Acid Alkali Neutralisation Plant

Air Quality Impact Assessment

Report Number 610.16735-R02

12 June 2017

Toxfree Australia Pty Ltd
40 Christie Street
St Marys
NSW 4399

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Air Quality Impact Assessment

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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Toxfree Australia Pty Ltd (Toxfree) to perform an air quality impact assessment (AQIA) to assess impacts from the proposed acid-alkali neutralisation (AAN) plant to be located within their chemical waste storage and treatment facility at 40 Christie Street, St Mary's, NSW (the Project site).

In September 2016, SLR completed a qualitative odour impact assessment (OIA) for the Project Site (SLR 2016), including assessment of odour impacts from the AAN plant. Following a review of the OIA, NSW Environment Protection Authority (EPA) requested that a quantitative assessment be completed for the AAN plant, assessing ground level concentrations of chlorine (Cl_2) and sulfur dioxide (SO_2).

The aim of this assessment is to quantify the air quality impacts due to residual Cl_2 and SO_2 emissions from the AAN plant.

The NSW EPA document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (EPA 2017) (hereafter 'the Approved Methods') outlines the requirements for conducting an AQIA as follows:

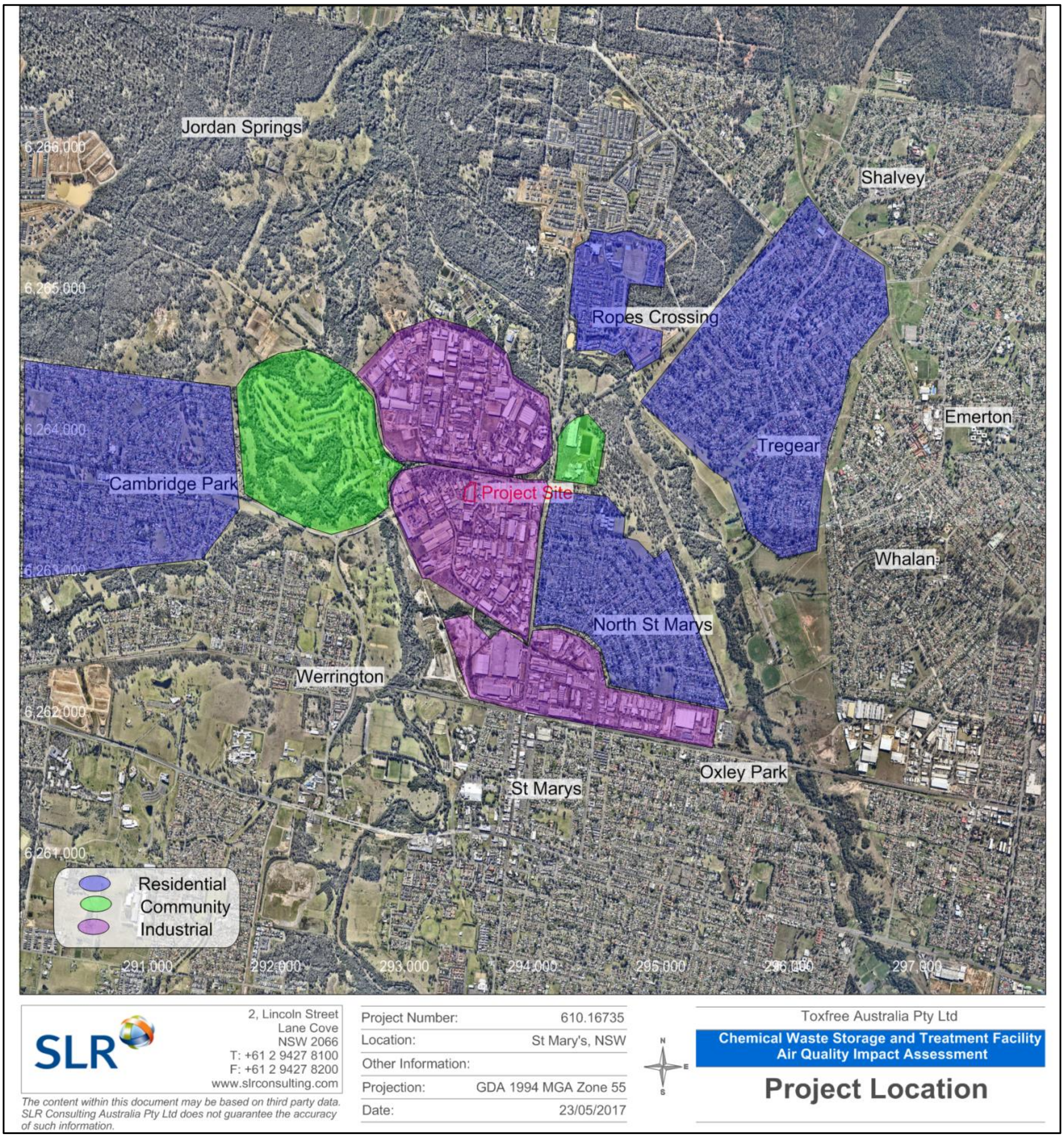
- Description of activities carried out on site including location, a detailed discussion of all unit operations carried out on the site and a description of all aspects of the air emission control system (**Section 2.3**).
- Site plan including a description of local topographic features and sensitive receptor locations (**Section 2.5** and **Section 2.6** respectively).
- Establishment of air quality assessment criteria (**Section 3**).
- Meteorological data including a detailed discussion of the prevailing dispersion meteorology, wind roses, stability class and mixing height and demonstration that the site representative data adequately describes the expected meteorological patterns (**Section 4.4**).
- Emission inventory including detailed discussion of methodology used and detailed calculation of pollutant emission rates for each source (**Section 5**).
- Background air quality data used including a detailed discussion of the methodology used to calculate the background concentrations for each pollutant (**Section 6.3**).
- Dispersion modelling including a detailed discussion of air quality impacts for all relevant pollutants based on predicted ground level concentrations at all sensitive receivers (**Section 7**).

2 PROJECT OVERVIEW

2.1 Project Location

The existing facility is located within the established St Mary's industrial estate at 40 Christie Street, St Mary's. The site is approximately 7 km east of the Nepean Hospital, 650 m east of Wianamatta Creek, approximately 650 m to the nearest residence and surrounded by other industrial facilities. The location of the Project site is shown in **Figure 1**.

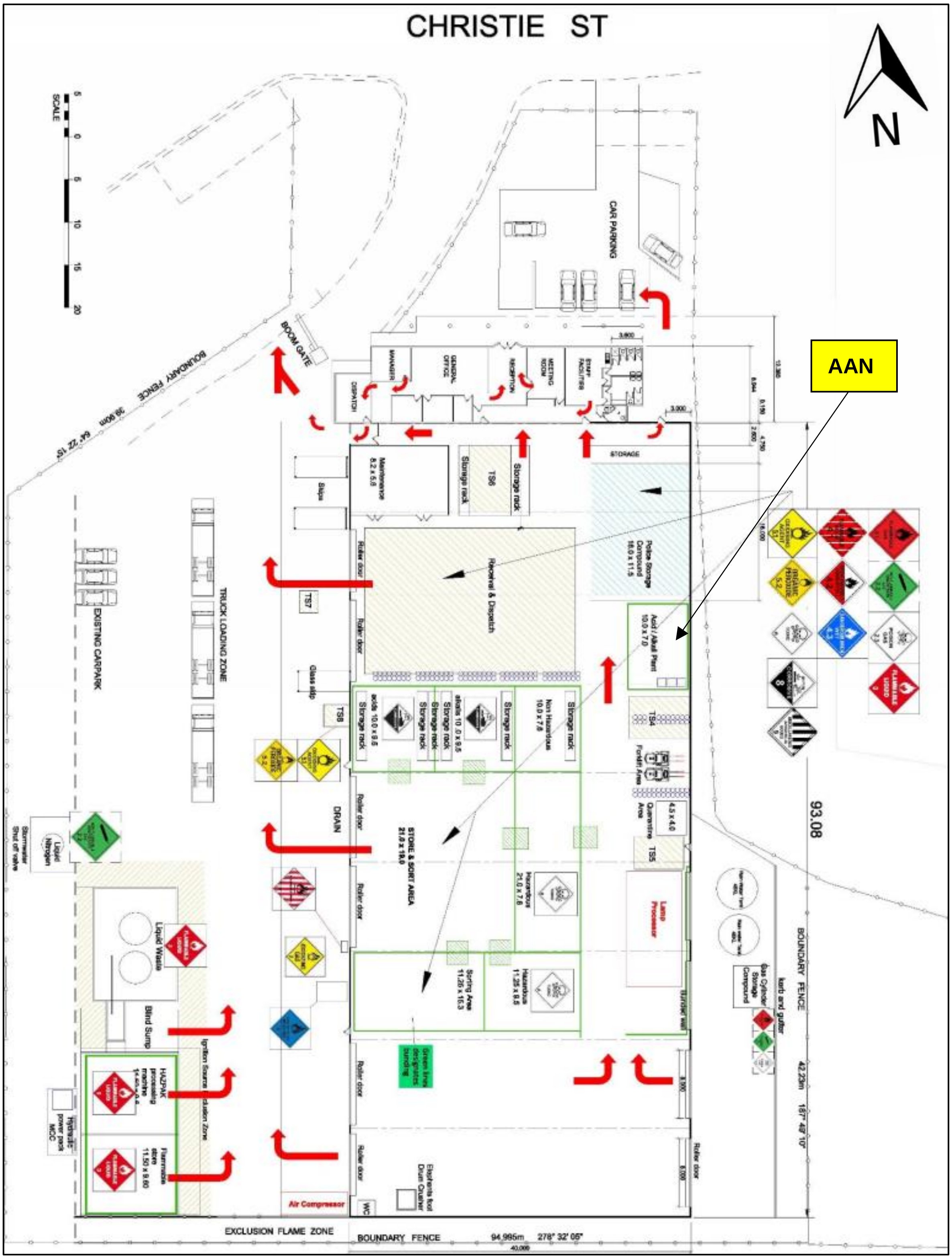
Figure 1 Regional Location of the Project Site



2.2 Site Layout

The current site layout is shown in **Figure 2**. The proposed location of the AAN process can be seen along the western wall of the main factory building.

Figure 2 Current Project Site Layout and Proposed AAN Processing Locations



Source: Advitech 2017

2.3 Process Description

The AAN process is proposed to be carried out as a semi-batch process. The following steps are the key components of the full AAN process (Advitech 2017):

- Pre-consolidation of acid and alkali liquid wastes occur. Each liquid waste stream is consolidated into a separate 1,000 litre (L) intermediate bulk container (IBC).
- The AAN mixing tank is prefilled with 500 L of consolidated alkali liquid waste.
- The acid solution is added to the mixing tank at a rate of 10 L/min.
- AAN mixing tank is well mixed.
- Reaction chemistry proceeds instantaneously and is characterised by the reaction between a strong acid and a strong alkali. It is assumed that 38 wt% hydrogen chloride (HCl) will react with 33 wt% sodium hypochlorite (NaOCl) or 98 wt% sulphuric acid (H_2SO_4) will react with 33 wt% NaOCl.
- Continuous pH and temperature monitoring on the AAN mixing tank and gas scrubber.
- Up to four batches will be processed daily, with a maximum of one batch processed per hour.
- The air from the mixing tank passed through the gas scrubber unit before it is released into the atmosphere. At the time of writing this report, the scrubber design has not been finalised, however based on the preliminary design estimates provided by Toxfree, it has been assumed for the purposes of this AQIA that the scrubber will operate at a minimum 99% efficiency.

Depending on the type of waste acid to be neutralised (HCl or H_2SO_4), the following two reactions are anticipated to occur to release chlorine gas and sulfur dioxide gas respectively:

$$NaOCl + HCl \leftrightarrow Cl_2 + NaOH \qquad \textbf{Equation 1}$$

$$2NaOCl + H_2SO_4 \leftrightarrow Na_2SO_4 + 2HCl + SO_2 \qquad \textbf{Equation 2}$$

2.4 Hours of Operation

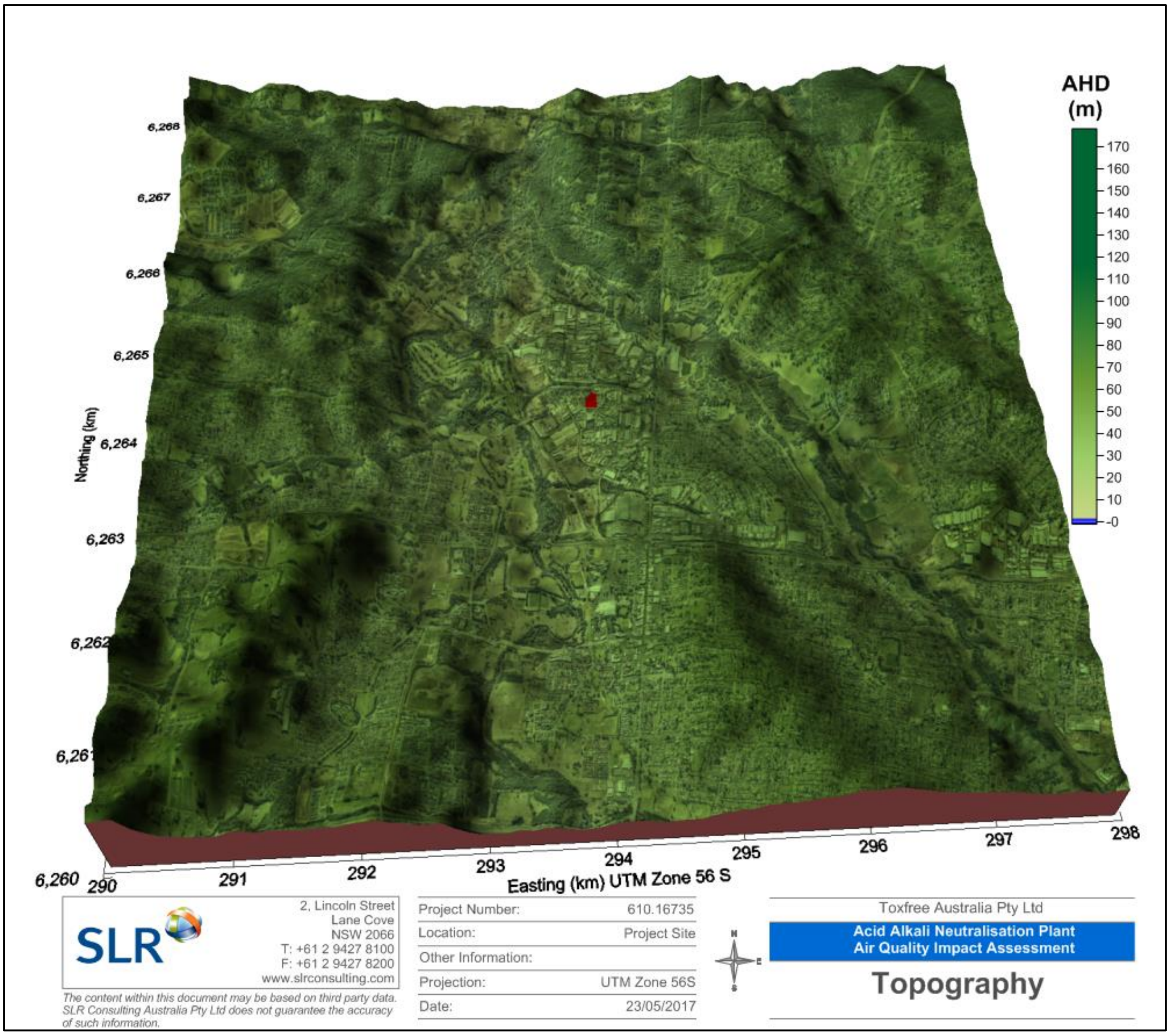
The Project Site is attended by staff on weekdays between the hours of 5:00 am and 10:00 pm. However it has been notified by Toxfree that the AAN process will only be conducted between the hours of 10:00 am and 1:00 pm for hydrochloric acid neutralisation (chlorine release) and between the hours of 7:00 am and 1:00 pm for sulfuric acid neutralisation (sulfur dioxide release).

2.5 Local Topography

Figure 3 illustrates the topography of the area surrounding the Project Site. The topographical data used in the modelling assessment was sourced from the United States Geological Service's Shuttle Radar Topography Mission database that has recorded topography across Australia with a 3 arc second (approximately 90 metre [m]) spacing.

The topography of the area surrounding the Project site is relatively flat, with gently undulating terrain present in the northwest and southwest directions, with an approximate range of 5 m to 170 m Australian Height Datum (AHD).

Figure 3 Local Topography around the Project Site



Note: Vertical elevations have been exaggerated.

2.6 Sensitive Receptors

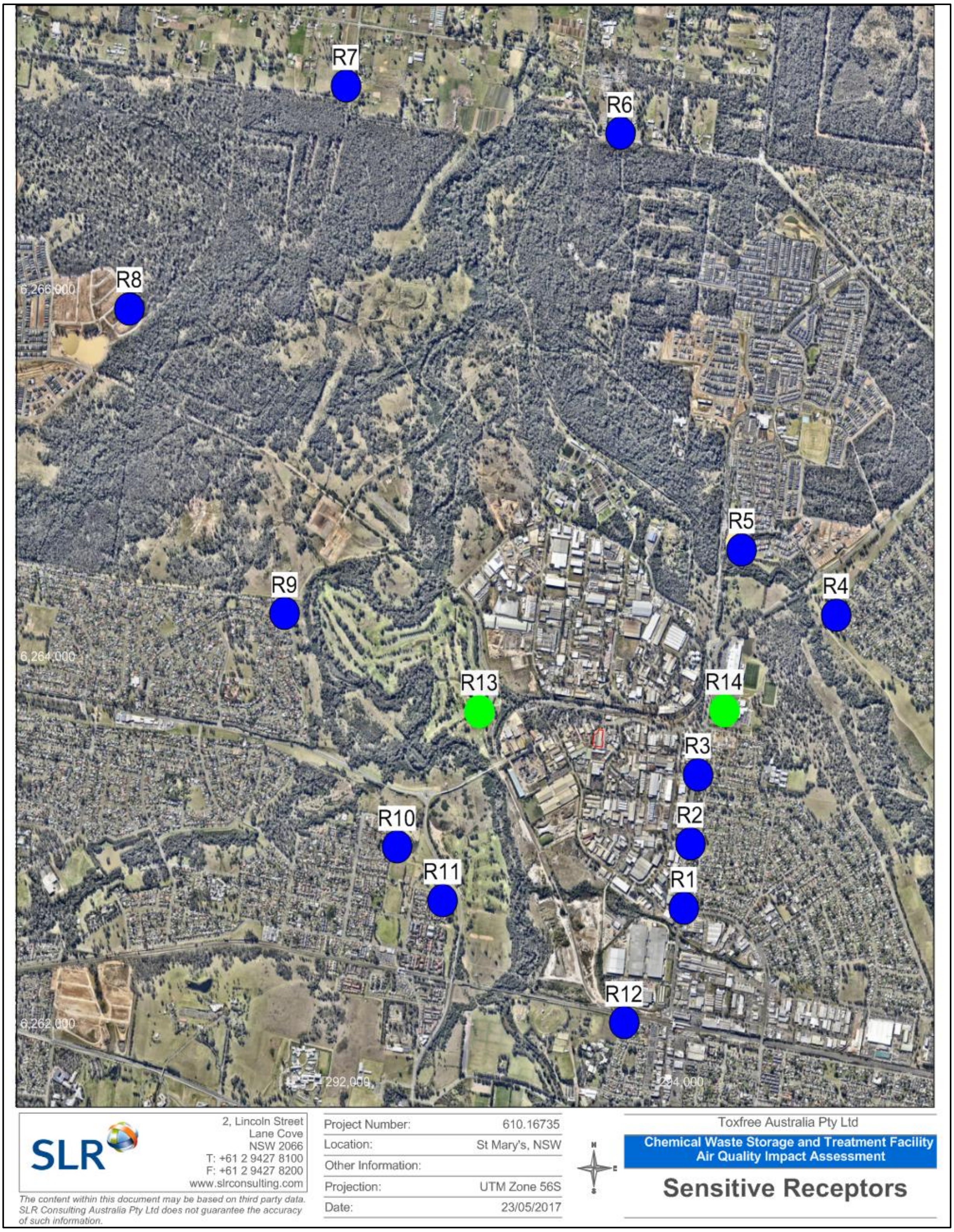
A number of residential and industrial properties have been identified as sensitive receptor locations in the area surrounding the Project Site. The locations of the identified representative sensitive receptors in the vicinity of the Project Site are listed in **Table 1** and shown in **Figure 4**.

Table 1 Locations of Identified Sensitive Receptors Surrounding the Project Site

Receptor ID	Easting (km)	Northing (km)	Type
R1	294.010	6,262.628	Existing residential
R2	294.049	6,262.979	Existing residential
R3	294.095	6,263.357	Existing residential
R4	294.924	6,264.227	Existing residential
R5	294.357	6,264.582	Existing residential
R6	293.629	6,266.849	Existing residential
R7	291.983	6,267.107	Existing residential
R8	290.687	6,265.896	Future residential
R9	291.618	6,264.234	Existing residential
R10	292.291	6,262.962	Existing residential
R11	292.564	6,262.671	Existing residential
R12	293.653	6,262.005	Existing residential
R13	292.786	6,263.700	Dunheved Golf course
R14	294.254	6,263.704	St Marys Rugby League Club

In addition to the identified sensitive receptors listed in **Table 1**, ground level concentrations predicted along the boundary of the Project Site have been assessed, as required by the Approved Methods (see **Section 3**) for the assessment of air toxics (chlorine).

Figure 4 Identified Sensitive Receptors Surrounding the Project Site



Note: Project Site boundary shown in ‘red’.

3 ASSESSMENT CRITERIA

3.1 Pollutants Assessed

As discussed in the previous sections, the pollutants assessed in this assessment are chlorine (Cl_2) and sulfur dioxide (SO_2).

3.2 Health Effects of Pollutants

3.2.1 Chlorine

Inhalation of small amounts of chlorine causes few or no symptoms. In larger amounts, it is a powerful irritant to the mucous membranes of the eyes, nose, and throat.

According to Australian Government's Department of the Environment and Energy (DEE 2017a), exposure to low concentrations can cause burning of eyes, nose, and mouth; as the concentration increases, the effects become more severe: lacrimation (tear formation) and rhinorrhea (streaming nose); coughing, sneezing, choking, and substernal (chest) pain; nausea and vomiting; headaches and dizziness; fainting; fatal pulmonary oedema; pneumonia; conjunctivitis; inflammation of the cornea; pharyngitis; burning chest pain; difficulty breathing; bleeding in the respiratory system; oxygen deficiency; dermatitis; and skin blisters. Cardiac arrest may occur secondary to oxygen deficiency.

Chronic exposure can cause corrosion of the teeth.

3.2.2 Sulfur Dioxide

According to Australian Government's Department of the Environment and Energy (DEE 2017b), exposure to high sulfur dioxide concentrations cause irritation of the eyes, nose and throat, choking and coughing.

Exposure of the eyes to liquid sulfur dioxide (for example, from an industrial accident) can cause severe burns, resulting in the loss of vision. On the skin it produces burns. Other health effects include headache, general discomfort and anxiety. Those with impaired heart or lung function and asthmatics are at increased risk. Repeated or prolonged exposure to moderate concentrations may cause inflammation of the respiratory tract, wheezing and lung damage. It has also proved to be harmful to the reproductive systems of experimental animals and caused developmental changes in their newborn.

3.3 Project Criteria

The Approved Methods lists the criteria for individual air pollutants. The relevant criteria for chlorine and sulfur dioxide are shown in **Table 2**.

Table 2 NSW EPA Criteria (Individual Air Pollutant)

Pollutant	Averaging Period	Percentile	Assessment Criteria ($\mu g/m^3$)
Chlorine	1-hour	99.9th	50[a]
Sulfur dioxide	10 minute	100th	712[b]
	1-hour		570[b]
	24-hours		228[b]
	Annual		60[b]

Notes:

[a] At and beyond the boundary of the facility

[b] At the nearest existing or likely future off-site sensitive receptor

In addition, Worker Exposure Standards i.e Time Weighted Averages (TWA) and Short Term Exposure Limits (STEL) apply for chlorine and sulfur dioxide concentrations in occupational environments (which would be more relevant to the surrounding industrial areas), as shown in **Table 3**.

Table 3 Safe Work Australia Workplace Exposure Limits

	Chlorine	**Sulfur Dioxide**	**Units**
Time Weighted Average (TWA)[1]	3,000	5,200	µg/m^3
Short Term Exposure Limit (STEL)[2]	-	13,000	µg/m^3

Source: SWA 2011

[1] The average airborne concentration of a particular substance when calculated over an eight-hour working day, for a five-day working week

[2] The airborne concentration of a particular substance calculated as a time-weighted average over 15 minutes

4 AIR DISPERSION MODELLING METHODOLOGY

4.1 Model Selection

Emissions from the Project Site have been modelled using the CALPUFF (Version 6) modelling system. CALPUFF is one of the modelling tools accepted by the NSW EPA. CALPUFF is a transport and dispersion model that breaks emission plumes into "puffs" of material emitted from modelled sources. The model predicts the trajectory of these puffs, simulating dispersion and transformation processes along the way.

In order to model the trajectory and dispersion / transformation of these puffs, the model requires input data on the emissions themselves (location, release times / frequencies, type and strength of the releases), the terrain over which the puffs travel and the meteorological conditions that occur at the location and in the time period under consideration. Both the terrain and meteorological data are in incorporated in three dimensions.

For the meteorological data, CALPUFF typically uses wind field data generated by the meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentrations or hourly deposition fluxes calculated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

4.2 Accuracy of Air Dispersion Modelling

Atmospheric dispersion models represent a simplification of the many complex processes involved in the dispersion of pollutants in the atmosphere. To obtain good quality results it is important that the most appropriate model is used and the quality of the input data (meteorological, terrain, source characteristics) is adequate.

The main sources of uncertainty in dispersion models, and their effects, are discussed below.

- **Oversimplification of physics**: This can lead to both under-prediction and over-prediction of ground level pollutant concentrations. Errors are greater in Gaussian plume models as they do not include the effects of non-steady-state meteorology (i.e., spatially- and temporally-varying meteorology).
- **Errors in emission rates**: Ground level concentrations are proportional to the pollutant emission rates. In addition, most modelling studies assume constant worst case emission levels or are based on the results of a small number of stack tests, however operations (and thus emissions) are often quite variable. Accurate measurement of emission rates and source parameters requires continuous monitoring.
- **Errors in source parameters**: Plume rise is affected by source dimensions, temperature and exit velocity. Inaccuracies in these values will contribute to errors in the predicted height of the plume centreline and thus ground level pollutant concentrations.
- **Errors in wind direction and wind speed**: Wind direction affects the direction of plume travel, while wind speed affects plume rise and dilution of plume. Errors in these parameters can result in errors in the predicted distance from the source of the plume impact, and magnitude of that impact. In addition, aloft wind directions commonly differ from surface wind directions. The preference to use rugged meteorological instruments to reduce maintenance requirements also means that light winds are often not well characterised.
- **Errors in mixing height**: If the plume elevation reaches 80% or more of the mixing height, more interaction will occur, and it becomes increasingly important to properly characterise the depth of the mixed layer as well as the strength of the upper air inversion.

- **Errors in temperature**: Ambient temperature affects plume buoyancy, so inaccuracies in the temperature data can result in potential errors in the predicted distance from the source of the plume impact, and magnitude of that impact.
- **Errors in stability estimates**: Gaussian plume models use estimates of stability class, and 3D models use explicit vertical profiles of temperature and wind (which are used directly or indirectly to estimate stability class for Gaussian models). In either case, errors in these parameters can cause either under-prediction or over-prediction of ground level concentrations. For example, if an error is made of one stability class, then the computed concentrations can be off by 50% or more.

The US EPA makes the following statement in its Modelling Guideline (USEPA 2005) on the relative accuracy of models:

> *"Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to 40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognised for these models. However estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable."*

The above sources of error have been minimised in this AQIA through the following:

- The emission rates have been calculated using a combination of mass balance principles and stoichiometric reactions proposed to be occurring in the AAN process. A conservative assumption of 100% reaction of the acid has been made.
- This study utilises the CALPUFF dispersion model in full 3D mode, incorporating the 3D meteorological output from CALMET and TAPM (refer **Section 4.3**).
- The meteorological dataset has been compiled using observations from nearby automatic weather stations and a 5-year period of meteorological data was reviewed to ensure that the year selected for use in the modelling is representative of long-term meteorological conditions of the region.

4.3 Meteorological Modelling Methodology

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the Earth's boundary layer (that layer of the atmosphere closest to the surface of the Earth. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading.

Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Oke 2004).

To adequately characterise the dispersion meteorology of the study site, information is needed on the prevailing wind regime, mixing depth and atmospheric stability and other parameters such as ambient temperature, rainfall and relative humidity.

Meteorological data collected over the period 2012-2016 at the nearest Bureau of Meteorology (BoM) station (Penrith Lakes Automatic Weather Station [AWS], located 9 km west of the Project Site) were analysed to select a representative year for dispersion modelling. The analysis showed that data collected during the 2013 calendar year are in reasonably good agreement with long term averages compared to other years and was therefore selected for use in this assessment.

4.3.1 TAPM

In order to calculate all required meteorological parameters required by the dispersion modelling process, meteorological modelling using The Air Pollution Model (TAPM, v 4.0.4) has been performed. TAPM, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a prognostic model which may be used to predict three-dimensional meteorological data and air pollution concentrations.

TAPM predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate site-specific hourly meteorological observations at user-defined levels within the atmosphere.

TAPM may assimilate actual local wind observations so that they can optionally be included in a model solution. In this assessment, TAPM predictions have been nudged with the locally monitored observational data, as shown in **Table 4**.

Table 4 Meteorological Parameters used for this Study (TAPM v 4.0.4)

Modelling Period	1 January 2013 to 31 December 2013
Centre of analysis	293,511 E 6,263,546 N (UTM Coordinates)
Number of grid points	25 × 25 × 25
Number of grids (spacing)	5 (30 km, 10 km, 3 km, 1 km, 0.3 km)
Data assimilation	Penrith Lakes AWS (Station # 67113) Badgerys Creek AWS (Station # 67108) Horsley Park Equestrian Park AWS (Station # 67119) Richmond RAAF (Station # 67105) NSW OEH St Marys Air Quality Monitoring Station (AQMS)
Terrain	AUSLIG 9 second DEM

4.3.2 CALMET

In the simplest terms, CALMET is a meteorological model that develops wind and temperature fields on a three-dimensional gridded modelling domain. Associated two-dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final wind field thus reflects the influences of local topography and land uses.

CALMET modelling was conducted using the nested CALMET approach, where the final results from a coarse-grid run were used as the initial “guess” of a fine-grid run. This has the advantage that off-domain terrain features including slope flows and blocking effects can be allowed to take effect and the larger scale wind flow provides a better start in the fine-grid run.

The outer domain (30 km × 30 km) was modelled with a resolution of 600 m. TAPM-generated 3-dimensional meteorological data was used as the initial guess wind field and the local topography and available surface weather observations in the area were used to refine the wind field predetermined by TAPM data. Hourly surface meteorological data from BoM stations were incorporated in the outer domain modelling.

The output from the outer domain CALMET modelling was then used as the initial guess field for the mid domain CALMET modelling. The mid domain encompasses an area of 15 km × 15 km. A horizontal grid spacing of 300 m was used to adequately represent the important local terrain features and land use.

The output from the mid domain CALMET modelling was then used as the initial guess field for the inner domain CALMET modelling. The inner domain encompassed an area of 8 km × 8 km with a horizontal grid spacing of 100 m to adequately represent the important local terrain features and land use. The fine scale local topography and land use information were used in this run to refine the wind field parameters predetermined by the coarse CALMET run. **Table 5** details the parameters used in the CALMET modelling.

The CALMET modelling approach used in this assessment is identified in TRC 2011 as the CALMET Hybrid Mode and is considered to be an ‘advanced model simulation’.

Table 5 Meteorological Parameters used in this Assessment (CALMET v 6.42)

Outer Domain	
Meteorological grid	30 km × 30 km
Meteorological grid resolution	600 m
Surface station data	Penrith Lakes AWS (Station # 67113) Richmond RAAF (Station # 67105) NSW OEH St Marys AQMS
Initial guess filed	3D output from TAPM modelling
Mid Domain	
Meteorological grid	15 km × 15 km
Meteorological grid resolution	300 m
Initial guess field	3D output from ‘outer’ domain model run
Inner Domain	
Meteorological grid	8 km × 8 km
Meteorological grid resolution	100 m
Initial guess field	3D output from ‘mid’ domain model run

4.4 Meteorological Data Used in Modelling

To provide a summary of the meteorological conditions predicted at the Project Site using the methodology described in **Section 4.3**, a single-point, ground-level meteorological dataset was ‘extracted’ from the 3-dimensional dataset at the Project Site and is presented in this section.

4.4.1 Wind Speed and Direction

A summary of the annual wind behaviour predicted at the Project Site for the 2013 calendar year is presented as wind roses in **Figure 5** and an annual wind speed frequency chart is shown in **Figure 6**.

The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from north). The direction of the bar shows the direction from which the wind is blowing. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day. There are times when the wind is calm (defined as being from zero to 0.5 metres/second), and the percentage of the time that winds are calm are shown as a note on the wind rose.

The following description of wind speeds at the Project site references the Beaufort Wind Scale, as outlined in **Table 6**. Use of the Beaufort Wind Scale is consistent with terminology used by the BoM.

Table 6 Beaufort Wind Scale

Beaufort Scale #	Description	m/s	Description on land
0	Calm	0-0.5	Smoke rises vertically
1	Light air	0.5-1.5	Smoke drift indicates wind direction
2-3	Light/gentle breeze	1.5-5.3	Wind felt on face, leaves rustle, light flags extended, ordinary vanes moved by wind
4	Moderate winds	5.3-8.0	Raises dust and loose paper, small branches are moved
5	Fresh winds	8.0-10.8	Small trees in leaf begin to sway, crested wavelets form on inland waters
6	Strong winds	>10.8	Large branches in motion, whistling heard in telephone wires; umbrellas used with difficulty

Source: http://www.bom.gov.au/lam/glossary/beaufort.shtml

Figure 5 shows wind roses for the full year and for each season, and indicates that wind direction is seasonally dependent. The seasonal wind roses indicate that typically:

- In summer, wind speeds range from light to a gentle breeze (between 0.5 m/s and 5.3 m/s). The majority of winds blow from between the north-northeast and south-southwest directions, with very few winds from between the northwest and southwest directions. Calm wind conditions are predicted to occur for approximately 9% of the time during summer.
- During autumn, wind speeds range from light to gentle breeze (between 0.5 m/s and 5.3 m/s). The majority of winds blow from between the north and west-southwest directions, with very few winds from northwest quadrant. Calm wind conditions are predicted to occur for approximately 21% of the time during autumn.
- During winter and spring, wind speeds range from light to gentle breeze (between 0.5 m/s and 8 m/s) and blow from almost evenly from all quadrants with west-southwest winds dominating slightly. Calm wind conditions during winter and spring occur approximately 19% and 14% respectively.

Figure 6 shows a very low frequency of winds greater than 6 m/s.

Figure 5 Annual and Seasonal Wind Roses for the Project Site (CALMET Predictions, 2013)

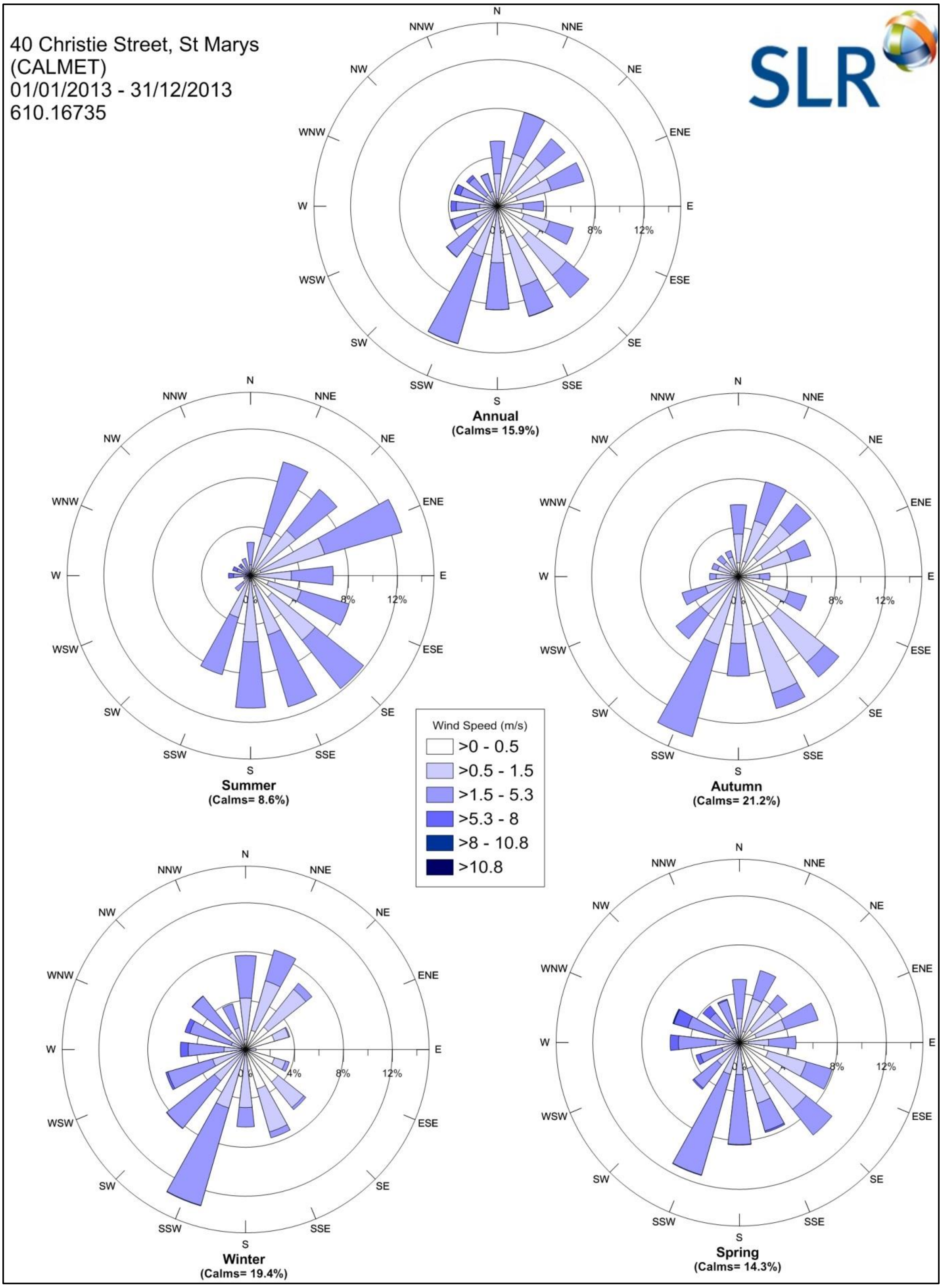
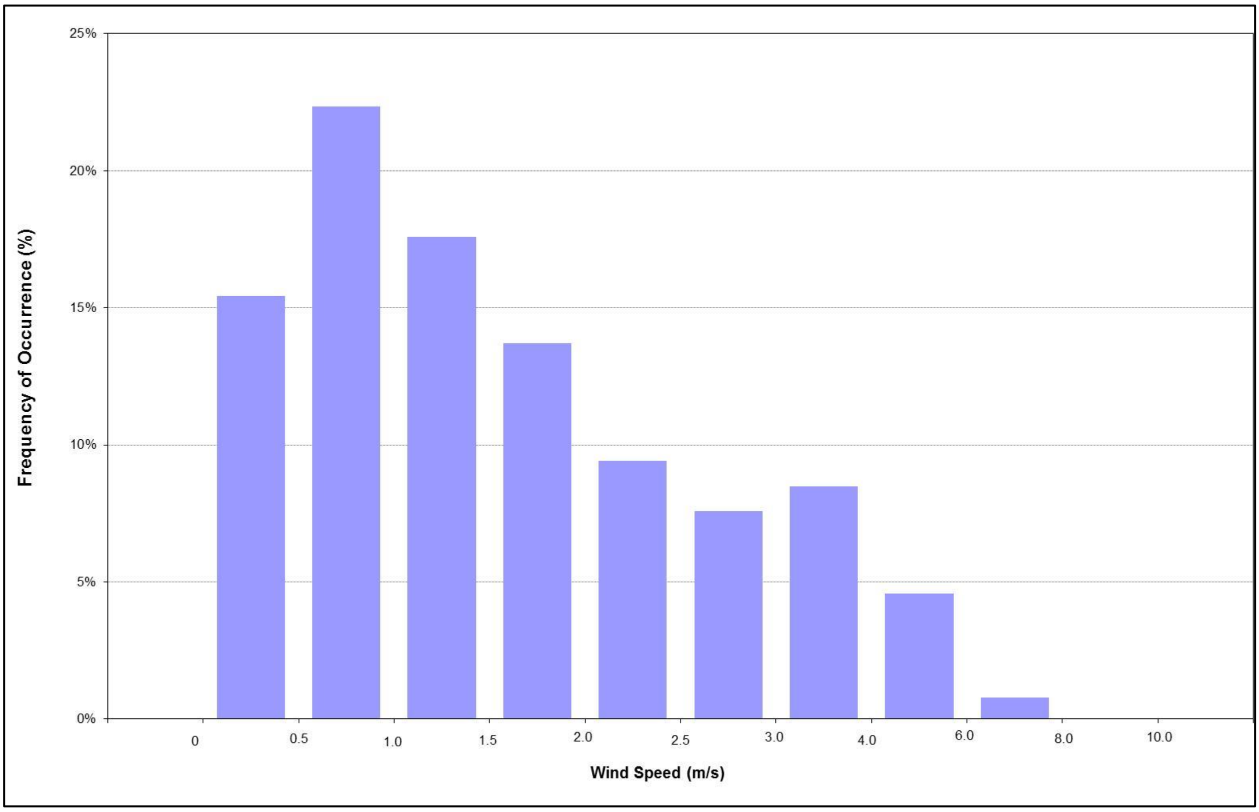


Figure 6 Annual Wind Speed Frequencies at the Project Site (CALMET predictions, 2013)



4.4.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion and therefore vertical mixing. The Pasquill-Turner assignment scheme identifies six Stability Classes, A to F, to categorize the degree of atmospheric stability as follows:

- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions
- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each Pasquill stability class are shown in **Table 7**.

The frequency of each stability class predicted by CALMET for 2013, extracted at the Project site, is presented in **Figure 7**.

The results indicate a high frequency of conditions typical to Stability Class F. Stability Class F is indicative of stable night time conditions, which will inhibit pollutant dispersion resulting in higher pollutant concentrations at ground level at surrounding areas.

Table 7 Meteorological Conditions Defining Pasquill Stability Classes

Surface wind speed (m/s)	Daytime insolation			Night-time conditions	
	Strong	**Moderate**	**Slight**	**Thin overcast or > 4/8 low cloud**	**<= 4/8 cloudiness**
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

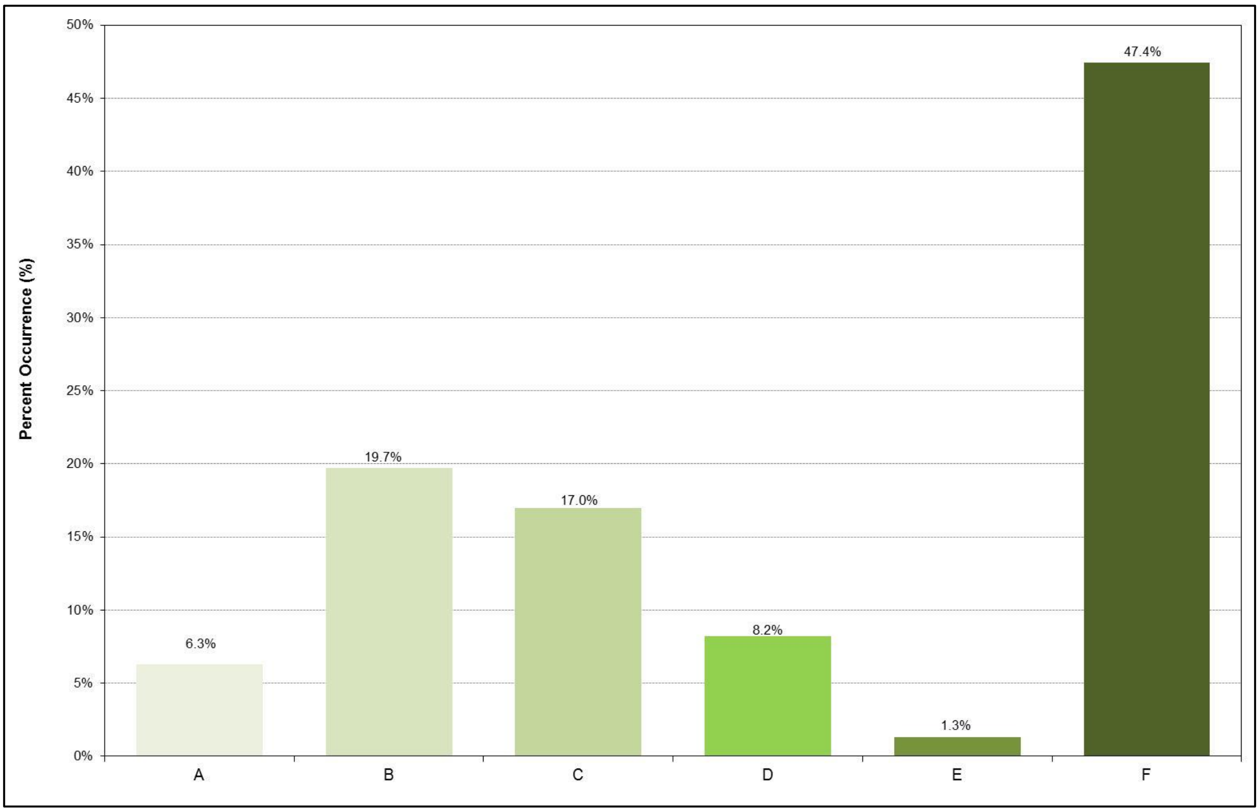
[1] Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.

[2] Night refers to the period from 1 hour before sunset to 1 hour after sunrise.

[3] The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

[4] Source: (Pasquill 1961)

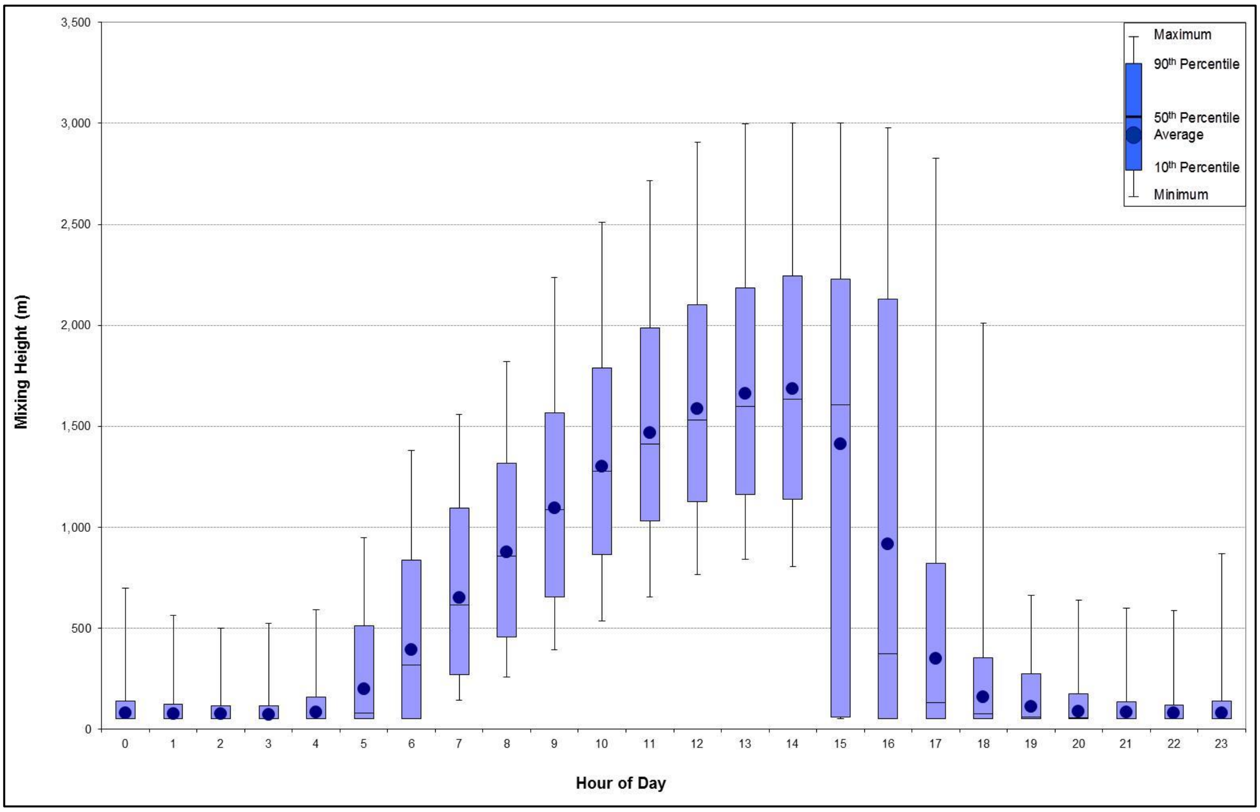
Figure 7 Predicted Stability Class Frequencies at the Project Site (CALMET predictions, 2013)



4.4.3 Mixing Heights

Diurnal variations in maximum and average mixing heights predicted by CALMET at the Project site during the 2013 modelling period are illustrated in **Figure 8**. As would be expected, an increase in mixing height during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure 8 Predicted Mixing Heights at the Project Site (CALMET predictions, 2013)



5 EMISSIONS ESTIMATION

As discussed in **Section 2.3**, gases produced in the AAN mixing tank will be subjected to treatment in a scrubber before the treated air is released into the atmosphere. The calculation of chlorine and sulfur dioxide emissions from the AAN mixing plant are shown in the following sections.

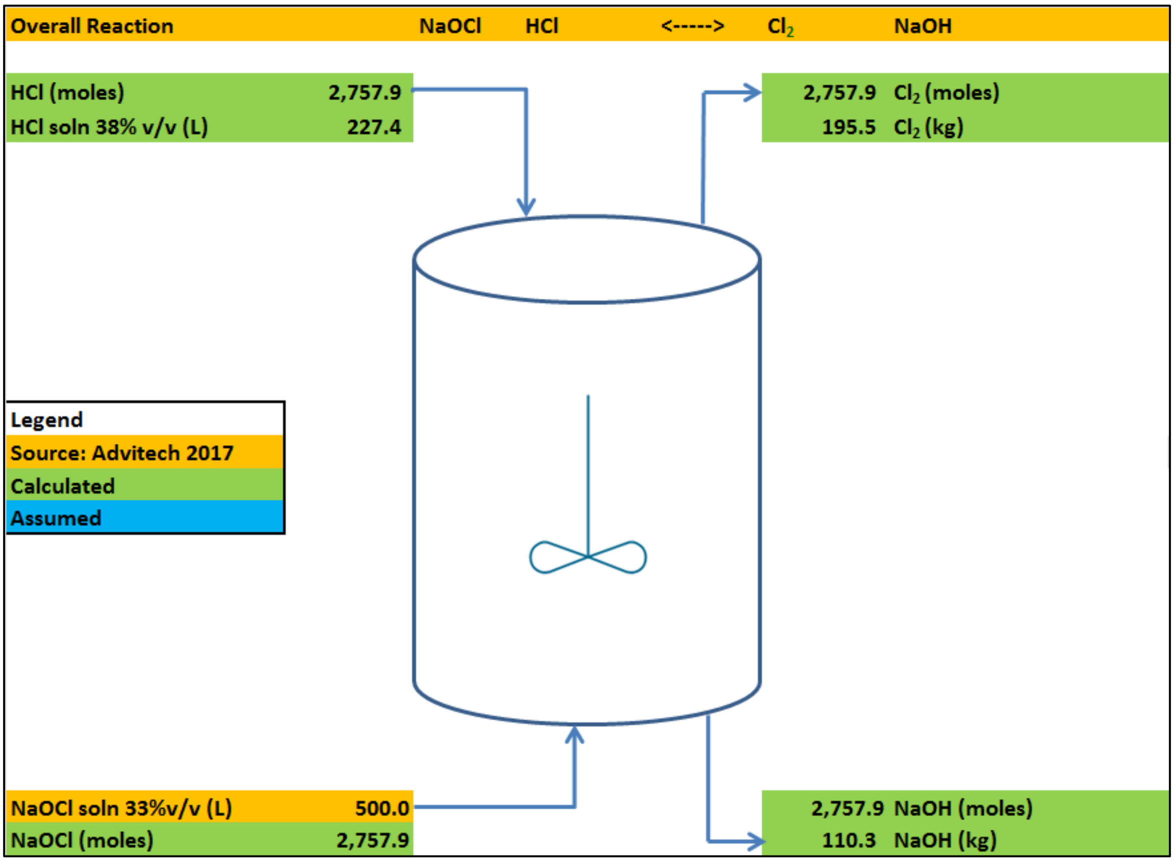
5.1 Chlorine

Based on a maximum input rate of 500 L of NaOCl (33%) solution and **Equation 1**, stoichiometric calculations have been performed to estimate the quantity of hydrochloric acid that will be needed for the required treatment. A summary of the stoichiometric calculations and the mass balance calculations are shown in **Figure 9**. The total amount of chlorine gas released from the neutralisation of one batch is calculated to be 195.5 kg.

The generated chlorine is then subjected to treatment in the scrubber with a solution of sodium hydroxide. The residual chlorine emission rate in the treated gas stream was then calculated based on an assumed 99% efficiency of the scrubbing process. Off-gases from the ANN mixing tank will be passed through a wet scrubber to remove chlorine from the gas stream using a sodium hydroxide solution. Toxfree have committed to the installation of a scrubbing system with a minimum 99% removal efficiency and the neutralisation of hydrochloric acid between the hours of 10:00 am and 1:00 pm only (see **Section 2.4**).

Based on the above, and assuming that a maximum of one batch is processed per hour, a chlorine mass emission rate of 1.95 kilograms per hour (kg/h) (or 0.543 grams per second [g/s]) has been used in this assessment.

Figure 9 Mass Balance Calculations for the AAN Mixing Tank (Chlorine)



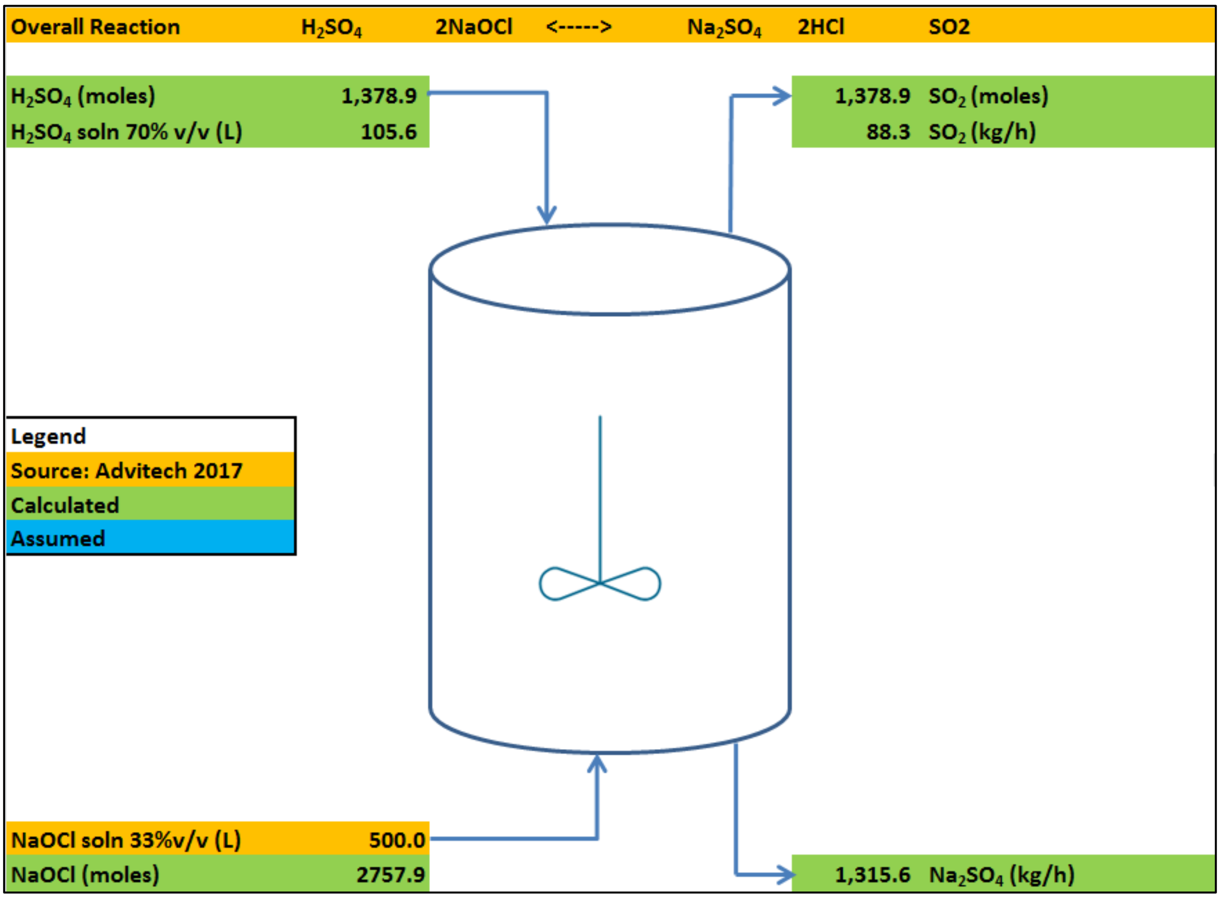
5.2 Sulfur Dioxide

Based on a maximum input rate of 500 L of NaOCl (33%) solution and **Equation 2**, stoichiometric calculations have been performed to estimate the quantity of sulfuric acid that will be needed for the required treatment. A summary of the stoichiometric calculations and the mass balance calculations are shown in **Figure 10**. The total amount of sulfur dioxide gas released from the neutralisation of one batch is calculated to be 88.3 kg.

The generated sulfur dioxide is then subjected to treatment in the scrubber with a solution of sodium hydroxide. The residual sulfur dioxide emission rate in the treated gas stream was then calculated based on an assumed 99% efficiency of the scrubbing process. Off-gases from the ANN mixing tank will be passed through the wet scrubber which has been assumed to have a minimum 99% removal efficiency for sulfur dioxide.

Assuming that a maximum of one batch is processed per hour, a sulfur dioxide mass emission rate of 0.88 kg/h (or 0.245 g/s) has been used in this assessment.

Figure 10 Mass Balance Calculations for the AAN Mixing Tank (Sulfur Dioxide)



6 DISPERSION MODELLING INPUTS

6.1 Source Characteristics

A summary of the source parameters used in the assessment is shown in **Table 8**. The AAN stack location is shown in **Figure 11**.

Table 8 Source Parameters used in the Modelling Study

UTM X (km)[1]	UTM Y (km)[1]	Stack Height (m)[1]	Stack Diameter (m)[1]	Exit Velocity (m/s)[1]	Exit Temperature (°C)[1]	Emission Rate	
						Cl_2 (g/s)[2]	SO_2 (g/s)[3]
293.512	6263.550	15	0.065	10.0	60	0.543	0.245

[1] Source: Advitech 2017

[2] Note: The chlorine emission rate is applicable to hours between 10am to 1pm.

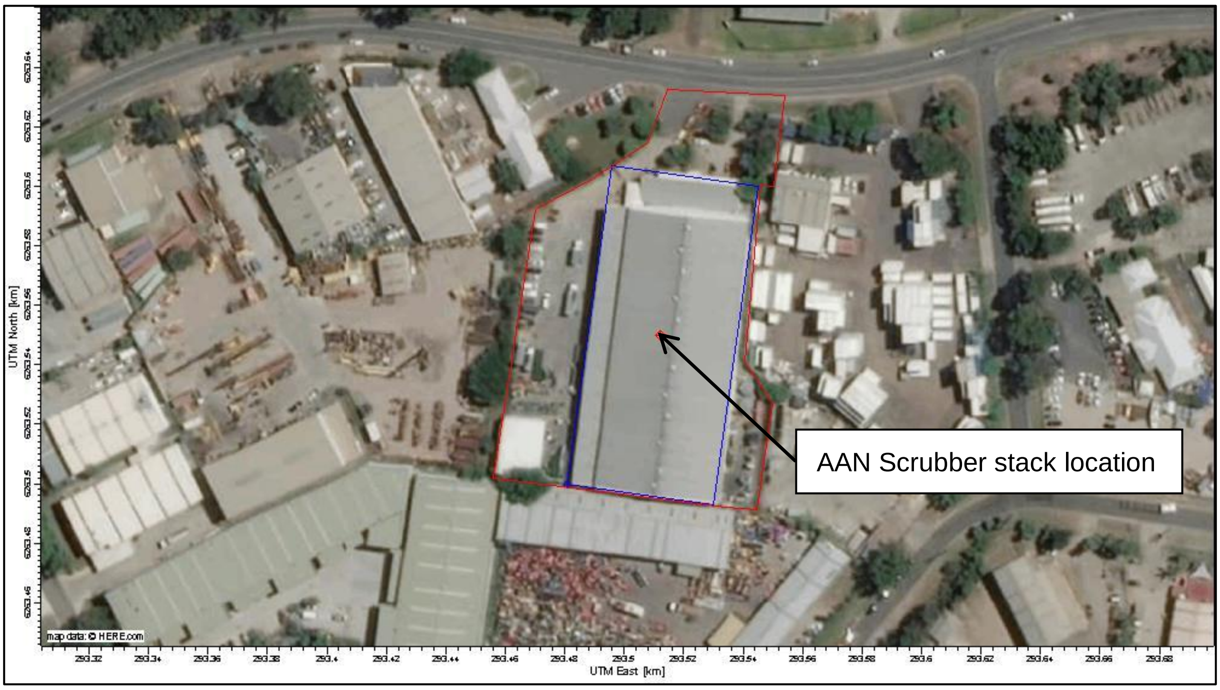
[3] Note: The sulfur dioxide emission rate is applicable to hours between 7am to 1pm.

6.2 Building Wake Effects

Building wake effects have the potential to influence plume behaviour and may result in higher concentrations close to the stack through premature plume grounding, and potentially lower concentrations further away from the stack due to the initial increased mixing effects.

The buildings included in the dispersion modelling are shown in **Figure 11** (blue line). A building height of 12 m was assumed for this assessment.

Figure 11 Building Layout included in the Dispersion Modelling



6.3 Background Air Quality Data

6.3.1 Chlorine

The NSW Office of Environment and Heritage (OEH) operate a comprehensive air quality monitoring network to provide the community with accurate and up-to-date information about air quality.

However chlorine concentrations are not monitored as part of the monitoring activities.

The following sources have been identified from a desktop mapping study of sites regulated by the NSW EPA and those that are required to report under the provisions of *Protection of the Environment (General) Regulation 2009* and with information stored in the National Pollutant Inventory (NPI).

The NPI database provides details on industrial emissions of over 4,000 facilities across Australia. The requirement to return emissions estimates to the NPI is determined by the activities/processes being undertaken at the facility, and also whether those processes exceed process-specific thresholds in terms of activity rates (i.e. throughput and/or consumption). A search of the NPI database for the region that the Project Site is located in, showed that postcode 2760 covers the full Project Area, as shown in **Figure 12**.

Figure 12 Post Code Areas for the Project Site and Identified NPI Reportable Industries

Source: http://www.aus-emaps.com/postcode_finder.php

Sources of NPI reportable airborne pollutants within the vicinity of the Project Site include the following industries (see **Figure 12**):

- (A) St Marys Advanced Water Treatment Plant
- (B) St Marys Sewage Treatment Plant
- (C) Chemcolour Industries Australia Pty Ltd

However chlorine emissions were reported from sources 'A' and 'B' only. A summary of the chlorine emissions data for the region for the period 1 July 2015 to 30 June 2016 is shown in **Table 9**. As shown in **Table 9,** chlorine emissions from sources 'A and 'B' are minimal and would not be expected to result in measureable background levels in the vicinity of the Project site. Hence for the purpose of this assessment, the background concentrations of chlorine are assumed to be zero

Table 9 Total Chlorine Emissions (Air) for Postcode 2760 (1 July 2015 – 30 June 2016)

Pollutant	Source A	Source B	Units
Chlorine	146	228	kg/year

Source: NPI Database, available online, www.npi.gov.au

6.3.2 Sulfur Dioxide

Background air quality data for sulfur dioxide has been obtained from the Vineyard and Richmond air quality monitoring stations (AQMS) located approximately 12 km northeast and 14.5 km northwest of the Project site respectively.

The annual average and daily maximum 1-hour average sulfur dioxide concentrations recorded by the Vineyard and Richmond AQMS during the year 2013 are presented in **Table 10**. As prescribed by the Approved Methods, it is standard practice to use background monitoring datasets taken from the same year as the meteorological dataset chosen for use in the dispersion modelling assessment, in this case 2013.

Table 10 Sulfur Dioxide Background Concentrations (2013)

Averaging Period	Vineyard AQMS	Richmond AQMS	Units
10 minute average[1]	41.5	37.2	µg/m^3
Daily maximum 1-hour average	29	26	µg/m^3
Maximum 24-hour average	7.9	5.2	µg/m^3
Annual average	0.9	0.7	µg/m^3

[1] Calculated from the 1-hour average data using the Turner equation (Turner 1974)

It is noted that the sulfur dioxide concentrations recorded at Vineyard AQMS are higher than those recorded at Richmond AQMS.

For the purpose of this assessment, the concentrations recorded in 2013 by the Vineyard AQMS have been used to provide conservative estimates of background SO_2 concentrations in the vicinity of the Project site.

7 RESULTS AND DISCUSSION

7.1 Chlorine

Table 11 presents the 1-hour average 99.9th percentile, ground level chlorine concentrations predicted by the dispersion modelling at each of the sensitive receptors, using the emission rates calculated in **Section 5**. The 99.9th percentile 1-hour average and maximum 8-hour average results for the site boundary locations are compared to the 1-hour average criterion for chlorine set by NSW EPA in the Approved Methods and the WES-TWA respectively, given that the area surrounding the site is industrially zoned. However, as noted in **Section 3.3**, it is recognised that the criterion in the Approved Methods applies at and beyond the boundary of the facility regardless of the surrounding land use.

As discussed in **Section 6.3.1**, the background chlorine concentration has been assumed to be zero.

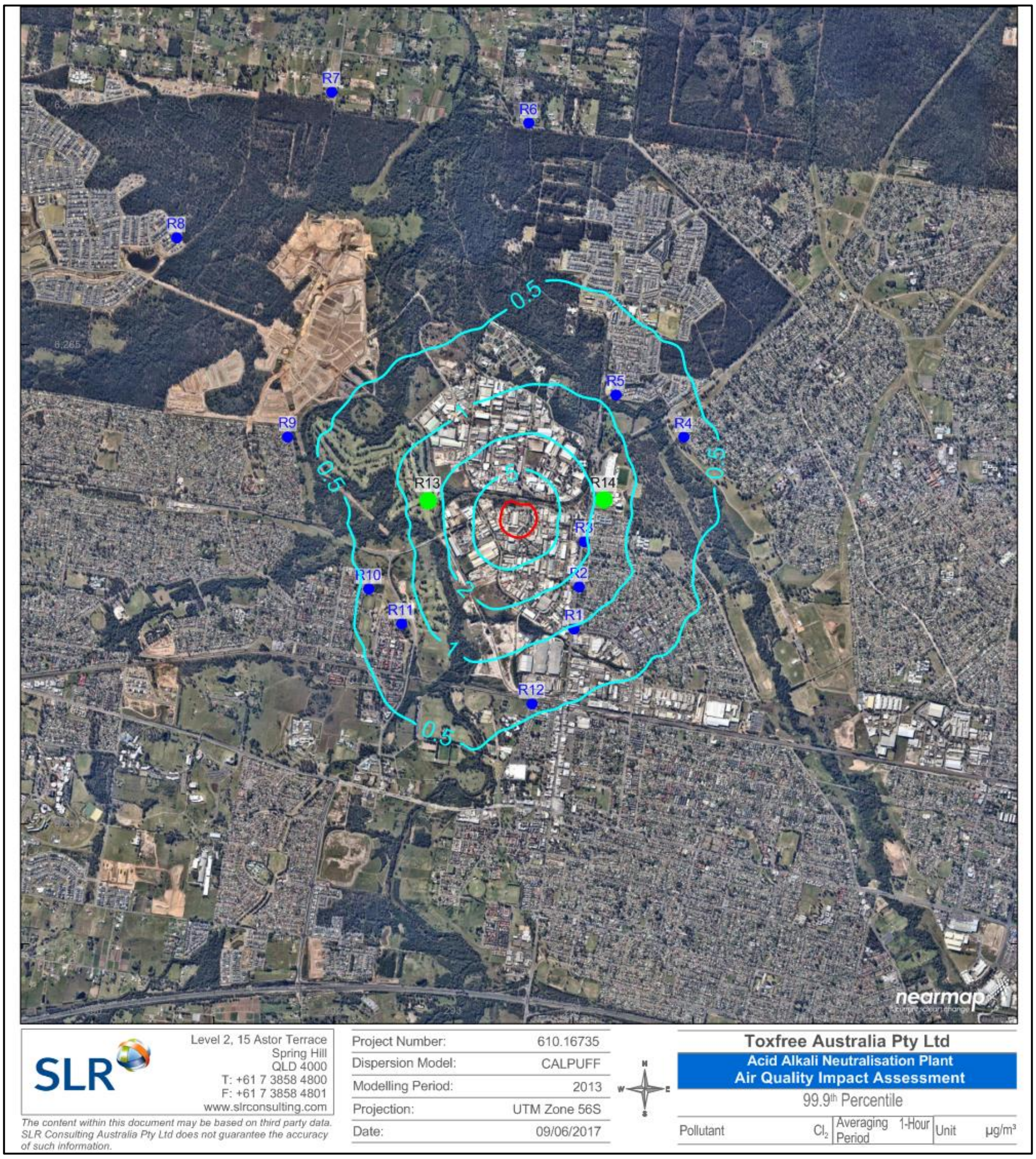
Table 11 Dispersion Modelling Predicted Chlorine Concentrations

Receptor	**Predicted Cl_2 Concentration (µg/m^3)**	
Residential and Recreational Receptors	**99.9th Percentile 1-Hour Average**	
R1 - Residential	1.0	
R2 – Residential	1.5	
R3 – Residential	2.1	
R4 – Residential	0.6	
R5 – Residential	0.9	
R6 – Residential	0.2	
R7 – Residential	0.1	
R8 – Residential	0.1	
R9 – Residential	0.4	
R10 – Residential	0.6	
R11 – Residential	0.8	
R12 – Residential	0.5	
R13 – Recreational (Dunheved golf course)	1.5	
R14 – Recreational (St Marys rugby league club)	1.6	
Criterion	**50**	
Industrial Area	**99.9th Percentile 1-Hour Average**	**Maximum 8-Hour Average**
Highest along northern boundary	204	76
Highest along eastern boundary	665	281
Highest along southern boundary	228	91
Highest along western boundary	256	105
Criteria	**50**	**3,000 (WES-TWA)**

As shown in **Table 11**, the 99.9th percentile 1-hour average chlorine concentrations predicted at the identified sensitive receptor locations are well below the Project criterion of 50 µg/m^3. The maximum concentration predicted for these receptors occurs at receptor ‘R3’, representing approximately 4% of the Project criterion. For the boundary receptors, it was predicted that the 99.9th percentile 1-hour average concentrations exceed the NSW EPA ambient air quality criterion. However it is noted that the maximum 8-hour average concentrations predicted along the Project site boundary and within the St Marys industrial area comply with the TWA of 3,000 µg/m^3.

The contour plot of ground level 99.9th percentile chlorine concentrations predicted for a 99% efficient scrubber is shown in **Figure 13**. The contour plot does not reflect chlorine concentrations occurring at any particular instant in time, but rather illustrates a compilation of the 99.9th percentile (9th highest) chlorine concentrations predicted at all locations downwind, taking into account all combinations of meteorological conditions modelled, across the entire year. It is noted from the contour plots that the 1-hour average assessment criterion of 50 µg/m^3 is only exceeded within a localised area beyond the Project Site boundary.

Figure 13 Predicted Ground Level 99.9th Percentile Chlorine Concentrations



The results predicted from the dispersion modelling should be viewed as conservative due to a number of conservative assumptions adopted in this assessment (eg, complete reaction of the full 500 L of alkali liquid waste, solution percentage i.e if the sodium hypochlorite solution is less than 33% (v/v), then lesser mass of gas will be released etc). Notwithstanding above, it is recommended that the chlorine gas released into atmosphere from the AAN process, is subjected to additional treatment before or after the wet scrubber treatment. Based on the results of the modelling, the maximum allowable chlorine emission rate to achieve compliance with the NSW EPA ambient air quality criterion at the site boundary is 0.04 g/s (0.15 kg/hr).

7.2 Sulfur Dioxide

Table 12 presents the maximum 1-hour average, 24-hour average and annual average sulfur dioxide concentrations predicted by the dispersion modelling at each of the nominated residential/recreational receptors using the sulfur dioxide emission rate presented in **Section 6.3.2**.

The maximum cumulative concentrations include the background concentrations recorded by the Vineyard AQMS in 2013 as discussed in **Section 6.3.2**.

Table 12 Predicted Maximum Sulfur Dioxide Concentrations

Receptor ID	10-Minute Average		1-Hour Average		24-Hour Average		Annual Average	
	Maximum Increment	Maximum Cumulative	Maximum Increment	Maximum Cumulative	Maximum Increment	Maximum Cumulative	Maximum Increment	Maximum Cumulative
	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)
R1	9.2	38.2	6.5	48.0	0.4	8.3	<0.1	<1.0
R2	9.5	38.5	6.6	48.1	0.3	8.2	<0.1	<1.0
R3	10.4	39.4	7.3	48.8	0.4	8.3	<0.1	<1.0
R4	6.5	35.5	4.5	46.0	0.3	8.2	<0.1	<1.0
R5	7.8	36.8	5.4	46.9	0.3	8.2	<0.1	<1.0
R6	1.4	30.4	1.0	42.5	0.1	8.0	<0.1	<1.0
R7	0.2	29.2	0.2	41.7	<0.1	<8.0	<0.1	<1.0
R8	0.2	29.2	0.1	41.6	<0.1	<8.0	<0.1	<1.0
R9	1.9	30.9	1.3	42.8	0.1	8.0	<0.1	<1.0
R10	3.2	32.2	2.3	43.8	0.1	8.0	<0.1	<1.0
R11	4.7	33.7	3.3	44.8	0.2	8.1	<0.1	<1.0
R12	6.7	35.7	4.7	46.2	0.2	8.1	<0.1	<1.0
R13	8.9	37.9	6.2	47.7	0.3	8.2	<0.1	<1.0
R14	13.7	42.7	9.6	51.1	0.5	8.4	<0.1	<1.0
Criteria		**712**		**570.0**		**228.0**		**60.0**

The maximum cumulative 10-minute average, 1-hour average, 24-hour average and annual average sulfur dioxide concentrations are predicted to be below the NSW EPA criteria of 712 µg/m³, 570 µg/m³, 228 µg/m³ and 60 µg/m³ respectively at all of the sensitive receptors.

The corresponding contour plots for maximum cumulative 10-minute average, 1-hour average, 24-hour average and annual average sulfur dioxide concentrations are shown in **Figure 14**, **Figure 15**, **Figure 16** and **Figure 17** respectively.

Figure 14 Predicted Ground Level Maximum 10-Minute Average Sulfur Dioxide Concentrations

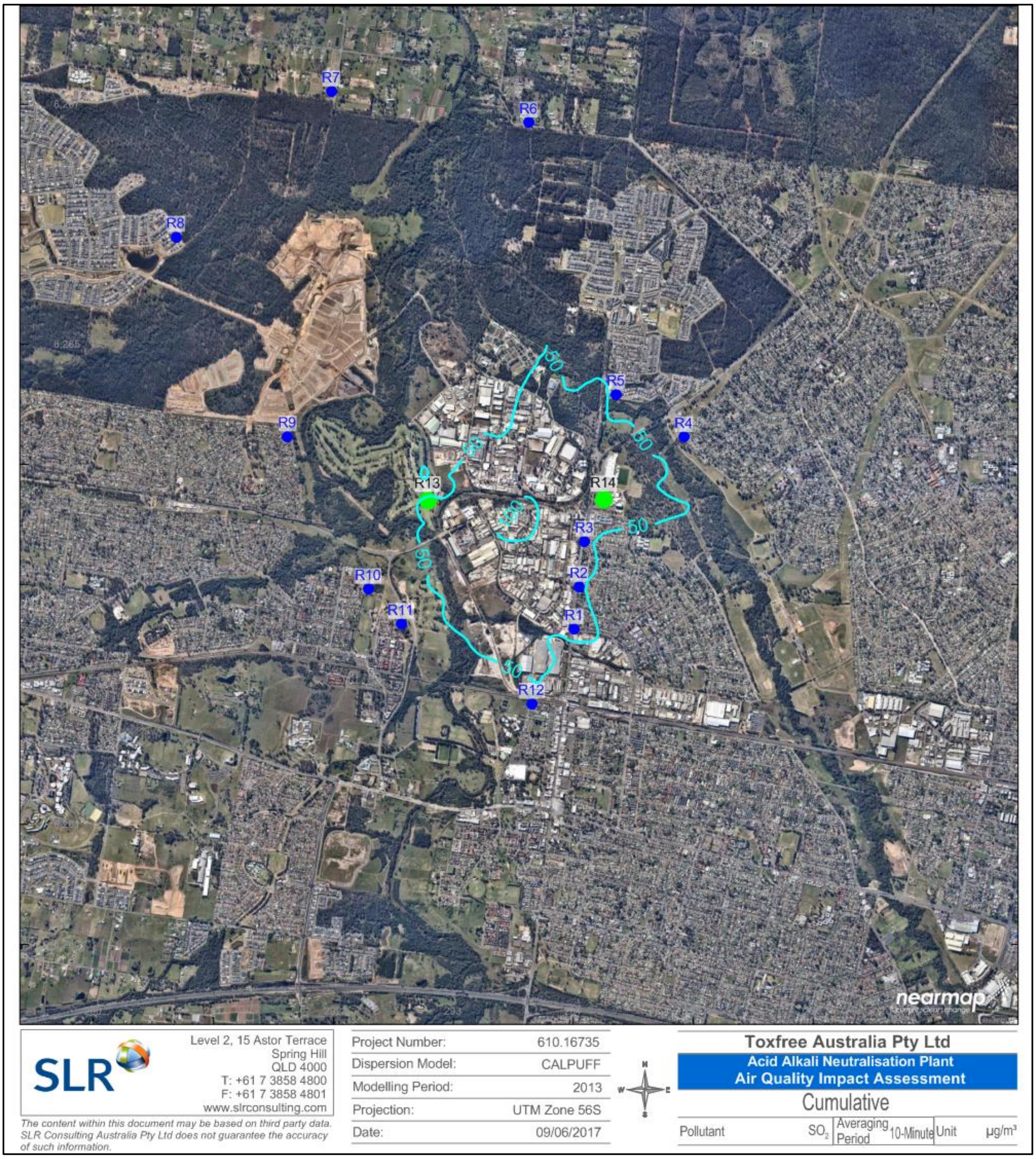


Figure 15 Predicted Ground Level Maximum 1-hour Average Sulfur Dioxide Concentrations

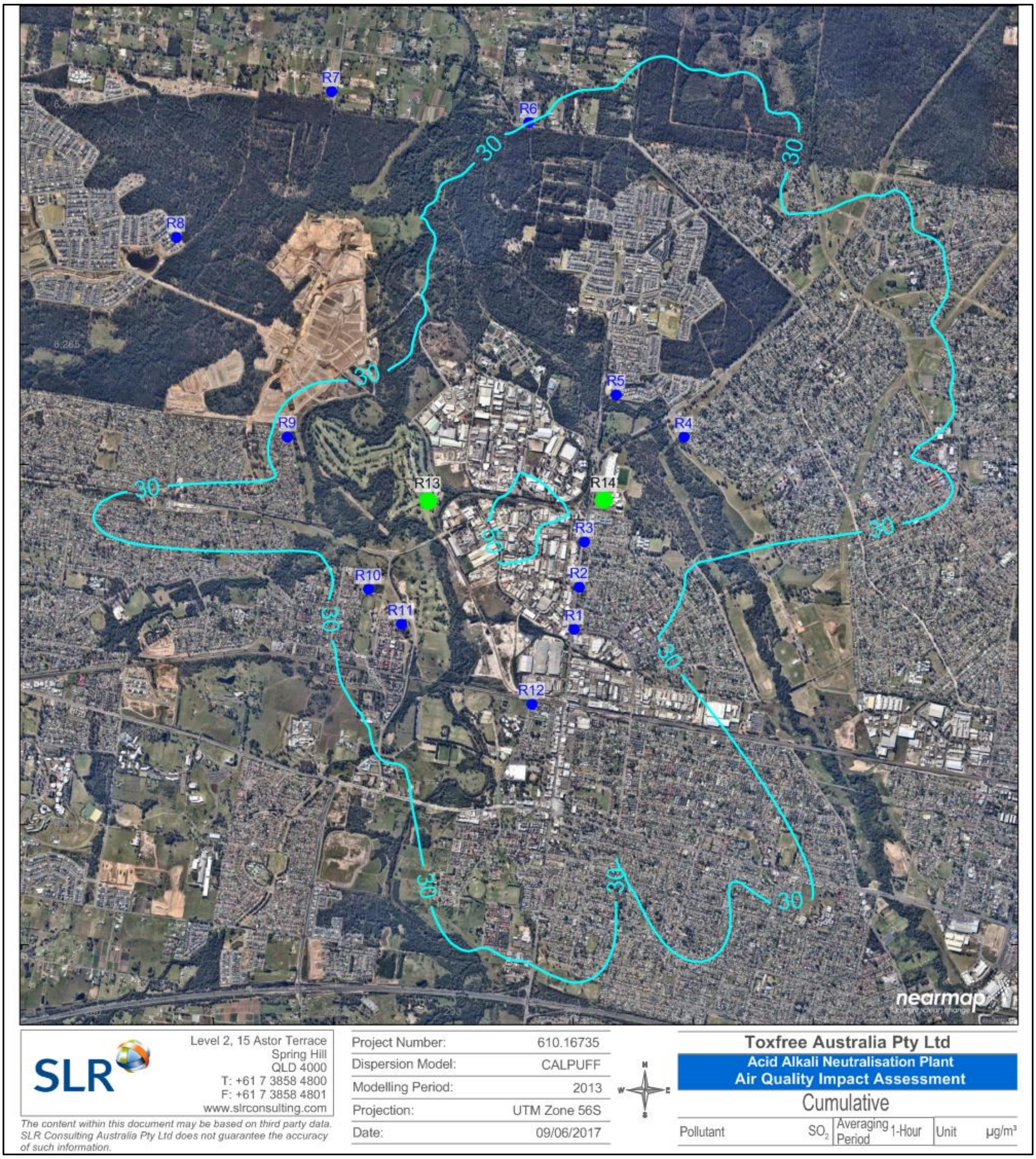


Figure 16 Predicted Ground Level Maximum 24-hour Average Sulfur Dioxide Concentrations

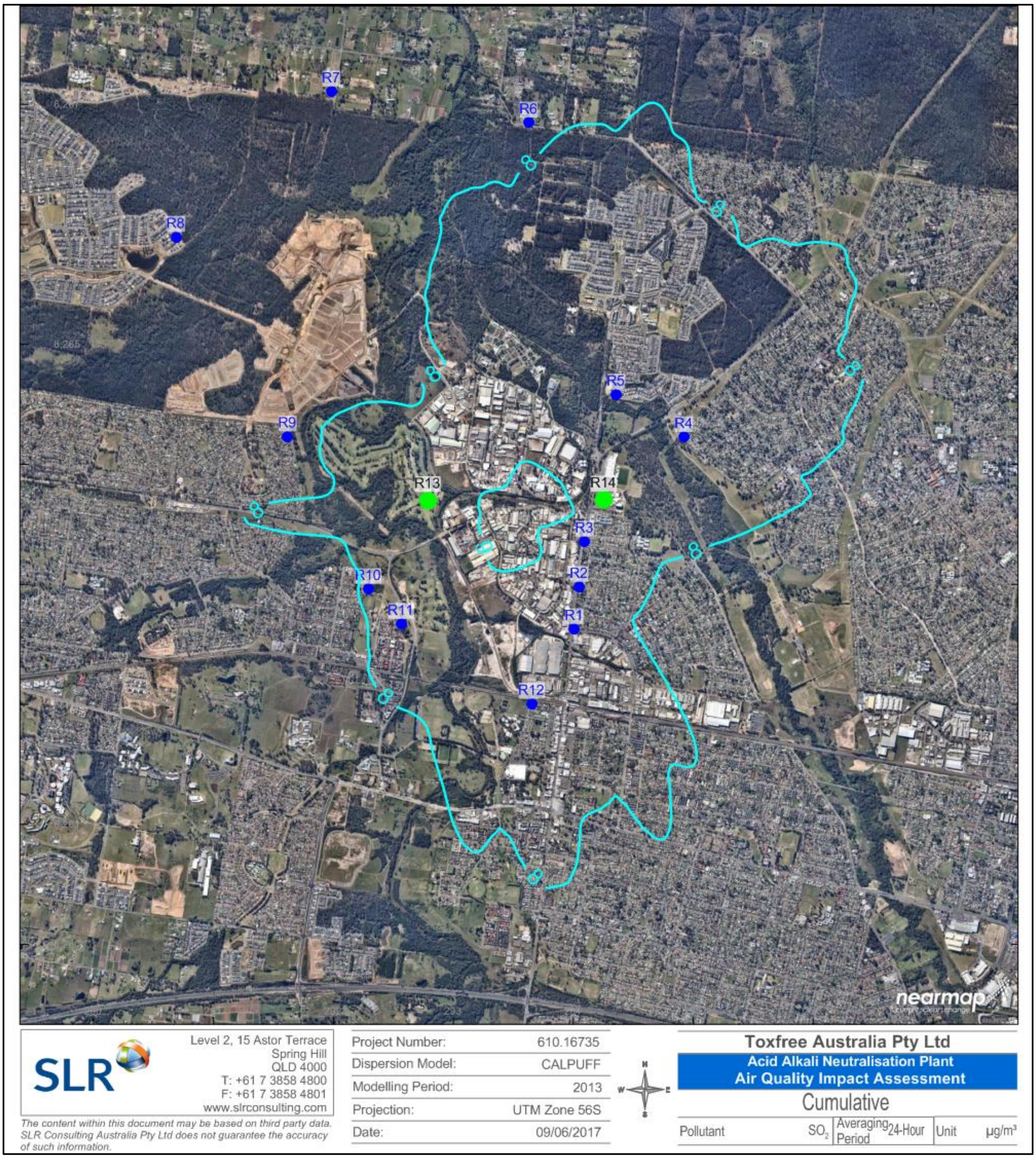
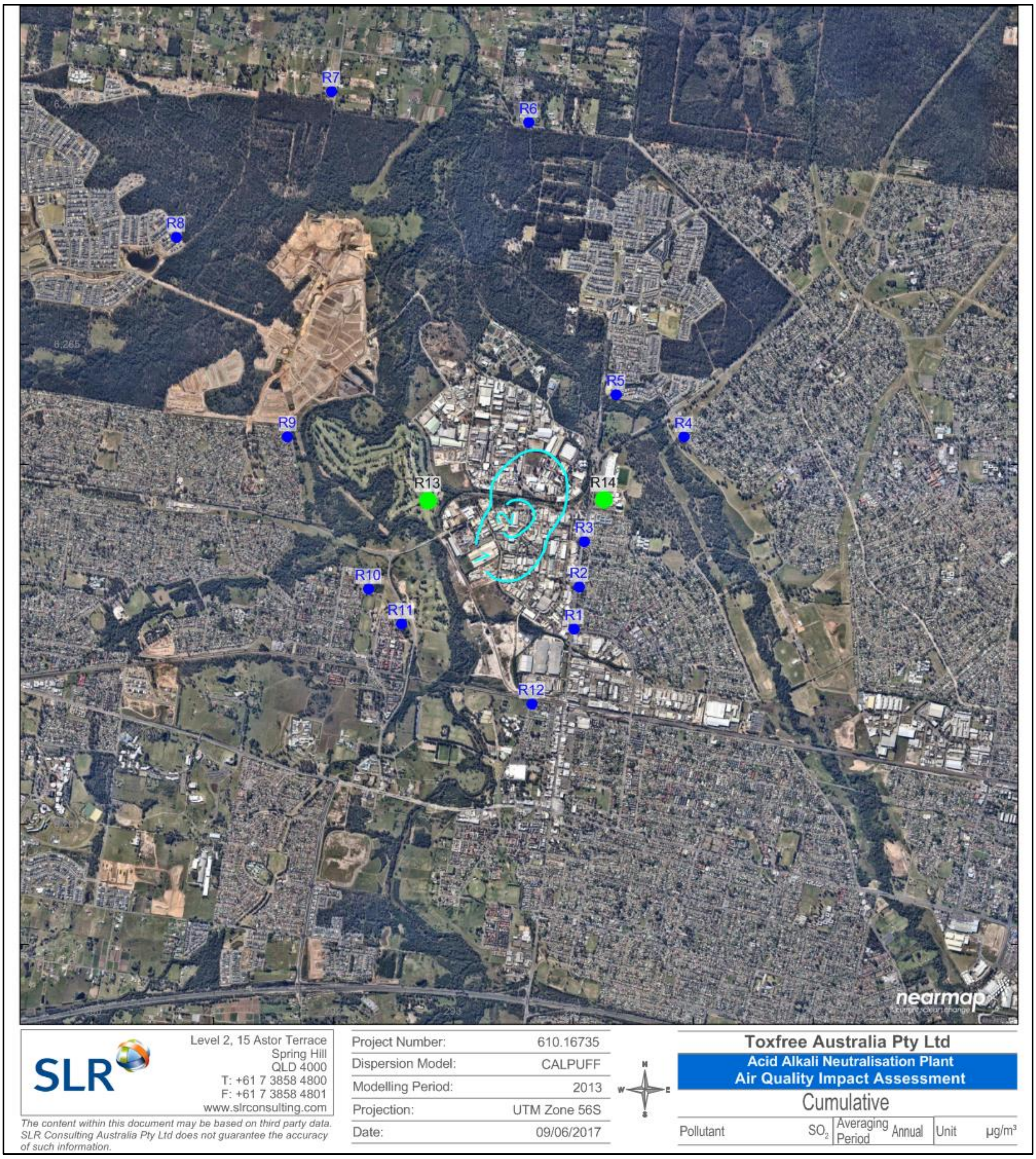


Figure 17 Predicted Ground Level Annual Average Sulfur Dioxide Concentrations



8 CONCLUSIONS

SLR Consulting Australia Pty Ltd (SLR) was commissioned by Toxfree Australia Pty Ltd (Toxfree) to perform an AQIA to assess impacts from the proposed AAN plant to be located within their chemical waste storage and treatment facility at 40 Christie Street, St Mary's, NSW.

The aim of this assessment was to quantify the air quality impacts due to residual air emissions from the AAN plant. This AQIA was completed in accordance with the Approved Methods using the CALPUFF model.

Stoichiometric calculations were performed to estimate the quantity of hydrochloric acid and sulfuric acid that will be needed for the required neutralisation. The residual chlorine and sulfur dioxide emission rates were then calculated based on the input load and an assumed 99% efficiency of the scrubbing process.

In order to assess the background chlorine concentration in the region, a number of industrial facilities with the potential to have a cumulative impact on the local airshed were identified. However based on the minimal chlorine emissions from surrounding industries, the background chlorine concentrations were assumed to be zero.

In order to assess the background sulfur dioxide concentration in the region, data was sourced from the Vineyard AQMS, located approximately 12 km northeast of the Project Site. The maximum daily 1-hour average and 24-hour average concentrations recorded during 2013 (concurrent with the meteorological data used in the modelling) were conservatively adopted as constant background concentrations for this assessment.

The predicted results indicate that for chlorine, the 1-hour average 99.9th percentile (9th highest) concentrations are well below the NSW EPA ambient air quality criterion of 50 $\mu g/m^3$ at all sensitive receptor locations identified in the vicinity of the Project Site. However the NSW EPA ambient air quality criterion was predicted to be exceeded at the boundary of the Project Site. As the Project site is located within an industrial area, the model predictions were also assessed against the 8-hour average WES-TWA of 3,000 $\mu g/m^3$. The maximum 8-hour average predictions given by dispersion modelling at the Project site boundary complied with the WES-TWA, with the highest concentrations predicted along the eastern boundary of the Project Site being 9% of the WES-TWA.

It is recommended that the chlorine gas released into atmosphere from the AAN process is subjected to additional treatment before or after the wet scrubber treatment.

For sulfur dioxide, the predicted results indicate that the maximum 10-minute average, 1-hour average, 24 hour average and annual average concentrations are well below the respective NSW EPA ambient air quality criteria at all sensitive receptor locations identified in the vicinity of the Project Site.

9 REFERENCES

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