**Port of Gladstone**
**Gatcombe and Golding Cutting**
**Channel Duplication Project**

Environmental Impact Statement

# Appendix J
# Air quality emissions data

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## Activity data

**Table 1 Construction of bund walls and barge unloading facility**

| Parameter | | WBE reclamation area | | BUF | Information source |
|---|---|---|---|---|---|
| | | Southern | Northern | | |
| **Operations** | | | | | |
| Operating hours | days/week | 6 | | | EIS assumption |
| | hours/day | 12 | | | EIS assumption |
| Generator operating hours | days/week | 7 | | | EIS assumption |
| | hours/day | 24 | | | EIS assumption |
| Timeframe | months | 18 | 18 | 12 | EIS assumption |
| **Materials** | | | | | |
| Density | tonnes/m³ | 2.6 (rock density) | | 1.8 (reclaimed material – after settling in reclamation area) | EIS assumption |
| Fines content (core material) | % | 10 | | - | EIS assumption |
| Moisture content (bund wall material) | % | 2.1 | | - | AP42, Chapter 13.2.4 Mean value for various limestone products (stone quarry and processing) |
| Moisture content (reclaimed material) | % | - | | 3.4 | AP42, Chapter 13.2.4 Mean value for exposed ground (western surface coal mining) |
| Silt loading (Paved road) | $g/m^2$ | 1 | | - | Conservative estimate based on review of public road silt loading values from AP42, Chapter 13.2.1 |
| Silt content | | | | | |
| ▪ Dusty bund wall material | % | 10 | | | EIS assumption |
| ▪ Unpaved road | % | 8.5 | | | AP42, Chapter 13.2 Mean value for construction sites, scraper routes |
| Materials required for construction of outer bund walls and BUF | | | | | |
| ▪ Armour | m³ | 60,000 | 113,000 | - | EIS assumption |
| ▪ Core | m³ | 387,568 | 567,730 | - | EIS assumption |
| ▪ Reclaimed material | m³ | - | - | 200,000 | EIS assumption |
| **Equipment** | | | | | |
| B-doubles (to haul materials from Yarwun/Targinnie quarry area) | | | | | |
| ▪ Empty weight | tonnes | 23 | | 23 | EIS assumption |

| Parameter | | WBE reclamation area | | BUF | Information source |
|---|---|---|---|---|---|
| | | Southern | Northern | | |
| ■ Payload | tonnes | 40 | | 40 | EIS assumption |
| ■ Maximum number of trips | trips/day | 130 | 198 | 21 | EIS assumption |
| Dozers | # | 2 | | - | EIS assumption |
| Graders | # | 1 | | - | EIS assumption |
| Average speed | km/hour | 11.4 | | - | AP42, Chapter 11.9. Geometric mean of grader speeds |
| Generator | # | 4 | | - | EIS assumption |
| Power output | kW | 550 | | - | EIS assumption |
| **Dimensions** | | | | | |
| Width of bund wall | m | 23 | | - | Estimated from EIS cross-sections |
| Exposed area | ha | 16 | 32 | 2.2 | Calculated from width and layout diagrams |
| Distance (one way) | | | | | |
| ■ Quarry area to site (sealed road) | km | 4.2 | | | EIS assumption |
| ■ Unsealed road, up to bund wall | km | 0 | 1.9 | | EIS assumption |
| ■ Average distance travelled along bund wall | km | 1.27 | 1.32 | | EIS assumption |
| ■ Average distance travelled from reclamation areas to BUF | km | - | - | 2.3 | EIS assumption |
| Distance travelled | | | | | |
| ■ Quarry area to site (sealed road) | VKT/day | 1,099 | 1,673 | | Calculated based on amount of material moved |
| ■ Distance travelled around bund wall | VKT/day | 330 | 1,255 | | |
| ■ Reclamation areas to BUF | VKT/day | - | - | 98 | Calculated based on volume of material used |
| ■ On-site haulage at quarry area | VKT/day | 32.5 | 49.5 | - | Calculated based on amount of material moved and assumed haul length of 500m per trip |

Dust emissions associated with the following sources at quarry area have been estimated:

- Material transfers (extraction, stockpile loading, truck loading)
- Processing (one crusher, one screen, and one conveyor transfer)
- Onsite haulage
- Wind erosion of 37ha of exposed ground, estimated from aerial imagery.

Table 2 Dredging operations

| Parameter | | Value | Information source |
|---|---|---|---|
| **TSHD** | | | |
| TSHD count | # | 1 | EIS assumption |
| Operating hours | days/week | 7 | EIS assumption |
| | hours/day | 24 | EIS assumption |
| Power | | | |
| ■ Pump power (trailing) | kW | 3,400 | Based on 8700 TSHD (www.jandenul.com) with hopper capacity of 18,000m$^3$ |
| ■ Pump power (discharging) | kW | 14,000 | |
| ■ Propulsion power | kW | 15,000 | |
| ■ Total installed diesel power | kW | 22,540 | |
| ■ Auxiliary power | kW | 4,140 | Calculated from total installed diesel power less propulsion and trailing power |
| **CSD** | | | |
| CSD count | # | 1 | EIS assumption |
| Operating hours | days/week | 7 | EIS assumption |
| | hours/day | 24 | EIS assumption |
| Power | | | |
| ■ Submerged pump power | kW | 3,800 | Based on J.F.J. DE NUL CSD (www.jandenul.com) with total installed diesel power similar to the 8700 TSHD |
| ■ Inboard pump power | kW | 12,000 | |
| ■ Cutter power | kW | 7,600 | |
| ■ Propulsion power | kW | 7,600 | |
| ■ Total installed diesel power | kW | 27,240 | |
| ■ Auxiliary power | kW | 3,840 | Calculated from total installed diesel power less submerged pump, inboard pump and cutter powers |
| **Barges (propelled by pushbusters)** | | | |
| ■ Barge count | # | 4 | EIS assumption |
| ■ Operating hours | days/week | 7 | EIS assumption |
| | hours/day | 24 | EIS assumption |
| Power | | | |
| ■ Total installed engine capacity | kW | 4,163 | EIS assumption (based on https://www.vanoord.com/activities/hopper-barge-and-pushbuster) |
| ■ Propulsion capacity | kW | 3,650 | |
| ■ Auxiliary engine capacity | kW | 513 | |
| **Tug at BUF** | | | |
| ■ Tug count | # | 1 | EIS assumption |
| ■ Operating hours | days/week | 7 | EIS assumption |
| | hours/day | 24 | EIS assumption |
| Power | | | |
| ■ Total installed engine capacity | kW | 3,271 | Table 3-10 US EPA, mean values for tugs. |
| ■ Propulsion capacity | kW | 3,080 | |
| ■ Auxiliary engine capacity | kW | 100.2 | |

Table 3 **Dredged management placement**

| Parameter | | Value | Information source |
|---|---|---|---|
| **Operations** | | | |
| Operating hours | days/week | 7 | EIS assumption |
| | hours/day | 24 | EIS assumption |
| Dozers | number | 2 | EIS assumption |
| Graders | number | 1 | EIS assumption |
| Average grader speed | Km/h | 11.4 | Geometric mean in Table 11.9-3, AP42 documents |
| Compactors | number | 1 | EIS assumption |
| Dredged material moisture content | % | 3.4 | Average for exposed ground from AP42 13.2, Western surface coal mining |
| Dredged material silt content – Stage 2 | % | 2.0 | EIS assumption |
| Dredge material – initial dredging works | $Mm^3$ | 0.31 | EIS assumption |
| Dredged material – Stage 1 | $Mm^3$ | 9.06 | EIS assumption |
| Dredged material – Stage 2 | $Mm^3$ | 6.69 | EIS assumption |
| **Dimensions** | | | |
| Footprint of exposed area | ha | 86 | Obtained from EIS concept design site layouts |
| **Haulage** | | | |
| Silt content of haul route | % | 8.5 | AP42, Chapter 13.2.2, Mean value for construction sites, scraper routes |
| Haul truck payload | tonnes | 32.5 | EIS assumption |
| Haul truck empty weight | tonnes | 28.2 | EIS assumption |
| Distance (one way) | km | 1.4 | EIS assumption |
| Average distance travelled per day | VKT/day | 4,282 | Calculated from distance and amount of material moved |

# Emission factors

## Wheel-generated dust on haul roads

The emission factors for unpaved roads were calculated from the AP42 documents in Section 13.2.2 titled ‘unpaved roads’ dated December 2003.

The equation included in the assessment is as follows:

$$E = 281.9 * k \left(s/12\right)^{a} \left(W/3\right)^{b}$$

where

E = emission factor (g/VKT)

s = surface material silt content (%)

W =mean vehicle weight (tons) and the following constants were assumed.

The multiplier of 281.9 converts the units from lb/VMT to g/VKT.

The particle size multiplier in the equation k and exponents varies with aerodynamic particle size range, as defined in Table 4.

**Table 4 Constants used in calculating emissions from wheel-generated dust**

| Constant | TSP (assumed from $PM_{30}$) | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|
| k (lb/VMT) | 4.9 | 1.5 | 0.15 |
| a | 0.7 | 0.9 | 0.9 |
| b | 0.45 | 0.45 | 0.45 |

## Materials handling

Emissions for materials handling are dependent on the amount of materials being transferred. Materials handling and transfers include truck loading and dumping using front end loaders and excavators, transfer points at conveyor transfer stations. These were calculated from the AP42 documents, using the following equation:

$$EF = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

*EF* = emission factor (kg/Mg)

*k* = particle size multiplier (dimensionless)

*U* = mean wind speed (m/s)

*M* = material moisture content (%)

The particle size multiplier in the equation *k*, varies with aerodynamic particle size range, as follows:

*k = 0.74* Particle size < 30 µm

*k = 0.35* Particle size < 10 µm

*k = 0.053* Particle size < 2.5 µm

### Dozing

The TSP emission factor for dozing is based on the AP42 Ch. 11.9 emission factor. PM10 emissions were assumed to be 75% TSP emissions, while PM2.5 emissions were assumed to be 10.5% of TSP emissions. These are based on the PM10:TSP and PM2.5:PM10 ratios of AP42 emission factors.

In equation form, the emission factor is:

$$EF_{TSP} = 2.6 \times \left(\frac{s^{1.2}}{M^{1.3}}\right)$$

where:

$EF_{TSP}$ = emission factor for TSP (kg/hr)

$s$ = silt content (%)

$M$ = material moisture content (%)

### Wind erosion from exposed areas

Emissions from erosion of exposed areas were based on the AP42 Ch. 11.9 emission factor of 0.85 Mg/ha/year. Of TSP emissions, 50% are estimated to be PM10 and 7.5% of TSP emissions are estimated to be PM2.5. The particulate matter size distribution is based on the USEPA AP42 document, Chapter 13.2.5.

## Exhaust emissions

### Auxiliary engines

Emission factors for auxiliary engines are estimated based on the NPI EET manual (NPI 2012) for maritime operations for auxiliary engines using marine diesel oil. These are summarised in Table 5.

**Table 5 Emission factors (kg/kWh) for auxiliary engines (marine diesel oil)**

| Pollutant | Emission Factor (kg/kWh) |
|---|---|
| $NO_X$ (uncontrolled) | 1.39 X 10-2 |
| CO | 1.10 X 10-2 |
| $PM_{2.5}$ | 2.8 X 10-4 |
| $PM_{10}$ | 7.5 X 10-4 |
| $SO_2$ | 6.16 X 10-3 |

### Engine room engines

Emission factors for all engines in the engine room are based on the maximum of emission factors for stationary large diesel engines (NPI 2008), and medium speed diesel engines running on marine diesel oil (USEPA 2009), with the exception of NOx and $SO_2$ which have been selected as detailed in Section 12.2.1.4.

The emission factors used are summarised in Table 6.

**Table 6 Emission factors (kg/kWh) for auxiliary engines (marine diesel oil)**

| Pollutant | Emission Factor (kg/kWh) | Source |
|---|---|---|
| $NO_X$ | 3.40E-03 | Tier III emission limit (AMSA 2015) |
| CO | 3.30E-03 | Maximum out of large diesel engine NPI emission factor and US EPA vessel emission factor |
| $PM_{2.5}$ | 4.30E-04 | |
| $PM_{10}$ | 4.70E-04 | |
| $SO_2$ | 1.99E-03 | As for CO, with emission factor adjusted to reflect 0.5% sulfur content (ASMA 2015) |

# Dispersion modelling

## Meteorological modelling

### TAPM meteorological simulations

The prognostic meteorological model, TAPM (The Air Pollution Model) Version 3.0.7, was developed by the CSIRO and has been validated by the CSIRO, Katestone Environmental and others for many locations in Australia, in southeast Asia and in North America (see www.cmar.csiro.au/research/tapm for more details on the model and validation results from the CSIRO). Katestone Environmental has used the TAPM model throughout Australia as well as in parts of Southeast Asia and North America. This model has performed well for simulating regional winds patterns. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM is a prognostic meteorological model which predicts the flows important to regional and local scale meteorology, such as sea breezes and terrain-induced flows from the larger-scale meteorology provided by the synoptic analyses. TAPM solves the fundamental fluid dynamics equations to predict meteorology at a mesoscale (20km to 200km) and at a local scale (down to a few hundred metres). TAPM includes parameterisations for cloud/rain micro-physical processes, urban/vegetation canopy and soil, and radiative fluxes.

TAPM requires synoptic meteorological information for the Gladstone region. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data are supplied on a grid resolution of approximately 75km, and at elevations of 100m to 5km above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

TAPM was configured as follows:

- Mother domain of 30km with three nested daughter grids of 10km, 3km and 1km
- 48 x 34 grid points for all modelling domains resulting in a 48 x 34km grid at 1km resolution
- 30 vertical levels, from the surface up to an altitude of 8,000m above ground level
- AUSLIG 9 second DEM terrain data
- The TAPM defaults for sea surface temperature and land use
- Default options selected for advanced meteorological inputs
- Year modelled: 1 April 2006 to 30 March 2007.

The land use for the inner 1km grid required significant modification due to the coarseness of the TAPM dataset. Representative data was derived from vegetation maps obtained from EPA and from aerial imaging by Google Earth. The coastline was also re-defined in the database to better represent the complex coastline and islands in Gladstone. Detailed 9-second arc DEM elevation data (resolution approximately 100m) was obtained from Auslig for this modelling domain. TAPM was modelled using data assimilation from three meteorological sites; Boyne Smelter (BOY), Gladstone Radar (GLR), and Targinnie Swann's Road (YAR) with the following configuration:

- BOY assimilation radius of influence 4km over the lowest 4 vertical levels
- GLR assimilation radius of influence 7km over the lowest 3 vertical levels
- YAR assimilation radius of influence 5km over the lowest 3 vertical levels.

## CALMET meteorological simulations

CALMET is an advanced non-steady-state diagnostic 3-dimensional (3D) meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF dispersion model. CALMET is capable reading in hourly meteorological data as data assimilation from multiple sites within the modelling domain; it can also be initialised with the gridded 3D prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET v6 was used to simulate meteorological conditions in the Gladstone airshed. The modelling domain was set to mirror the TAPM 1km grid described above. CALMET was initialised with the gridded TAPM three dimensional wind field data from the 1km grid. Standard modelling procedure would indicate that a 3 to 1 ratio of model resolutions from TAPM to CALMET should be maintained. However the terrain characteristics of the Gladstone region are not well represented by the coarse 3km TAPM grid and CALMET's reliance on detailed meteorological inputs from TAPM required the use of the 1km grid resolution to capture the terrain and mesoscale wind patterns pertinent to dispersion (MfE NZ 2004).

CALMET treats the prognostic model output as the initial guess field for the diagnostic model wind fields. CALMET then adjusts the initial guess field for the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation. The coupled approach unites the mesoscale prognostic capabilities of TAPM with the refined terrain and landuse capabilities of CALMET.

The use of a three dimensional wind field is a significant improvement as the CALMET modelling domain has a complete set of meteorological variables at every grid point and vertical level for every hour of the simulated year. No data assimilation was used in CALMET as the modelling domain covered a region larger than the meteorological stations could reasonably cover adequately and eliminate any possibly of erroneous convergence due to the overlap of radii of influence.

The model was set up with 12 vertical levels with heights at 20m, 60m, 100m, 150m, 200m, 250m, 350m, 500m, 800m, 1600m, 2,600m and 4,600m at each grid point. The geophysical data (land use and terrain heights) were generated from TAPM, using the adjusted land use for the 1km grid. All default options and factors were selected except where noted below.

Key features of CALMET used to generate the windfields are as follows:

- Domain area of 48 by 34km with 1km grid spacing
- 1 year time scale (1 April 2006 to 1 March 2007), divided into individual months for analysis
- Prognostic wind fields input as MM5/3D.Dat 'initial guess' field only (as generated from TAPM)
- Mixing height parameters all set as default
- Step 1 wind field options include kinematic effects, divergence minimisation, Froude adjustment to a critical Froude number of 1* and slope flows
- Terrain radius of influence set at 2km
- Cloud cover calculated from prognostic relative humidity.

*Froude number (Fn) adjustments the wind for terrain features, such that if the local Fn is less than the critical Fn and the wind at that grid point has an uphill component, the wind direction is adjusted to be tangent to the terrain.

## CALPUFF dispersion modelling

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

The assessment was conducted using CALPUFF model version 7.2.1. Technical details of the configuration of the CALPUFF model are discussed in Appendix B.

Key features of CALPUFF used to simulate dispersion:

- Domain area of 36 by 32 grids at 200m spacing, nested from the CALMET grid of 1km
- 365 days modelled (1 April 2006 to 31 March 2007)
- Gridded 3D hourly-varying meteorological conditions generated by CALMET
- Partial plume path adjustment for terrain modelled
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables
- PDF used for dispersion under convective conditions
- Dry deposition on
- Minimum turbulence velocities over land and water set to 0.2 m/s and
- All other options set to default.

Dust emissions associated with construction of bund walls and creation of final land form were modelled as area sources. Operational emissions were modelled during day hours (from 7:00am to 6:00pm). Wind erosion sources were modelled for 24 hours. With the exception of the quarry, all construction emissions were modelled as area sources with an effective height of 8m and initial vertical dispersion coefficient of 2.

The quarry was modelled as a volume source with an effective height of 15m, initial sigma-y of 100 and initial sigma-z of 10.

Dust emissions during dredge placement were modelled as area sources with an effective height of 1m for wind erosion (sigma-z of 0.3) and 5m for landscaping activities (sigma-z of 1.3).

Stack heights used for modelling emissions from the dredge vessels have been estimated from images in the manufacturer's specifications. An exit velocity of 15m/s has been assumed for both vessels.

Characteristics of the point sources used to model emissions from the dredging vessels are detailed in Table 7. Multiple point sources were used to represent the TSHD dredging in the channel, and travelling from the channel to the transfer location. All point sources were configured as shown in Table 7.

Table 7 Stack characteristics used to model emissions from the dredging vessels

| Parameter | Units | CSD | TSHD | Tug | Barges | Information source |
|---|---|---|---|---|---|---|
| Stack height | m | 19.3 | 30.5 | 10 | 10 | Estimated from images and vessel dimensions on manufacturer's specifications |
| Stack diameter | m | 1.3 | 1.0 | 0.5 | 0.5 | |
| Exit velocity | m/s | 15 | 15 | 30 | 6.7 | EIS assumption |
| Exit temperature | K | 428 | 428 | 600 | 428 | EIS assumption |