



ROYAL HASKONING

APPENDIX 3

AIR QUALITY

SUBJECT

Emission Calculations

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INTRODUCTION

- These calculations set out the methods and assumptions used in deriving the input data for the air quality impact assessment for the proposed Bathside Bay Container Terminal Development.
- Current emission factors have been obtained from the UK Emission Factors Database (www.naei.org.uk) where applicable. Where no factors exist for a particular type of source, the assumptions have been clearly set out.
- All emission sources are included within the ADMS-Roads (version 1.6) air quality model as points, areas or roads.
- Emissions for each source must be derived in terms of:
 - Point source: Grams per second (g/s)
 - Area source: Grams per square metre per second (g/m²/s)
 - Road source: Grams per kilometre per second (g/km/s)

| | | | | |
|---|---|----------------------|---------------------|---------------|
|  | CALCULATIONS | JOB No. M1274 | SHEET No C3 | REV. 2 |
| SUBJECT Emission Calculations | PROJECT Bathside Bay Air Quality Assessment | | FILE REF. E2 | |
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| A: A1: | <p>Moving Ship Emissions</p> <p>Assumptions:</p> <ul style="list-style-type: none"> ➤ Consider emissions for both incoming and outgoing moving vessels. ➤ Moving point sources cannot be modelled. Therefore equivalent emissions will be calculated for two line sources, with emissions in g/km/s. ➤ Emissions will be modelled without plume rise, but will have an elevation equivalent to the funnel height. ➤ Consider emissions between the berth and a point some 7km from Bathside Bay (between Rolling Ground and Deane navigation lights). Emissions from vessels beyond this point may be considered negligible. ➤ Up to 4 container vessels are expected per day, equivalent to between 6 to 8 vessel movements every 24 hours ➤ Main engines on container vessels use heavy fuel oil (HFO). ➤ Assume linear relationship between main engine power and emissions ➤ Consider largest vessel likely to use Bathside - S Class Maersk container vessel (Overall length = 347 metres, Main engine max. rating = 54.84 MW, Gross international tonnage = 91,560 t) ➤ Incoming vessels use little power, relying on tugboats for manoeuvring. Emissions from tugs are considered minor in comparison to the main engine of a container vessel. | | | |

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- Following Meeting with Harwich Haven Authority on 03.07.02, the following data was obtained:

| Phase | Comment | Location | Container Ship | | | Tug |
|----------|---------------------------|---------------------------------------|-----------------------------|----|--------|-------------|
| | | | Main Engine | | Thrust | Main Engine |
| | | | Speed | % | % | % |
| Incoming | 1 Cruising Speed | Over 15 miles offshore | Full Ahead | 85 | 0 | 0 |
| | 2 Wait for Pilot to board | 15 miles offshore "Sunk Light Vessel" | DS Ahead | 33 | 0 | 0 |
| | 3 1 Tug Fixed | At edge of Stour | Stopped | 0 | 25 | 70 |
| | 4 Turning vessel | North bank of Stour | Bursts of DS Ahead & Astern | 33 | 25 | 70 |
| | 5 Berthing vessel | Alongside berth | Stopped | 0 | 25 | 0 |
| Outgoing | 1 Moving off berth | Alongside berth | Stopped | 0 | 25 | - |
| | 2 Moving to channel | To edge of Stour | DS Ahead | 33 | 0 | - |
| | 3 Moving to Stour limits | Out of Estuary | Slow Ahead | 49 | 0 | - |
| | 4 Setting course | At open sea | Half Ahead | 66 | 0 | - |
| | 5 Cruising speed | 15 miles offshore | Full Ahead | 85 | 0 | - |

Key: DS = Dead Slow, % = % of duty engine power rating used for manoeuvre

A2: Factored emission rates

- Outgoing Vessel

| Averaging Period | Emission rates factored for averaging period (g/km/sec) | | | | | | |
|------------------|---|--------------|-----------------|------------------------------------|-----------------|--------------|--------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| 15mins | 6.163 | 0.068 | 0.001 | 0.369 | 0.406 | 0.001 | 0.038 |
| 30mins | 12.326 | 0.137 | 0.003 | 0.738 | 0.812 | 0.003 | 0.076 |
| 1-hour | 24.652 | 0.273 | 0.006 | 1.476 | 1.624 | 0.006 | 0.152 |
| 8-hours | 9.245 | 0.102 | 0.002 | 0.554 | 0.609 | 0.002 | 0.057 |
| 24-hours | 8.209 | 0.091 | 0.002 | 0.492 | 0.541 | 0.002 | 0.051 |
| Annual | 8.209 | 0.091 | 0.002 | 0.492 | 0.541 | 0.002 | 0.051 |

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B: Berthed Ship Emissions
B1: Assumptions:

- Two berthed ships shall be modelled as point sources.
- When berthed, vessels use only their auxiliary generators, NOT their main engines
- Consider worst-case ship - S Class Maersk container vessel
- This vessel has 5 No. 3 MW auxiliary generators for heating, lighting and refrigeration of some containers.
- The three individual generators are small enough for each vessel to be modelled as single point source
- Auxiliary generators use Heavy Fuel Oil, with a sulphur content of 2% (subject to future IMO Regulation).
- From correspondence with Maersk Sealand: All three generators use a total of 9.5 tonnes of HFO per day.
- These emissions are constant, and therefore do not require the application of time factors.

B2: Emissions based on fuel use

- Fuel use = 9.5 tonnes per day at berth = 0.396 t/hour
- From UK Emission Factors Database (www.naei.org.uk)
- Units of kt pollutant/mt fuel → equivalent to kg pollutant/t fuel
- Emission rate for one berthed vessel:

| Fuel Type | Emission rate for one berthed vessel (g/s) | | | | | | |
|-----------|--|------|-----------------|------------------------------------|-----------------|---------|------|
| | CO ₂ | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| HFO | 93.5 | 0.05 | 0.0022 | 0.77 | 2.86 | - | 0.11 |

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C: Container Terminal and Car Park Emissions
C1: Overview

- When operational, the terminal will be used by a number of vehicles involved in the handling and movement of containers, as well as staff parking and dredging operations.
- Find emissions from each source, before totalling and dividing uniformly across the area of terminal development.
- Peak throughput of port is 1.7 million TEU per annum.
- Consider all terminal vehicles to operate over the total area of development (less landscaped areas), equivalent to 992,000 m².

C2: Car Parking

- The car park is expected to accommodate approximately 25 cars, giving 25 cold starts per day.
- For benzene, hot soak emissions will also be considered for 25 cars
- For the purposes of this assessment, it will be assumed that there is a steady flow of staff vehicles throughout the day.
- In reality, the emissions recorded for a cold start are released over the first 2 to 8km of a car's journey, but the calculation assumes a worst-case that all are released within the terminal area.

a) From the UK Emissions Factors Database, cold starts

| Petrol car | Emission factor (grams/trip) | | | | | | |
|------------|------------------------------|----|-----------------|------------------------------------|-----------------|---------|------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| Cold start | - | 28 | - | 1.54 | - | 0.08 | - |
| Hot soak | - | - | - | - | - | 0.00322 | - |

b) Hence, for the staff car park:

| Fuel Type | Emission rate from car parking (g/m2/sec) | | | | | | |
|-----------|---|---------|-----------------|------------------------------------|-----------------|----------|------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| Petrol | | 8.16e-9 | | 4.49e-10 | | 2.43e-11 | |

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C3: Rail Mounted Gantry Cranes

- All Rail Mounted Gantry (RMG) cranes run along a set course, adjacent to the quay, or over the rail loading area.
- RMGs are electrically powered, the supply running within a cable pit or being wound on a reel attached to each unit.
- As such, there will be no significant emissions generated by the Rail Mounted Gantry Cranes

C4: Internal Movement Vehicles

- Internal Movement Vehicles (IMV) are small trucks with trailers, used to move containers between the stacking areas and the quay.

| | | | |
|-----------------------------|--------|-------|---------|
| Number of IMV | 44 | No. | |
| Power rating of IMV | 130 | kW | |
| Total Hours worked per year | 7240 | hours | Assumed |
| Total annual power output | 41,413 | MWh | |

C5: Rubber Tyred Gantry Cranes

- RTGs are used to move containers between stacks and load/unload the IMVs

| | | | |
|-----------------------------|---------|-------|-----------|
| Number of RTG | 45 | No. | Hutchison |
| Power rating of RTG | 400 | kW | Assumed |
| Total hours worked per year | 7240 | Hours | Assumed |
| Total annual power output | 130,320 | MWh | |

C6: Reach Stackers

- Reach Stackers are small tractor units, occasionally used to move individual containers around the terminal, or to a workshop.

| | | | |
|-----------------------------|------|-------|---------|
| Number of Reach Stackers | 4 | No. | Assumed |
| Power rating of RS | 246 | kW | + |
| Total hours worked per year | 5110 | Hours | Assumed |
| Total annual power output | 5028 | MWh | |

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C7:

➤ UK Emissions Factors Database: Other Industrial Offroad vehicles

| Fuel | Emission rates (kg pollutant / tonne fuel) | | | | | | | |
|---------|--|----|-----------------|------------------------------------|-----------------|---------|------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 | Benzo-a-pyrene |
| Gas oil | 857 | 16 | 1.37 | 43 | 2.64 | 0.00441 | 4.30 | 12 |

➤ Summary of container terminal and car park emissions

| Fuel | Emission rates (g/m2/sec) | | | | | | | |
|---------------|---------------------------|----------------|-----------------|------------------------------------|-----------------|----------------|----------------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 | Benzo-a-pyrene |
| Port vehicles | 3.79e-04 | 7.08e-6 | 6.06e-7 | 1.90e-5 | 1.17e-6 | 1.95e-9 | 1.90e-6 | 5.31e-6 |
| Cars | - | 8.16e-9 | - | 4.49e-10 | - | 2.43e-11 | - | - |
| Total | 3.79e-4 | 7.09e-6 | 6.06e-7 | 1.9e-5 | 1.17e-6 | 1.97e-9 | 1.90e-6 | 5.31e-6 |

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D: Traffic Figures and Emissions

- Existing and Future peak flows were Subconsultant Highways Solutions Ltd (HSL)
- Data from automatic traffic count (ATC) at Wix was analysed to derive the relationship between peak and 24-hour average flows
- Additional information must be calculated for Benzene and SO₂

D1: 2001 Actual counts (peak hour)
D2: 2007 Predicted flows No Development (peak hour)
D3: 2007 Predicted flows with Project (peak hour)
D4: 2010 Predicted flows No Development (peak hour)
D5: 2010 Predicted flows with Project (peak hour)
D6: 2022 Predicted flows No Development(peak hour)
D7: 2022 Predicted flows with Project (peak hour)
D8: Benzene and SO₂ emissions

- Benzene and SO₂ are not included in the ADMS default calculations
- Calculate g/km/sec based on UK Emission Factors Database and vehicle counts
- UK Emissions Factors Database: SO₂ and Benzene emissions - All cars and HGVs

| Year | All Cars | | HGV (articulated) | | Included in model year |
|------|-----------------|---------|-------------------|----------|------------------------|
| | SO ₂ | Benzene | SO ₂ | Benzene | |
| | g/km/v | g/km/v | g/km/v | g/km/v | |
| 2000 | 0.01000 | 0.00696 | 0.02000 | 0.000536 | 2002 |
| 2005 | 0.00467 | 0.00339 | 0.02000 | 0.000424 | 2007 |
| 2010 | 0.00440 | 0.00267 | 0.02000 | 0.000268 | 2010 & 2022 |

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E: Petrochem Carless - Parkeston

- Refinery has 9 release points - model as a single point source

E1: Environment Agency figures

From Authorisation (Ref. AB2963), Grid Ref 623500, 232300, Pollution Inventory

Emission Rates

- Assume worst case - emission is maximum value stated by Pollution Inventory
- Assume emissions constant over year (31,536,000 seconds)

| Process | Emission rates (g/s) | | | | | | | |
|--------------------|----------------------|-------|-----------------|------------------------------------|-----------------|---------|-------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 | Benzo-a-pyrene |
| Refinery Emissions | 3583 | 0.758 | - | 1.294 | 0.317 | 1.14 | 0.032 | - |

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F: Rail Emissions

F1: Expected rail movements

- From the predicted 1.7m TEU handled:
- 30% transhipped (i.e. do not leave the terminal)
- 10% rail movements (in and out of the terminal)
- Existing rail movements approximately 2 per day
- Predicted rail movements approximately 4 per day
- Assume only 1 power car per train
- Consider rail movements between Terminal and Manningtree junction

F2: Emission rates

- Used DUKES statistics on fuel consumption based on freight power car fuel use
- Rail section under consideration is 15 km long
- Consider emissions averaged over one year period

F2: Existing rail movements

- Emission rates (averaged over year)

| Process | Emission rates (g/km/s) | | | | | | | |
|---------|-------------------------|---------|---------|------------|---------|---------|---------|---------|
| | CO2 as C | CO | NOx | NOx as NO2 | SO2 | VOC | PM10 | Benzene |
| Freight | 1.22E-1 | 6.94E-4 | 2.48E-3 | | 5.97E-4 | 5.09E-4 | 1.16E-4 | |

F3: Future rail movements

- Emission rates (averaged over year)

| Process | Emission rates (g/km/s) | | | | | | | |
|---------|-------------------------|---------|---------|------------|---------|---------|---------|---------|
| | CO2 as C | CO | NOx | NOx as NO2 | SO2 | VOC | PM10 | Benzene |
| Freight | 2.44E-1 | 1.39E-3 | 4.96E-3 | | 1.19E-3 | 1.02E-3 | 2.32E-4 | |

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G: Dredging
G1: Existing Maintenance Dredging

- Existing dredging takes place for Harwich and Felixstowe Ports
- Details obtained from Harwich Haven Authority
- One small (1000m³) dredger works 240 hrs, 3 times/year. Uses 360 litres/hour gas oil.
- Two large (6000m³) dredgers work 240 hrs, 5 times/year. Use 1200 litres/hour HFO and 150 litres/hour gas oil
- Emissions modelled as an area source, with constant emission
- Dredge area Trinity Quay to Landguard Point approx. 300 hectares
- Emissions averaged over the dredge area, over a one year period

| Fuel Type | Emission Rate (g/m2/sec) | | | | | | |
|--------------|--------------------------|-----------------|-----------------|------------------------------------|-----------------|-----------------|-----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| Fuel oil | 7.70E-07 | 8.53E-09 | 1.84E-10 | 4.61E-08 | 5.07E-08 | 1.84E-10 | 4.75E-09 |
| Gas oil | 7.07E-07 | 8.11E-09 | 2.02E-10 | 5.48E-08 | 1.60E-08 | 1.73E-10 | 3.09E-09 |
| Total | 1.48E-06 | 1.66E-08 | 3.86E-10 | 1.01E-07 | 6.67E-08 | 3.57E-10 | 7.83E-09 |

G2: Future Maintenance Dredging

- Future dredging will include that mentioned above, plus additional work around Bathside Bay
- Emissions modelled as an area source, with constant emission
- One large (8000m³) dredger, 240 hrs, 5 times/year. Uses 1480 litres/hour HFO and 160 litres/hour gas oil
- One small (1000m³) dredger, 240 hrs, 3 times/year. Uses 360 litres/hour gas oil
- Dredge area along new quay to Stour approx 100 hectares

- Using UK Emission factors as above:

| Fuel Type | Emission Rate (g/m2/sec) | | | | | | |
|--------------|--------------------------|----------------|-----------------|------------------------------------|-----------------|-----------------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| Fuel oil | 2.02E-6 | 2.24E-8 | 4.83E-10 | 1.21E-7 | 1.33E-7 | 4.83E-10 | 1.24E-8 |
| Gas oil | 2.87E-7 | 3.30E-9 | 8.21E-11 | 2.23E-8 | 6.52E-9 | 7.04E-11 | 1.26E-9 |
| Total | 2.31E-6 | 2.56E-8 | 5.65E-10 | 1.43E-7 | 1.39E-7 | 5.54E-10 | 1.37E-8 |

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H: Construction Period Emissions
H1: Earthmoving Plant

- The following plant was assumed to be in operation for 12 hours per day, during the whole construction period.
- Add all on-site HGV movements generated by construction phase (HSL)
- Consider these emissions over the area used in section C

| Plant | Model (example) | No. | Operation | |
|--------------|-----------------|-----|-----------|-------------|
| | | | Gross Kw | MWh |
| Bulldozer | CAT844 | 1 | 503 | 1630 |
| Face Shovel | CAT 814F | 1 | 164 | 531 |
| Backhoe | CAT422D | 1 | 73 | 237 |
| Total | | | | 2398 |

- All construction plant will use gas oil.
- UK Emissions Factors Database: Other Industrial Offroad vehicles

| Fuel | Emission rates (kg pollutant / tonne fuel) | | | | | | | |
|---------|--|----|-----------------|------------------------------------|-----------------|---------|------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 | Benzo-a-pyrene |
| Gas oil | 857 | 16 | 1.37 | 43 | 2.64 | 0.00441 | 4.30 | 12 |

- Modelled emission rates (averaged over 12 months)

| Fuel | Emission rates (kg pollutant / tonne fuel) | | | | | | | |
|---------|--|---------|-----------------|------------------------------------|-----------------|----------|---------|----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 | Benzo-a-pyrene |
| Gas oil | 9.15E-6 | 1.71E-7 | 1.47E-8 | 4.59E-7 | 2.81E-8 | 4.71E-11 | 4.59E-8 | 1.28E-7 |

H2: Capital Dredging

- Two dredgers would be operational for around 6 months around Bathside Bay.
- Consider these emissions over the area used in section G2
- Two suction dredgers, 24hrs/day, 6 months/year
- Using UK Emission factors (as per section G1)

| Fuel Type | Emission Rate (g/m ² /sec) | | | | | | |
|--------------|---------------------------------------|-----------------|-----------------|------------------------------------|-----------------|-----------------|-----------------|
| | CO ₂ as C | CO | NO _x | NO _x as NO ₂ | SO ₂ | Benzene | PM10 |
| Fuel oil | 4.34E-05 | 4.81E-07 | 1.04E-08 | 2.60E-06 | 2.86E-06 | 1.04E-08 | 2.68E-07 |
| Gas oil | 7.14E-06 | 8.19E-08 | 2.04E-09 | 5.54E-07 | 1.62E-07 | 1.75E-09 | 3.12E-08 |
| Total | 5.06E-05 | 5.63E-07 | 1.24E-08 | 3.16E-06 | 3.02E-06 | 1.22E-08 | 2.99E-07 |

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I: Summary

- This section sets out information used in the ADMS-Roads air quality models, including receptor locations, background concentrations and a schedule of the sources included within each model.

I1: Receptors

- ADMS-Roads can plot results over a receptor grid. However, the following discrete receptors were also considered, in order to produce more accurate results.

- Table of Individual Receptor Locations:

| Receptor No. | Location | Postcode | National Grid Reference | |
|--------------|--|-----------|-------------------------|----------|
| | | | Easting | Northing |
| R0 | Harwich Tourist Information Centre, near Safeway supermarket | CO12 4EN | 624 170 | 231 925 |
| R1 | Shotley Gate – Residential Home, Marina Approach | IP9 1QJ ? | 624 800 | 233 890 |
| R2 | Bristol Arms PH, Shotley Gate, Marina Approach | IP9 1PU | 624 620 | 233 610 |
| R3 | Harwich Community Primary School, 66 Main Road, Harwich | CO12 3LP | 625 990 | 232 110 |
| R4 | Mayflower Primary School, Main Road, Dovercourt, Harwich | CO12 4AJ | 624 720 | 231 290 |
| R5 | Larksfield Crescent, Dovercourt, Harwich | CO12 4BL | 624 460 | 231 730 |
| R6 | Spring Meadow Primary School, Pound Farm Drive, Harwich | CO12 4LB | 624 050 | 231 300 |
| R7 | Harwich High Street, Junction with Victoria Street | CO12 3AP | 625 720 | 231 670 |
| R8 | Sweden Close, nr Parkeston roundabout | CO12 4JU | 623 760 | 231 550 |
| R9 | Two Village Primary School, Wix Road, Ramsey | CO12 5HP | 620 740 | 230 250 |
| R10 | Wix – Harwich Road/Colchester Road junction | CO11 2RU | 616 260 | 228 420 |
| R11 | Wix & Wrabness Primary School, Colchester Road, Wix, Manningtree | CO11 2RS | 615 970 | 228 340 |
| R12 | The Cross Inn, Clacton Road Horsley Cross, Manningtree | CO11 2NX | 612 340 | 227 370 |
| R13 | The Bricklayers Arms PH, Little Bentley, Colchester | CO7 8SL | 611 660 | 225 790 |
| R14 | Chase Road West, Hare Green (A120 / A133) | CO7 7UA | 609 560 | 225 060 |

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I2: Model Runs

➤ In summary, the input derived in these calculations is included within different model runs, as shown in the table below.

➤ Schedule of sources and models

| No. | Title | Year | Emission Source | | | | | | | |
|---------------|--------------|------|-----------------|---------------|-------------------|--------------|----------|------|----------|--------------|
| | | | Moving Ships | Berthed Ships | Terminal Vehicles | A120 Traffic | Refinery | Rail | Dredging | Construction |
| 1: | Existing | 2001 | | | | D1 | E1 | F2 | G1 | |
| 2: | Do Nothing | 2007 | | | | D2 | E1 | F2 | G1 | |
| 3 | Project | 2007 | A2 | B2 | C7 | D3 | E1 | F3 | G1+G2 | |
| 4 | Do Nothing | 2010 | | | | D4 | E1 | F2 | G1 | |
| 5 | Project | 2010 | A2 | B2 | C7 | D5 | E1 | F3 | G1+G2 | |
| 6 | Do Nothing | 2022 | | | | D6 | E1 | F2 | G1 | |
| 7 | Project | 2022 | A2 | B2 | C7 | D7 | E1 | F3 | G1+G2 | |
| 8 | Construction | 2007 | | | | D2 | E1 | F2 | G1 | H1+H2 |
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