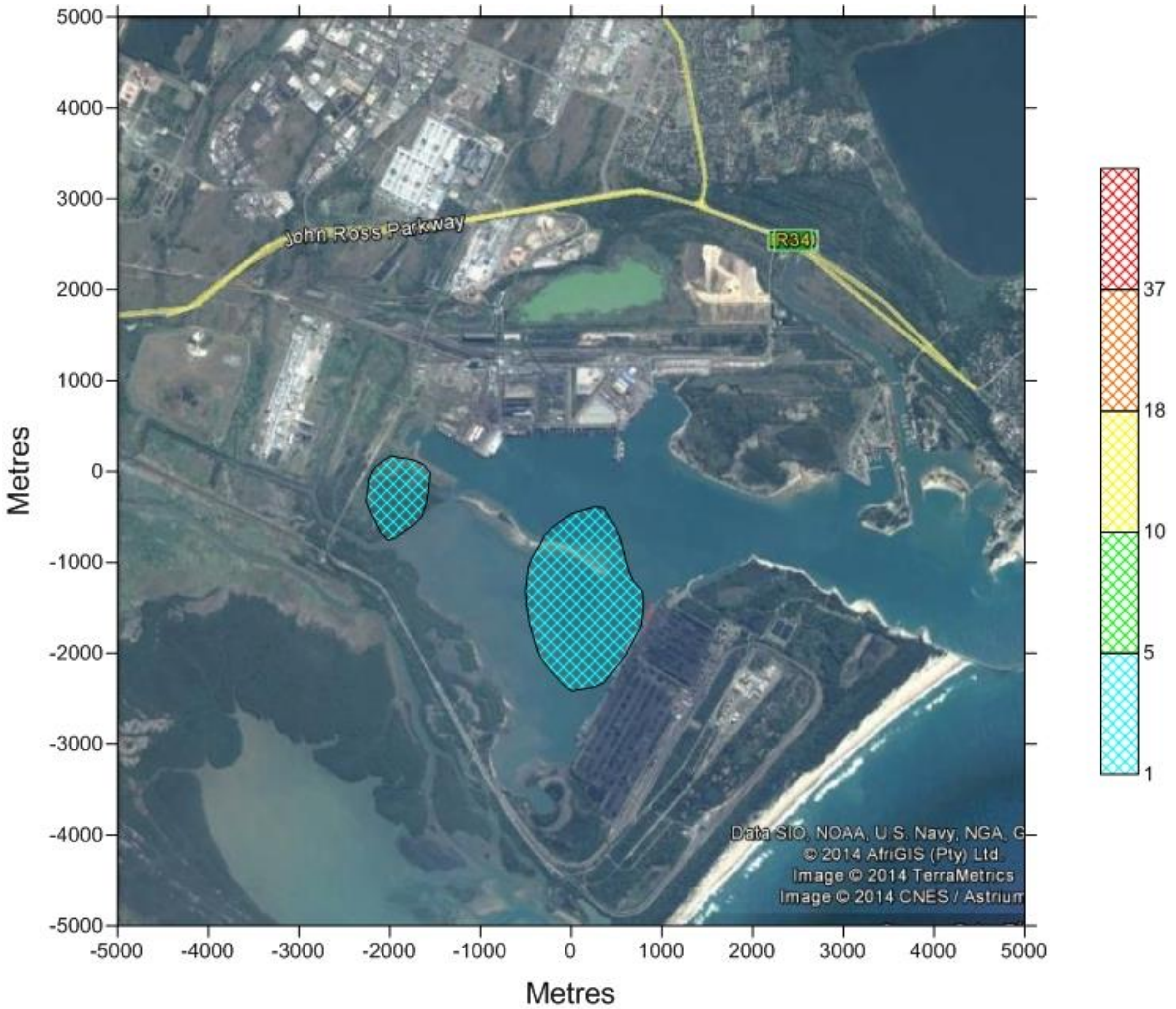


Figure 13: Modelled representation of $PM_{10}$ dispersion from proposed increased in shipping. Long term averages, 24 hour averaging period, levels indicated in $\mu g/m^3$

The expected increase in local average $PM_{10}$ levels as a result of the increase in shipping is marginal and the effect is unlikely to be felt outside of the harbour.

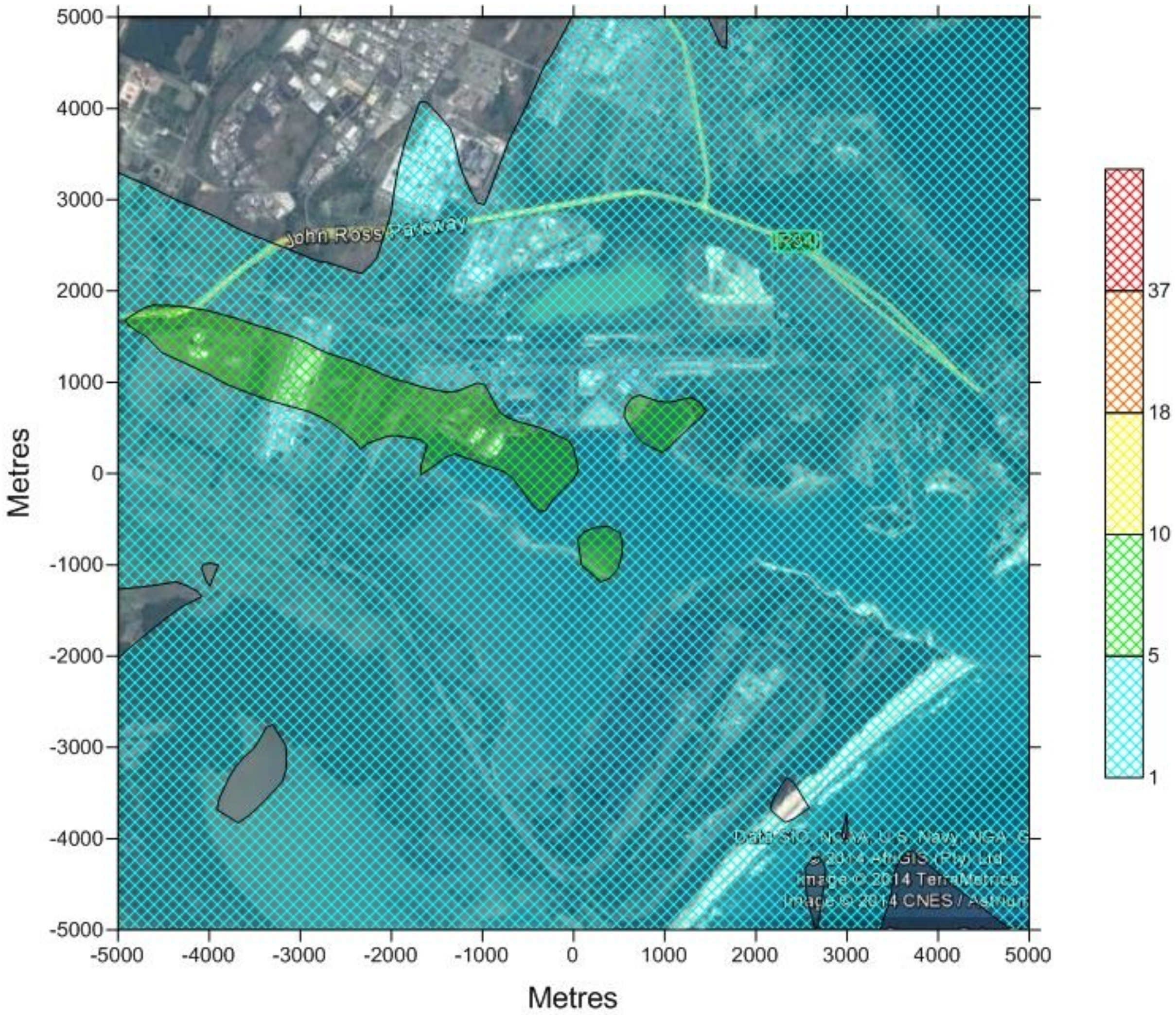


Figure 14: Modelled representation of $PM_{10}$ dispersion from proposed increased in shipping. 100th percentile, 24 hour averaging period, levels indicated in µg/m$^3$

The 100th percentile plot indicates a diffuse impact of additional particulates over the area with a marginally more concentrated plume to the west. Particulates never exceeded the 18.75 µg/m$^3$ level (25% of ambient standard).

### 6.3 Nitrogen dioxide

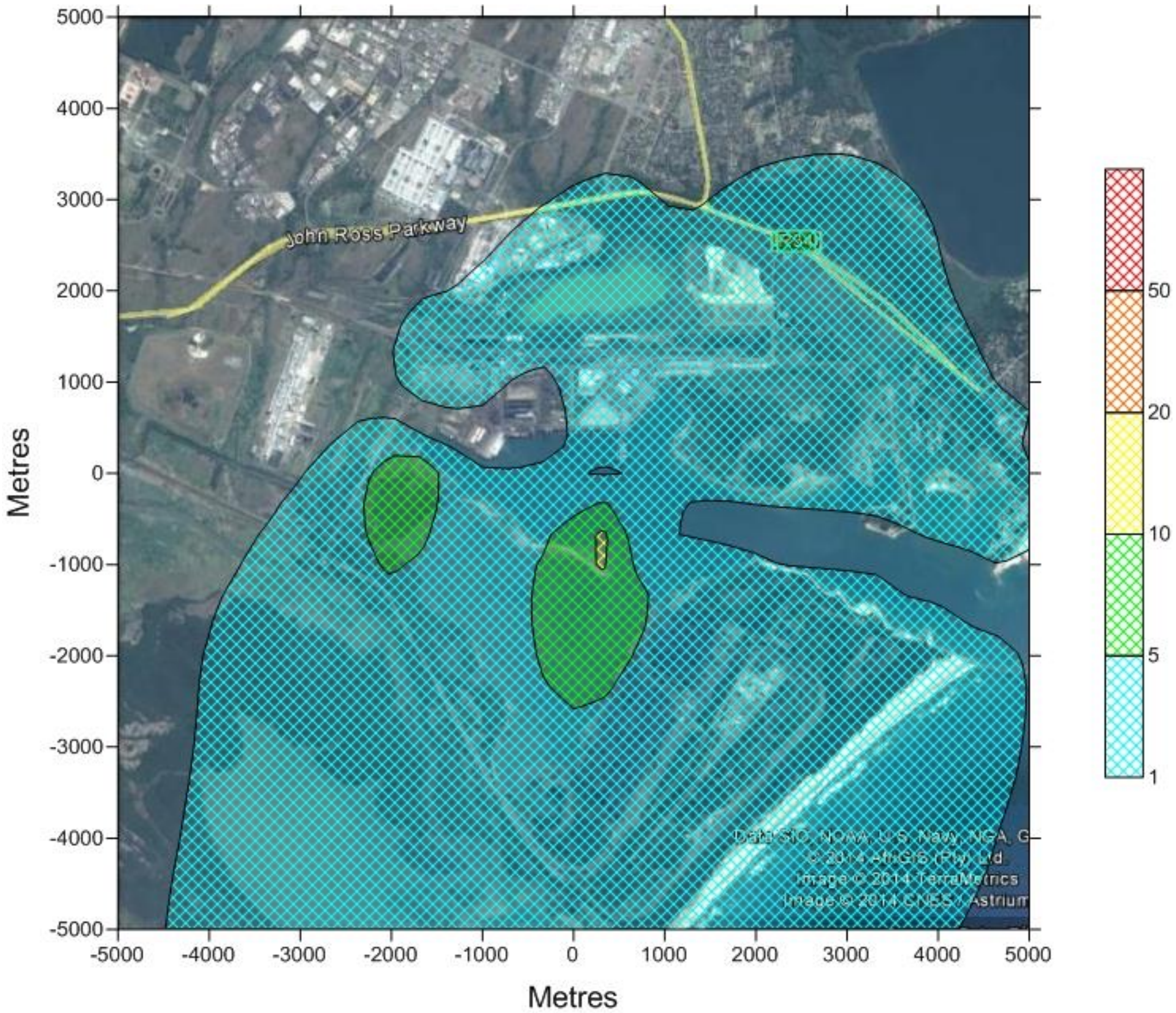


Figure 15: Modelled representation of $NO_x$ dispersion from proposed increased in shipping. Long term averages, 1 hour averaging period, levels indicated in $\mu g/m^3$

The expected increase in local average $NO_x$ levels as a result of the increase in shipping is marginal and diffuse over a wide area with some concentration immediately adjacent to the new berths.

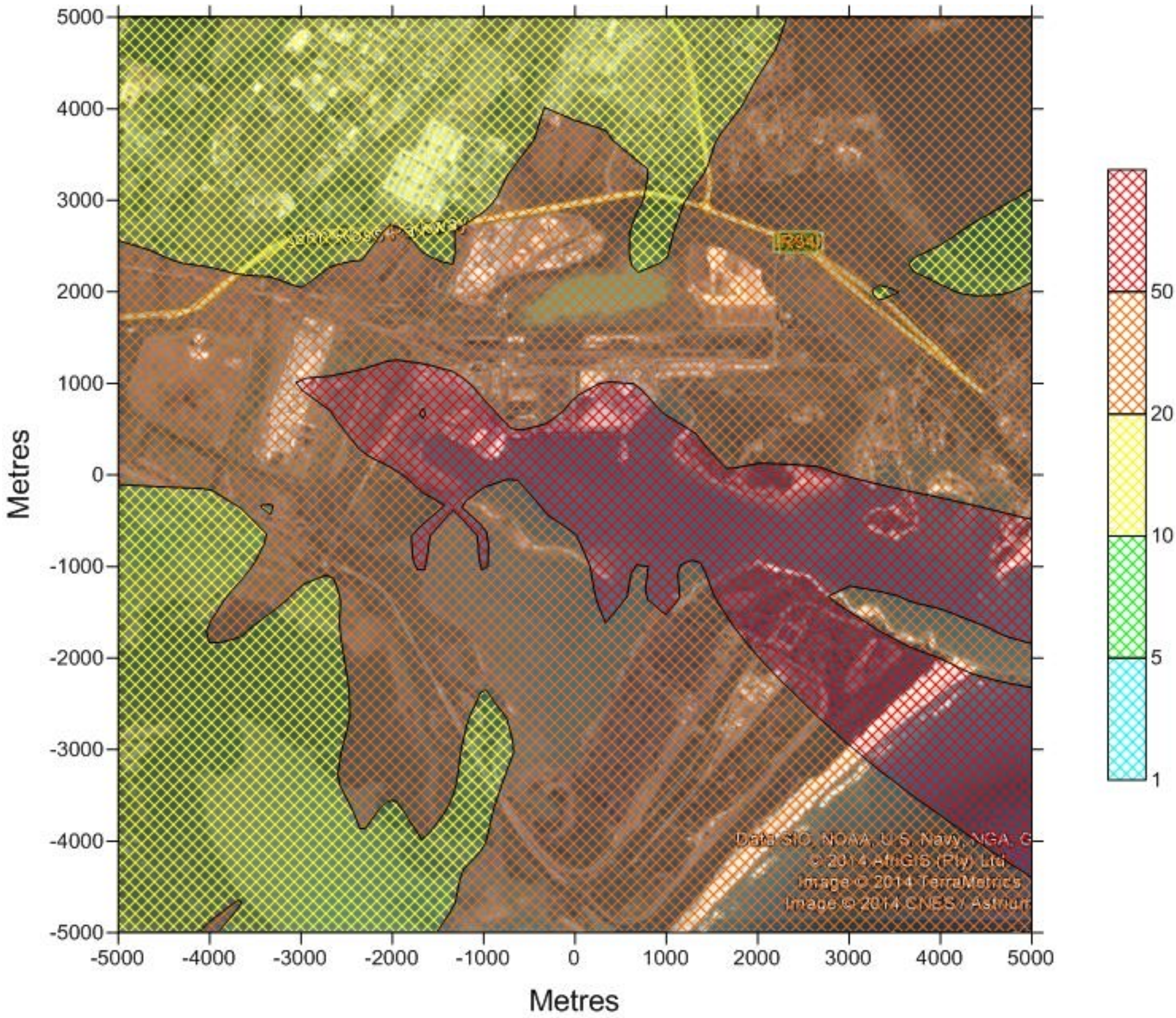


Figure 16: Modelled representation of $NO_x$ dispersion from proposed increased in shipping. $100^{th}$ percentile, 1 hour averaging period, levels indicated in µg/m$^3$

The $100^{th}$ percentile shows spikes in $NO_x$ for the surrounding area, with ships manoeuvring in and out of the harbour mouth resulting in periodic spikes in pollution along that path. Occasional exceedences of the 50 µg/m$^3$ level (25% of the national standard) may be experienced adjacent to the berths and along the path to the harbour mouth.

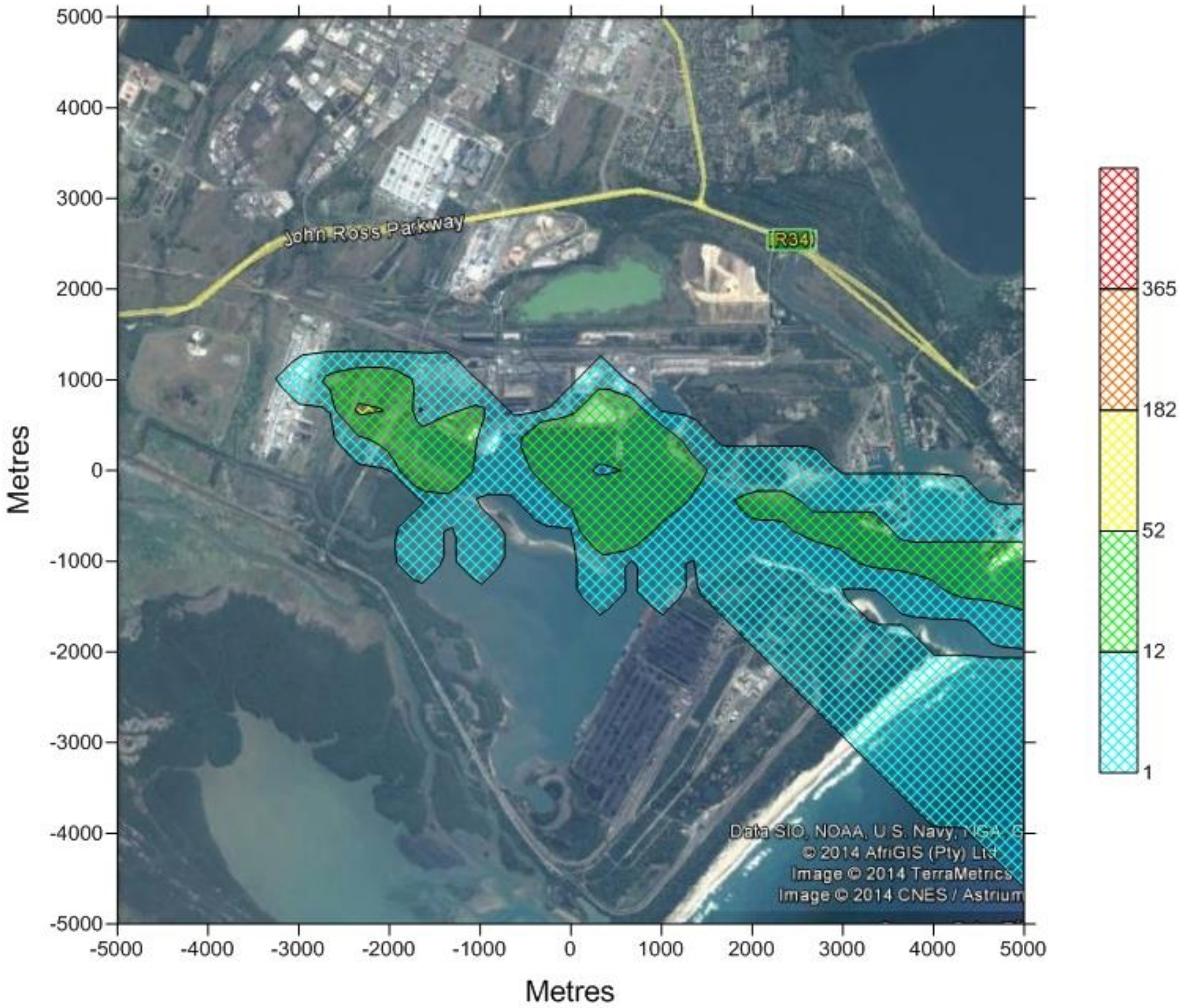


Figure 17: Modelled representation of incidences of ambient $NO_x$ levels (1 hour average) from the proposed increased in shipping exceeding the 50µg/$m^3$ level (25% of ambient standard).

The 50µg/$m^3$ level may be exceeded at least once a month around the new berths and along the path to the mouth, dispersed to the northern edge of the mouth. Weekly exceedences may result in the west of the harbour, adjacent to the new berths.

## 7. CONCLUSIONS

The dispersion plots above indicate that the expected increase in shipping should have a marginal impact on the particulate load of the area, with slightly more serious increases expected in $SO_2$ and $NO_x$ levels. Without a comprehensive understanding of all emissions sources in the area, it is difficult to accurately predict the expected impact that the additional ship traffic will have but it does appear that, although some impact will be felt, that impact is unlikely to be significant in the context of the general pollution profile of an industrial area like Richards Bay.

Areas that are likely to experience increases and occasional spikes in pollution are the area immediately to the west of the harbour (fortuitously, where the Bayside $SO_2$ monitoring station is already situated) and along the northern edge of the harbour mouth. These spikes may be exacerbated by the periodic nature of real ship emissions rather than the long term steady emissions that can be modelled here.

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