Appendix N – Air and Odour Assessment Reports

Air Quality Assessment Report

Odour Assessment Report

Hitachi Zosen Inova, Besix and Itochu

Dubai Waste Management Center
Air Quality Assessment

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Glossary and acronyms

Acronym	Description
AQMS	Air quality monitoring station
As	Arsenic
Cd	Cadmium
CO	Carbon monoxide
Cr	Chromium
Cu	Copper
DEWA	Dubai Electrical and Water Authority
DM	Dubai Municipality
EPA	US Environmental Protection Agency
HCl	Hydrogen chloride
HF	Hydrogen fluoride
Hg	Mercury
GLC	Ground level concentration
IBA	Incinerator bottom ash
IED	Industrial Emissions Directive 2010/75/EU
IFC	International Finance Corporation
mg	Milligram
mg/Nm^3	Milligram per normal cubic metre
Mn	Manganese
MSW	Municipal solid waste
MW	Mega watt
ng	Nanogram
NH_3	Ammonia
Ni	Nickel
NOx	Nitrogen oxides
NO_2	Nitrogen dioxide
NSW AMMAAP	Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales
O_3	Ozone
OSHA	US Occupational Safety and Health Administration
Pb	Lead
$PM_{2.5}$	Particulate matter (with 2.5 microns or less in diameter)
PM_{10}	Particulate matter (with 10 microns or less in diameter)
SO_2	Sulphur dioxide
STP	Sewage treatment plant
TCDD	Dioxin and furans
tpd	Tonnes per day
TSP	Total suspended particulates
TWA	Time-weighted average
UAE	United Arab Emirates
$\mu g/m^3$	Micrograms per cubic metre
$\mu g/Nm_3$	Micrograms per normal cubic metre
VOC	Volatile organic compound
WHO	World Health Organization
WMC	Waste Management Center

1. Introduction

Hitachi Zosen Inova, Besix and Itochu (HZI, Besix and Itochu) are constructing a Waste Management Center (WMC) in the Emirate of Dubai of the United Arab Emirates (UAE) as initiated by the Dubai Municipality (DM). The proposed WMC (the Project) will utilise municipal solid waste (MSW) from the Emirate of Dubai, processing 5,666 tonnes of waste per day at peak capacity. The WMC will be the largest of its kind to be developed in the world.

The Project site is located approximately 17 km east of Bur Dubai and 10 km south-east of the Dubai International Airport. It is estimated that the facility will cover an area of approximately 651,700 m^2. Figure 1-1 shows the location of the WMC in the Emirate of Dubai within the UAE.

The Project is located on the waste landfill site in Warsan, Dubai, specifically Warsan 2 and the facility will be situated east of the Al Aweer Sewage Treatment Plant (STP). The areas immediately surrounding the Project site consist of industrial facilities including the Dubai Electrical and Water Authority (DEWA) and the Dubai Police Transport Impounding Area. To the north of the Project site exists several residential and attraction areas including the Desert Palm Polo Club and Hotel and Dubai Safari Park. Residential and commercial areas are situated further north, south and west of the project site.

Figure 1-1 Project location

1.1 Project description

The WMC will recover energy through the production of electricity from what would have been waste material sent to landfill, and will produce bottom ash which can be used as an aggregate. The electricity generated will be exported to the electrical grid of DEWA located approximately 3 km south of the Project and to Al Aweer Sewage Treatment Plant. The design of the WMC consists of five lines, each with an operating capacity of 47.2 tonnes per hour (amounting to 5,666 tonnes per day (tpd) for the facility). Previously, this amount was stated to be 5660 tpd, however, the change in throughput is negligible and will not cause a significant impact to air quality. The difference is due to rounding values only and as such, there is no actual change to the throughput volume. Once in operation, the plant will reduce the waste volume transferred to landfills to a small percentage and therefore emissions from landfilling and ultimately traffic/traffic emissions caused by the transfer will be reduced.

1.2 Approach

The approach adopted for this air quality assessment is summarised in the following points. Each point is described in detail in the subsequent sections of this report.

- Outline of the WMC, including process description (Section 2).
- Identification of the appropriate air quality guidelines applicable to this assessment under the legal framework and standards (Section 3).
- Description of the baseline environment including background air quality, meteorology and sensitive receptors (Section 4).
- Calculation of air emission sources and air dispersion modelling for the assessment of predicted air quality impacts during operation of the WMC (Section 5).
- Suggested management procedures and mitigation measures (Section 6).
- Conclusions drawn from the above assessments (Section 7).

1.3 Scope of work

GHD has been engaged to conduct an air quality assessment. The purpose of the assessment was to predict the potential air quality impacts from the operation of the WMC. The scope of works involved:

- Completing an air quality assessment to assess predicted pollutant ground level concentrations (GLCs) at nearby sensitive receptors.
- Completing air dispersion modelling as follows:
  - Use meteorological data from Dubai International Airport to develop a meteorological input file for the AERMOD dispersion model.
  - Use source emission limits from the Industrial Emissions Directive 2010/75/EU (European Union, 2010; known as the IED) to calculate emission rates for each operating source. Emission characteristics such as stack height, stack diameter, stack exit temperature and exhaust flow rate, were provided by HZI, Besix and Itochu and used to characterise emissions sources in AERMOD.
  - Significant buildings were incorporated into the model to account for possible building wake effects and potential resultant grounding of the plume.
  - Air dispersion modelling for one operating scenario, with the WMC operating at full capacity.
- Model predicted GLCs were assessed against relevant ambient air quality and occupational exposure criteria.

1.4 Limitations

This report has been prepared by GHD for HZI, Besix and Itochu and may only be used and relied on by HZI, Besix and Itochu for the purpose agreed between GHD and the HZI, Besix and Itochu as set out in Section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than HZI, Besix and Itochu arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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1.5 Assumptions

This assessment assumes the following:

- All information provided by HZI, Besix and Itochu to GHD, including emission source parameters and Project site layout is correct.
- All parameters used in the model are based on best estimates using information provided by HZI, Besix and Itochu and other relevant data.
- The meteorological data used in this assessment is representative of the meteorology at the Project site.
- The modelling scenario included in this assessment is assumed a worst-case with all five lines operating simultaneously during all hours of the year. It is acknowledged that in reality not all lines will operate simultaneously for all hours of the year due to planned outages and maintenance.

2. Project overview

2.1 Project outline

Dubai Municipality initiated the construction of the WMC in order to produce electricity from the treatment of MSW, in line with their waste management strategy. The WMC is expected to treat approximately 1,888,000 tonnes of municipal waste solids per year to generate an estimated 193 MW of electricity in order to power 135,000 homes.

With reference to the WMC performance guarantees, the facility is designed to produce maximum emission concentrations of pollutants in line with limits set forth in the IED (European Union 2010), under the full range of firing conditions and input conditions.

2.2 Facility description

Generally, all WMCs consist of a combustion process, boiler system, steam turbine and flue gas treatment system. A typical concept for the Dubai WMC is shown in Figure 2-1.

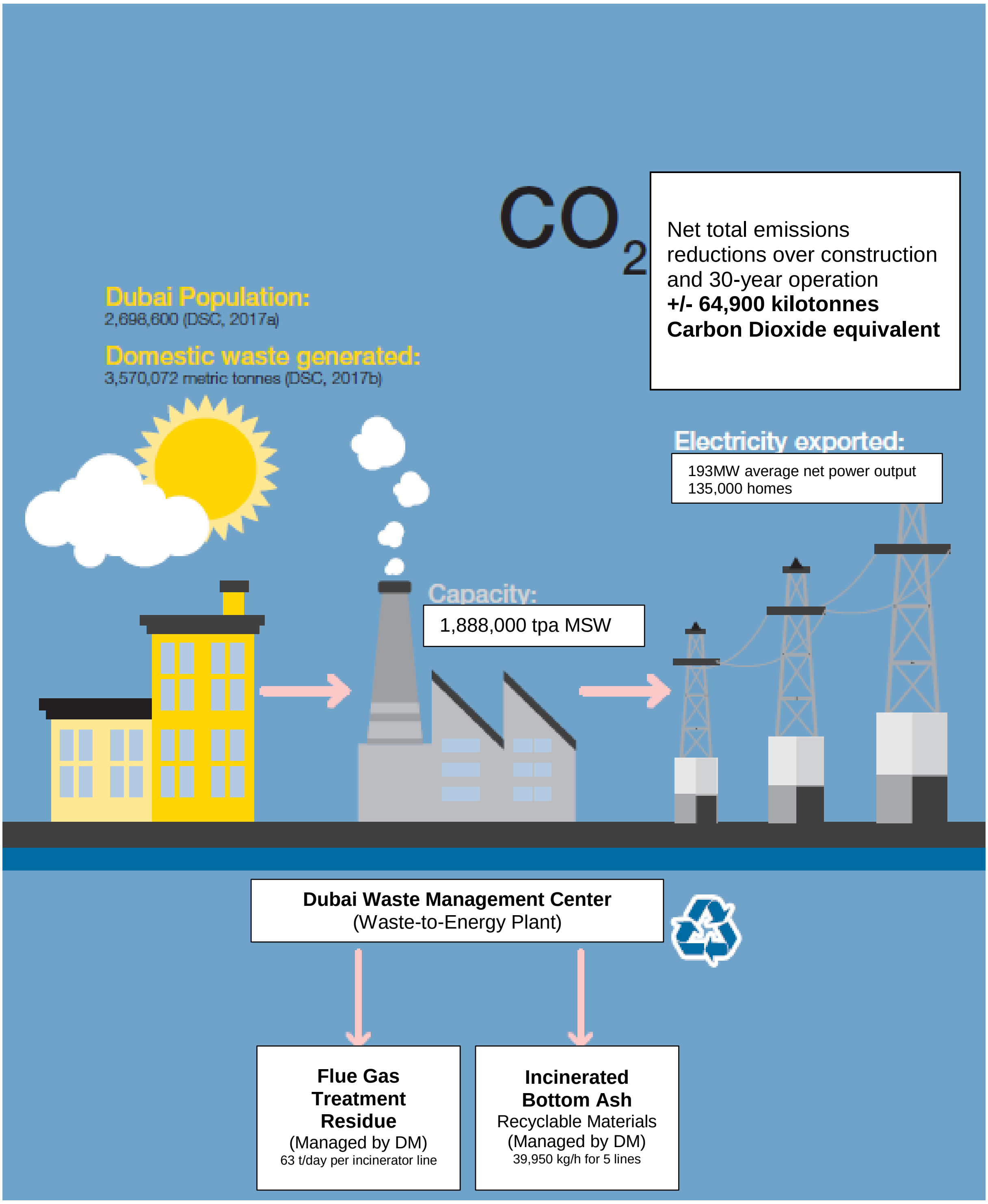


Figure 2-1 Concept diagram

2.2.1 Key components

Delivery of MSW from DM will occur via approximately 23 waste truck deliveries per hour on average, and approximately 70 waste truck deliveries per hour during peak periods.

The Dubai WMC will contain the following major components:

- Site access (access roads, carparks, fire detection equipment)
- Landscaping and security
- Entrances, weighbridges
- Waste bunkers, tipping bay area, waste cranes and mobile shredder
- Combustion system and boiler area
- Flue gas treatment area
- Turbine unit, generator and associated equipment
- Water treatment system
- Emission stacks
- Enclosed IBA management area, including - Incinerator bottom ash (IBA) pre-treatment, process hall, temporary and maturation area.
- Residue storage silo
- Auxiliary systems
- Fuel and storage tanks
- Maintenance/ warehouse area and cranes
- Electrical systems and back-up power
- Miscellaneous process equipment
- Weather station
- Administration buildings

2.2.2 Operating hours

The WMC will operate on a 24 hour per day, 7 day per week schedule, with four shifts anticipated, and each shift to be an estimated 12 hours.

3. Legal framework and standards

The predicted GLCs of pollutants emitted from the WMC will be compared to relevant air quality criteria. The following criteria were reviewed for relevance to the Project and most appropriate criteria selected.

- Cabinet Decree (12) of 2006 Regarding Regulation Concerning Protection of Air from Pollution
- US Occupational Safety and Health Administration (OSHA), 29 CFR, Part 1910 (Standards for Air Contaminants)
- US Environmental Protection Agency (EPA) National Ambient Air Quality Standards (NAAQs) 40 CFR Part 50
- World Bank Air Quality Standards
- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial emissions (integrated pollution prevention and control)

Where appropriate legislative standards do not exist for a particular pollutant, alternative criteria have been adopted for the purpose of this assessment. The following criteria were included as part of the legislative review:

- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (Australia)
- European Commission Air Quality Standards

The criteria adopted to compare against predicted GLCs are outlined in Table 3-13.

3.1 Cabinet Decree (12) of 2006 Regarding Regulation Concerning Protection of Air from Pollution

This regulation provides the maximum allowable limits of air pollutants emitted from different source installations, in work areas and in the ambient air. The standards and limits specified in this Ministerial Order are applicable to the Project and shall be maintained, where possible, to safeguard human health in the UAE.

The maximum allowable emission limits of air pollutants emitted from solid waste incinerators, are provided in Table 3-1. The ambient air quality standards are provided in Table 3-2.

Table 3-1 Maximum allowable emission limits of air pollutants emitted from solid waste incinerators

Pollutant	Max. allowable emission limits (mg/Nm^3)
	Incinerator capacity 3 ton/hour
Total suspended particulates (TSP)	30
Carbon monoxide (CO)	100
Oxides of nitrogen (NO_X)	300
Sulphur dioxide (SO_2)	300
Hydrogen chloride (HCl)	20
Hydrogen fluoride (HF)	2
Total volatile organic compounds (TVOC)	20
Nickel (Ni) Arsenic (As)	Total (1)
Cadmium (Cd) Mercury (Hg)	Total (0.1)
Lead (Pb) Chromium (Cr) Copper (Cu) Manganese (Mn)	Total (1)
Dioxins and furans (TCDD)	0.1 (ng TEQ/m^3)

Source: Cabinet Decree (12) of 2006 Regarding Regulation Concerning Protection of Air from Pollution, Annex (3)

Notes:

1. *The concentration of any substance specified in the first column emitted from the incinerator shall not at any point before admixture with air, smoke or other gases, exceed the specified limits.*
2. *''Nm^3" means normal cubic meter, being that amount of gas which when dry, occupies a cubic metre at a temperature of 25 degree Celsius and at an absolute pressure of 760 millimetres of mercury (1 atmosphere).*
3. *"mg" means milligram*
4. *"ng" means nanogram*
5. *Exclude "Dioxins and Furans" the emission limits for TSP, CO, NO_x, SO_2, NCl, HF and VOC are conducted as a daily average value, the remaining are conducted as an average values over the sample period of a minimum 60 minutes and a maximum of 8 hours.*
6. *"Dioxins and Furans": Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans are calculated using the concept of toxic equivalence in accordance with Annex 5.*

Table 3-2 UAE Federal ambient air quality standards

Pollutant	Maximum allowable limits (µg/Nm^3)	Average time
Nitrogen dioxide (NO_2)	400 150	1-hour 24-hour
Sulphur dioxide (SO_2)	350 150 60	1-hour 24-hour 1 year
Carbon monoxide (CO)	30000 10000	1-hour 8-hour
Ozone (O_3)	200 120	1-hour 8-hour
Total suspended particulates (TSP)	230 90	24-hour 1-year
Particulate matter with a diameter equal to or less than 10 microns (PM_{10})	150	24-hour
Lead (Pb)	1	1-year

Source: Cabinet Decree (12) of 2006 Regarding Regulation Concerning Protection of Air from Pollution, Annex (8)

Notes:

1. *"mg" means milligram*
2. *"µg" means microgram*
3. *"Nm^3" means normal cubic meter, being that amount of gas which when dry, occupies a cubic metre at a temperature of 25 degree Celsius and at an absolute pressure of 760 millimetres of mercury (1 atmosphere).*

3.2 US Occupational Safety and Health Administration 29 CFR, Part 1910 (Standards for Air Contaminants)

Under the United States Department of Labour, the Occupational Safety and Health administration put forth Occupational Safety and Health Standards for toxic and hazardous substances. The standards state that an employee's exposure to any substance may not at any time exceed the exposure limit. Exposure limits for substances relevant to this Project are listed in Table 3-3. Where an adjustment factor is applicable, the 8-hour time weighted average (TWA) has been adjusted to a 12-hour TWA to reflect the anticipated 12-hour shifts at the WMC using the Quebec model described in SWA 2013.

Table 3-3 US OSHA standards for air contaminants exposure limits

Pollutant	Limit (µg/m^3)
NO_2	9000 (exposure shall at no time exceed this value)
SO_2	13000 (calculated as a 12-hour TWA, adjusted from an 8-hour TWA)
CO	26700 (calculated as an 8-hour TWA – no adjustment factor)
TSP	15000 (calculated as an 8-hour TWA – no adjustment factor)
HCl	7000 (exposure shall at no time exceed this value)
HF	2680 (calculated as an 8-hour TWA – no adjustment factor)
Ammonia (NH_3)	35000 (calculated as an 8-hour TWA – no adjustment factor)
Hg	100 (exposure shall at no time exceed this value)
Cd	25 (calculated as a 12-hour TWA, adjusted from an 8-hour TWA)

Source: Table Z-1; Table Z-2 and Standard Number 1910.1027 (Cadmium)

Notes:

1. *Exposure limits for pollutants except HF and Hg are given in mg/m^3 and were converted to µg/m^3 for this assessment*
2. *Exposure limit for HF is given in ppm and was converted to µg/m^3 for this assessment*
3. *Exposure limit for Hg is given in mg/10m^3 and was converted to µg/m^3 for this assessment*

3.3 US EPA National Ambient Air Quality Standards 40 CFR Part 50

The Clean Air Act requires the EPA to set National Ambient Air Quality Standards (40 CFR Part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of national ambient air quality standards. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The standards for the criteria pollutants are shown in Table 3-4. These standards where reviewed, however were less stringent than the adopted assessment criteria and also being international standards, were considered less relevant to the Project than the UAE Federal criteria.

Table 3-4 Air Quality Standards for the Criteria Pollutants under 40 CFR Part 50

Pollutant	Primary/secondary	Averaging time	Level (µg/m^3)	Form
CO	Primary	8-hours	11,254	Not to be exceeded more than once per year
		1-hour	43,766	
Pb	Primary and secondary	Rolling 3-month average	0.15	Not to be exceeded
NO_2	Primary	1-hour	205	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	Primary and secondary	1-year	109	Annual mean
O_3	Primary and secondary	8-hours	150	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
$PM_{2.5}$ (particulate matter with a diameter equal to or less than 2.5 microns)	Primary	1-year	12	annual mean, averaged over 3 years
	Secondary	1-year	15	annual mean, averaged over 3 years
	Primary and secondary	24-hours	35	98th percentile, averaged over 3 years
PM_{10}	Primary and secondary	24-hours	150	Not to be exceeded more than once per year on average over 3 years
SO_2	Primary	1-hour	215	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	Secondary	3-hours	1.4	Not to be exceeded more than once per year

Source: US EPA NAAQS 40 CFR Part 50

Note that gaseous pollutants converted from ppb to µg/m^3 at 0 ºC and 1 atmosphere

3.4 World Bank air quality standards

The World Bank (International Finance Corporation; IFC) has referred to WHO air quality guidelines for different key air pollutants. The WHO air quality *guidelines* are intended for worldwide use but have been developed to support actions to achieve air quality that protects public health in different contexts. Air quality *standards*, conversely, are set by each country to protect the public health of their citizens and will vary depending on several factors including the national capability to manage air quality. Governments should consider their own local circumstances carefully before adopting the WHO air quality guidelines directly as legally based standards (WHO 2005).

WHO promulgated air quality guidelines as well as several interim targets for a number of pollutants (based on an extensive body of scientific evidence relating to air pollution and its health consequences) for particulate matter, ozone, nitrogen dioxide and sulphur dioxide in the Global Update 2005 (WHO 2005). However, other pollutants, such as carbon monoxide and lead, were not included in the Global Update 2005 review due to the limited resources available to the project. As a result, the 2000 WHO guidelines (WHO 2000) will remain in effect for pollutants not considered in the 2005 update. A summary of the WHO's Air Quality Guideline levels and interim targets are detailed in Table 3-5 and Table 3-6.

IFC Environmental Health and Safety guidelines 2007 (IFC 2007) outlines that projects with significant sources of air emissions should minimise impacts by ensuring that emissions do not exceed national legislated standards. In this case, the most relevant national legislated standards are UAE Federal criteria as presented in Section 3.1. In line with this directive, UAE Federal criteria have been adopted for this assessment, and World Bank/WHO guidelines have been referred to only where national standards do not exist.

Additionally, IFC (2007) suggest, as a general rule, that emissions from the project should amount to no more than 25 percent of the applicable air quality standards to allow for additional, future sustainable development in the same airshed.

Table 3-5 World Bank/WHO ambient air quality guidelines and interim targets

Pollutant	WHO interim target 1 ($\mu g/m^3$)	WHO interim target 2 ($\mu g/m^3$)	WHO interim target 3 ($\mu g/m^3$)	Air quality guideline ($\mu g/m^3$)	Averaging time
SO_2	125	50	N/A	20[1]	24-hour
O_3	160	N/A	N/A	100[2]	8-hour
PM_{10}	70	50	30	20	Annual
	150	100	75	50[3]	24-hour
$PM_{2.5}$	35	25	15	10	Annual
	75	50	37.5	25	24-hour

Table 3-6 World Bank/WHO ambient air quality guidelines

Pollutant	Air quality guideline ($\mu g/m^3$)	Averaging time
NO_2	200	1-hour
	40	Annual
CO	30000	1-hour
	10000	8-hour
	25	24-hour
Pb	0.5	Annual

[1] This denotes the World Bank guideline value for SO_2 Air Quality Standard. Interim target 1 and interim target 2 values for SO_2 are 125 $\mu g/m^3$ and 50 $\mu g/m^3$ respectively.

[2] This denotes the World Bank guideline value for O_3 Air Quality Standards. Interim target 1 value for O_3 is 160 $\mu g/m_3$.

[3] This denotes the World Bank guideline value for PM_{10} 99_{th} percentile Air Quality Standards. Interim target 1, interim target 2 and interim target 3 values for PM_{10} are 150 $\mu g/m_3$, 100 $\mu g/m_3$, and 75 $\mu g/m_3$ respectively.

3.5 Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial emissions (integrated pollution prevention and control)

Emission limit values for this modelling assessment have been adopted from the Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial emissions (integrated pollution prevention and control) (IED). Emission limits were taken from Annex VI, Part 3 of the document as shown in Table 3-7 to Table 3-10.

Table 3-7 Daily average emission limit values for polluting substances

Pollutant	Emission limit (mg/Nm^3)
TSP	10
HCl	10
HF	1
SO_2	50
NO_2	200

Source: IED Annex VI, Part 3, Table 1.1

Table 3-8 Average emission limit values for heavy metals over a sampling period of a minimum of 30 minutes and a maximum of eight hours

Pollutant	Emission limit (mg/Nm^3)
Cd and thallium (total)	0.05
Hg	0.05

Source: IED Annex VI, Part 3, Table 1.3

Table 3-9 Average emission limit value for dioxins and furans over a sampling period of a minimum 6 hours and maximum 8 hours

Pollutant	Emission limit (ng/Nm^3)
Dioxins and furans	0.1

Source: IED Annex VI, Part 3, section 1.4

Table 3-10 Emission limit value in the waste gases

Pollutant	Emission limit (mg/Nm^3)
CO	50 daily average value

Source: IED Annex VI, Part 3, section 1.5

3.6 Other air quality standards

3.6.1 *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Australia)

The *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW AMMAAP; NSW DEC 2005) lists the impact assessment criteria for individual toxic air pollutants. Principal toxic air pollutants (cadmium and dioxins and furans) are defined on the basis that they are carcinogenic, mutagenic, teratogenic, highly toxic or highly persistent in the environment. NSW AMMAAP directs that “toxic air pollutants must be minimised to the maximum extent achievable through the application of best-practice process design and/or emission controls” (NSW DEC 2005). Criteria for other individual toxic air pollutants are shown in Table 3-11.

Table 3-11 NSW AMMAPP impact assessment criteria

Substance	Max. allowable limit as the 99.9th percentile (µg/m3)	Averaging time
HCl	140	1-hour
HF	2.9 (as the maximum)	24-hour
NH3	330	1-hour
Hg	1.8	1-hour
TCDD	2.0 E-06	1-hour
Cd	0.018	1-hour
Ni	0.18	1-hour

3.6.2 European Commission Air Quality Standards

The European Union has developed an extensive body of legislation, which establishes health-based standards and objectives for air pollutants. These are displayed in Table 3-12.

Table 3-12 European Commission Air Quality Standards

Pollutant	Concentration (µg/m^3)	Averaging period
NO_2	200	1-hour
	40	24-hour
SO_2	350	1-hour
	125	24-hour
CO	10000	8-hour
PM_{10}	50	24-hour
	410	Annual
$PM_{2.5}$	25	Annual
Pb	0.5	Annual
Cd	0.005	Annual

3.6.3 Adopted assessment criteria

Following the above review of the relevant legislation and guideline criteria for air quality standards, the criteria considered most appropriate for this assessment were adopted based on existing surrounding land use and the long-term benefits afforded by the Project to the local area. The adopted assessment criteria are displayed in Table 3-13. The GLCs will also be compared to the US OSHA standards for air contaminants exposure limits set out in Table 3-3.

Table 3-13 Adopted assessment criteria

Pollutant	Averaging time	Authority	Criteria (µg/m^3)
NO_2	1-hour	UAE	400
	24-hours	UAE	150
	Annual	WHO	40
SO_2	1-hour	UAE	350
	24-hours	UAE	150
	Annual	UAE	60
CO	1-hour	UAE	30000
	8-hours	UAE	10000
TSP	24-hours	UAE	230
	Annual	UAE	90
PM_{10}	24-hours	UAE	150
	Annual	WHO	20
$PM_{2.5}$	24-hours	WHO	25
	Annual	WHO	10

Pollutant	Averaging time	Authority	Criteria (µg/m^3)
HCl	1-hour 99.9th percentile	NSW AMMAAP	140
HF	24-hours	NSW AMMAAP	2.9
TCDD	1-hour 99.9th percentile	NSW AMMAAP	2.00 E-06
NH_3	1-hour 99.9th percentile	NSW AMMAAP	330
Hg	1-hour 99.9th percentile	NSW AMMAAP	1.8
Cd	1-hour 99.9th percentile	NSW AMMAAP	0.018
	Annual	European Commission	0.005

4. Description of the baseline environment

Air quality is relatively variable in the Emirate of Dubai depending on several factors including the nature of the location of the area. Air quality monitoring stations (AQMS) measure air pollutants in the UAE as required in Cabinet Decree 12 of 2006.

A description of existing ambient air quality near the Project site is presented in this section using information from the AQMS to provide context for the modelling results. Relevant background concentrations are adopted for cumulative assessment of modelling results against the assessment criteria.

4.1 Annual average ambient air quality

AQMS' situated in residential areas (Deira and Mushrif Park) and industrial areas (Warsan and Dubai International Airport) of the Emirate of Dubai continuously monitor criteria pollutants such as PM_{10}, SO_2, NO_2 and CO. The locations of these AQMS are shown in Figure 4-1.

The results of air quality monitoring at the four stations (where available) in 2017 are provided in Table 4-1. Annual average PM_{10} exceeds the WHO limit, as shown in red text, at both available stations. Annual SO_2 measurements comply with the UAE Federal standard for all stations. The WHO annual NO_2 standard is exceeded at three out of the four stations. There are no annual standards for CO, although concentrations measured at all four stations are considered relatively low.

4.1.1 Adopted annual average background concentrations

For a cumulative assessment of annual average concentrations, data presented in Table 4-1 was adopted as background concentrations. As the sensitive receptors in this assessment are located in residential areas, data from the closest residential AQMS was used, this being Mushrif Park, highlighted in Table 4-1 in bold.

Figure 4-1 AAQMS locations

Table 4-1 Monthly and annual average air quality concentrations in Dubai for 2017

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual average
SO_2 (µg/m^3): UAE Federal Standard – 60 µg/m^3 (annual)													
Deira (residential)	8	8	10	16	13	13	10	8	8	8	10	8	10
Mushrif Park (residential)	3	5	5	5	5	5	5	8	3	3	5	5	**6**
Warsan (industrial)	5	8	13	16	8	3	5	8	16	10	5	8	8
Dubai International airport (industrial)	8	5	10	13	10	5	8	5	5	8	8	8	8
NO_2 (µg/m^3): WHO Standard – 40 µg/m^3 (annual)													
Deira (residential)	49	53	53	64	55	47	53	51	56	49	53	62	53
Mushrif Park (residential)	32	30	32	41	38	36	36	28	39	36	32	34	**34**
Warsan (industrial)	45	43	43	56	47	45	43	39	47	43	45	51	46
Dubai International airport (industrial)	49	45	43	53	55	49	39	39	43	38	43	49	45
CO (*µg/m^3):*													
Deira (residential)	400	400	400	900	400	300	300	300	300	300	300	400	400
Mushrif Park (residential)	200	300	200	600	300	300	200	200	300	300	200	300	300
Warsan (industrial)	300	300	300	600	400	300	400	400	600	500	400	400	400
Dubai International airport (industrial)	400	400	400	800	300	300	300	300	300	300	300	400	400

Source: National Centre of Meteorology and Seismology as cited in Federal Competitiveness and Statistics Authority

Annual averages may not match due to rounding

Exceedances shown in red

4.2 24-hour average ambient air quality

Direct 24-hour background air quality measurements were not available from the AQMS discussed in Section 4.1. However, it is considered appropriate to apply a factor to an annual concentration in order to determine short-term ambient concentrations to use as background concentrations in an air quality assessment such as this. The United Kingdom Environment Agency guideline (United Kingdom Environment Agency 2016) suggests adopting a 24-hour background concentration based on the annual average ambient concentration multiplied by a factor of two.

4.2.1 Adopted 24-hour background concentrations

For a cumulative assessment of 24-hour average concentrations, the above methodology was adopted. 24-hour background concentrations used in this assessment, based on the annual background concentrations are shown in Table 4-2.

Table 4-2 Adopted 24-hour background concentrations

Pollutant	Background concentration (µg/m³)
NO_2	68
SO_2	12

4.3 1-hour average ambient air quality

Dubai Municipality provides the highest recordings at several monitoring sites in the Emirate of Dubai as Air Pollution Indicators. Data from 11 AQMS (locations shown in Figure 4-2) are provided in Table 4-3 showing the highest recorded 1-hour concentrations for industrial and residential areas. This data is also displayed graphically in Figure 4-3 to Figure 4-5. All measurements of NO_2, CO and SO_2 at the available AQMS are below the respective UAE standards of 400 µg/m³, 30,000 µg/m³ and 350 µg/m³.

4.3.1 Adopted 1-hour background concentrations

For a cumulative assessment of 1-hour average concentrations, these Air Pollution Indicators (where available) have been adopted as the background concentrations and are considered a conservative estimate. As the sensitive receptors in this assessment are located in residential areas, data from the closest residential AQMS was used, this being Mushrif Park. Data from the most recent monitoring period (2017) was used, highlighted in Table 4-3 in bold.

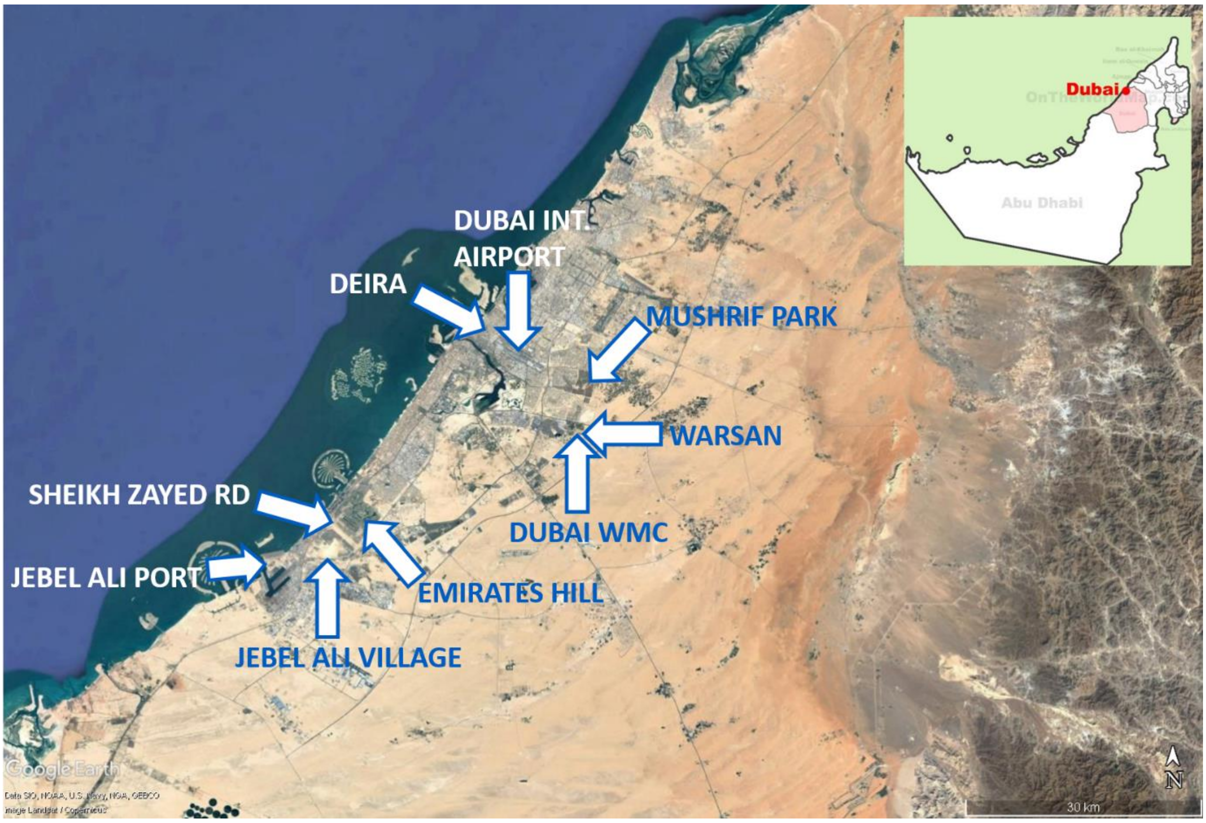


Figure 4-2 Air Pollution Indicator monitoring sites

Table 4-3 1-hour average air quality concentrations in Dubai for 2015 to 2017 (highest recorded readings)

	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
	Mushrif Park (residential)			*Jebel Ali Village (residential)*			*Jebel Ali Port (industrial)*			*Warsan (industrial)*		
NO_2 (µg/m³)	226	226	**185**	164	226	164	267	-	226	144	205	164
SO_2 (µg/m³)	-	86	**86**	172	114	200	229	-	286	286	86	86
CO (µg/m³)	-	3264	**5477**	1913	2789	1963	-	-	1788	1913	2000	1625
	Sheikh Mohammed Bin Zayed Rd (mixed use)			*Deira (residential)*			*Al Karma (residential)*			*Zabeel Park (residential)*		
NO_2 (µg/m³)	205	267	185	205	267	185	205	267	185	164	267	164
SO_2 (µg/m³)	257	86	114	257	86	114	257	86	114	257	114	143
CO (µg/m³)	2338	2100	1963	2338	2100	1963	2338	2100	1963	2851	3101	3301
	Emirates Hill (residential)			*Dubai Airport (industrial)*			*Sheikh Zayed Rd (residential)*					
NO_2 (µg/m³)	185	185	144	205	226	185	246	205	164			
SO_2 (µg/m³)	143	86	143	286	114	114	172	114	114			
CO (µg/m³)	1813	2713	3126	2951	3164	2826	3364	2738	3189			

Source: Dubai Municipality (Government of Dubai 2017)

Concentrations converted from PPM to µg/m³ at 0 º and 1 atmosphere

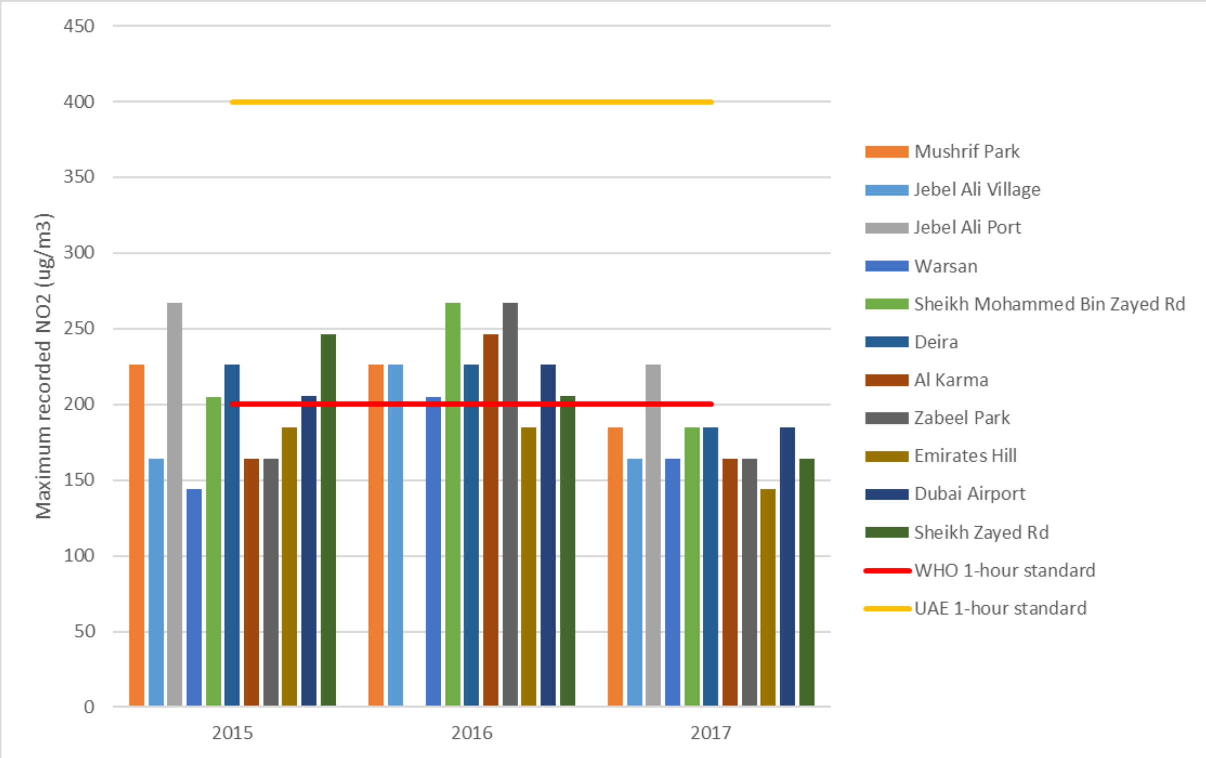


Figure 4-3 Air Pollution Indicator (NO_2) for 2015 to 2017

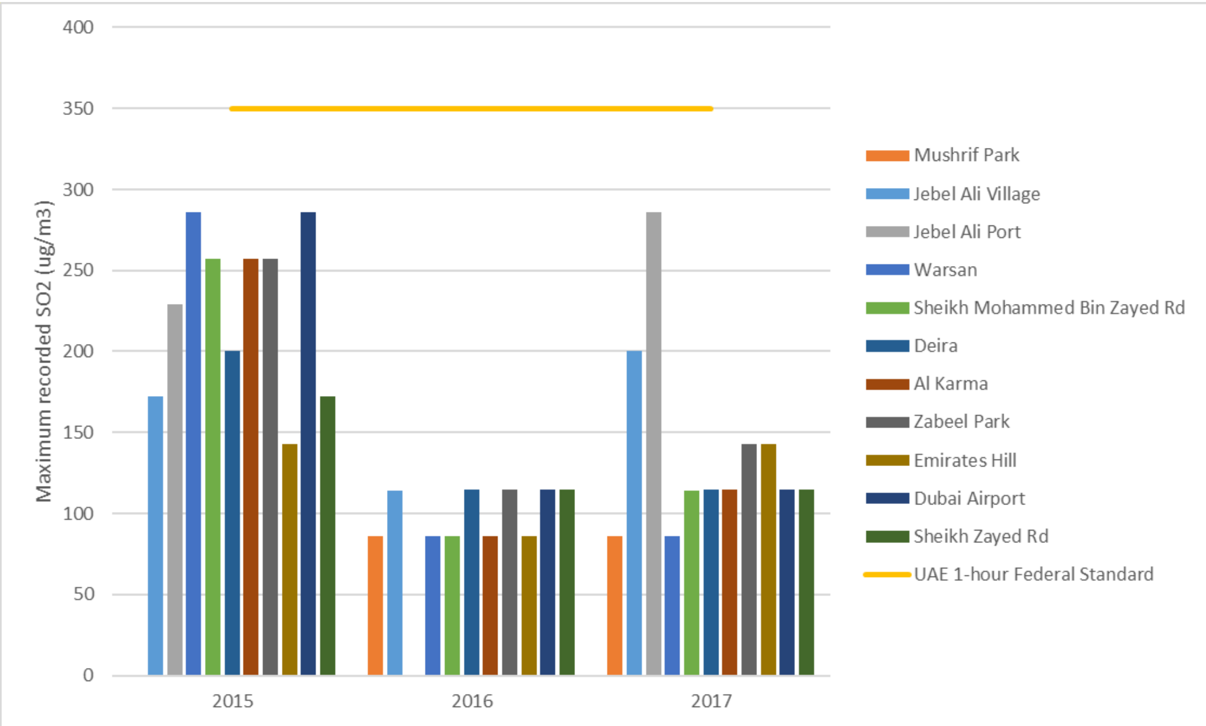


Figure 4-4 Air Pollution Indicator (SO_2) for 2015 to 2017

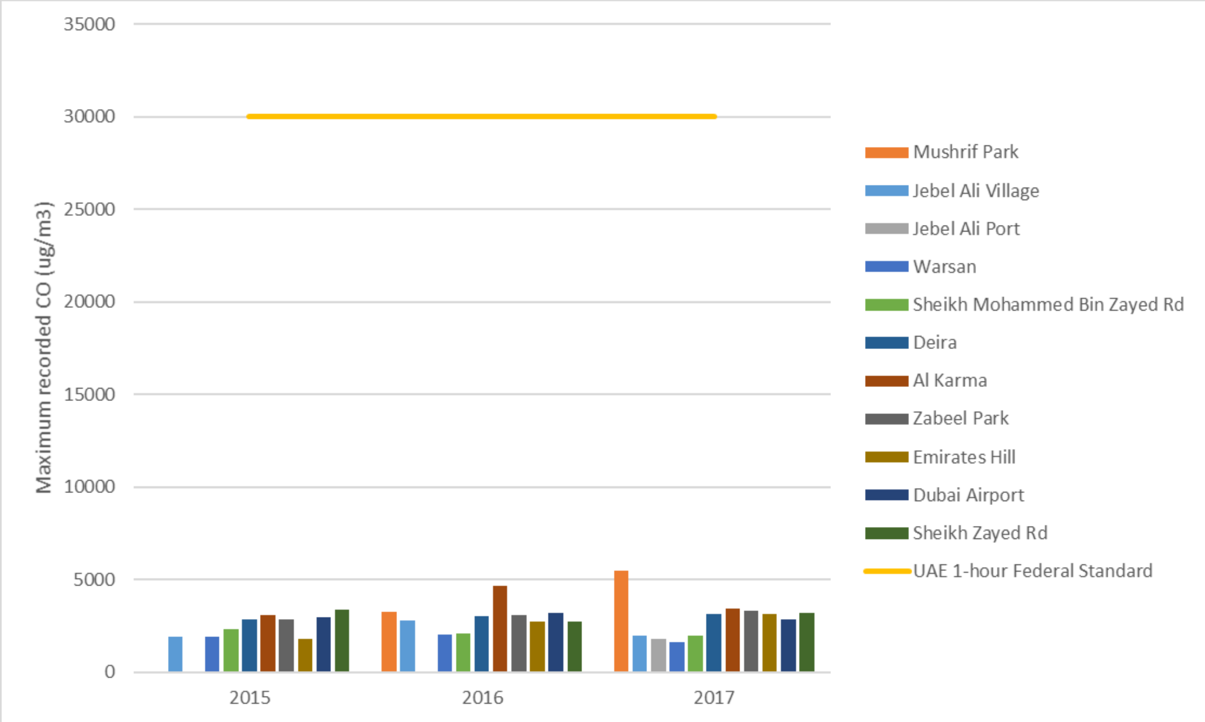


Figure 4-5 Air Pollution Indicator (CO) for 2015 to 2017

4.4 PM_{10} and $PM_{2.5}$ ambient air quality

Ambient air quality monitoring was carried out for the year 2017 for PM_{10} at Emirates Hill, Mushrif and Sheikh Mohammed Bin Zayed Road. Similarly, ambient air quality monitoring for $PM_{2.5}$ was carried out for Mushrif and Sheikh Mohammed Bin Zayed Road. The 75th percentile 24-hour and annual averages for these parameters are displayed in Table 4-4.

Table 4-4 Ambient air quality for PM_{10} and $PM_{2.5}$

Pollutant	Location	24-hour average (µg/m³)	Annual average (µg/m³)
PM_{10}	Emirates Hills	161	131
	Mushrif	**169**	**141**
	Sheikh Mohammed Bin Zayed Rd	195	157
$PM_{2.5}$	Mushrif	**60**	**48**
	Sheikh Mohammed Bin Zayed Rd	63	50

Source: Dubai Municipality

Exceedances shown in red

It can be seen that the ambient air quality data for PM_{10} and $PM_{2.5}$ exceeds both the 24-hour and annual WHO criteria. Data from Mushrif will be used as part of the cumulative assessment in Section 5.3, and are highlighted in Table 4-4 in bold.

4.5 Climate and meteorology

The climate of the UAE can be described as a subtropical dry, hot desert climate with low annual rainfall and high annual temperatures becoming very high in summer. There is a large difference between maximum and minimum temperatures, especially in the inland areas. The coastal areas are slightly influenced by the waters of the Arabian Gulf, having higher humidity and lower maximum but higher average temperatures.

The extended summer is very hot with long periods of negligible levels of rainfall. Daily maximum temperatures easily reach 40°C or more. UAE winter is cooler with occasional rainfall, while spring and autumn/fall are again very warm and mostly dry with maximum temperatures between 25◦C and 35 ◦C and cooler night time temperatures between 15 ◦C and 22 ◦C. Figure 4-6 shows the daily temperatures recorded at Dubai International Airport in 2015.

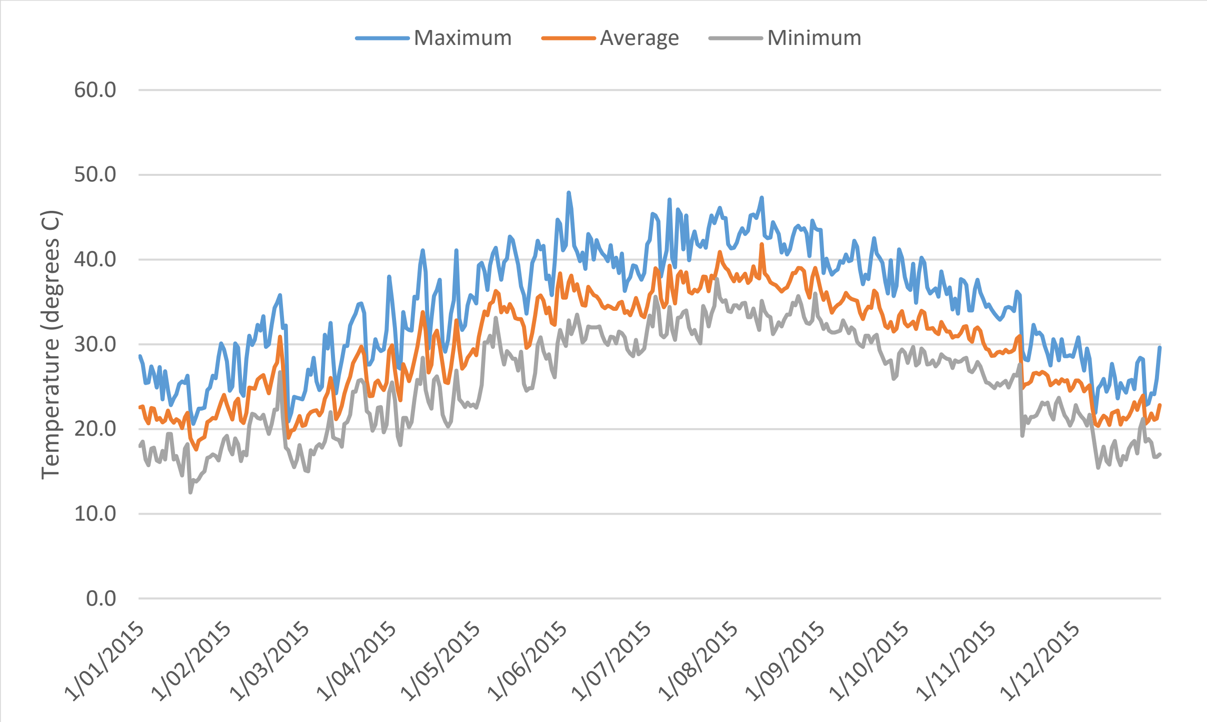


Figure 4-6 Daily temperatures recorded at Dubai Airport for 2015 (National Centre of Meteorology 2018)

From Figure 4-6 it is shown the 2015 year resembles average long-term temperatures observed in the Emirate of Dubai. In summer, maximum temperatures exceed 40 ºC and spring maximum temperatures falling between 25 ºC and 35 ºC

Winds are variable throughout the year and average 3 to 4 m/s. The wind speed and wind direction data for 2015 for Dubai International Airport are displayed in Figure 4-7 and Figure 4-8, which are considered representative of annual wind trends in Dubai.

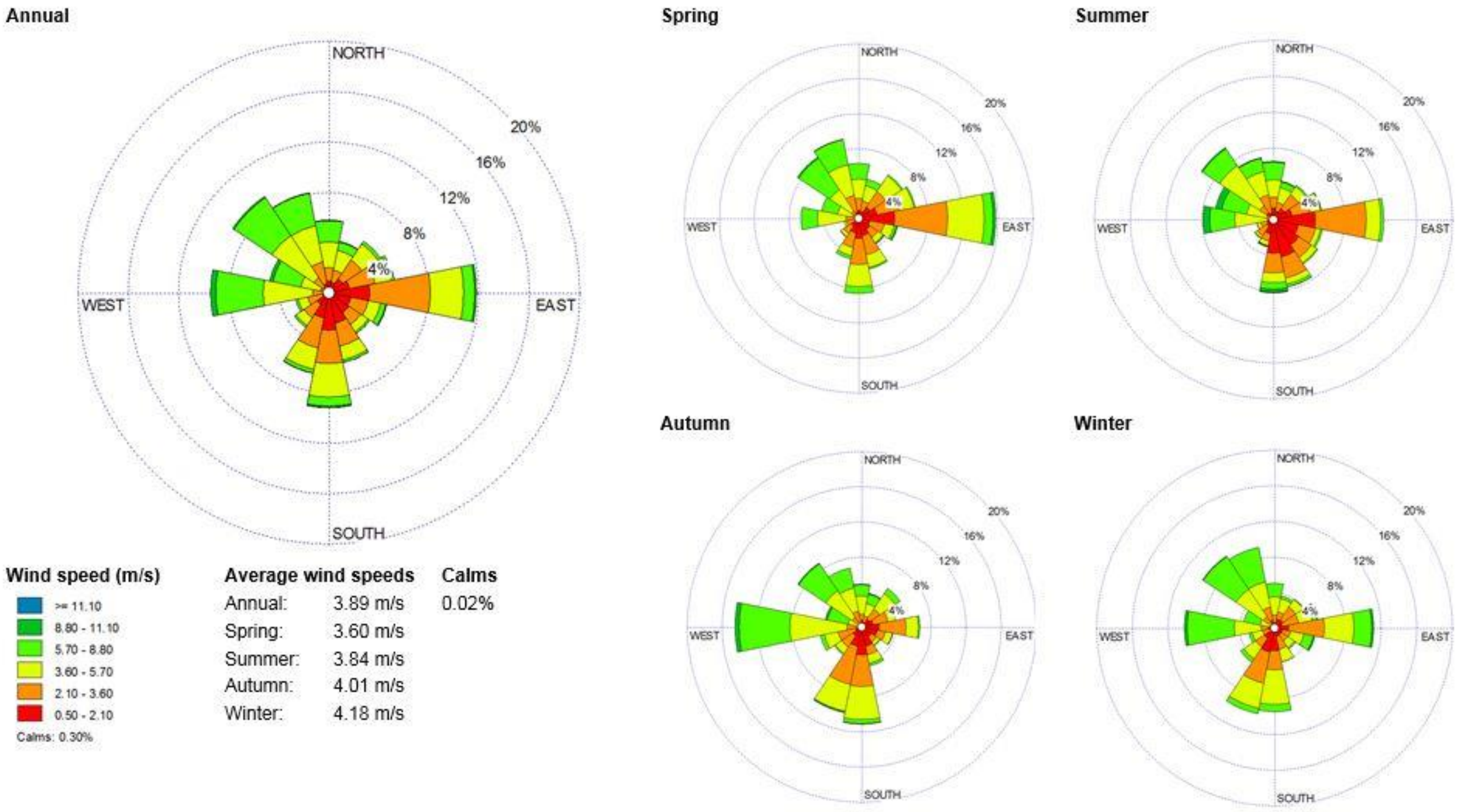


Figure 4-7 Annual and seasonal wind roses for Dubai International Airport 2015

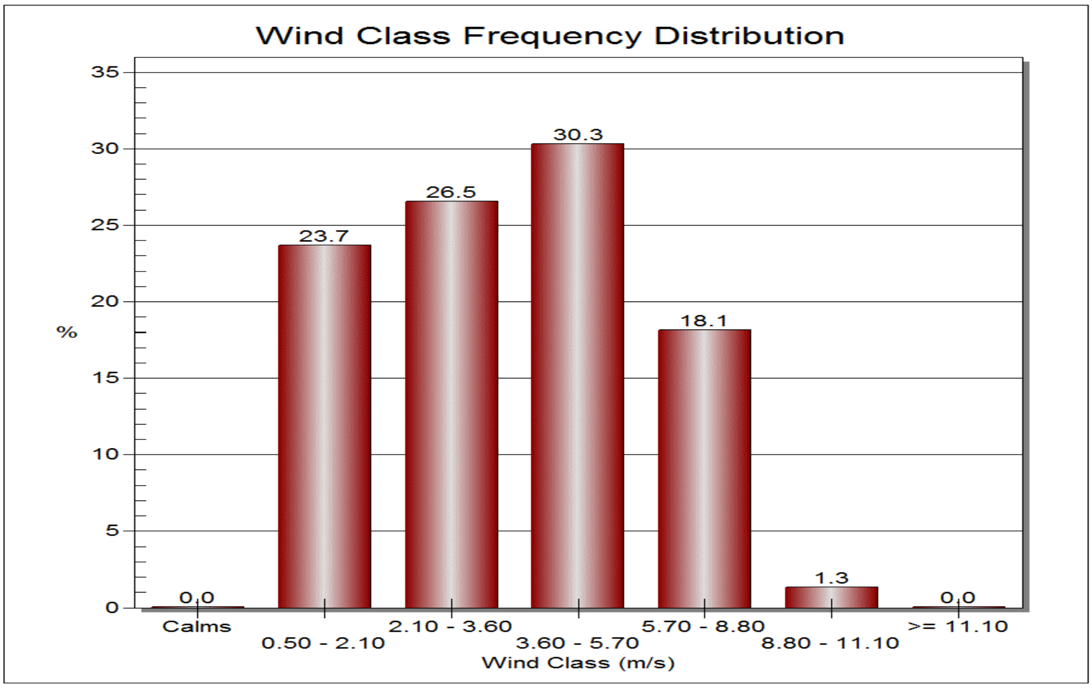


Figure 4-8 2015 annual wind class frequency distribution for Dubai International Airport

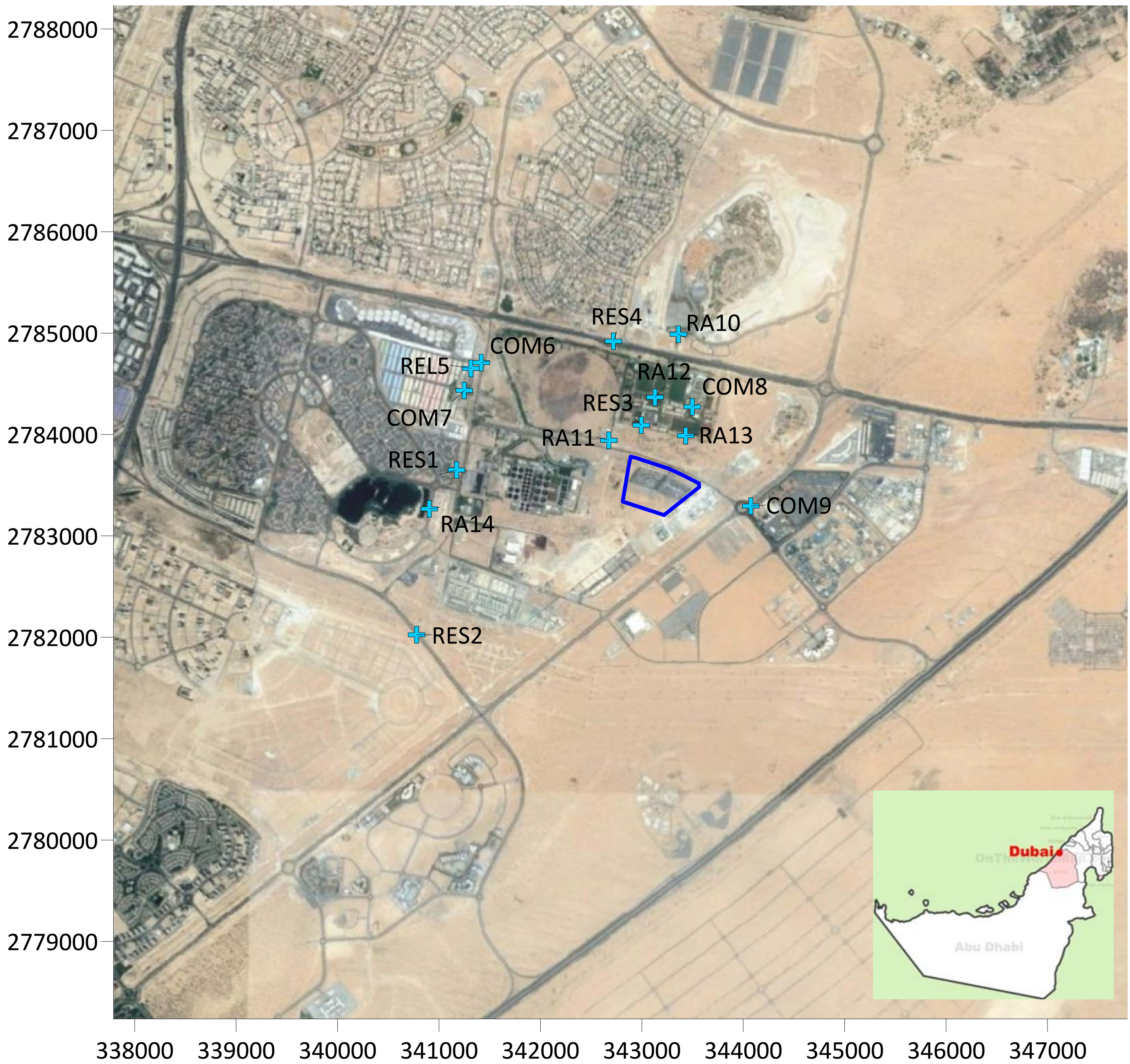
Emissions from stack sources such as the one in this proposed development are typically associated with moderate wind speeds (roughly 2-4 m/s, shown in orange in Figure 4-7). Given that these winds are predominantly from the east for the site, it would be expected that the dispersion model would follow a similar pattern. Figure 4-8 shows the wind class frequency distribution for the Dubai International Airport. The most frequently occurring wind class is 3.6-5.7 m/s which are experienced 30 percent of the time. Calm conditions with wind speeds less than 0.5 m/s are experienced only 0.02 percent of the time.

4.6 Sensitive receptors

Sensitive receptors are classified as places where people are likely to reside. This may include dwellings, schools, hospitals, offices or public recreational areas (NSW DEC 2005). 14 sensitive receptors have been identified within 5 km from the Project and are detailed in Table 4-5. Sensitive receptor locations are shown in Figure 4-9

Table 4-5 Sensitive receptors

ID	Description	Location (m UTM)	Distance from site (km)	Elevation (m ASL)
RES1	Dubai International City- EMR 14, Emirates Cluster	341174 E 2783650 N	1.4	29
RES2	International City Phase II (under construction)	340779 E 2782024 N	1.3	30
RES3	Residential Villas (Desert Palm)	342995 E 2784091 N	0.3	43
RES4	AL Warqa 4 (north of Al Awir Road)	342720 E 2784920 N	1.1	28
REL5	Dragon Mart Mosque	341316 E 2784651 N	1.6	24
COM6	Dragon Mart Commercial Centre	341417 E 2784708 N	1.6	21
COM7	Dubai Textile City	341250 E 2784434 N	1.6	22
COM8	Desert Palm Resort and Hotel	343498 E 2784272 N	0.6	47
COM9	Dubai Plant Nursery	344076 E 2783294 N	0.6	47
RA10	Dubai Safari Park (north of Al Awir Road)	343361 E 2784988 N	1.3	26
RA11	Pivot Fields	342675 E 2783943 N	0.15	42
RA12	Desert Palm Polo Club	343130 E 2784366 N	0.6	43
RA13	Desert Palm Riding Schools	343433 E 2783988 N	0.3	40
RA14	Warsan Lake	340905 E 2783266 N	1.4	30



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

LEGEND

Sensitive receptor

Project site perimeter

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

CLIENTS | PEOPLE | PERFORMANCE

Hitachi Zosen Inova, Besix and Itochu
Dubai Waste Management Center

FIGURE 4-9

Sensitive receptors

DRAWING NO.	REVISION	DATE
Fig 4-9.srf	8	13.03.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Air Quality Assessment\05. WP\Surfer

5. Dispersion modelling

5.1 Emission sources

Air emissions for the facility will be emitted from:

- Five point sources (tall stacks), which are associated with fuel combustion sources from the boilers. The stacks will be located at the main building.
- IBA management area. This will consist of:
  - Wheel generated dust from IBA product being transported offsite.
  - Wheel-generated dust will be assessed for TSP, PM_{10} and $PM_{2.5}$ only.
  - There are no dust emissions associated with wind erosion from any IBA stockpiles, as the stockpiles within the IBA maturation area are entirely enclosed in the IBA building.
  - Similarly, there are no dust emissions from loading of IBA product, as this will occur within the enclosed IBA building.
  - There will be no emissions from the IBA pre-treatment or IBA process hall as both areas are located within a building.

Calculation methodology for both stack emissions wheel-generated dust are discussed below.

Main building - stack emissions

HZI, Besix and Itochu provided stack air emissions information to GHD for use in the air assessment. The emissions information consisted of a technical process description and emission guarantees for the various pollutants, which are expected to be produced from the WMC. Stack parameters and stack gas flow emission loads were also provided. Table 5-1 summarises the stack parameters for the WMC as used in the modelling.

The following assumptions have been made by GHD in the modelling assessment:

- Building wake effects were modelled based on provided building dimensions
- Source locations were provided by HZI, Besix and Itochu to GHD for use in the dispersion model

One operating case has been identified in which a thermal load of 100 percent is assumed. Boiler emission rates modelled (g/s) and the total annual emissions (kg/yr) are presented in Table 5-2. Air pollutant emission rate estimations were calculated using IED, Annex VI, Part 3 (Tables 1.1, 1.3 and sections 1.4 and 1.5) (European Union 2010) and methods from NSW AMMAAP (NSW DEC 2005). An oxygen content of 11 percent was assumed as per IED. The following emission concentrations limits, controls and considerations have been made for this assessment:

- NO_x to NO_2 ratio of 40 percent has been assumed. A ratio of 20 percent to 30 percent is typical for combustion sources in low background ozone atmosphere, such as the Project area. Therefore, the adopted conversion rate is considered appropriate for this assessment.
- Modelled NO_x emission rates correspond to a concentration of 200 mg/Nm^3 (daily)
- Modelled SO_2 and CO emission rates each correspond to a concentration of 50 mg/Nm^3 (daily)
- Modelled TSP and HCl emission rates each correspond to a concentration of 10 mg/Nm^3 (daily)
- Modelled HF emission rates correspond to a concentration of 1 mg/Nm^3 (daily)

- Modelled NH_3 emission rates correspond to a UAE stack limit concentration of 10 mg/Nm^3 (Federal Environment Agency 2006)
- Modelled Dioxins and furans emission rates correspond to a concentration of 0.1 ng/Nm^3 (six to eight hours)
- Modelled Hg and Cd emission rates each correspond to a concentration of 0.05 mg/Nm^3 (30 minutes to eight hourly). It is noteworthy that the emission limit for Cd is specified in the IED as the total of Cd and thallium, equal to 0.05 mg/Nm^3. A conservative approach was taken, assuming that 100% of the emissions are Cd. A comparison of Cd emissions from other WMCs constructed by Hitachi Zosen Inova is shown in Section 5.1.1.
- A conservative approach of the ratio of 1:1 was assumed for TSP to PM_{10} and $PM_{2.5}$
- The daily IED concentrations were adopted for NO_x, SO_2, CO, TSP and HCl over the half hour limits as the shorter duration limits are designed for upset conditions, which typically do not last longer than half an hour. As this assessment relates to ambient air quality associated with typical plant operation, it is not considered appropriate to use the IED half hour limits, as this will result in unrealistic emissions, and would not represent long-term plant operation. Further, a similar facility built by HZI has demonstrated NO_x (as NO_2) half hourly average values to be between 150 mg/m^3 and 196 mg/m^3 (Element 2020), which is less than half the half hourly limit for NO_2 of 400 mg/m^3. Using the half hourly limit would therefore severely over-predict ambient concentrations. Finally, HZI Besix and Itochu have committed to a NO_x control system to be implemented, which will control NO_x to ensure an average concentration of NO_x below 200 mg/Nm^3, and with few peaks above this. The control system for NO_x will therefore ensure that the concentration will not reach the half hour emission limit value of 400 mg/Nm^3.

Table 5-2 presents the adopted emission rates for activities associated from the stacks.

IBA management area emissions

As discussed in Section 5.1, the transportation of IBA product is likely to cause particulate emissions from the IBA management area. The activities occurring at the IBA management area are:

- IBA pre-treatment storage – IBA is conveyed (via enclosed conveyor) to a covered storage area where it is stored up to five days to reduce the moisture content prior to the treatment / metal separation in the IBA process hall. Dried IBA is conveyed (via enclosed conveyor) to the process hall.
- IBA process hall – IBA from pre-treatment storage is processed and is undertaken for ferrous and non-ferrous metals by a series of different flows including crusher, overband magnets, magnetic drum, eddy current separators, a hand sorting platform, screens and belts, producing mineral fractions of different particle sizes. The IBA is then transferred by a front end loader to the IBA maturation area, which is enclosed in the IBA building.
- IBA maturation area – Different mineral fractions are stockpiled for up to 12 weeks for maturation and further stabilisation with periodical moistening and restacking, resulting in aggregates as the final product of this stage. The moistening also allows for dust suppression.
- Once IBA maturation has been completed, the material is loaded onto a tipping truck and transported offsite.

Emission factors for fugitive road dust were estimated based on emission rates for fly ash in coal fired power stations (Mueller et al., 2013). This is likely to lead to an over estimation and therefore the assessment is considered conservative. The emission rates were based on the following assumptions for activities occurring at the IBA maturation area:

- 282,300 tpa of mineralic aggregate is expected to be transported offsite during either the temporary or maturation process.
- Stockpiles and temporary storage of IBA will be enclosed within the IBA building.
- Loading/unloading of material will occur within the IBA building and is therefore expected to generate negligible dust.
- A conservative approach was taken as 50 percent TSP assessed as PM_{10}.
- For all the factor listed above, two scenarios were modelled:
  - Without dust control
  - With dust control. Dust control includes water spraying, as frequently as required on transport routes. This will result in 50 percent dust control efficiency for fugitive road dust emissions.

Meuller *et al*. (2013) estimated fly ash emission rates based on field data and AP-42 emissions estimation techniques. For this assessment, this assessment has adopted the emission factors estimated based on field trial data for the fugitive road dust emissions.

Table 5-2 presents the adopted emission rates for activities occurring at the IBA management area. Location of emissions sources modelled are shown in Figure 5-1.

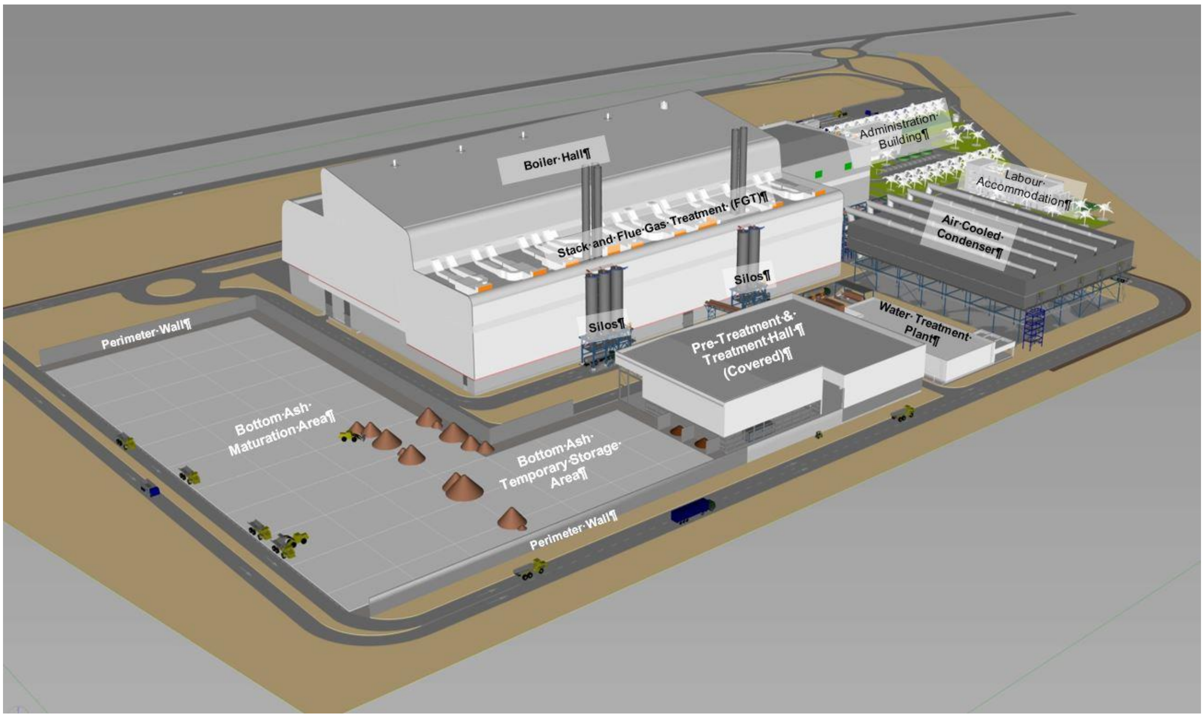


Figure 5-1 Source locations

Table 5-1 Emission source parameters as used in the AERMOD model

Source ID	Activity description	Source type	Location (UTM)	Stack base elev. (m)	Stack height (m)	Stack diameter (m)	Exit velocity (m/s)	Exit temp (ºK)
1	Stack 1	Point source	343046 E 2783416 N	34	70	2.4	19	408.2
2	Stack 2	Point source	343051 E 2783414 N	34	70	2.4	19	408.2
3	Stack 3	Point source	343047 E 2783411 N	34	70	2.4	19	408.2
4	Stack 4	Point source	343118.7 E 2783393 N	35	70	2.4	19	408.2
5	Stack 5	Point source	343123 E 2783391 N	35	70	2.4	19	408.2
Source ID	Activity description	Emissions type	Location (UTM)	Effective height (m)	Base elevation	Initial sigma z (m)		
7	Truck	Volume	342884 E 2783471 N	1	37	1		

Table 5-2 Source emission rates for modelling

Emissions type	Emission rate per stack	Unit
Stacks		
NO_x	5.47	g/s
	172,411	kg/yr
SO_2	3.42	g/s
	107,757	kg/yr
CO	3.42	g/s
	107,757	kg/yr
TSP, PM_{10} and $PM_{2.5}$	0.68	g/s
	21,551	kg/yr
HCl	0.68	g/s
	21,551	kg/yr
HF	0.068	g/s
	2155	kg/yr
NH^3	0.68	g/s
	21,551	kg/yr
TCDD	$6.83x10^{-9}$	g/s
	0.00022	kg/yr
Cd	0.0034	g/s
	108	kg/yr
Hg	0.0034	g/s
	108	kg/yr

Emissions type		Emission rate per stack	Unit
IBA and mineral fraction			
Fugitive road dust	TSP – No dust control	0.81	g/s
		25,597	kg/yr
	TSP – Dust control	0.41	g/s
		12,798	kg/yr
	PM_{10} – No dust control	0.41	g/s
		12,798	kg/yr
	PM_{10} – Dust control	0.20	g/s
		6,399	kg/yr
	$PM_{2.5}$ – No dust control	0.05	g/s
		1,419	kg/yr
	$PM_{2.5}$ – Dust control	0.02	g/s
		710	kg/yr

5.1.1 Comparison of Cd emission rates with similar WMCs

In Table 5-2, the emission rate for Cd for this Project is shown to be calculated at 0.0034 g/s, or 108 kg/yr. A comparison to the most recently built WMCs by Hitachi Zosen Inova is hereby included to demonstrate the conservative nature of the emission rate for Cd used in this assessment. Table 5-3 shows the Cd emission rates as monitored at several WMCs.

Table 5-3 Comparison of estimated emission rates of Cd for this Project and monitored emission rates of Cd for a number of existing WMCs

	Dubai WMC (this Project) – emission estimation	FCC Waste Services (UK) Ltd, Millerhill – December 2018[1]	FCC Waste Services (UK) Ltd, Millerhill – February 2019[1]	Covanta, Dublin 4, Line 1– September 2017[1]	Covanta, Dublin 4, Line 2– September 2017[1]
Cd and thallium total emission rate (g/s)	0.0034[1]	0.00003	0.00006	<0.00004	<0.00004
Cd and thallium total emission rate (kg/yr)	108[1]	1.05	1.75	<1.31	<1.14

Source: Email correspondence with Hitachi Zosen Inova

Note that monitored emission rates of Cd were provided in g/hr and were converted to g/s and kg/yr for comparative purposes

1. Cd emission rate as 100%

From Table 5-3, it is evident that the emission rate for Cd and Thallium as monitored at the existing Hitachi Zosen Inova WMCs is significantly less than the rate calculated for use in this assessment. The FFC Waste Services WMC at Millerhill has an identical air pollution control system as designed for the Dubai WMC, so it is expected that emissions of Cd in reality, will be closer to 0.00006 g/s or 0.00003 g/s as opposed to the estimated 0.0034 g/s used in this assessment.

5.2 Model description

5.2.1 AERMET

Meteorological data file construction

Atmospheric dispersion modelling for regulatory purposes requires meteorological data that is representative of conditions at the site for input into the modelling software. GHD has used meteorological data from the nearby Dubai International Airport. Data from the year 2015 was used as this year is relatively recent and is generally seen to be representative of average weather, with no unusual weather events. The meteorological parameters provided in the file include temperature, wind speed and direction, cloud cover and ceiling height.

AERMET usage

The AERMOD meteorological processor, AERMET, was used to synthesize the AERMOD meteorological file. This process was undertaken in accordance with US EPA guidance. AERMET was used in 'on-site' observation mode using the input raw, hourly meteorological data obtained from Dubai International Airport and appropriate land use categorisations for the site. The non-default approved option of "Adjust Surface Friction Velocity (ADJ_U*)" was applied.

At the time of writing this report, the acceptable modelling method included the usage of the non-default options of "LOWWIND3" and "FASTALL" which were generally accepted to better resolve dispersion associated with light wind conditions. Since then, the US EPA approved modelling methods have changed, allowing the modeller to carry out sensitivity testing with these non-default options and choose the most appropriate method. Therefore, sensitivity testing was carried out for this assessment with both the "LOWWIND3" and "FASTALL" options both on and off. Subsequent predicted concentrations were found to differ minimally, and were considered a nominal difference for the purpose of this assessment. In general, these non-default options are important for ground level sources and less so for elevated sources, such as the tall stacks in this assessment. It is noteworthy that with the "LOWWIND3" and "FASTALL" options both on, concentrations were slightly higher and therefore these options were used in the modelling described below for a more conservative approach.

5.2.2 AERMOD

AERMOD is the US EPA's approved model for estimating the impacts of emissions to air by industry. AERMOD is an advanced Gaussian plume model and extends on the Pasquill-Gifford atmospheric stability categorisation by modelling the turbulence using micro-meteorological parameters to calculate the Monin-Obukov length. This provides a continuously varying measure of atmospheric turbulence from one hour to the next. A sample AERMOD configuration file used in this assessment is shown in Appendix A.

5.2.3 Model configuration

Table 5-4 provides the AERMOD parameters that were applied to the model.

Table 5-4 Model configuration parameters

Parameter	Setting
Averaging times	1-hour, 8-hour, 24-hour or annual
Model grid centre coordinates (m UTM)	342619.00 E, 2783755.00 N
Emission rate	Constant (as per Table 5-2)
Topography	Default AERMAP databases used
Surrounding land use	Rural with land use as per the AERMET definition

Gridded receptors

The model domain was set up using uniform Cartesian (gridded) receptors at a resolution of 50 m. 221 by 221 gridded receptors were set up to cover an area of 11 km by 11 km covering the Project site as shown in Figure 5-2.

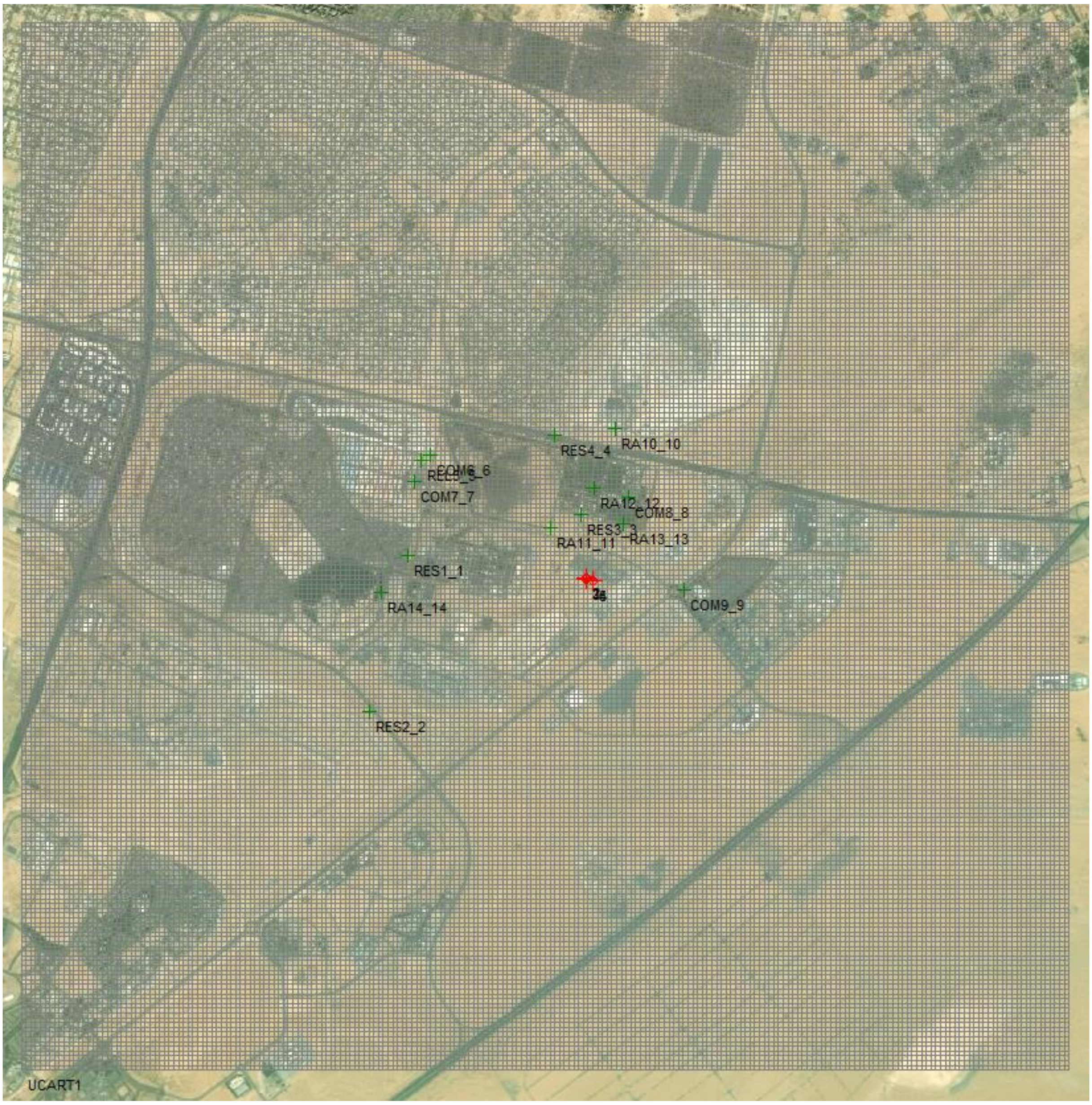


Figure 5-2 Gridded receptor network used in model

Building downwash

HZI, Besix and Itochu supplied building information to GHD, which was incorporated into the model. Building downwash algorithms were applied using the US EPA/BPIP geometry scheme to inform the PRIME building wake algorithm. The model was established to include the wake effects of the facility's major structures. The setup is for these building structures, including the source locations are shown in Figure 5-3.

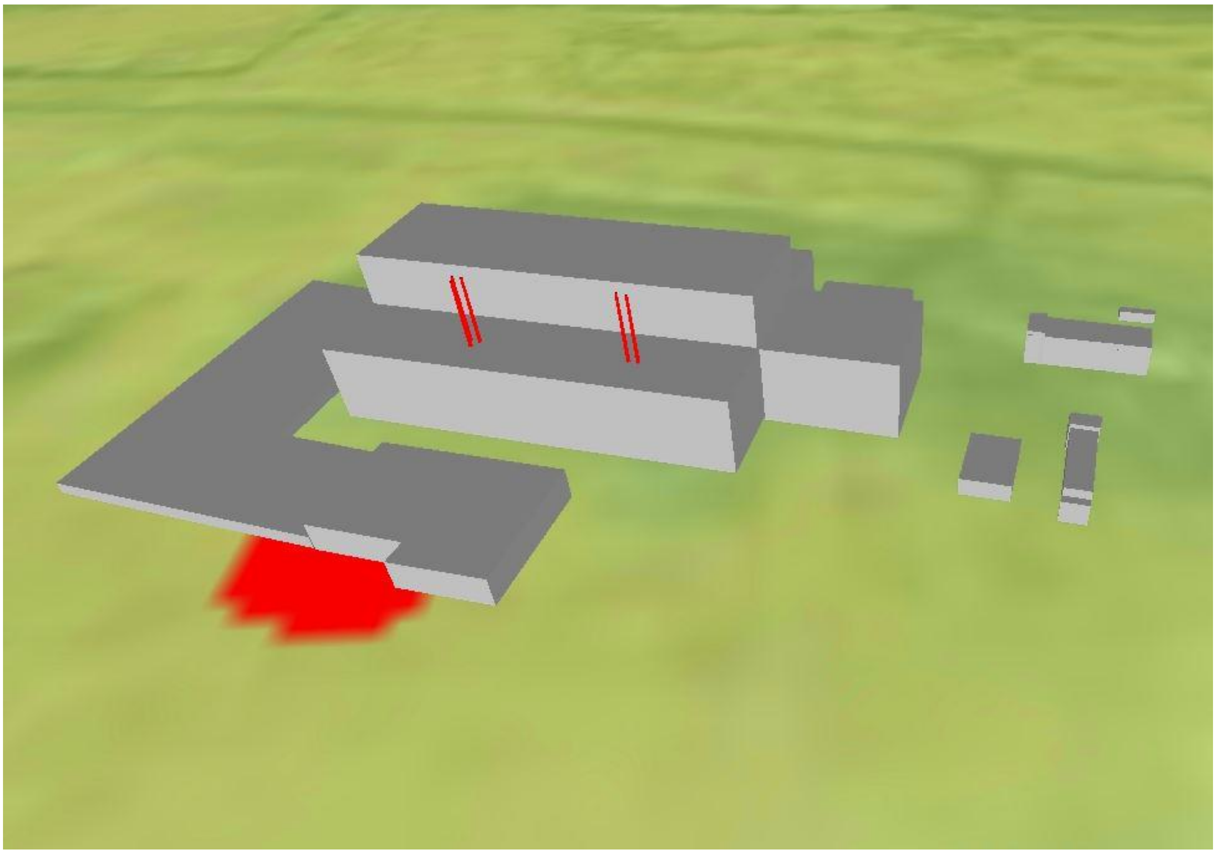


Figure 5-3 Significant buildings included in the model (stacks shown in red)

5.3 Dispersion modelling results

The modelling scenario included in this assessment is assumed a worst-case with all five lines operating simultaneously during all hours of the year. It is acknowledged that in reality not all lines will operate simultaneously for all hours of the year due to planned outages and maintenance.

Table 5-5 to Table 5-16 show the predicted GLCs for each air pollutant at the identified sensitive receptors. Where background data were available, results in the tables below show both predicted incremental and predicted cumulative (inclusive of measured background concentrations discussed in Section 4) concentrations, as well as a percentage comparison of the cumulative concentrations. Where background data were not available, an incremental assessment only is shown.

Assessment of GLCs against US OSHA standards are presented in Appendix B.

5.3.1 Nitrogen dioxide

Table 5-5 shows the predicted 1-hour, 24-hour and annual GLCs for NO_2.

The adopted background concentrations for NO_2 are:

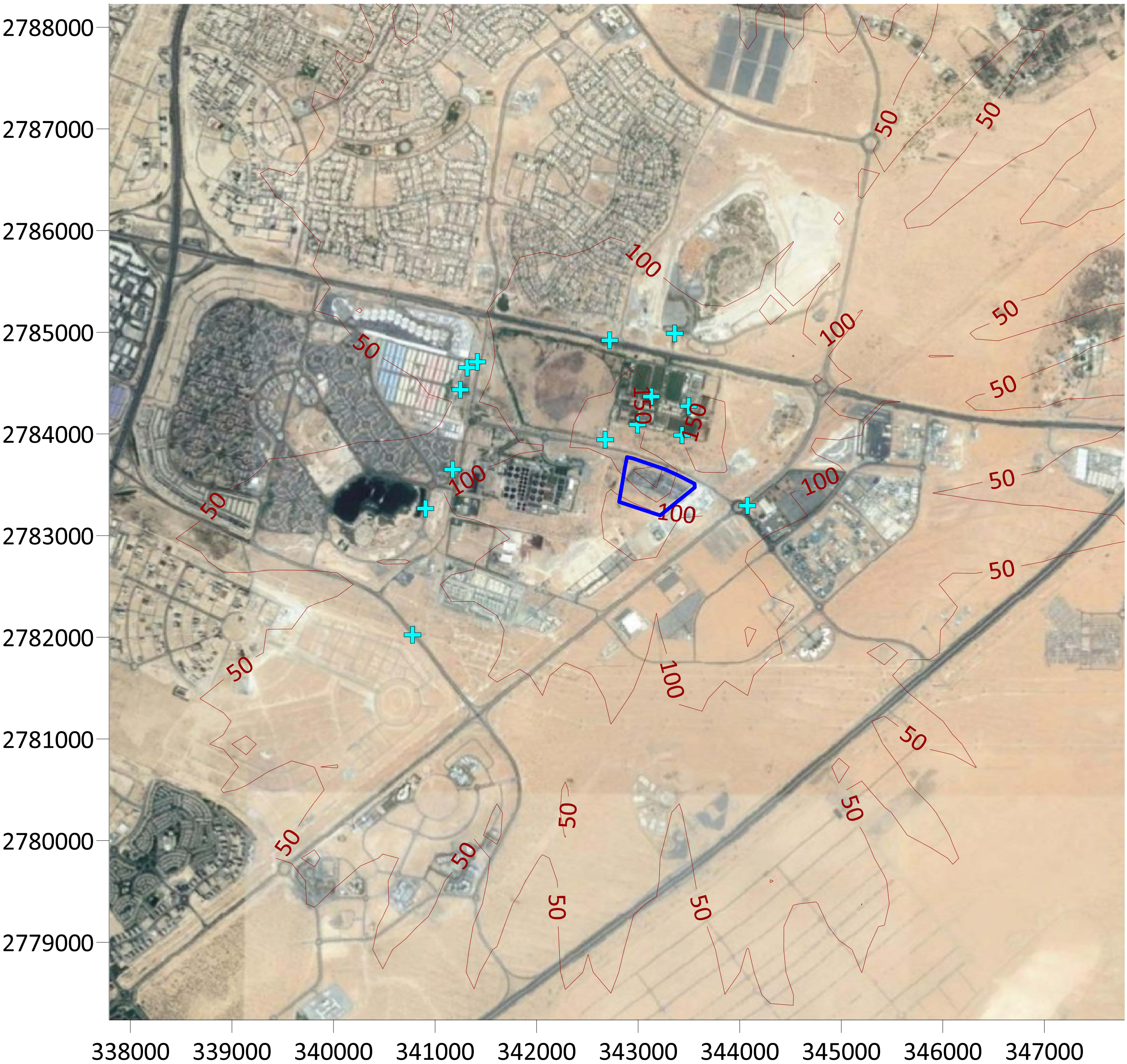
- 1-hour concentration – 185 µg/m^3, which is 46 percent of the UAE assessment criteria of 400 µg/m^3.
- 24-hour concentration – 68 µg/m^3, which is 45 percent of the UAE assessment criteria of 150 µg/m^3.
- Annual concentration – 34 µg/m^3, which is 85 percent of the WHO assessment criteria of 40 µg/m^3.

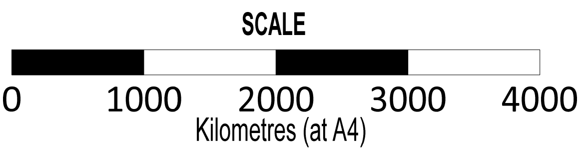
Using the NO_x to NO_2 ratio of 40 percent, the highest predicted cumulative concentrations fall below the assessment criteria, with one exception only. This occurs at Residential Villas (Desert Palm), with a cumulative annual average concentration of 41 µg/m^3, equating to 103 percent of the WHO criteria of 40 µg/m^3.

It is noteworthy that the NO_x to NO_2 conversion ratio of 40 percent is conservative. It is likely that ambient concentrations of NO_2 associated with the operation of the stacks will be lower in reality (in the range of 20 percent NOx to NO_2). The incremental and cumulative 1-hour NO_2 ground level concentration contours are presented in Figure 5-4 and Figure 5-5 respectively.

Table 5-5 Predicted 1-hour, 24-hour and annual NO_2 concentrations

Receptor	Incremental 1-hour NO_2 (µg/m³)	Cumulative 1-hour NO_2 (µg/m³)	Cumulative % of criteria	Incremental 24-hour NO_2 (µg/m³)	Cumulative 24-hour NO_2 (µg/m³)	Cumulative % of criteria	Incremental annual NO_2 (µg/m³)	Cumulative annual NO_2 (µg/m³)	Cumulative % of criteria
Criteria (µg/m³)	400 (UAE)			150 (UAE)			40 (WHO)		
Dubai International City-EMR 14, Emirates Cluster	88	273	68%	11	79	53%	2	36	89%
International City Phase II (under construction)	81	266	66%	15	83	55%	1	35	87%
Residential Villas (Desert Palm)	173	358	90%	45	113	76%	7	41	103%
AL Warqa 4 (north of Al Awir Road)	127	312	78%	23	91	61%	3	37	92%
Dragon Mart Mosque	90	275	69%	6	74	49%	1	35	87%
Dragon Mart Commercial Centre	97	282	71%	9	77	51%	1	35	87%
Dubai Textile City	103	288	72%	8	76	51%	1	35	87%
Desert Palm Resort and Hotel	137	322	80%	27	95	64%	4	38	96%
Dubai Plant Nursery	144	329	82%	23	91	61%	3	37	92%
Dubai Safari Park (north of Al Awir Road)	110	295	74%	16	84	56%	2	36	91%
Pivot Fields	166	351	88%	34	102	68%	5	39	97%
Desert Palm Polo Club	141	326	82%	23	91	61%	5	39	97%
Desert Palm Riding Schools	146	331	83%	34	102	68%	6	40	99%
Warsan Lake	104	289	72%	15	83	55%	2	36	89%





Criterion:

UAE Federal: 400 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 1-hour NO_2 concentrations contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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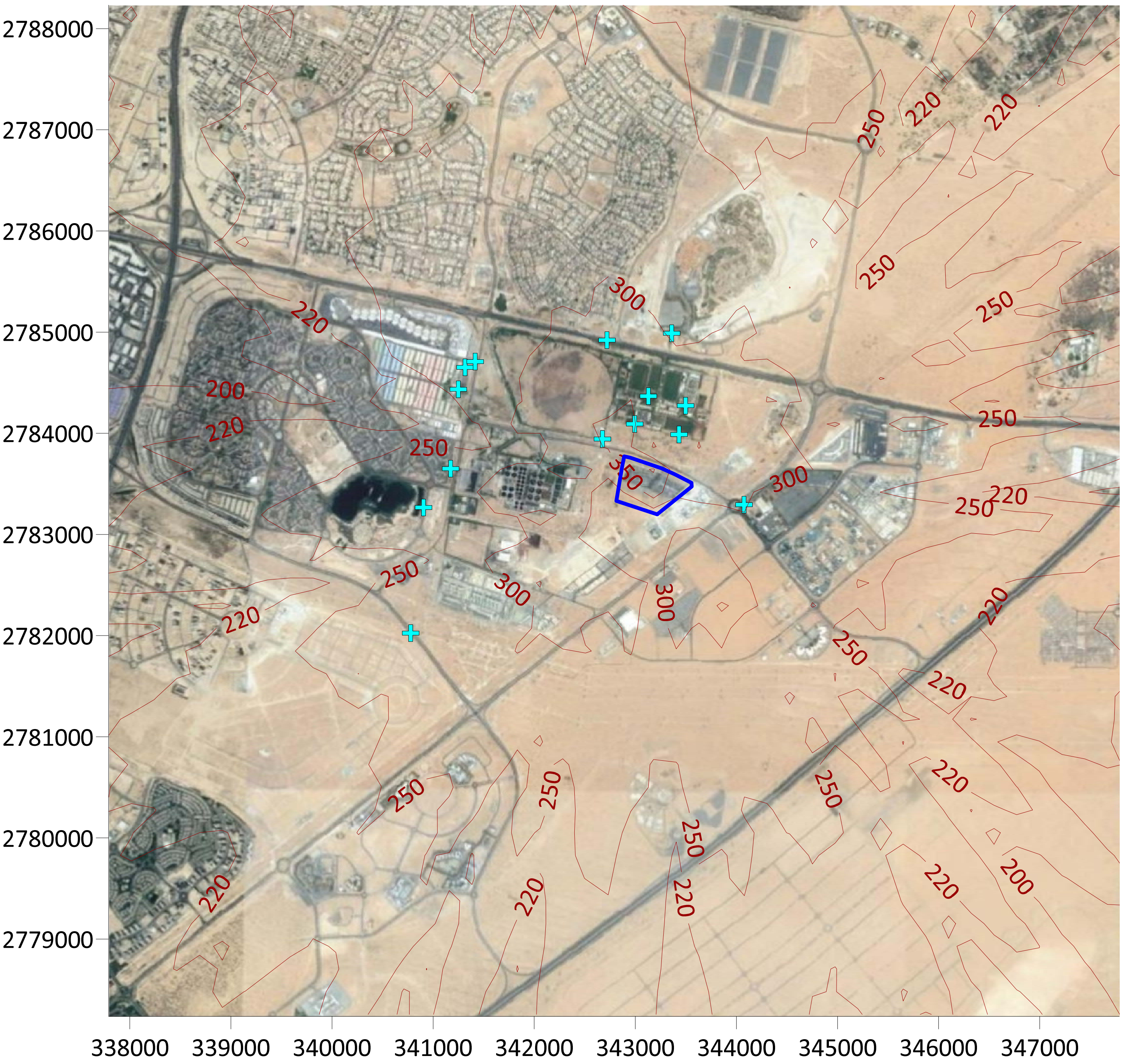
FIGURE 5-4

Predicted incremental 1-hour NO_2 concentrations

DRAWING NO.	REVISION	DATE
Fig 5-4.srf	8	22.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE Federal: 400 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 1-hour NO_2 concentrations contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-5

Predicted cumulative 1-hour NO_2 concentrations

DRAWING NO.	REVISION	DATE
Fig 5-5.srf	8	22.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.2 Sulphur dioxide

Table 5-6 shows the predicted 1-hour, 24-hour and annual GLCs for SO_2.

The adopted background concentrations for SO_2 are:

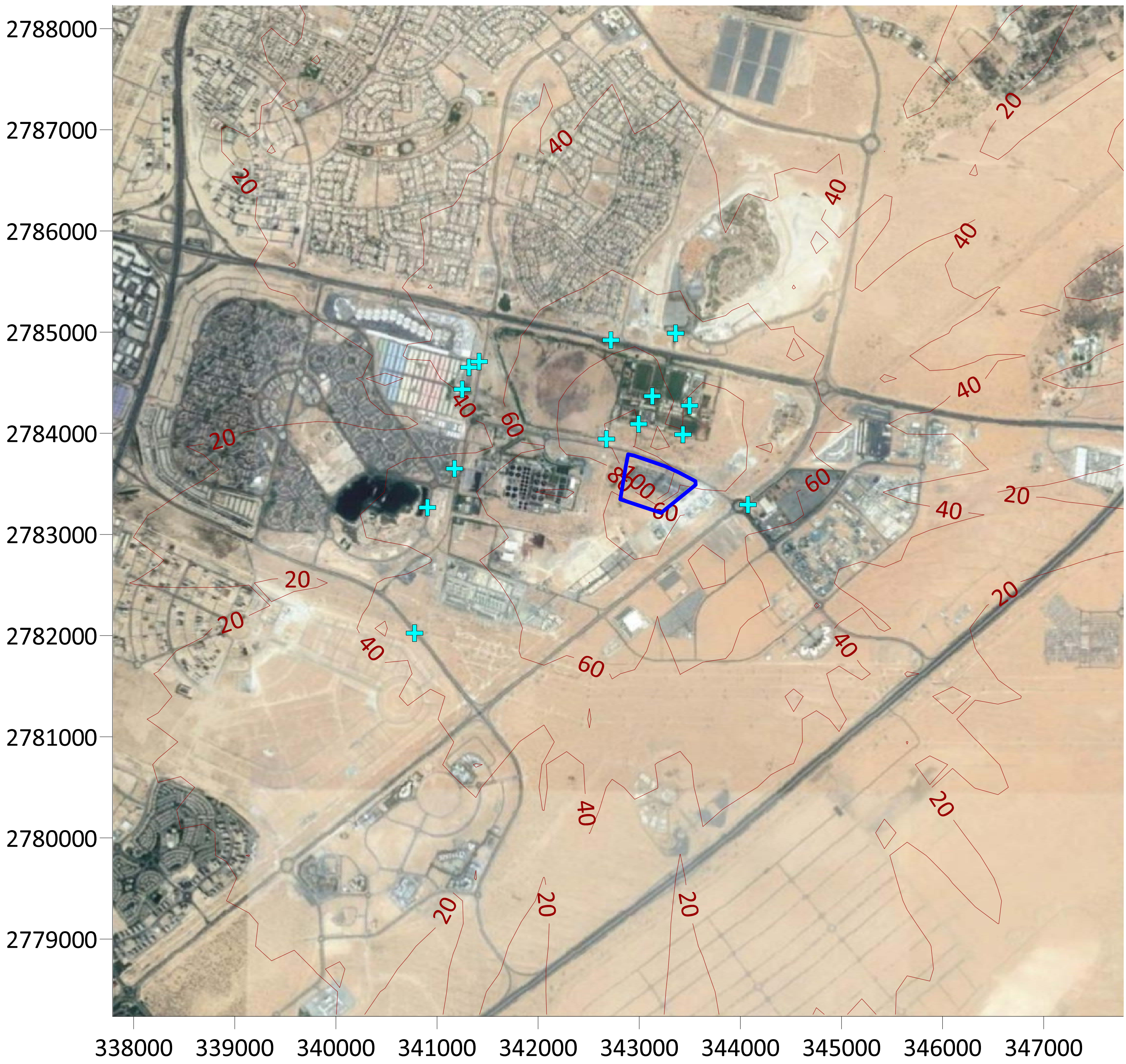
- 1-hour concentration – 86 µg/m^3, which is 25 percent of the UAE assessment criteria of 350 µg/m^3.
- 24-hour concentration – 12 µg/m^3, which is eight percent of the UAE assessment criteria of 150 µg/m^3.
- Annual concentration – 6 µg/m^3, which is 10 percent of the UAE assessment criteria of 60 µg/m^3.

The highest predicted cumulative concentrations fall below the assessment criteria.

The incremental and cumulative 1-hour SO_2 ground level concentration contours are presented in Figure 5-6 and Figure 5-7 respectively.

Table 5-6 Predicted 1-hour, 24-hour and annual SO_2 concentrations

Receptor	Incremental 1-hour SO_2 (µg/m³)	Cumulative 1-hour SO_2 (µg/m³)	Cumulative % of criteria	Incremental 24-hour SO_2 (µg/m³)	Cumulative 24-hour SO_2 (µg/m³)	Cumulative % of criteria	Incremental annual SO_2 (µg/m³)	Cumulative annual SO_2 (µg/m³)	Cumulative % of criteria
Criteria (µg/m³)	350 (UAE)			150 (UAE)			60 (UAE)		
Dubai International City-EMR 14, Emirates Cluster	48	134	38%	7	19	13%	1	7	12%
International City Phase II (under construction)	44	130	37%	9	21	14%	1	7	11%
Residential Villas (Desert Palm)	103	189	54%	28	40	27%	4	10	17%
AL Warqa 4 (north of Al Awir Road)	73	159	45%	14	26	18%	2	8	13%
Dragon Mart Mosque	51	137	39%	3	15	10%	1	7	11%
Dragon Mart Commercial Centre	52	138	40%	6	18	12%	1	7	11%
Dubai Textile City	53	139	40%	5	17	11%	1	7	11%
Desert Palm Resort and Hotel	81	167	48%	17	29	19%	3	9	15%
Dubai Plant Nursery	86	172	49%	14	26	17%	2	8	13%
Dubai Safari Park (north of Al Awir Road)	67	153	44%	10	22	15%	2	8	13%
Pivot Fields	100	186	53%	21	33	22%	3	9	15%
Desert Palm Polo Club	85	171	49%	14	26	18%	3	9	15%
Desert Palm Riding Schools	88	174	50%	21	33	22%	4	10	16%
Warsan Lake	53	139	40%	9	21	14%	1	7	12%



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:
UAE Federal: 350 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 1-hour SO_2 concentration contours

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS)
Zone 40 R

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

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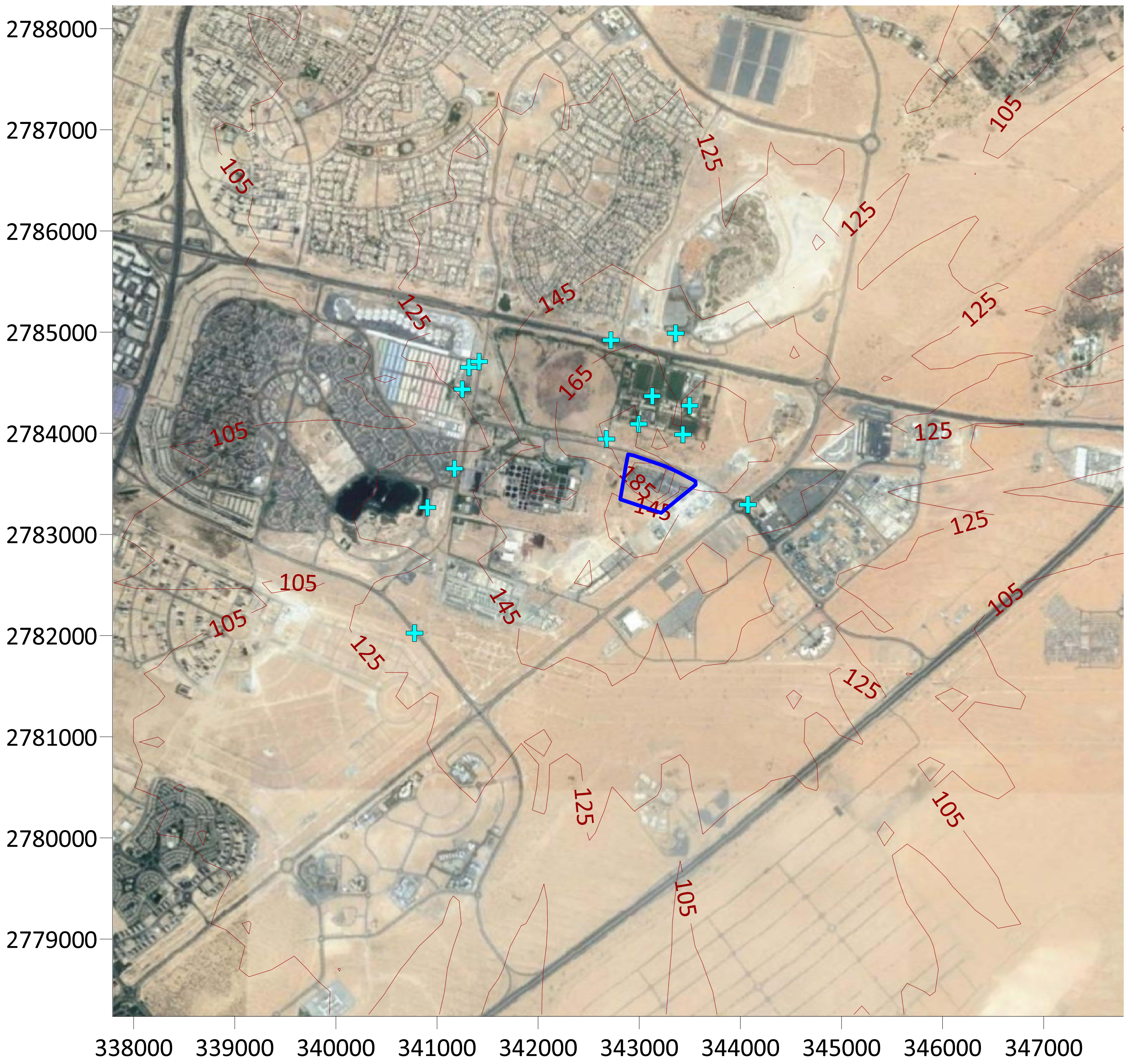
FIGURE 5-6

Predicted incremental 1-hour SO_2 concentrations

DRAWING NO.	REVISION	DATE
Fig 5-6.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:
UAE Federal: 350 ug/m³

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 1-hour SO_2 concentration contours

MAP PROJECTION: Transverse Mercator
HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R
GRID: SRTM1 Global (~30 m)- Version 3
DATA SOURCE: GoogleEarth

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FIGURE 5-7

Predicted cumulative 1-hour SO_2 concentrations

DRAWING NO.	REVISION	DATE
Fig 5-7.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.3 Carbon monoxide

Table 5-7 shows the predicted 1-hour and 8-hour GLCs for CO.

The adopted background concentrations for CO are:

- 1-hour concentration – 5477 µg/m^3, which is 18 percent of the UAE assessment criteria of 30,000 µg/m^3.
- 8-hour concentration – no data available, incremental assessment only is shown.

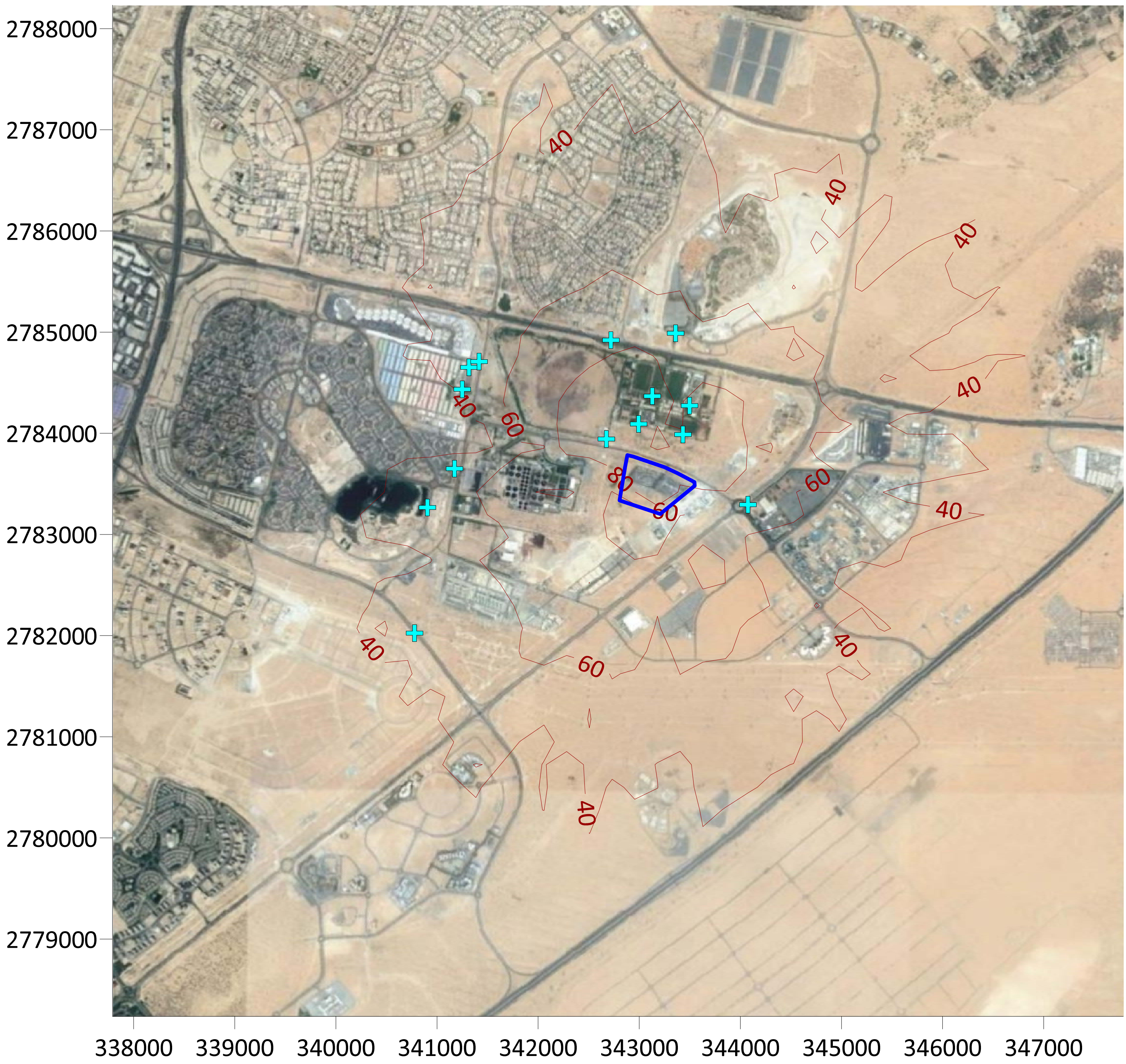
The highest predicted cumulative (1-hour averaging period) and incremental (8-hour averaging period) concentrations fall below the assessment criteria.

For the incremental assessment, the highest predicted 8-hour concentration occurs at Pivot Fields, equating to <1 percent of the UAE assessment criteria. This complies comfortably with the WHO guideline regarding 25 percent of the criteria.

The incremental and cumulative 1-hour CO ground level concentration contours are presented in Figure 5-8 and Figure 5-9 respectively

Table 5-7 Predicted 1-hour and 8-hour CO concentrations

Receptor	Incremental 1-hour CO (µg/m^3)	Cumulative 1-hour CO (µg/m^3)	Cumulative % of criteria	Incremental 8-hour CO (µg/m^3)	Incremental % of criteria
Criteria (µg/m^3)	30000 (UAE)			10000 (UAE)	
Dubai International City-EMR 14, Emirates Cluster	48	5525	18%	13	0.1%
International City Phase II (under construction)	44	5521	18%	15	0.2%
Residential Villas (Desert Palm)	103	5580	19%	49	0.5%
AL Warqa 4 (north of Al Awir Road)	73	5550	18%	38	0.4%
Dragon Mart Mosque	51	5528	18%	9	0.1%
Dragon Mart Commercial Centre	52	5529	18%	17	0.2%
Dubai Textile City	53	5530	18%	14	0.1%
Desert Palm Resort and Hotel	81	5558	19%	39	0.4%
Dubai Plant Nursery	86	5563	19%	23	0.2%
Dubai Safari Park (north of Al Awir Road)	67	5544	18%	24	0.2%
Pivot Fields	100	5577	19%	56	0.6%
Desert Palm Polo Club	85	5562	19%	33	0.3%
Desert Palm Riding Schools	88	5565	19%	44	0.4%
Warsan Lake	53	5530	18%	15	0.2%



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE Federal: 30,000 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 1-hour CO concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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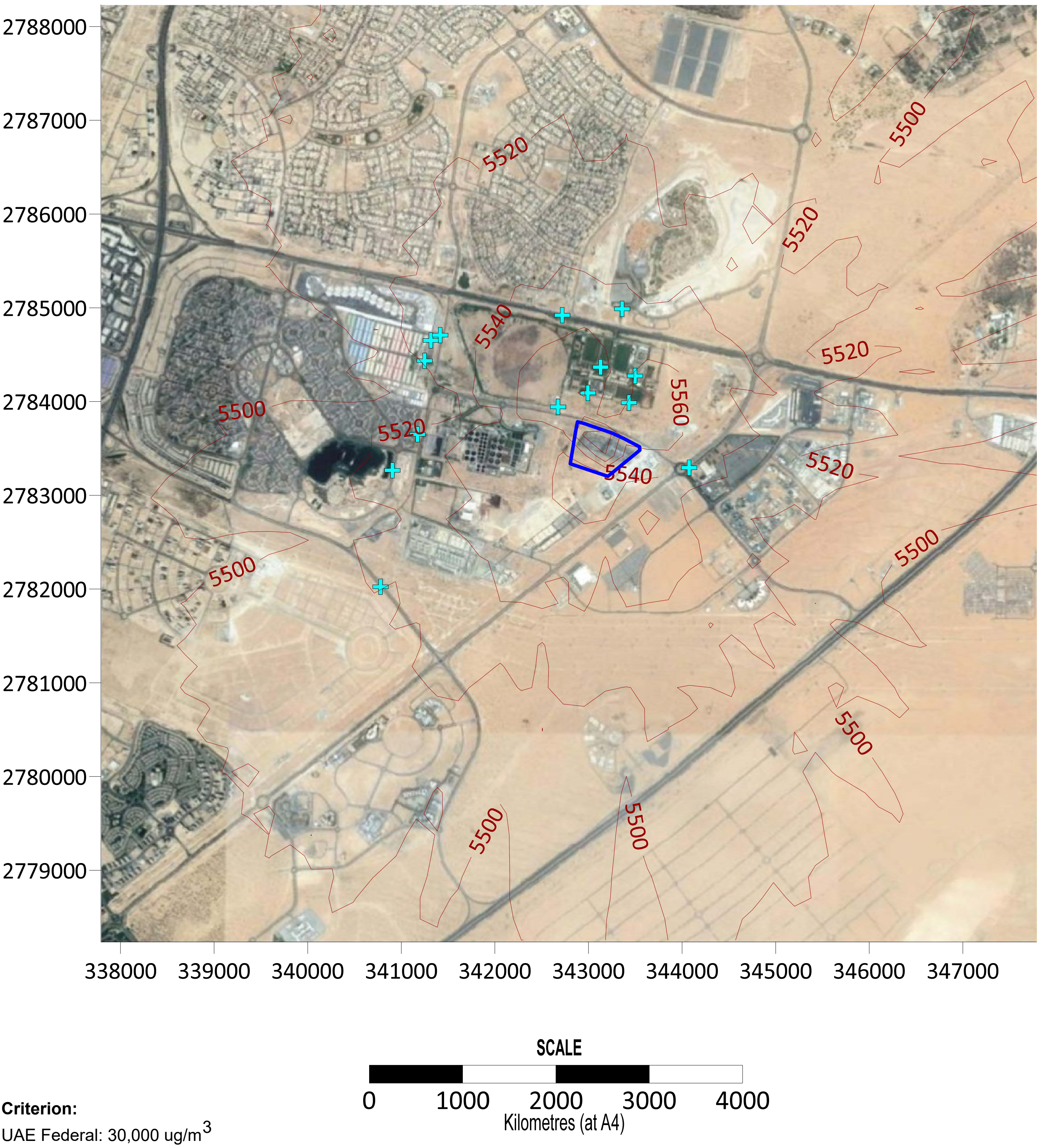
FIGURE 5-8

Predicted incremental 1-hour CO concentrations

DRAWING NO.	REVISION	DATE
Fig 5-8.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



Criterion:
UAE Federal: 30,000 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 1-hour CO concentration contours

MAP PROJECTION: Transverse Mercator
HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R
GRID: SRTM1 Global (~30 m)- Version 3
DATA SOURCE: GoogleEarth

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FIGURE 5-9

Predicted cumulative 1-hour CO concentrations

DRAWING NO.	REVISION	DATE
Fig 5-9.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.4 Total suspended particulates

Table 5-8 and Table 5-9 show the predicted 24-hour and annual GLCs for TSP without and with dust control respectively, as described in Section 5.1.

Background concentrations were not included for TSP, as appropriate data were not available for use in this assessment. Therefore, an incremental assessment only is shown.

Results have been presented as stack TSP concentrations, IBA TSP concentrations and total TSP concentrations in order to give a greater understanding of the proportion of TSP being emitted at each source.

For no dust control (Table 5-8), the highest predicted incremental 24-hour and annual averaging period concentrations fall below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The highest predicted incremental 24-hour and annual total TSP concentrations both occur at Pivot Fields, equating to 5 percent and 1.9 percent of the UAE assessment criteria respectively. These comply comfortably with the WHO guideline regarding 25 percent of the criteria.

Similarly, with dust control (Table 5-9), the highest predicted incremental 24-hour and annual averaging period concentrations fall below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The highest predicted incremental 24-hour total TSP concentration occurs at Pivot Fields, equating to 3 percent of the UAE assessment criteria. The highest predicted incremental annual total TSP concentration occurs at Pivot Fields and Residential Villas (Desert Palm) equating to 1.3 percent of the UAE assessment criteria. These comply comfortably with the WHO guideline regarding 25 percent of the criteria.

The predicted maximum 24-hour concentration from stack emissions do not necessarily occur on the same day as predicted maximum 24-hour concentrations from the IBA management area. Hence summed stack 24-hour TSP concentrations with IBA management area's 24-hour TSP concentrations do not equal the Project's total predicted maximum TSP concentrations. This is due to daily varying meteorological parameters, such as wind speed and wind direction enabling a differing TSP dispersion patterns.

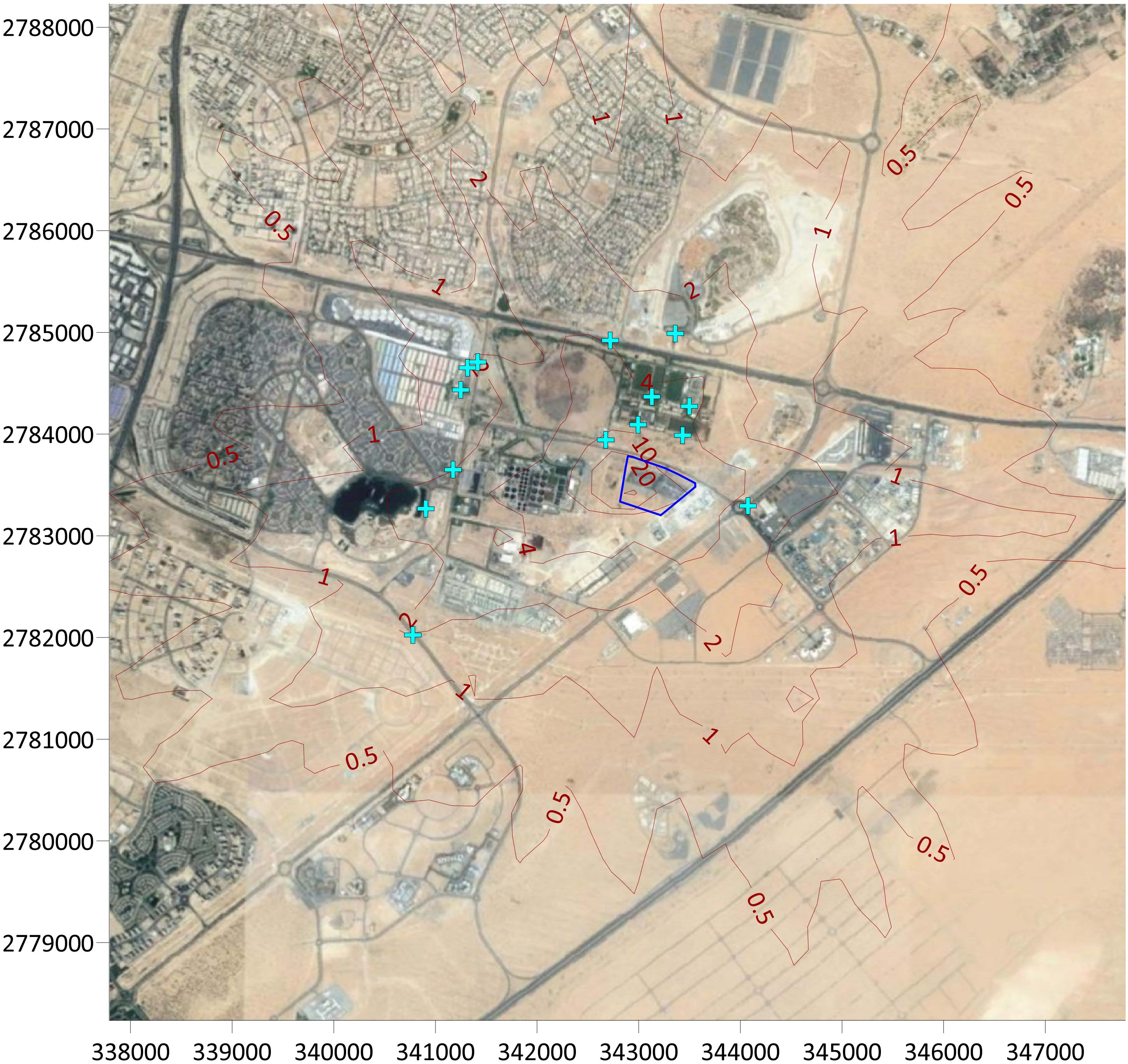
The incremental 24-hour TSP ground level concentration contours without and with dust control are presented in Figure 5-10 and Figure 5-11 respectively

Table 5-8 Predicted 24-hour and annual TSP concentrations – No dust control

Receptor	Incremental stack 24-hour TSP (µg/m^3)	Incremental IBA 24-hour TSP (µg/m^3)	Incremental total 24-hour TSP (µg/m^3)	Incremental % of criteria	Incremental stack annual TSP (µg/m^3)	Incremental IBA annual TSP (µg/m^3)	Incremental total annual TSP (µg/m^3)	Incremental % of criteria
Criteria (µg/m3)	230 (UAE)				90 (UAE)			
Dubai International City- EMR 14, Emirates Cluster	1	1	2	1%	0.2	0.1	0.3	0.3%
International City Phase II (under construction)	2	0.4	2	1%	0.1	0.0	0.1	0.1%
Residential Villas (Desert Palm)	6	6	7	3%	0.9	0.7	1.5	1.7%
AL Warqa 4 (north of Al Awir Road)	3	1	4	2%	0.4	0.2	0.5	0.6%
Dragon Mart Mosque	1	1	1	1%	0.1	0.1	0.2	0.2%
Dragon Mart Commercial Centre	1	1	2	1%	0.1	0.1	0.2	0.2%
Dubai Textile City	1	1	1	1%	0.1	0.1	0.2	0.2%
Desert Palm Resort and Hotel	3	2	5	2%	0.6	0.1	0.7	0.8%
Dubai Plant Nursery	3	2	4	2%	0.3	0.1	0.4	0.4%
Dubai Safari Park (north of Al Awir Road)	2	1	2	1%	0.3	0.1	0.4	0.5%
Pivot Fields	4	7	11	5%	0.6	1.1	1.7	1.9%
Desert Palm Polo Club	3	3	5	2%	0.6	0.3	0.9	1.0%
Desert Palm Riding Schools	4	2	5	2%	0.7	0.2	0.9	1.0%
Warsan Lake	2	1	3	1%	0.2	0.1	0.3	0.3%

Table 5-9 Predicted 24-hour and annual TSP concentrations – With dust control

Receptor	Incremental stack 24-hour TSP (µg/m³)	Incremental IBA 24-hour TSP (µg/m³)	Incremental total 24-hour TSP (µg/m³)	Incremental % of criteria	Incremental stack annual TSP (µg/m³)	Incremental IBA annual TSP (µg/m³)	Incremental total annual TSP (µg/m³)	Incremental % of criteria
Criteria (µg/m3)	230 (UAE)				90 (UAE)			
Dubai International City-EMR 14, Emirates Cluster	1	0.5	2	1%	0.2	0.05	0.2	0.3%
International City Phase II (under construction)	2	0.2	2	1%	0.1	0.01	0.1	0.1%
Residential Villas (Desert Palm)	6	3.1	6	3%	0.9	0.3	1.2	1.3%
AL Warqa 4 (north of Al Awir Road)	3	0.7	3	1%	0.4	0.1	0.5	0.5%
Dragon Mart Mosque	1	0.5	1	0.4%	0.1	0.04	0.1	0.2%
Dragon Mart Commercial Centre	1	0.5	2	1%	0.1	0.04	0.2	0.2%
Dubai Textile City	1	0.4	1	1%	0.1	0.04	0.1	0.2%
Desert Palm Resort and Hotel	3	1.2	4	2%	0.6	0.1	0.6	0.7%
Dubai Plant Nursery	3	1.1	3	1%	0.3	0.03	0.4	0.4%
Dubai Safari Park (north of Al Awir Road)	2	0.5	2	1%	0.3	0.1	0.4	0.4%
Pivot Fields	4	3.7	7	3%	0.6	0.5	1.1	1.3%
Desert Palm Polo Club	3	1.7	3	2%	0.6	0.2	0.7	0.8%
Desert Palm Riding Schools	4	1.1	4	2%	0.7	0.1	0.8	0.9%
Warsan Lake	2	0.4	2	1%	0.2	0.04	0.2	0.3%



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE Federal: 230 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour TSP concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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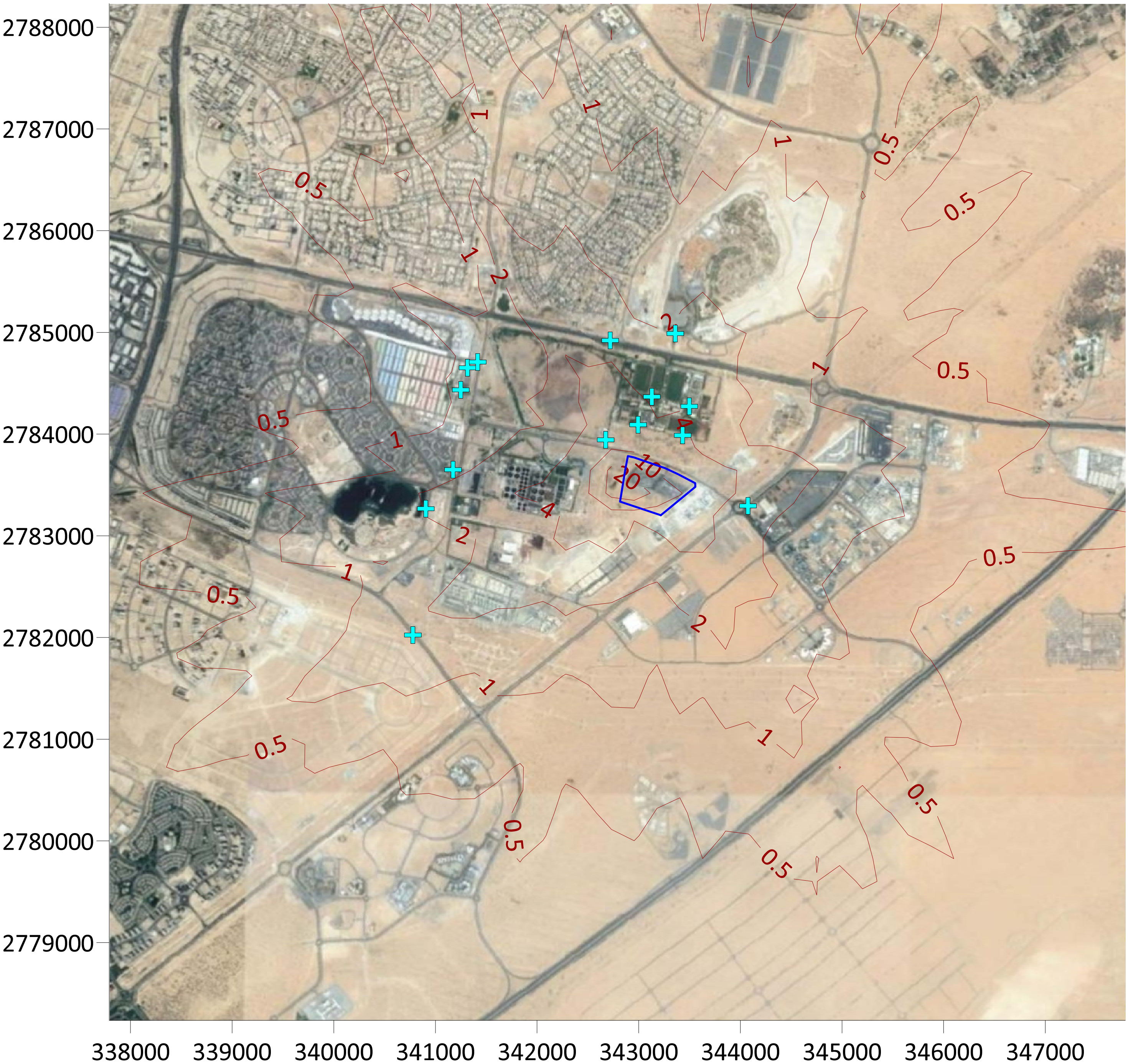
FIGURE 5-10

Perdicted incremental 24-hour TSP concentrations - no dust control

DRAWING NO.	REVISION	DATE
Fig 5-10.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE Federal: 230 ug/m3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour TSP concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-11
Predicted incremental 24-hour TSP concentrations - dust control

DRAWING NO.	REVISION	DATE
Fig 5-11.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.5 PM_{10}

Table 5-10 and Table 5-11 show the predicted 24-hour and annual GLCs for PM_{10} without and with dust control respectively, as described in Section 5.1.

The adopted background concentrations for PM_{10} are:

- 24-hour concentration – 169 µg/m^3, which is 113 percent of the UAE assessment criteria of 150 µg/m^3.
- Annual concentration – 141 µg/m^3, which is 705 percent of the WHO assessment criteria of 20 µg/m^3.

Stack emissions were calculated assuming a conservative ratio of 1:1 for TSP to PM_{10} and wheel-generated emissions were calculated using emission-specific factors.

Results have been presented as stack PM_{10} concentrations, IBA PM_{10} concentrations and total PM_{10} concentrations in order to give a greater understanding of the proportion of PM_{10} being emitted at each source.

For no dust control (Table 5-10), the highest predicted incremental 24-hour and annual averaging period concentrations fall well below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The predicted cumulative 24-hour total PM_{10} concentrations exceed the UAE criteria (with a maximum of 176 µg/m^3 occurring at Pivot Fields, equating to 117 percent of the criteria) due to the background concentration exceeding the criteria. The predicted cumulative annual total PM_{10} concentrations exceed the WHO criteria (with a maximum of 142 µg/m^3 occurring at Pivot Fields and Residential Villas (Desert Palm), equating to 711 percent of the criteria) due to the background concentration exceeding the criteria.

Similarly, with dust control (Table 5-11), the highest predicted incremental 24-hour and annual averaging period concentrations fall well below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The predicted cumulative 24-hour total PM_{10} concentrations exceed the UAE criteria (with a maximum of 175 µg/m^3 occurring at Residential Villas (Desert Palm), equating to 117 percent of the criteria) due to the background concentration exceeding the criteria. The predicted cumulative annual total PM_{10} concentrations exceed the WHO criteria (with a maximum of 142 µg/m^3 occurring at Pivot Fields and Residential Villas (Desert Palm), equating to 711 percent of the criteria) due to the background concentration exceeding the criteria.

The predicted maximum 24-hour concentration from stack emissions do not necessarily occur on the same day as predicted maximum 24-hour concentrations from the IBA management area. Hence summed stack 24-hour PM_{10} concentrations with IBA management area's 24-hour PM_{10} concentrations do not equal the Project's total predicted maximum PM_{10} concentrations. This is due to daily varying meteorological parameters, such as wind speed and wind direction enabling a differing PM_{10} dispersion patterns.

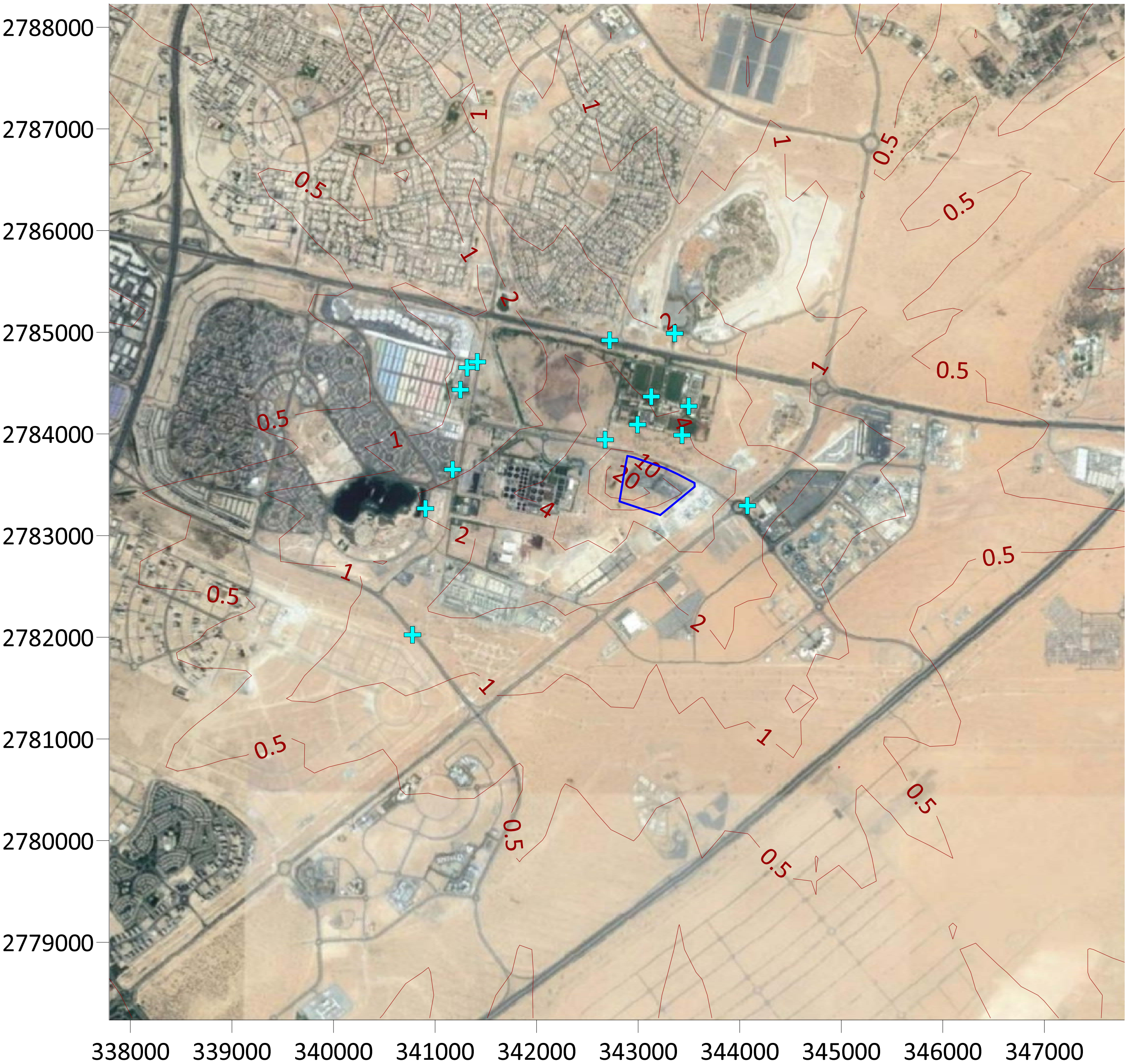
The incremental and cumulative 24-hour PM_{10} ground level concentration contours with no dust control are presented in Figure 5-12 and Figure 5-13 respectively. The incremental and cumulative 24-hour PM_{10} ground level concentration contours with dust control are presented in Figure 5-14 and Figure 5-15 respectively.

Table 5-10 Predicted 24-hour and annual PM_{10} concentrations – No dust control

Receptor	Incremental 24-hour Stack PM_{10} ($\mu g/m^3$)	Incremental 24-hour IBA PM_{10} ($\mu g/m^3$)	Incremental total 24-hour PM_{10} ($\mu g/m^3$)	Cumulative total 24-hour PM_{10} ($\mu g/m^3$)	Cumulative % of criteria	Incremental stack annual PM_{10} ($\mu g/m^3$)	Incremental IBA annual PM_{10} ($\mu g/m3$)	Incremental total annual PM_{10} ($\mu g/m^3$)	Cumulative total annual PM_{10} ($\mu g/m^3$)	Cumulative % of criteria
Criteria (µg/m3)	150 (UAE)					20 (WHO)				
Dubai International City- EMR 14, Emirates Cluster	1	0.5	2	170.6	114%	0.2	0.05	0.2	141.2	706%
International City Phase II (under construction)	2	0.2	2	170.9	114%	0.1	0.01	0.1	141.1	706%
Residential Villas (Desert Palm)	6	3.1	6	175.2	117%	0.9	0.33	1.2	142.2	711%
AL Warqa 4 (north of Al Awir Road)	3	0.7	3	172.2	115%	0.4	0.09	0.5	141.5	707%
Dragon Mart Mosque	1	0.5	1	170.0	113%	0.1	0.04	0.1	141.1	706%
Dragon Mart Commercial Centre	1	0.5	2	170.6	114%	0.1	0.04	0.2	141.2	706%
Dubai Textile City	1	0.4	1	170.2	113%	0.1	0.04	0.1	141.1	706%
Desert Palm Resort and Hotel	3	1.2	4	172.9	115%	0.6	0.07	0.6	141.6	708%
Dubai Plant Nursery	3	1.1	3	172.0	115%	0.3	0.03	0.4	141.4	707%
Dubai Safari Park (north of Al Awir Road)	2	0.5	2	171.2	114%	0.3	0.06	0.4	141.4	707%
Pivot Fields	4	3.8	7	176.2	117%	0.6	0.55	1.1	142.1	711%
Desert Palm Polo Club	3	1.8	3	172.5	115%	0.6	0.16	0.7	141.7	709%
Desert Palm Riding Schools	4	1.1	4	173.4	116%	0.7	0.09	0.8	141.8	709%
Warsan Lake	2	0.4	2	171.2	114%	0.2	0.04	0.2	141.2	706%

Table 5-11 Predicted 24-hour and annual PM_{10} concentrations – Dust control

Receptor	Incremental 24-hour Stack PM_{10} ($\mu g/m^3$)	Incremental 24-hour IBA PM_{10} ($\mu g/m^3$)	Incremental total 24-hour PM_{10} ($\mu g/m^3$)	Cumulative total 24-hour PM_{10} ($\mu g/m^3$)	Cumulative % of criteria	Incremental annual Stack PM_{10} ($\mu g/m^3$)	Incremental annual IBA PM_{10} ($\mu g/m^3$)	Incremental total annual PM_{10} ($\mu g/m^3$)	Cumulative annual PM_{10} ($\mu g/m^3$)	Cumulative % of criteria
Criteria (µg/m3)	150 (UAE)					20 (WHO)				
Dubai International City- EMR 14, Emirates Cluster	1	0.2	1	170.5	114%	0.2	0.02	0.2	141.2	706%
International City Phase II (under construction)	2	0.1	2	170.9	114%	0.1	0.004	0.1	141.1	706%
Residential Villas (Desert Palm)	6	1.5	6	174.9	117%	0.9	0.16	1.0	142.0	710%
AL Warqa 4 (north of Al Awir Road)	3	0.4	3	171.9	115%	0.4	0.04	0.4	141.4	707%
Dragon Mart Mosque	1	0.2	1	169.8	113%	0.1	0.02	0.1	141.1	706%
Dragon Mart Commercial Centre	1	0.2	1	170.4	114%	0.1	0.02	0.1	141.1	706%
Dubai Textile City	1	0.2	1	170.0	113%	0.1	0.02	0.1	141.1	706%
Desert Palm Resort and Hotel	3	0.6	4	172.5	115%	0.6	0.03	0.6	141.6	708%
Dubai Plant Nursery	3	0.6	3	171.9	115%	0.3	0.01	0.3	141.3	707%
Dubai Safari Park (north of Al Awir Road)	2	0.2	2	171.1	114%	0.3	0.03	0.3	141.3	707%
Pivot Fields	4	1.9	6	174.7	116%	0.6	0.27	0.9	141.9	709%
Desert Palm Polo Club	3	0.9	3	172.1	115%	0.6	0.08	0.7	141.7	708%
Desert Palm Riding Schools	4	0.6	4	173.3	116%	0.7	0.04	0.8	141.8	709%
Warsan Lake	2	0.2	2	171.0	114%	0.2	0.02	0.2	141.2	706%



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE: 150 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour PM_{10} concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-12

Predicted incremental 24-hour PM_{10} concentrations - no dust control

DRAWING NO. Fig 5-12.srf

REVISION 8

DATE 06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
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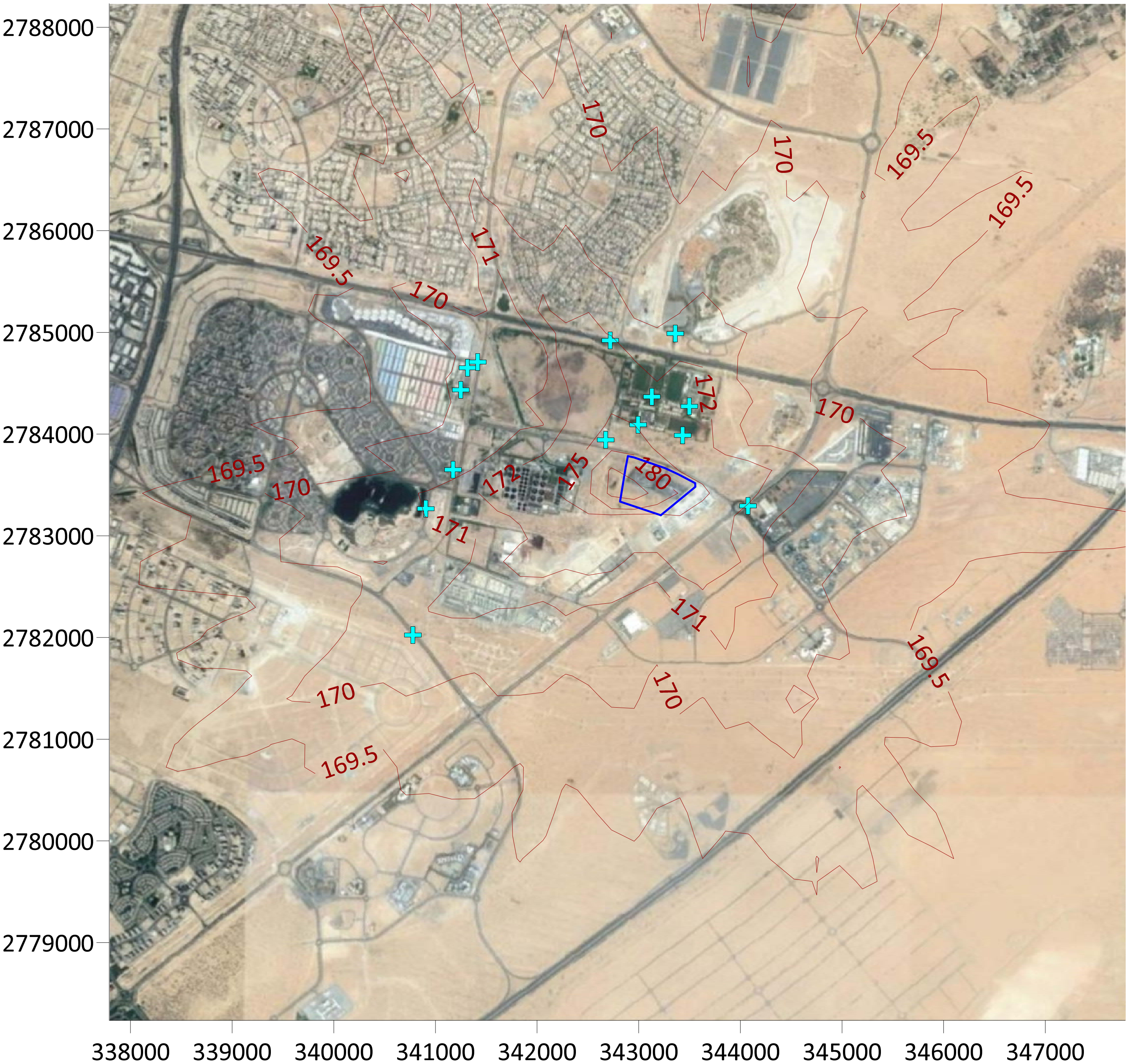

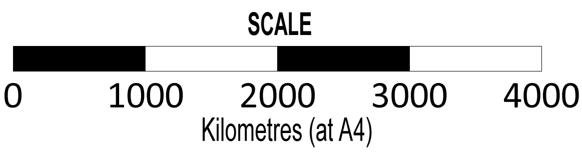

Criterion:
UAE: 150 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 24-hour PM_{10} concentration contours

MAP PROJECTION: Transverse Mercator
HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R
GRID: SRTM1 Global (~30 m)- Version 3
DATA SOURCE: GoogleEarth

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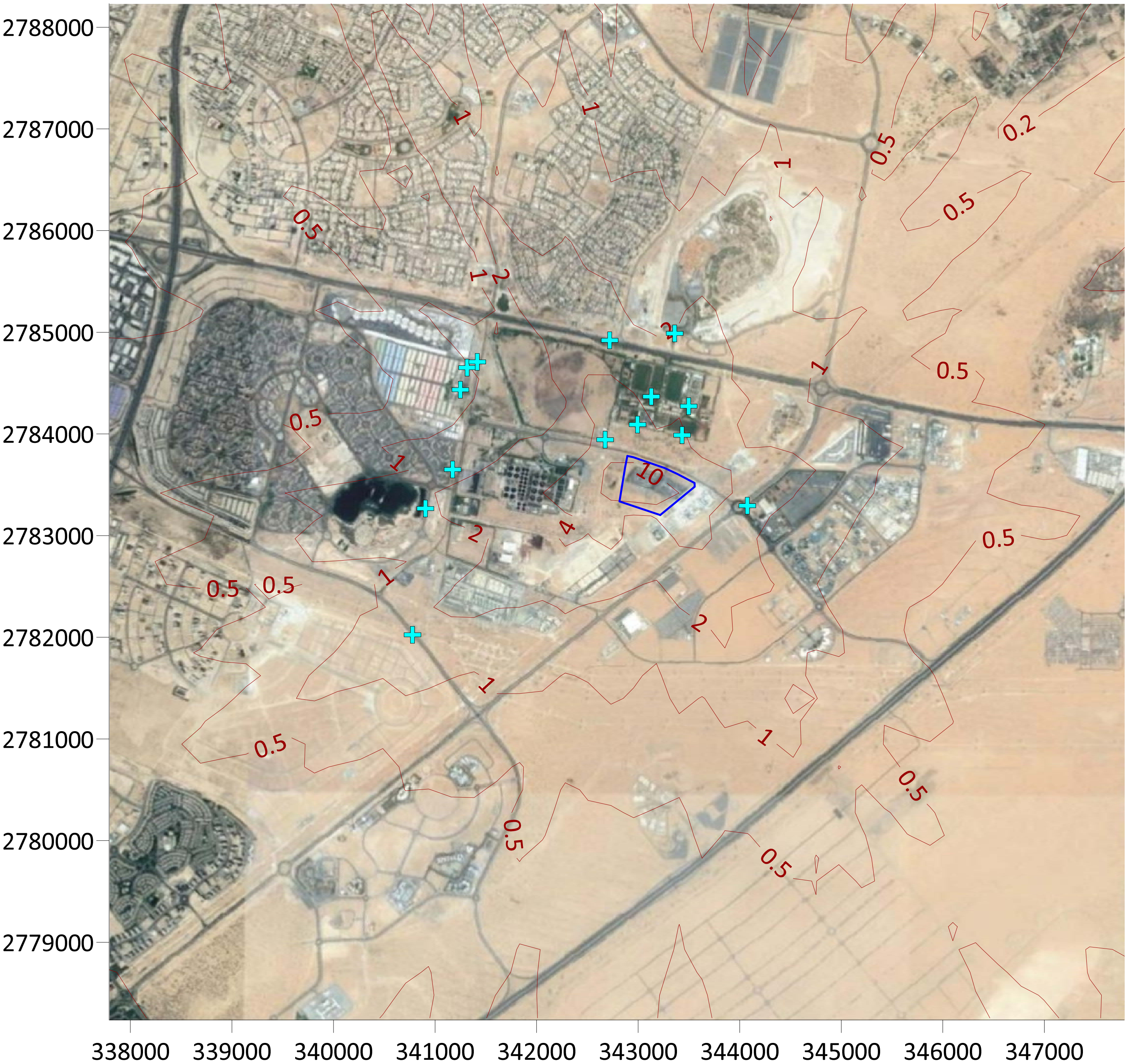
FIGURE 5-13
Predicted cumulative 24-hour PM_{10} concentrations - no dust control

DRAWING NO.	REVISION	DATE
Fig 5-13.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE: 150 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour PM_{10} concentration contours

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS)
Zone 40 R

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

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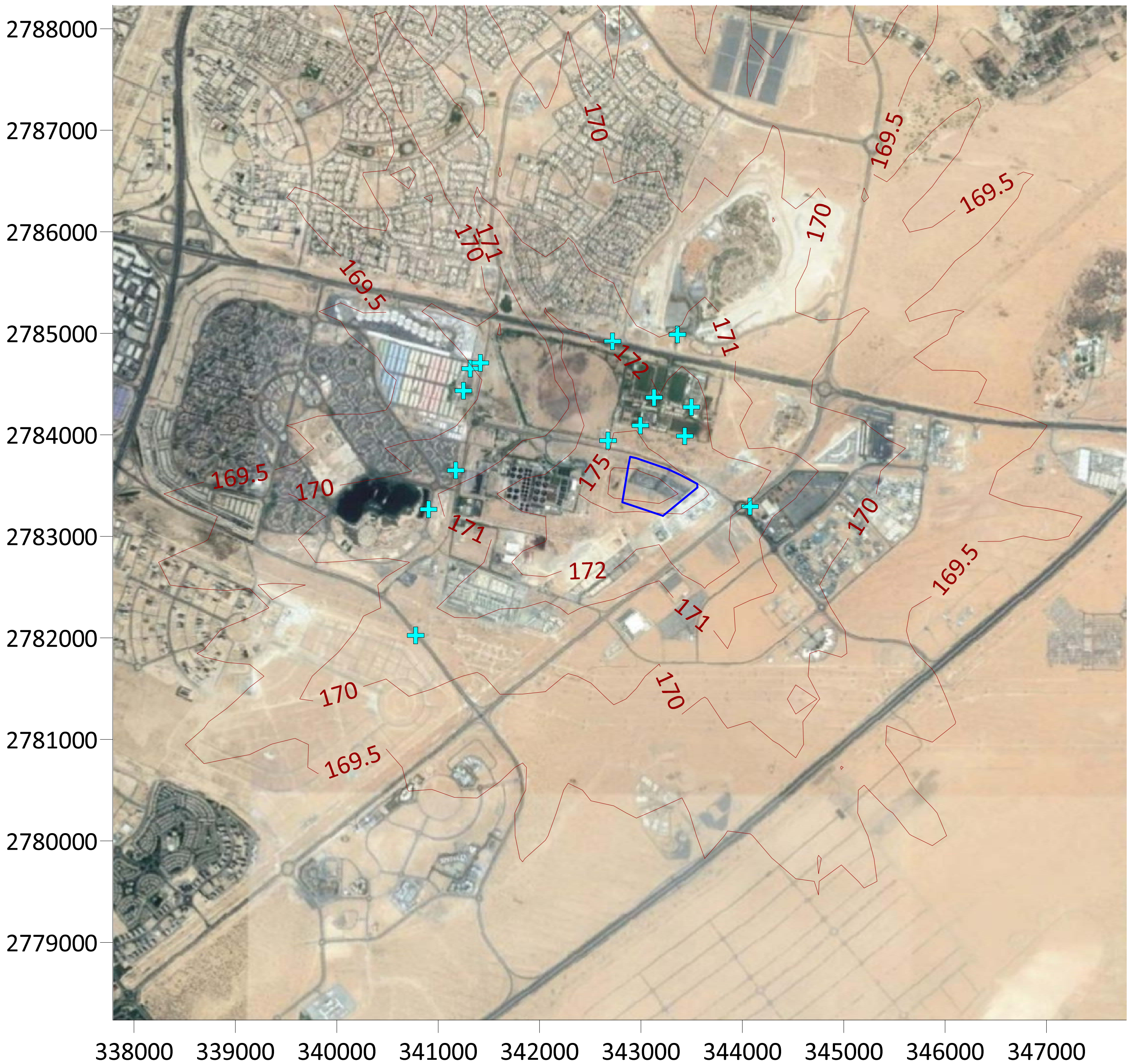
FIGURE 5-14

Predicted incremental 24-hour PM_{10} concentrations - with dust control

DRAWING NO.	REVISION	DATE
Fig 5-14.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

UAE: 150 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 24-hour PM_{10} concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-15

Predicted cumulative 24-hour PM_{10} concentrations - with dust control

DRAWING NO.	REVISION	DATE
Fig 5-15.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.6 $PM_{2.5}$

Table 5-12 and Table 5-13 show the predicted 24-hour and annual GLCs for $PM_{2.5}$ without and with dust control respectively, as described in Section 5.1.

The adopted background concentrations for $PM_{2.5}$ are:

- 24-hour concentration – 60 µg/m^3, which is 240 percent of the WHO assessment criteria of 25 µg/m^3.
- Annual concentration – 48 µg/m^3, which is 480 percent of the WHO assessment criteria of 10 µg/m^3.

Stack emissions were calculated assuming a conservative ratio of 1:1 for TSP to $PM_{2.5}$ and wheel-generated emissions were calculated using emission-specific factors.

Results have been presented as stack $PM_{2.5}$ concentrations, IBA $PM_{2.5}$ concentrations and total $PM_{2.5}$ concentrations in order to give a greater understanding of the proportion of $PM_{2.5}$ being emitted at each source.

For no dust control (Table 5-12), the highest predicted incremental 24-hour and annual averaging period concentrations fall well below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The predicted cumulative 24-hour total $PM_{2.5}$ concentrations exceed the WHO criteria (with a maximum of 66 µg/m^3 occurring at Residential Villas (Desert Palm), equating to 263 percent of the criteria) due to the background concentration exceeding the criteria. The predicted cumulative annual total $PM_{2.5}$ concentrations exceed the WHO criteria (with a maximum of 49 µg/m^3 occurring Residential Villas (Desert Palm), equating to 489 percent of the criteria) due to the background concentration exceeding the criteria.

Similarly, with dust control (Table 5-13), the highest predicted incremental 24-hour and annual averaging period concentrations fall well below the assessment criteria for both the stack and IBA emissions, as well as the total of these. The predicted cumulative 24-hour total $PM_{2.5}$ concentrations exceed the WHO criteria (with a maximum of 66 µg/m^3 occurring at Residential Villas (Desert Palm), equating to 263 percent of the criteria) due to the background concentration exceeding the criteria. The predicted cumulative annual total $PM_{2.5}$ concentrations exceed the WHO criteria (with a maximum of 49 µg/m^3 occurring at Residential Villas (Desert Palm), equating to 489 percent of the criteria) due to the background concentration exceeding the criteria.

The predicted maximum 24-hour concentration from stack emissions do not necessarily occur on the same day as predicted maximum 24-hour concentrations from the IBA management area. Hence summed stack 24-hour $PM_{2.5}$ concentrations with IBA management area's 24-hour $PM_{2.5}$ concentrations do not equal the Project's total predicted maximum $PM_{2.5}$ concentrations. This is due to daily varying meteorological parameters, such as wind speed and wind direction enabling a differing $PM_{2.5}$ dispersion patterns.

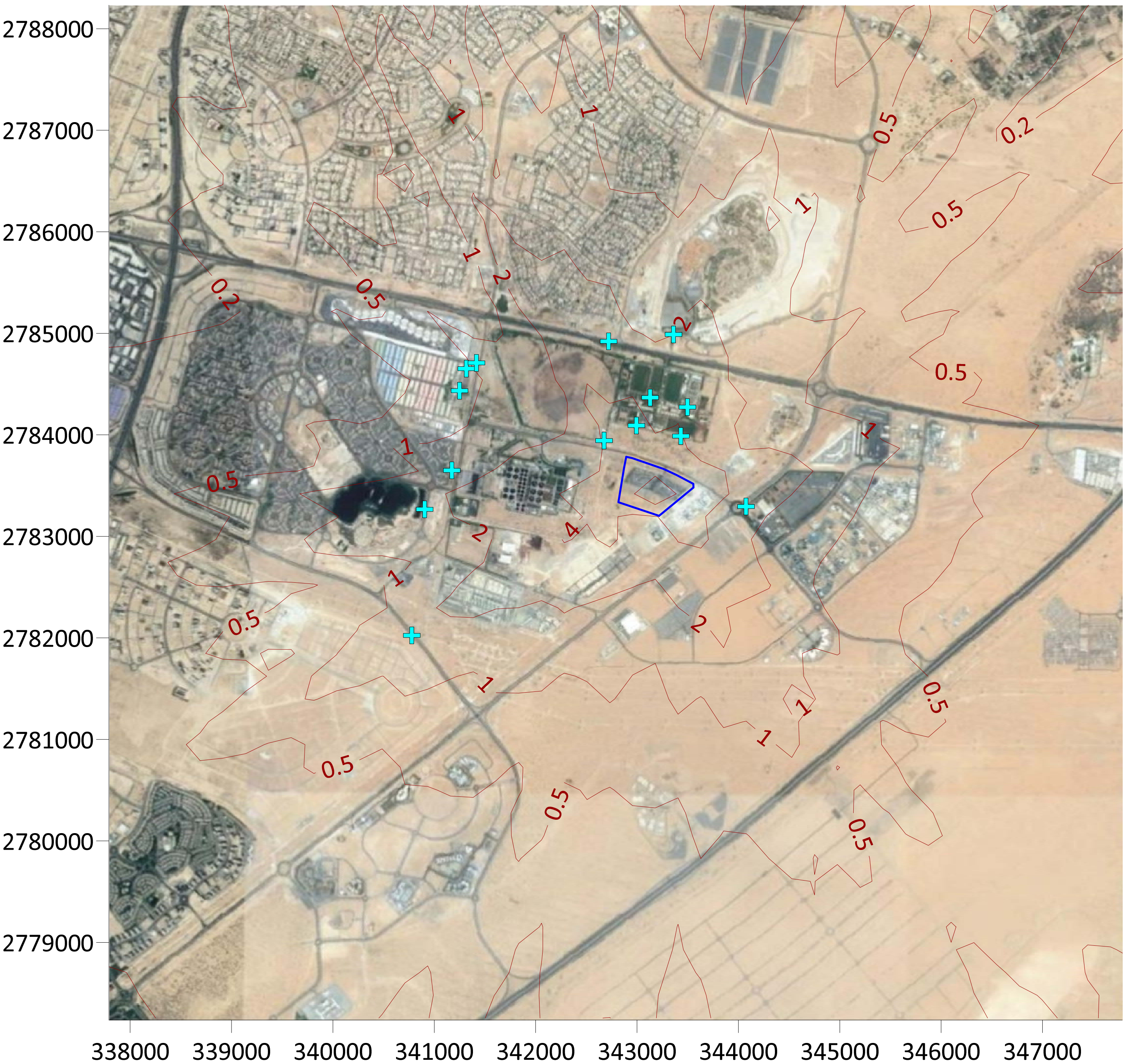
The incremental and cumulative 24-hour $PM_{2.5}$ ground level concentration contours with no dust control are presented in Figure 5-16 and Figure 5-17 respectively. The incremental and cumulative 24-hour $PM_{2.5}$ ground level concentration contours with dust control are presented in Figure 5-18 and Figure 5-19 respectively.

Table 5-12 Predicted 24-hour and annual $PM_{2.5}$ concentrations – No dust control

Receptor	Incremental 24-hour Stack $PM_{2.5}$ (µg/m³)	Incremental 24-hour IBA $PM_{2.5}$ (µg/m³)	Incremental total 24-hour $PM_{2.5}$ (µg/m³)	Cumulative total 24-hour $PM_{2.5}$ (µg/m³)	Cumulative % of criteria	Incremental stack annual $PM_{2.5}$ (µg/m³)	Incremental IBA annual $PM_{2.5}$ (µg/m³)	Incremental total annual $PM_{2.5}$ (µg/m³)	Cumulative total annual $PM_{2.5}$ (µg/m³)	Cumulative % of criteria
Criteria (µg/m³)	25 (WHO)					10 (WHO)				
Dubai International City- EMR 14, Emirates Cluster	1	0.1	1	61.4	246%	0.2	0.006	0.2	48.2	482%
International City Phase II (under construction)	2	0.03	2	61.8	247%	0.1	0.001	0.1	48.1	481%
Residential Villas (Desert Palm)	6	0.4	6	65.7	263%	0.9	0.041	0.9	48.9	489%
AL Warqa 4 (north of Al Awir Road)	3	0.1	3	62.9	251%	0.4	0.011	0.4	48.4	484%
Dragon Mart Mosque	1	0.1	1	60.7	243%	0.1	0.004	0.1	48.1	481%
Dragon Mart Commercial Centre	1	0.1	1	61.2	245%	0.1	0.005	0.1	48.1	481%
Dubai Textile City	1	0.0	1	61.0	244%	0.1	0.004	0.1	48.1	481%
Desert Palm Resort and Hotel	3	0.1	3	63.4	254%	0.6	0.008	0.6	48.6	486%
Dubai Plant Nursery	3	0.1	3	62.9	251%	0.3	0.004	0.3	48.3	483%
Dubai Safari Park (north of Al Awir Road)	2	0.1	2	62.0	248%	0.3	0.007	0.3	48.3	483%
Pivot Fields	4	0.5	5	64.6	258%	0.6	0.067	0.7	48.7	487%
Desert Palm Polo Club	3	0.2	3	62.9	252%	0.6	0.019	0.6	48.6	486%
Desert Palm Riding Schools	4	0.1	4	64.3	257%	0.7	0.011	0.7	48.7	487%
Warsan Lake	2	0.1	2	61.9	247%	0.2	0.005	0.2	48.2	482%

Table 5-13 Predicted 24-hour and annual $PM_{2.5}$ concentrations – Dust control

Receptor	Incremental 24-hour Stack $PM_{2.5}$ (µg/m³)	Incremental 24-hour IBA $PM_{2.5}$ (µg/m³)	Incremental total 24-hour $PM_{2.5}$ (µg/m³)	Cumulative total 24-hour $PM_{2.5}$ (µg/m³)	Cumulative % of criteria	Incremental stack annual $PM_{2.5}$ (µg/m³)	Incremental IBA annual $PM_{2.5}$ (µg/m³)	Incremental total annual $PM_{2.5}$ (µg/m³)	Cumulative total annual $PM_{2.5}$ (µg/m³)	Cumulative % of criteria
Criteria (µg/m³)	25 (UAE)					10 (WHO)				
Dubai International City- EMR 14, Emirates Cluster	1	0.03	1	61.4	245%	0.2	0.003	0.2	48.2	482%
International City Phase II (under construction)	2	0.01	2	61.8	247%	0.1	0.0005	0.1	48.1	481%
Residential Villas (Desert Palm)	6	0.17	6	65.7	263%	0.9	0.019	0.9	48.9	489%
AL Warqa 4 (north of Al Awir Road)	3	0.04	3	62.8	251%	0.4	0.005	0.4	48.4	484%
Dragon Mart Mosque	1	0.03	1	60.7	243%	0.1	0.002	0.1	48.1	481%
Dragon Mart Commercial Centre	1	0.03	1	61.2	245%	0.1	0.002	0.1	48.1	481%
Dubai Textile City	1	0.02	1	61.0	244%	0.1	0.002	0.1	48.1	481%
Desert Palm Resort and Hotel	3	0.07	3	63.4	254%	0.6	0.004	0.6	48.6	486%
Dubai Plant Nursery	3	0.06	3	62.8	251%	0.3	0.002	0.3	48.3	483%
Dubai Safari Park (north of Al Awir Road)	2	0.03	2	62.0	248%	0.3	0.003	0.3	48.3	483%
Pivot Fields	4	0.21	4	64.4	258%	0.6	0.031	0.6	48.6	486%
Desert Palm Polo Club	3	0.10	3	62.9	252%	0.6	0.009	0.6	48.6	486%
Desert Palm Riding Schools	4	0.06	4	64.3	257%	0.7	0.005	0.7	48.7	487%
Warsan Lake	2	0.02	2	61.8	247%	0.2	0.002	0.2	48.2	482%



SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

WHO: 25 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour $PM_{2.5}$ concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-16

Predicted incremental 24-hour $PM_{2.5}$ concentrations - no dust control

DRAWING NO.	REVISION	DATE
Fig 5-16.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
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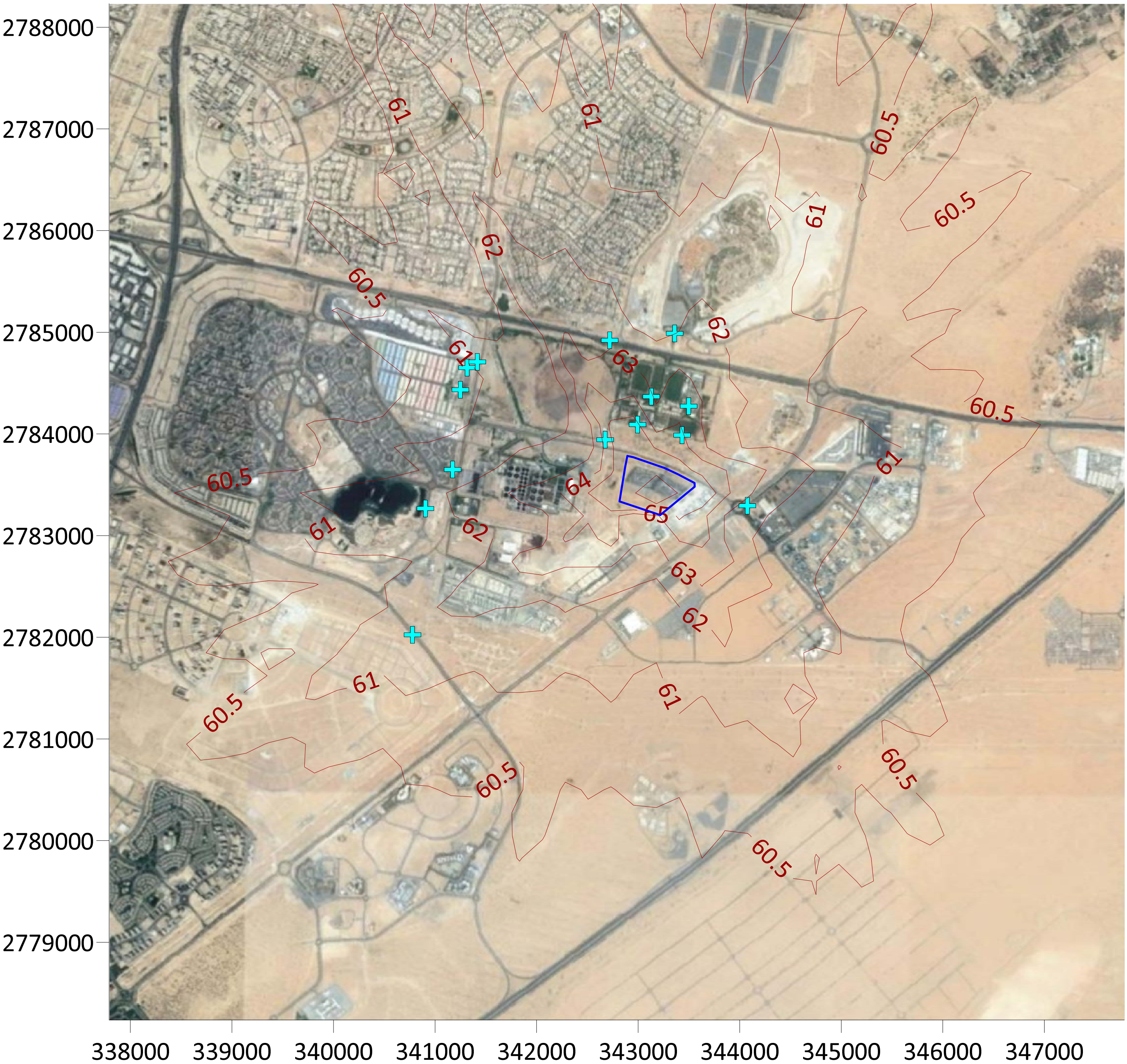

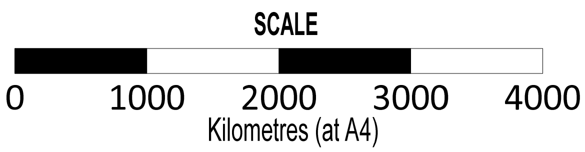

Criterion:

WHO: 25 ug/m^3

LEGEND

Sensitive receptor

Project site perimeter

Max 24-hour $PM_{2.5}$ concentration contours

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS)
Zone 40 R

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

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FIGURE 5-17

Predicted cumulative 24-hour $PM_{2.5}$ concentrations - no dust control

DRAWING NO.	REVISION	DATE
Fig 5-17.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
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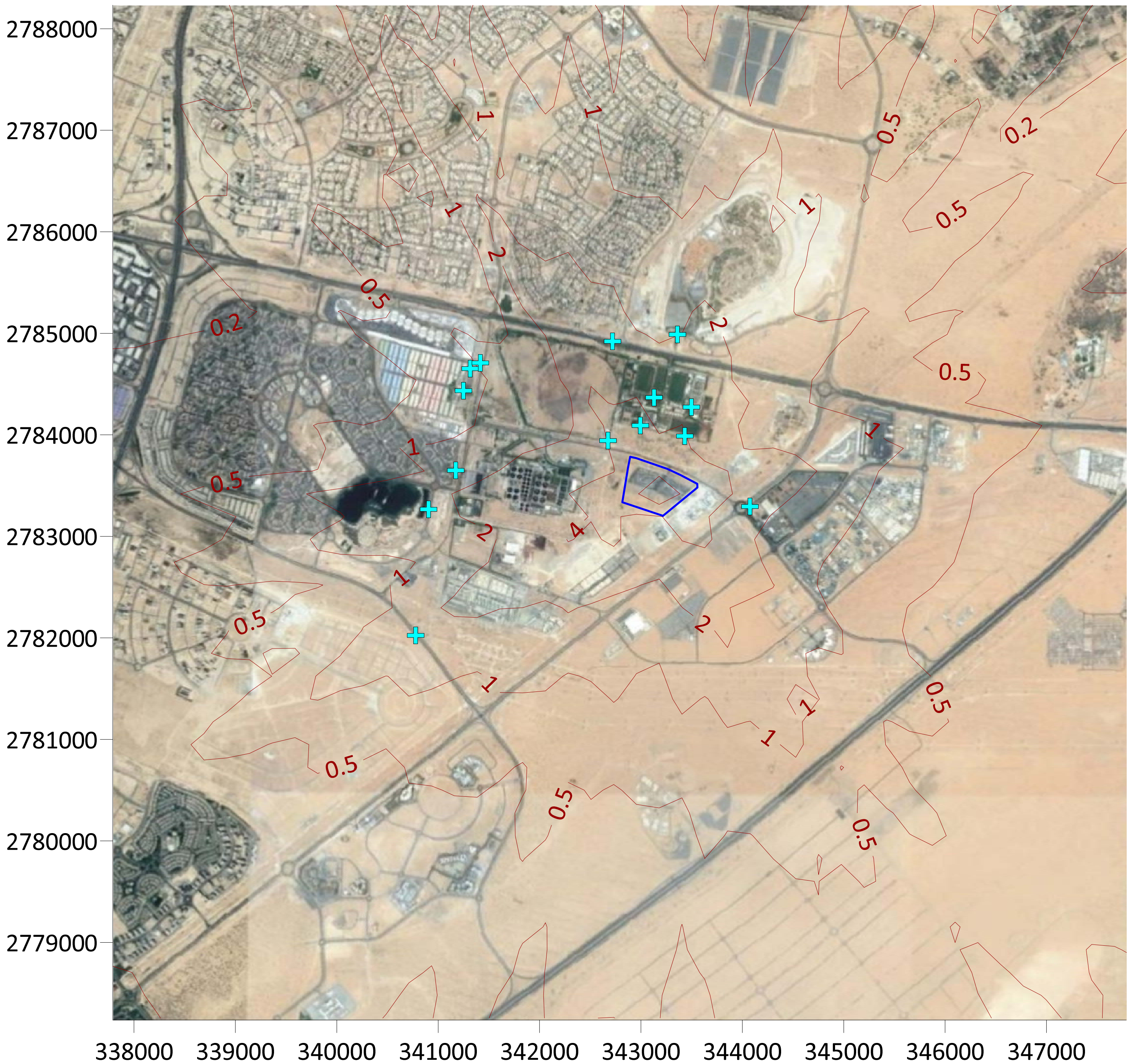

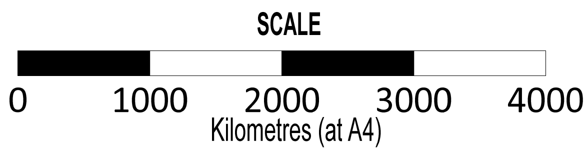

Criterion:
WHO: 25 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 24-hour $PM_{2.5}$ concentration contours

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS)
Zone 40 R

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

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FIGURE 5-18

Predicted incremental 24-hour $PM_{2.5}$ concentrations - with dust control

DRAWING NO.	REVISION	DATE
Fig 5-18.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
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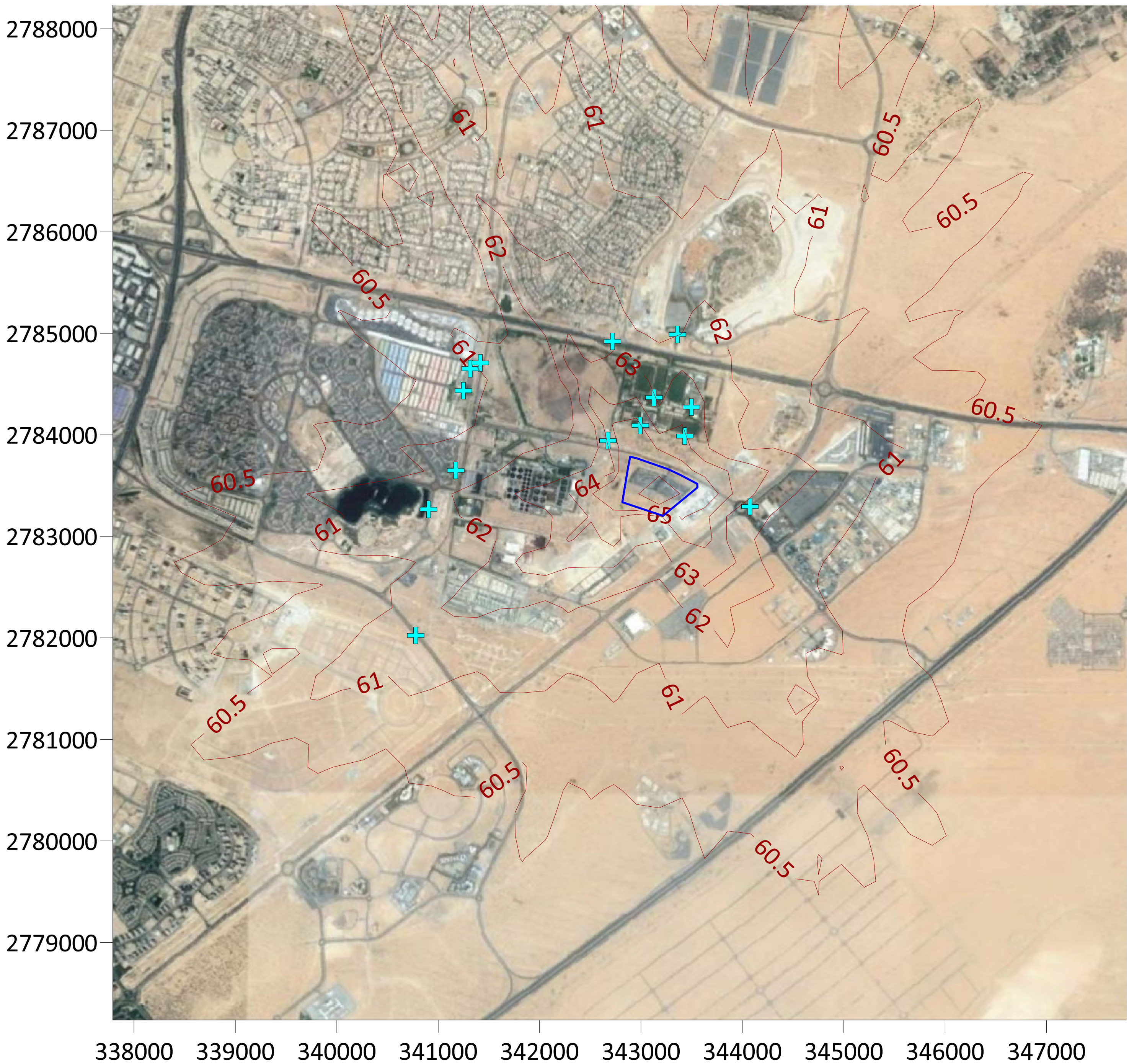

SCALE

0 1000 2000 3000 4000

Kilometres (at A4)

Criterion:

WHO: 25 ug/m^3

LEGEND

- Sensitive receptor
- Project site perimeter
- Max 24-hour $PM_{2.5}$ concentration contours

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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FIGURE 5-19

Predicted cumulative 24-hour $PM_{2.5}$ concentrations - with dust control

DRAWING NO.	REVISION	DATE
Fig 5-19.srf	8	06.05.2020

CREATED	CHECKER	APPROVER	FILE PATH
GF	AST	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\05. WP\Surfer\Contours\Run 9

5.3.7 Acid gases (hydrogen chloride and hydrogen fluoride)

Table 5-14 shows the predicted 99.9th percentile 1-hour HCl and 24-hour HF ground level concentrations.

Background concentrations were not included for HCl or HF, as appropriate data were not available for use in this assessment. Therefore, an incremental assessment only is shown.

The highest predicted 1-hour 99.9th percentile concentration for HCl occurs at Pivot Fields, Residential Villas (Desert Palm) and Desert Palms Riding Schools, equating to 12 percent of the NSW AMMAAP assessment criteria. This complies comfortably with the WHO guideline regarding 25 percent of the criteria.

The highest predicted 24-hour concentration for HF occurs at Residential Villas (Desert Palm), equating to 19 percent of the NSW AMMAAP assessment criteria. This complies with the WHO guideline regarding 25 percent of the criteria.

Table 5-14 Predicted 99.9th percentile 1-hour HCl and 24-hour HF concentrations

Receptor	Incremental 1-hour 99.9th HCl (µg/m³)	Incremental % of criteria	Incremental 24-hour HF (µg/m³)	Incremental % of criteria
Criteria (µg/m³)	140(NSW AMMAAP)		2.9(NSW AMMAAP)	
Dubai International City- EMR 14, Emirates Cluster	7	5%	0.14	5%
International City Phase II (under construction)	9	6%	0.18	6%
Residential Villas (Desert Palm)	17	12%	0.56	19%
AL Warqa 4 (north of Al Awir Road)	13	9%	0.28	10%
Dragon Mart Mosque	6	4%	0.07	2%
Dragon Mart Commercial Centre	10	7%	0.11	4%
Dubai Textile City	10	7%	0.10	3%
Desert Palm Resort and Hotel	14	10%	0.34	12%
Dubai Plant Nursery	9	7%	0.28	10%
Dubai Safari Park (north of Al Awir Road)	13	9%	0.20	7%
Pivot Fields	17	12%	0.42	15%
Desert Palm Polo Club	15	11%	0.29	10%
Desert Palm Riding Schools	17	12%	0.43	15%
Warsan Lake	6	4%	0.18	6%

5.3.8 Ammonia and dioxins and furans

Table 5-15 shows the predicted 99.9th percentile 1-hour TCDD and NH_3 ground level concentrations.

Background concentrations were not included for TCDD or NH_3, as appropriate data were not available for use in this assessment. Therefore, an incremental assessment only is shown.

The highest predicted 1-hour 99.9th percentile concentration for TCDD occurs at Pivot Fields, Residential Villas (Desert Palm) and Desert Palms Riding Schools, equating to 9 percent of the NSW AMMAAP assessment criteria. This complies comfortably with the WHO guideline regarding 25 percent of the criteria.

The highest predicted 1-hour 99.9th percentile concentration for NH_3 occurs at Pivot Fields, Residential Villas (Desert Palm) and Desert Palms Riding Schools, equating to 5 percent of the NSW AMMAAP assessment criteria. This complies comfortably with the WHO guideline regarding 25 percent of the criteria.

Table 5-15 Predicted 1-hour TCDD and NH_3 concentrations

Receptor	Incremental 1-hour 99.9th TCDD (ng/m^3)	Incremental % of criteria	Incremental 1-hour 99.9th NH_3 (µg/m^3)	Incremental % of criteria
Criteria (µg/m^3)	2.00E-06 (NSW AMMAAP)		330 (NSW AMMAAP)	
Dubai International City- EMR 14, Emirates Cluster	7.11E-08	4%	7	2%
International City Phase II (under construction)	8.54E-08	4%	9	3%
Residential Villas (Desert Palm)	1.72E-07	9%	17	5%
AL Warqa 4 (north of Al Awir Road)	1.31E-07	7%	13	4%
Dragon Mart Mosque	5.85E-08	3%	6	2%
Dragon Mart Commercial Centre	1.01E-07	5%	10	3%
Dubai Textile City	1.03E-07	5%	10	3%
Desert Palm Resort and Hotel	1.44E-07	7%	14	4%
Dubai Plant Nursery	9.43E-08	5%	9	3%
Dubai Safari Park (north of Al Awir Road)	1.32E-07	7%	13	4%
Pivot Fields	1.72E-07	9%	17	5%
Desert Palm Polo Club	1.54E-07	8%	15	5%
Desert Palm Riding Schools	1.73E-07	9%	17	5%
Warsan Lake	5.99E-08	3%	6	2%

5.3.9 Mercury and cadmium

Table 5-16 shows the predicted 99.9th percentile 1-hour and annual Hg and Cd ground level concentrations.

Background concentrations were not included for Hg or Cd, as appropriate data were not available for use in this assessment. Therefore, an incremental assessment only is shown.

The highest predicted 1-hour 99.9th percentile concentration for Hg occurs at Pivot Fields, Residential Villas (Desert Palm) and Desert Palms Riding Schools, equating to 5 percent of the NSW AMMAAP assessment criteria. This complies comfortably with the WHO guideline regarding 25 percent of the criteria.

Predicted 1-hour concentrations of Cd exceed the criteria at all sensitive receptors. However, the NSW AMMAAP can be considered a guideline only as opposed to a strict limit and states "toxic air pollutants must be minimised to the maximum extent achievable through the application of best-practice process design and/or emission controls" (NSW DEC, 2005). As this is a national guideline designed for relevance to Australian projects, it is apparent that the European Commission criteria are more suitable since the stack emissions of the WMC are complying with the European IED. The highest predicted annual concentration for Cd occurs at Residential Villas (Desert Palm), equating to 87 percent of the European Commission criteria.

Cd emission rates for this assessment were based on the regulatory IED concentration of 0.05 mg/Nm^3, equating to an emission rate of 0.0034 g/s. This rate is for the total of Cd and thallium emissions combined and therefore a conservative approach was taken, assuming that 100% of the emissions are Cd. However, it is noteworthy that Cd levels in MSW are expected to be relatively low and therefore, emission rates of the pollutant would not reach the levels demonstrated. As shown in Section 5.1.1, WMCs most recently constructed by Hitachi Zosen Inova showed emission rates of Cd and thallium to range between 0.00003 g/s to 0.00006 g/s for the WMC with an identical air pollution control system to be implemented in the Dubai WMC. Therefore, the expected maximum ambient concentration of Cd at the sensitive receptors in reality is likely to be significantly lower.

Table 5-16 Predicted 1-hour and annual mercury and cadmium concentrations

Receptor	Incremental 1-hour 99.9th Hg (µg/m³)	Incremental % of criteria	Incremental 1-hour 99.9th Cd (µg/m³)	Incremental % of criteria	Incremental annual Cd (µg/m³)	Incremental % of criteria
Criteria (µg/m³)	1.8 (NSW AMMAAP)		0.018 (NSW AMMAAP)		0.005 (European Commission)	
Dubai International City- EMR 14, Emirates Cluster	0.04	2%	0.04	197%	0.001	19%
International City Phase II (under construction)	0.04	2%	0.04	236%	0.001	12%
Residential Villas (Desert Palm)	0.09	5%	0.09	475%	0.004	87%
AL Warqa 4 (north of Al Awir Road)	0.07	4%	0.07	362%	0.002	36%
Dragon Mart Mosque	0.03	2%	0.03	162%	0.001	11%
Dragon Mart Commercial Centre	0.05	3%	0.05	280%	0.001	12%
Dubai Textile City	0.05	3%	0.05	286%	0.001	11%
Desert Palm Resort and Hotel	0.07	4%	0.07	399%	0.003	56%
Dubai Plant Nursery	0.05	3%	0.05	261%	0.002	33%
Dubai Safari Park (north of Al Awir Road)	0.07	4%	0.07	364%	0.002	31%
Pivot Fields	0.09	5%	0.09	474%	0.003	59%
Desert Palm Polo Club	0.08	4%	0.08	427%	0.003	57%
Desert Palm Riding Schools	0.09	5%	0.09	478%	0.004	71%
Warsan Lake	0.03	2%	0.03	166%	0.001	21%

6. Management and mitigation measures

6.1 Operational WMC emissions

The predicted incremental results from air dispersion modelling of the proposed operations of the WMC indicates the Project is not anticipated to exceed relevant air quality criteria for NO_2, SO_2, CO, TSP, PM_{10}, $PM_{2.5}$, HCl, HF, TCDD, NH_3 and Hg provided that:

- The emission concentration guarantees listed in IED, Annex VI, Part 3 (Tables 1.1, 1.3 and Section 1.4 and 1.5) (European Union 2010) and set out in Section 5.1 are met.
- The stack parameters and emission rates used in this assessment as detailed in Table 5-1 and Table 5-2 respectively are adhered to.
- Throughputs of IBA remain at the assumed rate (282,300 tpa)

Although the model predictions indicate exceedances of 1-hour incremental Cd for the NSW AMMAAP criteria, this is only a guideline, and the European Commission annual criteria is considered more appropriate. Predicted annual Cd concentrations comply with the European Commission criteria. Further, the modelled emission rate reflects the regulatory maximum of 0.05 mg/Nm^3 (sumof Cd and Hg), and it is considered unlikely that the emission rate for Cd in reality would reach this level.

7. Conclusions

For this assessment, air quality criteria including Ministerial Oder No, 12, 2006, US OSHA, 29 CFR, Part 1910, US EPA NAAQs 40 CFR Part 50, WHO Ambient Air Quality Standards, the NSW AMMAAP and European Commission standards were reviewed, and the most appropriate of these used as a comparison to predicted GLCs of selected air pollutants. The results demonstrate predicted incremental GLCs for NO_2, SO_2, CO, TPS, PM_{10}, $PM_{2.5}$, HCl, HF, NH_3, TCDD and Hg do not exceed the adopted assessment criteria, based on the stack characteristics and emission rates assumed for the Project.

Predicted incremental 1-hour concentrations of Cd exceed the NSW AMMAAP guidelines. This is likely due to the conservative assumption that the IED emission limit of 0.05 mg/Nm^3, was 100% Cd as opposed to the total of Cd and thallium, as the IED limits state. Ambient concentrations of Cd associated with the stacks are likely to be lower in reality. As discussed in Section 5.3.9, WMCs most recently constructed by Hitachi Zosen Inova showed emission rates of Cd and thallium to range between 0.00003 g/s to 0.00006 g/s as opposed to the 0.0034 g/s used in this assessment. Further, the European Commission annual standard for Cd is considered more relevant for this assessment over the Australian guidelines (NSW AMMAAP). The predicted annual concentrations of Cd comply with the European Commission criteria at all sensitive receptors.

The maximum predicted cumulative concentration for 24-hour NO_2 exceeds the UAE criteria by 3 percent, however the incremental concentration complies with the criteria. The cumulative exceedance is attributed to the background concentration being 85% of the criteria. It is also noted that the conservative NO_x to NO_2 ratio of 40 percent was used, where in reality, this ratio is likely to be around 20 percent for combustion sources.

The cumulative concentrations for PM_{10} exceed the UAE 24-hour and annual WHO criteria, while the cumulative concentrations for $PM_{2.5}$ exceed the WHO 24-hour and annual criteria due to the adopted background concentrations exceeding the criteria. The incremental contribution of the WMC to TSP, PM_{10}, and $PM_{2.5}$ ambient concentrations are less than the respective assessment criteria, including the WHO Interim target 1.

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Appendices

Appendix A – Sample AERMOD input file

```
**
****************************************
**
** AERMOD Input Produced by:
** AERMOD View Ver. 9.5.0
** Lakes Environmental Software Inc.
** Date: 09-Mar-20
** File: F:\Dubai\Run 9_BPIP update\NO2\Dubai_RRF.ADI
**
****************************************
**
**
****************************************
** AERMOD Control Pathway
****************************************
**
**
CO STARTING
   TITLEONE C:\Dubai_RRF\Dubai_RRF.isc
   MODELOPT CONC FASTALL BETA LOWWIND3
   AVERTIME 1 24 ANNUAL
   POLLUTID NO2
   RUNORNOT RUN
   ERRORFIL Dubai_RRF.err
CO FINISHED
**
****************************************
** AERMOD Source Pathway
****************************************
**
**
```

SO STARTING

** Source Location **

** Source ID - Type - X Coord. - Y Coord. **

LOCATION 1 POINT 343046.392 2783415.858 34.000

** DESCRSRC Stack

LOCATION 2 POINT 343050.677 2783414.478 34.000

** DESCRSRC Stack

LOCATION 3 POINT 343047.265 2783411.166 34.000

** DESCRSRC Stack

LOCATION 4 POINT 343118.726 2783392.552 35.000

** DESCRSRC Stack

LOCATION 5 POINT 343123.014 2783391.190 35.000

** DESCRSRC Stack

** Source Parameters **

SRCPARAM 1 10.93 70.000 408.200 19.00000 2.400

SRCPARAM 2 10.93 70.000 408.200 19.00000 2.400

SRCPARAM 3 10.93 70.000 408.200 19.00000 2.400

SRCPARAM 4 10.93 70.000 408.200 19.00000 2.400

SRCPARAM 5 10.93 70.000 408.200 19.00000 2.400

** Building Downwash **

BUILDHGT 1 62.00 62.00 62.00 62.00 62.00 62.00

BUILDHGT 1 62.00 62.00 62.00 62.00 62.00 62.00

BUILDHGT 1 62.00 62.00 62.00 62.00 62.00 62.00

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BUILDHGT 2	62.00	62.00	62.00	62.00	62.00	62.00
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BUILDHGT 2	62.00	62.00	62.00	62.00	62.00	62.00

BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 3	62.00	62.00	62.00	62.00	62.00	62.00

BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 4	62.00	62.00	62.00	62.00	62.00	62.00

BUILDHGT 5	62.00	62.00	62.00	62.00	62.00	62.00
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BUILDHGT 5	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 5	62.00	62.00	62.00	62.00	62.00	62.00
BUILDHGT 5	62.00	62.00	62.00	62.00	62.00	62.00

BUILDWID 1	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 1	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 1	124.81	149.52	169.69	184.71	194.11	197.62
BUILDWID 1	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 1	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 1	124.81	149.52	169.69	184.71	194.11	197.62

BUILDWID 2	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 2	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 2	124.81	149.52	169.69	184.71	194.11	197.62
BUILDWID 2	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 2	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 2	124.81	149.52	169.69	184.71	194.11	197.62

BUILDWID 3	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 3	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 3	124.81	149.52	169.69	184.71	194.11	197.62
BUILDWID 3	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 3	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 3	124.81	149.52	169.69	184.71	194.11	197.62

BUILDWID 4	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 4	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 4	124.81	149.52	169.69	184.71	194.11	197.62
BUILDWID 4	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 4	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 4	124.81	149.52	169.69	184.71	194.11	197.62

BUILDWID 5	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 5	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 5	124.81	149.52	169.69	184.71	194.11	197.62
BUILDWID 5	195.12	192.44	197.33	196.23	189.16	176.34
BUILDWID 5	158.17	135.19	108.10	77.73	64.86	96.30
BUILDWID 5	124.81	149.52	169.69	184.71	194.11	197.62

BUILDLEN 1	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 1	184.71	194.11	197.62	195.12	192.44	197.33

BUILDLEN 1	196.23	189.16	176.34	158.17	135.19	108.10
BUILDLEN 1	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 1	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 1	196.23	189.16	176.34	158.17	135.19	108.10

BUILDLEN 2	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 2	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 2	196.23	189.16	176.34	158.17	135.19	108.10
BUILDLEN 2	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 2	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 2	196.23	189.16	176.34	158.17	135.19	108.10

BUILDLEN 3	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 3	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 3	196.23	189.16	176.34	158.17	135.19	108.10
BUILDLEN 3	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 3	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 3	196.23	189.16	176.34	158.17	135.19	108.10

BUILDLEN 4	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 4	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 4	196.23	189.16	176.34	158.17	135.19	108.10
BUILDLEN 4	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 4	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 4	196.23	189.16	176.34	158.17	135.19	108.10

BUILDLEN 5	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 5	184.71	194.11	197.62	195.12	192.44	197.33
BUILDLEN 5	196.23	189.16	176.34	158.17	135.19	108.10
BUILDLEN 5	77.73	64.86	96.30	124.81	149.52	169.69
BUILDLEN 5	184.71	194.11	197.62	195.12	192.44	197.33

BUILDLEN	5	196.23	189.16	176.34	158.17	135.19	108.10
XBADJ	1	4.43	16.74	5.40	-6.11	-17.42	-28.21
XBADJ	1	-38.14	-46.91	-54.26	-59.96	-66.71	-78.14
XBADJ	1	-87.20	-93.61	-97.17	-97.78	-95.42	-90.16
XBADJ	1	-82.16	-81.60	-101.70	-118.70	-132.10	-141.48
XBADJ	1	-146.57	-147.20	-143.36	-135.16	-125.73	-119.19
XBADJ	1	-109.03	-95.55	-79.17	-60.39	-39.77	-17.94
XBADJ	2	5.05	16.57	4.45	-7.81	-19.82	-31.24
XBADJ	2	-41.70	-50.90	-58.55	-64.42	-71.22	-82.55
XBADJ	2	-91.37	-97.42	-100.51	-100.55	-97.52	-91.54
XBADJ	2	-82.77	-81.43	-100.75	-117.00	-129.70	-138.46
XBADJ	2	-143.01	-143.22	-139.07	-130.70	-121.23	-114.78
XBADJ	2	-104.85	-91.74	-75.83	-57.62	-37.66	-16.56
XBADJ	3	8.90	20.85	9.02	-3.07	-15.07	-26.62
XBADJ	3	-37.35	-46.96	-55.13	-61.63	-69.14	-81.24
XBADJ	3	-90.88	-97.76	-101.67	-102.49	-100.19	-94.85
XBADJ	3	-86.63	-85.71	-105.32	-121.73	-134.45	-143.07
XBADJ	3	-147.36	-147.16	-142.49	-133.49	-123.31	-116.09
XBADJ	3	-105.34	-91.40	-74.67	-55.68	-35.00	-13.25
XBADJ	4	14.83	13.90	-10.59	-34.75	-57.85	-79.20
XBADJ	4	-98.15	-114.11	-126.60	-135.25	-142.66	-152.45
XBADJ	4	-157.60	-157.96	-153.53	-144.43	-130.94	-113.47
XBADJ	4	-92.55	-78.76	-85.71	-90.06	-91.67	-90.49
XBADJ	4	-86.56	-80.01	-71.02	-59.87	-49.78	-44.89
XBADJ	4	-38.63	-31.19	-22.81	-13.74	-4.25	5.37
XBADJ	5	15.42	13.71	-11.55	-36.46	-60.26	-82.23

XBADJ	5	-101.70	-118.09	-130.88	-139.70	-147.15	-156.83
XBADJ	5	-161.75	-161.76	-156.85	-147.17	-133.02	-114.83
XBADJ	5	-93.15	-78.58	-84.75	-88.35	-89.26	-87.46
XBADJ	5	-83.01	-76.03	-66.74	-55.42	-45.29	-40.50
XBADJ	5	-34.47	-27.40	-19.50	-11.00	-2.17	6.73
YBADJ	1	-37.60	-29.51	-20.52	-10.91	-0.97	9.00
YBADJ	1	18.70	27.83	36.11	43.30	49.17	53.55
YBADJ	1	56.30	57.34	56.64	54.21	50.14	44.55
YBADJ	1	37.60	29.51	20.52	10.91	0.97	-9.00
YBADJ	1	-18.70	-27.83	-36.11	-43.30	-49.17	-53.55
YBADJ	1	-56.30	-57.34	-56.64	-54.21	-50.14	-44.55
YBADJ	2	-33.14	-25.00	-16.12	-6.74	2.84	12.34
YBADJ	2	21.46	29.93	37.49	43.91	49.00	52.60
YBADJ	2	54.60	54.94	53.61	50.65	46.16	40.26
YBADJ	2	33.14	25.00	16.12	6.74	-2.84	-12.34
YBADJ	2	-21.46	-29.93	-37.49	-43.91	-49.00	-52.60
YBADJ	2	-54.60	-54.94	-53.61	-50.65	-46.16	-40.26
YBADJ	3	-35.93	-27.09	-17.42	-7.23	3.18	13.50
YBADJ	3	23.40	32.60	40.80	47.76	53.28	57.17
YBADJ	3	59.33	59.69	58.23	55.00	50.10	43.68
YBADJ	3	35.93	27.09	17.42	7.23	-3.18	-13.50
YBADJ	3	-23.40	-32.60	-40.80	-47.76	-53.28	-57.17
YBADJ	3	-59.33	-59.69	-58.23	-55.00	-50.10	-43.68
YBADJ	4	37.69	46.44	53.78	59.49	63.38	65.36
YBADJ	4	65.34	63.34	59.42	53.69	46.33	37.56
YBADJ	4	27.66	16.91	5.64	-5.79	-17.05	-27.79
YBADJ	4	-37.69	-46.44	-53.78	-59.49	-63.38	-65.36

```
   YBADJ    4           -65.34   -63.34   -59.42   -53.69   -46.33   -37.56
   YBADJ    4           -27.66   -16.91    -5.64     5.79    17.05    27.79

   YBADJ    5            42.14    50.93    58.17    63.64    67.18    68.67
   YBADJ    5            68.08    65.43    60.78    54.29    46.15    36.60
   YBADJ    5            25.95    14.50     2.62    -9.35   -21.03   -32.07
   YBADJ    5           -42.14   -50.93   -58.17   -63.64   -67.18   -68.67
   YBADJ    5           -68.08   -65.43   -60.78   -54.29   -46.15   -36.60
   YBADJ    5           -25.95   -14.50    -2.62     9.35    21.03    32.07

   SRCGROUP ALL
SO FINISHED
**
****************************************
** AERMOD Receptor Pathway
****************************************
**
**
RE STARTING
   INCLUDED Dubai_RRF.rou
RE FINISHED
**
****************************************
** AERMOD Meteorology Pathway
****************************************
**
**
ME STARTING
   SURFFILE Dubai_2015.SFC
   PROFFILE Dubai_2015.PFL
   SURFDATA 0 2015
```

```
   UAIRDATA 999 2015
   SITEDATA 999 2015
   PROFBASE 10.0 METERS
ME FINISHED
**
****************************************
** AERMOD Output Pathway
****************************************
**
**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 1 1ST
   RECTABLE 24 1ST
** 1-Hour Binary POSTFILE(s) for the Plume Animation
   POSTFILE 1 ALL UNFORM Dubai_RRF.AD\1HGALLUN_PA.POS 31
** Auto-Generated Plotfiles
   PLOTFILE 1 ALL 1ST Dubai_RRF.AD\01H1GALL.PLT 32
   PLOTFILE 24 ALL 1ST Dubai_RRF.AD\24H1GALL.PLT 33
   PLOTFILE ANNUAL ALL Dubai_RRF.AD\AN00GALL.PLT 34
   SUMMFILE Dubai_RRF.sum
OU FINISHED
**
****************************************
** Project Parameters
****************************************
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse Mercator
** DATUM    World Geodetic System 1984
** DTMRGN   Global Definition
** UNITS    m
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** ZONE   40

** ZONEINX 0

**

Appendix B - US OSHA standards for air contaminants exposure limits

Table B-1 shows the predicted maximum incremental concentrations compared to the US OSHA standards for air contaminants. It is evident that all predicted concentrations fall below the exposure limits.

Table B-1 Predicted maximum incremental concentrations for pollutants compared to US OSHA standards for air contaminants exposure limits

Pollutant	Maximum predicted incremental GLC (µg/m^3)	Limit (µg/m^3)	% of criteria
NO_2	295	9000 (exposure shall at no time exceed this value)	3%
SO_2	184	13000 (calculated as a 12-hour TWA, adjusted from an 8-hour TWA)	1%
CO	184	26700 (calculated as an 8-hour TWA)	1%
TSP	870	15000 (calculated as an 8-hour TWA)	6%
HCl	31	7000 (exposure shall at no time exceed this value)	0.4%
HF	2	2680 (calculated as an 8-hour TWA)	0.1%
NH_3	31	35000 (calculated as an 8-hour TWA)	0.1%
Hg	0.2	100 (exposure shall at no time exceed this value)	0.2%
Cd	0.2	25 (calculated as a 12-hour TWA, adjusted from an 8-hour TWA)	1%

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613558306-45638-69/https://projects.ghd.com/oc/WesternAustralia1/dubairrfairquality/Delivery/Documents/61355806-REP-8_Air Quality Assessment.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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Rev 3	G Formentin A Sala Tenna	J Forrest		J Forrest		14/06/2019
Rev 4	G Formentin A Sala Tenna	J Forrest		J Forrest		19/06/2019
Rev 5	G Formentin A Sala Tenna	A Sala Tenna		A Sala Tenna		1/10/2019
Rev 6	G Formentin	J Forrest		J Forrest		4/5/2020
Rev 7	G Formentin	J Forrest		J Forrest		11/5/2020
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Hitachi Zosen Inova, Besix and Itochu

Dubai Waste Management Center
Odour Assessment Report

December 2018

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Glossary and Acronyms

Acronym	Description
DEWA	Dubai Electrical and Water Authority
DM	Dubai Municipality
EPA	Environmental Protection Agency
H_2S	Hydrogen sulphide
MRF	Materials recovery facility
MSW	Municipal solid waste
OER	Odour Emission Rate (OER) is the product of the odour concentration (OU/m^3) and the volumetric flow rate of air (m^3/s) and is written as OU.m^3/s.
OU	Odour units (OU) are the units used to describe odour concentration. One OU corresponds to a concentration of odour in air that is just detectable by 50% of a population
NH_3	Ammonia
STP	Sewage treatment plant
tpd	Tonnes per day
UAE	United Arab Emirates
WMC	Waste Management Center

1. Introduction

Dubai Municipality (DM) (the Project Proponent) proposes the development of the Dubai Waste Management Center (WMC), a proposed Waste-to-Energy Plant, (Project) (Figure 1) at the existing Dubai Municipality (DM) owned and operated vehicle storage site in Warsan, Dubai.

The proposed WMC will treat in the order of 1,825,000 tonnes of municipal solid waste (MSW) per year, with a nominal design capacity of 5,000 tonnes per day (tpd)) to generate an estimated minimum power output of 171 Megawatts of electricity to power about 120,000 homes.

Under contract with the Project Proponent, Hitachi Zosen Inova (HZI), a global leader in Energy-from-Waste technology, NV Besix SA, Sharjah branch (BESIX), a Belgian construction company, and Itochu, a Japanese company formed a partnership to build, operate and transfer the WMC over a 30-year period. The contract is shared between a Special Project Vehicle and Engineering, Procurement and Construction partnership.

HZI commissioned GHD Global Pty Ltd (GHD) as the Project environmental consultant to undertake the Environmental Impact Assessment and prepare documentation to support applications for environmental clearance for the proposed Project. The application for environmental clearance is made to the Dubai Municipality-Environmental Department in accordance with Technical Guidelines 1 (Environmental Impact Assessment) and 2 (EIA for Land Development, Infrastructure and Utility Projects) (August 2018).

1.1 Purpose of report

The purpose of this report is to carry out an odour assessment to satisfy requirements as per the letter of *Conditional Approval of the Revised Environmental Impact Assessment Scope of Work* (Reference No. 812/02/02/1/1810704), received from the Dubai Municipality Environmental Department dated 8 August 2018.

1.2 Scope of work

The scope of works includes:

- Develop an emissions inventory for the WMC
- Undertake odour modelling for one modelling scenario for operation of the WMC to determine the potential impacts to nearby sensitive receptors
- Compare predicted odour levels to those of relevant nearby odour sources

1.3 Approach

The adopted approach is as follows:

- Description of Project site and facility operation (Section 2)
- Description of assessment criterion and odour assessment for nearby odour sources (Section 3)
- Develop inventory of odour emission rates for the WMC (Section 4)
- Description of meteorology (Section 5)
- Description of odour dispersion modelling (Section 6)
- Dispersion modelling results (Section 7)

- Recommended mitigation measures (Section 8)
- Conclusions drawn (Section 9)

1.4 Limitations

This report: has been prepared by GHD for HZI, Besix and Itochu – AG Abu Dhabi (HZI), N.V. Besix S.A. Sharjah Branch (Besix) and Itochu Corporation (Itochu) and may only be used and relied on by HZI, Besix and Itochu for the purpose agreed between GHD and the HZI, Besix and Itochu as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than HZI, Besix and Itochu arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 2.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by HZI, Besix and Itochu and others (e.g. Fichtner) who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work.

GHD does not accept liability in connection with such unverified information, including errors and omissions in the report, which were caused by errors, or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

1.5 Assumptions

This assessment assumes the following:

- All information provided by Hitachi Zosen Inova Ltd to GHD, including WMC operations and Project site layout is correct
- All parameters used in the model are based on best estimates using information provided by Hitachi Zosen Inova Ltd and other relevant data
- The meteorological data used in this assessment is representative of the meteorology at the Project site

2. Site description

2.1 Site location

The Project site is located approximately 17 km east of Bur Dubai and 10 km south-east of the Dubai International Airport. It is estimated that the facility will cover an area of approximately 651,700 m^2. Figure 2-1 shows the location of the WMC in the Emirate of Dubai within the United Arab Emirates (UAE).

Figure 2-1 Project location

2.2 Facility description

Generally, all WMCs consist of a combustion process, boiler system, steam turbine and flue gas treatment system. A typical concept diagram, for the Dubai WMC is shown in Figure 2-2.

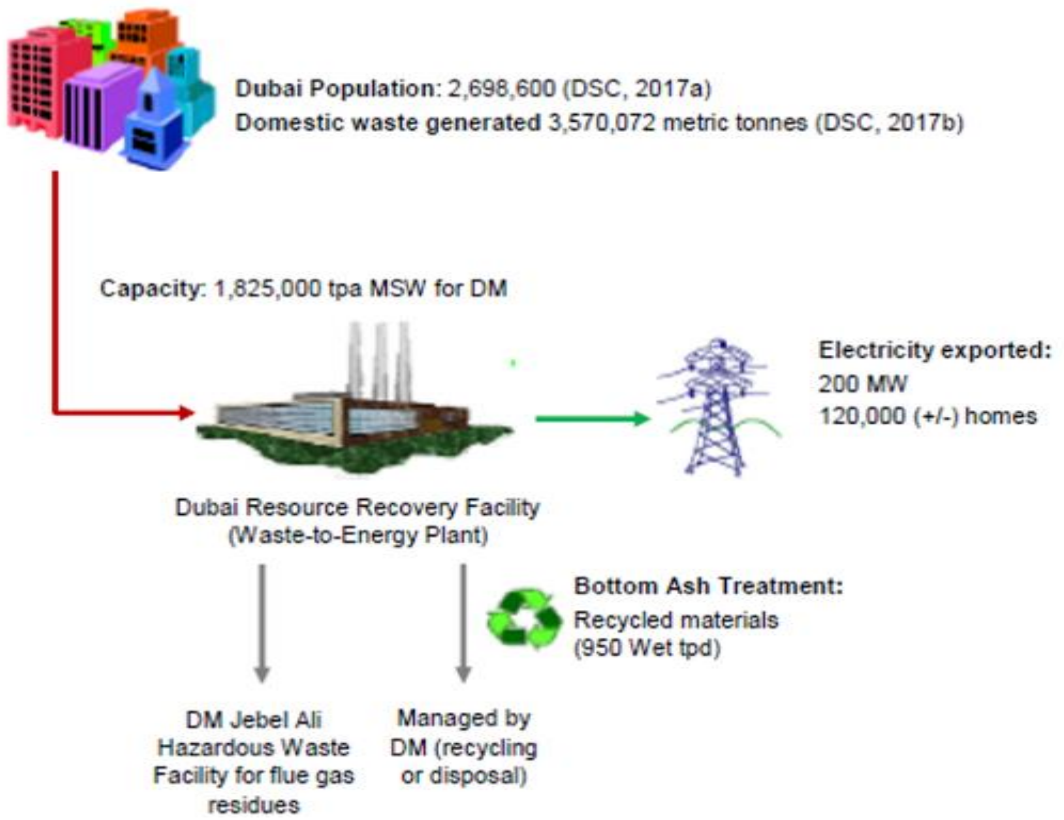


Figure 2-2 Concept diagram

2.2.1 Key components

Delivery of MSW from DM will occur via approximately 43 waste truck deliveries per hour on average, and approximately 129 waste truck deliveries per hour during peak periods (Hitachi Zosen Inova AG 2018).

The Dubai WMC will contain the following major components:

- Site access (access roads, carparks, fire detection equipment)
- Landscaping and security
- Entrances, weighbridges
- Waste bunkers (accessible by 27 roller doors), open tipping bay area, waste cranes
- Combustion system and boiler area
- Flue gas treatment area
- Turbine unit, generator and associated equipment
- Water treatment system
- Emission stacks
- Bottom ash handling facilities
- Residue storage silo
- Auxiliary systems
- Fuel and storage tanks
- Maintenance/ warehouse area and cranes
- Electrical systems and back-up power

- Miscellaneous process equipment
- Weather station
- Administration buildings

2.2.2 Operating hours

The WMC will operate on a 24-hour per day, 7-day per week schedule, with four shifts anticipated, and each shift to be an estimated 12 hours.

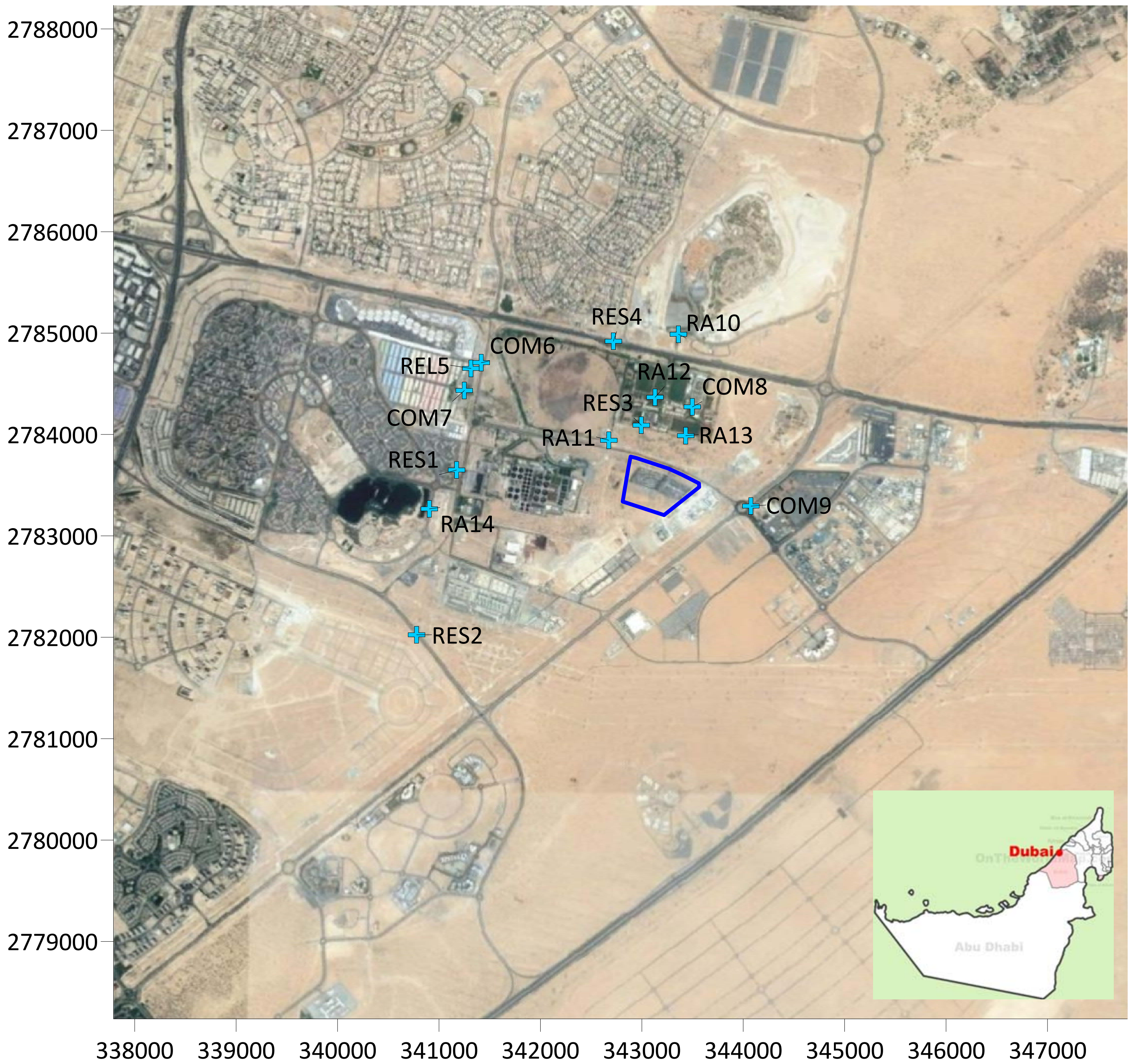
2.3 Surrounding land use and sensitive receivers

The Project is located on the waste landfill site in Warsan, Dubai, specifically Warsan 2 and the facility will be situated east of the Al Aweer Sewage Treatment Plant. The areas immediately surrounding the Project site consist of industrial facilities including the DEWA and the Dubai Police Transport Impounding Area. To the north of the Project site exists several residential and attraction areas including the Desert Palm Polo Club and Hotel and Dubai Safari Park. Residential and commercial areas are situated further north, south and west of the project site.

A number of sensitive receptors have been identified within proximity to the Project site, as presented in Table 2-1 and Figure 2-3.

Table 2-1 Sensitive receptors

ID	Description	Location (m UTM)	Distance from site (km)	Elevation (m ASL)
RES1	Dubai International City-EMR 14, Emirates Cluster	341174 E 2783650 N	1.4	29
RES2	International City Phase II (under construction)	340779 E 2782024 N	1.3	30
RES3	Residential Vilas (Desert Palm)	342995 E 2784091 N	0.3	43
RES4	AL Warqa 4 (north of Al Awir Road)	342720 E 2784920 N	1.1	28
REL5	Dragon Mart Mosque	341316 E 2784651 N	1.6	24
COM6	Dragon Mart Commercial Centre	341417 E 2784708 N	1.6	21
COM7	Dubai Textile City	341250 E 2784434 N	1.6	22
COM8	Desert Palm Resort and Hotel	343498 E 2784272 N	0.6	47
COM9	Dubai Nursery	344076 E 2783294 N	0.6	47
RA10	Dubai Safari Park (north of Al Awir Road)	343361 E 2784988 N	1.3	26
RA11	Pivot Fields	342675 E 2783943 N	0.15	42
RA12	Desert Palm Polo Club	343130 E 2784366 N	0.6	43
RA13	Desert Palm Riding Schools	343433 E 2783988 N	0.3	40
RA14	Warsan Lake	340905 E 2783266 N	1.4	30



SCALE

0 500 1000 1500 2000

Kilometres (at A4)

LEGEND

Sensitive receptor

Project site perimeter

MAP PROJECTION:
Transverse Mercator

HORIZONTAL DATUM:
World Geodetic System 84 (WGS)
Zone 40 R

GRID:
SRTM1 Global (~30 m)- Version 3

DATA SOURCE:
GoogleEarth

CLIENTS | PEOPLE | PERFORMANCE

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FIGURE 2-3

Sensitive receptors

DRAWING NO.	REVISION	DATE
Fig 2-3.srf	A	23.10.2018

CREATED	CHECKER	APPROVER	FILE PATH
GF	JF	JF	\\ghdnet\ghd\A\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\Odour\4. WP\Figures\Surfer

2.4 Baseline odour sampling

Baseline odour monitoring was conducted by Al Futtaim Element Materials Technology (Al Futtaim Element Technology 2018) at four locations at the Project site (Figure 2-4). This section presents the results from the baseline odour monitoring to provide context for the predicted odour modelling results.

Odour monitoring was carried out for a period of eight hours at each monitoring location. The following species were monitored:

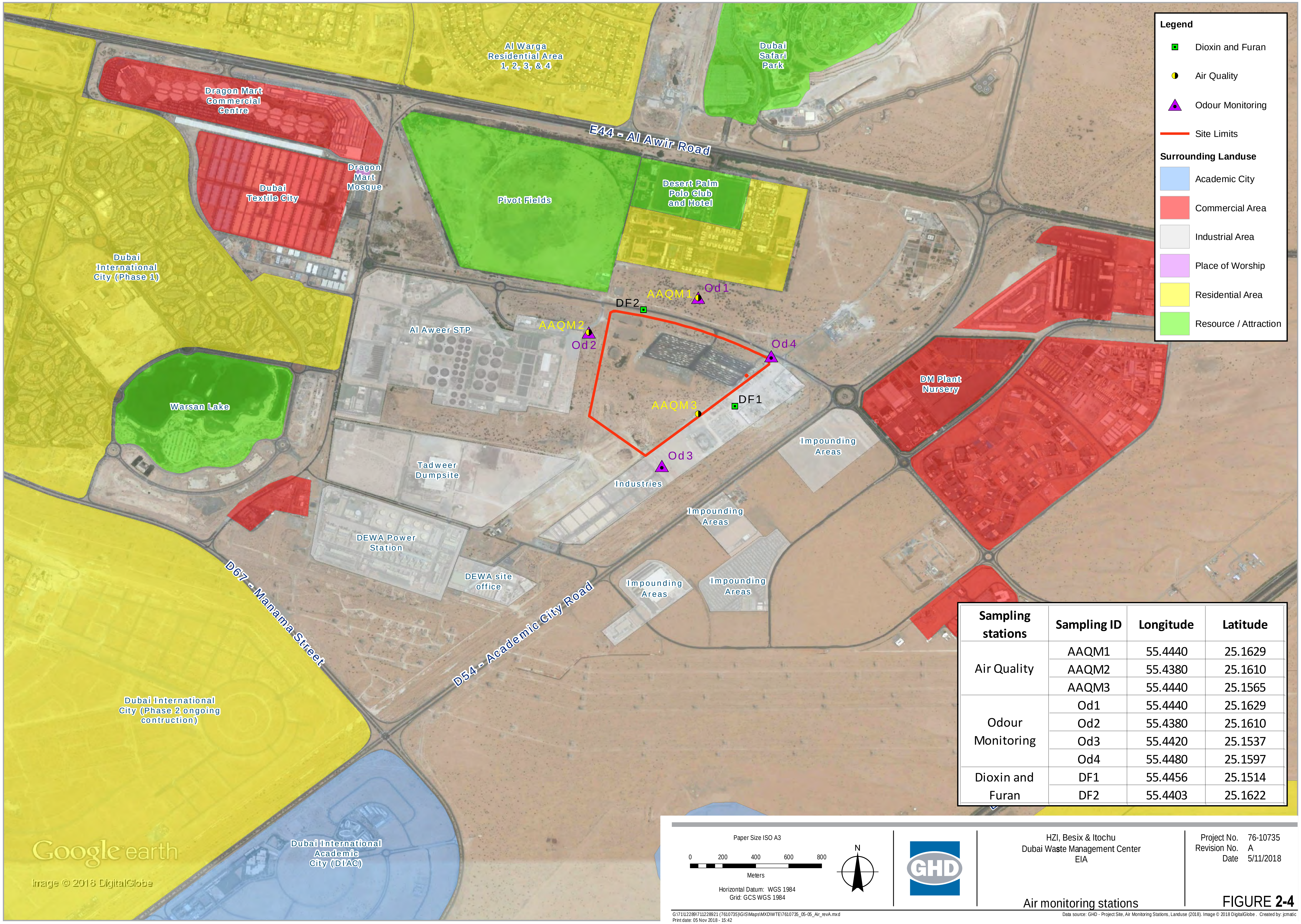
- Hydrogen sulphide (H_2S)
- Ammonia (NH_3)
- Mercaptans
- Dimethyl disulphide
- Dimethyl sulphide

Results for the monitoring are shown in Table 2-2. Prevailing meteorological conditions at Dubai International Airport on the day of sampling are also included in Table 2-2.

It can be seen that concentrations of H_2S are highest at N2, which is west of the proposed WMC site and east of the Al Aweer Sewage Treatment Plant (STP). On this occasion, wind was blowing west dispersing H_2S from the STP in the direction of the monitor.

Concentrations of NH_3 were only high enough to be detected by the equipment at one monitoring location. This was at N3, situated south of the proposed WMC and east of the STP. On this occasion, winds were blowing from a north westerly direction carrying NH_3 from the STP.

Concentrations of dimethyl disulphide and dimethyl sulphide were not high enough to be detected by the equipment at any monitoring location throughout the monitoring period.



Sampling stations	Sampling ID	Longitude	Latitude
Air Quality	AAQM1	55.4440	25.1629
	AAQM2	55.4380	25.1610
	AAQM3	55.4440	25.1565
Odour Monitoring	Od1	55.4440	25.1629
	Od2	55.4380	25.1610
	Od3	55.4420	25.1537
	Od4	55.4480	25.1597
Dioxin and Furan	DF1	55.4456	25.1514
	DF2	55.4403	25.1622

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Dubai Waste Management Center
EIA

Air monitoring stations

Project No. 76-10735
Revision No. A
Date 5/11/2018

FIGURE **2-4**

G:\71\12289\711228921 (7610735)\GIS\Maps\MXD\WTE\7610735_05-05_Air_revA.mxd
Print date: 05 Nov 2018 - 15:42

Data source: GHD - Project Site, Air Monitoring Stations, Landuse (2018). Image © 2018 DigitalGlobe . Created by: jcmatic

Table 2-2 Baseline odour monitoring results

Location	Latitude, longitude	Date/time	Wind direction (° from north)	Wind strength (km/hr)	Temperature (° C)	Humidity (%)	H_2S	NH_3	Mercaptans	Dimethyl disulphide	Dimethyl sulphide
			Measurements taken at 12 pm				(µg/m^3)				
Al Warsan Od1	25.1629, 55.4444	15/10/2018 08:15 – 16:15	West	23	35	47	6	<1	<10	<5	<5
Al Warsan Od2	25.1610, 55.4384	15/10/2018 08:30 – 16:30	West	23	35	47	20	<1	<10	<5	<5
Al Warsan Od3	25.1537, 55.4419	16/10/2018 08:00 – 16:00	North-west	17	33	57	11	3	<10	<5	<5
Al Warsan Od4	25.1597, 55.4479	16/10/2018 08:20 – 16:20	North-west	17	33	57	<5	<1	<10	<5	<5

Note: < denotes the results is less than the laboratory limit of detection

3. Assessment criteria

3.1 *The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Environmental Protection Agency; EPA)

There are no odour criteria for the UAE. As an alternative, odour criteria from Environmental Protection Agency was used for this assessment, *The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (EPA, 2016) list the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in New South Wales, Australia. The assessment criteria for odour is applied to the defined sensitive receptors in Section 2.3.

Odour impact is subjective and can be described using the following factors, called the FIDOL factors:

- **F**requency of exposure
- **I**ntensity of odour
- **D**uration of odour episodes
- **O**ffensiveness of odour
- **L**ocation of odour source

The odour assessment criteria is defined to take account of two of these factors (**F** is set at the 99th percentile; **I** is set from 2 to 7 OU). The choice of assessment criteria is also dependent on the population of the affected area as shown in

Table 3-1 Odour assessment criterion

Population of affected community	Odour performance criteria (nose response odour certainty units at 99th percentile)
Single residence (≤~2)	7
~10	6
~30	5
~125	4
~500	3
Urban (≥~2,000)	2

The criteria assumes that 7 OU at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be encountered. The criteria of 2 OU at the 99th percentile is considered to be acceptable for large populations (more than 2000 people).

The criteria have also been specified at an averaging time of 1 second. The choice of the short averaging time recognises that the human nose has a response time of less than 1 second, so that modelling of odour impact should allow for the short-term concentration fluctuations in an odour plume due to turbulence.

For urban areas located adjacent to the WMC, the 2 OU criteria would be applicable and is adopted for this assessment.

3.2 Reference to nearby odour sources

To gauge the level of odour the WMC is predicted to contribute to the local environment, odour concentrations from this assessment will also be compared to predicted odour concentrations from nearby odour sources.

3.2.1 Hyder Environmental Performance Audit report

Odour impact from the Al Aweer STP was assessed by Hyder in an Environmental Performance Audit Report for the Dubai Municipality in 2017 (Hyder 2017). The report predicted odour concentrations at Al Aweer STP, Tadweer Materials Recovery Facility (MRF), Al Aweer Landfill and Al Serkal/Envirol Grease Trap Waste Recycling Plant. These odour sources are situated within 1.5 km of the proposed WMC, the locations of which are shown in Figure 3-1. The predicted odour contour plots are shown in Figure 3-2.

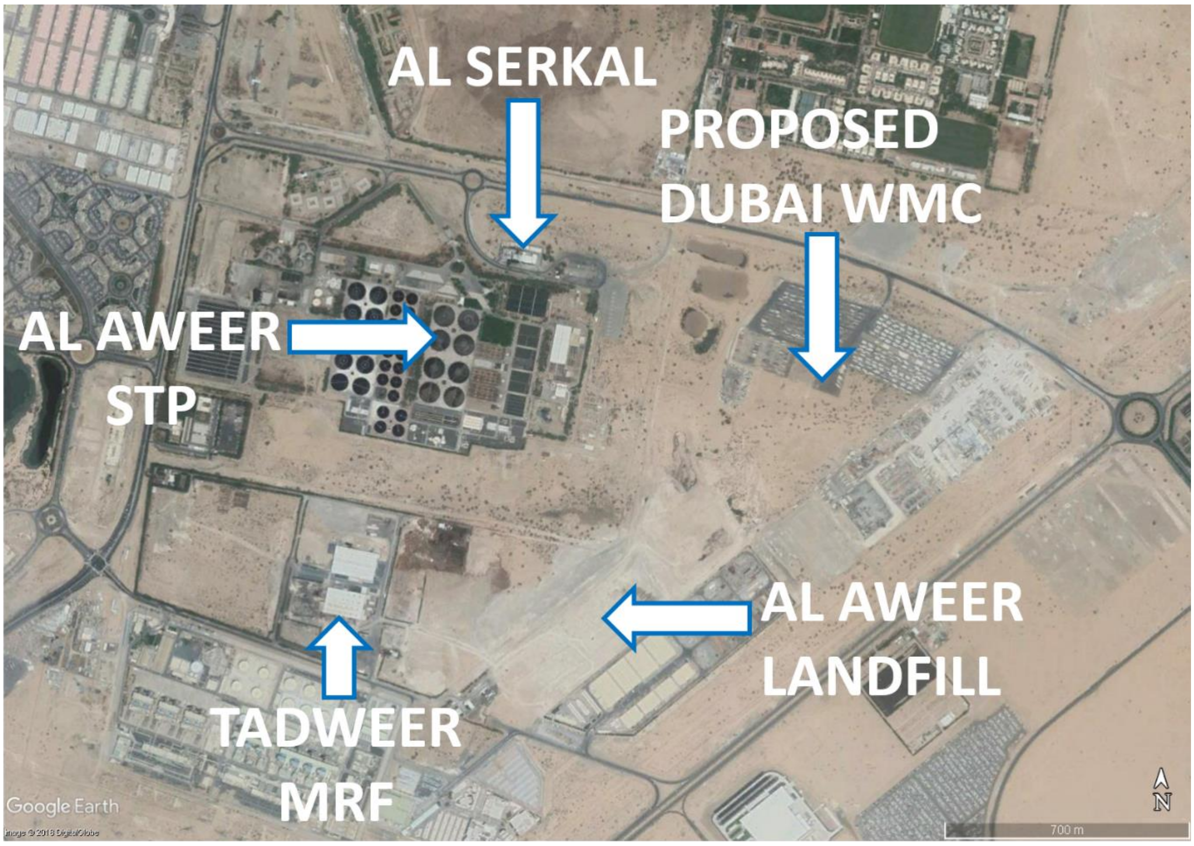


Figure 3-1 Nearby odour sources

Figure 3-2 shows that odour concentrations at the STP reach up to 45 OU/m^3 immediately surrounding the source, and extends to sensitive receptors Dubai International City, Dubai Textile City.

At the remaining three sources, odour concentrations range between 10 OU/m^3 and 5 OU/m^3, with concentrations not dispersing as far as any defined sensitive receptors.

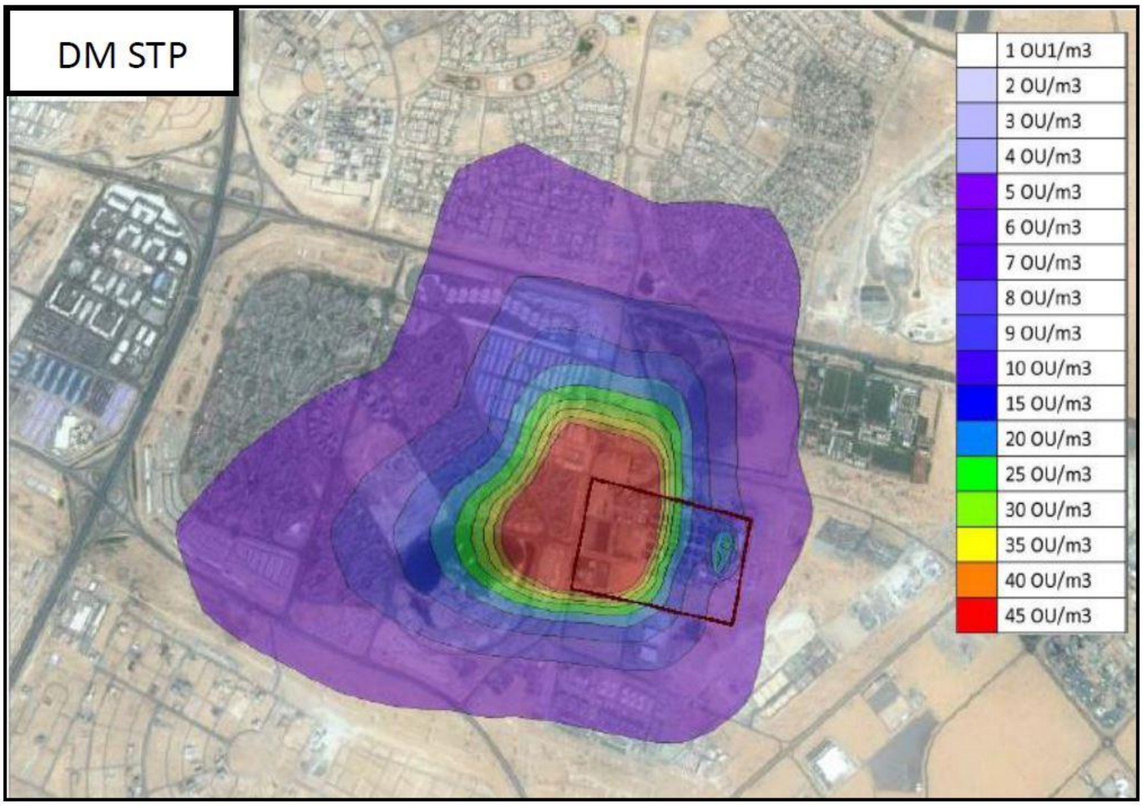


Figure 3-2 Predicted 1-hour, 99th percentile odour concentration plot for Al Aweer STP

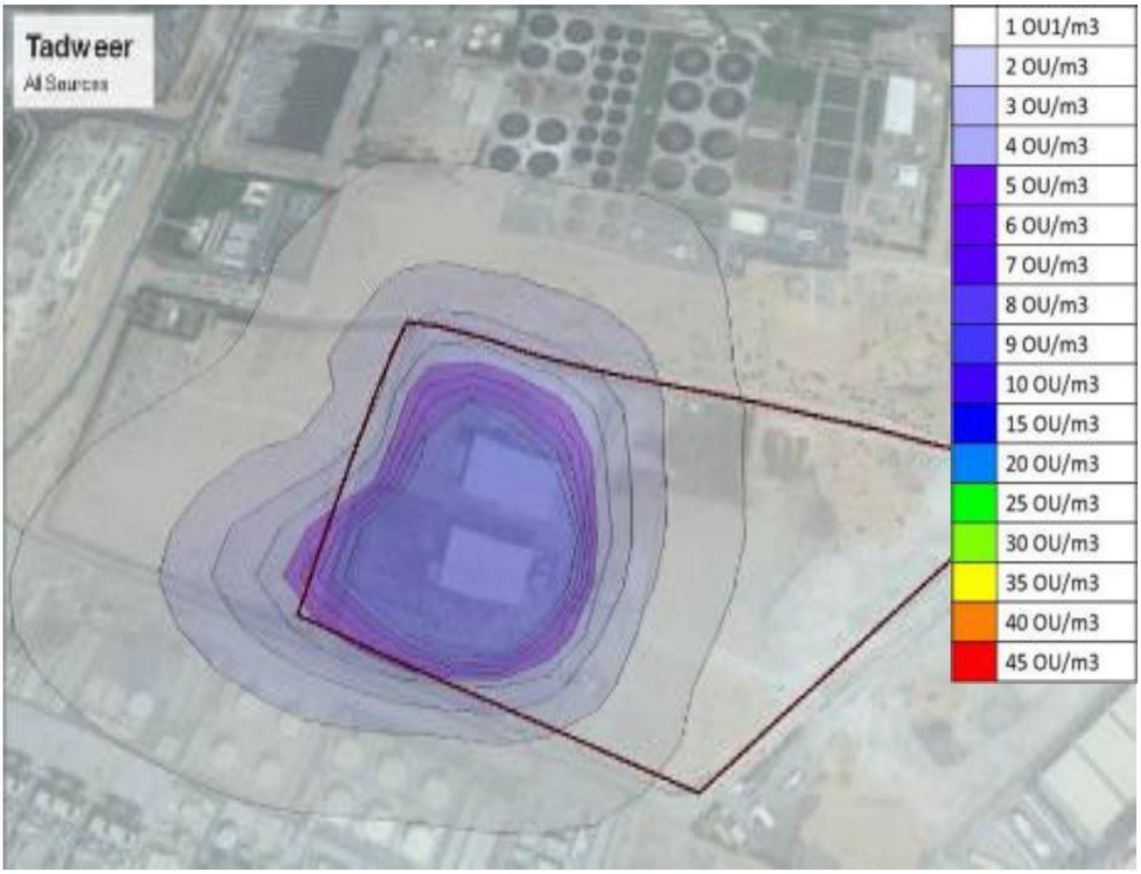


Figure 3-3 Predicted 1-hour, 99th percentile odour concentration plot for Tadweer MRF

Figure 3-4 Predicted 1-hour, 99th percentile odour concentration plot for Al Aweer Landfill

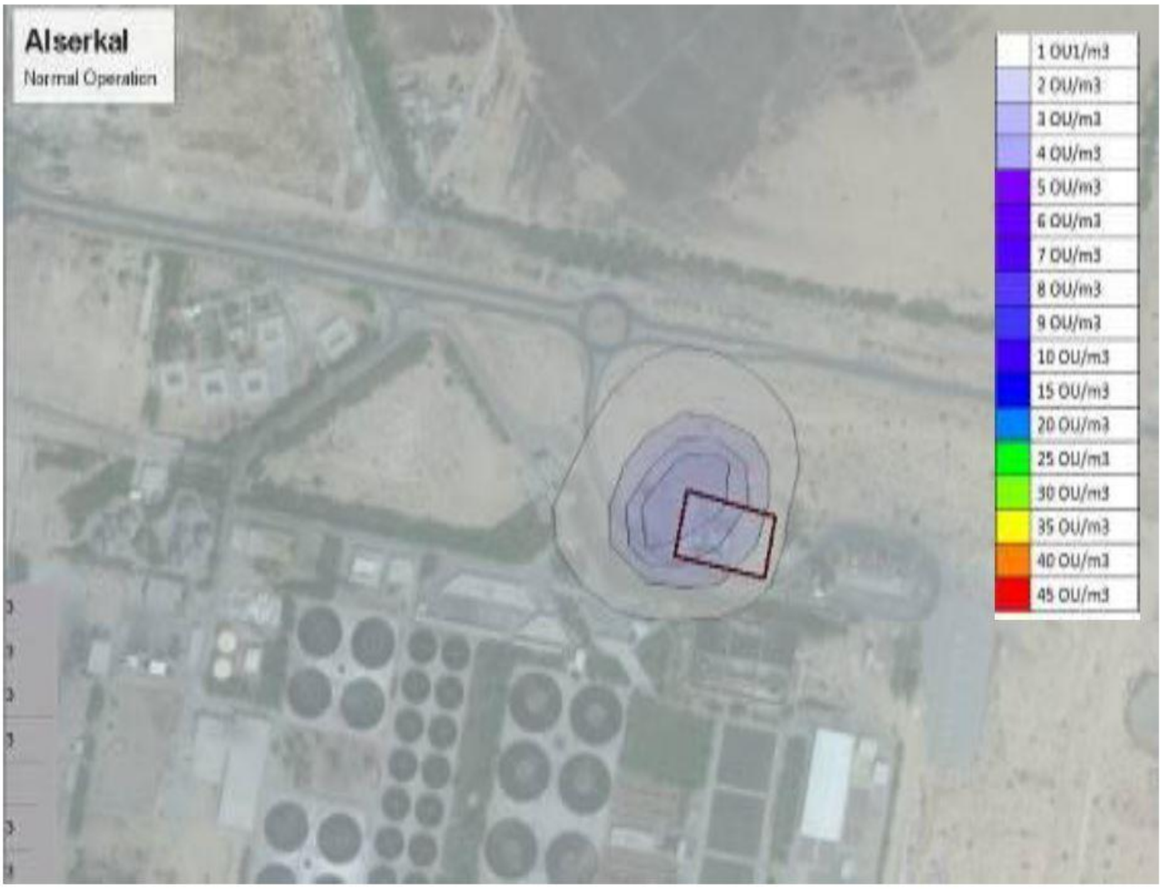


Figure 3-5 Predicted 1-hour, 99th percentile odour concentration plot for Al Serkal Waste Recycling Plant

3.2.2 Tadweer Waste Treatment LLC

Odour modelling was carried out at the Tadweer Waste Treatment LLC and the 1-hour 98th percentile odour concentration was predicted. Model results showed that the Tadweer Waste Treatment LLC emitted odour concentrations of 5 OU at the perimeter boundary of the facility. The contour figure for the assessment are shown in Figure 3-6.

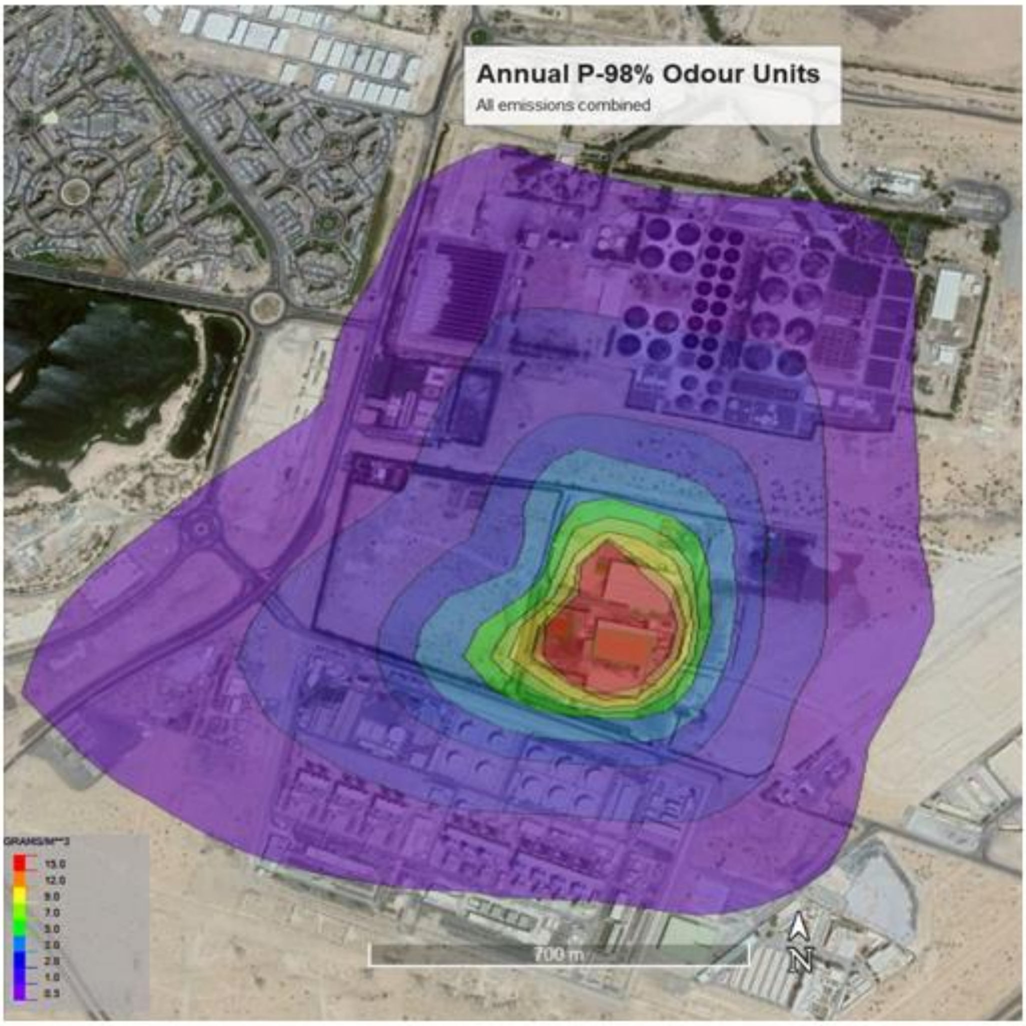


Figure 3-6 Predicted 98th percentile 1-hour average ground level odour concentrations

4. Estimated emissions

4.1 Odour sources

The main source of odour in the WMC is the MSW stored in the waste bunker. The odour results from the waste composition and the aging process of the waste. The waste bunker is split into two sections, one of which serves two of the incineration lines, and the other serves the remaining three incineration lines. The waste bunker is located within the main building as shown in Figure 4-1.

The waste bunker is accessed by 27 tipping bays, each of which have a roller door which remain open only during the presence of a waste delivery truck (for approximately 6 minutes per delivery). 43 waste truck deliveries are anticipated every hour.

The waste bunker is expected to manage a nominal throughput of 231.48 t/hour. It is designed with a four day capacity of waste under nominal operating conditions equating to a storage capacity of 22,219 tonnes (Hitachi Zosen Inova AG 2018).

The waste bunker dimensions were taken from Hitachi Zosen Inova (2018) to be a total of 33 m in height, 23 m depth and 143 m in width. Therefore, the total volume of the bunker is 108,537 m^3.

For the purpose of this assessment, when the tipping bay doors are closed, the fugitive odour emissions from the waste bunker are considered negligible. Similarly, as the trucks are enclosed, any odorous emissions from trucks are assumed negligible. No odour emissions are expected from the stacks as the odorous compounds would have undergone chemical decomposition during incineration.

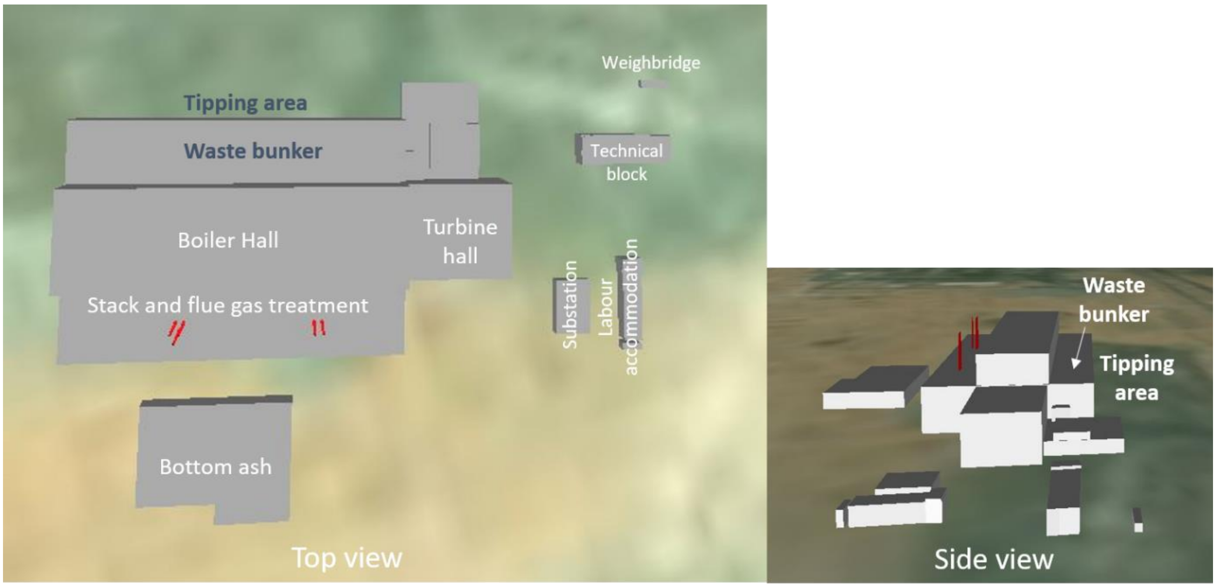


Figure 4-1 Waste bunker and tipping area locations

4.2 Upset conditions

During normal operating procedure, air in the waste bunker is sucked into the boiler for combustion and is replaced by fresh air. This flow of air provides a sufficient negative pressure in the waste bunker, preventing the majority of odour from escaping. A minimum of two of the five incineration lines will be in operation at any one time in order to maintain the slight negative pressure and prevent the release of odorous gas.

This assessment was carried out for three operating scenarios, one of which represents nominal operating conditions and two of which represent upset conditions to simulate worst case for odour dispersion. The worst case conditions used in the model consist of:

- Temporary loss of negative pressure in the waste bunker due to shutdown of all five incineration lines
- The delivery of MSW as normal (43 truck deliveries per hour)

4.3 Adopted OER inventory

In order to best estimate the odour emissions from the facility during a loss of negative pressure, the model was set up with regard to the number of tipping bay doors, tipping bay door dimensions and the duration the doors are open. It was estimated that during nominal operation, four tipping bay doors would remain open continuously each hour. Therefore, the source was configured to represent the equivalent of having four tipping bay doors open. It was assumed that the area of each roller door would be 4.4 m in width and 9 m in height, resulting in an area of 39.6 m^2.

4.3.1 Flow rate

Flow rate accounts for the volumes of air that escape the tipping bay when the doors are open. Several flow rates were used for sensitivity testing of the model reflecting negative pressure maintained and negative pressure lost. Flow rates used were 0.1 m/s (negative pressure maintained), 0.6 m/s (based on two air exchanges per hour when negative pressure is lost) and 1.2 m/s (worst case scenario based on four air exchanges per hour when negative pressure is lost).

4.3.2 Peak to mean ratio

The Gaussian Plume model used in this assessment for the dispersion modelling of odour can only predict odour concentrations over an averaging period of 3-minutes or more. However, as discussed in Section 3.1, the human response time to odour is approximately 1 second. During a 3-minute period, odour levels can fluctuate significantly.

The peak to mean ratio is the ratio between the one second peak concentrations and three minute and longer average period concentrations.

Katestone Scientific Pty Ltd (1995, 1998) were commissioned by the EPA to determine a suitable peak to mean ratio for a Gaussian Plume model and this ratio was adopted for this assessment. The peak to mean ratio used was 2.3.

4.3.3 OER

As no site specific OERs were available for the Project as it was still in the approvals phase, the OER was adopted from PEL 2015, which is considered to be representative of odour emission rates at the WMC. The odour concentration adopted from PEL 2015 was supported by an article by Loghurst (2007), exploring the principle of landfill odour emission.

The OER for the WMC was estimated using the following equations:

$$OER = (Odour\ conc \times area) flow\ rate \times PMR$$

$$Modelled\ OER\ for\ volume\ source = OER \times n_{open\ tipping\ bay\ doors}$$

Where:

Odour concentration	558 OU
Area	39.6 m^2
Flow rate	0.1 m/s, 0.6 m/s, or 1.2 m/s
PMR	2.3
$n_{open\ tipping\ bay\ doors}$	4

The modelled OERs are presented in Table 4-1.

Table 4-1 Modelled odour emission rates for each scenario

Flow rate (m/s)	Modelled OER (OU.m^2/s)
0.1 (nominal conditions)	20,328
0.6 (upset conditions)	121,974
1.2 (upset conditions – worst case)	243,948

5. Meteorological data

5.1 Climate and meteorology of the UAE

The climate of the UAE can be described as a subtropical dry, hot desert climate with low annual rainfall and high annual temperatures becoming very high in summer. There is a large difference between maximum and minimum temperatures, especially in the inland areas. The coastal areas are slightly influenced by the waters of the Arabian Gulf, having higher humidity and lower maximum but higher average temperatures.

The extended summer is very hot with long periods of negligible levels of rainfall. Daily maximum temperatures easily reach 40°C or more. UAE winter is cooler with occasional rainfall, while spring and autumn/fall are again very warm and mostly dry with maximum temperatures between 25 ◦C and 35 ◦C and cooler night time temperatures between 15 ◦C and 22 ◦C.

5.2 Representative meteorological year

A representative model year was determined for this assessment. The objective was to avoid extra dry or wet periods, which indicates usual cloudiness, influencing the surface energy balance. Using an unrepresentative year would increase the uncertainty of the modelled results.

Meteorological data from the Dubai International Airport was used for this assessment as the weather station is situated relatively close to the Project site (approximately 13 km north east) and is considered representative of the Project site. The location of Dubai International Airport is shown in Figure 5-1.

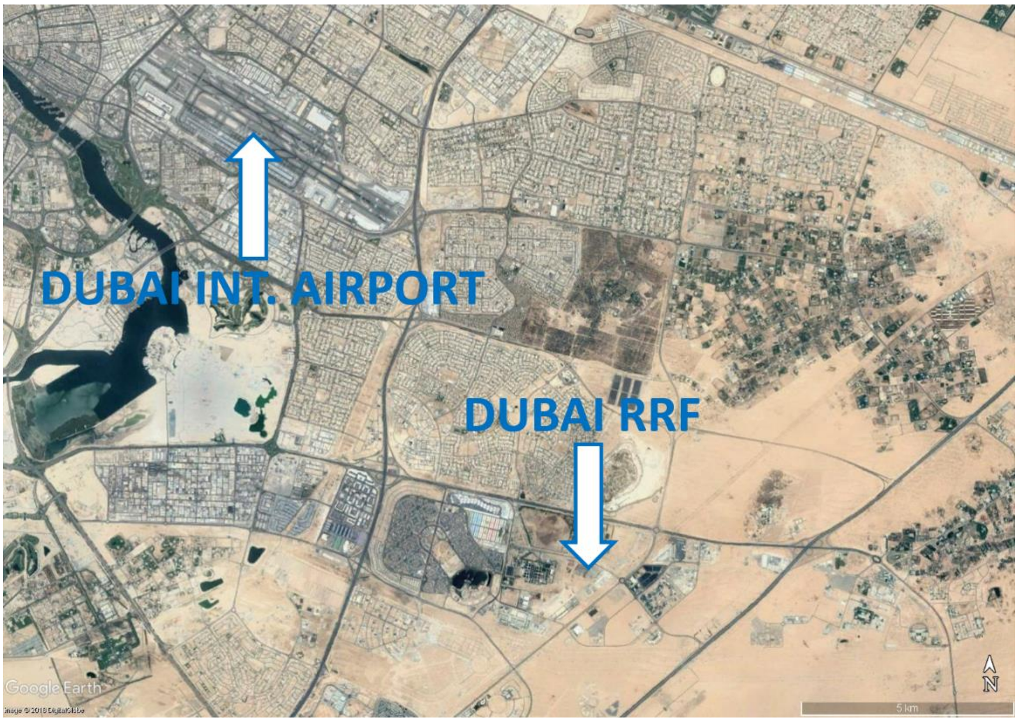


Figure 5-1 Dubai International Airport

Figure 5-2 shows the daily temperatures recorded at Dubai International Airport near the Project site in 2015. From Figure 5-2 it is shown the 2015 year resembles average long-term temperatures observed in the Emirate of Dubai. In summer, maximum temperatures exceed 40 ºC and spring maximum temperatures falling between 25 ºC and 35 ºC.

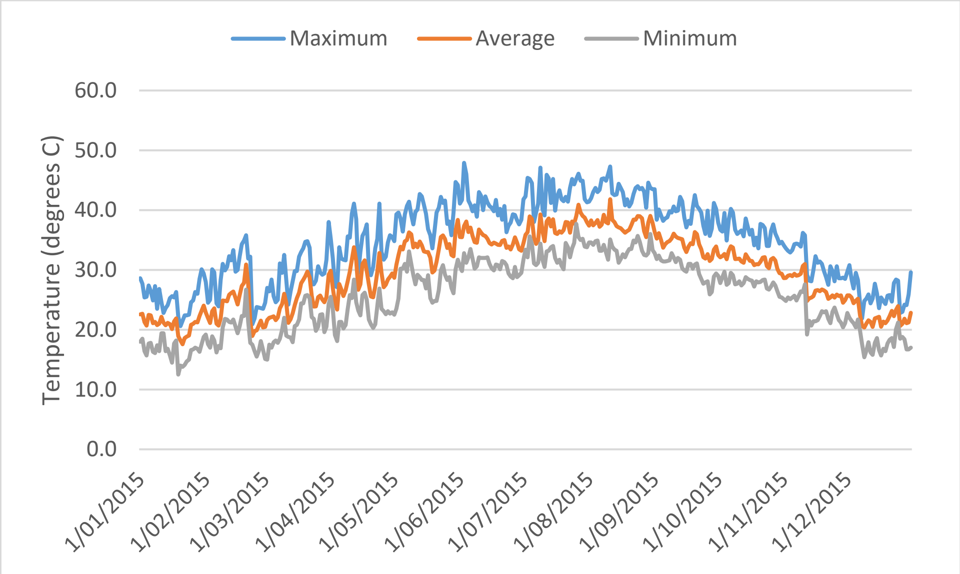


Figure 5-2 Daily temperatures recorded at Dubai Airport for 2015 (National Centre of Meteorology 2018)

Winds are variable throughout the year and average 3 to 4 m/s. The wind speed and wind direction data for 2015 for Dubai International Airport are displayed in Figure 5-3 and Figure 5-4 which are considered representative of annual wind trends in Dubai.

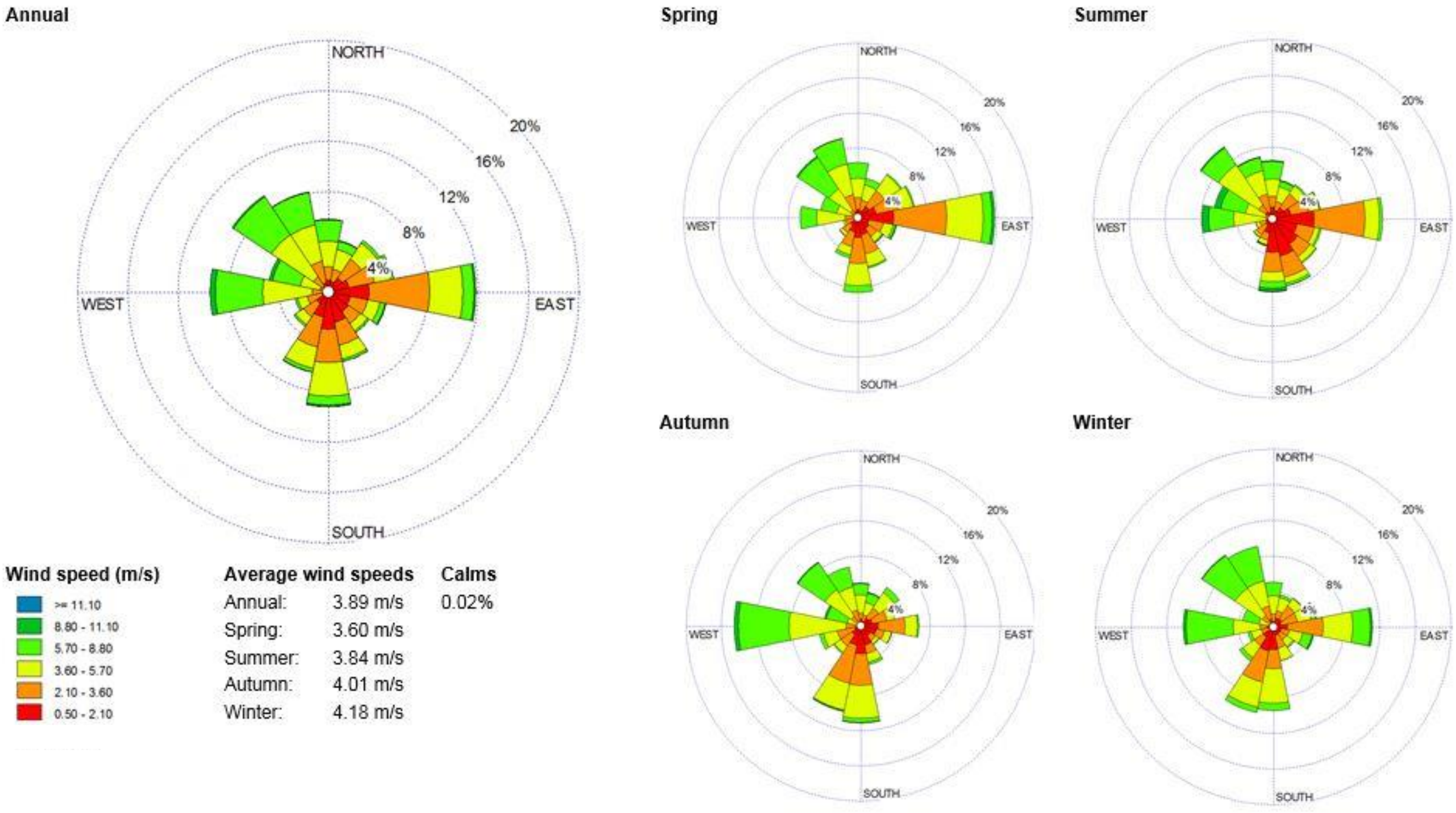


Figure 5-3 Annual and seasonal wind roses for Dubai International Airport 2015

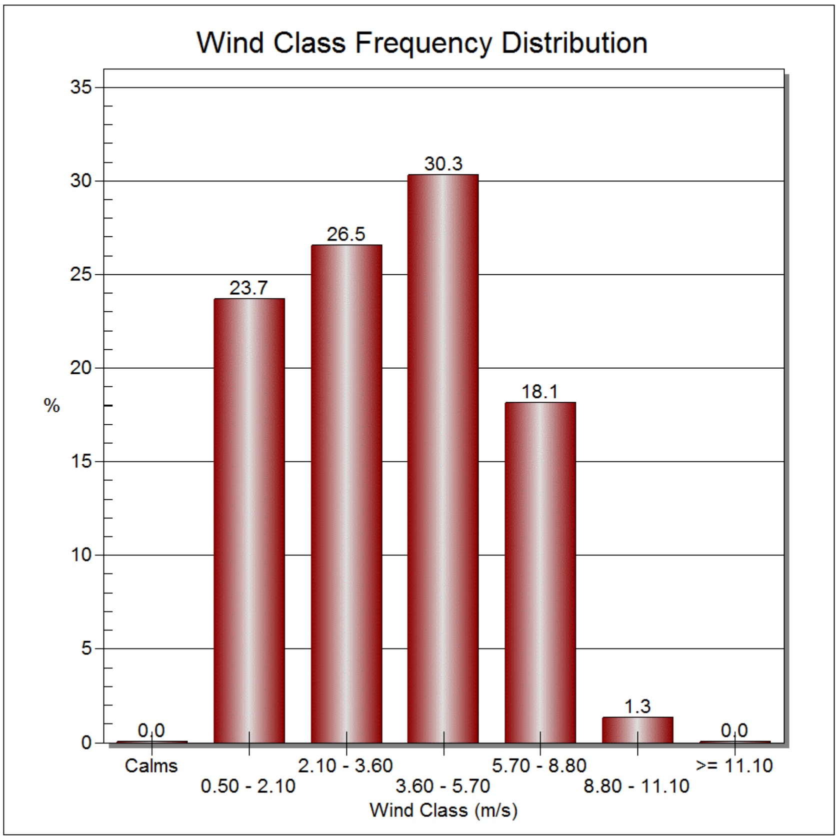


Figure 5-4 2015 annual wind class frequency distribution for Dubai International Airport

6. Approach to odour modelling

6.1 AERMET

AERMET is the meteorological pre-processor to AERMOD, which uses measured (or modelled) meteorological observations to generate two meteorological input files required by AERMOD. These two files consist of a surface file and an upper air file, which are used by AERMOD to characterise boundary layer characteristics which influences dispersion in the atmosphere.

Using monitored data from Dubai International Airport, the following parameters were input into AERMET, for the period 1 January 2015 to 31 December 2015:

- Year
- Month
- Day
- Hour
- Wind speed (m/s converted from knots)
- Wind direction (º True North)
- Temperature (º Celsius)
- Cloud cover (in tenths converted from OKTAS)
- Ceiling height (in km*10 converted from 1000 feet)

6.2 Dispersion modelling

The USEPA preferred model – AERMOD is chosen for this assessment based on relatively short distance between emission source and sensitive receptors. AERMOD is a steady-state Gaussian Plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources and both simple and complex terrain.

The odour source was modelled as a volume source in AERMOD, with the size of the source representative of 4 tipping bay doors open at any one time. The volume source parameters used in the model are displayed in Table 6-1.

Table 6-1 Volume source parameters used in model

Source coordinates	343091.26 m N 2783498.58 m E
Base elevation	34.73 m
Release height	4.5 m (taken as half the roller door height)
Length of side of source	17.6 m (to reflect 4 doors x 4.4 m width)
Initial lateral dimension	4.093 m (calculated by AERMOD)
Initial vertical dimension	15.35 m (calculated by AERMOD)

6.2.1 Building wake effects

Building geometry of the WMC was incorporated into the model to include the influences of building wake effects on odour dispersion. Building downwash algorithms were applied using the US EPA/BPIP geometry scheme to inform the PRIME building wake algorithm. The model was established to include the wake effects of the plants major structures. The set-up is for these structures, including the source locations are shown in Figure 6-1.

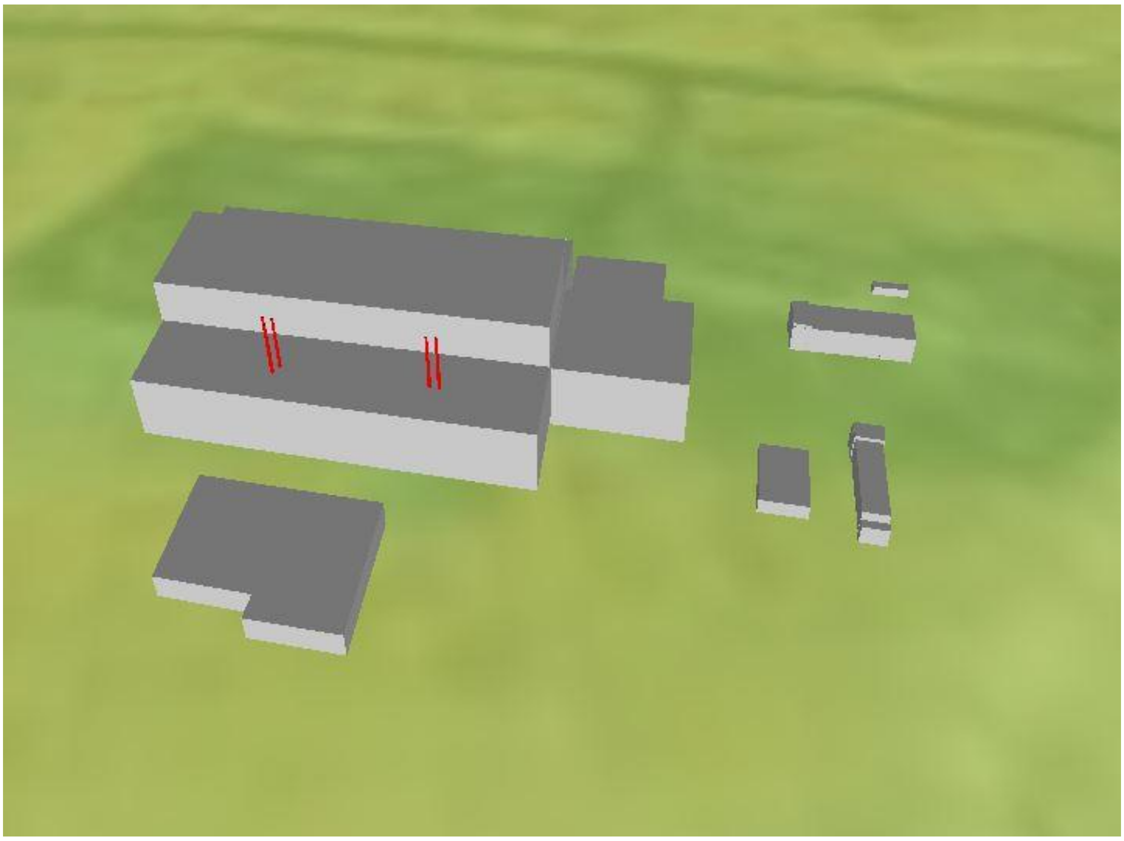


Figure 6-1 Significant buildings included in the model

7. Assessment of impacts

7.1 Incremental impact

This section presents quantitative assessments of the potential odour impacts on nearby receptors from the operation of the WMC. This assessment has been undertaken based on proposed operating procedures, to simulate worst case conditions, as detailed in Section 4.2.

Based on dispersion modelling results, the predicted operational odour impacts on nearby receptors is presented numerically in Table 7-1 and graphically as contours in Figure 7-1 to 7.3.

Table 7-1 Predicted 1-hour 99th percentile peak odour concentration

Receptor	Predicted odour concentration (OU)		
	Flow rate 0.1 m/s (negative pressure maintained)	Flow rate 0.6 m/s (negative pressure lost)	Flow rate 1.2 m/s (negative pressure lost)
Dubai International City-EMR 14, Emirates Cluster	0.11	0.6	1.3
International City Phase II (under construction)	0.06	0.4	0.7
Residential Vilas (Desert Palm)	0.93	5.6	11.1
AL Warqa 4 (north of Al Awir Road)	0.27	1.6	3.2
Dragon Mart Mosque	0.11	0.7	1.3
Dragon Mart Commercial Centre	0.10	0.6	1.2
Dubai Textile City	0.10	0.6	1.2
Desert Palm Resort and Hotel	0.58	3.5	7.0
Dubai Nursery	0.08	0.5	0.9
Dubai Safari Park (north of Al Awir Road)	0.22	1.3	2.6
Pivot Fields	0.85	5.1	10.1
Desert Palm Polo Club	0.54	3.2	6.5
Desert Palm Riding Schools	0.73	4.4	8.8
Warsan Lake	0.08	0.5	1.0

Review of Table 7-1 indicates that with the negative pressure maintained, predicted odour concentrations at the defined sensitive receptors are lower than 1 OU. It is likely that with negative pressure maintained odour from the WMC will not be detectable by the majority of the population. This complies with the EPA assessment criterion of 2 OU.

With negative pressure lost and a flow rate of 0.6 m/s assumed (typical two air exchanges per hour), predicted odour concentrations range from less than 1 OU (Dubai International City, International City Phase II, Dragon mart Mosque, Dragon Mart Commercial Centre, Dubai Textile City, Dubai Nursery and Warsan Lake) to 5.6 OUs (Residential Vilas). The EPA assessment criterion of 2 OU is predicted to be exceeded at five defined sensitive receptor (Residential Vilas, Desert Palm Resort and Hotel, Pivot Fields, Desert Palm Polo Club and Desert Palm Riding Schools).

With negative pressure lost and a worst case flow rate of 1.2 m/s assumed (conservative four air exchanges per hour), odour concentrations range from less than 1 OU (International City Phase II and Dubai Nursery) to 11.1 OUs (Residential Vilas) at the defined sensitive receptors. This is considered a worst case scenario as the flow rate of 1.2 m/s is conservative. The EPA assessment criterion of 2 OU is predicted to be exceeded at seven defined sensitive receptors (Residential Vilas, Al Warqa 4, Desert Palm Resort and Hotel, Dubai Safari Park, Pivot Fields, Desert Palm Polo Club and Desert Palm Riding Schools).

The contour plots in Figure 7-1 to Figure 7-3 indicate that the highest odour concentrations are found to occur within the north-east boundary of the WMC, which is supported by the predicted concentrations in Table 7-1.

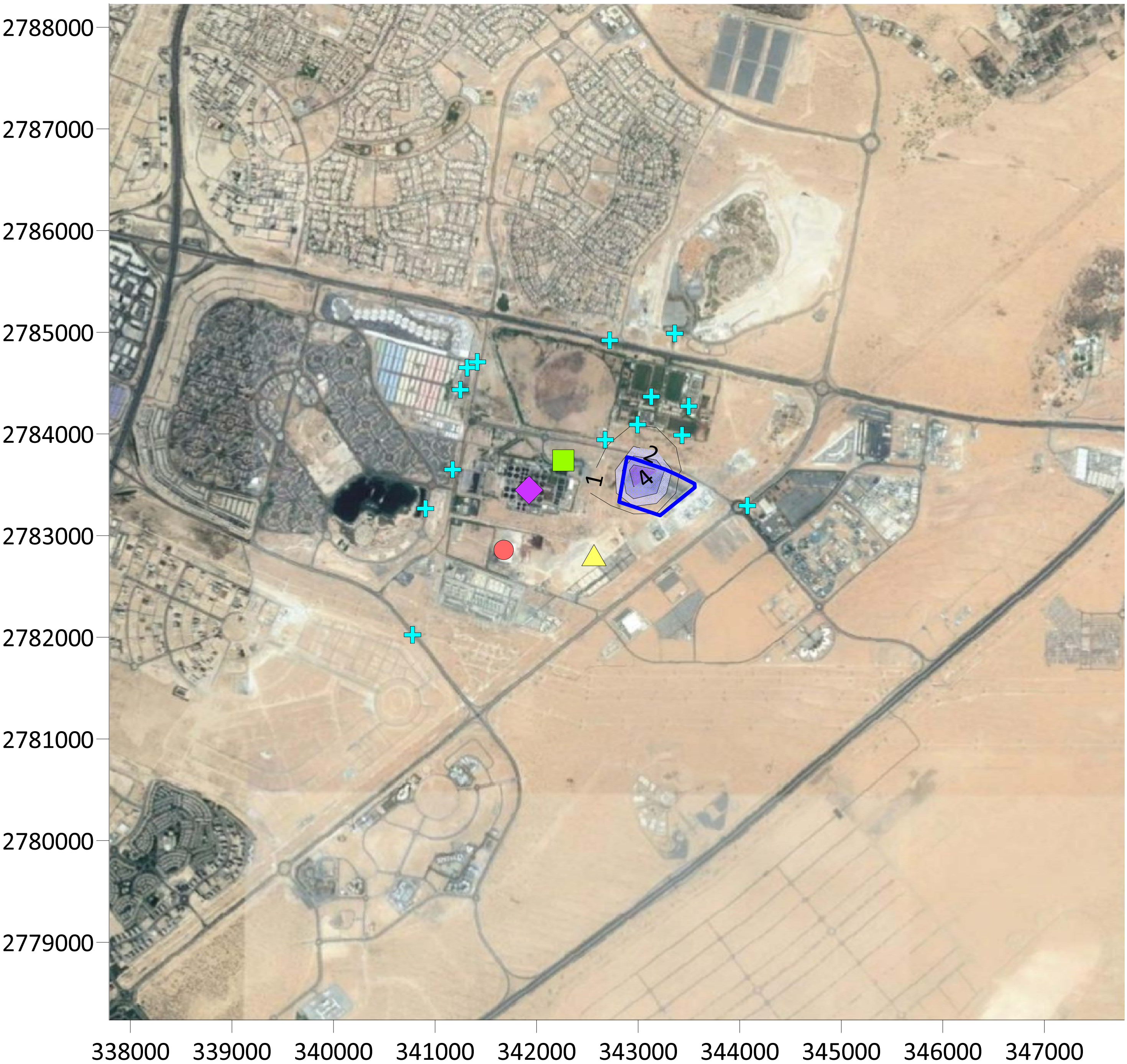
7.2 Cumulative impact

To assess cumulative impacts of the WMC on sensitive receptors, the predicted odour concentrations from the WMC were added to the predicted odour concentrations from the Al Aweer STP discussed in Section 3.2.

With negative pressure maintained, the contribution of odour from the WMC to the cumulative odour impact at sensitive receptors Dubai International City, Dubai Textile City and Warsan Lake is negligible (approximately 2% of the STP odour concentration).

With negative pressure lost, the contribution of odour from the WMC to the cumulative odour impact at sensitive receptors Dubai International City, Dubai Textile City and Warsan Lake remains negligible for both flow rates (approximately 3% of the STP odour concentration).

The defined sensitive receptors that are predicted to be impacted the most from odour concentrations from the WMC are not predicted to be impacted by odour concentrations from the STP (Residential Vilas and Pivot Fields). I.e. there is no cumulative impact predicted for these sensitive receptors.



SCALE

0 1000 2000 3000

Kilometres (at A4)

Negative pressure maintained - flow rate 0.1 m/s

LEGEND

- Sensitive receptor
- Project site perimeter
- 1-hour 99th percentile odour concentrations
- Al Aweer landfill
- Tadweer MRF
- Al Aweer STP
- Al Serkal

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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Dubai Waste Management Center Odour Assessment

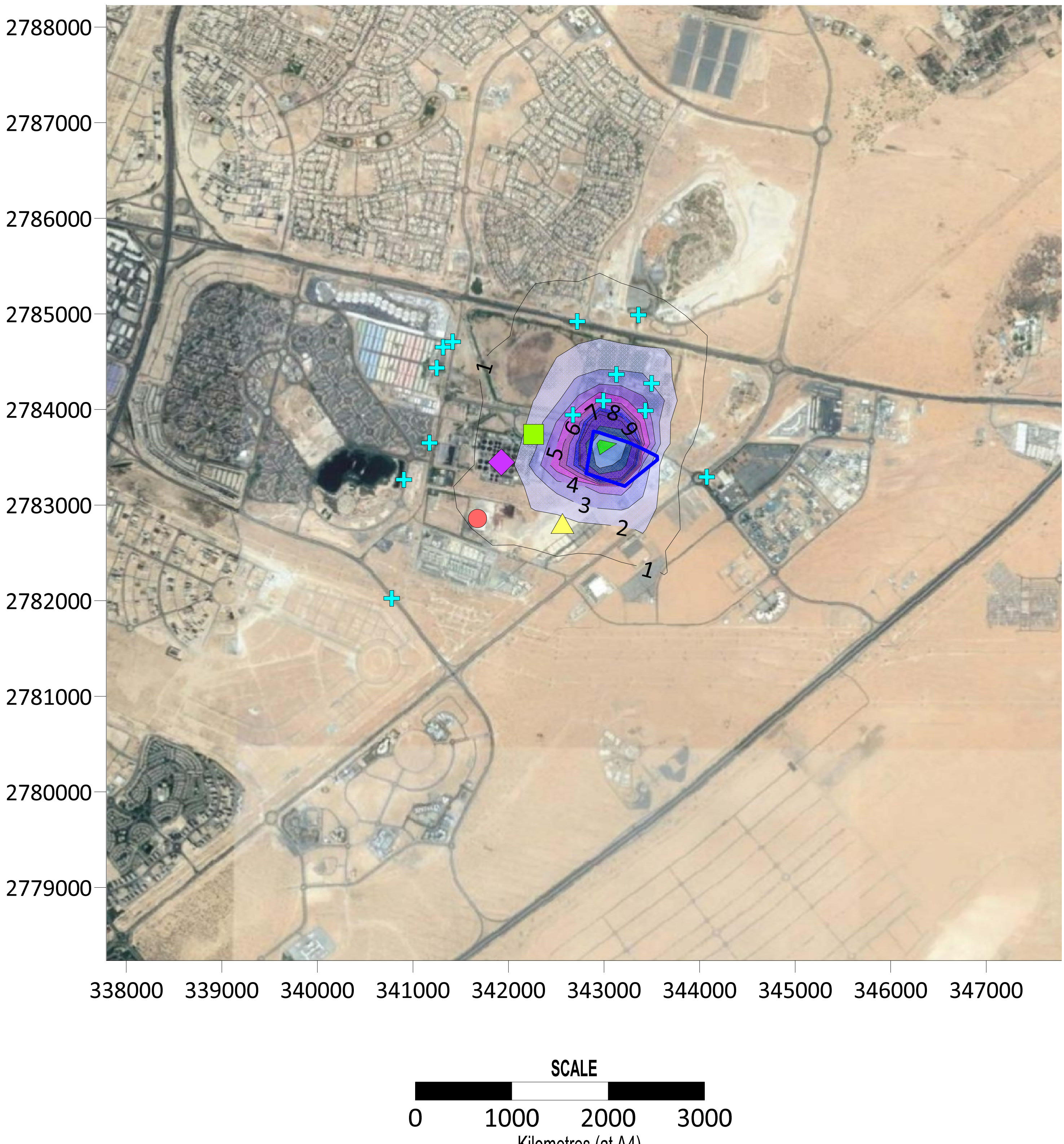
N

FIGURE 7-1

Predicted 1-hour 99th percentile odour concentrations (flow rate 0.1 m/s)

DRAWING NO.	REVISION	DATE
Fig 7-1.srf	A	07.11.2018

CREATED	CHECKER	APPROVER	FILE PATH
GF	JF	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\Odour\4. WP \Figures\Surfer



Negative pressure lost - flow rate 0.6 m/s

LEGEND

- Sensitive receptor
- Project site perimeter
- 1-hour 99th percentile odour concentrations
- Al Aweer landfill
- Tadweer MRF
- Al Aweer STP
- Al Serkal

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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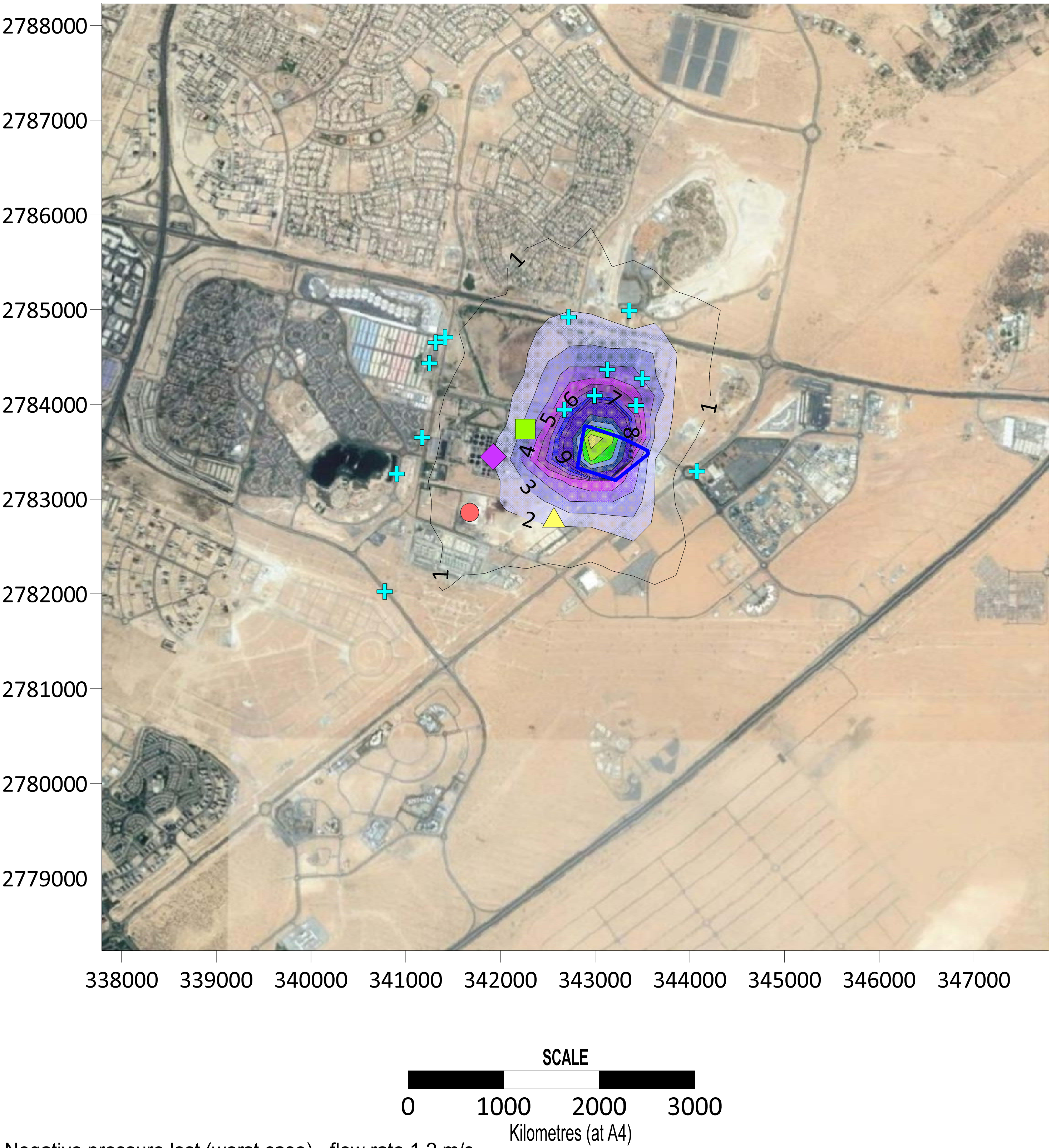
Dubai Waste Management Center Odour Assessment

FIGURE 7-2

Predicted 1-hour 99th percentile odour concentrations (flow rate 0.6 m/s)

DRAWING NO.	REVISION	DATE
Fig 7-2.srf	A	07.11.2018

CREATED	CHECKER	APPROVER	FILE PATH
GF	JF	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\Odour\4. WP \Figures\Surfer



Negative pressure lost (worst case) - flow rate 1.2 m/s

LEGEND

- Sensitive receptor
- Project site perimeter
- 1-hour 99th percentile odour concentrations
- Al Aweer landfill
- Tadweer MRF
- Al Aweer STP
- Al Serkal

MAP PROJECTION: Transverse Mercator

HORIZONTAL DATUM: World Geodetic System 84 (WGS) Zone 40 R

GRID: SRTM1 Global (~30 m)- Version 3

DATA SOURCE: GoogleEarth

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Dubai Waste Management Center Odour Assessment

FIGURE 7-3

Predicted 1-hour 99th percentile odour concentrations (flow rate 1.2 m/s)

DRAWING NO.	REVISION	DATE
Fig 7-3.srf	A	07.11.2018

CREATED	CHECKER	APPROVER	FILE PATH
GF	JF	JF	\\ghdnet\ghd\AU\Perth\Projects\61\3558306\Tech\Dubai RRF\Odour\4. WP \Figures\Surfer

8. Operational procedures and mitigation measures

The following measures should be taken in order to reduce the impact of odour on nearby sensitive receptors:

- To reduce the odour resulting from the aging process of the waste, the waste should not be stored significantly longer than five days in the bunker. The storage capacity of the waste bunker in the Dubai WMC plant is four days' worth of MSW at nominal operating conditions.
- Maintain operation of four out of five lines at any one time (shutdown of one line at a time for maintenance purposes) to maintain slight negative pressure in the waste bunker and ensure continual flow of fresh air into the waste bunker and avoid the escape of odorous air.

9. Conclusions

GHD has conducted an odour impact assessment for the proposed Dubai Waste Management Center.

A quantitative assessment of potential odour impacts from the operation of the WMC has been conducted, based on measured meteorological data from the Dubai International Airport for the year 2015 and AERMOD plume dispersion modelling. The intention of this assessment was to demonstrate odour concentrations for the WMC during upset conditions. Nominal conditions (flow rate of 0.1 m/s) were modelled as a baseline. Results for the worst case scenario (flow rate of 1.2 m/s) are considered highly conservative with results for the upset conditions with a flow rate of 0.6 m/s considered to be more representative of realistic conditions.

The results of the dispersion modelling indicate that when negative pressure is maintained, predicted odour concentrations reaching the defined sensitive receptors will be undetectable to the majority of the population. If negative pressure is lost and a flow rate of 0.6 m/s is achieved, predicted odour concentrations at 7 out of 14 sensitive receptors should be undetectable. Predicted odour concentrations at some sensitive receptors north of the WMC site may experience odour concentrations of up to 5.6 OU. If worst case conditions prevailed resulting in a flow rate of 1.2 m/s during a loss of negative pressure, predicted odour concentrations at 2 out of 14 sensitive receptors should be undetectable. Predicted odour concentrations at some sensitive receptors may experience odour concentrations of up to 11.1 OU.

Modelling assessment of the Al Aweer STP indicates that STP will contribute higher odour concentrations in comparison to the proposed WMC.

Besides the inherent model limitations, it is worth noting that the odour model used in this assessment is limited by insufficient on site data input, i.e. Specific Odour Emission Rates. It is recommended that site specific odour sampling be undertaken in order to validate the model results.

10. References

Al Futtaim Element Technology 2017. *Test Report GHD – DM Waste to Energy – Odour*. Dubai, 2017.

Hitachi Zosen Inova 2018. *Design Waste Bunker Dimensions.* Document number 50071810 and 50071808. Hitachi Zosen Inova, 2018.

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Katestone Scientific 1998. Report from Katestone Scientific to Environmental Protection Authority of NSW, P*eak to Mean Ratios for Odour Assessments.* Katestone Scientific, Brisbane, 1998.

Longhurst 2007. *Principles of Landfill Odour Emission and Control – Understanding prioritising and controlling emissions*. AWE International, March 2007. From https://www.aweimagazine.com/article/principles-of-landfill-odour-emission-and-control-478, Accessed 12 November 2018.

National Centre of Meteorology, 2018. *Climate Data Dubai Int'l Airport.* From: http://www.ncm.ae/#!/Radar_UAE_Merge/26, accessed 26 June 2018.

PEL 2015. *Energy from Waste Facility – Odour Assessment, the Next Generation.* Pacific Environment Limited, February 2015.

Appendix

Appendix A – AERMOD input file

*** MODELOPTs: NonDFAULT CONC ELEV FASTALL ALPHA RURAL ADJ_U*

*** MODEL SETUP OPTIONS SUMMARY ***

- -

**Model Is Setup For Calculation of Average CONCentration Values.

-- DEPOSITION LOGIC --

**NO GAS DEPOSITION Data Provided.

**NO PARTICLE DEPOSITION Data Provided.

**Model Uses NO DRY DEPLETION. DRYDPLT = F

**Model Uses NO WET DEPLETION. WETDPLT = F

**Model Uses RURAL Dispersion Only.

**Model Allows User-Specified Options:

1. Stack-tip Downwash.
2. Model Accounts for ELEVated Terrain Effects.
3. Use Calms Processing Routine.
4. Use Missing Data Processing Routine.
5. No Exponential Decay.
6. Full Conversion Assumed for NO2.

**Other Options Specified:

FASTALL - Use effective sigma-y to optimize meander for
POINT and VOLUME sources, and hybrid approach
to optimize AREA sources (formerly TOXICS option)

ADJ_U* - Use ADJ_U* option for SBL in AERMET

CCVR_Sub - Meteorological data includes CCVR substitutions

TEMP_Sub - Meteorological data includes TEMP substitutions

**Model Assumes No FLAGPOLE Receptor Heights.

**The User Specified a Pollutant Type of: OU

**Model Calculates 1 Short Term Average(s) of: 1-HR

**This Run Includes: 1 Source(s); 1 Source Group(s); and 48855 Receptor(s)

with: 0 POINT(s), including

0 POINTCAP(s) and 0 POINTHOR(s)

and: 1 VOLUME source(s)

and: 0 AREA type source(s)

and: 0 LINE source(s)

and: 0 OPENPIT source(s)

and: 0 BUOYANT LINE source(s) with 0 line(s)

**Model Set To Continue RUNning After the Setup Testing.

**The AERMET Input Meteorological Data Version Date: 15181

**Output Options Selected:

Model Outputs Tables of Highest Short Term Values by Receptor (RECTABLE Keyword)

Model Outputs External File(s) of Concurrent Values for Postprocessing (POSTFILE Keyword)

Model Outputs External File(s) of High Values for Plotting (PLOTFILE Keyword)

Model Outputs Separate Summary File of High Ranked Values (SUMMFILE Keyword)

**NOTE: The Following Flags May Appear Following CONC Values: c for Calm Hours

m for Missing Hours

b for Both Calm and Missing Hours

**Misc. Inputs: Base Elev. for Pot. Temp. Profile (m MSL) =   10.00 ; Decay Coef. =   0.000   ; Rot. Angle =   0.0

Emission Units = OU/S   ; Emission Rate Unit Factor =   1.0000

Output Units   = OU/M**3

**Approximate Storage Requirements of Model =   9.0 MB of RAM.

**Input Runstream File: aermod.inp

**Output Print File: aermod.out

**Detailed Error/Message File: Dubai_RRF.err

**File for Summary of Results: Dubai_RRF.sum

*** MODELOPTs: NonDFAULT CONC ELEV FASTALL ALPHA RURAL ADJ_U*

*** METEOROLOGICAL DAYS SELECTED FOR PROCESSING ***

(1=YES; 0=NO)

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

NOTE: METEOROLOGICAL DATA ACTUALLY PROCESSED WILL ALSO DEPEND ON WHAT IS INCLUDED IN THE DATA FILE.

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***

(METERS/SEC)

1.54, 3.09, 5.14, 8.23, 10.80,

*** MODELOPTs: NonDFAULT CONC ELEV FASTALL ALPHA RURAL ADJ_U*

*** UP TO THE FIRST 24 HOURS OF METEOROLOGICAL DATA ***

Surface file: ..\..\..\02. Meteorology\Met run 3\AERMET\Dubai_2015.SFC Met Version: 15181

Profile file: ..\..\..\02. Meteorology\Met run 3\AERMET\Dubai_2015.PFL

Surface format: FREE

Profile format: FREE

Surface station no.: 0 Upper air station no.: 999

Name: UNKNOWN Name: UNKNOWN

Year: 2015 Year: 2015

First 24 hours of scalar data

YR	MO	DY	JDY	HR	H0	U*	W*	DT/DZ	ZICNV	ZIMCH	M-O LEN	Z0	BOWEN	ALBEDO	REF WS	WD	HT	REF TA	HT
15	01	01	1	01	-13.1	0.166	-9.000	-9.000	-999.	162.	31.7	0.31	3.53	1.00	1.50	70.	10.0	294.1	2.0
15	01	01	1	02	-23.0	0.238	-9.000	-9.000	-999.	278.	62.3	0.31	3.53	1.00	2.10	80.	10.0	293.1	2.0
15	01	01	1	03	-23.0	0.238	-9.000	-9.000	-999.	278.	62.3	0.31	3.53	1.00	2.10	70.	10.0	293.1	2.0
15	01	01	1	04	-23.0	0.238	-9.000	-9.000	-999.	278.	62.3	0.31	3.53	1.00	2.10	70.	10.0	293.1	2.0
15	01	01	1	05	-23.1	0.238	-9.000	-9.000	-999.	278.	62.2	0.31	3.53	1.00	2.10	80.	10.0	292.1	2.0
15	01	01	1	06	-28.9	0.297	-9.000	-9.000	-999.	389.	97.3	0.31	3.53	1.00	2.60	100.	10.0	292.1	2.0

15 01 01 1 07 -13.1 0.166 -9.000 -9.000 -999. 173. 31.5 0.31 3.53 1.00 1.50 90. 10.0
291.1 2.0

15 01 01 1 08 -19.0 0.239 -9.000 -9.000 -999. 280. 64.9 0.31 3.53 0.59 2.10 100. 10.0
292.1 2.0

15 01 01 1 09 48.8 0.333 0.407 0.005 50. 462. -68.6 0.31 3.53 0.33 2.60 110. 10.0
293.1 2.0

15 01 01 1 10 138.6 0.412 1.203 0.005 454. 635. -45.6 0.31 3.53 0.25 3.10 80. 10.0
295.1 2.0

15 01 01 1 11 205.9 0.373 1.552 0.005 657. 548. -22.8 0.31 3.53 0.23 2.60 60. 10.0
297.1 2.0

15 01 01 1 12 246.3 0.431 1.822 0.005 889. 679. -29.4 0.31 3.53 0.22 3.10 80. 10.0
299.1 2.0

15 01 01 1 13 257.6 0.381 1.978 0.005 1088. 567. -19.5 0.31 3.53 0.22 2.60 90. 10.0
300.1 2.0

15 01 01 1 14 168.7 0.250 1.797 0.005 1246. 312. -8.4 0.31 3.53 0.22 1.50 65. 10.0
299.1 2.0

15 01 01 1 15 138.9 0.464 1.789 0.005 1492. 757. -64.8 0.31 3.53 0.23 3.60 40. 10.0
299.1 2.0

15 01 01 1 16 91.0 0.677 1.698 0.005 1949. 1337. -308.6 0.31 3.53 0.27 5.70 350. 10.0
298.1 2.0

15 01 01 1 17 31.1 0.597 1.283 0.005 2451. 1117. -618.0 0.31 3.53 0.37 5.10 20. 10.0
298.1 2.0

15 01 01 1 18 -38.7 0.418 -9.000 -9.000 -999. 680. 191.9 0.31 3.53 0.73 3.60 20. 10.0
298.1 2.0

15 01 01 1 19 -28.4 0.297 -9.000 -9.000 -999. 402. 97.4 0.31 3.53 1.00 2.60 20. 10.0
297.1 2.0

15 01 01 1 20 -28.4 0.297 -9.000 -9.000 -999. 389. 97.4 0.31 3.53 1.00 2.60 50. 10.0
297.1 2.0

15 01 01 1 21 -28.5 0.297 -9.000 -9.000 -999. 389. 97.3 0.31 3.53 1.00 2.60 10. 10.0
296.1 2.0

15 01 01 1 22 -28.5 0.297 -9.000 -9.000 -999. 389. 97.3 0.31 3.53 1.00 2.60 60. 10.0
296.1 2.0

15 01 01 1 23 -34.3 0.357 -9.000 -9.000 -999. 512. 140.3 0.31 3.53 1.00 3.10 80. 10.0
295.1 2.0

15 01 01 1 24 -13.1 0.166 -9.000 -9.000 -999. 196. 31.7 0.31 3.53 1.00 1.50 125. 10.0
295.1 2.0

First hour of profile data

```
YR MO DY HR HEIGHT F  WDIR    WSPD AMB_TMP sigmaA  sigmaW  sigmaV
15 01 01 01   10.0 1   70.    1.50   294.2   99.0  -99.00  -99.00
```

F indicates top of profile (=1) or below (=0)

*** MODELOPTs: NonDFAULT CONC ELEV FASTALL ALPHA RURAL ADJ_U*

*** THE SUMMARY OF HIGHEST 1-HR RESULTS ***

** CONC OF OU IN OU/M**3 **

DATE NETWORK

GROUP ID AVERAGE CONC (YYMMDDHH) RECEPTOR (XR, YR, ZELEV, ZHILL, ZFLAG) OF TYPE GRID-ID

- -

ALL HIGH 1ST HIGH VALUE IS 57.42714 ON 15033103: AT (343069.00, 2783505.00, 35.00, 35.00, 0.00) GC UCART1

*** RECEPTOR TYPES: GC = GRIDCART

GP = GRIDPOLR

DC = DISCCART

DP = DISCPOLR

*** MODELOPTs: NonDFAULT CONC ELEV FASTALL ALPHA RURAL ADJ_U*

*** Message Summary : AERMOD Model Execution ***

--------- Summary of Total Messages --------

A Total of 0 Fatal Error Message(s)

A Total of 1 Warning Message(s)

A Total of 504 Informational Message(s)

A Total of 8760 Hours Were Processed

A Total of 0 Calm Hours Identified

A Total of 504 Missing Hours Identified (5.75 Percent)

******** FATAL ERROR MESSAGES ********

*** NONE ***

******** WARNING MESSAGES ********

ME W187 66 MEOPEN: ADJ_U* Option for Stable Low Winds used in AERMET

GHD

Level 10
999 Hay Street
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