Port of Gladstone
Gatcombe and Golding Cutting
Channel Duplication Project

Environmental Impact Statement

12

Air quality and greenhouse gas assessment

Contents

12 Air quality and greenhouse gas assessment

12.1 Chapter purpose

The purpose of this chapter is to describe the air quality conditions that apply to the Project and the Project impact areas. This includes existing air quality levels for various parameters, existing greenhouse gas (GHG) emissions sources and inventory, potential air quality and GHG impacts from Project activities, and the identification of mitigation measure to be implemented. Elements of the air quality and GHG assessment include:

- Describing the existing air quality of the Gladstone region, including the influences of local terrain and existing land uses and ambient air quality concentrations (refer Section 12.4.1)
- Describing the existing GHG sources inventory (refer Section 12.4.2)
- Project emissions inventory as key assumptions into the air quality and GHG impact assessment and modelling (refer 12.5.1)
- Assessment of potential air quality impacts during the construction and operational phases of the Project (refer Section 12.5.2)
- Assessment of predicted GHG emissions from the Project (refer Section 12.5.3)
- Identification of mitigation measures to be implemented to minimise the potential air quality and GHG impacts from the Project (refer Section 12.6).

The air quality and GHG assessment also informs the Project description and other impact assessment chapters in the EIS, including:

- Project description (Chapter 2)
- Nature conservation (Chapter 9)
- Cumulative impact assessment (Chapter 21).

12.2 Methodology

12.2.1 Air quality

12.2.1.1 General approach

The air quality assessment is based on a dispersion modelling study that incorporates site-specific meteorology, terrain, land use and the geographical location of sensitive receptors with source characteristics and air pollution emission rates estimated from Project concept design, publicly available information and emission estimation technique manuals. Considerations for assessing air pollutants are discussed in Section 12.3.1, including the relevant air pollutants and the legislative framework for managing air pollutants emissions.

The existing environment, including local geography, meteorology and existing air quality, are discussed in Section 12.4.1. A brief discussion of climate is contained in Section 12.4.1.3 and further detail in Chapter 11 (climate and climate change assessment).

The assessment has been conducted in accordance with recognised regulatory techniques for meteorological modelling and dispersion modelling. A meteorological data file previously generated as part of the Gladstone Airshed Modelling System (GAMS) (Katestone 2009) was used to drive the CALPUFF dispersion model.

The methodologies that were used to generate the meteorological dataset, calculate emissions, determine scenarios, and considerations for cumulative impacts are discussed in the sections below. Technical specifications of the meteorological and dispersion model input files are detailed in Appendix J.

Ground-level concentrations of key pollutants, including dust during construction and dredged material placement, and exhaust pollutants emitted by dredging vessels and land based equipment were predicted across a network of evenly-spaced gridded receptors and at sensitive receptor locations and compared to the relevant air quality objectives and guidelines (refer Section 12.3.1).

12.2.1.2 Existing conditions

Air quality in Queensland is regulated and managed by the Queensland Government through the EP Act and the EPP (Air). Guidance on the information to be included as part of the application process for ERAs is provided by the DES's application requirements for activities with impacts to air.

The Gladstone region is highly industrialised and, consequently, the ambient air quality is currently monitored by a network of monitoring stations operated by DES. The main air pollutant emitted by the Project will be particulate matter.

Features of the Gladstone region that affect the flow of winds include its coastal proximity, the large deep-water harbour and elevated terrain around Mt Larcom. Seasonal variations in wind patterns are largely influenced by southeast trade winds with diurnal variations due to sea breezes resulting in a high percentage of easterly daytime winds. In general, the predominant land uses near the Project are the residential, port infrastructure, industrial and open space areas (e.g. parks, reserves) of Gladstone with agriculture, shrubland and forest located further inland and scattered along the coastline.

12.2.1.3 Project activities

Different activities associated with different phases of the Project are anticipated to generate dust and emit a number of pollutants in varying degrees. These are summarised in Table 12.1.

Where emissions are identified to be significant to the Project, emissions were quantified and modelled explicitly. For Project phases that span several years, the worst-case scenario was assessed. Factors considered in the selection of a scenario included the total emissions, location of sources relative to sensitive receptors, and operational factors.

There are a number of Project activities wherein emissions are expected to negligible or are expected to occur a considerable distance from the sensitive receptors considered. These have not been considered further.

Table 12.1 Summary of Project activities and their relevance to air quality

Activity description	Relevance to air quality
Placement of navigational aids	The removal and relocation of existing navigational aids and the installation of the new navigational aids require the use of a diesel generator with hydraulic pumps. Exhaust emissions will be generated. However, these are expected to be negligible and will occur in the vicinity of the channel duplication area to be dredged, located a significant distance from any of the sensitive receptors. These have not been considered further in the air quality assessment.

Activity description	Relevance to air quality
Construction of the BUF and WBE reclamation outer bund wall	The construction of bund walls through the placement of armour and core material, and subsequent dozing to shape the structures will generate dust emissions. The Targinnie/Yarwun quarry area will be the source of armour and core material for the construction of the bund walls. Dust emissions associated with the extraction of material that is required for the construction of bund walls from the quarry area have been quantified and explicitly modelled. This includes wheel-generated dust emissions from the transport of materials from the quarry to the WBE reclamation area. Unloading and dozing the materials at the WBE reclamation area will result in localised dust emissions. Dozing will occur during daylight hours. There will be a generator to provide electricity for hydraulic pumps and to provide electricity to 20 workers. Detailed information regarding the generators is not available at this time. Emissions from four 550 kilowatt (kW) generators operating 12 hours per day have been accounted for in this assessment. There will also be exhaust emissions from vehicles transporting the materials, as well as from other vehicles. These emissions are transient and are expected to be negligible compared to dust emissions and have not been considered further in the air quality assessment.
Initial dredging works	Dredging of the barge access channel to allow barges to transport dredged material from the Gatcombe and Golding Cutting Channels to the WB and WBE reclamation areas will take approximately 6.5 weeks. The dredging will be conducted by a CSD and small TSHD. There will be exhaust emissions associated with the operation of the TSHD and CSD. Both the TSHD and CSD have several types of engines (for propulsion, trailing pumps, discharging pumps and auxiliary uses). The different engines will be running at different times, depending on whether the vessels are dredging or unloading. Key exhaust pollutants from this scenario have been modelled in this assessment.
Dredging using TSHD for the channel duplication dredging	Key exhaust pollutants from the TSHD dredging the Gatcombe and Golding Cutting shipping channels have been considered in this assessment.
Transport of workers using workboat	While the workboat will operate in closer proximity to the coast, it is anticipated that emissions will be negligible and will only occur for short periods. These have not been considered further in the air quality assessment.
Transport of dredged material to the BUF and unloading dredged material for placement within the WB and WBE reclamation areas	The TSHD will load the dredged material from the Gatcombe and Golding Cutting shipping channels into barges which will be transported using a pushbuster to the BUF, to then be unloaded using large excavators into trucks for placement within the existing WB and WBE reclamation areas. Management of dredged material within the WB and WBE reclamation areas includes gradual de-watering prior to licenced discharge into Port Curtis. Minimal dust emissions will occur until the surface areas dry out. Dust emissions due to the handling and transport of dredged material from the BUF to the existing WB and WBE reclamation areas, and maintenance of the reclamation areas have been modelled in this assessment.
Final landform, maintenance of the reclamation area, and maintenance dredging	The creation of reclaimed land above the existing surface level requires the use of construction equipment such as grader, dozer, and loaders. Operation of this equipment will result in dust emissions. Dozing will take place during daylight hours. The final landform will include a portion of the area within the bund wall being reclaimed land. There will be potential dust emissions due to wind erosion of the exposed area. As the surface will continuously be compacted during reclamation, the surface will not be as dusty compared to an exposed area with loose soil. A portion of the area within the bund walls will contain polishing ponds, and other areas will remain available for potential future capital dredging projects. This land has been assumed to remain wet. There will be exhaust emissions from the construction equipment and the maintenance dredger. However, these are anticipated to be negligible and have not been considered further.

12.2.1.4 Emissions estimation

Dust emissions

To assess potential impacts due to the activities associated with the Project, potential dust emissions from relevant activities were accounted for and have been explicitly modelled.

Dust emission rates were estimated using the base equation:

$$ER = A \times EF \times (1 - CF)$$

where:

ER = Emission rate
A = Activity/operations data
EF = Emission factor
CF = Reduction in emissions due to the implementation of control measures

Emissions of total suspended particulates (TSP), particulates less than 10 micrometres in diameter (PM_{10}) and particulates less than 2.5 micrometres in diameter ($PM_{2.5}$) were estimated using recognised and accepted methods of dust emissions estimation. These include approximation of emission factors and emission rates from National Pollutant Inventory (NPI) emissions estimation technique handbooks and the United States Environmental Protection Agency (US EPA) AP42 emission handbooks (US EPA 1998; US EPA 2004; US EPA 2006a; US EPA 2006b). The emissions estimation techniques applied in this assessment are based on standard methods that are applied throughout Australia and in the United States. These methods are consistent with those adopted for other air quality assessments conducted in Australia. The size distribution of dust particles was derived from the emission rates estimated for TSP, PM_{10} and $PM_{2.5}$.

Details of activity data and emission factor equations used in estimating dust emissions are discussed in detail in Appendix J.

Exhaust emissions

Trace emissions of NO_X, CO, volatile organic hydrocarbons (VOCs) and other pollutants will occur due to vehicle movements, however, these emissions are transient and are expected to be negligible compared to dust emissions during construction and therefore have not been considered further.

Exhaust emissions from the operation of diesel generators during construction have been estimated using emission factors in the NPI Emission Estimation Technique Manual for Combustion Engines (NPI 2008).

Exhaust emissions for the TSHD and CSD have been based on engine sizes for dredgers of these types with a TSHD hopper capacity of approximately 20,000m^3, published emission factors for combustion engines and maritime operations (NPI 2012; US EPA 2009) and information on air emissions published by the AMSA (AMSA 2015).

Exhaust emissions for the tug boat and pushbusters have been based on a total engine sizes of 3.3MW and 4.2MW for each vessel, respectively, and published emission factors for combustion engines and maritime operations (NPI 2012; US EPA 2009).

12.2.1.5 Site-specific meteorology

To manage air quality in Gladstone, the DES’s predecessor the Environmental Protection Agency with the support and backing of the Coordinator-General agreed in June 1999 to develop modelling tools specific for the Gladstone region. These tools used recently available advanced modelling techniques in a user-friendly framework. Katestone has developed and maintained the GAMS since 2001 on behalf of the Queensland Government’s Coordinator-General.

GAMS was configured based on a dispersion modelling study that incorporated site-specific meteorology, terrain, land use, and the geographical location of sensitive receivers with source characteristics and air pollution (Katestone 2009).

GAMS included a 3D meteorological dataset representative of the Gladstone region. This dataset was generated by coupling the prognostic model TAPM (developed by CSIRO) to the diagnostic model CALMET (developed by EarthTec). Observations from eight automatic weather stations maintained by the BoM and the DES monitoring stations were assimilated into the TAPM model. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the innermost nest. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

In 2008, Katestone completed an upgrade of the GAMS. Modelling was updated to the period from 1 April 2006 to 31 March 2007. The configuration of all models also took into account more recognised regulatory techniques for modelling, as well as more recent versions of the models. TAPM version 3.0.7 and CALMET version 6 were used.

12.2.1.6 Nitric oxide to nitrogen dioxide conversion

The modelling results presented in this chapter due to exhaust emissions from stack source (i.e. TSHD, CSD, generator) have assumed a constant conversion ratio of NOx to nitrogen dioxide (NO_2) of 30%. This is a conservative assumption; particularly, as maximum concentrations are anticipated to occur in the near field. The actual degree of conversion of NOx in the plume to NO_2 will depend on atmospheric conditions at the time that the emissions occur.

The percentage of NO_2 within the plume exiting the stack usually ranges from 5% to 10%. After release from the stack, nitric oxide (NO) gradually oxidises to form NO_2. The rate and extent to which this occurs depends on the presence of other atmospheric pollutants such as ozone and volatile organic compounds, and on the presence of sunlight. Measurements around power stations in central Queensland show, under worst-case conditions, that a conversion rate of 25% to 40% can occur within the first 10km of plume travel and suggest a rate of 30% at distances less than 10km. During days with elevated background levels of hydrocarbons (generally originating from bushfires), the conversion is usually below 50% in the first 30km of travel (Bofinger et al. 1986).

At nearby locations, such as those analysed for this chapter, the assumption of a 30% conversion will give a conservative estimate of the ground-level concentration of NO_2.

12.2.1.7 Dispersion modelling

Source characteristics and pollutant emission rates were incorporated into a dispersion modelling study. This was conducted using a standard regulatory model developed by EarthTec, the CALPUFF model (version 7). Ground-level concentrations of pollutants due to the various Project activities have been predicted across a Cartesian grid of receptors and compared to relevant air quality criteria. Details of the dispersion model configuration can be found in Appendix J.

12.2.1.8 Cumulative impacts

The potential cumulative impact has been estimated by adding an ambient background concentration derived from representative monitoring data to dispersion model predictions. This accounts for existing sources of key pollutants in the area. In addition, for the assessment of dust emissions during construction, dust emissions due to the extraction and transport of material required for the Project from the Targinnie/Yarwun quarry area have also been included explicitly in the dispersion model.

12.2.2 Greenhouse gas assessment

GHG emissions associated with the Project are predominantly related to construction and dredging activities. Post-dredging period activities and their likely contribution to ongoing GHG emissions associated with GPC operations are also considered.

Construction and dredging activities associated with the Project will result in Scope 1 GHG emissions, in addition to ongoing annual emissions associated with GPC controlled activities. The Project emissions will be due to the combustion of fuel in dredging vessels, earth moving equipment, generators and vehicles. The Project does not require grid electricity. Consequently, there will be no Scope 2 emissions relevant to the Project.

12.2.2.1 Construction emissions

Dependant on the availability of dredging equipment there are two potential scenarios guiding the schedule of construction activities for the Project:

- A staged approach (Stages 1 and 2)
- A singular campaign.

Indicative timings associated with each scenario are summarised in Table 12.2 and Table 12.3, respectively. Commencement of dredging activities is subject to actual and forecast Port throughput and associated vessel movements over the next 5 to 10 years. The potential delayed commencement of the dredging program provides the opportunity to construct the reclamation bund walls over an extended period to minimise potential environmental impacts (e.g. noise, dust) and allow gradual placement and settlement of bund wall material.

Annual GHG emissions associated with the Project have been estimated for each scenario according to Project components. Assumptions associated with the estimation of GHG emissions associated with each stage of the Project are discussed in the sections below. A summary of estimated annual emissions, expressed as tonnes of CO_2 equivalent (CO_2-e) is presented in Section 12.4.2.2.

Table 12.2 Staged approach – Project components and indicative timing for estimation of annual greenhouse gas emissions

Project component	Indicative timing	Duration
WBE reclamation area bund wall construction Southern area (18 months) Northern area (18 months)	Year 1	12 months
	Year 2	12 months
	Year 3	12 months
Construction of BUF	Year 3	12 months
Initial dredging works	Year 4	6.5 weeks
Dredging – Stage 1	Year 4	33 weeks
Dredged material earthworks – Stage 1	Year 4	12 months
Dredging – Stage 2	Year 7	25 weeks
Dredged material earthworks – Stage 2	Year 7	7 months
Navigational aids	Year 7	2 to 3 months

Table 12.3 Singular campaign - Project components and indicative timing for estimation of annual greenhouse gas emissions

Project stage	Indicative timing	Duration
Bund wall construction (36 months)	Year 1	12 months
	Year 2	12 months
	Year 3	12 months
Initial dredging works	Year 4	6.5 weeks
Singular dredging campaign (Stages 1 and 2)	Year 4	45.5 weeks
	Year 5	12.5 weeks
Dredged material placement and earthworks (Stages 1 and 2)	Years 4 and 5	19 months
Navigational aids	Year 5	2 to 3 months

The methodologies used to estimate the GHG emissions resulting from the Project are consistent with the:

- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
- National Greenhouse Accounts, July 2017 (DoEE 2017)
- Greenhouse Gas Protocol (WRI/WBCSD 2007).

Greenhouse gases considered for this assessment and their associated global warming potential are summarised in Table 12.4.

Table 12.4 Greenhouse gases and their global warming potential

Greenhouse gas	Chemical formula	Global warming potential
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298

Table notes:
CH_4 = methane
N_2O = nitrous oxide

Source: NGA Factors July 2017

The emission factors (EF) and energy content factors used for this assessment are summarised in Table 12.5. These were taken from the *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Commonwealth of Australia 2017).

Table 12.5 Emission factor summary (Schedule 1, National Greenhouse and Energy Reporting Determination)

Emission source description	Energy content (GJ/kL)	EF CO_2 (kg CO_2-e/GJ)	EF CH_4 (kg CO_2-e/GJ)	EF N_2O (kg CO_2-e/GJ)	EF CO_2-e (kg CO_2-e/GJ)
Earthmoving equipment and heavy vehicles (combustion of diesel oil for stationary energy purposes)	38.6	69.9	0.1	0.2	70.20
Dredging (combustion of fuel oil for stationary energy purposes)	39.7	73.6	0.07	0.6	74.27
Electricity generation (combustion of diesel oil for stationary energy purposes)	38.9	69.9	0.1	0.2	70.20

Table notes:
GJ/kL = gigajoule per kilolitre
kg CO_2-e/GJ = kilogram of carbon dioxide equivalent per gigajoule

12.2.2.2 Post-dredging operations

After completion of the channel duplication dredging operations, GHG emissions will occur due to operational management of the final Project reclamation landform and maintenance dredging of the duplicated channel.

GHG emissions resulting from the operational management of the reclamation areas, following the completion of the Project, constitute a minor change in GPC's overall emissions inventory and therefore have not been quantified. Reporting of GHG emissions relating to maintenance dredging activities will continue to be the responsibility of the dredging company (i.e. the principal contractor and controlling entity for maintenance dredging activities).

12.2.2.3 Scope 3 emissions

Scope 3 emissions are considered to be outside of the scope of the GHG assessment for the Project.

12.3 Legislative and policy context

12.3.1 Air quality

The EP Act provides for the management of the air environment in Queensland. The EP Act gives the DES the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. The EPP (Air) was developed under the EP Act and gazetted in 1997, the EPP (Air) was revised and reissued in 2008.

The objective of the EPP (Air) is to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the EP Act (i.e. ecologically sustainable development).

The environmental values to be enhanced or protected under the EPP (Air) are the qualities of the environment that are conducive to:

- Protecting health and biodiversity of ecosystems
- Human health and wellbeing
- Protecting the aesthetics of the environment, including the appearance of building structures and other property
- Protecting agricultural use of the environment.

The administering authority must consider the requirements of the EPP (Air) when it decides an application for an environmental authority, amendment of a licence or approval of a draft environmental management plan. Schedule 1 of the EPP (Air) specifies air quality indicators and objectives for contaminants that may be present in the air environment.

The EPP (Air) air quality objectives relevant to the key air pollutants that may be generated from the Project are presented in Table 12.6.

Also relevant is the DES's application requirements for activities with impacts to air, which outlines the information to be provided to DES as part of the application process for ERAs and how the information is used. For example, how the proposed activity will be assessed by comparison with the requirements stipulated in the EP Act. In particular, an application should include, if applicable, the following:

- Description of the site and surrounding areas, including topography, prevailing winds and ambient air quality (refer Section 12.4.1)
- Any nearby sensitive places must be identified and assessed appropriately (refer Section 12.4.1.2)
- Identification and evaluation of possible impacts on air quality (refer Section 12.5.1)
- Proposed mitigation measures (refer Section 12.6.1).

The air quality assessment has been conducted in accordance with these requirements.

Also shown in Table 12.6 is the dust deposition guideline commonly used in Queensland as a benchmark for avoiding amenity impacts due to dust. The dust deposition guideline is not defined in the EPP (Air) but was recommended by the DES as a design objective and has been adopted for this Project.

The *National Environmental Protection* (Ambient Air Quality) *Measure* (Air NEMP) was established under the *National Environment Protection Act 1994* to provide a nationally consistent framework for monitoring and reporting on seven common ambient air pollutants. The standards contained in the Air NEMP have not been considered here as they apply to the assessment of ambient air quality rather than the potential impact of an individual project.

Table 12.6 Ambient air quality objectives (EPP (Air))

Pollutant	Environmental value	Averaging period	Air quality objective (µg/m³)	Number of days of exceedance allowed per year
NO_2	Health and wellbeing	1 hour	250	1
		1 year	62	N/A
	Health and biodiversity of ecosystems	1 year	33	N/A
SO_2	Health and wellbeing	1 hour	570	1
		24 hour	230	1
		1 year	57	N/A
	Protecting agriculture	1 year	32	N/A
	Health and biodiversity of ecosystems (for forests and natural vegetation)	1 year	22	N/A
CO	Health and wellbeing	8 hour	11,000	N/A
TSP	Health and wellbeing	1 year	90	N/A
PM_{10}	Health and wellbeing	24 hour	50	5
$PM_{2.5}$	Health and wellbeing	24 hour	25	N/A
		1 year	8	N/A
Dust deposition rate for total insoluble solids	Amenity guideline	1 month	120mg/m^2/day	N/A

Table notes:

mg/m^2/day = milligrams per square metre per day
µg/m³ = micrograms per cubic metre
CO = carbon monoxide
SO_2 = sulfur dioxide

Source: EPP (Air)

12.3.2 Greenhouse gas emissions

12.3.2.1 National Policy

Australia will meet its targets, under the Paris Agreement, through the Commonwealth Government's Direct Action Plan. The Queensland Government has released the Climate Change Transition Strategy to address the Paris Agreement. The Emissions Reduction Fund is a central component of the Direct Action policies that is made up of an element to credit emissions reductions, a fund to purchase emissions reductions, and a Safeguard Mechanism.

The Safeguard Mechanism has been put in place to ensure that emissions reductions purchased by the Commonwealth Government through the Emissions Reduction Fund are not offset by significant increases in emissions by large emitters elsewhere in the economy. The Safeguard Mechanism commenced on 1 July 2016 and requires Australia's largest emitters to keep emissions within baseline levels. It applies to around 140 large businesses that have facilities with direct emissions (Scope 1 Emissions) of more than 100,000 tonnes of carbon dioxide equivalent (tCO_2-e) a year and is expected to cover approximately half of Australia's emissions.

Due to the nature of the Project, GHG emissions will result from construction activities. The Safeguard Mechanism for GPC controlled activities will not be triggered for such emissions or ongoing operational emissions which is assessed and reported each year.

12.3.2.2 National Greenhouse and Energy Reporting

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report GHG emissions and energy consumption.

The NGER Regulation recognises Scope 1 and Scope 2 emissions as follows:

- Scope 1 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility
- Scope 2 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

Registration and reporting is mandatory for corporations that have energy production, energy use or GHG emissions that exceed specified thresholds. GHG emission thresholds include Scope 1 and Scope 2 emissions. NGER reporting thresholds are summarised in Table 12.7.

Table 12.7 National Greenhouse and Energy Reporting thresholds – greenhouse gas emissions and energy use

Threshold level	Threshold type	
	GHG ($ktCO_2$-e)	Energy consumption (TJ)
Facility	25	100
Corporate	50	200

Table notes:

$ktCO_2$-e = kilotonnes of carbon dioxide equivalent
TJ = terajoule

12.4 Existing environment

12.4.1 Air quality

12.4.1.1 Local terrain and land use

The coastal city of Gladstone is located approximately 525km north of Brisbane in Central Queensland. It is situated in a sub-tropical region comprising of a flat coastal plain bordered by a range of mountains to the west, typically 5km to 10km from the coast, with the most prominent peak, Mt Larcom, rising up to 600m in elevation. The coastline in the region faces northeast to the Pacific Ocean while two large barrier islands, Curtis Island to the north and Facing Island to the east, shelter the Gladstone coast to form a deep-water harbour known as Port Curtis.

The region’s physical attributes have led to the development of the Port of Gladstone as a major shipping port and encouraged industrial growth. The Gladstone region is now a major industrial centre with highly developed chemical and mineral processing and refining, power generation and bulk raw material handling sectors. The infrastructure of the region includes the deep-water port, rail and road connections and the GSDA. Land covered by the GSDA is managed by the Queensland Government for existing and future industrial purposes.

The GSDA is situated at the western edge of the Gladstone region and the western shore of Port Curtis. Due to its coastal location, local winds in the GSDA are strongly influenced by the sea breeze and the prevailing southeasterly winds that are associated with the trade winds and flows along the coast. Near the centre of the GSDA lies Mt. Larcom, the region’s most dominant land-side feature.

The area to be dredged is located between Facing Island and the coastline and will extend approximately 15km in a southeast to northwest direction.

The WBE reclamation area is located at the northern end of Port Curtis adjacent to the existing Fisherman's Landing port facilities and the Western Basin reclamation area. There is an existing mining lease (ML 80003) directly to the west of the site, land surrounding ML 80003, including the residents in the Targinnie Valley are located in the GSDA. The majority of land in this area is either government-owned or industry owned, including Cement Australia, Rio Tinto and QER operated sites. The WBE reclamation area is also located opposite the three LNG facilities on Curtis Island and to the south of The Narrows.

12.4.1.2 Sensitive receptors

The nearest residences to the WBE reclamation area are located in the Targinnie Valley approximately 4km to the southwest of the site. Targinnie Valley is located within the GSDA and, accordingly, this area is intended for industrial land uses rather than residential uses.

Potential migratory bird habitats are located along the shoreline and surround the site (refer Figure 12.1). The potential impacts of air quality on these ecological values is addressed in Chapter 9 (nature conservation) (refer Section 9.15).

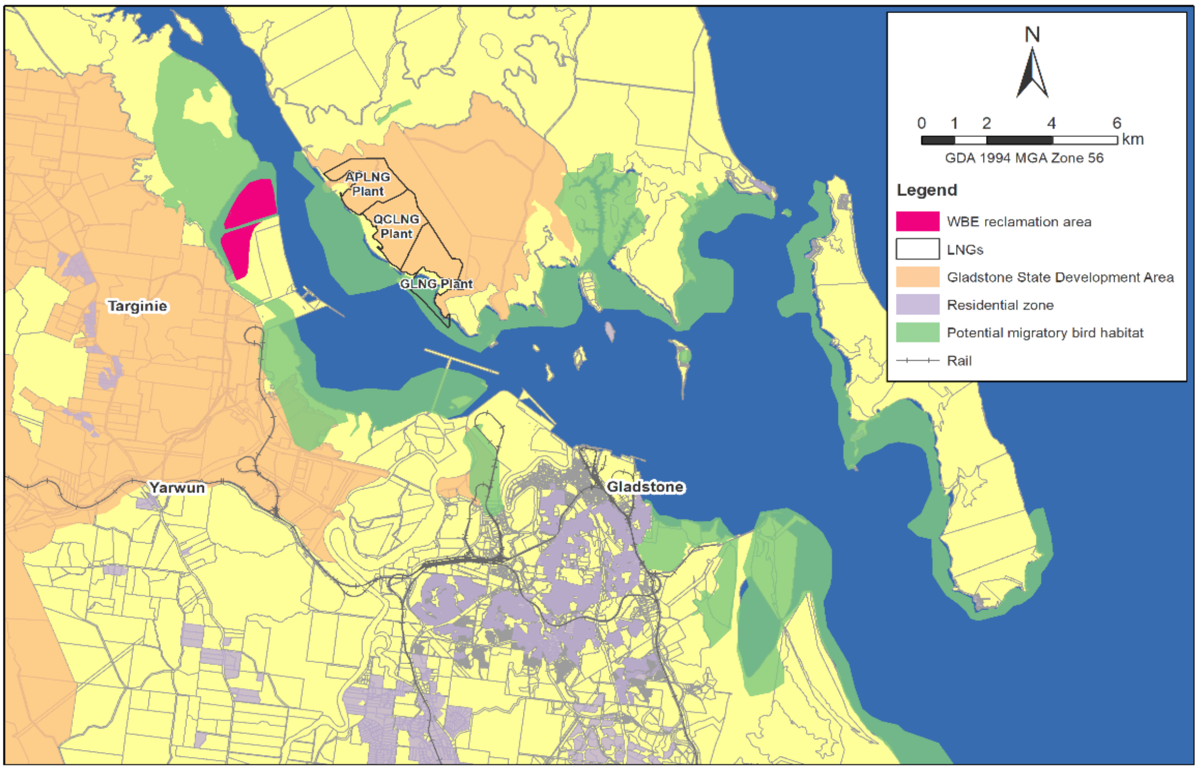


Figure 12.1 Western Basin Expansion reclamation area and adjacent land uses

12.4.1.3 Climate summary

The climate and local meteorology will influence the dispersion of air pollutants from the Project activities. In general, it is under hot, dry and windy conditions where particulate emissions have the highest potential to adversely impact on air quality away from their point of release.

The Gladstone region is located within a subtropical climate, in which generally the summer months are hotter, more humid and experience higher rainfall. This is compared to winter when the climate is drier and cooler.

Gladstone's coastal proximity, large deep-water port and elevated terrain around Mt Larcom provide a number of complexities in the flow of winds across the region. The predominant annual wind flows at Gladstone are from the sector between the northeast and south southeast with 60% of winds blowing from this direction. These winds tend to dominate the daytime flows and early evening winds, particularly during spring, summer and autumn months. During the cooler late autumn and winter months there is a more pronounced nocturnal (midnight to 6.00am) drainage flow, with winds blowing from the southern and western sectors between the south southeast and the west for 53% of the time (autumn and winter only).

Variations in seasonal wind patterns are largely influenced at a synoptic scale by the southeast trade winds. Diurnal variations in wind flows across the Gladstone region are strongly influenced by sea breezes, resulting in a high percentage of easterly daytime winds. The sea breeze generally develops around 10.00am to 11.00am each day and is often preceded by a significant shift in wind direction from the more southerly and westerly night time drainage flows.

Further detail of the key climate and meteorological parameters is provided in Chapter 11. Key meteorological parameters likely to influence the dispersion of pollutants from the Project activities are based on data recorded at the BoM's Gladstone monitoring station between 1996 and 2017.

12.4.1.4 Existing industries in the region

There are a number of industries currently operating within the Gladstone regional airshed, including a 1,650 megawatt coal-fired power station, two large alumina refineries, an aluminium smelter, an ammonium nitrate and cyanide manufacturing facility, coal handling and port facilities, a cement manufacturing facility, quarrying, mining and landfilling activities. There are also three operational LNG plants located on Curtis Island. Emissions from industry include NO_X, CO, SO_2, VOCs, metals and other air pollutants. Particulate matter emissions are also reported as TSP, PM_{10} and $PM_{2.5}$. Other sources of NO_X, SO_2 and particulate matter include heavy site vehicles, machinery and shipping. Other sources of particulate matter in the region include bushfires, landfills, commuter and freight trains, including raw material transport, exposed areas of land, construction activities and traffic on public roads.

A summary of the NPI emissions database for industries within approximately 20km of Gladstone for the 2016 to 2017 reporting period is presented in Table 12.8 (NPI 2018). All other industries reporting to the NPI are located approximately 60km or more from Gladstone or did not commence operations until after this reporting period. The APLNG plant on Curtis Island is not included in the database as operations commenced after this reporting period.

Table 12.8 Emissions from existing industries in the Gladstone region for the 2016 to 2017 National Pollutant Inventory reporting period

Facility	Main activities	Distance and direction from Gladstone (km)	CO (t/year)	NOx (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	SO_2 (t/year)
WICT	Coal export terminal	1.6 W	6.6	22	140	1.7	1.9
Gladstone Power Station	Electricity generation using mineral gas including coal gas	2.8 SW	720	29,000	150	48	24,000
RGTCT	Port operation	3.1 NW	180	390	400	20	0
QAL	Bauxite refining	4.7 E	611	7,367	391	54	4,830
Orica Yarwun Site	Production and storage of ammonium nitrate, nitric acid, sodium cyanide, chlorine, hydrochloric acid, caustic soda, sodium hypochlorite and expanded polystyrene beads	8.3 W	32	240	10	3	1

Facility	Main activities	Distance and direction from Gladstone (km)	CO (t/year)	NOx (t/year)	PM_{10} (t/year)	$PM_{2.5}$ (t/year)	SO_2 (t/year)
RTA Yarwun Pty Ltd	Alumina refining	9.8 W	320	2,500	530	65	2,600
Gladstone Meter Station (Queensland Gas Pipeline)	Gas pipeline	9.9 W	1	1	0	0	0
Curtis Island LNG Plant	LNG manufacturing	10.5 NW	330	63	220	47	15
Northern Oil Refinery	Used oil recycling	11.1 WNW	0	20	3	0	100
Fisherman's Landing	Cement manufacture	11.5 NW	,300	3,200	150	4	6
Boyne Smelters Limited	Aluminium smelting (from alumina)	12.2 SE	34,000	580	600	360	13,000
APLNG Facility - Curtis Island	Liquefied natural gas manufacturing	12.3 NW	1,500	5,000	31	30	8
Gladstone Quarry	Drill and blast, load and haul, crushing and screening, stockpiling and loading trucks	13.3 W	4	13	1	1	0

Table note:

t/year = tonnes per year

Source: NPI (2018)

12.4.1.5 Ambient air quality

State Government monitoring

The Gladstone region is highly industrialised and consequently the DES operates a network of ambient air quality monitoring stations in the Gladstone region (refer Figure 12.2). The main air pollutant emitted by Project activities will be particulate matter. A summary of DES monitoring station information for PM_{10} and $PM_{2.5}$ that has been reviewed for this air quality assessment is provided in Table 12.9

Table 12.9 Ambient air quality monitoring of PM_{10} and $PM_{2.5}$ at Department of Environment and Science monitoring sites in the Gladstone region

Monitoring station	Start date	Air pollutants monitored	Location/proximity to sources
South Gladstone	July 1992	NO_2, SO_2, PM_{10} and $PM_{2.5}$	Residential district
Boat Creek	June 2008	SO_2, NO_2, PM_{10} and $PM_{2.5}$	Industrial area north of Gladstone
Clinton	February 2001	SO_2, NO_2, PM_{10} and $PM_{2.5}$	Gladstone airport, close to residential areas
Auckland Point	August 2011	PM_{10}	Residential district
Targinnie	June 2008 (Swan's Road)	SO_2, NO_2, PM_{10} and $PM_{2.5}$	Industrial area north of Gladstone
	January 2000 to 2008 (Stupkins Lane)	NO_2, SO_2, PM_{10} and $PM_{2.5}$	Near shale oil plant
Boyne Island	October 2008	NO_2, SO_2, PM_{10}, $PM_{2.5}$ and CO	Northern part of residential community. Likely to be impacted by industrial emissions.

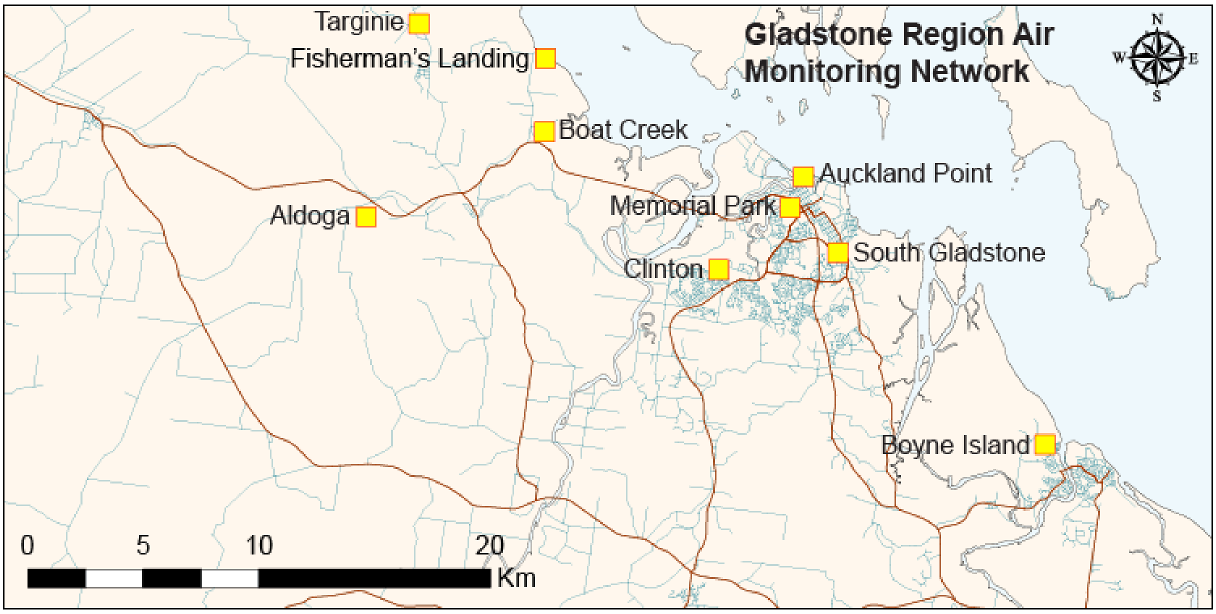


Figure 12.2 **Location of Department of Environment and Science's air quality monitoring stations in Gladstone**

Source: Queensland Government (2018)

Particulates as PM_{10}

The assessment of ambient concentrations of PM_{10} has been carried out through an analysis of the DES monitoring data recorded at all monitoring sites shown in Table 12.11. A summary of the data is presented in Table 12.10 and Table 12.11, respectively. These concentrations comply with the EPP (Air) objective for 24 hour average PM_{10} concentrations except at the Targinnie monitor, which recorded concentrations greater than 50µg/m^3 on six days during 2014. The 70th percentile, typically used to estimate ambient background concentrations, is well below the EPP (Air) objective, with an average of 16.5µg/m^3 over all stations.

Table 12.10 Summary of Department of Environment and Science monitoring information for 24 hour average concentrations of PM_{10} in the Gladstone area

Site	Year	Number of exceedances[1]	Maximum 24 hour average concentration (µg/m³)	70th percentile 24 hour average concentration (µg/m³)
Clinton	2013	0	47.0	19.8
	2014	1	69.1	14.2
	2015	0	28.9	13.3
	2016	0	28.0	14.3
	2017	0	44.6	12.9
South Gladstone	2013	0	37.6	19.0
	2014	0	49.3	18.5
	2015	0	31.5	15.0
	2016	0	32.1	16.7
	2017	0	40.2	15.5
Boat Creek	2013	1	50.5	18.5
	2014	0	38.6	17.6
	2015	1	60.1	14.8
	2016	0	30.6	16.0
	2017	1	141.2	14.6
Auckland Point	2013	0	43.1	21.0
	2014	1	86.2	17.9
	2015	1	72.8	17.8
	2016	0	46.2	19.4
	2017	0	46.2	19.5
Boyne Island	2013	0	41.2	15.4
	2014	0	29.4	13.2
	2015	0	27.6	13.0
	2016	0	42.7	15.3
	2017	0	42.7	15.4
Targinnie	2013	4	84.1	22.2
	2014	6	68.1	17.6
	2015	3	55.5	13.6
	2016	0	25.9	13.7
	2017	0	45.0	15.0
Average				**16.5**

Table note:

1 EPP (Air) objective is 50µg/m³ with five exceedances allowed

Particulates as $PM_{2.5}$

The assessment of ambient concentrations of $PM_{2.5}$ has been carried out through an analysis of the DES monitoring data recorded at all monitoring sites shown in Table 12.11. Twenty-four hour average concentrations higher than the objective of 25µg/m³ have been recorded at a number of stations; however, the annual average objective has been met at all stations during 2013 to 2017.

Table 12.11 Summary of Department of Environment and Science monitoring information for 24 hour and annual average concentrations of $PM_{2.5}$ in the Gladstone area

Site	Year	Number of exceedances[1]	Maximum 24 hour average concentration (µg/m³)	70th percentile 24 hour average concentration (µg/m³)	Annual average[2] (µg/m³)
Clinton	2013	0	23.5	8.9	7.9
	2014	1	64.8	5.9	5.5
	2015	0	17.1	4.8	4.3
	2016	0	16.8	5.3	4.8
	2017	0	22.0	4.9	4.1
South Gladstone	2013	0	18.3	6.0	5.6
	2014	1	44.0	7.3	6.0
	2015	0	13.8	5.1	4.3
	2016	0	15.9	6.3	5.7
	2017	1	28.6	6.2	5.6
Boat Creek	2013	0	19.9	5.4	4.7
	2014	0	14.8	4.9	4.2
	2015	1	50.6	5.8	5.1
	2016	0	13.2	5.1	4.6
	2017	2	122.3	5.0	4.9
Boyne Island	2013	3	30.5	7.8	5.7
	2014	0	23.7	5.0	4.6
	2015	0	13.6	4.3	3.8
	2016	1	32.2	5.0	4.5
	2017	1	32.2	5.0	4.5
Targinnie	2013	1	25.2	6.4	5.7
	2014	0	23.2	5.1	4.3
	2015	4	41.2	3.9	4.0
	2016	0	11.7	5.2	4.5
	2017	2	31.5	5.0	4.5
Average				**5.6**	**4.9**

Table notes:

1 EPP (Air) objective is 25µg/m³ for 24 hour average concentrations
2 EPP (Air) objective is 8µg/m³ for annual averages

Oxides of nitrogen

The assessment of ambient concentrations of NO_2 has been carried out through an analysis of the DES monitoring data recorded at all monitoring sites shown in Table 12.12. One hour average and annual average concentrations have met the relevant objectives at all stations during 2013 to 2017.

Table 12.12 Summary of Department of Environment and Science monitoring information for 1 hour and annual average concentrations of NO_2 in the Gladstone area

Site	Year	Number of exceedances[1]	Maximum 1 hour average concentration (µg/m³)	70th percentile 1 hour average concentration (µg/m³)	Annual average[2] (µg/m³)
Clinton	2013	0	69.7	10.25	9.3
	2014	0	69.7	10.25	8.9
	2015	0	67.7	8.2	7.1
	2016	0	61.5	8.2	7.5
	2017	0	65.6	8.2	6.9
South Gladstone	2013	0	84.0	14.35	11.8
	2014	0	94.3	12.3	11.1
	2015	0	88.1	12.3	10.4
	2016	0	75.9	12.3	11.1
	2017	0	151.7	10.3	9.6
Boat Creek	2013	0	69.7	16.4	13.0
	2014	0	80.0	16.4	12.3
	2015	0	80.0	12.3	9.8
	2016	0	67.7	12.3	10.4
	2017	0	118.9	12.3	9.9
Boyne Island	2013	0	59.4	2.05	3.1
	2014	0	57.4	2.05	2.5
	2015	0	47.2	2.05	2.4
	2016	0	55.4	2.05	2.0
	2017	0	55.4	2.1	2.1
Targinnie	2013	0	67.7	8.2	8.0
	2014	0	71.8	6.15	7.2
	2015	0	77.9	6.15	7.0
	2016	0	88.1	8.2	7.9
	2017	0	92.3	8.2	7.4
Average				**8.9**	**7.9**

Table notes:

1 EPP (Air) objective is 250µg/m³ for 1 hour average concentrations
2 EPP (Air) objective is 62µg/m³ for annual averages

Sulfur dioxide

The assessment of ambient concentrations of SO_2 has been carried out through an analysis of the DES monitoring data recorded at all monitoring sites shown in Table 12.13. One hour, 24 hour and annual average concentrations have met the relevant objectives at all stations during 2013 to 2017.

Table 12.13 Summary of Department of Environment and Science monitoring information for 1 hour, 24 hour and annual average concentrations of SO_2 in the Gladstone area

Site	Year	Average concentration (µg/m³)					Annual average[3] (µg/m³)
		Maximum 1 hour[1]	90th percentile 1 hour	70th percentile 1 hour	Maximum 24 hour[2]	70th percentile 24 hour	
Clinton	2013	97.2	5.7	2.9	37.1	3.6	2.9
	2014	140.1	8.6	2.9	16.3	4.6	3.7
	2015	151.6	8.6	2.9	15.4	4.3	3.5
	2016	148.7	8.6	2.9	19.4	4.4	3.5
	2017	128.7	8.6	2.9	17.2	2.9	3.2
South Gladstone	2013	191.6	14.3	2.9	36.7	5.5	5.0
	2014	194.5	14.3	2.9	41.4	5.6	5.7
	2015	220.2	14.3	5.7	37.4	7.0	6.6
	2016	174.5	17.2	2.9	34.2	6.9	6.4
	2017	208.8	11.4	2.9	31.5	5.7	5.0
Boat Creek	2013	191.6	11.4	2.9	36.1	6.7	5.6
	2014	225.9	14.3	2.9	41.5	6.2	5.3
	2015	314.6	14.3	2.9	28.2	6.1	4.8
	2016	171.6	14.3	2.9	38.9	7.0	5.8
	2017	157.3	11.4	2.9	40.0	5.7	5.2
Boyne Island	2013	260.3	2.9	2.9	78.3	1.9	2.6
	2014	194.5	5.7	2.9	37.3	3.1	3.7
	2015	263.1	2.9	0.0	33.3	1.5	1.4
	2016	248.8	2.9	0.0	39.9	1.6	2.0
	2017	248.8	2.9	0.0	40.0	2.9	1.9
Targinnie	2013	125.8	14.3	5.7	24.1	7.6	6.1
	2014	128.7	11.4	2.9	30.2	6.0	4.7
	2015	100.1	11.4	2.9	21.1	6.6	4.3
	2016	205.9	20.0	2.9	34.9	8.6	6.8
	2017	134.4	5.7	0.0	28.6	2.9	2.6
Average			**10.2**	**3.6**	**-**	**5.0**	**4.3**

Table notes:

1 EPP (Air) objective is 570µg/m³ for 1 hour average concentrations
2 EPP (Air) objective is 230µg/m³ for 24 hour average concentrations
3 EPP (Air) objective is 57µg/m³ for annual averages

Carbon monoxide

The assessment of ambient concentrations of CO has been carried out through an analysis of the DES monitoring data recorded at Boyne Island (refer Table 12.14). CO is not measured at any other DES monitoring stations in the Gladstone region. Eight hour average concentrations have met the relevant objective during 2013 to 2017.

Table 12.14 Summary of Department of Environment and Science monitoring information for 8 hour average concentrations of CO in the Gladstone area

Site	Year	Maximum 8 hour average concentration (µg/m³)[1]	70th percentile 8 hour average concentration (µg/m³)	Annual average (µg/m³)
Boyne Island	2013	625	78	52
	2014	1125	125	81
	2015	464	125	96
	2016	1359	125	81
	2017	1251	115	74
Average			**114**	**77**

Table note:

1 EPP (Air) objective is 11,000µg/m³ for 8 hour average concentrations

Air toxics

The Clean and Healthy Air for Gladstone Project (CHAG Project) is a Queensland Government initiative, established to gain a better understanding of air pollution in the Gladstone area and to identify any potential risks to public health. The monitoring program established as part of the CHAG Project covered a wide range of air pollutants. The Queensland Government published a final human health risk assessment report for the Gladstone area in 2010 (Queensland Health 2010). The report presents monitoring results for several air toxic species in the Gladstone region and concludes that the maximum concentrations of these species were low or very low. The overall conclusions of the report for the pollutants of interest to this study have been summarised below.

- Metals
  - Ambient levels of manganese in air were below 7.5% of the relevant objective
  - Ambient levels of nickel in air were below 5% of the relevant objective
  - For all other metals, ambient levels in air were below 2% of the relevant objective
- VOCs
  - Ambient levels of benzene in air across all monitoring sites were below 25% of the relevant objective
  - For all other VOCs, measured and modelled levels in air were well below the relevant objective
- Carbonyl compounds
  - The estimated mean levels of acetaldehyde in air at all sites were less than 10% of the relevant objective
  - For acrolein, no samples during the expanded monitoring program showed quantifiable levels of acrolein in air
  - For formaldehyde, estimated mean levels in air across the monitoring sites ranged up to 4.5% of the relevant objective
- PAHs
  - Based on the health risk assessment conducted by Queensland Health and the complementary report by EnTox, levels of PAHs in air were within relevant health-based guidelines

- PCBs
  - Based on the health risk assessment conducted by Queensland Health and the complementary report by EnTox, levels of PCBs in air either do not contribute significantly to nor exceed available international exposure standards for intake of ‘dioxin-like’ PCBs recommended by the National Health and Medical Research Council within Australia
- Dioxins and Furans
  - Based on the health risk assessment conducted by Queensland Health and the complementary report by EnTox, levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in air either do not contribute significantly to nor exceed available international exposure standards for intake of PCDD/Fs recommended by the National Health and Medical Research Council within Australia.

GPC monitoring

GPC conducts monitoring of dust and meteorological conditions in a number of locations in Gladstone (refer Figure 12.3). Data recorded by GPC's ‘Site 12’ monitoring station has been provided for use in this assessment due to the proximity to the channel duplication area to be dredged. The monitoring station is located approximately 400m from the coastline at Auckland Point and measures particulate matter as PM_{10} using a tapered element oscillating microbalance. The data is summarised in Table 12.15. The monitoring results from Site 12 comply with the EPP (Air) objective for 24 hour average concentrations of PM_{10}.

The EPP (Air) objective is 50µg/m^3 with five exceedances allowed per year. Validated data recorded at Site 12 between 1 October 2013 and 31 December 2018 has been analysed. Site 12 recorded 24 hour average PM_{10} concentrations above the EPP (Air) objective of 50µg/m^3 on eight days during 2018 and for the remainder of the period, concentrations complied with the EPP (Air) objective. The 70th percentile is similar in value to that recorded by the monitoring stations operated by DES in the wider region.

Figure 12.3 Location of Gladstone Ports Corporation’s tapered element oscillating microbalance and weather monitoring stations

Table 12.15 Summary of PM_{10} data recorded at Gladstone Ports Corporation Site 12

Parameter	Value
Date of monitoring	1 October 2013 to 31 December 2018
Data capture	88%
Maximum 24 hour	105.2µg/m³
Minimum 24 hour	1.7µg/m³
70th percentile (24 hour)	17.1µg/m³
Number of days > 50µg/m³	8

Dust deposition monitoring is undertaken by GPC at 25 sites around Gladstone. Data from a selection of sites relevant to this Project, including Tide Island, Lord Street, Carter Street and at Auckland Point has been analysed (refer Table 12.16). A summary of the data collected at these sites is provided in Table 12.16. The Tide Island monitoring station was decommissioned in March 2015.

The levels presented in Table 12.16 and Figure 12.4 are low and indicative of background levels without significant influence from industry.

Table 12.16 Summary of dust deposition monitoring

Site	Period of monitoring analysed	Deposition rate (g/m²/month)			
		Highest	Coal content in highest reading	Mean	Minimum
Tide Island	June 2013 to February 2015	3.1	15% or 0.5[1]g/m²/month	0.7	0.2
Lord Street	March 2014 to December 2018	8.0	15% or 1.2[1] g/m²/month	1.1	0.5
Carter Street	July 2013 to December 2018	2.4	25% or 0.6[1] g/m²/month	0.9	0.2
Auckland Point	July 2013 to December 2018	11.6	25% or 2.9[2] g/m²/month	0.9	0.4

Table notes:

g/m²/month = grams per metres squared per month

1 Reported as the fraction of coal in the sample

2 Reported as the fraction of mineral matter in the sample

3 Includes data from Auckland Point B&B up to December 2014, and the 9A monitoring location from June 2016 onwards

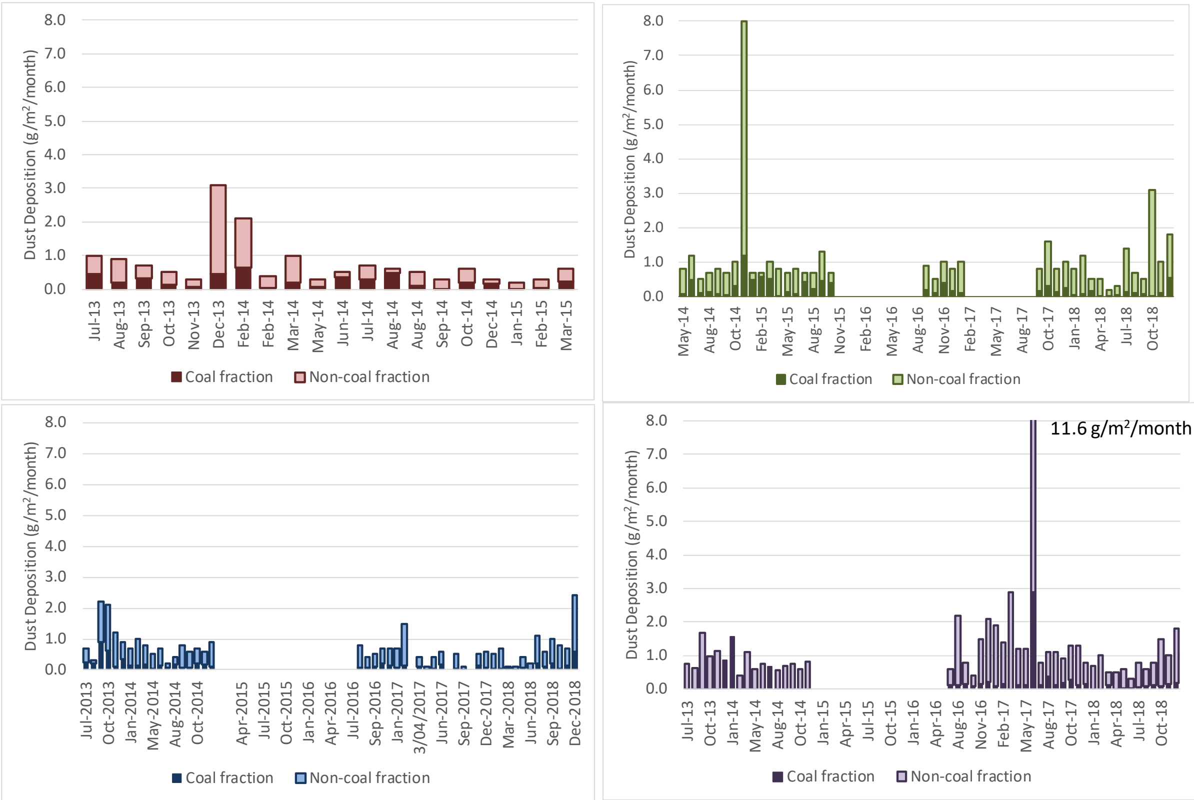


Figure 12.4 Dust deposition rates measured at Tide Island (top left), 45 Lord Street (top right), Carter Street (bottom left) and Auckland Point (bottom right)

GPC measures wind speed as part of its environmental monitoring program. Wind distributions measured by weather station 4 show that the winds are generally consistent with those measured at the BoM monitoring stations in the area, with a large portion of strong winds from the south southwest, and also from easterly directions.

Ambient background concentrations

Table 12.17 details the ambient background concentrations selected for use in the air quality assessment, which are based on the available monitoring data for the region.

Table 12.17 Ambient background concentrations selected for use in the air quality assessment

Parameter	Averaging period	Value	Source
TSP	Annual	29.0µg/m^3	Calculated from the average of the annual PM_{10} measurements at DES monitoring stations around Gladstone, assuming the PM_{10}/TSP ratio is 50%
PM_{10}	24 hour	16.5µg/m^3	Average of the 70th percentile measurements at DES monitoring stations around Gladstone
$PM_{2.5}$	24 hour	5.6µg/m^3	
	Annual	4.9µg/m^3	Average of the annual measurements at DES monitoring stations around Gladstone
Dust deposition	Monthly	32.5mg/m^2/day	Average of the measurements at GPC's Tide Island, Carter Street, 45 Lord Street and Auckland Point monitoring stations
NO_2	1 hour	8.9µg/m^3	Average of the 70th percentile measurements at DES monitoring stations around Gladstone
	Annual	7.9µg/m^3	Average of the annual measurements at DES monitoring stations around Gladstone

Parameter	Averaging period	Value	Source
SO_2	1 hour	10.2µg/m^3	Average of the 90th percentile measurements at DES monitoring stations around Gladstone
	24 hour	5.0µg/m^3	Average of the 70th percentile measurements at DES monitoring stations around Gladstone
	Annual	4.3µg/m^3	
CO	8 hour	114µg/m^3	Average of the 70th percentile measurements at DES's Boyne Island monitoring station

12.4.2 Greenhouse gas emissions existing conditions

GPC has been required to submit NGER reports for a number of years, including the most recent 2017-18 reporting period. Table 12.18 provides a summary of recent NGER reporting for GPC's activities. Based on recent reporting periods, GPC will have ongoing reporting obligations under the NGER scheme that will need to include GHG emissions associated with its controlled activities as part of this Project, aligned with the relevant reporting period. GPC controlled activities include bund wall and BUF construction, and the installation of navigational aids

Table 12.18 Summary of recent National Greenhouse and Energy Reporting for Gladstone Ports Corporation Limited

Reporting period	Energy consumed (GJ)	Scope 1 Emissions (tCO_2-e)	Scope 2 Emissions (tCO_2-e)	Total (tCO_2-e)
2017/18	854,554	30,479	59,209	89,688
2016/17	938,703	33,587	60,824	94,411
2015/16	997,593	34,215	64,758	98,973
2014/15	1,044,010	41,842	69,753	111,595
2013/14	1,050,783	42,606	72,085	114,691
2012/13	984,373	38,005	67,352	105,357
2011/12	1,006,798	39,226	70,226	109,452

Table note:
GJ = gigajoule

GHG emissions from GPC controlled facilities contribute to State and National GHG inventories. A summary of Queensland and Australia's most recently published GHG emissions inventories including categories relevant to the Project is provided in Table 12.19 (Commonwealth of Australia 2018).

Table 12.19 Summary of greenhouse gas emissions for Australia and Queensland – 2018

Category	Australia	Queensland	
	Emissions ($MtCO_2$-e)	Emissions ($MtCO_2$-e)	Contribution to national emissions
Inventory total	533.7	152.1	28.5%
Manufacturing and construction	41.6	9.1	21.9%
Transport	101.7	17.9	17.6%

Table note:
$MtCO_2$-e = million tonnes of carbon dioxide equivalent

12.5 Potential impacts

12.5.1 Air quality emissions inventory

12.5.1.1 Key dust-generating Project activities

Key dust-generating activities for the Project include:

- Construction of the BUF and WBE reclamation area bund walls, including:
  - Extraction of earth fill and rock material from Targinnie/Yarwun quarry area
  - Transport of construction material from quarries to the WB and WBE reclamation areas
  - Transport of dredged material from the WB reclamation area to the BUF
  - Unloading construction materials
  - Dozing
  - Road maintenance
- Final Project landform
  - Earthworks associated with the creation of final Project design level (i.e. 8m LAT)
  - Wind erosion from exposed area prior to rehabilitation.

Emissions of dust and degree of impact are largely dependent on the layout, equipment inventory, volume of materials, and size of exposed areas. Other factors that may also affect emissions include material characteristics, rainfall and other mitigation measures.

12.5.1.2 Construction – dust emissions during construction of bund walls

Dust is the primary air pollutant associated with the construction of the BUF and the WBE reclamation area bund walls. The construction of the BUF and bund walls requires external sourcing of materials (armour, core and fill material), transport to the site, bulldozing, and wind erosion. Dust emissions are dependent on operation details, volume of materials to be used during construction, vehicle fleet, and locations of sources relative to sensitive receptors. Dozing and the handling of construction materials will occur during daylight hours. Night time emissions will only come from wind erosion of exposed areas.

Data used in estimating emissions are detailed in Appendix J.

Dust emissions from Project activities will be reduced by the implementation of control measures (refer Table 12.20).

Dust emissions due to the extraction of the bund wall material from the Targinnie/Yarwun quarry area, and transport from the quarry to the BUF and WBE reclamation area have also been quantified as part of the cumulative assessment of the Project. It has been assumed that watering is used at the Targinnie/Yarwun quarry area to achieve a 75% reduction in emissions due to wheel generated dust from haul truck movements onsite, and a 50% control on all other extraction and processing activities. Note that these dust emissions are based on the volume of bund wall material, not the total quarry extraction rate.

Dust emissions due to material haulage have been based on the average number of trips expected per day.

Trace emissions of NO_X, CO, VOCs and other pollutants will also occur due to vehicle emissions. These emissions are transient and are expected to be negligible compared to dust emissions and have not been considered further.

The WBE reclamation area bund walls for the southern area and the northern area will be constructed over two 18 month periods (i.e. 18 months for each reclamation area). The WBE reclamation area (southern area) is shown in Figure 12.5, while the WBE reclamation area (northern area) is shown in Figure 12.6). The construction of the BUF will commence 12 months prior to dredging commencing.

Total emissions and dust emission rates for both reclamation areas are summarised in Table 12.21 and Table 12.22, respectively. Dust emissions due to the construction of the BUF have been considered in addition to construction activities in the northern area, as these will occur simultaneously for the 12 months prior to dredging commencing. Dust emissions due to construction of the WBE reclamation area (northern area) and BUF are significantly higher than during the WBE reclamation area (southern area) due to a longer travel distance from the quarry area to the northern bund wall, and due to a higher maximum number of trips per day from the quarry area, and associated BUF construction activities. Dust emissions due to the WBE reclamation area (northern area) and BUF construction have been modelled as this is expected to provide a worst-case assessment of dust impacts during the construction phase.

Table 12.20 Control measures to mitigate dust emissions during construction of bund walls and the barge unloading facility

Activity/emission source	Control measure	Reduction
Extraction of materials from Targinnie/Yarwun quarry area	Watering	50%
Onsite haulage at Targinnie/Yarwun quarry area	Watering	75%
Unsealed haul roads	Watering	50%
Exposed areas	Water truck for dust control/conditioning earth fill for compaction	50%
Movement of dredged material from the WB reclamation area to the BUF	Watering	50%
Dozing	No control	0%

Table 12.21 Total dust emissions (tonnes) for construction of bund walls at Western Basin Expansion reclamation area (18 months) and the barge unloading facility (12 months)

Activity	Location	Southern area			Northern area		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Extraction of material from Targinnie/ Yarwun quarry area	Targinnie/ Yarwun quarry area	89.3	34.1	4.6	123.5	45.7	6.0
Transport of materials from Targinnie/ Yarwun quarry area to site	Public road network	98.3	18.9	4.6	149.7	28.7	7.0
Onsite haulage and dumping of materials	Bund wall	175.0	51.2	4.9	651.4	187.9	17.8
Dozing	Bund wall	573.8	406.2	48.3	573.8	406.2	48.3
Wind erosion	Bund wall	10.1	5.1	0.8	23.6	11.8	1.8
BUF construction - Movement of dredged material from the WB reclamation area and the BUF	BUF	-	-	-	137.7 *	40.1 *	3.8 *
Total		**946.5**	**515.4**	**63.2**	**1,659.8**	**720.5**	**84.7**

Table note:

* BUF will be constructed over a 12 month period. All other construction activities in the northern area occur over 18 months.

Table 12.22 **Dust emission rates (g/s) for construction of bund walls at Western Basin Expansion reclamation area and barge unloading facility**

Activity	Location	Southern area			Northern area		
		TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Extraction of material from Targinnie/ Yarwun quarry area	Targinnie/ Yarwun quarry area	1.9	0.7	0.1	2.6	1.0	0.1
Transport of materials from Targinnie/ Yarwun quarry area to site	Public road network	2.1	0.4	0.1	3.2	0.6	0.1
Onsite haulage and dumping of materials	Northern bund wall	3.7	1.1	0.1	13.8	4.0	0.4
Dozing	Northern bund wall	12.1	8.6	1.0	12.1	8.6	1.0
Wind erosion	North and south bund walls	0.2	0.1	0.02	0.4	0.2	0.03
BUF construction - Movement of dredged material from the WB reclamation area and the BUF	WB reclamation area and the BUF	-	-	-	4.4	1.3	0.1
Total (day time)		**20.0**	**10.9**	**1.3**	**36.5**	**15.6**	**1.8**
Total (night time)		**0.2**	**0.1**	**0.02**	**0.4**	**0.2**	**0.03**

Table note:
g/s = grams per second

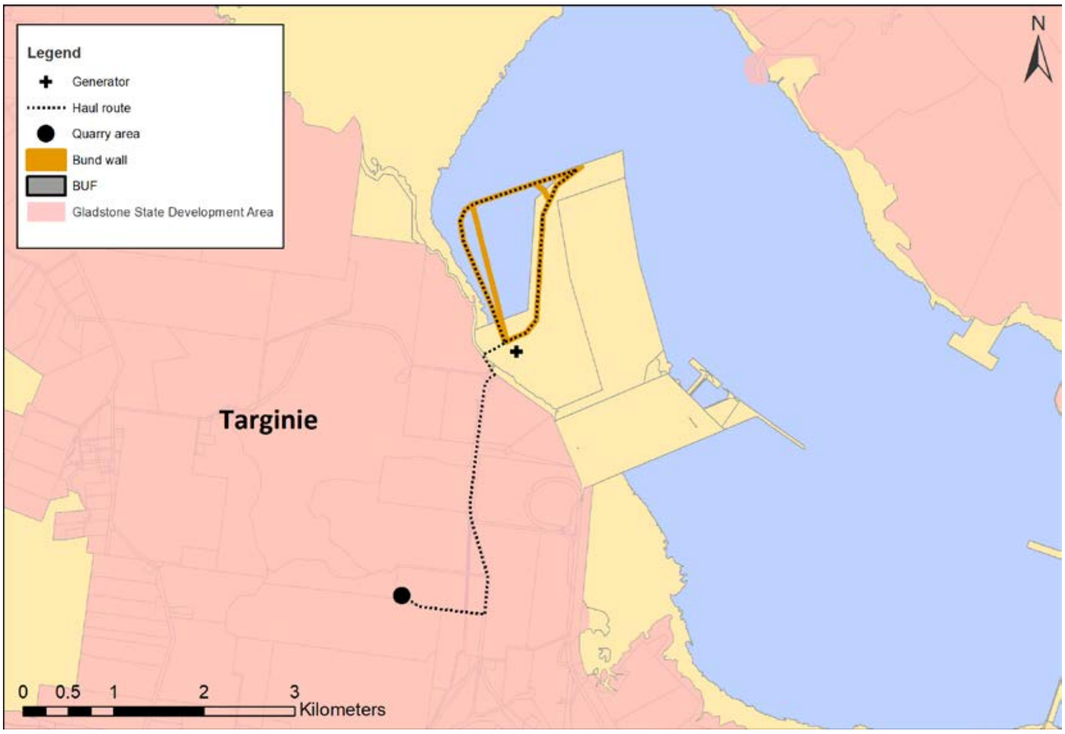


Figure 12.5 **Western Basin Expansion reclamation area (southern area)**

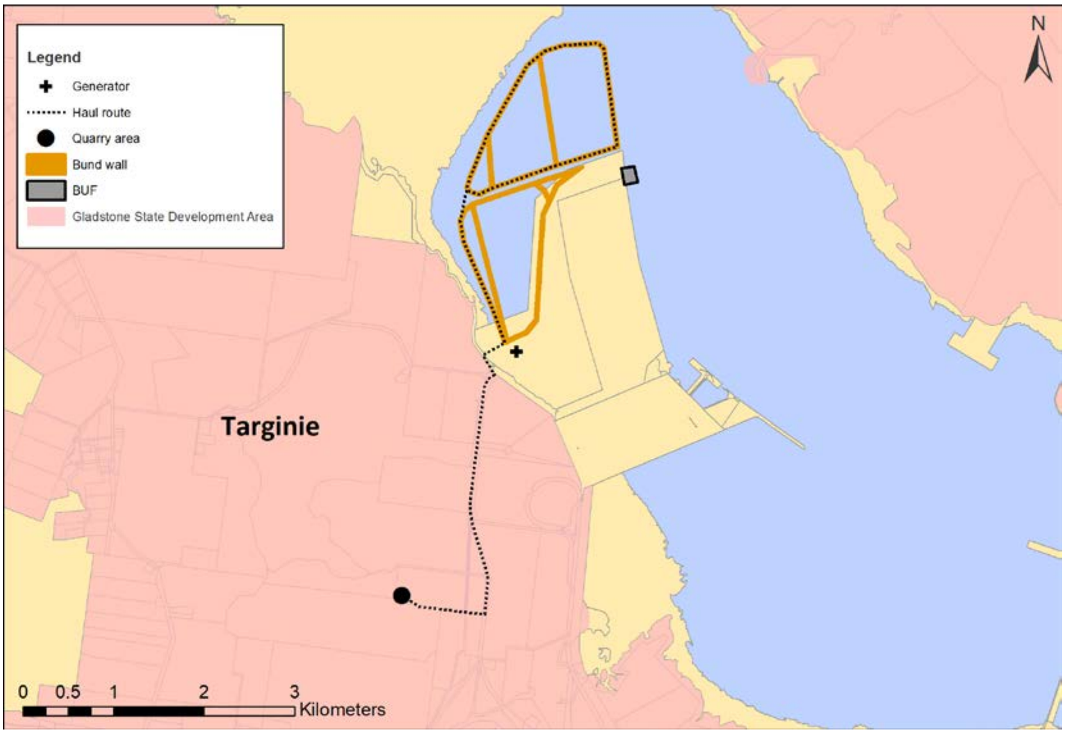


Figure 12.6 **Western Basin Expansion reclamation area (northern area) and barge unloading facility Construction – electricity generation**

During construction, it is anticipated that diesel generators will operate at the construction compound, which is to be located south of the southern area bund wall. As detailed information about the generators is not available, it has been assumed that 4 x 550kW generators will operate 12 hours/day. Emission rates have been estimated using emission factors in the NPI Emission Estimation Technique Manual for Combustion Engines (NPI 2008) and stack characteristics have been based on manufacturer's specifications for a 550kW diesel generator. Emission rates and stack characteristics used in the assessment are presented in Table 12.23.

It has been assumed that the generator stacks are not wake affected.

Table 12.23 **Emission rates and stack characteristics used in the dispersion modelling of the generators**

Parameter	Units	Value	Information source
Number	number	4	Assumed
Operating hours	hours/day	12	As for construction operations
Power output	kW	550	Assumed
Stack height	m	6.45	Assumed
Stack diameter	m	0.2	Assumed
Temperature	°C	515	Manufacturer's specifications – Cummings C550 D5e
Exit velocity	m/s	43.6	Calculated
NO_x emission rate	g/s	1.207	Calculated using emission factor for NO_x (controlled) from NPI for combustion engines
CO emission rate	g/s	0.504	Calculated using emission factors from NPI for combustion engines
$PM_{2.5}$ emission rate	g/s	0.064	
PM_{10} emission rate	g/s	0.066	
SO_2 emission rate	g/s	7.49×10^{7}	

12.5.1.3 Dredging – dust emissions during dredged material placement

Whilst the placement of dredged material into the WB and WBE reclamation areas will not involve dust emissions, as the material is wet, the surface of the reclaimed land will dry out and will be landscaped by dozers, graders and compactors resulting in dust emissions and wind erosion of dried areas. In addition, the most significant source of dust emissions will occur due to the transport of dredged material from the BUF to the reclamation areas in trucks.

The dust emissions due to these Project activities are expected to exceed ambient air quality objectives and as such have potential impacts on the flora and fauna values identified in Chapter 9.

Dust emissions due to these Project activities have been estimated for Stage 1 and Stage 2. For the estimate of emissions during Stage 2, it has been assumed that the entire future port development area has dried out and is therefore a source of wind-blown dust. This is a conservative approach and reflects a time close to the end of the dredged material placement phase of the Project that will result in the highest potential dust emissions during the dredged placement stage. It is anticipated that dredged material placement activities will occur 24 hours per day. A 75% reduction in emissions due to wheel generated dust has been used to account for watering of the haul routes used to transport dredged material.

Dust emissions during dredged material placement in Stage 2 have been modelled, as these were slightly higher than dust emissions during Stage 1. With a variation in emission rates of less than 5%, this is expected to provide an adequate assessment of the operations, with no further 'worse-case' scenario required.

Dust emissions due to truck movements have been modelled as occurring across the northern and southern WBE reclamation areas, as these travel routes may vary across these areas.

Dust emission rates associated with the transport of dredged material and management of reclaimed land are summarised in Table 12.24 and the location of these emissions are shown in Table 12.25 and Figure 12.7.

Table 12.24 Dust emission rates during dredge placement

Activity	Emission rates (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Dozing	0.7	0.5	0.1
Wind erosion	1.2	0.6	0.1
Grader	0.1	0.04	0.002
Compacting	0.3	0.3	0.04
Haulage	47.3	13.5	1.3
Total (day and night)	**49.5**	**14.9**	**1.5**

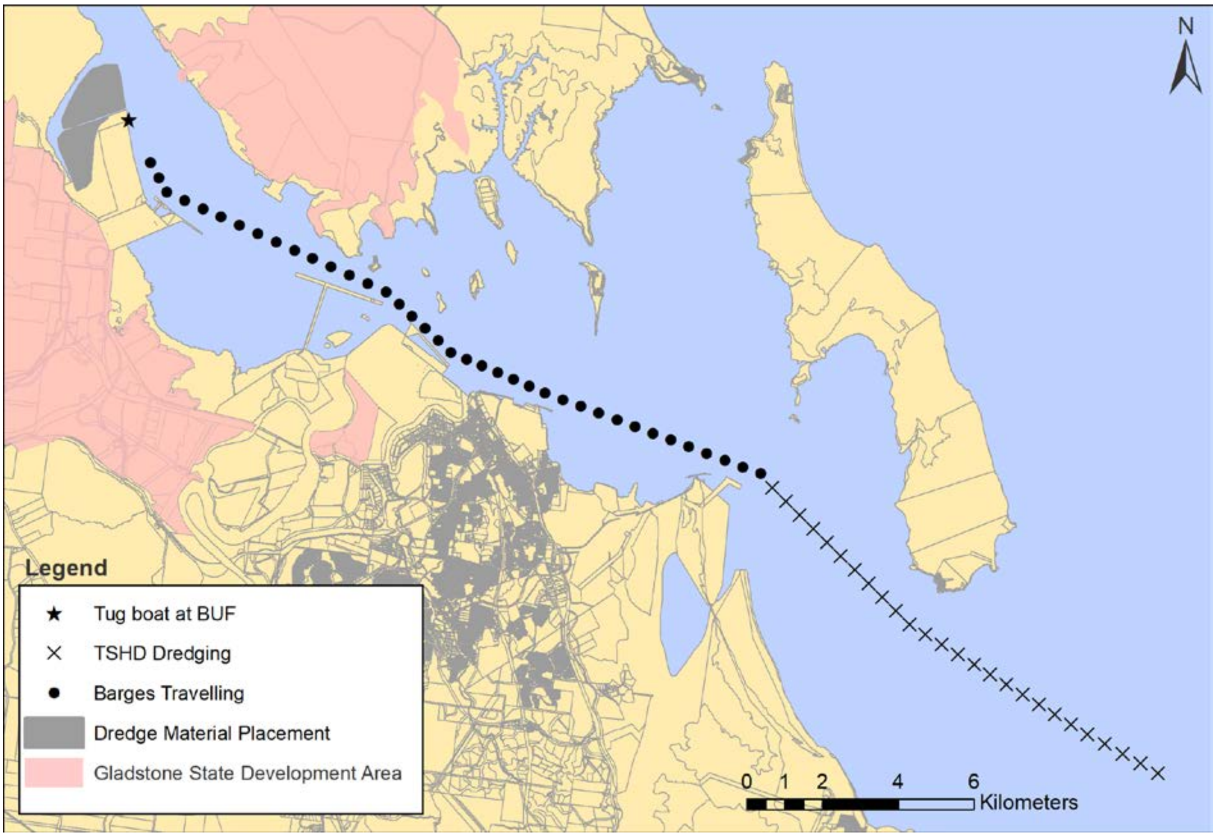


Figure 12.7 Location of emissions during dredging and dredge placement

12.5.1.4 Dredging – exhaust emissions from dredging vessels

Emissions to air will occur due to the combustion of marine diesel oil in the dredging vessels and the assisting tugs and pushbusters that transport the barges. Both the TSHD and CSD have a number of different engines onboard (including propulsion engines, engines for pumping/discharging, and auxiliary engines). The different engines of the TSHD will run at different times depending on the main activity of the vessel.

As the exact vessel types are not yet known, engine sizes listed in supplier's specifications for a small CSD and large TSHD with a hopper capacity of approximately 20,000m^3 have been used. A total installed engine capacity of 3.3MW for the tug and 4.2MW for each pushbuster have been used. This is anticipated to provide an indication of the overall potential impacts that may be likely to occur during dredging.

During the initial dredging stage, both the CSD and TSHD will operate within the barge access channel. It has been assumed that the CSD would operate all engines at all times, and the TSHD would operate the pumps (trailing) and propulsion engines whilst dredging, and auxiliary and pumps (discharging) when unloading from the hopper.

During dredging of the Gatcombe and Golding Cutting shipping channels it has been assumed that the pumps (trailing) and propulsion engines of the TSHD would operate at all times.

Emission rates for auxiliary engines have been calculated using the NPI Emission Estimation Technique Manual for Maritime Operations (NPI 2012).

Emission rates for all other engines on the dredging vessels have been calculated as follows:

- For NO_x, the Tier III emission limit of 3.4 kg/kWh has been used (ASMA 2015). This applies to marine diesel engines installed on ships constructed on or after 1 January 2016.
- For all other pollutants, emission factors for medium speed engines running on marine diesel published by the US EPA (2009) have been used

- For SO_2, the emission factor has been adjusted to reflect a sulfur content of 0.5% which is the limit to be applied from January 2020 outside emission control areas (ASMA 2015).

The emission rates of exhaust pollutants for the CSD and TSHD in various modes of operation, as well as the emissions rates for the pushbuster and tug are presented in Table 12.25.

Emission rates of exhaust pollutants from the tug boats operating at the BUF, and the pushbusters used to transport the barges with dredged material have been calculated using published emission factors for combustion engines (NPI 2008).

Emission factors used in estimating emissions, and further details on the engine sizes used in the calculations, are detailed in Appendix J.

Schematics illustrating the location of the modelled sources in the initial dredging stage and during the main dredging campaigns are presented in Figure 12.8 and Figure 12.7, respectively.

Total emissions of PM_{10} and $PM_{2.5}$ due to the combination of dredged material placement activities in the WBE reclamation area, and higher than emissions of these during construction of the WBE reclamation area bund walls. For this reason, the dispersion modelling of the Project dredging activity has included PM_{10} and $PM_{2.5}$, as well as key exhaust pollutants, including NO_x, SO_2 and CO.

It is expected that this scenario adequately addresses the potential 'worse-case' emissions during operations. It assumes that all vessels operate continuously, and that the maximum expected number of vessels are located at the BUF.

Table 12.25 Emission rates (g/s) associated with the operation of trailing suction hopper dredger, cutter suction dredger, pushbuster and tug

Pollutant	TSHD		CSD	Pushbuster (per vessel)	Tug
	Dredging	Transferring			
NO_x	17.4	20.4	28.8	15.2	12.8
CO	16.9	13.4	22.0	3.3	2.8
$PM_{2.5}$	2.2	1.9	3.0	0.4	0.4
PM_{10}	2.4	2.1	3.3	0.4	0.4
SO_2	10.1	9.9	14.9	0.4	0.4

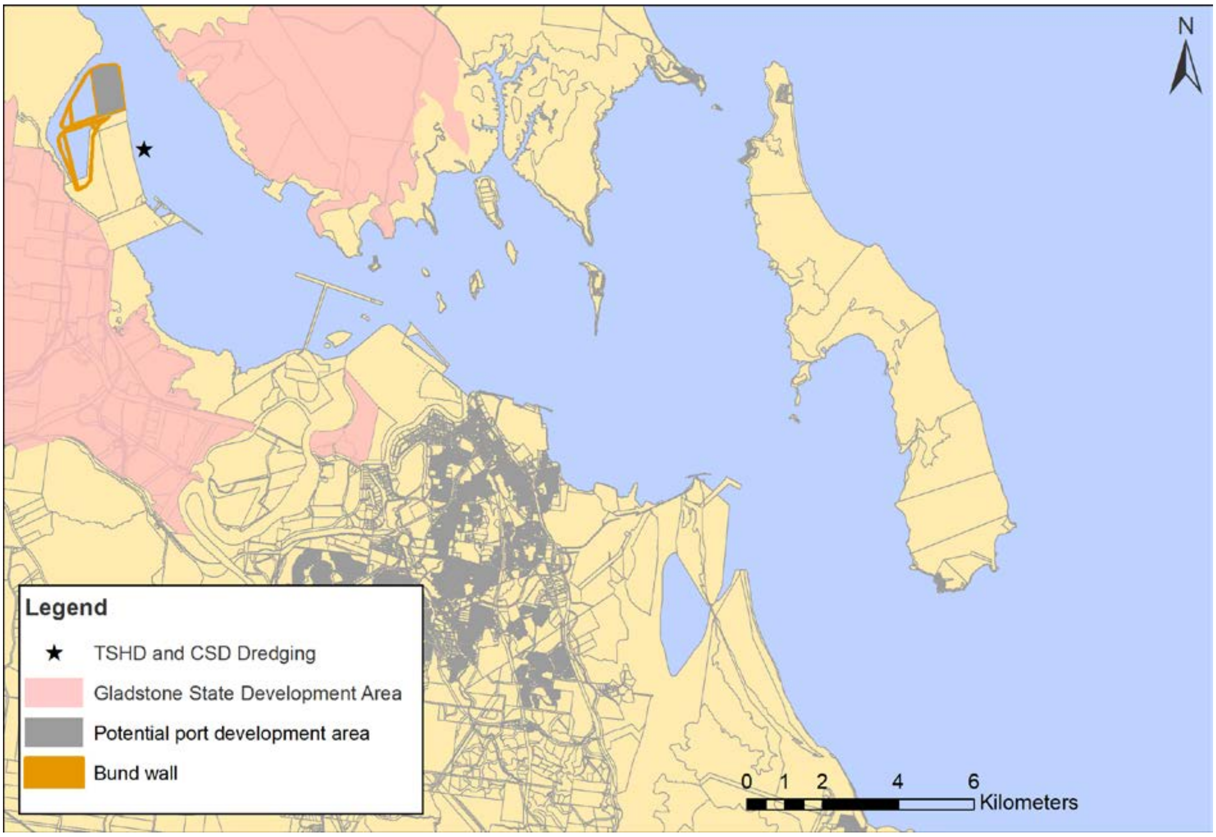


Figure 12.8 Initial dredging scenario: Location of emission sources

12.5.1.5 Final Project landform

The final landform associated with this Project is shown in Figure 12.9. The potential port development area may be a source of wind-blown dust, whilst all other areas will remain wet.

Dust emissions from this final landform stage will be lower than those calculated due to the management of reclaimed land and this final stage has therefore not been included in the dispersion model.

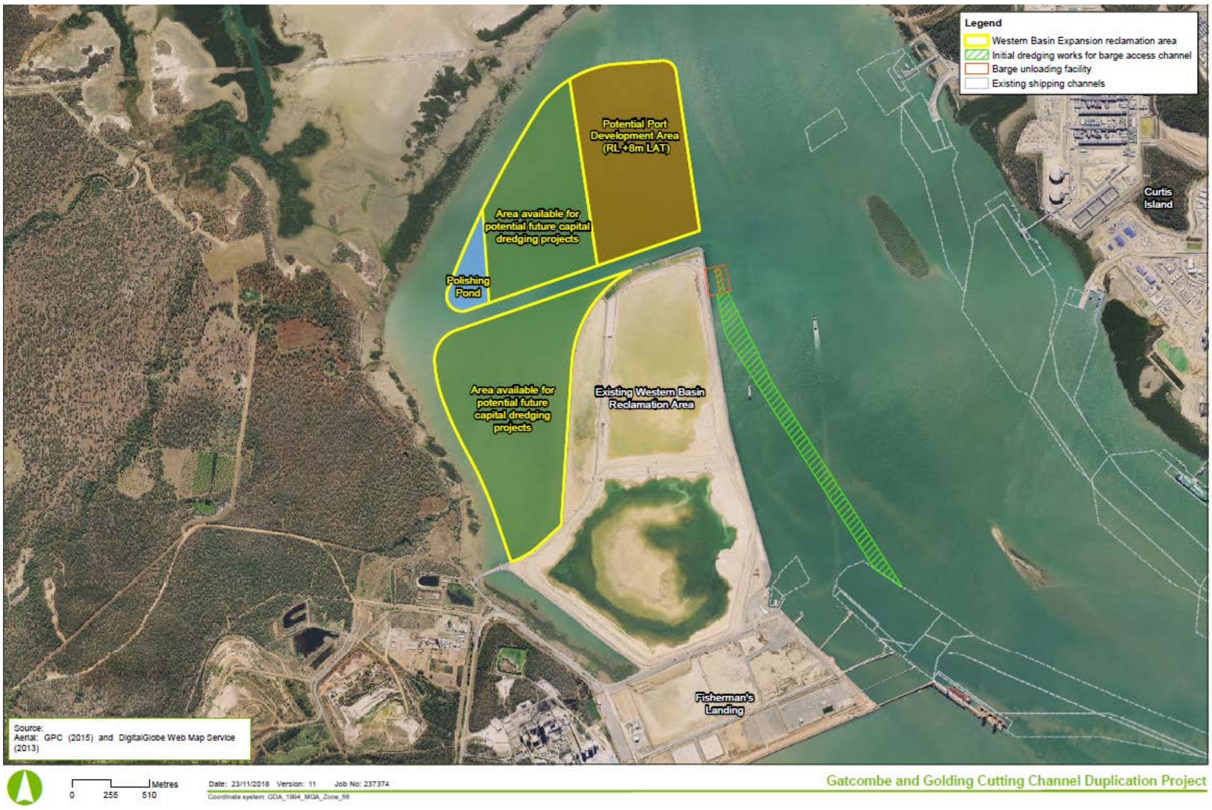


Figure 12.9 Western Basin Expansion final land uses – Project dredged material

12.5.2 Air quality

12.5.2.1 Compliance impact assessment methodology

To assess and appropriately manage the potential air quality impacts as a result of the Project, a compliance impact assessment process has been implemented (refer Figure 12.10). The compliance impact assessment focuses on assessing the extent of compliance with the relevant air quality objectives relevant to the Project impact areas and Project activities.

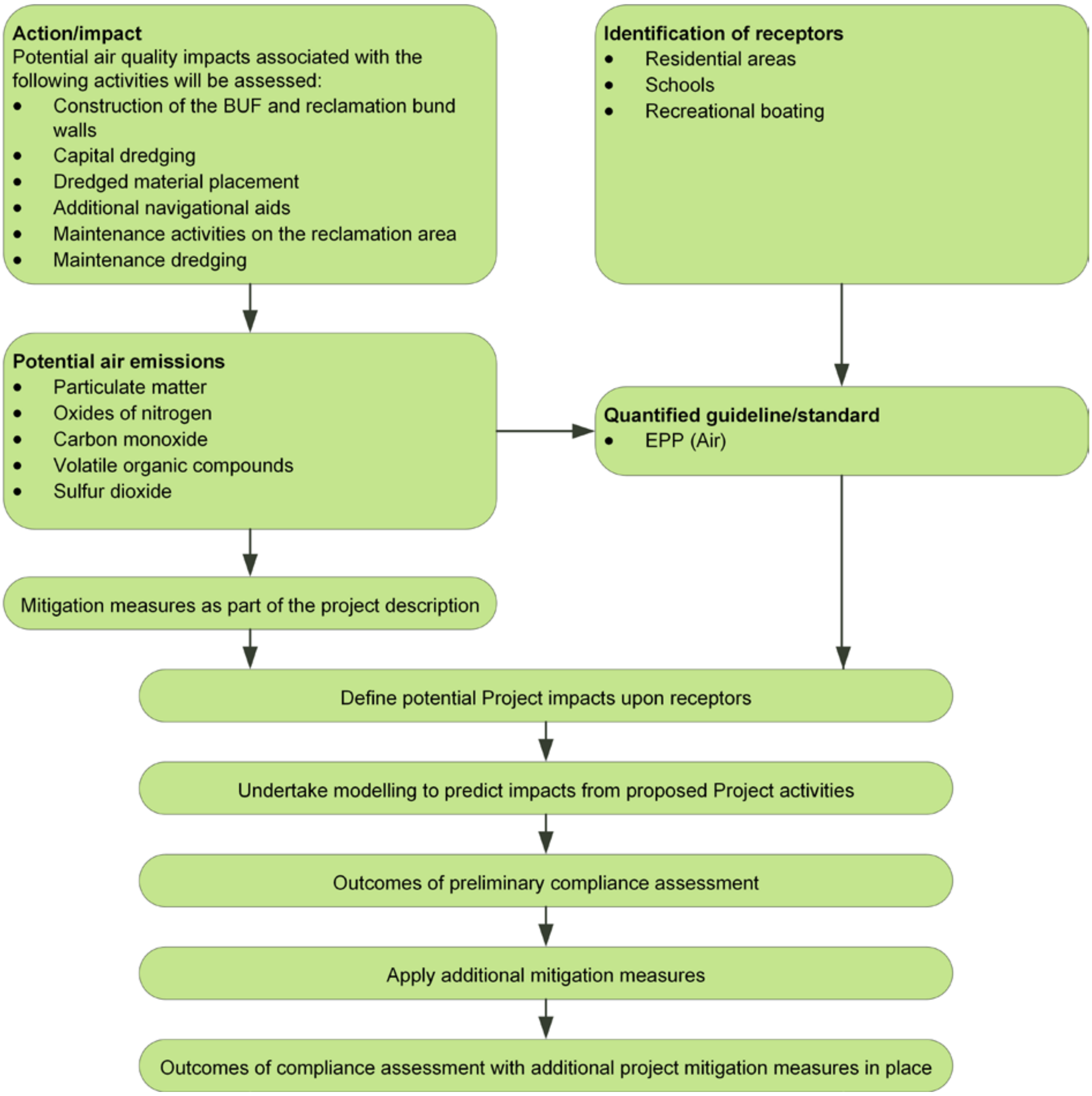
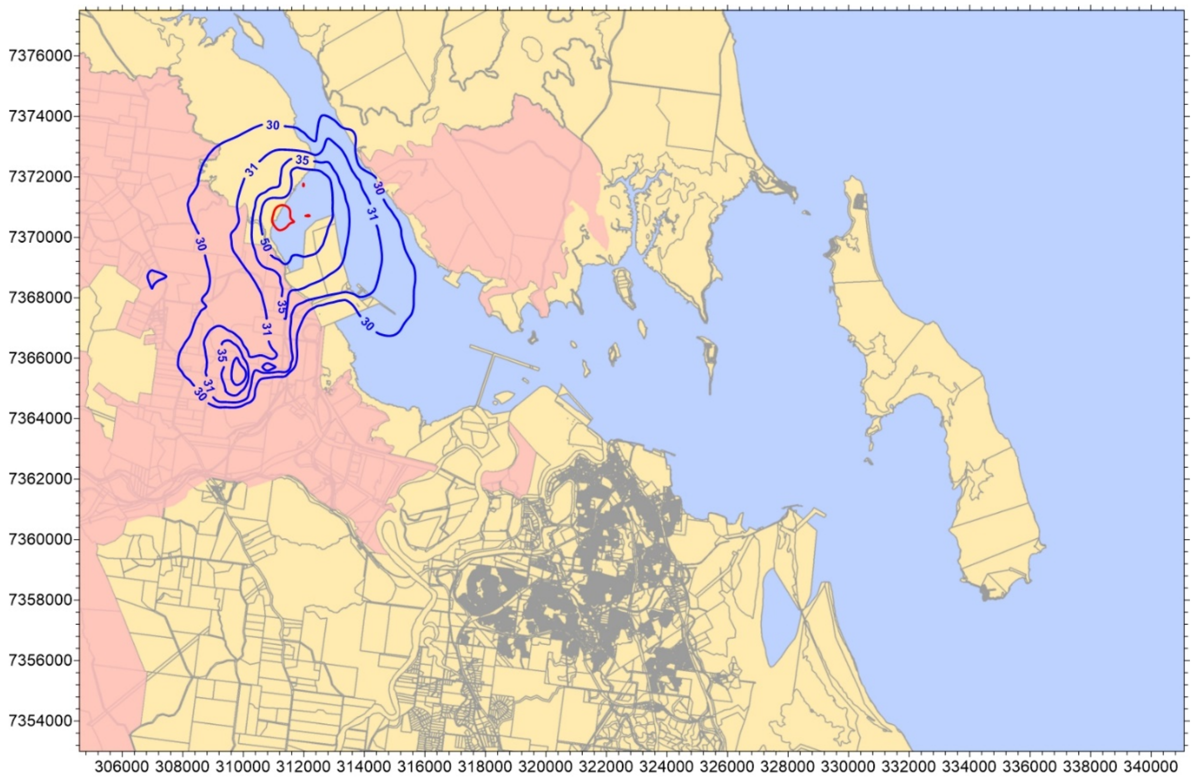


Figure 12.10 Air quality compliance impact assessment methodology

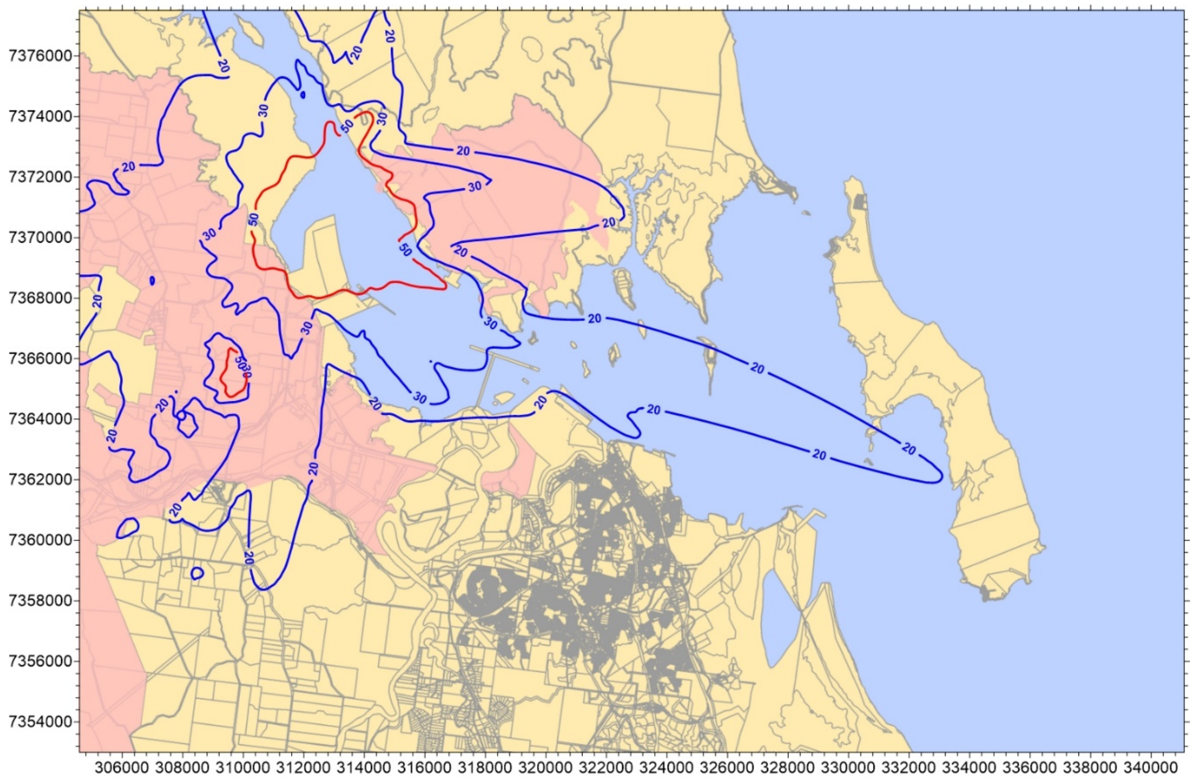
12.5.2.2 Construction of the Western Basin Expansion reclamation area bund walls

Figure 12.11 to Figure 12.15 present the predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates due to the WBE reclamation area (northern area) construction works. The results for TSP, PM_{10} and $PM_{2.5}$ include emissions from the diesel generators. Twenty four hour average PM_{10} is the key pollutant emitted during construction. The maximum 24 hour average ground-level concentrations of PM_{10} are predicted to **exceed** 50µg/m^3 in some areas; however, this is localised around the Targinnie/Yarwun quarry area and the WBE reclamation area.



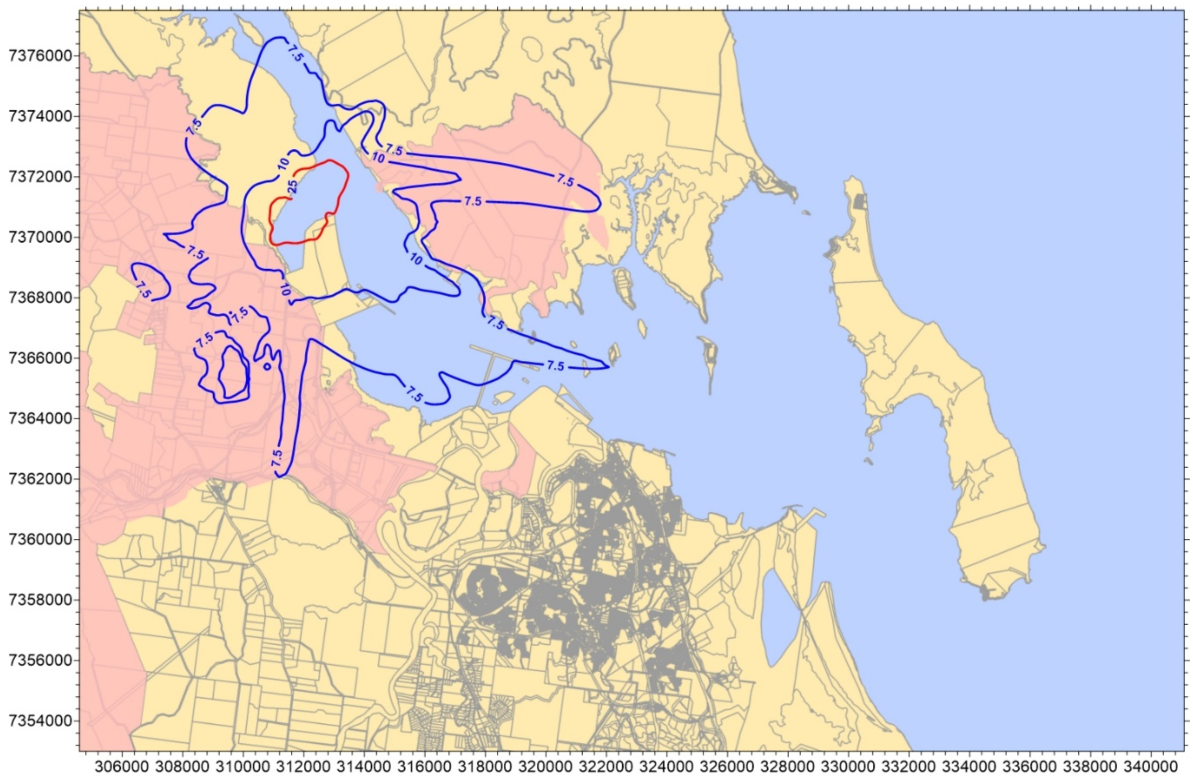
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	90µg/m^3	Annual	Calpuff	µg/m^3

Figure 12.11 Construction of Western Basin Expansion reclamation area (northern area) – Ground-level concentrations of annual average TSP due to bund wall construction and diesel generators plus an ambient background



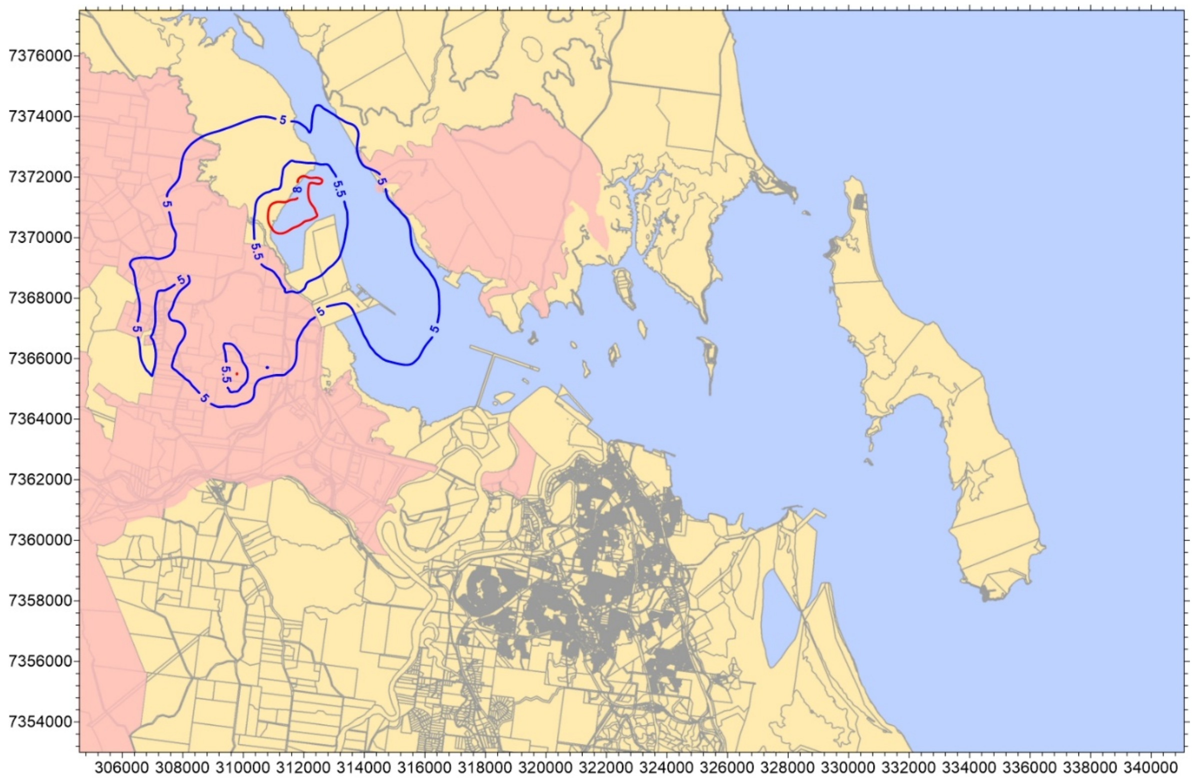
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	50µg/m^3	24 hours	Calpuff	µg/m^3

Figure 12.12 Construction of Western Basin Expansion reclamation area (northern area) – Maximum ground-level concentrations of 24 hour average PM_{10} due to bund wall construction and diesel generators plus an ambient background



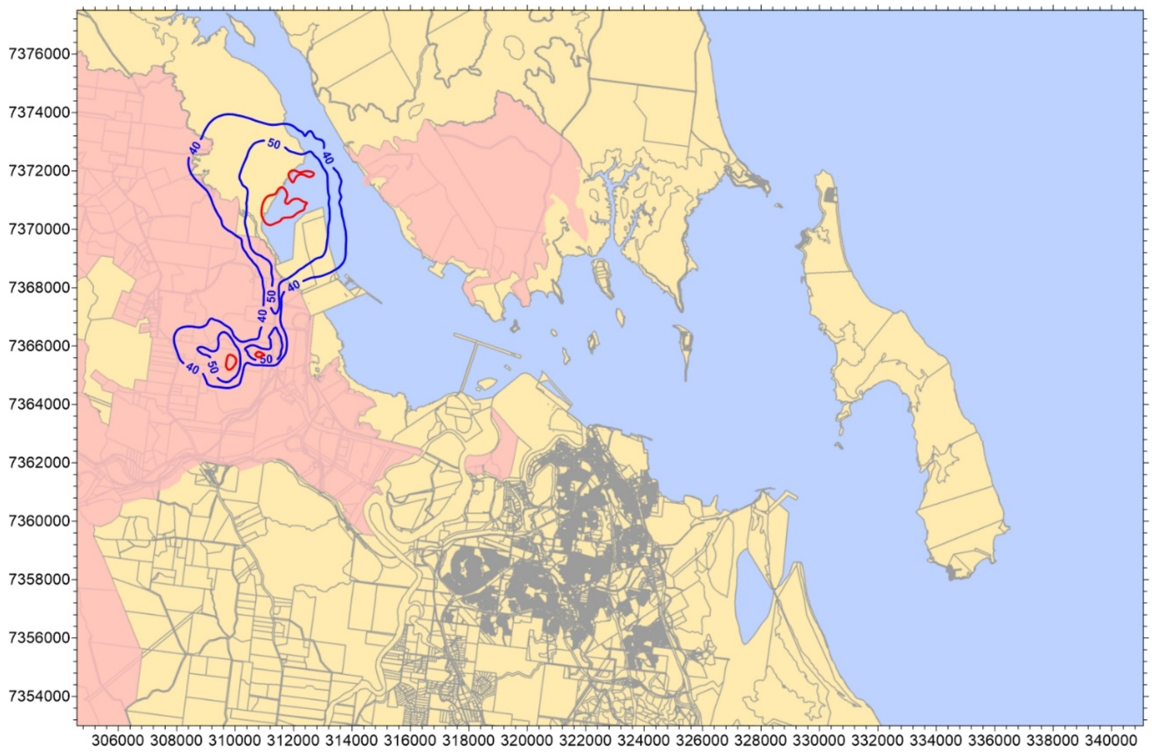
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	25µg/m^3	24 hours	Calpuff	µg/m^3

Figure 12.13 **Construction of Western Basin Expansion reclamation area (northern area) – Maximum ground-level concentrations of 24 hour average $PM_{2.5}$ due to bund wall construction and diesel generators plus an ambient background**



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	8µg/m^3	Annual	Calpuff	µg/m^3

Figure 12.14 **Construction of Western Basin Expansion reclamation area (northern area) – Ground-level concentrations of annual average $PM_{2.5}$ due to bund wall construction and diesel generators plus an ambient background**

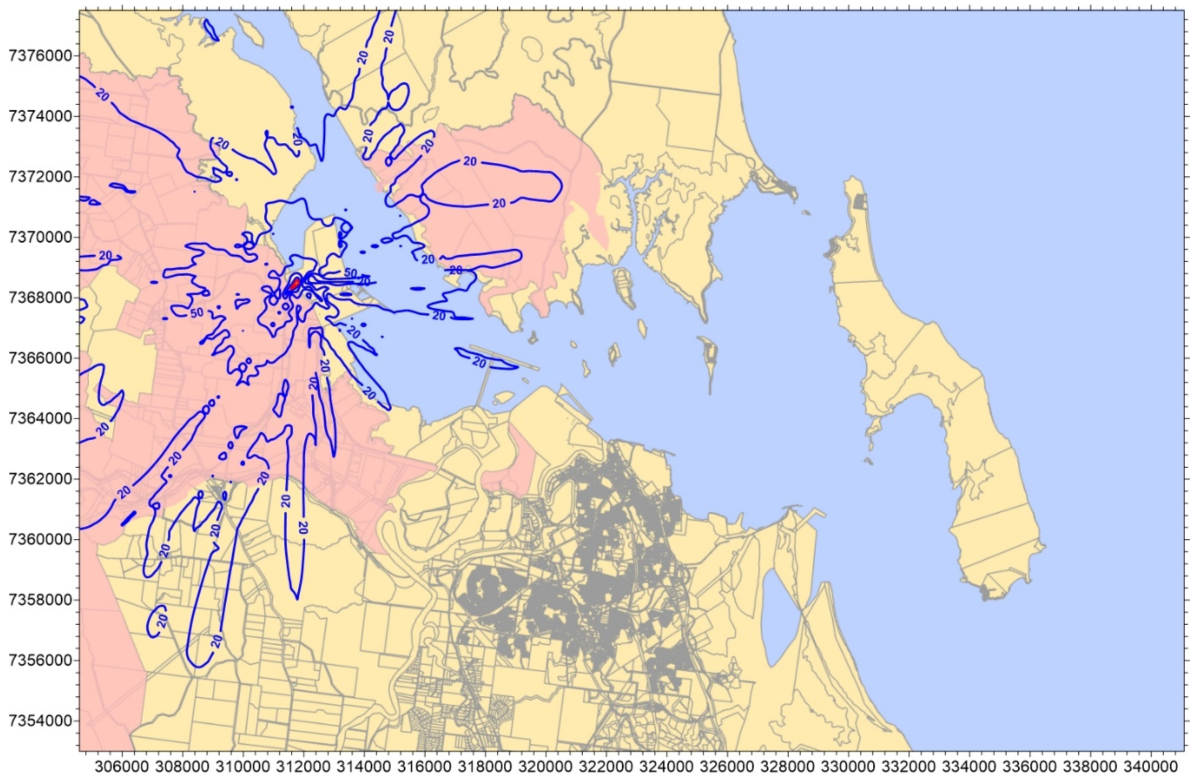


Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	120mg/m^2/day	1 month	Calpuff	µg/m^3

Figure 12.15 Construction of Western Basin Expansion reclamation area (northern area) – Maximum monthly dust deposition rates due to bund wall construction and diesel generators plus an ambient background

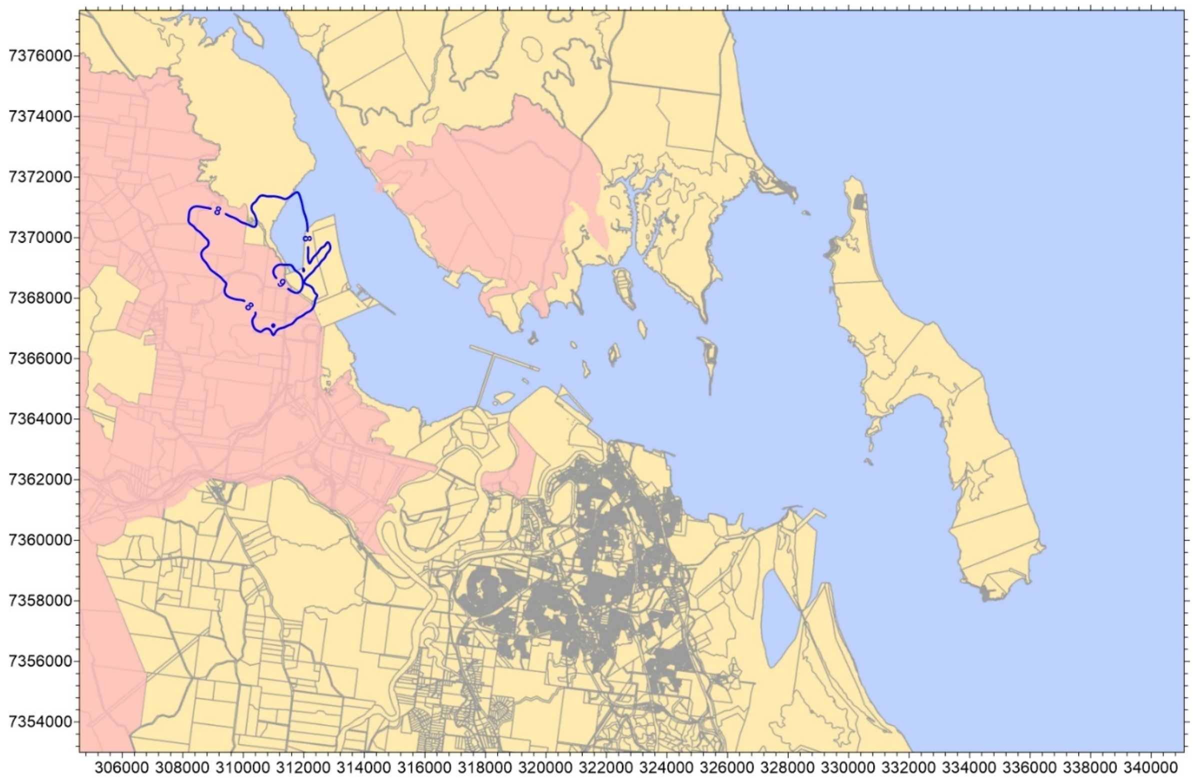
Figure 12.16 to Figure 12.21 present the predicted ground-level concentrations of NO_2, SO_2 and CO from the diesel generators. These results show that, with the exception of a small area immediately surrounding the generators for 1 hour average NO_2, ground-level concentrations of NO_2, SO_2 and CO are predicted to **comply** with the relevant air quality objectives across the model domain.

Additional management measures will be applied to further reduce ground-level concentrations of particulates during construction, including additional watering to ensure material being dozed or graded is damp or applying suppressants to further reduce emissions from material haulage over completed sections of the bund wall.



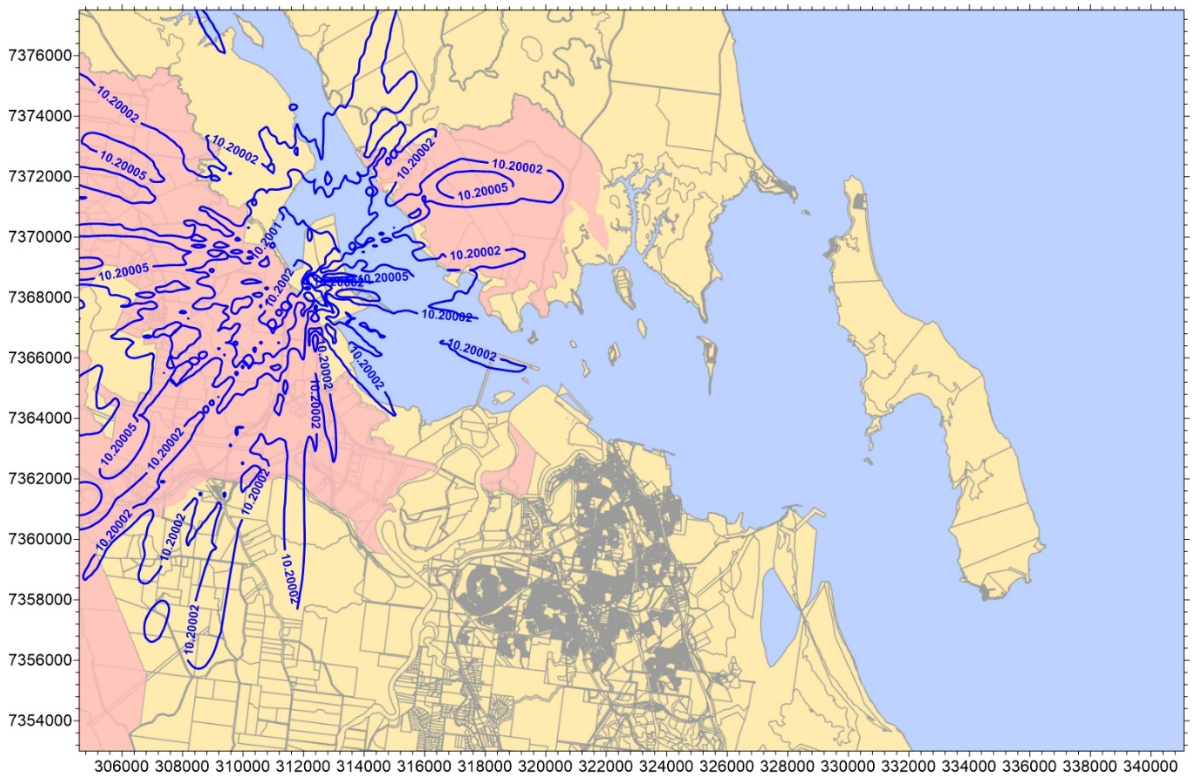
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	250µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.16 **Construction of Western Basin Expansion reclamation area (northern area) – Maximum ground-level concentration of 1 hour average NO_2 due to diesel generators plus an ambient background**



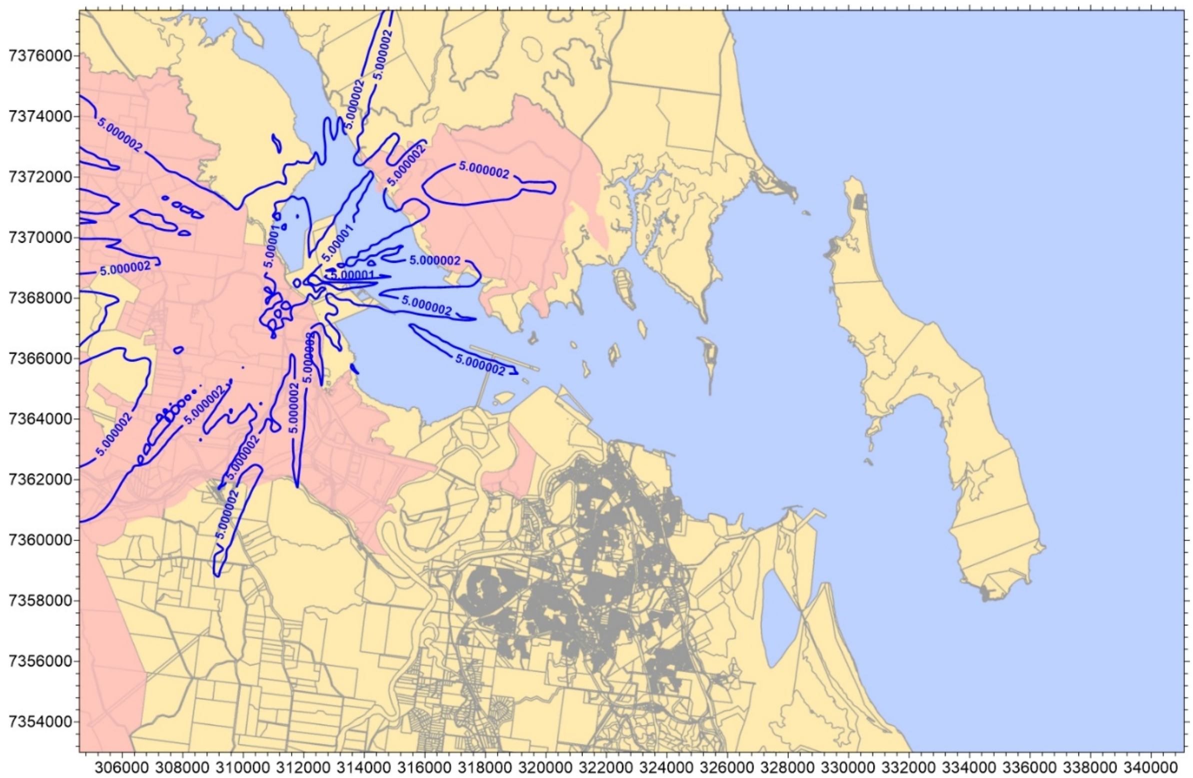
Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	62µg/m^3	1 year	Calpuff	µg/m^3

Figure 12.17 **Construction of Western Basin Expansion reclamation area (northern area) – Annual average ground-level concentration of NO_2 due to diesel generators plus an ambient background**



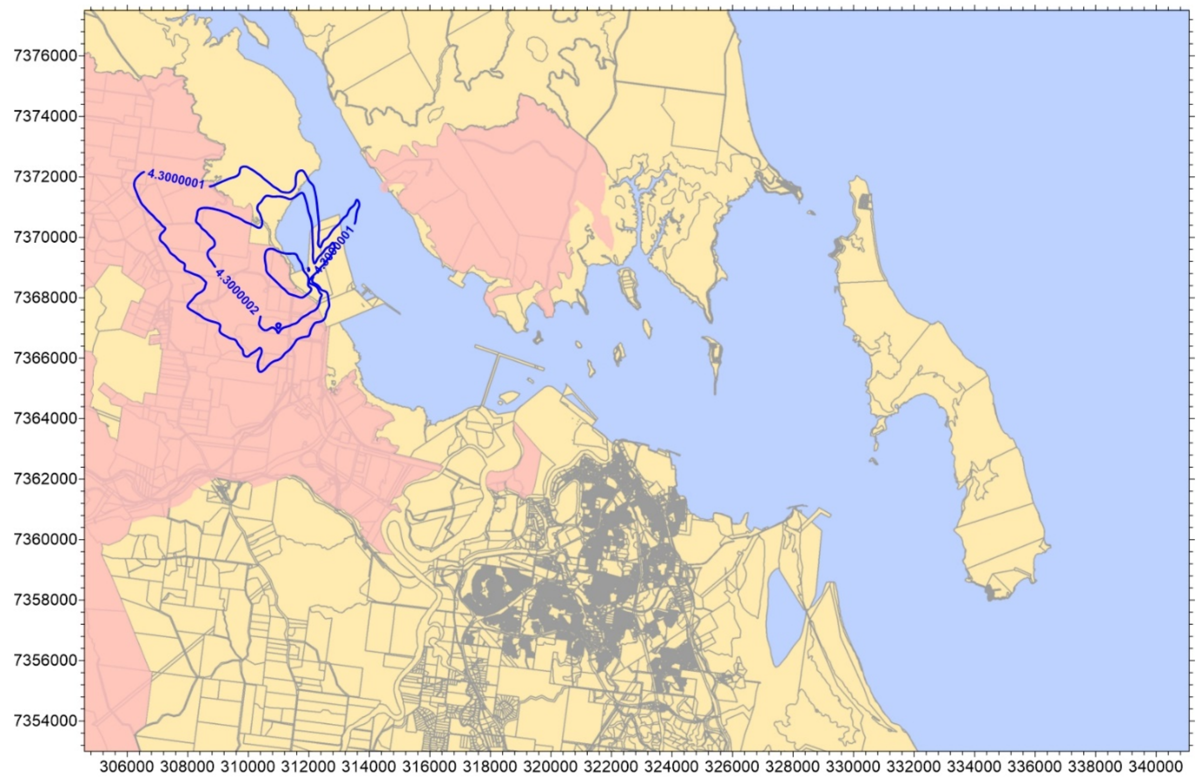
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	570µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.18 Construction of Western Basin Expansion reclamation area (northern area) – Maximum ground-level concentration of 1 hour average SO_2 due to diesel generators plus an ambient background



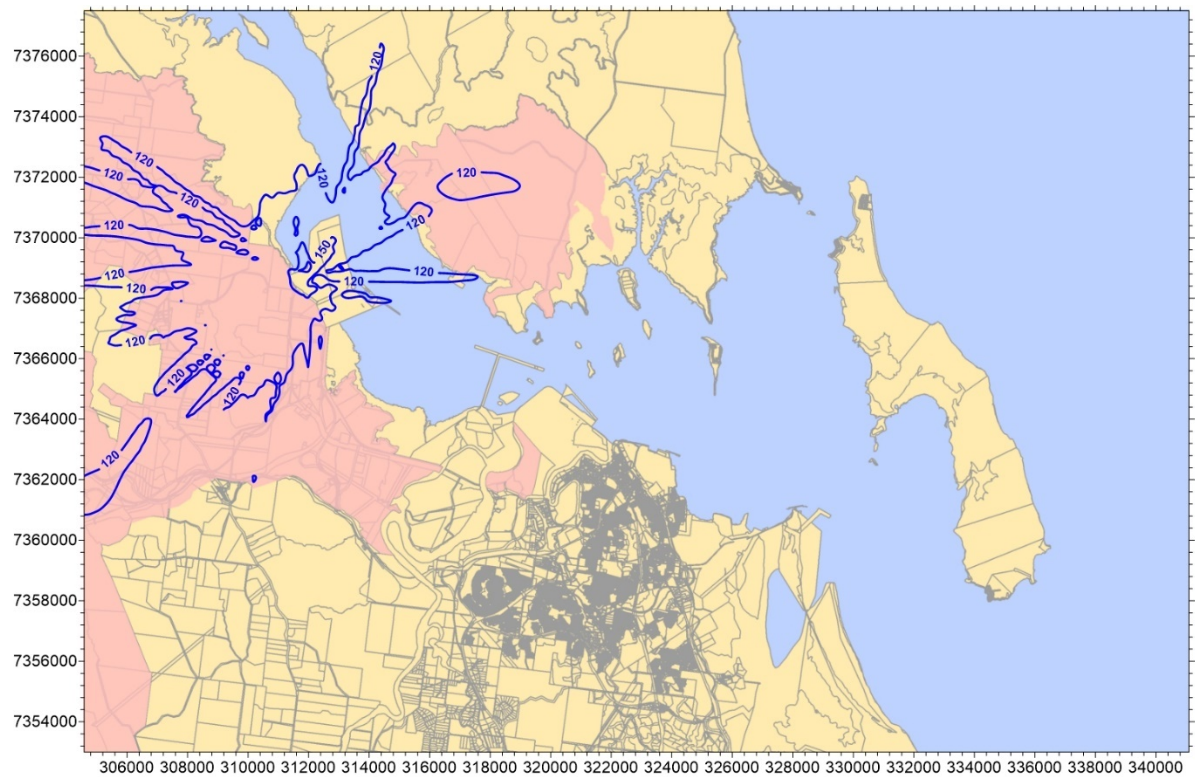
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	230µg/m^3	24 hour	Calpuff	µg/m^3

Figure 12.19 Construction of Western Basin Expansion reclamation area (northern area) – Maximum 24 hour average ground-level concentration of SO_2 due to diesel generators plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	57µg/m[3]	1 year	Calpuff	µg/m[3]

Figure 12.20 **Construction of Western Basin Expansion reclamation area (northern area) – Annual average ground-level concentration of SO_2 due to diesel generators plus an ambient background**



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	11,000µg/m[3]	1 year	Calpuff	µg/m[3]

Figure 12.21 **Construction of Western Basin Expansion reclamation area (northern area) – Maximum 8 hour average ground-level concentration of CO due to diesel generators plus an ambient background**

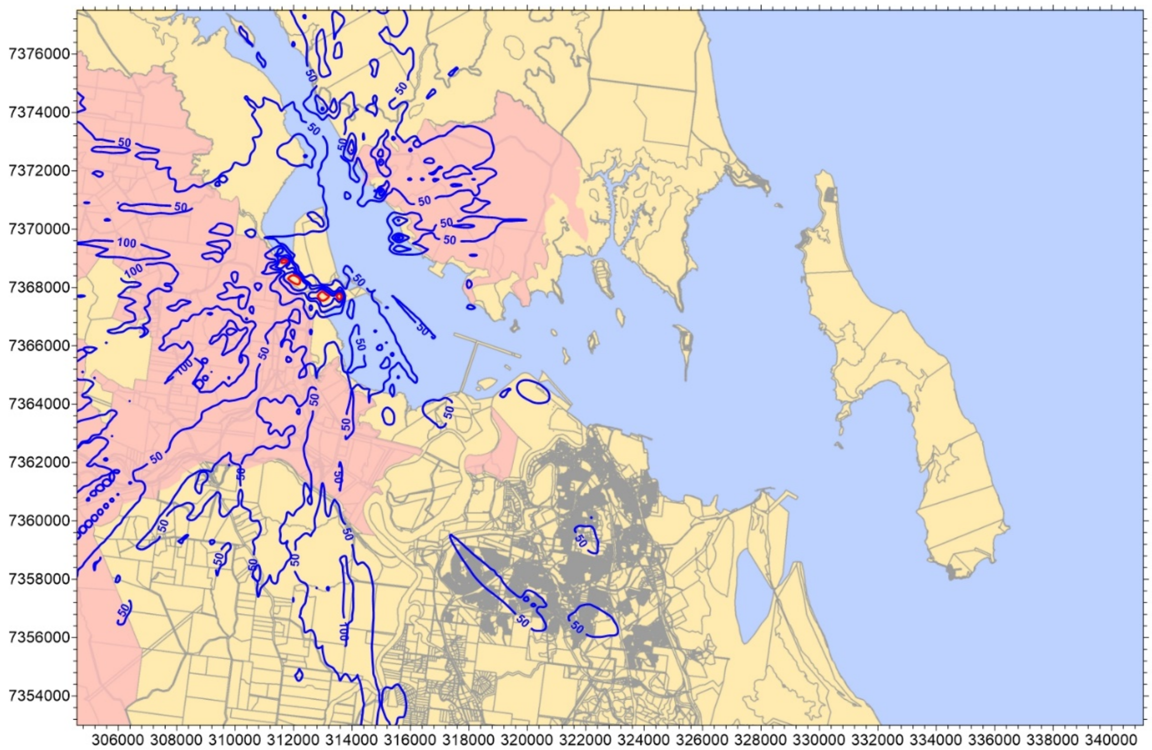
12.5.2.3 Dredged material placement and dredging operations

Initial dredging of the barge access channel

Figure 12.22 to Figure 12.25 present the predicted ground-level concentrations of exhaust pollutants due to both the TSHD and CSD during the initial dredging works to create the barge access channel. As this will only occur for 6.5 weeks, results for air quality criteria with short term averaging periods only have been presented.

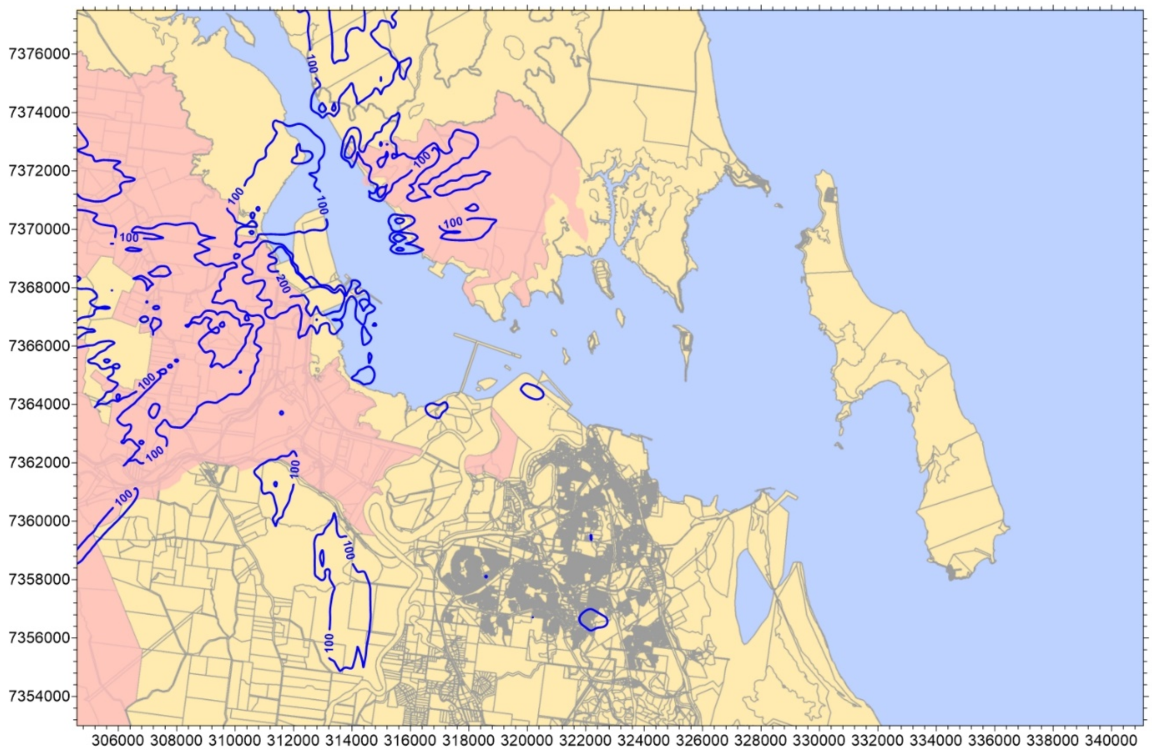
The results show that, with the exception of 1 hour average NO_2, ground-level concentrations of all other pollutants, and annual average NO_2 due to the initial dredging of the access channel plus ambient background concentrations **comply** with the air quality objectives.

Predicted ground-level concentrations of 1 hour average NO_2 are predicted to be above 250µg/m^3 in small areas close to the WBE reclamation area. However, ground-level concentrations at the LNG facilities and across the Targinnie area **comply** with the air quality objective.



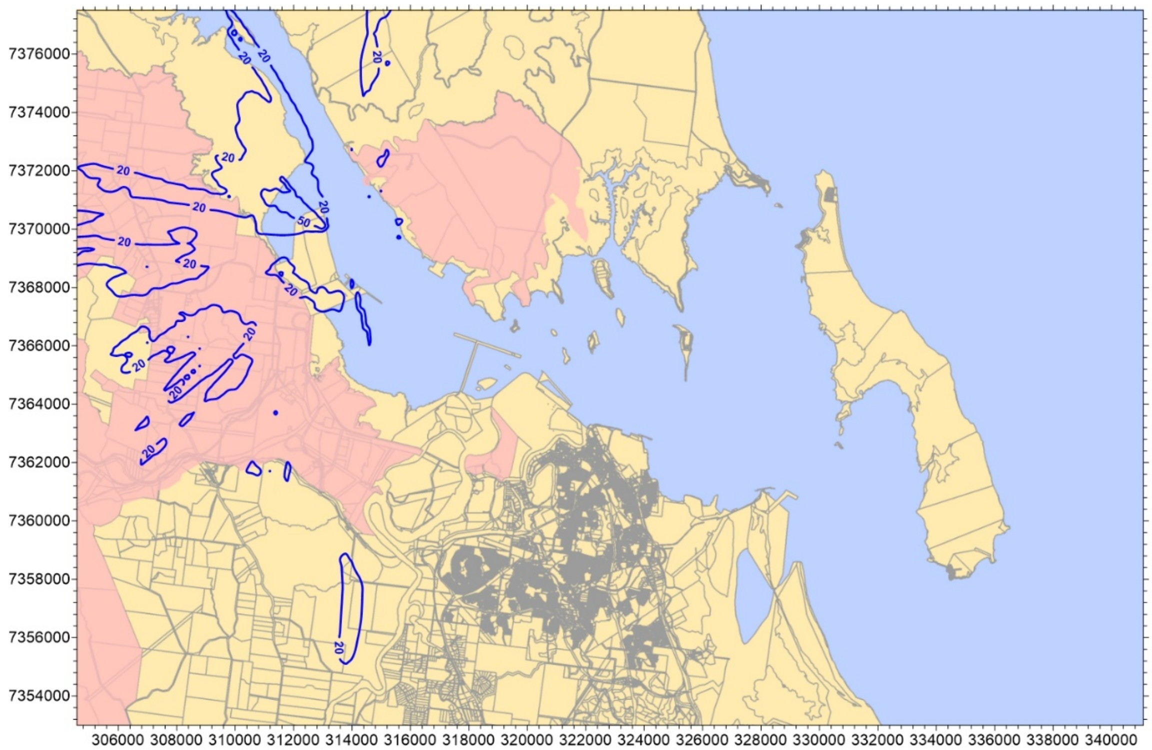
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	250µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.22 Western Basin – Initial dredging works – Maximum ground-level concentration of 1 hour average NO_2 plus an ambient background



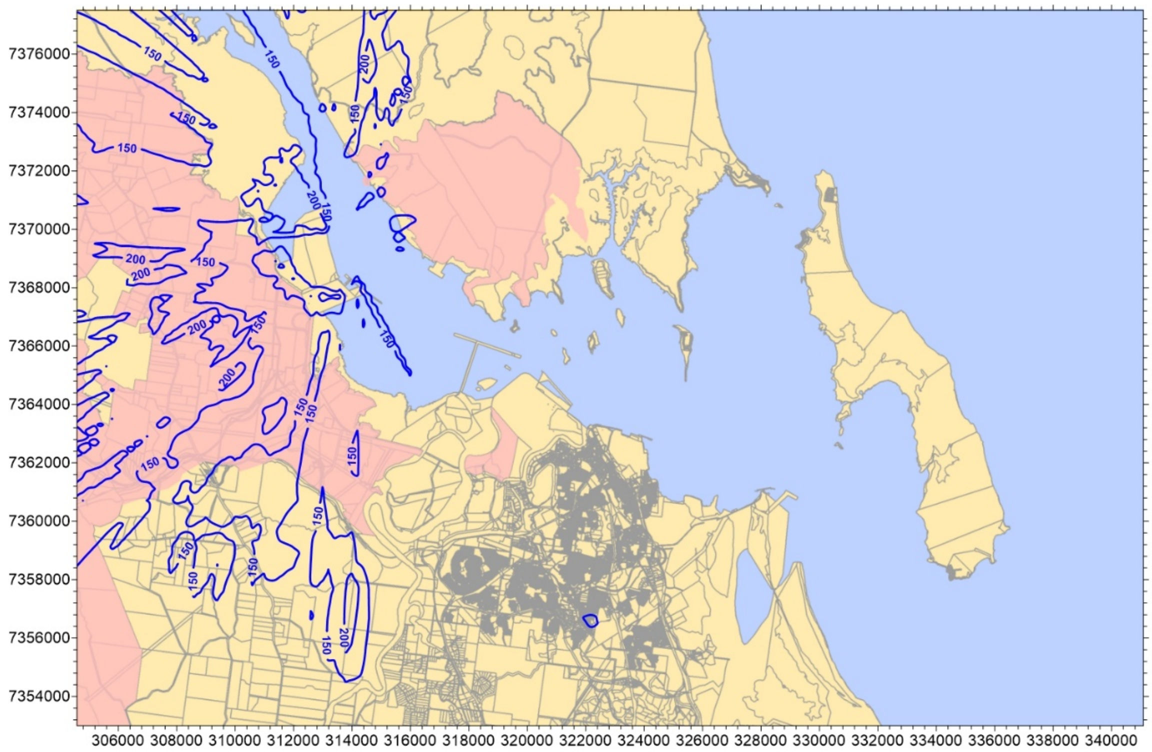
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	570µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.23 Western Basin – Initial dredging works – Maximum ground-level concentration of 1 hour average SO_2 plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	230µg/m^3	24 hour	Calpuff	µg/m^3

Figure 12.24 Western Basin – Initial dredging works – Maximum 24 hour average ground-level concentration of SO_2 plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	11,000µg/m^3	8 hour	Calpuff	µg/m^3

Figure 12.25 Western Basin – Initial dredging works – Maximum 8 hour average ground-level concentration of CO plus an ambient background

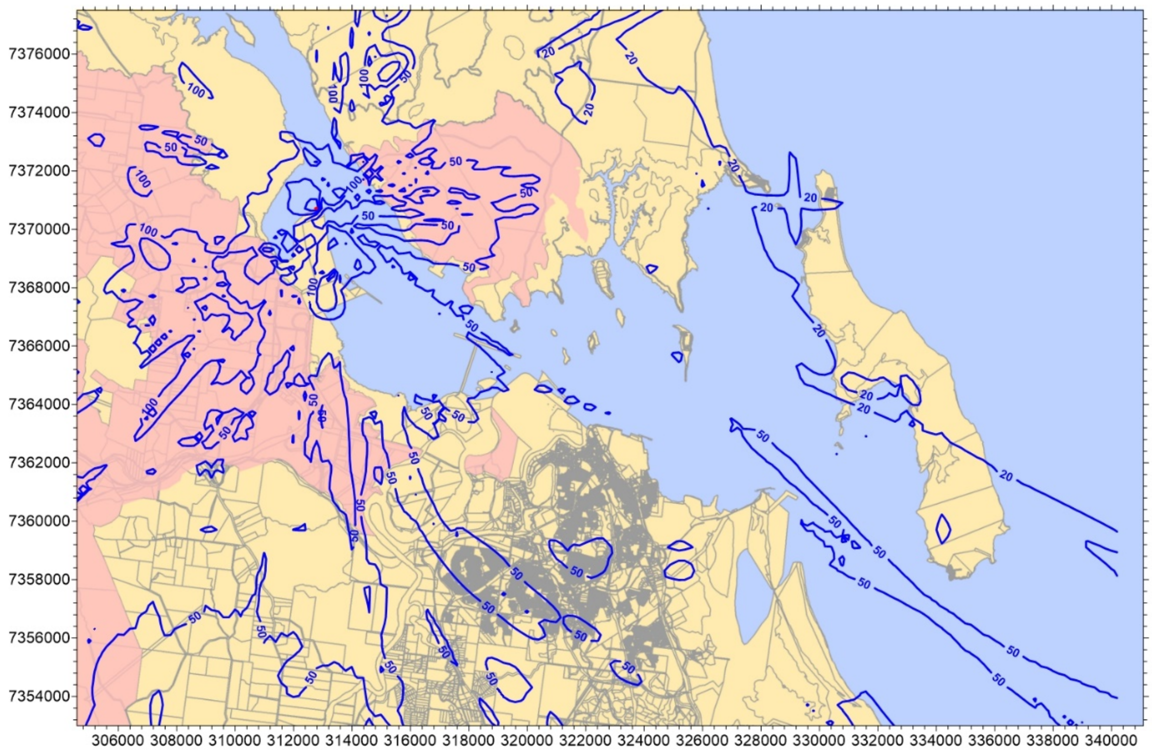
Dredging of the channel – exhaust emissions

Figure 12.26 to Figure 12.31 present the predicted ground-level concentrations of exhaust pollutants due to the following:

- TSHD dredging in the channel
- One pushbuster travelling in the channel
- Two pushbusters travelling between the channel and the BUF
- One pushbuster and one tug operating at the BUF.

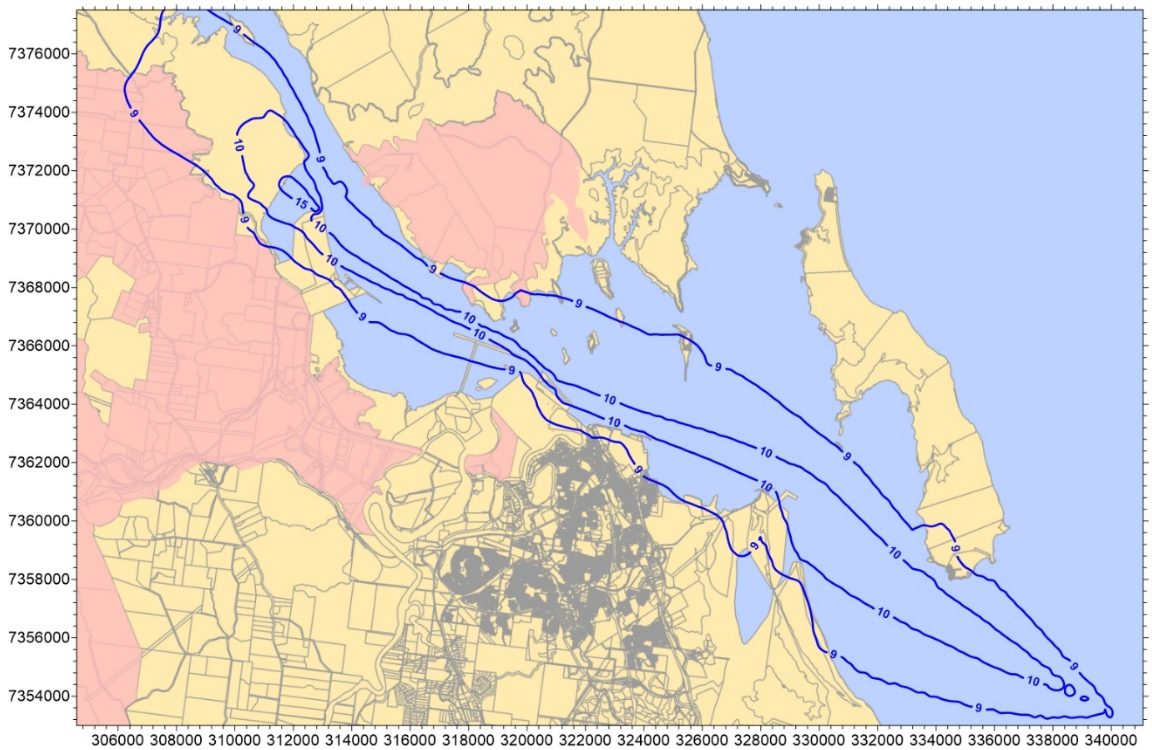
The results show that, ground-level concentrations of all other pollutants due to the dredging of the channel plus ambient background concentrations **comply** with the air quality objectives.

Predicted ground-level concentrations of PM_{10} and $PM_{2.5}$ presented in the section below include the contribution of particulate emissions from the TSHD, tug and pushbuster exhausts.



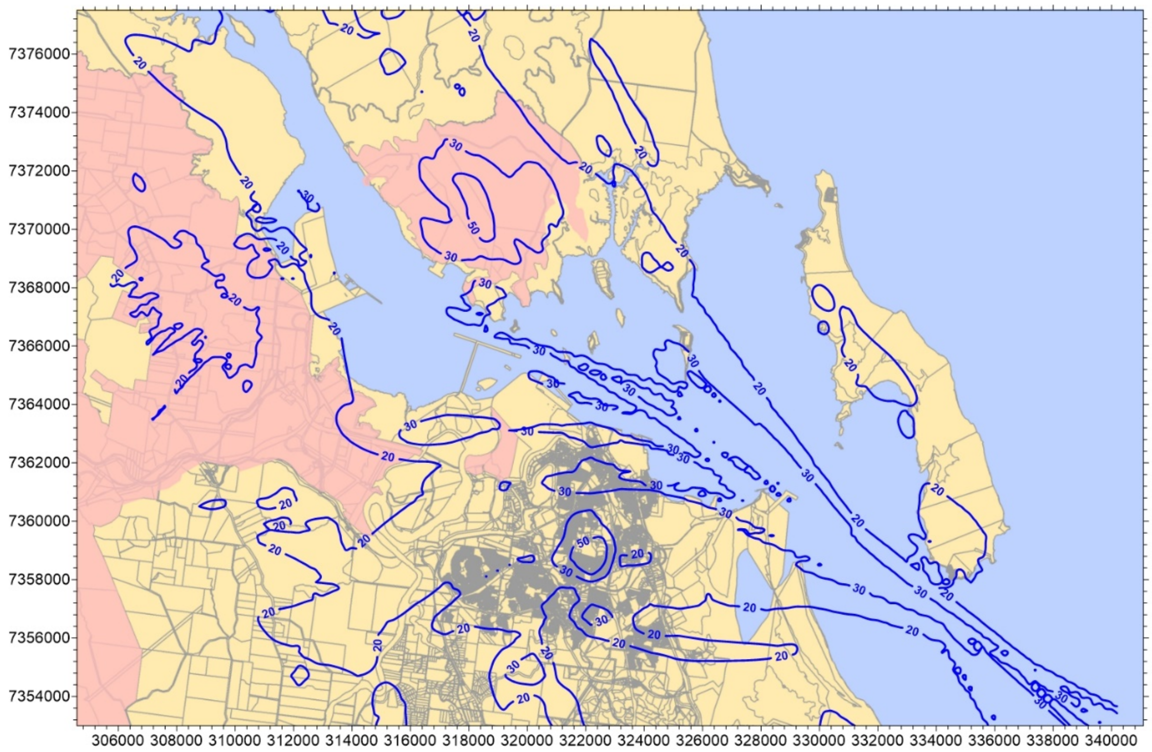
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	250µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.26 Western Basin – Dredging – Maximum ground-level concentration of 1 hour average NO_2 plus an ambient background



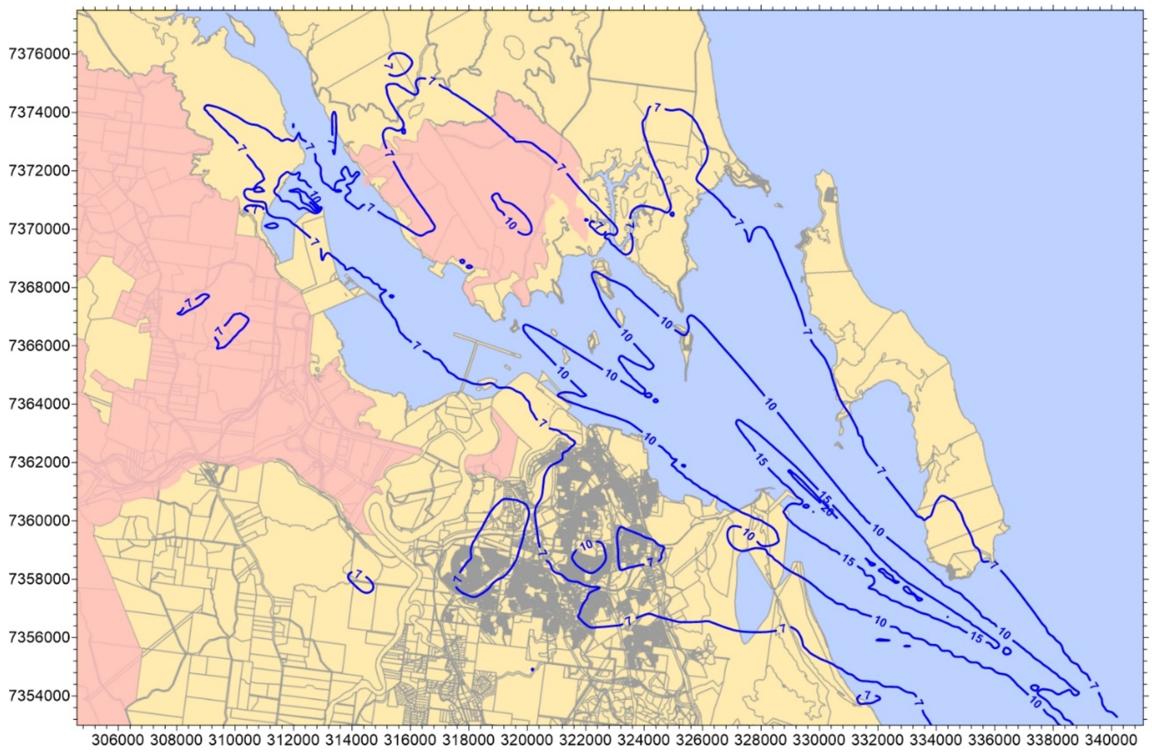
Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	62µg/m^3	1 year	Calpuff	µg/m^3

Figure 12.27 Western Basin – Dredging – Annual average ground-level concentration of NO_2 plus an ambient background



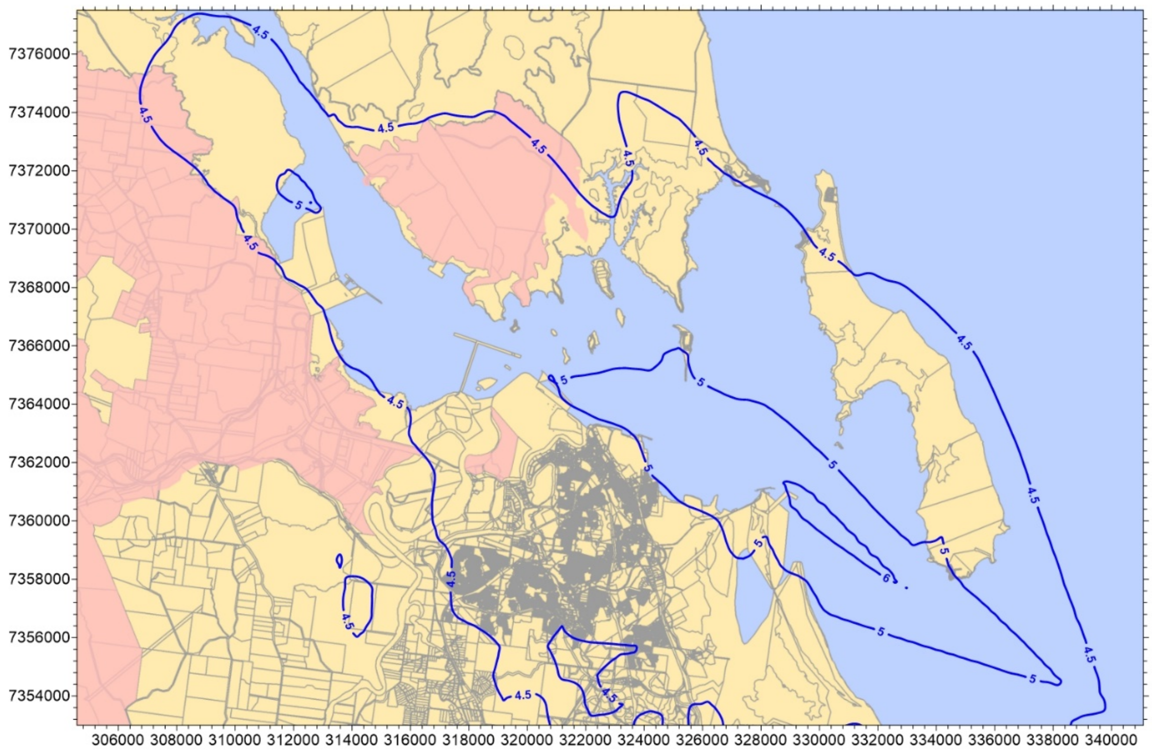
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	570µg/m^3	1 hour	Calpuff	µg/m^3

Figure 12.28 Western Basin – Dredging – Maximum ground-level concentration of 1 hour average SO_2 plus an ambient background



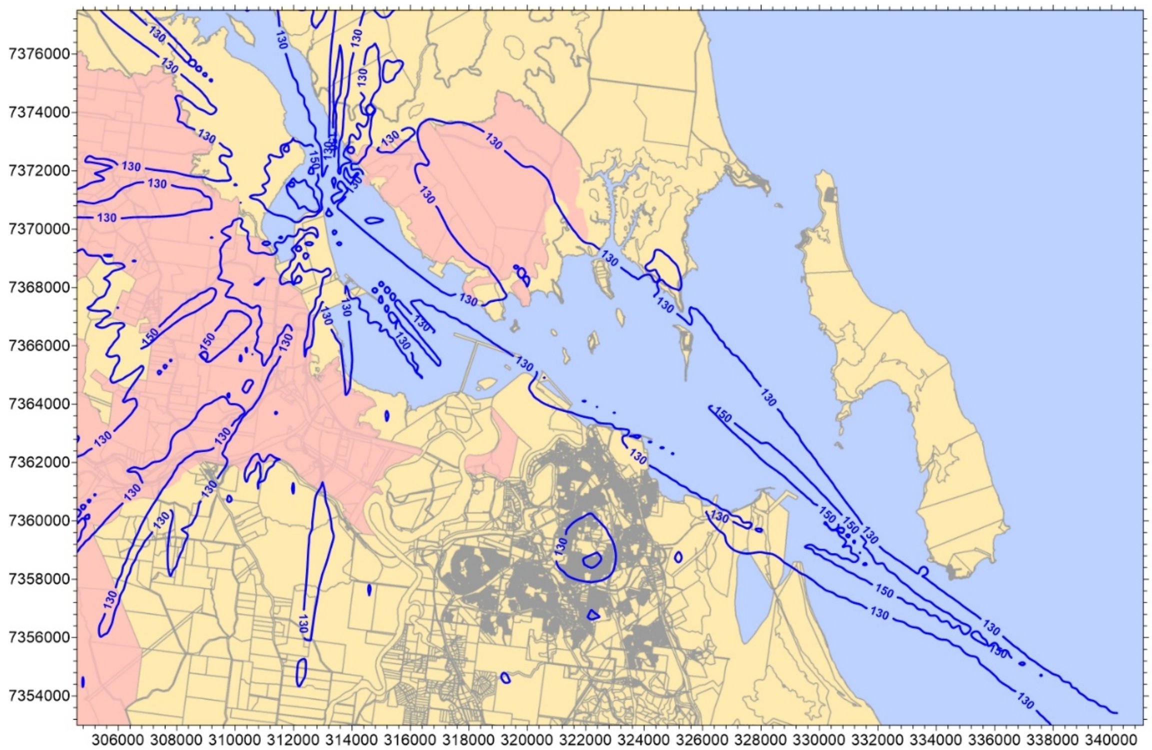
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	230µg/m^3	24 hour	Calpuff	µg/m^3

Figure 12.29 Western Basin – Dredging – Maximum 24 hour average ground-level concentration of SO_2 plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	57µg/m^3	1 year	Calpuff	µg/m^3

Figure 12.30 Western Basin – Dredging – Annual average ground-level concentration of SO_2 plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	11,000µg/m^3	1 year	Calpuff	µg/m^3

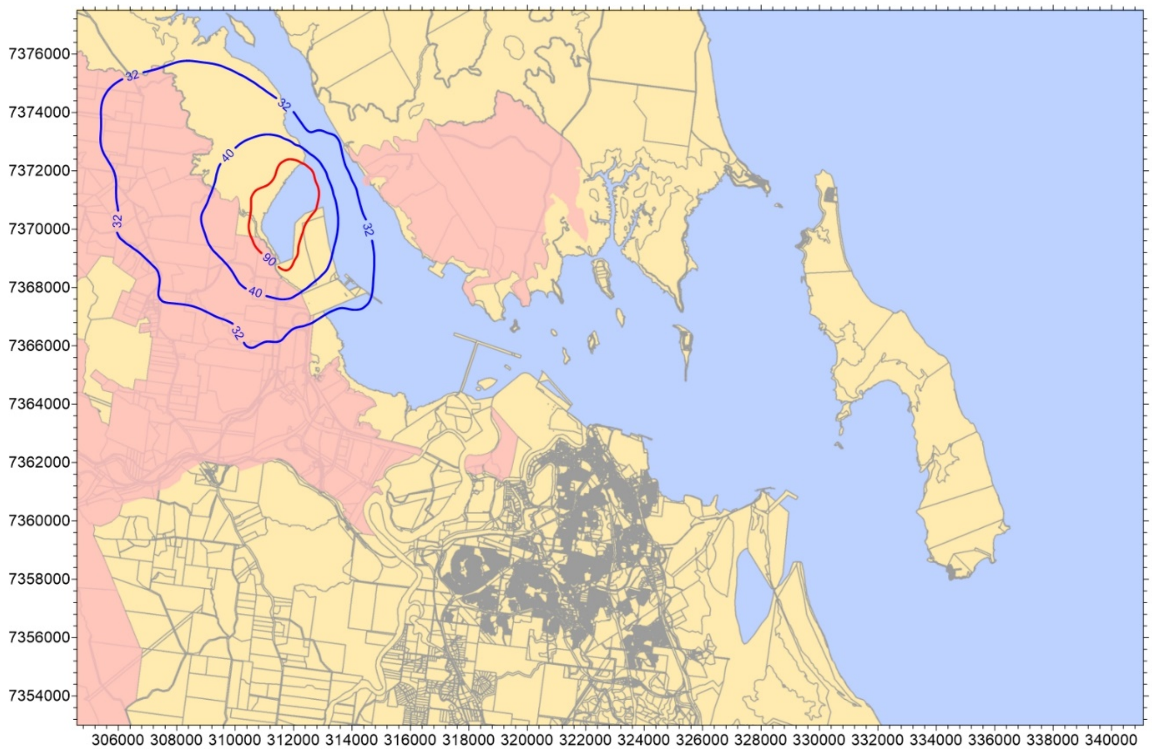
Figure 12.31 Western Basin – Dredging – Maximum 8 hour average ground-level concentration of CO plus an ambient background

Dredged material placement – dust emissions

Figure 12.32 to Figure 12.36 present the predicted ground-level concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rates due to the transport of dredged material from the BUF to the reclamation areas, and for PM_{10} and $PM_{2.5}$, the particulate emissions from the TSHD, pushbuster and tug exhausts. Twenty four hour average PM_{10} is the key pollutant emitted during dredge transport. The maximum 24 hour average ground-level concentrations of PM_{10} are predicted to **exceed** 50µg/m^3 in some areas.

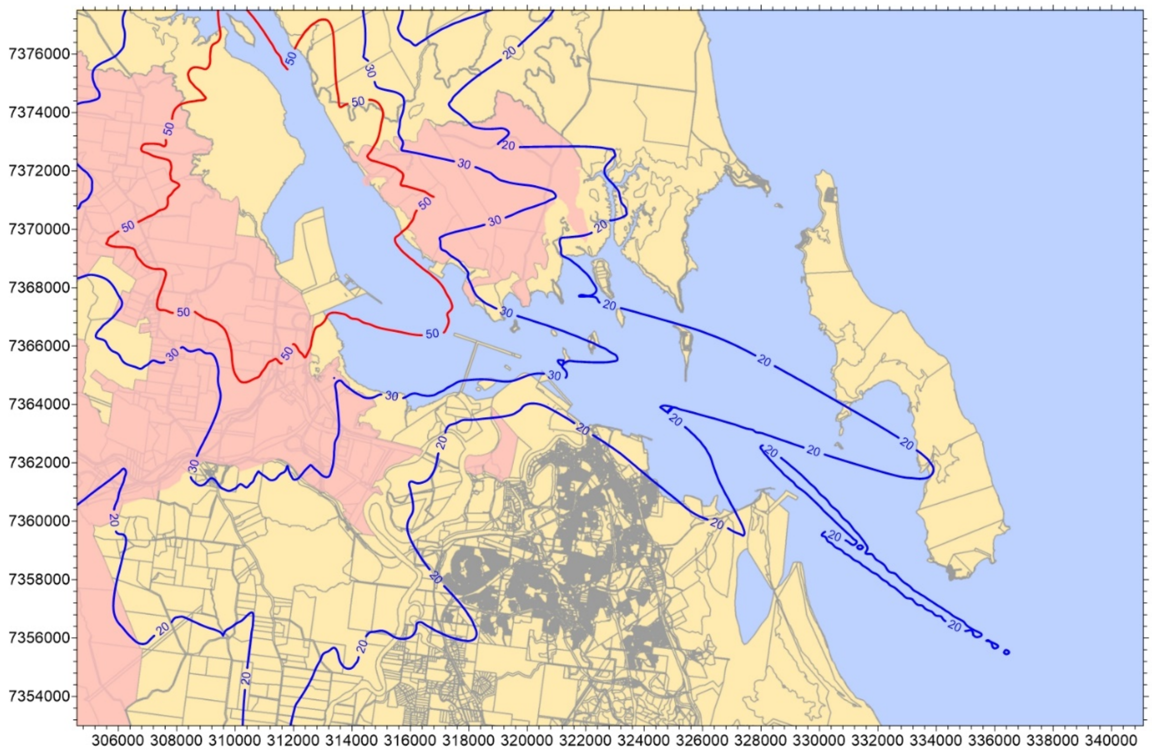
Predicted dust deposition rates during Project activities are expected to exceed ambient air quality objectives and as such have potential impacts on the flora and fauna values identified in Chapter 9.

Additional management measures may be applied to further reduce ground-level concentrations of particulates and dust deposition rates during dredged material placement, including additional watering to ensure material being dozed or graded is damp and applying suppressants to further reduce emissions from material haulage where practical. Dust deposition monitoring could be considered near the wetlands and bird habitat areas to assist in validating actual levels due to the Project.



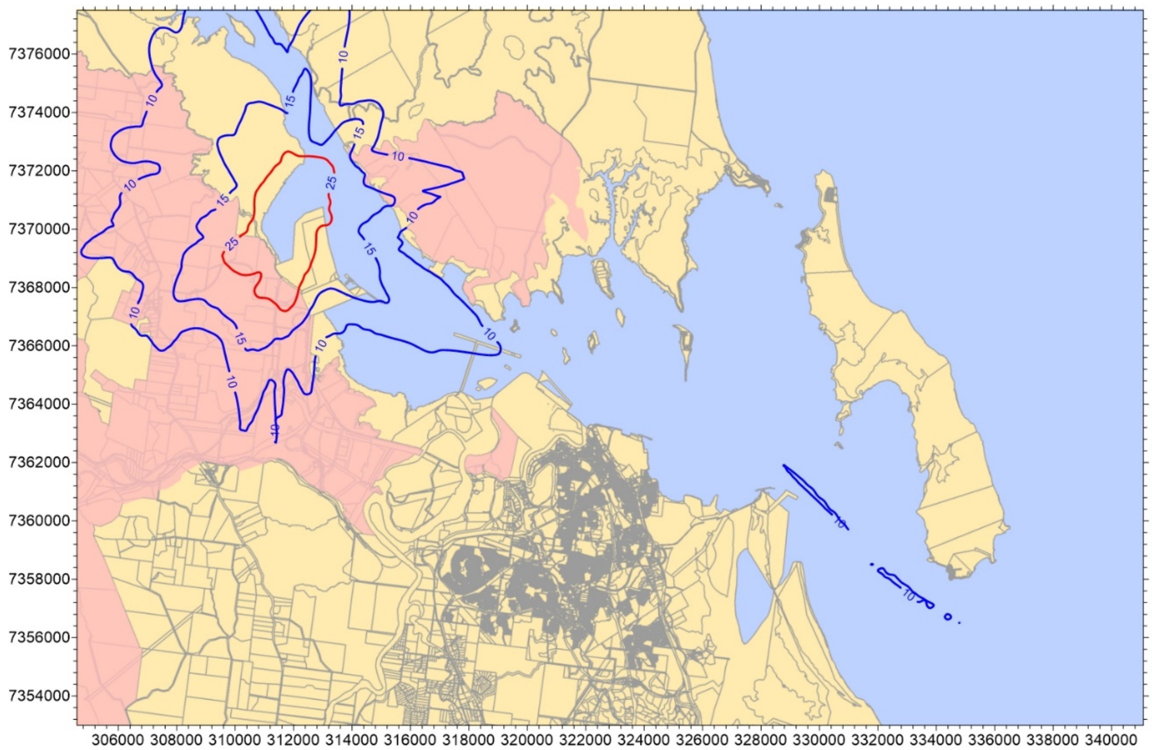
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	90µg/m^3	Annual	Calpuff	µg/m^3

Figure 12.32 Dredge material placement – Ground-level concentrations of annual average TSP due to dredge material transport plus an ambient background



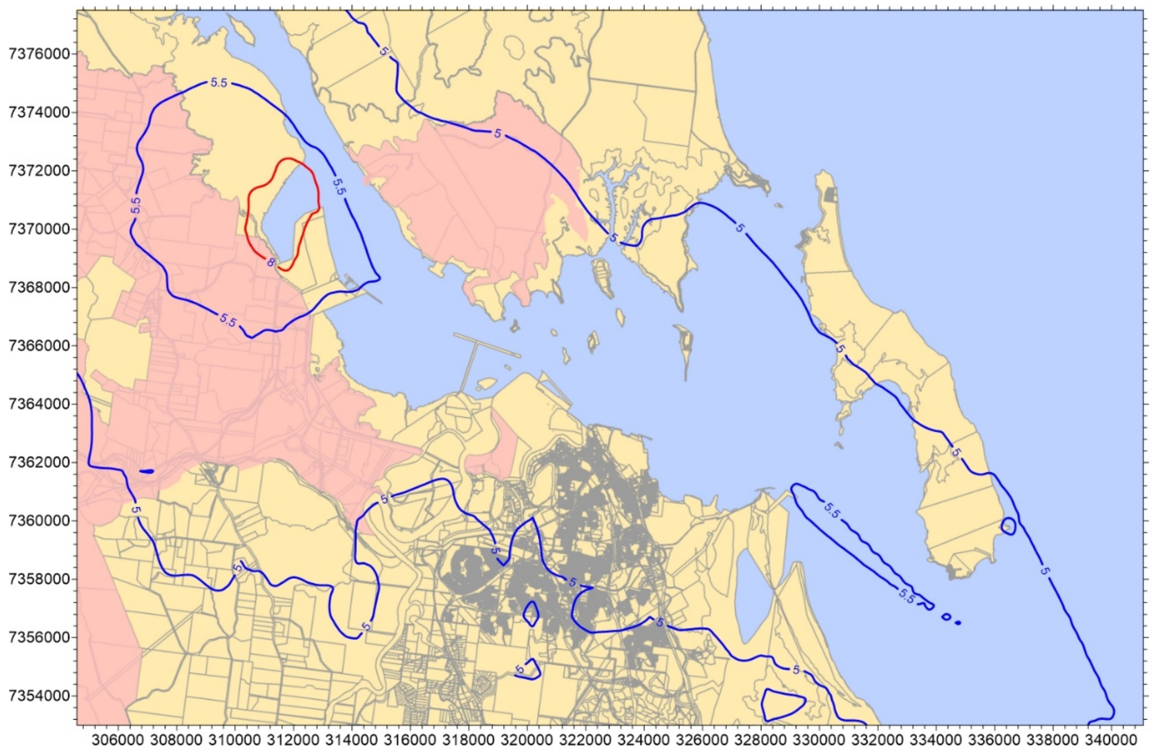
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	50µg/m^3	24 hours	Calpuff	µg/m^3

Figure 12.33 Dredge material placement – Maximum ground-level concentrations of 24 hour average PM_{10} due to dredge material transport, vessel exhausts plus an ambient background



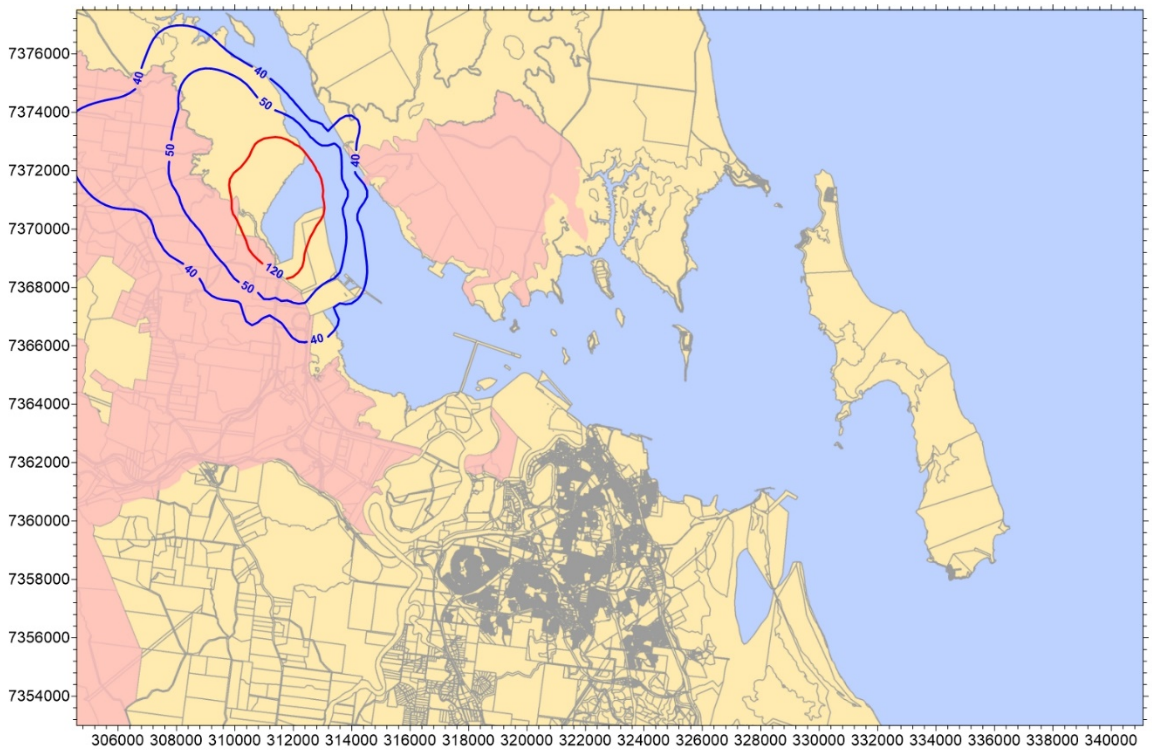
Type:	Objective:	Averaging period:	Data source:	Units:
Maximum contours	25µg/m^3	24 hours	Calpuff	µg/m^3

Figure 12.34 Dredge material placement – Maximum ground-level concentrations of 24 hour average $PM_{2.5}$ due to dredge material transport, vessel exhausts plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	8µg/m^3	Annual	Calpuff	µg/m^3

Figure 12.35 Dredge material placement – Ground-level concentrations of annual average $PM_{2.5}$ due to dredge material transport, vessel exhausts plus an ambient background



Type:	Objective:	Averaging period:	Data source:	Units:
Average contours	120mg/m^2/day	1 month	Calpuff	µg/m^3

Figure 12.36 Dredge material placement – Maximum monthly dust deposition rates due to dredge material transport, vessel exhausts plus an ambient background

12.5.2.4 Summary

The assessment has shown that the construction of the BUF and WBE reclamation area bund walls, and the Project dredging activities are unlikely to adversely impact air quality in the area provided that emission rates and management measures are consistent with those presented in the assessment. Elevated ground-level concentrations of some pollutants are predicted to occur in localised areas close to the WBE reclamation area during the construction stages. However, ground-level concentrations at all receptor locations, including those nearest the Project, such as the isolated rural residences in Targinnie, are well below the air quality objectives during construction. During dredging, the transport of dredged material from the BUF to the reclamation areas results in elevated ground-level concentrations of dust that are predicted to occur across some of the residential areas in Targinnie. However, additional dust mitigation measures such as the use of chemical suppressants on transport routes during this stage of the Project could be used to assist in preventing these elevated concentrations.

The Project activities are unlikely to have cumulative impacts on air quality as none of the 'other projects' assessed in the cumulative impact assessment have the potential to impact on air quality in the vicinity of the WBE reclamation area bund wall and BUF (refer Section 21.5.10).

Further the elevated dust emissions that are predicted to occur during Project activities have the potential to impact on flora and fauna values identified in Chapter 9. Chapter 9 provides details on the potential impacts.

12.5.3 Greenhouse gas emissions sources and inventory

12.5.3.1 Emissions sources

The type of equipment and their number were estimated based on engineering practice and past experience in similar types of projects (refer Table 12.26 to Table 12.30). The actual Project equipment and their specifications may differ from those indicated and will be largely dependent on availability and choice of contractors during the construction phase of the Project.

Table 12.26 Equipment summary for bund wall construction

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
CAT 12 G grader (blade width 2.5m)	1	Diesel	5.3L/km	To evenly spread the material, trimming to required line and level
Dozer (D6) – medium	1	Diesel	29.1L/km	Spread/push earth fill or rock fill
Dozer (D9) – large	1	Diesel	56.4L/km	Spread/push earth fill or rock fill
Excavator – medium	1	Diesel	32.1L/km	Placing of core, armour and revetments and geotextile
Haul truck - dump trucks/trailer (B-Doubles)	20	Diesel	27.9L/km	Quarry material – including public roads
Water cart (minimum - 10,000L)	1	Diesel	28.7L/km	Dust control/conditioning earth fill for compaction
Small skid-steer (Bobcat)	1	Diesel	33.8L/km	To spread material on very soft soils and placement of geotextile
Vibratory roller (smooth/sheep foot) CB534D	1	Diesel	15.1L/km	Finishing earth fill surface
Diesel Generator	1	Diesel	12.7L/km	Diesel generator for site compound
Excavator – large	2	Diesel	114.0L/km	Quarry area – excavate rock fill
Loader – medium	2	Diesel	33.8L/km	Quarry area – load rock fill into trucks

Table 12.27 Equipment summary for barge unloading facility

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
Sheet pile driver	1	Diesel	114.0L/km	Installation of sheet piling
Loader – medium	1	Diesel	33.8L/km	Load excavated material into trucks
Haul truck - dump trucks/trailer (B-Doubles)	2	Diesel	27.9L/km	Transport of excavated material
Excavator – large	1	Diesel	32.1L/km	Placing of core, armour and revetments and geotextile
Loader – medium	2	Diesel	33.8L/km	Quarry area – load rock fill into trucks

Table 12.28 Equipment summary for placement of navigational aids

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
Barge (15m x15m) with crane (> 50t)	1	Diesel	200L/hr	
Diesel generator with hydraulic pumps	1	Diesel	12.7L/hr	Piling will be less than 4 hours per navigational aid
Junttan hydraulic impact hammer - HHK 10S	1			

Table note:

L/hr = litres per hour

Table 12.29 Equipment summary for dredging operations

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
TSHD – 20,000m³ (25,540kW)	1	Heavy fuel oil	110g/kWh	Capital dredging of channels
CSD – 20,000m³ (27,240kW)	1	Heavy fuel oil	194g/kWh	Initial dredging works
Tug boat	1	Heavy fuel oil	185g/kWh	Transfer of dredged material to BUF
Barge (pushbuster)	4			
Work boat	1	Diesel	50L/hr	Transporting crew

Table notes:

g/kWh = gallons per kilowatt hour
L/hr = litres per hour

Table 12.30 Equipment summary for dredged material placement and earthworks

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
Excavators – large	6	Diesel	32.1L/km	Loading of dredged material onto trucks at BUF
Trucks	32	Diesel	27.9L/km	Transport of dredged material from BUF to placement areas
CAT 12 G grader (blade width 2.5m)	1	Diesel	5.3L/km	To evenly spread the material, trimming to required line and level. Grading only required at end of dredged material earthwork activities to level final land form.
Dozer (D6) – medium	1	Diesel	29.1L/hr	Spread/push dredged spoil
Dozer (D9) – large	1	Diesel	56.4L/hr	Spread/push dredged spoil

Equipment type	Number	Fuel type	Fuel rate	Purpose/activity
Loader – medium	1	Diesel	33.8L/hr	Earthworks - general
Water cart (minimum - 10,000L)	1	Diesel	28.7L/hr	Dust control/conditioning earth fill for compaction
Small skid-steer (Bobcat)	1	Diesel	33.8L/hr	To spread material on very soft soils
Compactor - vibratory roller (smooth) CB534D	1	Diesel	15.1L/hr	Finishing surface/compaction dredged spoil
Diesel generator	1	Diesel	12.7L/hr	Diesel generator for site compound

Construction works for each component of the Project were assumed to generally occur for an average of 20 days in a month for 12 hours a day. This is to account for anticipated downtime related to weekends, holidays and inclement weather. However, due to the limited availability of dredging vessels, the TSHD is assumed to operate for 24 hours per day for approximately 12 to 13 days per fortnight, allowing for crew change each fortnight. The CSD is assumed to operate for 24 hours per day for 5 days per week while in use. The CSD is unlikely to have onboard accommodation.

Fuel usage was estimated for both the staged approach and the singular campaign scenarios, presented in Table 12.31 and Table 12.32, respectively. The estimates are based on equipment characteristics and utilisation rates against the approximated schedules presented in Table 12.2 and Table 12.3.

Table 12.31 and Table 12.32 are organised by the controlling entity associated with the emission source (GPC or the dredging contractor), providing an indication of the envisaged reporting responsibility under the NGER program.

Table 12.31 Staged approach - emissions source summary

Component	Fuel type	Total fuel consumption (L)						
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
GPC controlled activities								
Bund wall construction - earthworks								
Earthmoving equipment	Diesel	745,579	745,579	745,579				
Quarry area	Diesel	2,460,623	2,460,623	2,460,623				
Generators	Diesel	36,607	36,607	36,607				
BUF construction								
Earthmoving equipment	Diesel			914,958				
Generators	Diesel			36,607				
Navigational aids								
Barge	Diesel							144,000
Generator	Diesel							9,152
Dredging contractor controlled activities								
Initial dredging								
TSHD	Heavy fuel oil				142,528			
CSD	Heavy fuel oil				2,673,924			
Dredging operations								
TSHD	Heavy fuel oil				16,605,511			12,579,933
Barge/Tugboat	Heavy fuel oil				15,611,618			11,826,984
Workboat	Diesel				8,962			6,789
Dredged material earthworks								
BUF dredged material transfer	Diesel				12,835,831			7,487,568
Dredged material placement and earthmoving equipment	Diesel				750,676			425,547
Generators	Diesel				36,607			21,354
Total diesel		**3,242,809**	**3,242,809**	**4,194,374**	**13,632,075**	**-**	**-**	**8,094,410**
Total fuel oil		**-**	**-**	**-**	**35,033,582**	**-**	**-**	**24,406,916**

Table 12.32 Singular campaign approach - emissions source summary

Component	Fuel type	Total fuel consumption (L)				
		Year 1	Year 2	Year 3	Year 4	Year 5
GPC controlled activities						
Bund wall construction - earthworks						
Earthmoving equipment	Diesel	745,579	745,579	745,579		
Quarry area	Diesel	2,460,623	2,460,623	2,460,623		
Generators	Diesel	36,607	36,607	36,607		
BUF construction						
Earthmoving equipment	Diesel			914,958		
Generators	Diesel			36,607		
Navigational aids						
Barge	Diesel					144,000
Generator	Diesel					9,152
Dredging contractor controlled activities						
Initial dredging						
TSHD	Heavy fuel oil				142,528	
CSD	Heavy fuel oil				2,673,924	
Dredging operations						
TSHD	Heavy fuel oil				22,895,477	6,289,966
Barge/Tugboat					21,525,110	5,913,492
Workboat	Diesel				12,357	3,395
Dredged material earthworks						
BUF dredged material transfer	Diesel				12,835,831	7,487,568
Dredged material placement and earthmoving equipment	Diesel				750,676	425,547
Generators	Diesel				36,607	21,354
Total diesel		**3,242,809**	**3,242,809**	**4,194,374**	**13,635,470**	**8,091,015**
Total fuel oil		**-**	**-**	**-**	**47,237,040**	**12,203,458**

12.5.3.2 Greenhouse gas emissions inventory

Estimated annual energy use and associated GHG emissions for the Project are summarised in Table 12.33 and Table 12.34, respectively. Annual energy use and GHG summaries are organised by Project scenario and then by Project component. GPC controlled emissions should be included in GPC's annual reporting under the NGER program. A more accurate estimate of annual GHG will be made during the detailed design phase of the Project.

The total energy use and GHG emissions associated with the Project are equal for both scenarios. However, the annual energy use and GHG emissions vary in line with the scheduling of Project components associated with each scenario.

The range of annual GHG emissions according to each scenario is:

- Staged approach – 8,787 to 139,638 tCO_2-e over a period of approximately 7 years
- Singular campaign – 8,787 to 175,421 tCO_2-e over a period of approximately 5 years.

The maximum annual emissions estimated for the Project of 175,421 tCO2-e represent 0.03% and 0.12% of national and State emissions, respectively.

In terms of the main components of the Project, the majority of GHG emissions are associated with dredging operations (67%) followed by bund wall construction (11%) and dredged material earthworks (22%) as illustrated in Figure 12.37.

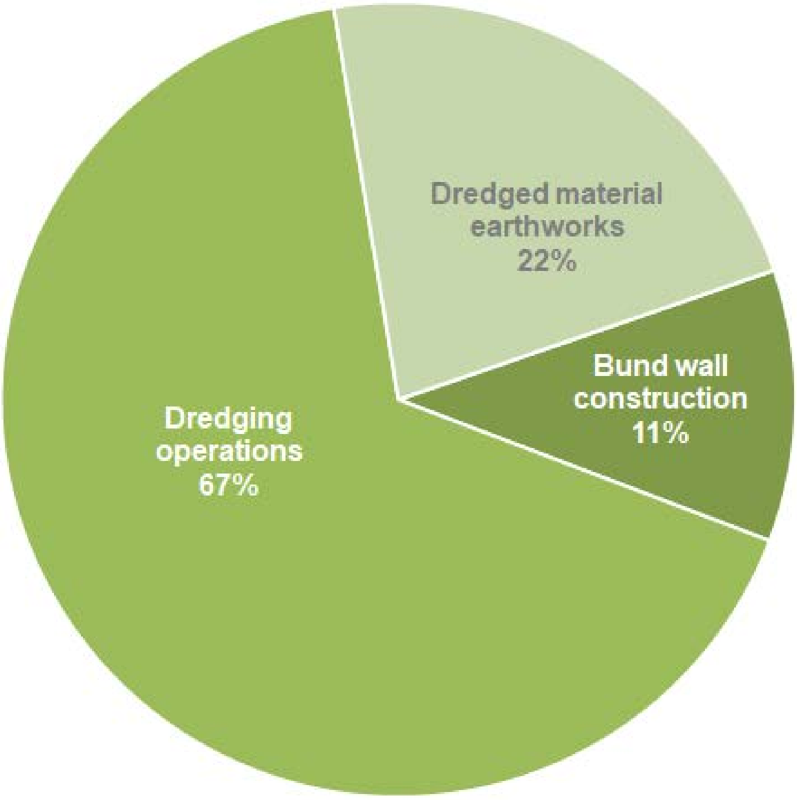


Figure 12.37 Estimated greenhouse gas emissions by Project component

Table 12.33 Annual energy use (TJ) summarised by scenario and component

Year	Staged dredging approach					Singular campaign				
	Bund wall construction[1, 2]	Dredging operations[3]	Dredged material earthworks[3,4]	Navigational aids[1]	Total	Bund wall construction[1,2]	Dredging operations[3]	Dredged material earthworks[3,4]	Navigational aids[1]	Total
1	125	-	-	-	**125**	125	-	-	-	**125**
2	125	-	-	-	**125**	125	-	-	-	**125**
3	162	-	-	-	**162**	162	-	-	-	**162**
4	-	1,391	526	-	**1,917**	-	1,876	526	-	**2,402**
5	-	-	-	-	**-**	-	485	306	6	**797**
6	-	-	-	-	**-**	-	-	-	-	**-**
7	-	969	306	6	**1,281**	-	-	-	-	**-**
Total	**-**	**2,360**	**832**	**6**	**3,611**	**412**	**2,360**	**832**	**6**	**3,611**

Table notes:

1 GPC controlled activities 2 Includes BUF construction 3 Dredging contractor controlled activities 4 Includes transfer of dredged material from BUF

Table 12.34 Annual greenhouse gas emissions (tCO_2-e) summarised by scenario and component

Year	Staged dredging approach					Singular campaign				
	Bund wall construction[1,2]	Dredging operations[3]	Dredged material earthworks[3,4]	Navigational aids[1]	Total	Bund wall construction[1,2]	Dredging operations[3]	Dredged material earthworks[3,4]	Navigational aids[1]	Total
1	8,787	-	-	-	**8,787**	8,787	-	-	-	**8,787**
2	8,787	-	-	-	**8,787**	8,787	-	-	-	**8,787**
3	11,366	-	-	-	**11,366**	11,366	-	-	-	**11,366**
4	-	102,723	36,915	-	**139,638**	-	138,506	36,915	-	**175,421**
5	-	-	-	-	**-**	-	35,783	21,500	415	**57,698**
6	-	-	-	-	**-**	-	-	-	-	**-**
7	-	71,566	21,500	415	**93,481**	-	-	-	-	**-**
Total	**28,940**	**174,289**	**58,415**	**415**	**262,059**	**28,940**	**174,289**	**58,415**	**415**	**262,059**

Table notes:

1 GPC controlled activities 2 Includes BUF construction 3 Dredging contractor controlled activities 4 Includes transfer of dredged material from BUF

12.5.4 Greenhouse gas

GHG emissions from the Project would contribute to Australia's and Queensland's annual emissions inventory. The maximum annual emissions estimated for the Project of 175,421 tCO_2-e represent approximately 0.03% and 0.12% of the national and State 2017 annual emissions inventory, respectively.

In terms of reporting obligation under the NGER program, GPC and the dredging contractor should be considered as separate facilities. Consequently, GPC would be required to include GHG emissions associated with the bund wall construction, removal and installation of navigational aids and ongoing maintenance of the WB and WBE reclamation areas in its annual reporting under the NGER program, while the dredging contractor would be responsible for comparable reporting associated with dredging operations.

The GHG emissions from the Project would increase GPC's annual GHG emissions. In comparison to the 2017-18 NGER reporting period, the maximum annual GHG emissions attributable to GPC of 11,366 tCO_2-e are approximately equivalent to:

- 13% of GPC's annual NGER emissions of 89,688 tCO_2-e (Scope 1 + Scope 2)
- 37% of GPC's annual Scope 1 emissions of 30,479 tCO_2-e.

Mitigation measures to manage GHG emissions associated with the Project are discussed in Section 12.6.2.

12.5.5 Odour

The sediment within the areas to be dredged are considered clean as per NAGD (2009), as described in Chapter 6 (sediment quality). There are limited organic compounds within the sediments to produce noxious odours. However, the soft silty clay sediment, particularly in the northern portion of the barge access channel, contains high concentrations of ammonia, which produces a nuisance odour.

In addition, these soft silty clay sediments are likely PASS, which has the potential to form hydrogen sulfide (H_2S) as a by-product from the oxidation of pyrite (i.e. if the dredged material is exposed to the atmosphere). However, as noted in Chapter 5 (topography, geology and soils), dredged materials will remain saturated during dredging and reclamation activities to limit the oxidation of PASS and the dredging process is such that the excess neutralising capacity will be become available to neutralise any acidity and limit the formation of H_2S (refer Section 5.4.4.4).

It is also noted that the majority of the dredged material, particularly within the Gatcombe and Golding Cutting shipping channels, comprises stiff sandy clay with limited potential to form H_2S and is anticipated to produce less odour than the soft silty clays.

12.6 Mitigation measures

12.6.1 Air quality

During construction and dredged material placement, the following management measures will be implemented:

- Watering of haul roads or routes used for the haulage of material
- Watering of exposed areas to reduce wind-blown dust
- Watering to ensure material being dozed or graded is damp or applying suppressants to further reduce emissions from material haulage over completed sections of bund wall or other transport routes.

A number of assumptions were used in the assessment of the diesel generators, for example, that exhaust emissions from the generators will not be wake affected. To achieve this and avoid localised elevated pollutant levels, exhaust emissions from generators will be released at a point that is 2.5 times higher than buildings or structures within 10 stack heights of the exhausts.

The assessment of exhaust emissions from dredging also included a number of assumptions or management measures. These included:

- NO_x emissions as per Tier III requirements
- SO_2 emissions reflective of 0.5% fuel sulfur content.

During selection of dredging vessels, the total emissions and characteristics will be reviewed against the assumptions made in this assessment to ensure that emissions are consistent with the above assumptions.

12.6.2 Greenhouse gas

12.6.2.1 Bund wall construction

Bund wall construction, including BUF construction, contributes up to 11,366 tCO_2-e annually. The majority of emissions are associated with the excavation and transport of quarry material to the reclamation area. There are three main aspects that govern the fuel consumption for their Project components, including:

- Quantity of rock required for the construction of the bund walls
- Transport distance from the quarry area to the reclamation site
- Selection and operation of equipment and vehicles used in the excavation and transport of quarry materials.

Potential quarry locations are already as close as possible to the reclamation site. Other measures to be implemented include:

- Selection of fuel efficient machinery and vehicles, where possible, matched to the delivery requirements of quarry materials to the reclamation site
- Appropriate equipment maintenance
- Optimisation of transport of materials through load optimisation and delivery scheduling.

12.6.2.2 Dredging operations

The majority of energy use and associated GHG emissions for the Project result from dredging operations, contributing up to 138,506 tCO_2-e annually. Project specific characteristics that affect fuel usage rates of dredging equipment include material depth, thickness of material to be removed, material type and dredged material placement site distance from the dredging area. These aspects of the Project are somewhat fixed; however, there are a number of opportunities that will be implemented relating to the selection and operation of dredging vessels that assist to minimise the fuel usage associated with dredging operations, including:

- Management of dredging operations will include the development of key performance indicators for fuel usage, delegation of responsibilities for monitoring, measurement and reporting
- Fuel efficiency for dredging operations can be achieved by maximising payload while minimising fuel consumption. Moving non-payload weight can unnecessarily increase fuel consumption. Measures to maximise payload include (De Cuyper et al. 2015):
  - Match vessel capacity to application
  - Minimise water and sediment trapped in the barges
  - Minimise non-payload weight, including spare parts and bunker fuel volumes

  - Minimise idle time

- Although the GHG emissions associated with the dredging vessels journey to and from the area to be dredged and the WBE reclamation area has not been assessed, a singular campaign could reduce these emissions significantly compared to a staged approach.

Due to the nature of the Project, GHG emissions will result from construction activities. The Safeguard Mechanism for GPC controlled activities will not be triggered for such emissions or ongoing operational emissions which is assessed and reported each year.

12.6.2.3 Dredged material earthworks

Similar to bund wall construction, diesel consumption associated with earthworks on the reclamation site will be minimised through equipment selection, maintenance and operational procedures.

12.6.2.4 Fuel switching

A further option for reducing GHG emissions associated with diesel combustion is to supplement fuel volumes with bio-fuel. Many heavy equipment manufacturers now support the use of B20 fuel types, however the availability (i.e. currently not available in Gladstone) or cost of B20 fuels is often prohibitive. The potential for the use of bio-diesel will be considered and evaluated by GPC during the detailed design phase of the Project.

An additional measure to reduce heavy fuel consumption in dredging vessels is to connect to mains power while docked. This option will be utilised where available and practical.

12.6.2.5 Possible reduction in indirect emissions due to reduce hotelling and anchorage

While Scope 3 emissions are outside of the scope of the EIS, it is anticipated that a reduction in Scope 3 GHG emissions may be achieved as result of the Project due to reduced hotelling times at the various Port berths and the offshore anchorages, in particular for Capesize vessels.

12.6.3 Odour

As described in the Victoria EPA guidelines for dredging (2001), odour from dredged marine sediments containing H_2S is generally temporary in nature (i.e. odour is gone after a few days). The dredged material is to remain saturated during dredging and placement at WBE reclamation area. Given the nearest residences to the WBE reclamation area are located approximately 4km southwest of the site, it is considered unlikely for odour to cause a noticeable impact.

However, daily inspections will include an odour survey on the downwind boundary of the WBE reclamation area during placement of dredged material to ensure there is no discernible impact from odour.

12.7 Summary

An air quality assessment was undertaken to describe the air quality conditions that apply to the Project, to identify emission sources and to quantify impacts from Project activities.

The air quality assessment has shown the following:

- Dust emissions associated with the Project are predicted to be highest during dredging due to the transport of dredged material from the BUF to the reclamation areas in haul trucks
- During construction, predicted ground-level concentrations of particulates, and dust deposition rates due to the worst-case construction scenario are predicted to **comply** with the relevant air quality objectives at the locations of sensitive receptors, provided a 75% control due to watering is achieved to reduce dust emissions due to haulage along the bund walls

- Predicted ground-level concentrations of exhaust emissions from the diesel generator are predicted to **comply** with the relevant air quality objectives at the locations of sensitive receptors, provided the exhaust emissions are not wake affected
- Exhaust emissions from the dredging vessels during various modes of operation are also predicted to **comply** with the relevant air quality objectives at the locations of sensitive receptors, provided emissions of NO_x are in accordance with Tier III limits, and a fuel sulfur content of 0.5% can be achieved.
- During dredging, predicted ground-level concentrations of PM_{10} are predicted to exceed at some residential locations in Targinnie. Additional management measures such as the use of chemical suppressants on haulage routes could assist in preventing elevated dust concentrations during this stage of the Project.
- No cumulative air quality impacts are predicted when the Project is assessed against other known projects expected to be delivered within similar timeframes to the Project.

The GHG emissions from the Project components that would be under GPC's control would temporarily increase GPC's annual GHG emissions. However the total GPC annual GHG emissions are predicted to be under the Safeguard Mechanism trigger.

GHG emissions associated with the two scenarios are equivalent, however the annual GHG emissions are spread across 7 years and 5 years for the staged approach and the singular campaign, respectively.

The total GHG emissions associated with the Project are 262,059 tCO_2-e, all significant GHG emissions were assumed to be associated with the construction phase of the Project. Dredging activities accounted for the majority of emissions (67%).

The most practical opportunities for the mitigation of GHG emissions are predominantly fuel efficiency initiatives include:

- Equipment selection – selection of fuel efficient dredging vessels, machinery and vehicles matched to the application in terms of capacity
- Equipment operation – operation and maintenance of equipment in line with manufacturer recommendations
- Logistics planning – load optimisation and delivery scheduling for dredging operations and quarry materials delivered to site
- Quarry location – the proximity of the quarry area to the reclamation site
- Dredging operations – maximize payload weight.

The scheduling of the Project components has been approximated for this assessment to provide an indication of annual emissions. The actual profile of GHG emissions associated with the Project, however is subject to change dependent on the actual timing of the components, including start dates and the actual duration required to complete each component. The GHG estimates are also highly dependent on the equipment type and numbers as well as the work schedule in terms of annual operating hours. A more accurate estimate of annual GHG will be made during the detailed design phase of the Project.