

Prepared for

# Shell Refining (Australia) Pty Ltd

## Response to Submissions

### Fluidised Catalytic Cracking Unit Reactor and Regenerator Rejuvenation Project



Final

November 2007

Reference: 340173



# CH2MHILL



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## 1 Introduction

An Environmental Assessment (EA) was prepared for Shell Refining (Australia) Pty Ltd (Shell) to assess the environmental impacts of the proposed upgrade to the Reactor and Regeneration Unit, located within the Fluidised Catalytic Cracking Unit (FCCU) complex at Shell's Clyde Refinery, Rosehill, NSW.

The EA was prepared in accordance with the *Environmental Planning and Assessment Act, 1979* (the EP&A Act) and the *Environmental Planning and Assessment Regulation, 2000* (the EP&A Regulation).

This Response to Submissions document supports the EA of the proposed upgrade to the Reactor and Regeneration Unit by providing a response to matters raised during the public exhibition period.

### 1.1 Site Location

Clyde Refinery is located at Camellia, Sydney. The site is described as Lot 1 DP 109739, Lot 2 DP 224288, Lot 101 DP 809340, Lot 398 DP 41324 and Lot 1 DP 383675 (PCC, Section 149 Planning Certificate, November 2003). The FCCU is located within Lot 1 DP 109739. The Refinery site has a road frontage to Grand Avenue, Durham Street, Devon Street and Colquhoun Street and is bounded to the north-east and south-east by the Parramatta River and Duck River respectively. The FCCU is located on the southern half of the Refinery south of Tank Farm C (see **Figure 1.1**).

### 1.2 Outline of the Project

The purpose of the Project is to replace critical components of the FCCU, that is, the reactor vessel and the stripper vessel, which are approaching the end of their design life. The Project would also involve the replacement of other minor components of the Unit also approaching the end of their design life, including the cyclones located inside the regenerator and miscellaneous large bore piping and control valves (refer to **Figure 1.2**).

The Project is essentially a "like for like" replacement of part of the existing FCCU and would not take up any additional area within the Refinery. The throughput of the Unit and operation of the existing FCCU would not change, and the use of modern equipment as part of the replacement would result in beneficial environmental effects, including a significant reduction in energy consumption as well as a reduction in hydrocarbon inventory within the system, i.e. reduction in hazards as well as improved Unit efficiency.

The secondary part of the project aims to increase the coke burning capacity of the regenerator to allow increased conversion from the FCCU. This would result in improved process efficiency therefore producing a higher yield of product for the same feed intake. This is achieved through improved cyclone design for the

regenerator and 4th stage separator, which are requiring replacement as end of life.

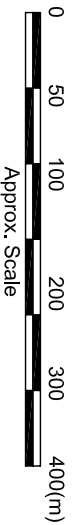
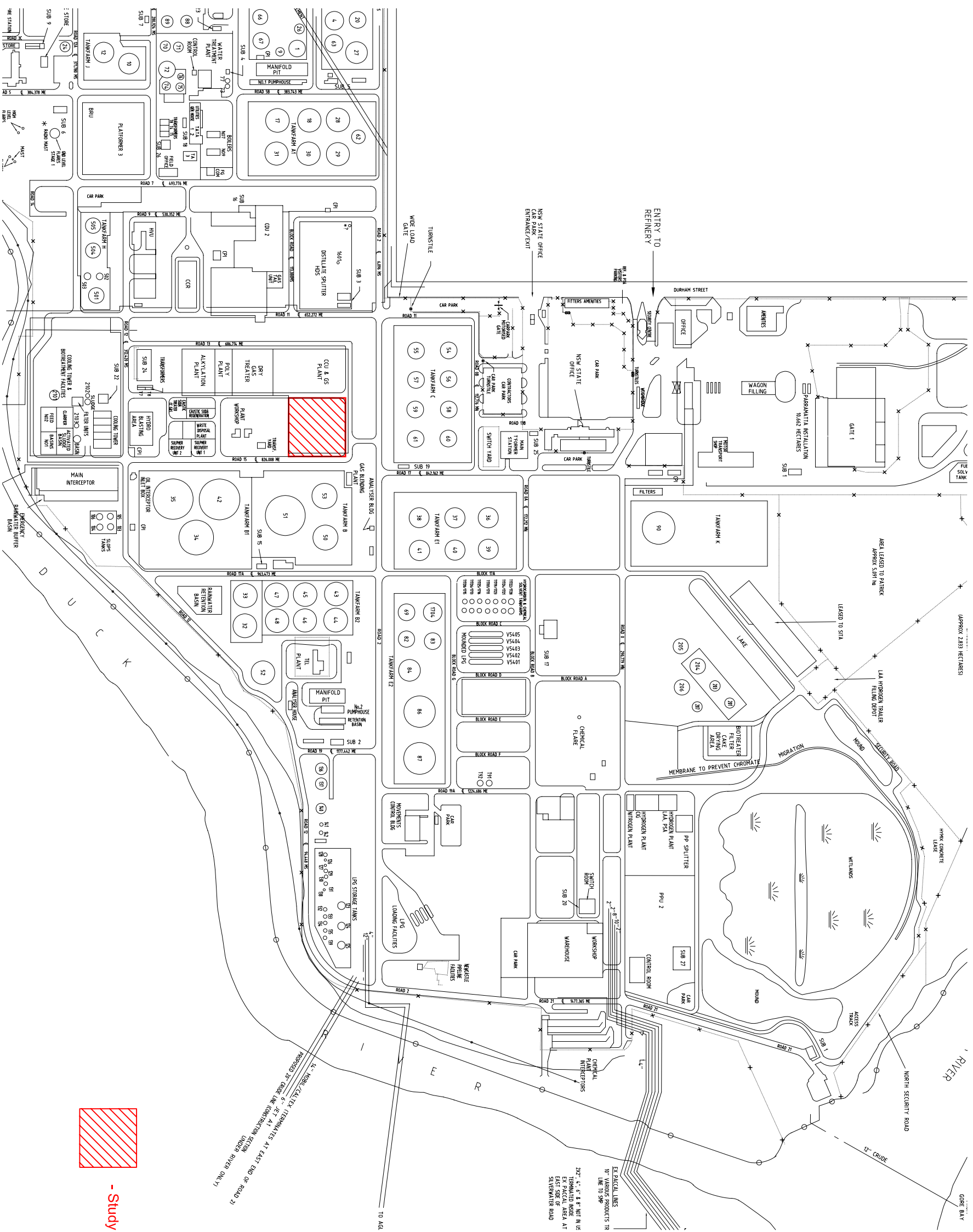
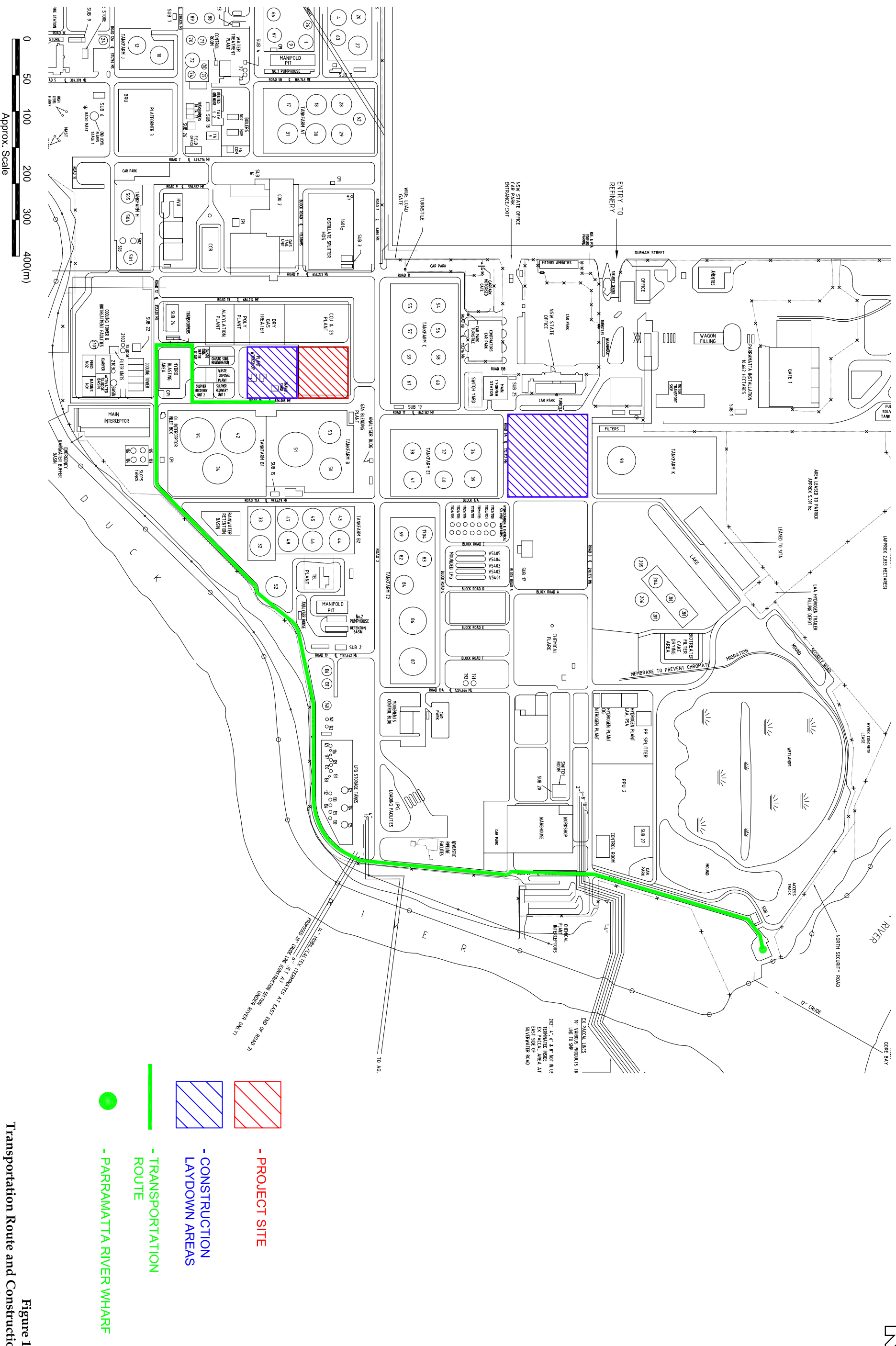


Figure 1-1  
Site Layout Plan



The Project would have an estimated capital investment value of approximately AUD\$77.77 million, with a significant percentage of that cost associated with the new reactor and stripper.

### **1.3 Public Exhibition**

The exhibition period for public comment on the EA was undertaken for a total of 32 days from Thursday the 27 September 2007 to Monday 29 of October 2007.

An advertisement detailing the release and availability of this document was placed in the Parramatta Advertiser on the 26 of September 2007. A copy of this public notice and invitation to comment was available at Shell's website.

The document was also made available for public viewing at three public localities, including:

- Department of Planning (DoP): Information Centre, 23-33 Bridge Street, Sydney
- Parramatta City Council, 30 Darcy Street, Parramatta
- Nature Conservation Council: Level 2, 301 Kent St, Sydney.

Additionally, a total of 16 hard copies and 20 electronic copies were provided to eight agencies, as follows:

- DoP
- Parramatta City Council
- Nature Conservation Council
- Department of Water and Energy (DoWE)
- Department of Environment and Climate Change (DECC)
- Sydney Water Corporation
- NSW Maritime
- NSW Fire Brigades.

A total of three submissions were received by DoP during the public comment period. Additional comments have been sought from NSW Maritime and NSW Fire Brigade.

**Table 1-1** below is a summary of the submissions received and a response.

### **1.4 Updated Reporting – Air Quality**

During the exhibition period, it was discovered that some data used for the Air Quality Assessment had been inadvertently included into the cumulative assessment. The air quality report was subsequently updated (see **Appendix A**) and submitted to DoP and DECC with an explanation. It is noted that SO<sub>x</sub> concentrations are still well below the criteria, and that there is no need to change the findings of the Report or the mitigative measures.

**Table 1-1 Summary of issues raised in submissions and proposed response**

Authority	Issue Raised	Response
Department of Environment and Climate Change (DECC)	Air Quality	<p>SO<sub>2</sub> impacts on the community</p> <p>As discussed in <b>Section 8</b> of the EA, Shell commits to 12 months of monitoring and evaluation of SO<sub>x</sub> emissions, with SoC updated in <b>Appendix B</b> to reflect further detail requested by DECC. It is noted that our commitments at present extend to the proposed PRP 17 only. If the results from PRP indicate exceedances, Shell will commit to further PRPs to mitigate these impacts, with these PRPs to be agreed in consultation with DECC at the time of completing PRP 17.</p>
	Air Quality	<p>Group 6 Concentration Limits for Point 9</p> <p>It is noted that Type 1 and 2 substances (in aggregate) are not listed under schedule 3 of the POEO Clean Air Regulations for Petroleum Refining Activities. Further, detailed air modelling and stack monitoring indicates that Shell is within compliance limits and would not impact on sensitive receptors for these pollutants.</p> <p>All other limits with respect to nitrogen oxides and solid particles as per Group 6 for Petroleum Refining Activities are accepted.</p> <p>It is also noted that the requirement for an “SO<sub>2</sub>/SO<sub>3</sub> concentration limit” is dependant upon the outcome of the air monitoring program; therefore, the inclusion should be subject to this monitoring report. It is also noted that SO<sub>2</sub>/SO<sub>3</sub> concentration limits are not listed under schedule 3 of the POEO Clean Air Regs for Petroleum Refining Activities. On this basis, Shell does not see the need for these substances to be included at this stage, and support the PRP approach as a mechanism for including when the issue and limits are understood.</p>

Authority	Issue Raised	Response
Noise	Noise generated by the Fluidised Catalytic Cracking Unit reactor and Regenerator shall not exceed 35 dB(A) LAeq,15minute during the day, evening and night at any residence within a residential area.	<p>The Noise Assessment carried out by Bridges Acoustics indicates that Shell will comply with this condition (See <b>Table 5</b> in the Noise Assessment).</p> <p>Further, it is difficult to differentiate the FCCU complex from the rest of the site and hence the current site approach as detailed in PRP12 of Shell's licence, is considered adequate.</p>
	Construction and Demolition Activities shall be limited to the hours 7am to 6pm Monday to Friday and 8am to 1pm Saturdays and at no other times without the prior approval of the DECC unless inaudible at any noise sensitive location not associated with the development.	<p>As discussed in the EA in <b>Section 6</b>, preconstruction will occur during the normal working hours. However, during the turnaround, activities will be on a 24 hour basis, and all potentially noisy activities will be limited to day time. The site has a good history with respect to minimal noise complaints and modelling shows that noise criteria is unlikely to be exceeded. As such, for the 24hour construction period during the turnaround, Shell would undertake noise monitoring only as a response to community complaints, per Section 11.1.1. of the NSW Industrial Noise Policy.</p> <p>It is acknowledged as a requirement by DECC that Shells' activities should be inaudible at any noise sensitive location outside the standard construction hours.</p>
Waste Management	Waste management assessment not included in the EA	<p>Shell has prepared a waste management plan in accordance with the requirements of the <i>Protection of the Environment Operations Act, 1997</i> and the Environmental Guidelines: Assessment, classification and management of liquid and non-liquid wastes (2004) – see SoCs – <b>Appendix B</b>. It is noted this waste management plan is for both the project and the maintenance turnaround, which are scheduled for the same time (<b>Appendix C</b>).</p>

Authority	Issue Raised	Response
Department of Water and Energy	A license for dewatering must be obtained prior to interception of the aquifer	<p>Footings for the Project have since been addressed/approved through a separate DA under Part 4 of the EP&amp;A Act pertaining to the replacement of the FCCU Stairwell and Lift. A DA was granted for this activity on 2 October 2007 (DA No. DA/769/2007).</p> <p>To seek clarification on this requirement (for future project work), Shell has made numerous attempts to contact the Department of Water and Energy, without success, to discuss this issue.</p> <p>It is also noted that the site is a fully operation site, which has a Refinery wide environmental licence with DECC that governs the disposal of waste and water from site. As detailed in the EA, the amount of water generated is &lt;10tonnes and this water is easily contained and processed within Shell’s water treatment plant (capacity up to 4500t/d). As the water will be recycled within the site, and any wastewater discharged from site is governed by Shell’s licence EPL No.570, it is considered that sufficient controls and licences are already in place, and the need for a dewatering license is not required.</p>
Parramatta City Council	Waterway use requirements for the Duck and Parramatta Rivers to be quantified and assessed	The contractor will obtain relevant permits from NSW Maritime associated with delivery of the main equipment by barge to the Parramatta River refinery wharf.
	Requirement to minimise transport via road during peak hours, split traffic between Parramatta road and James Ruse Drive entrances and consider rail transport.	There will be a small and limited number of large/over-sized equipment delivered by road. These deliveries will be directed to be transported out of hours. Road transport studies are being undertaken for these deliveries, which will be submitted to the RTA for approval by contractor.
	Dredging requirements to be quantified and assessed	Shell’s initial investigations indicate that no dredging or ploughing is required based on the proposed/identified barge to be used and has been confirmed by the transport company.

<b>Authority</b>	<b>Issue Raised</b>	<b>Response</b>
Department of Planning	Confirm what zone the FCCU project is in and what type of development it is classified as under SREP 28	Regional Enterprise Zone and is classified for industrial development.
	Identify any impacts associated with ploughing the Parramatta River and as part of this, detail consultation with NSW Maritime about this process and any approvals required	Shell's initial investigations indicate that no dredging or ploughing is required, as per above.
	Confirm what approvals would be required for use of the Parramatta River	Shell contractor will respond to NSW Maritime.
	Confirm that no excavation would be required when replacing piping and cyclones	No excavation is required for the pipework and cyclones. All existing piping is above ground and construction will utilise the existing supports/structures. Portions of the new piping will be attached to the new lift/stairwell. The cyclones are located within an existing vessel, which will be removed and replaced.
	Provide further details for waste likely to be generated by the project	Shell has prepared a Waste Management Plan in accordance with DECC's requirements (see SOC's) for both the project and the maintenance turnaround. This document can be provided separately. The document clearly outlines the amount of waste, recycle/reuse options and disposal options, as well as system/processes in place to manage waste.

Authority	Issue Raised	Response
	Confirm the location of the closest sensitive receiver	It is noted that the EA identifies two different closest sensitive receivers. The air quality assessment ( <b>Section 8.1.2</b> ) identifies that the closest sensitive receiver is located 500m to the south of the FCCU, Carnarvon Street. The noise assessment ( <b>Section 8.3.1</b> ) identifies the closest sensitive receiver as 720m to the south east of the FCCU, Silverwater residences. This discrepancy is due to the air quality and noise assessments utilising different methods for calculating the “closest sensitive receiver. This is somewhat explained by the different attenuation and dispersion characteristics of air pollutants as apposed to noise pollution.
	Provide further details of dewatering	See above response with respect to Department of Water and Energy.
	Confirm length of time for shut-down for the upgrade to the FCCU	This information is commercially sensitive/confidential information. As indicated in <b>Section 6.2</b> of the EA, the project will occur during a major site turnaround, and will commence and be completed within 2nd Quarter of 2008.
NSW Maritime	Dredging/ploughing of rivers	As per previous discussions, Shell’s initial investigations indicate that no dredging or ploughing is required. If dredging/ploughing is required, the transport company will consult with NSW Maritime and obtain the relevant permits as required.
Sydney Water	The developer will need a Section 73 Compliance Certificate from Sydney Water	This is an existing site with an existing water supply. The project does not require any additional water connections or increase in water supply; in fact the project will reduce water consumption. Further, a Section 73 compliance certificate is usually required to confirm that water mains are sized correctly and water charges have been paid. This is not applicable to this project and Shell therefore does not see the need for acquiring the Section 73 compliance certificate.

## **2 Statement of Commitments**

### **2.1 General**

Following the requirements of Part 3A of the EP&A Act, Draft SOCs were prepared as part of the EA. These SOCs describe Shell's commitment to environmental mitigation, management and monitoring for the proposed upgrade to the FCCU.

Suggested SOCs provided in submissions/responses to the EA have been considered and a final consolidated SOC is provided in **Appendix B**.

### **2.2 Overview**

The environmental assessment of the proposed FCCU upgrade has identified a range of environmental outcomes and management measures that would be required to avoid or reduce the environmental impacts of the project. Environmental mitigation, management and monitoring options have been proposed by Shell to reduce the environmental risk of the project. Where possible, the measures have been based on achieving a defined performance standard or implementing a proposed process. Specific actions which aim to deliver the desired outcomes where practicable are based on:

- Developing project designs which are capable of achieving the outcomes.
- Developing environment management and mitigation measures during the planning and design phase.
- Implementing, monitoring and review of these measures during the construction and operational phases.

Following approval of the project, the finalised commitments would guide the subsequent phases of the project development process to reduce impacts on the environment. Unless otherwise directed by the DoP or other relevant authority, Shell would endeavour to comply with the environmental commitments outlined in **Appendix B**.



**Appendix A**  
**Updated Air Quality Report**

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**AIR QUALITY IMPACT ASSESSMENT**

**Fluidised Catalytic Cracker Unit Reactor and Regenerator Rejuvenation Project  
- Shell Clyde Refinery**

*7 November 2007 FINAL – Amended Cumulative SO<sub>2</sub> Concentrations*

*Prepared for  
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Figure 11: Maximum predicted 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – normal conditions

Figure 12: Maximum predicted 24-hour average PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) – upset conditions

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## 1. INTRODUCTION

This report has been prepared by Holmes Air Sciences for CH2M HILL Australia Pty Ltd on behalf of Shell Refining (Australia) Pty Ltd. Shell is proposing to upgrade the Fluidised Catalytic Cracking Unit (FCCU) at the Clyde Refinery. This document provides an air quality assessment of the air emissions from the existing operations of the FCCU and those after the proposed upgrade. As a result of the proposed upgrade, changes are also expected to emissions from Boiler 7/9 stack and therefore this is also included in the assessment. All other units are unaffected by the upgrade. The report comprises the following sections.

- Description of the project
- Estimate of emissions
- Discussion of air quality issues
- Description of local climate and dispersion meteorology
- Approach to modelling
- Assessment of impacts

The AUSPLUME dispersion model (Version 6.0) was used to predict ground-level concentrations of the following pollutants:

- Carbon monoxide (CO)
- Oxides of nitrogen (NO<sub>x</sub>)
- Particulate matter less than 10 microns (PM<sub>10</sub>)
- Total suspended particulates (TSP)
- Sulfur dioxide (SO<sub>2</sub>)
- Sulfur trioxide (SO<sub>3</sub>)
- Benzo(a)pyrene
- Speciated VOCs
- Metals

The dispersion modelling was undertaken in accordance with the NSW Department of Environment and Climate Change (DECC) (formerly Department of Environment and Conservation "Approved methods and guidance for the modelling and assessment of air pollutants in NSW" (NSW DEC, 2005a) (herein referred to as the Approved Methods).

## 2. LOCAL SETTING AND DESCRIPTION OF THE PROJECT

### 2.1 Local setting

Clyde Refinery is located at the confluence of the Parramatta and Duck Rivers, approximately 16 km west of Sydney's central business district (CBD). The surrounding landuse is predominantly industrial with the closest Silverwater residences approximately 720m south-east, Rydalmere residences approximately 1250 m northeast and Harris Park residences approximately 1500m west (as shown on **Figure 1**).

**Figure 1** shows the regional location of Clyde Refinery and the location of the stack associated with the FCCU (via No. 8 Boiler) and Boiler 7/9 stack. A more detailed site layout is shown in **Figure 2**.

### 2.2 Existing operations

The FCCU is the major secondary processing unit in which crude oil residue is converted into gasoline, diesel, LPGs, propylene and other fuel oil blending components. **Figure 3** shows a simplified process flow diagram of the existing FCCU operations.

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The flue gas from the FCCU travels out of the regenerator via two sets of cyclones which separate the entrained catalyst from the vapour. Due to environmental reasons and to protect the power recovery machines from erosion, the flue gas travels through an additional stage of clean up, the third stage separations. Flue gas then travels via the power recovery turbines, or via the bypassline to the orifice chamber, before going to No.8 Boiler for further heat recovery from the flue gas. This is considered to be the main gas and particulate emission source associated with the FCCU.

### **2.3 Proposed operations**

Critical components of the Reactor and Regeneration (R&R) section are approaching end-of-life and hence Shell is proposing to replace them. In addition to the changes to the FCCU emissions (which exit via No. 8 Boiler stack), there would be a reduced steam production from Boiler 7/9 stack associated with increased steam production/efficiency from No. 8 boiler. No other units at the site would be affected by the proposed upgrade.

**Figure 4** shows a simplified process flow diagram of the proposed FCCU operations.

### **2.4 Startup and shutdown procedure**

The startup and shutdown procedure would not change for the proposed operations.

The typical start-up procedure is as follows:

1. Introduce hot air to the unit and commence with heat up and dry-out of the unit. In most cases this is to allow curing of the refractory. Hot air is vented to atmosphere through silencers.
2. Once the unit is hot, the catalyst is loaded from the spent catalyst hopper and returned to the regenerator only, maintaining air flow through to the regenerator and out to the flue gas system during this period. As air is exiting via the flue gas system it passes through all regenerator cyclones.
3. Steam is introduced to the reactor side venting to atmosphere to keep the unit warm. Steam is vented via dedicated silencers.
4. Once the steam is in the reactor (and free of air), the flow path from reactor to fractionation section is opened and steam is forced across into the main fractionators to be condensed and recovered as per shutdown procedure.
5. The catalyst circulation is then established on the unit, using steam or air to move the catalyst around.
6. Once the catalyst circulation is steady, feed is reintroduced to the unit and the unit is stabilised.

The planned shutdown frequency for the FCCU is once every 4 years. The typical shutdown procedure is as follows:

1. The hydrocarbon feed is removed from the unit and replaced with steam to purge the hydrocarbons from the unit. Steam is directed to the fractionation section where it is condensed, treated and returned as process water to the site. Excess water is treated in the biotreater and used as make-up for the cooling water tower.

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2. Once the hydrocarbons are displaced, isolation is provided between the reactor section and fractionation section (to prevent back flow of hydrocarbons from the fractionation section back into the reactor).
  3. Catalyst circulation and air injection to the regenerator is maintained to burn residual coke from the catalyst. Once the coke is removed, the catalyst is transported from the unit to the catalyst storage hoppers. During this process air is vented and there is some minimal catalyst loss as fugitive emissions. Once the unit is removed from the regenerator system, air flow to the regenerator is stopped.
  4. Steam purging through the reactor to atmosphere is continued for 1-2 days to cool down hot coke (~500 °C) in the reactor. This will be minimised with the new reactor design as the new reactor will not generate as much coke as present with the current unit. Cooling is required as coke can spontaneously ignite when opened to air atmosphere.
  5. Once cool, steam cooling is stopped and unit is opened to atmosphere for inspection and maintenance.

If there is a problem with the unit (for example loss of feed to unit, loss of instrument air/power, problems with the regenerator), an unplanned shutdown would be required. Unplanned shutdowns are infrequent; the last unplanned shutdown occurred in early 2000. An unplanned shutdown generally follows the same process as that for the planned shutdown, detailed above.

With respect to air quality, if there are problems with the regenerator (which is where the catalyst/flue gas separation takes place), this can result in elevated concentrations of total solid particles (TSP) emissions in the plume.

An upset situation is detected based on operating experience and online analyser outputs which uses the opacity of the No.8 Boiler plume as a surrogate for TSP concentrations. On observation of opacity greater than 15% there is an investigation into the source of the increased particulates. If the opacity remains above 20% for more than one week then stack testing is carried out to determine the in-stack concentration of the particulate matter.

There are three typical scenarios of problems with the regenerator:

- (a) Steam injection nozzle can fail due to erosion from the catalyst moving at high rates in the unit. When it fails, there is less resistance to flow and hence flow can increase significantly causing attrition and an increase in fines make/losses. This is currently resolved within a few days by cutting back the steam once the source is identified. With the proposed upgrade there would be additional flow monitoring to provide information on the flow increases and hence there would be a faster response. In addition to this, improvements to the design of the proposed nozzles would help prevent such erosion/failure.
- (b) There is a temporary stalling of the catalyst in the cyclone. This can be resolved by altering catalyst levels in the regenerator. This takes a few days to diagnose and implement the changes. Such events are typically during start-up and shutdown of the unit, and not during normal operation.
- (c) There is significant cracking/damage to the regenerator cyclones (typically age related failure), resulting in loss of cyclone performance and hence catalyst loss. In this severe case, the unit will be shutdown once this mechanism is confirmed and hence inability to reduce the catalyst losses for repairs to be undertaken.

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The proposed upgrade would use a modern design of regenerator cyclones which would resolve the issue in (b) and (c).

Dispersion modelling has been completed to predict the impact of the upset conditions on the local air quality.

### **3. AIR QUALITY ASSESSMENT CRITERIA**

#### **3.1 Introduction**

This section of the report examines the relevant assessment criteria.

Two aspects have been considered:

- The requirements of the Clean Air (Plant and Equipment) Regulations 2002 relating to the in-stack concentrations of No.8 Boiler Stack of the FCCU.
- An examination of the relevant air quality impact assessment criteria for ground-level concentrations due to emissions from the stacks.

#### **3.2 Protection of the Environment Operations (Clean Air) Regulation 2002**

**Table 1** presents the Protection of the Environment Operations (POEO) Clean Air Regulation for petroleum refining. The FCCU was commissioned in the year 1962 and has operated since 1963. However as the proposed FCCU upgrade would take place after 1 September, 2005, it belongs to Group 6 standard of concentration.

The standard of concentration highlighted in **Table 1** is the maximum allowable in-stack concentration from the FCCU, via No.8 Boiler stack.

**Section 5.1.1** presents a summary of recent stack samples from the FCCU Boiler 8 stack and Boiler 7/9 stack.

<b>Table 1: POEO Clean Air Regulation for Petroleum Refining</b>			
<b>Air impurity</b>	<b>Activity or plant</b>	<b>Standard of concentration</b>	
Solid particles (total)	Any fuel burning equipment Any fluidized bed catalytic cracking unit regenerator	Group 1	400 mg/m <sup>3</sup>
		Group 2, 3 or 4	250 mg/m <sup>3</sup>
		Group 5	100 mg/m <sup>3</sup>
		Group 6	50 mg/m <sup>3</sup>
Nitrogen dioxide (NO <sub>2</sub> ) Nitric oxide (NO) both, as NO <sub>2</sub> equivalent	Any fuel burning equipment Any fluidized bed catalytic cracking unit regenerator	Group 1, 2, 3 or 4	2,500 mg/m <sup>3</sup>
		Group 5	2,000 mg/m <sup>3</sup>
		Group 6	350 mg/m <sup>3</sup>
Volatile organic compounds (VOCs), as n-propane equivalent	Any thermal oxidation process Any catalytic oxidation process Any vapour incineration	Group 1, 2, 3, 4 or 5	—
		Group 6	40 mg/m <sup>3</sup> VOCs or 125 mg/m <sup>3</sup> CO
	Any vapour recovery unit Any distillation process	Group 1, 2, 3, 4 or 5	—
		Group 6	40 mg/m <sup>3</sup> VOCs
Smoke	Any fuel burning equipment using a liquid or solid standard fuel or a non standard fuel Fluidized bed catalytic cracking unit regenerator Any boiler used in connection with power generation	Group 1, in approved circumstances	Ringelmann 3 or 60% opacity
		Group 1, in other circumstances	Ringelmann 2 or 40% opacity
		Group 2, 3, 4, 5 or 6, in approved circumstances	Ringelmann 3 or 60% opacity
		Group 2, 3, 4, 5 or 6, other circumstances	Ringelmann 1 or 20% opacity

### 3.3 Air quality Impact assessment criteria

The NSW DECC has historically noted air quality goals determined by the World Health Organisation (WHO), the United States Environmental Protection Agency (US EPA) and the National Health and Medical Research Council of Australia (NHMRC).

The National Environment Protection Council of Australia (NEPC) determined a set of air quality goals for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). In its publication "Action for Air" (**NSW EPA, 1998**), the NSW DECC adopted air quality goals for nitrogen dioxide and particulate matter which are consistent with the NEPM.

In addition to the criteria pollutants, ground-level concentration (glc) criteria are specified by NSW DECC for odorous and toxic air pollutants (**NSW DEC, 2005a**).

Emissions from the FCCU (via Boiler No.8 stack) and Boiler 7/9 stack include:

- Carbon monoxide (CO)
- Oxides of nitrogen (NO<sub>x</sub>)
- Total suspended particulates (TSP)
- Particulate matter less than 10 microns in diameter (PM<sub>10</sub>)
- Sulfur dioxide (SO<sub>2</sub>)
- Sulfur trioxide (SO<sub>3</sub>)

- Air toxics – including volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs)
- Metals

**Table 2** lists the relevant DECC's air quality goals for these pollutants. The basis of these air quality goals and, where relevant, the safety margins which they provide are outlined in **Appendix A**.

<b>Table 2: Relevant NSW impact assessment criteria</b>			
<b>Pollutant</b>	<b>Assessment criteria</b>	<b>Averaging Period</b>	<b>Agency</b>
Carbon monoxide (CO)	30 mg/m <sup>3</sup>	1-hour maximum	NSW DECC
	10 mg/m <sup>3</sup>	8-hour maximum	NSW DECC
Nitrogen dioxide (NO <sub>2</sub> )	246 µg/m <sup>3</sup>	1-hour maximum	NEPM, NSW DECC
	62 µg/m <sup>3</sup>	Annual Mean	NEPM, NSW DECC
Particulate matter < 10 µm (PM <sub>10</sub> )	50 µg/m <sup>3</sup>	24-hour maximum	NEPM, NSW DECC
	30 µg/m <sup>3</sup>	Annual mean	NSW DECC
Sulfur dioxide	712 µg/m <sup>3</sup>	10-minute maximum	NHMRC, NEPM
	570 µg/m <sup>3</sup>	1-hour maximum	NEPM
	228 µg/m <sup>3</sup>	1 day	NEPM
	60 µg/m <sup>3</sup>	Annual average	NHMRC, NEPM
Benzene	0.029 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
PAHs (as B[a]P)	0.0004 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
1,3-Butadiene	0.04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Cyclohexane	19 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Ethylbenzene	8 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
n-Hexane	3.2 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
n-Pentane	33 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Sulfuric Acid (as SO <sub>3</sub> )	0.018 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Trimethylbenzene	2.2 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Antimony	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Arsenic	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Beryllium	4.00E-06 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Cadmium	1.80E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Chromium VI	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Chromium III	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Cobalt	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Manganese	1.30E-02 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Mercury (organic)	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Mercury (inorganic)	1.80E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Nickel	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Selenium	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	NSW DECC
Lead	5.00E-04 mg/m <sup>3</sup>	Annual Mean	NSW DECC

Note: Impact assessment criteria are applicable at ground-level at the nearest off-site receptor

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## 4. LOCAL DISPERSION CONDITIONS AND EXISTING CLIMATE

This section describes the dispersion meteorology and general climate in the study area. It provides information on prevailing wind patterns, historical data on temperature, humidity and rainfall, to give a more complete picture of the local climate.

### 4.1 Dispersion Meteorology

The Gaussian dispersion models used for the dust assessment, AUSPLUME and ISCMOD, require information about the dispersion characteristics of the area. In particular, data are required on topography, wind speed, wind direction, atmospheric stability class<sup>1</sup> and mixing height<sup>2</sup>.

Data collected at the Clyde Refinery site for 2004 were used in the assessment.

### 4.2 Wind data

Meteorological data are collected at Clyde Refinery site (the location of the station is shown on **Figure 1**). Data collected from this site are used as an input for the air quality modelling conducted using the dispersion model AUSPLUME. Annual and seasonal windroses prepared from this data file are shown in **Figure 5**.

The windroses show that in summer the winds are predominantly from the east-north-east, east, east-south-east and south-east. In winter and autumn the predominant winds are from the west-north-west and north-west, though in autumn, there are also reasonably frequent winds from the south-west, east and east-north-east. In spring winds are frequent in most directions though they are predominantly from the east-north-east. The patterns on an annual basis show that winds are predominately from the west-north-west and north-west. The mean annual wind speed is 1.04 m/s.

### 4.3 Atmospheric stability

**Table 3** presents a frequency of atmospheric stability classes at the site. These data are available from the AUSPLUME input meteorological data set. Stable conditions (E and F), under which emissions will disperse slowly are estimated to prevail for just over 32% of the time.

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<sup>1</sup> In dispersion modelling stability class is used to categorise the rate at which a plume will disperse. In the Pasquill-Gifford stability class assignment scheme, as used in this study, there are six stability classes A through to F. Class A relates to unstable conditions such as might be found on a sunny day with light winds. In such conditions plumes will spread rapidly. Class F relates to stable conditions, such as occur when the sky is clear, the winds are light and an inversion is present. Plume spreading is slow in these circumstances. The intermediate classes B, C, D and E relate to intermediate dispersion conditions.

<sup>2</sup> The term mixing height refers to the height of the turbulent layer of air near the earth's surface into which ground-level emissions will be rapidly mixed. A plume emitted above the mixed-layer will remain isolated from the ground until such time as the mixed-layer reaches the height of the plume. The height of the mixed-layer is controlled mainly by convection (resulting from solar heating of the ground) and by mechanically generated turbulence as the wind blows over the rough ground.

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**Table 3: Frequency of atmospheric stability classes**

<b>Pasquill Gifford stability class</b>	<b>Frequency (%)</b>
A	10.9
B	10.3
C	12.9
D	33.9
E	13.2
F	18.8
TOTAL	100.0

**Appendix B** provides tables of joint wind speed, wind direction and atmospheric stability compiled from the 2004 Clyde Refinery data set.

#### **4.4 Temperature, dew point, humidity, rainfall and cloud cover**

The Shell Refinery site is situated 5 km south of the closest Bureau of Meteorology's observation station at Parramatta North (Mason's Drive). The Parramatta North data are summarised in **Table 4**, which shows information on temperature, relative humidity, and rainfall (**Bureau of Meteorology, 2006**).

##### **4.4.1 Temperature**

On average, January is the warmest month at North Parramatta with a mean monthly maximum temperature of 28.2°C. July is the coolest month experiencing a mean monthly minimum temperature of 6.2°C.

##### **4.4.2 Relative humidity**

Relative humidity observed at 9 am is lowest in September and October (63%) and highest in May (79%). For the 3 pm observations, the lowest relative humidity occurs in August and September (48%) and the highest in March and May (60%).

##### **4.4.3 Rainfall**

Mean annual rainfall is 964.6 mm. On average, the wettest month is February (monthly average 124.4 mm over an average of 12.1 days) and the driest is July (monthly average 46.3 mm over an average of 7.7 days).

<b>Table 4: Temperature, humidity and rainfall data for North Parramatta (Masons Drive)</b>													
Station number: 066124, Commenced: 1965; Last record: 2004; Latitude (deg S): -33.7917; Longitude (deg E): 151.0181													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
<b>9am Mean Temperature (°C) and Relative Humidity (%)</b>													
Dry Bulb	22.4	22	20.6	18	14.5	11.7	10.7	12.5	15.7	18.5	19.6	21.7	17.3
Humidity	72	78	77	75	79	78	73	68	63	63	68	68	72
<b>3pm Mean Temperature (°C) and Relative Humidity (%)</b>													
Dry Bulb	26.5	26.3	24.6	22.2	19.1	16.5	16.1	17.6	19.8	21.8	23.4	25.5	21.6
Humidity	57	59	60	58	60	59	54	48	48	51	54	54	55
<b>Daily Maximum Temperature (°C)</b>													
Mean	28.2	27.8	26.2	23.8	20.4	17.7	17.3	18.9	21.4	23.7	25.2	27.4	23.1
<b>Daily Minimum Temperature (°C)</b>													
Mean	17.4	17.5	15.8	12.8	10.1	7.4	6.2	7	9.2	11.8	13.8	16.2	12.1
<b>Rainfall (mm)</b>													
Mean monthly rainfall - mm	108.3	124.4	113.3	88.8	76.9	76.5	46.3	58.2	50.7	67.5	83.9	69.9	964.6
<b>Raindays (Number)</b>													
Mean no. of raindays	11.8	12.1	12.4	8.9	10.3	9.8	7.7	7.9	7.9	10.3	11.2	9.8	120.1

Source: *Bureau of Meteorology (2006)*.

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## 4.5 Existing Air Quality

Air quality standards and goals refer to pollutant levels which include the project and existing sources. To fully assess impacts against all the relevant air quality standards and goals (detailed in **Section 3**) it is necessary to have information or estimates on existing background pollutant concentrations in the area in which the project is likely to contribute to these levels. As the Clyde Refinery is an existing emissions source, these data are provided for information purposes only. The change in predicted impacts due to emissions from the FCCU project is assessed in **Section 7.1**.

The closest DECC monitoring station was located at Lidcombe, approximately 10 km southwest of the site. The Lidcombe site operated until April 2002. **Table 5** presents a summary of air monitoring data from the Lidcombe site from 1992 to 2001.

The closest site that is currently operating is located at Liverpool, approximately 20 km southwest of the Shell site. **Table 6** presents a summary of air monitoring data from the Liverpool site from 1993 to September 2005.

SO<sub>2</sub> data are collected at Randwick, which is approximately 20 km south-east of the site, and were also collected at Lindfield, approximately 14 km to the north-east of site, until February 2005. These data are summarised in **Table 7**.

The data are taken from the National Ambient Air Quality Status and Trends Report, 1991 – 2001 (**DEH, 2004**) and the NSW DECC quarterly air quality reports (**NSW DEC, 2002 - 2006**). Ozone, NO<sub>2</sub> and PM<sub>10</sub> are monitored at Liverpool.

Maximum 1-hour and 4-hour average O<sub>3</sub> concentration occasionally exceeds the air quality goals at both sites. These exceedances can be attributed in part to variability in meteorological conditions. Bushfires can also cause amplified ozone concentrations. The maximum 1-hour NO<sub>2</sub> concentration at Lidcombe exceeded the goal in 1992 and 1998, and in 1993 at Liverpool, however there has been a general decrease in concentrations. The annual average concentrations are below the air quality goal at both sites.

Annual average concentrations of PM<sub>10</sub> are below the NSW DECC air quality goal of 30 µg/m<sup>3</sup>. However, maximum concentrations are on occasions above the 24-hour goal of 50 µg/m<sup>3</sup>, for example in 2003, the maximum recorded 24-hour average concentration recorded at Liverpool was 283 µg/m<sup>3</sup>. Particle pollution is affected by environmental factors such as bushfires and dust storms and some of these high levels may be attributed to these factors.

**Table 5: Lidcombe air quality data 1992 - 2001**

Year	O <sub>3</sub> (ppm)		NO <sub>2</sub> (ppm)		PM <sub>10</sub> (TEOM) (µg/m <sup>3</sup> )	
	Maximum 1h average	Maximum 4h average	Maximum 1h average	Annual Average	Maximum 24h average	Annual average
<i>Goal</i>	<i>0.1 ppm</i>	<i>0.08 ppm</i>	<i>0.12 ppm</i>	<i>0.03 ppm</i>	<i>50 µg/m<sup>3</sup></i>	<i>30 µg/m<sup>3</sup></i>
1992 <sup>(a)</sup>	0.084	0.068	0.123	0.017	N/A	N/A
1993 <sup>(a)</sup>	0.150*	0.132*	0.109*	0.020*	N/A	N/A
1994 <sup>(a)</sup>	0.077*	0.064*	0.076*	0.016*	57.9*	13.0*
1995 <sup>(a)</sup>	0.083	0.062	0.099*	0.018*	37.4	16.3
1996 <sup>(a)</sup>	0.075*	0.065*	0.070*	0.015*	46.2*	16.2*
1997 <sup>(a)</sup>	0.168	0.134	0.080	0.015	49.8	17.5
1998 <sup>(a)</sup>	0.142	0.119	0.126*	0.016	38.7	14.5
1999 <sup>(a)</sup>	0.092	0.077	0.073	0.016	37.1*	16.2*
2000 <sup>(a)</sup>	0.118	0.095	0.070	0.015	52.5	17.1
2001 <sup>(a)</sup>	0.156	0.137	0.071	0.016	65.3	19.0

\* - one or more quarters of the year had data availability <75%

Sources:

<sup>(a)</sup> DEH (2004)

**Table 6: Liverpool air quality data 1993 - 2005**

Year	NO <sub>2</sub> (ppm)		O <sub>3</sub> (ppm)		TEOM PM <sub>10</sub> (µg/m <sup>3</sup> )	
	Maximum 1h average	Annual Average	Maximum 1-h average	Maximum 4-h average	Maximum 24-h average	Annual average
<i>Goal</i>	<i>0.12 ppm</i>	<i>0.03 ppm</i>	<i>0.1 ppm</i>	<i>0.08 ppm</i>	<i>50 µg/m<sup>3</sup></i>	<i>30 µg/m<sup>3</sup></i>
1993 <sup>(a)</sup>	0.123	0.015	0.141	0.118	No data	No data
1994 <sup>(a)</sup>	0.093	0.016	0.127*	0.109*	117.9	22.1
1995 <sup>(a)</sup>	0.088	0.015	0.113	0.096	40.0	17.8
1996 <sup>(a)</sup>	0.054	0.012	0.079	0.067	37.4*	16.6*
1997 <sup>(a)</sup>	0.060*	0.014*	0.092	0.078	58.7*	18.4*
1998 <sup>(a)</sup>	0.063	0.014	0.151	0.117	45.7	17.8
1999 <sup>(a)</sup>	0.054	0.014	0.130	0.108	46.1	16.5
2000 <sup>(a)</sup>	0.079	0.014	0.102	0.084*	64.1	17.7
2001 <sup>(a)</sup>	0.067	0.014	0.133	0.107	61.4	18.7
2002 <sup>(b)</sup>	0.068	0.015	0.141	0.120	128 <sup>(i)</sup>	25.0
2003 <sup>(b)</sup>	0.064	0.013	0.151	0.132	283 <sup>(ii)</sup>	21.0
2004 <sup>(b)</sup>	0.060	0.013	0.113	0.092	60 <sup>(iii)</sup>	21.5
2005 <sup>(b)</sup>	0.063	0.013	0.149	0.121	55 <sup>(iv)</sup>	21.2
2006 <sup>(c)</sup>	0.051	0.023	0.107	0.100	49	44.7

Data sources:

<sup>(a)</sup> DEH (2004)

<sup>(b)</sup> NSW DEC (2002 - 2005)

<sup>(c)</sup> NSW DEC (2006) to June 2006

Notes:

\* - one or more quarters of the year had data availability <75%

<sup>(i)</sup> attributed to bushfires (NSW EPA, 2003)

<sup>(ii)</sup> attributed to duststorms (NSW DEC, 2004)

<sup>(iii)</sup> attributed to bushfires (NSW DEC, 2005c)

<sup>(iv)</sup> attributed to drought condition (NSW DEC, 2006)

**Table 7: SO<sub>2</sub> air quality data 2003 - 2005**

Year	Lindfield			Randwick		
	Maximum 1h average (pphm)	Maximum 24h average (pphm)	Annual Average (pphm)	Maximum 1h average (pphm)	Maximum 24h average (pphm)	Annual Average (pphm)
<i>Goal</i>	<i>20 pphm</i>	<i>8 pphm</i>	<i>2 pphm</i>	<i>20 pphm</i>	<i>8 pphm</i>	<i>2 pphm</i>
2003	2.9	0.6	0.1	3.5	0.7	0.1
2004	2.1	0.4	0.1	2.4	0.7	0.2
2005 <sup>(a)</sup>	1.8	0.4	0.1	2.4	0.5	0.1
2006 <sup>(b)</sup>	-	-	-	1.9	0.8	0.1

Data sources:

<sup>(a)</sup> NSW DEC (2002 - 2005); Lindfield data only collected to February 2005

<sup>(b)</sup> NSW DEC (2006) to June 2006

## 5. EMISSION SOURCES

### 5.1 Introduction

This section presents an assessment of the sources of emissions related to the operation of FCCU. The sources of emissions are:

- Stack emissions from Boiler No. 8 stack and Boiler 7/9 stack
- Fugitive emissions from ducts and pipework and catalyst removal

#### 5.1.1 Stack emissions

The following pollutants are emitted from the FCCU (via Boiler No.8 stack) and Boiler 7/9 stack:

- SO<sub>3</sub>
- SO<sub>2</sub>
- NO<sub>x</sub>
- TSP
- PM<sub>10</sub>
- PAH's (expressed as Benzo(a)pyrene equivalent)
- VOCs
- Metals.

**Table 8** presents a summary of recent in-stack measurements for the FCCU for 2005 and 2006. The data for 2004 were not considered representative as the unit was in complete combustion mode following start-up.

**Table 9** presents a summary of recent in-stack measurements for Boiler 7/9 stack for 2004 and 2005.

The samples were collected by Stephenson Environmental using the following methodologies:

- Stack Gas Velocity- USEPA Method 12 and NSW DECC Method 15. Velocity profile were obtained across the stack utilizing an S-type pitot tube and inclined manometer;

- 
- Exhaust Gas Temperature- USEPA Method 2, 3 & 4. The exhaust gas temperature was measured using a Digital thermometer (0-12000C) connected to a chromel / alumel (K-type) thermocouple probe;
  - Particulate Matter (TSP/PM10) - Australian Standards AS 4323.2 1995 and NSW DECC Method 15. The Alundum Thimble Filtration Method was used for the particulate matter sampling from the discharge stack. Samples were collected at isokinetic rates from a traverse across the stack as per AS 4323.2 1995 and NSW DECC Approved Methods;
  - Sulfur Dioxide Model- NSW DEC TM-4, USEPA Method 6C. (Thermo Electron Pulsed Fluorescence Analyser Model 40 and Stack gas dilution system);
  - Oxides of Nitrogen- NSW DECC TM-11, USEPA method 7E. (Monitor Labs 9840 Chemiluminescent Analyser);
  - Volatile Organic Compounds- NSW DECC Test OM-2. A grab sample was taken in a nalathane bag and the analysis was performed by NATA accredited laboratory; and
  - Analysis of SO<sub>x</sub> and NO<sub>x</sub> was performed using Stephenson Environmental Management Australia's mobile combustion and environmental monitoring laboratories.

**Table 8: Stack measurement data – existing operations - FCCU**

Parameter		2006	2005	Average	Average emission rate (g/s)
Temp	°C	252	263	257.5	
Flow	Nm <sup>3</sup> /min	2571	2173	2372	
	Nm <sup>3</sup> /s	42.9	36.2	39.52	
SO <sub>3</sub>	mg/m <sup>3</sup>	36	31.9	34	1.34
SO <sub>2</sub>	mg/m <sup>3</sup>	660	588	624	24.67
NO <sub>x</sub>	mg/m <sup>3</sup>	69	23	46	1.82
CO	mg/m <sup>3</sup>	727	10345	5536	218.86
TSP	mg/m <sup>3</sup>	26	20	23	2.07
PM <sub>10</sub>	mg/m <sup>3</sup>	18.4	21.5	20	1.52
PAHs	ng/m <sup>3</sup>	19555	33616	26586	1.05E-03
BaP	ng/m <sup>3</sup>	15	11	13	5.14E-07
BaP <sub>eq</sub>	ng/m <sup>3</sup>	7.45	28.1	18	7.03E-07
Metals Total	mg/m <sup>3</sup>	0.433	0.9	0.7	2.63E-02
Antimony (Sb)	mg/m <sup>3</sup>	0.0193	0.0125	0.016	6.29E-04
Arsenic (As)	mg/m <sup>3</sup>	0.0131	0.0035	0.008	3.28E-04
Beryllium (Be)	mg/m <sup>3</sup>	<0.0068	<0.0086	0.008	1.83E-04 <sup>(a)</sup>
Cadmium (Cd)	mg/m <sup>3</sup>	<0.0008	0.0011	0.001	3.76E-05
Chromium (Cr)	mg/m <sup>3</sup>	0.0375	0.0121	0.025	9.80E-04
Cobalt (Co)	mg/m <sup>3</sup>	0.0058	0.0031	0.004	1.76E-04
Lead (Pb)	mg/m <sup>3</sup>	0.0071	0.107	0.057	2.26E-03
Manganese (Mn)	mg/m <sup>3</sup>	0.049	0.0404	0.045	1.77E-03
Mercury (Hg)	mg/m <sup>3</sup>	0.0009	0.1399	0.070	2.78E-03
Nickel (Ni)	mg/m <sup>3</sup>	0.0549	0.0504	0.053	2.08E-03
Selenium (Se)	mg/m <sup>3</sup>	<0.0054	<0.0069	0.006	2.43E-04
Tin (Sn)	mg/m <sup>3</sup>	0.236	0.029	0.133	5.24E-03
Vanadium (V)	mg/m <sup>3</sup>	0.0092	0.0063	0.008	3.06E-04

Source: **Shell, 2006**

Notes:

- <sup>(a)</sup> The emission rate for beryllium has been calculated as per the DECC Load Calculation Protocol (**NSW DEC, 2005b**), which states that when a sample is reported at below the Practical Quantitation Limit (PQL), half the PQL value may be used for that sample for load calculation purposes.

**Table 9: Stack measurement data – existing operations - Boiler 7/9**

Parameter		2005	2004	Average	Average emission rate (g/s)
Temp	°C	244	249	246.5	
Flow	Nm <sup>3</sup> /min	2453	2227	2340	
	Nm <sup>3</sup> /s	40.9	37.1	39	
SO <sub>3</sub>	mg/m <sup>3</sup>	5	12	9	0.33
SO <sub>2</sub>	mg/m <sup>3</sup>	44	114	79	3.08
NO <sub>x</sub>	mg/m <sup>3</sup>	166	166	166	6.47
CO	mg/m <sup>3</sup>	28	28	28	1.09
TSP*	mg/m <sup>3</sup>	10	10	10	0.39
PM <sub>10</sub> *	mg/m <sup>3</sup>	6	6	6	0.23
PAHs*	ng/m <sup>3</sup>	14074	14074	14074	5.49E-04
BaP*	ng/m <sup>3</sup>	18	18	18	7.02E-07
BaP <sub>eq</sub> *	ng/m <sup>3</sup>	47	47	47	1.83E-06
Metals Total*	mg/m <sup>3</sup>	0.2652	0.2652	0.265	1.05E-02
Antimony (Sb)*	mg/m <sup>3</sup>	0.0184	0.0184	0.018	7.18E-04
Arsenic (As)*	mg/m <sup>3</sup>	0.0075	0.0075	0.008	2.93E-04
Beryllium (Be)*	mg/m <sup>3</sup>	0.007	0.007	0.007	2.73E-04
Cadmium (Cd)*	mg/m <sup>3</sup>	0.0029	0.0029	0.003	1.13E-04
Chromium (Cr)*	mg/m <sup>3</sup>	0.0335	0.0335	0.034	1.31E-03
Cobalt (Co)*	mg/m <sup>3</sup>	0.0009	0.0009	0.001	3.51E-05
Lead (Pb)*	mg/m <sup>3</sup>	0.0109	0.0109	0.011	4.25E-04
Manganese (Mn)*	mg/m <sup>3</sup>	0.0248	0.0248	0.025	9.67E-04
Mercury (Hg)*	mg/m <sup>3</sup>	0.0019	0.0019	0.002	7.41E-05
Nickel (Ni)*	mg/m <sup>3</sup>	0.0447	0.0447	0.045	1.74E-03
Selenium (Se)*	mg/m <sup>3</sup>	0.0058	0.0058	0.006	2.26E-04
Tin (Sn)*	mg/m <sup>3</sup>	0.0743	0.0743	0.074	2.90E-03
Vanadium (V)*	mg/m <sup>3</sup>	0.001	0.001	0.001	3.90E-05

Source: **Shell, 2006**

\* Due to limitations with the stack ports it was not possible to collect samples of these pollutants from Boiler 7/9 stack. As the fuel used is identical to the Hydrodesulfurisation Unit (HDS), the concentration results from the HDS have been used to calculate the Boiler 7/9 stack emission rates. New stack ports have since been installed but no data are currently available.

**Table 10** presents a summary of the modelling parameters used for each of the stacks for both the existing and proposed operations. The location of each of the stacks in relation to the nearby residential areas is shown on **Figure 1** and in more detail on **Figure 2**.

The main changes between the existing and proposed operations are:

- Changes to FCCU (No. 8 Boiler stack) conditions as a consequence of the FCCU project (related to the increased flue gas flow associated with increasing the efficiency of the regeneration process).
- Changes to Boiler 7/9 stack conditions (that is, a reduction in flue gas) due to improved efficiency/steam generation on FCCU (No. 8 Boiler).

**Table 10: Stack parameters**

Parameter		FCCU (Boiler No.8 stack)		Boiler 7/9 Stack	
Location (MGA)	X (m)	318510		318135	
	Y (m)	6255109		6255048	
Height	(m)	80.1		100.6	
Diameter	(m)	2.35		3.35	
	<i>Scenario</i>	<i>Existing</i>	<i>Proposed</i>	<i>Existing</i>	<i>Proposed</i>
Temp	(°C)	257.5	275	246	200
Flow	(Nm <sup>3</sup> /min)	2372	2846	2340	1755
	(Am <sup>3</sup> /min)	4609	5713	4449	3041
Velocity	(m/s)	17.7	22.0	8.4	5.7

For all pollutants (except TSP and PM<sub>10</sub>), two operational scenarios have been modelled:

1. Existing operations, that is pre-FCCU upgrade
2. Proposed operations, that is post-FCCU upgrade

**Section 5.1.1.1** discusses how TSP and PM<sub>10</sub> emissions have been modelled.

#### 5.1.1.1 TSP and PM<sub>10</sub> concentrations

As discussed in **Section 3.2**, under the POEO regulations, the maximum allowable in-stack TSP concentration is 50 mg/Nm<sup>3</sup>.

**Table 8** shows that the maximum measured concentration from current operation of the FCCU was 26 mg/Nm<sup>3</sup>. Future operation has been designed for, and is expected to remain at a similar concentration, that is less than 50 mg/Nm<sup>3</sup> under normal operating conditions. In order to present a conservative prediction of the impacts, the modelling has been based on the assumption that “normal” operation has a TSP concentration of 50 mg/m<sup>3</sup>.

During an “upset” condition (for example, should damage occur to the separation equipment of the unit), TSP concentrations may temporarily exceed 50 mg/Nm<sup>3</sup> for approximately five days while the unit is safely shutdown or problem resolved, noting that such events are infrequent. The 75 mg/Nm<sup>3</sup> scenario has been arbitrarily chosen as a worst-case illustration of upset conditions to understand the impacts of short term upset. This is a temporary mode of operation while urgent action is taken to address the cause.

Therefore, for TSP and PM<sub>10</sub> a total of four scenarios have been modelled.

1. Pre- FCCU upgrade – Normal TSP = 50 mg/Nm<sup>3</sup>
2. Pre-FCCU upgrade – Upset TSP = 75 mg/Nm<sup>3</sup>
3. Post- FCCU upgrade – Normal TSP = 50 mg/Nm<sup>3</sup>
4. Post-FCCU upgrade – Upset TSP = 75 mg/Nm<sup>3</sup>

#### 5.1.2 Stack emission rates

A summary of the emission rates used in the dispersion modelling are presented in **Table 11** for the existing and proposed operations.

The proposed upgrade would result in an increase in the emission rate of pollutants from the FCCU (via No. 8 Boiler stack), most of which are offset by a decrease in the pollutant emission rate from the Boiler 7/9 stack.

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The increase in pollutant emission rate from the FCCU (via No.8 Boiler stack) is associated with an increase in regenerator efficiency, which allows an increase in the combustion of coke from the catalyst. This increased regenerator efficiency results in an increased production rate of products (petrol/diesel/LPG) for the same unit intake.

As a consequence of increased regenerator efficiency/coke burning capacity, flue gas from the FCCU increases and hence there is an increase in the pollutant emission rates. However, this flue gas would be directed to the waste heat boiler, for further heat recovery/steam generation, which will be utilised across the site. This additional steam production, coupled with less steam requirements for the new unit, requires less steam demand from the refinery main boilers (Boiler 7/9) and hence a reduction in the pollutant emission rate from the Boiler 7/9 combined stack.

**Table 11: Stack emission rates (g/s)**

Pollutant	Unit		
	FCCU (Boiler No.8 stack)		Boiler 7/9 Stack
	TSP = 50 mg/m <sup>3</sup>	TSP = 75 mg/m <sup>3</sup>	
<b>Emission rate pre-FCCU upgrade (g/s)</b>			
SO <sub>3</sub>	1.34		0.34
SO <sub>2</sub>	Variable CEMS data (see <b>Section 5.1.3</b> )		3.08
NO <sub>x</sub>	1.82		6.47
CO	218.86		1.09
TSP	2.07	3.10	0.39
PM <sub>10</sub>	1.520	2.281	0.23
PAHs	1.05E-03		5.79E-04
Benzo(a) pyrene equivalents	7.03E-07		1.94E-06
Metals Total	2.63E-02		1.03E-02
Antimony	6.29E-04		7.16E-04
Arsenic	3.28E-04		2.93E-04
Beryllium	2.69E-04		2.74E-04
Cadmium	4.35E-05		1.13E-04
Chromium	9.80E-04		1.30E-03
Cobalt	1.76E-04		3.45E-05
Lead	2.26E-03		4.25E-04
Manganese	1.77E-03		9.69E-04
Mercury	2.78E-03		7.28E-05
Nickel	2.08E-03		1.74E-03
Selenium	2.13E-04		2.26E-04
Tin	5.24E-03		2.90E-03
Vanadium	3.06E-04		3.71E-05
Pollutant	<b>Emission rate post-FCCU upgrade (g/s)</b>		
SO <sub>3</sub>	1.52		0.25
SO <sub>2</sub>	190		2.31
NO <sub>x</sub>	2.06		4.85
CO	218.86		0.82
TSP	2.52	3.78	0.29
PM <sub>10</sub>	1.824	2.736	0.17
PAHs	1.20E-03		4.34E-04
Benzo(a) pyrene equivalents	8.02E-07		1.45E-06
Metals Total	2.99E-02		7.76E-03
Antimony	7.12E-04		5.37E-04
Arsenic	3.72E-04		2.20E-04
Beryllium	3.05E-04		2.05E-04
Cadmium	4.93E-05		8.48E-05
Chromium	1.11E-03		9.78E-04
Cobalt	1.99E-04		2.58E-05
Lead	2.56E-03		3.19E-04
Manganese	2.00E-03		7.26E-04
Mercury	3.15E-03		5.46E-05
Nickel	2.36E-03		1.31E-03
Selenium	2.42E-04		1.69E-04
Tin	5.94E-03		2.17E-03
Vanadium	3.47E-04		2.78E-05

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### **5.1.3 SO<sub>2</sub> emissions data**

In addition to annual stack monitoring emissions data, the FCCU is fitted with a Continuous Emissions Monitoring System (CEMS). **Figure 6** presents a plot of these data. The wide variation in emission rates is due to variations in the sulfur content of the fuel. However, the average annual emission rate measured by the CEMS data is 36 g/s. This is only marginally higher than the average of the stack monitoring emission rates of 25 g/s presented in **Table 8**. The CEMS data were used in a variable emissions file in the AUSPLUME modelling. **Appendix C** shows an excerpt of the variable emissions file.

For the proposed operations, the maximum permissible emission rate to ensure compliance with the impact assessment criteria was calculated.

## **5.2 Fugitive emissions**

The FCCU process is a fully closed process. There are minimal fugitive emission sources along the process line. However, during stage 1 of the reactor / stripper replacement, there will be minor fugitive emission of particulate matter from construction activities and exhaust emissions (mainly diesel exhaust) from construction traffic and machinery.

### **5.2.1 Dust from catalyst removal**

During major planned and unplanned shutdowns of the FCCU, removal of catalyst from the unit into a catalyst storage hopper is required. Catalyst is stored in this vessel and returned to the unit following the shutdown.

During this shutdown process, process air from the unit is used to push catalyst across to the catalyst storage hopper, and hence particulate emissions are associated with the venting of this excess air from the hopper to a safe location. The concentrations of particulate emissions are estimated to be between 250 mg/Nm<sup>3</sup> and 1000 mg/Nm<sup>3</sup>. The rate of air flow is estimated to be 100 tonnes per day (t/d), compared with the normal airflow to the FCCU of between 3,000 and 4,000 t/day.

It is noted that such planned activities occur once every four years during the shutdown of the unit. The unloading process takes approximately six hours.

During normal operation, spent catalyst is unloaded at a rate of approximately 2-3 tonnes per day (compared with 700t in half day during a planned shutdown). The normal removal rate is managed without the need for significant airflow and hence there are very minimal particulate emissions. This spent catalyst is directed to cement kilns and disposed of in the cement manufacture process.

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## 6. APPROACH TO ASSESSMENT

The AUSPLUME dispersion model (Version 6.0) was used to predict ground-level concentrations of emissions of the following pollutants:

- CO
- NO<sub>x</sub>
- PM<sub>10</sub>
- TSP
- SO<sub>2</sub>
- SO<sub>3</sub>
- Benzo(a)pyrene
- Speciated VOCs (as presented in **Table 11**)
- Metals
- 

The meteorological data file discussed in **Section 4.1** was used in conjunction with the emission rates presented in **Section 5.1.1** to predict concentrations of emissions at a set of receptors arranged at 200 metres spacing approximately 15 km x 15 km around the plant. Additional receptors were placed at the nearest residential areas, as shown in **Figure 1**. The maximum predicted off-site concentration and the predicted concentrations at the discrete receptors have been compared with the relevant NSW DECC's impact assessment criteria in **Section 3**.

There are no concurrent background data available and therefore none have been included in the modelling. A cumulative impact assessment which took account of due to all emissions from the site, and a qualitative assessment including the existing background concentrations, are presented in **Section 7.2**.

Due to the tall stacks onsite, the DECC requested that additional modelling be carried out using the puff dispersion model, CALPUFF. **Appendix D** presents a summary of the differences between AUSPLUME and CALPUFF and a comparison of the proposed cumulative impacts using both models.

## 7. ASSESSMENT OF IMPACTS USING AUSPLUME

This section presents a summary of the predicted impacts using the AUSPLUME dispersion model. An assessment of the impacts using CALPUFF is presented in **Appendix D**.

### 7.1 FCCU and Boiler 7/9

This section presents an assessment of the air quality impacts due to emissions from the operation of the FCCU (Boiler No. 8 stack) and Boiler 7/9 stack.

#### 7.1.1 Maximum predicted off-site concentrations

**Table 12** presents a summary of the maximum predicted off-site concentrations. The location of the maximum concentrations are shown on **Figure 7** to **Figure 21** which present contour plots for the pollutants CO, NO<sub>x</sub>, PM<sub>10</sub>, TSP, SO<sub>2</sub> and SO<sub>3</sub>. These figures also show the cumulative impacts with all stack sources. The cumulative impacts are discussed in **Section 7.2.2**.

All the predicted concentrations due to emissions from the FCCU (Boiler No. 8 stack) and Boiler 7/9 are below the relevant impact assessment criteria for both the existing and proposed operations.

**Table 12: Maximum predicted off-site ground-level concentrations due to emissions from the FCCU and Boiler 7/9**

Pollutant	Assessment criteria	Averaging time	Scenario	Concentration
Carbon monoxide (CO)	30 mg/m <sup>3</sup>	1-hour maximum	Existing	0.55 mg/m <sup>3</sup>
			Proposed	0.53 mg/m <sup>3</sup>
	10 mg/m <sup>3</sup>	8-hour maximum	Existing	0.14 mg/m <sup>3</sup>
			Proposed	0.12 mg/m <sup>3</sup>
Nitrogen dioxide (NO <sub>2</sub> )	246 µg/m <sup>3</sup>	1-hour maximum	Existing	22 µg/m <sup>3</sup>
			Proposed	22 µg/m <sup>3</sup>
	62 µg/m <sup>3</sup>	Annual Mean	Existing	0.16 µg/m <sup>3</sup>
			Proposed	0.17 µg/m <sup>3</sup>
Particulate matter < 10 µm (PM <sub>10</sub> )	50 µg/m <sup>3</sup>	24-hour maximum	Existing – normal operations	0.44 µg/m <sup>3</sup>
			Proposed – normal operations	0.42 µg/m <sup>3</sup>
			Existing – upset conditions	0.65 µg/m <sup>3</sup>
			Proposed - upset conditions	0.63 µg/m <sup>3</sup>
	30 µg/m <sup>3</sup>	Annual mean	Existing – normal operations	0.05 µg/m <sup>3</sup>
			Proposed – normal operations	0.05 µg/m <sup>3</sup>
			Existing – upset conditions	0.07 µg/m <sup>3</sup>
			Proposed - upset conditions	0.07 µg/m <sup>3</sup>
TSP	90 µg/m <sup>3</sup>	Annual mean	Existing – normal operations	0.06 µg/m <sup>3</sup>
			Proposed – normal operations	0.07 µg/m <sup>3</sup>
			Existing – upset conditions	0.09 µg/m <sup>3</sup>
			Proposed - upset conditions	0.09 µg/m <sup>3</sup>
Sulfur dioxide	712 µg/m <sup>3</sup>	10-minute maximum	Existing	318 µg/m <sup>3</sup>
			Proposed (maximum emission rate)	659 µg/m <sup>3</sup>
	570 µg/m <sup>3</sup>	1-hour maximum	Existing	224 µg/m <sup>3</sup>
			Proposed (maximum emission rate)	488 µg/m <sup>3</sup>
	228 µg/m <sup>3</sup>	1 day	Existing	19.9 µg/m <sup>3</sup>
			Proposed (maximum emission rate)	19.8 µg/m <sup>3</sup>
	60 µg/m <sup>3</sup>	Annual average	Existing	1.2 µg/m <sup>3</sup>
			Proposed (maximum emission rate)	4.9 µg/m <sup>3</sup>
Sulfuric Acid (as SO <sub>3</sub> )	1.80E-02 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	8.82E-04 mg/m <sup>3</sup>
			Proposed	8.84E-04 mg/m <sup>3</sup>
PAHs (as B[a]P)	4.00E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	1.17E-06 mg/m <sup>3</sup>
			Proposed	1.20E-06 mg/m <sup>3</sup>
Arsenic	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	6.32E-07 mg/m <sup>3</sup>
			Proposed	6.85E-07 mg/m <sup>3</sup>
Beryllium	4.00E-06 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	2.60E-07 mg/m <sup>3</sup>
			Proposed	2.72E-07 mg/m <sup>3</sup>
Cadmium	1.80E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	4.12E-07 mg/m <sup>3</sup>
			Proposed	4.45E-07 mg/m <sup>3</sup>
Cobalt			Existing	1.19E-06 mg/m <sup>3</sup>
			Proposed	1.11E-06 mg/m <sup>3</sup>
Chromium VI	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	9.91E-04 mg/m <sup>3</sup>
			Proposed	6.31E-06 mg/m <sup>3</sup>
Mercury (organic)	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	5.01E-06 mg/m <sup>3</sup>
			Proposed	5.24E-06 mg/m <sup>3</sup>
Manganese	1.30E-02 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	4.45E-06 mg/m <sup>3</sup>
			Proposed	7.41E-06 mg/m <sup>3</sup>
Nickel	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	4.45E-06 mg/m <sup>3</sup>
			Proposed	7.41E-06 mg/m <sup>3</sup>
Antimony	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	8.03E-07 mg/m <sup>3</sup>
			Proposed	8.38E-07 mg/m <sup>3</sup>
Selenium	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	1.49E-05 mg/m <sup>3</sup>
			Proposed	1.56E-05 mg/m <sup>3</sup>
Tin			Existing	4.58E-05 mg/m <sup>3</sup>
			Proposed	3.78E-05 mg/m <sup>3</sup>
Vanadium			Existing	1.97E-06 mg/m <sup>3</sup>
			Proposed	1.86E-06 mg/m <sup>3</sup>
Lead	5.00E-04 mg/m <sup>3</sup>	Annual Mean	Existing	4.60E-09 mg/m <sup>3</sup>
			Proposed	4.61E-09 mg/m <sup>3</sup>

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### 7.1.2 Discrete receptor concentrations

**Table 13** to **Table 21** present a summary of the maximum predicted ground-level concentrations at each of the discrete receptors identified on **Figure 1**. The locations of these were chosen to represent the closest residential areas to the site. **Section 7.1.1** discussed the location of the maximum predicted off-site concentrations.

All the predicted concentrations due to emissions from the FCCU (Boiler No. 8 stack) and Boiler 7/9 at the discrete receptors are below the relevant impact assessment criteria for both the existing and proposed operations.

The predicted 1-hour average CO concentrations at the residential receptors are all below  $0.5 \text{ mg/m}^3$ , which is significantly below the impact assessment criteria of  $30 \text{ mg/m}^3$ . The predicted change in 1-hour average CO concentrations at the residential receptors ranges between no change at receptor 8 to a 19% decrease at receptor 1.

The 8-hour average CO concentrations are predicted to have between a 8% and a 22% decrease at the residential receptors and are significantly lower than the impact assessment criteria of  $10 \text{ mg/m}^3$ .

All the predicted 1-hour average and annual average  $\text{NO}_2$  concentrations are below the impact assessment criteria of  $246 \text{ } \mu\text{g/m}^3$  and  $62 \text{ } \mu\text{g/m}^3$ , respectively. There is a predicted decrease in 1-hour average  $\text{NO}_2$  concentrations at the majority of the residential receptors, the exceptions are receptors 1, 5 and 6 where there is a predicted increase of between 5% and 13%. Annual average  $\text{NO}_2$  concentrations are predicted to increase between 3% and 22%, but remain at less than  $0.05 \text{ } \mu\text{g/m}^3$  at all the discrete receptors.

For the normal operations, the 24-hour average  $\text{PM}_{10}$  concentrations are predicted to change between a 10% increase at receptor 5 and an 11% decrease at receptor 2. Predicted concentrations due to upset operations (in-stack concentration of  $75 \text{ mg/Nm}^3$ ) are predicted to have approximately the same percentage changes. All the predicted concentrations are significantly below the impact assessment criteria of  $50 \text{ } \mu\text{g/m}^3$ . The maximum predicted concentration of  $0.56 \text{ } \mu\text{g/m}^3$  at receptor 3 represents less than 1.2% of the impact assessment criteria of  $50 \text{ } \mu\text{g/m}^3$ .

The maximum predicted annual average  $\text{PM}_{10}$  concentration at the discrete receptors of  $0.06 \text{ } \mu\text{g/m}^3$  (in-stack concentration of  $75 \text{ mg/Nm}^3$ ) is significantly below the impact assessment criteria of  $10 \text{ } \mu\text{g/m}^3$ . The predicted changes due to the proposed upgrade varies between a 4% increase at receptor 7 and a 6% decrease at receptors 4 and 5.

The maximum predicted annual average TSP concentrations of  $0.08 \text{ } \mu\text{g/m}^3$  (Receptor 6, in-stack concentration of  $75 \text{ mg/Nm}^3$ ) is significantly below the impact assessment criteria of  $90 \text{ } \mu\text{g/m}^3$ . The predicted changes due to the proposed upgrade varies between a 6 % increase (receptor 7, in-stack concentration of  $50 \text{ mg/Nm}^3$  and  $75 \text{ mg/Nm}^3$ ) and a 5 % decrease (receptors 4, in-stack concentration of  $75 \text{ mg/Nm}^3$ ).

For the  $\text{SO}_2$  predictions, it is important to note that as discussed in **Section 5.1.3**, the existing operations were modelled using a varying emissions file collated from measured CEMS data, compared with the proposed operations which were modelled to provide the maximum permissible emission rate. Calculating the maximum allowable emission rate for the proposed operations ensures compliance with the assessment criteria with the varying range of sulfur content in the crude.

The change in predicted 10-minute average SO<sub>2</sub> concentrations at the residential receptors ranges from a 126% increase at receptor 1 to a 17% decrease at receptor 2. All concentrations are below the impact assessment criteria of 712 µg/m<sup>3</sup>.

The 1-hour average SO<sub>2</sub> concentrations at the residential receptors are predicted to change between a 126% increase at receptor 1 to an 11% decrease at receptors 2 and 3. All concentrations are below the impact assessment criteria of 570 µg/m<sup>3</sup>.

The change in predicted 24-hour average SO<sub>2</sub> concentrations at the residential receptors is a maximum 265% increase at receptor 7. All concentrations are significantly below the impact assessment criteria of 228 µg/m<sup>3</sup>.

The predicted change in the 1-hour average 99.9<sup>th</sup> percentile SO<sub>3</sub> concentrations varies between no change at receptor 6 and a 9% increase at receptor 4. All concentrations are below the impact assessment criteria of 0.018 mg/m<sup>3</sup>.

The 1-hour average 99.9<sup>th</sup> percentile PAH (as BaP equivalent) concentrations are predicted to change to a maximum 17% increase at receptor 17. All concentrations are significantly below the impact assessment criteria of 0.0004 mg/m<sup>3</sup>.

All the predicted metals concentrations are below the relevant assessment criteria.

**Table 13: Maximum predicted CO ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (mg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>1-hour</i>		<i>8-hour</i>	
<i>Impact assessment criteria</i>			<i>30 mg/m<sup>3</sup></i>		<i>10 mg/m<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations</b>	<b>Proposed operations</b>	<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>				
318574	6254217	1	0.19	0.16	0.05	0.04
319152	6256283	2	0.15	0.14	0.09	0.07
319267	6256088	3	0.16	0.14	0.09	0.07
319456	6256003	4	0.16	0.14	0.09	0.07
316840	6255957	5	0.12	0.11	0.06	0.05
316823	6255785	6	0.13	0.10	0.06	0.05
316783	6255539	7	0.11	0.11	0.06	0.05
316777	6255247	8	0.12	0.11	0.06	0.05

\*see **Figure 1** for location of receptors

**Table 14: Maximum predicted NO<sub>2</sub> ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (µg/m<sup>3</sup>)**

Averaging period			1-hour		Annual	
Impact assessment criteria <sup>(a)</sup>			246 µg/m <sup>3</sup>		62 µg/m <sup>3</sup>	
Receptor location*			Existing operations	Proposed operations	Existing operations	Proposed operations
X (m) MGA	Y (m) MGA	ID				
318574	6254217	1	0.7	0.8	0.01	0.01
319152	6256283	2	1.2	0.9	0.02	0.02
319267	6256088	3	1.1	0.9	0.02	0.02
319456	6256003	4	1.1	0.9	0.02	0.02
316840	6255957	5	0.7	0.8	0.03	0.03
316823	6255785	6	0.8	0.8	0.03	0.03
316783	6255539	7	0.8	1.0	0.03	0.03
316777	6255247	8	0.9	0.8	0.03	0.03

\* see **Figure 1** for location of receptors

Note:

<sup>(a)</sup> It has been assumed that the NO<sub>2</sub> concentrations are 20% of the total NO<sub>x</sub> concentrations.

**Table 15: Maximum predicted 24-hour average PM<sub>10</sub> ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (µg/m<sup>3</sup>)**

Averaging period			24-hour			
Impact assessment criteria			50 µg/m <sup>3</sup>			
			In-stack TSP concentration			
			50 mg/Nm <sup>3</sup>		75 mg/Nm <sup>3</sup>	
Receptor location*			Existing operations	Proposed operations	Existing operations	Proposed operations
X (m) MGA	Y (m) MGA	ID				
318574	6254217	1	0.13	0.14	0.20	0.21
319152	6256283	2	0.32	0.29	0.48	0.43
319267	6256088	3	0.38	0.34	0.56	0.51
319456	6256003	4	0.37	0.34	0.55	0.50
316840	6255957	5	0.23	0.25	0.33	0.36
316823	6255785	6	0.24	0.26	0.35	0.37
316783	6255539	7	0.20	0.22	0.29	0.31
316777	6255247	8	0.18	0.19	0.26	0.28

\* see **Figure 1** for location of receptors

**Table 16: Predicted annual average PM<sub>10</sub> ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>Annual</i>			
<i>Impact assessment criteria</i>			<i>30 µg/m<sup>3</sup></i>			
			<i>In-stack TSP concentration</i>			
			<i>50 mg/Nm<sup>3</sup></i>		<i>75 mg/Nm<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations</b>	<b>Proposed operations</b>	<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>				
318574	6254217	1	0.02	0.02	0.03	0.03
319152	6256283	2	0.03	0.03	0.04	0.04
319267	6256088	3	0.03	0.03	0.05	0.04
319456	6256003	4	0.03	0.03	0.05	0.04
316840	6255957	5	0.04	0.04	0.05	0.06
316823	6255785	6	0.04	0.04	0.06	0.06
316783	6255539	7	0.04	0.04	0.05	0.06
316777	6255247	8	0.04	0.04	0.05	0.05

\* see Figure 1 for location of receptors

**Table 17: Predicted annual average TSP ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>Annual</i>			
<i>Impact assessment criteria</i>			<i>90 µg/m<sup>3</sup></i>			
			<i>In-stack TSP concentration</i>			
			<i>50 mg/Nm<sup>3</sup></i>		<i>75 mg/Nm<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations</b>	<b>Proposed operations</b>	<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>				
318574	6254217	1	0.03	0.03	0.04	0.04
319152	6256283	2	0.04	0.04	0.06	0.06
319267	6256088	3	0.04	0.04	0.06	0.06
319456	6256003	4	0.04	0.04	0.06	0.06
316840	6255957	5	0.05	0.05	0.07	0.08
316823	6255785	6	0.06	0.06	0.08	0.08
316783	6255539	7	0.05	0.05	0.07	0.08
316777	6255247	8	0.05	0.05	0.07	0.07

\* see Figure 1 for location of receptors

**Table 18: Maximum predicted SO<sub>2</sub> ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>10-minute</i>		<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>712 µg/m<sup>3</sup></i>		<i>570 µg/m<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations<sup>(a)</sup></b>	<b>Proposed operations<sup>(b)</sup></b>	<b>Existing operations<sup>(a)</sup></b>	<b>Proposed operations<sup>(b)</sup></b>
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>				
318574	6254217	1	86	195	65	147
319152	6256283	2	203	168	142	126
319267	6256088	3	199	168	146	130
319456	6256003	4	163	174	132	128
316840	6255957	5	97	131	68	97
316823	6255785	6	94	120	69	93
316783	6255539	7	69	131	55	97
316777	6255247	8	81	133	57	99
<b>Receptor location*</b>			<i>24-hour</i>		<i>Annual</i>	
<b>Receptor location*</b>			<i>228 µg/m<sup>3</sup></i>		<i>60 µg/m<sup>3</sup></i>	
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>				
318574	6254217	1	4	15	0.5	2.0
319152	6256283	2	11	31	0.8	2.8
319267	6256088	3	11	36	0.9	3.0
319456	6256003	4	10	36	0.9	2.9
316840	6255957	5	8	25	0.9	3.8
316823	6255785	6	8	25	0.9	4.0
316783	6255539	7	6	21	0.9	3.8
316777	6255247	8	6	19	0.9	3.6

\* see Figure 1 for location of receptors

Note:

- (a) Existing operations were modelled using variable CEMS emission data.
- (b) Proposed operations were modelled using the maximum allowable emission rate that ensures compliance with the assessment criteria.

**Table 19: Predicted SO<sub>3</sub> ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations - 99.9<sup>th</sup> percentile (mg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>0.018 mg/m<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>		
318574	6254217	1	7.56E-04	8.02E-04
319152	6256283	2	8.34E-04	8.46E-04
319267	6256088	3	8.82E-04	8.84E-04
319456	6256003	4	8.29E-04	8.67E-04
316840	6255957	5	5.89E-04	6.40E-04
316823	6255785	6	6.15E-04	6.52E-04
316783	6255539	7	6.01E-04	6.25E-04
316777	6255247	8	6.01E-04	6.05E-04

\* see Figure 1 for location of receptors

**Table 20: Predicted PAH (as BaP equivalent) ground-level concentrations at discrete receptor due to FCCU & Boiler 7/9 operations - 99.9<sup>th</sup> percentile (mg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>0.0004 mg/m<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m)</b> <b>MGA</b>	<b>Y (m)</b> <b>MGA</b>	<b>ID</b>		
318574	6254217	1	9.57E-10	1.04E-09
319152	6256283	2	9.72E-10	1.01E-09
319267	6256088	3	1.02E-09	1.09E-09
319456	6256003	4	9.81E-10	1.04E-09
316840	6255957	5	1.03E-09	1.06E-09
316823	6255785	6	1.03E-09	1.07E-09
316783	6255539	7	1.02E-09	1.10E-09
316777	6255247	8	1.03E-09	1.21E-09

\* see **Figure 1** for location of receptors

**Table 21: Predicted ground-level concentrations of metals at discrete receptor due to existing FCCU & Boiler 7/9 operations (mg/m<sup>3</sup>)**

Pollutant		Goal (mg/m <sup>3</sup> )	Residence ID*							
			1	2	3	4	5	6	7	8
			Existing operations							
			99.9 <sup>th</sup> percentile 1-hour average concentrations (mg/m <sup>3</sup> )							
Antimony		9.00E-03	4.97E-07	5.06E-07	5.26E-07	5.28E-07	4.55E-07	4.76E-07	4.38E-07	4.35E-07
Arsenic		9.00E-05	2.26E-07	2.43E-07	2.47E-07	2.47E-07	2.07E-07	2.17E-07	1.98E-07	1.97E-07
Beryllium		4.00E-06	1.31E-07	1.32E-07	1.37E-07	1.38E-07	1.22E-07	1.27E-07	1.17E-07	1.16E-07
Cadmium		1.80E-05	5.85E-08	5.78E-08	5.85E-08	5.81E-08	5.56E-08	5.77E-08	5.50E-08	5.42E-08
Chromium	Cr VI	9.00E-05	9.91E-04	8.99E-04	9.00E-04	9.10E-04	8.35E-04	8.80E-04	8.17E-04	8.25E-04
	Cr III	9.00E-03								
Cobalt		-	1.02E-07	1.11E-07	1.18E-07	1.10E-07	7.76E-08	8.05E-08	7.56E-08	7.80E-08
Manganese		1.30E-02	1.06E-06	1.14E-06	1.24E-06	1.22E-06	8.93E-07	9.42E-07	8.67E-07	8.68E-07
Mercury	organic	1.80E-04	1.57E-06	1.65E-06	1.75E-06	1.63E-06	1.10E-06	1.15E-06	1.06E-06	1.05E-06
	inorganic	1.80E-03								
Nickel		1.80E-04	7.01E-07	1.07E-06	4.90E-07	7.77E-07	1.17E-06	6.19E-07	2.74E-06	7.90E-07
Selenium		-	1.62E-07	1.65E-07	1.72E-07	1.73E-07	1.48E-07	1.55E-07	1.42E-07	1.41E-07
Tin		-	3.13E-06	3.38E-06	3.68E-06	3.62E-06	2.65E-06	2.80E-06	2.58E-06	2.57E-06
Vanadium		-	1.06E-07	1.59E-07	7.63E-08	1.18E-07	1.77E-07	9.48E-08	4.10E-07	1.19E-07
Pollutant		Goal (mg/m <sup>3</sup> )	Annual average (mg/m <sup>3</sup> )							
Lead		5.00E-04	2.91E-08	4.34E-08	4.71E-08	4.68E-08	5.69E-08	6.04E-08	5.55E-08	5.32E-08

\*see Figure 1 for location of receptors

**Table 22: Predicted ground-level concentrations of metals at discrete receptor due to proposed FCCU & Boiler 7/9 operations (mg/m<sup>3</sup>)**

Pollutant	Goal (mg/m <sup>3</sup> )	Residence ID*								
		1	2	3	4	5	6	7	8	
		Proposed operations								
		99.9 <sup>th</sup> percentile 1-hour average concentrations (mg/m <sup>3</sup> )								
Antimony	9.00E-03	5.76E-07	5.49E-07	5.43E-07	5.52E-07	4.85E-07	5.13E-07	4.77E-07	4.81E-07	
Arsenic	9.00E-05	2.63E-07	2.65E-07	2.63E-07	2.66E-07	2.22E-07	2.33E-07	2.18E-07	2.18E-07	
Beryllium	4.00E-06	1.58E-07	1.44E-07	1.44E-07	1.46E-07	1.33E-07	1.40E-07	1.30E-07	1.31E-07	
Cadmium	1.80E-05	7.00E-08	6.45E-08	6.21E-08	6.23E-08	6.00E-08	6.29E-08	5.86E-08	5.99E-08	
Chromium	Cr VI	9.00E-05	9.91E-07	8.99E-07	9.00E-07	9.10E-07	8.35E-07	8.80E-07	8.17E-07	8.25E-07
	Cr III	9.00E-03								
Cobalt	-	1.02E-04	1.09E-04	1.14E-04	1.11E-04	8.22E-05	8.49E-05	8.09E-05	7.81E-05	
Manganese	1.30E-02	1.14E-06	1.25E-06	1.27E-06	1.24E-06	9.68E-07	1.01E-06	9.51E-07	9.31E-07	
Mercury	organic	1.80E-04	1.51E-06	1.59E-06	1.69E-06	1.62E-06	1.18E-06	1.20E-06	1.11E-06	1.14E-06
	inorganic	1.80E-03								
Nickel	1.80E-04	8.71E-07	1.39E-06	8.52E-07	1.02E-06	1.49E-06	9.59E-07	2.92E-06	8.98E-07	
Selenium	-	1.86E-07	1.79E-07	1.77E-07	1.82E-07	1.57E-07	1.66E-07	1.55E-07	1.56E-07	
Tin	-	3.39E-06	3.73E-06	3.79E-06	3.70E-06	2.88E-06	3.01E-06	2.83E-06	2.78E-06	
Vanadium	-	1.00E-07	1.51E-07	7.67E-08	1.18E-07	1.65E-07	8.65E-08	3.75E-07	1.12E-07	
Pollutant	Goal (mg/m <sup>3</sup> )	Annual average (mg/m <sup>3</sup> )								
Lead	5.00E-04	2.85E-08	4.01E-08	4.24E-08	4.19E-08	5.59E-08	5.91E-08	5.51E-08	5.23E-08	

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## 7.2 Cumulative impacts

### 7.2.1 Introduction

There are two points to consider regarding the cumulative impacts. Firstly, there is the cumulative off-site impact due to emissions from the other stack sources at the Shell Clyde site, and secondly there is the combined impact of all the off-site impacts with existing background concentrations, for both the existing and proposed operations.

Emissions from the Shell Clyde site are released from a total of six stacks and a twin flare. There are also fugitive emissions from tanks, flanges and valves. However, as discussed in **Section 5.2**, the FCCU is a fully closed process and therefore fugitive emissions are not included in this assessment.

### 7.2.2 Cumulative impacts of all stacks

#### 7.2.2.1 Maximum predicted off-site concentrations

**Table 23** presents a summary of the maximum predicted off-site concentrations. The location of the maximum concentrations are shown on **Figure 7** to **Figure 21** which present contour plots for the pollutants CO, NO<sub>x</sub>, PM<sub>10</sub>, TSP, SO<sub>2</sub> and SO<sub>3</sub>.

All the predicted concentrations due to cumulative stack emissions are below the relevant impact assessment criteria for both the existing and proposed operations.

**Table 23: Maximum predicted off-site ground-level concentrations due to emissions from all sources**

Pollutant	Assessment criteria	Averaging time	Scenario		Concentration	
			Existing	Proposed		
Carbon monoxide (CO)	30 mg/m <sup>3</sup>	1-hour maximum	Existing	0.57	mg/m <sup>3</sup>	
			Proposed	0.55		
	10 mg/m <sup>3</sup>	8-hour maximum	Existing	0.14	mg/m <sup>3</sup>	
			Proposed	0.13		
Nitrogen dioxide (NO <sub>2</sub> )	246 mg/m <sup>3</sup>	1-hour maximum	Existing	0	mg/m <sup>3</sup>	
			Proposed	49		
	62 mg/m <sup>3</sup>	Annual Mean	Existing	0.43	mg/m <sup>3</sup>	
			Proposed	0.46		
Particulate matter < 10 µm (PM <sub>10</sub> )	50 µg/m <sup>3</sup>	24-hour maximum	Existing – normal operations	0.56	µg/m <sup>3</sup>	
			Proposed – normal operations	0.61		
			Existing – upset conditions	0.78		
			Proposed - upset conditions	0.84		
	30 µg/m <sup>3</sup>	Annual mean	Existing – normal operations	0.06	µg/m <sup>3</sup>	
			Proposed – normal operations	0.06		
			Existing – upset conditions	0.08		
			Proposed - upset conditions	0.08		
TSP	90 µg/m <sup>3</sup>	Annual mean	Existing – normal operations	0.09	µg/m <sup>3</sup>	
			Proposed – normal operations	0.10		
			Existing – upset conditions	0.12		
			Proposed - upset conditions	0.12		
Sulfur dioxide	712 µg/m <sup>3</sup>	10-minute maximum	Existing	336	µg/m <sup>3</sup>	
			Proposed (maximum emission rate)	685		
	570 µg/m <sup>3</sup>	1-hour maximum	Existing	239	µg/m <sup>3</sup>	
			Proposed (maximum emission rate)	483		
	228 µg/m <sup>3</sup>	1 day	Existing	20.6	µg/m <sup>3</sup>	
			Proposed (maximum emission rate)	49.8		
	60 µg/m <sup>3</sup>	Annual average	Existing	1.4	µg/m <sup>3</sup>	
			Proposed (maximum emission rate)	4.9		
Sulfuric Acid (as SO <sub>3</sub> )	1.80E-02 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	7.44E-03	mg/m <sup>3</sup>	
			Proposed	7.15E-03		
PAHs (as B[a]P)	4.00E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	2.22E-08	mg/m <sup>3</sup>	
			Proposed	2.32E-08		
Arsenic	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	3.46E-06	mg/m <sup>3</sup>	
			Proposed	3.85E-06		
Beryllium	4.00E-06 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	1.23E-06	mg/m <sup>3</sup>	
			Proposed	1.32E-06		
Cadmium	1.80E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	6.49E-07	mg/m <sup>3</sup>	
			Proposed	7.07E-07		
Cobalt	-		Existing	1.19E-06	mg/m <sup>3</sup>	
			Proposed	1.11E-06		
Chromium VI	9.00E-05 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	9.49E-06	mg/m <sup>3</sup>	
			Proposed	1.01E-05		
Mercury (organic)	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	5.98E-06	mg/m <sup>3</sup>	
			Proposed	6.47E-06		
Manganese	1.30E-02 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	8.94E-06	mg/m <sup>3</sup>	
			Proposed	9.41E-06		
Nickel	1.80E-04 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	1.03E-05	mg/m <sup>3</sup>	
			Proposed	1.40E-05		
Antimony	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	6.04E-06	mg/m <sup>3</sup>	
			Proposed	6.27E-06		
Selenium	9.00E-03 mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile	Existing	2.18E-06	mg/m <sup>3</sup>	
			Proposed	2.24E-06		
Tin	-		Existing	4.58E-05	mg/m <sup>3</sup>	
			Proposed	3.78E-05		
Vanadium	-		Existing	1.97E-06	mg/m <sup>3</sup>	
			Proposed	1.86E-06		
Lead	5.00E-04 mg/m <sup>3</sup>	Annual Mean	Existing	9.05E-08	mg/m <sup>3</sup>	
			Proposed	9.18E-08		

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### 7.2.2.2 Discrete receptor concentrations

**Table 24** to **Table 32** present a summary of the cumulative predicted ground-level concentrations at the discrete receptors. All the predicted concentrations are below the relevant impact assessment criteria for both the existing and proposed operations.

### 7.2.3 Cumulative impacts of all stacks and existing background concentrations

There has been no monitoring undertaken specifically for this project, and therefore the assessment of cumulative impacts due to emissions from all the stacks is based on data from the closest DECC monitoring stations.

As presented in **Section 4.5**, the maximum 24-hour PM<sub>10</sub> concentrations are shown to exceed the impact assessment criteria of 50 µg/m<sup>3</sup> at both Lidcombe and Liverpool. The highest recorded concentrations are all attributed to bushfires and duststorms (**NSW EPA, 2003; NSW DEC 2005c, NSW DEC 2006**). The highest predicted 24-hour average PM<sub>10</sub> concentrations at the discrete receptors due to emissions from the FCCU and Boiler 7/9 are less than 0.1 µg/m<sup>3</sup> and are therefore unlikely to contribute to any additional exceedances of the impact assessment criteria.

The annual average PM<sub>10</sub> concentration at Lidcombe in 2001 was 19 µg/m<sup>3</sup> and at Liverpool for the period to June 2006 it was 20.1 µg/m<sup>3</sup>. The predicted annual average PM<sub>10</sub> concentrations at the residential receptors due to emissions from the FCCU (Boiler No.8 stack) and Boiler 7/9 stack are less than 0.6 µg/m<sup>3</sup>. It is therefore unlikely that the operation of the FCCU and Boiler 7/9 would result in exceedance of the impact assessment criteria of 30 µg/m<sup>3</sup>.

There are no TSP measurements taken at Liverpool or Lidcombe to estimate the cumulative impacts, however, given that the maximum predicted annual average concentrations are a maximum of 0.08 µg/m<sup>3</sup>, it is unlikely that this would result in an exceedance of the impact assessment criteria of 90 mg/m<sup>3</sup>.

The maximum measured 1-hour average NO<sub>2</sub> concentration at Lidcombe in 2001 was approximately 146 µg/m<sup>3</sup> and at Liverpool for the period to June 2006 approximately 105 µg/m<sup>3</sup>. The maximum predicted 1-hour average NO<sub>2</sub> concentration at the residential receptors is 1.2 µg/m<sup>3</sup>, it is therefore unlikely that the impact assessment criteria of 246 µg/m<sup>3</sup> would be exceeded.

The annual average NO<sub>2</sub> concentrations were approximately 32.8 µg/m<sup>3</sup> at Lidcombe and 47 µg/m<sup>3</sup> at Liverpool. Based on the maximum predicted concentrations at the residential receptors being 0.03 µg/m<sup>3</sup>, it is unlikely that the impact assessment criteria of 62 µg/m<sup>3</sup> would be exceeded.

The maximum measured 1-hour average SO<sub>2</sub> concentration at Randwick was approximately 100 µg/m<sup>3</sup>. Based on the maximum predicted 1-hour average cumulative concentration of 165 mg/m<sup>3</sup>, it is unlikely that the impact assessment criteria of 570 µg/m<sup>3</sup> would be exceeded.

**Table 24: Maximum predicted CO ground-level concentrations at discrete receptor due to cumulative operations (mg/m<sup>3</sup>)**

Averaging period			1-hour		8-hour	
Impact assessment criteria			30 mg/m <sup>3</sup>		10 mg/m <sup>3</sup>	
Receptor location			Existing operations	Proposed operations	Existing operations	Proposed operations
X (m) MGA	Y (m) MGA	ID				
318574	6254217	1	0.19	0.17	0.05	0.04
319152	6256283	2	0.15	0.14	0.09	0.07
319267	6256088	3	0.17	0.15	0.09	0.07
319456	6256003	4	0.16	0.14	0.09	0.07
316840	6255957	5	0.13	0.11	0.06	0.05
316823	6255785	6	0.13	0.10	0.06	0.05
316783	6255539	7	0.11	0.11	0.06	0.06
316777	6255247	8	0.12	0.11	0.06	0.05

**Table 25: Maximum predicted NO<sub>2</sub> ground-level concentrations at discrete receptor due to cumulative operations (µg/m<sup>3</sup>)**

Averaging period			1-hour		Annual	
Impact assessment criteria <sup>(a)</sup>			246 µg/m <sup>3</sup>		62 µg/m <sup>3</sup>	
Receptor location			Existing operations	Proposed operations	Existing operations	Proposed operations
X (m) MGA	Y (m) MGA	ID				
318574	6254217	1	1.6	1.9	0.05	0.05
319152	6256283	2	2.3	2.2	0.05	0.06
319267	6256088	3	2.1	2.1	0.06	0.06
319456	6256003	4	2.1	2.3	0.05	0.06
316840	6255957	5	1.4	2.0	0.08	0.08
316823	6255785	6	1.7	2.1	0.08	0.09
316783	6255539	7	1.7	2.4	0.07	0.08
316777	6255247	8	1.9	2.0	0.07	0.08

Note:

<sup>(a)</sup> It has been assumed that the NO<sub>2</sub> concentrations are 20% of the total NO<sub>x</sub> concentrations.

**Table 26: Maximum predicted 24-hour average PM<sub>10</sub> ground-level concentrations at discrete receptor due to cumulative operations (µg/m<sup>3</sup>)**

Averaging period			24-hour			
Impact assessment criteria			50 µg/m <sup>3</sup>			
Receptor location			In-stack TSP concentration			
			50 mg/Nm <sup>3</sup>		75 mg/Nm <sup>3</sup>	
X (m) MGA	Y (m) MGA	ID	Existing operations	Proposed operations	Existing operations	Proposed operations
318574	6254217	1	0.18	0.19	0.24	0.26
319152	6256283	2	0.38	0.37	0.54	0.49
319267	6256088	3	0.47	0.44	0.65	0.60
319456	6256003	4	0.44	0.42	0.62	0.58
316840	6255957	5	0.33	0.34	0.43	0.45
316823	6255785	6	0.34	0.36	0.44	0.47
316783	6255539	7	0.28	0.30	0.37	0.40
316777	6255247	8	0.26	0.28	0.34	0.36

**Table 27: Predicted annual average PM<sub>10</sub> ground-level concentrations at discrete receptor due to cumulative operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>Annual</i>			
<i>Impact assessment criteria</i>			<i>30 µg/m<sup>3</sup></i>			
<b>Receptor location</b>			<i>In-stack TSP concentration</i>			
			<i>50 mg/Nm<sup>3</sup></i>		<i>75 mg/Nm<sup>3</sup></i>	
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>	<b>Existing operations</b>	<b>Proposed operations</b>	<b>Existing operations</b>	<b>Proposed operations</b>
318574	6254217	1	0.03	0.03	0.04	0.04
319152	6256283	2	0.04	0.04	0.05	0.05
319267	6256088	3	0.04	0.04	0.06	0.05
319456	6256003	4	0.04	0.04	0.06	0.05
316840	6255957	5	0.05	0.05	0.07	0.07
316823	6255785	6	0.06	0.06	0.07	0.08
316783	6255539	7	0.05	0.05	0.07	0.07
316777	6255247	8	0.05	0.05	0.07	0.07

**Table 28: Predicted annual average TSP ground-level concentrations at discrete receptor due to cumulative operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>Annual</i>			
<i>Impact assessment criteria</i>			<i>90 µg/m<sup>3</sup></i>			
<b>Receptor location</b>			<i>In-stack TSP concentration</i>			
			<i>50 mg/Nm<sup>3</sup></i>		<i>75 mg/Nm<sup>3</sup></i>	
<b>X (m) MGA</b>	<b>Y (m) MGA</b>	<b>ID</b>	<b>Existing operations</b>	<b>Proposed operations</b>	<b>Existing operations</b>	<b>Proposed operations</b>
318574	6254217	1	0.05	0.05	0.06	0.06
319152	6256283	2	0.06	0.06	0.08	0.08
319267	6256088	3	0.06	0.06	0.08	0.08
319456	6256003	4	0.06	0.06	0.08	0.08
316840	6255957	5	0.08	0.08	0.10	0.10
316823	6255785	6	0.08	0.09	0.11	0.11
316783	6255539	7	0.08	0.08	0.10	0.10
316777	6255247	8	0.07	0.08	0.10	0.10

**Table 29: Maximum predicted SO<sub>2</sub> ground-level concentrations at discrete receptor due to cumulative operations (µg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>10-minute</i>		<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>712 µg/m<sup>3</sup></i>		<i>570 µg/m<sup>3</sup></i>	
<b>Receptor location*</b>			<b>Existing operations<sup>(a)</sup></b>	<b>Proposed operations<sup>(b)</sup></b>	<b>Existing operations<sup>(a)</sup></b>	<b>Proposed operations<sup>(b)</sup></b>
<b>X (m)</b>	<b>Y (m)</b>	<b>ID</b>				
<b>MGA</b>	<b>MGA</b>					
318574	6254217	1	91	200	69	144
319152	6256283	2	205	171	144	122
319267	6256088	3	201	172	147	126
319456	6256003	4	165	178	133	125
316840	6255957	5	100	135	70	96
316823	6255785	6	98	122	72	91
316783	6255539	7	70	135	58	95
316777	6255247	8	85	137	60	97
<b>X (m)</b>	<b>Y (m)</b>	<b>ID</b>	<i>24-hour</i>		<i>Annual</i>	
<b>MGA</b>	<b>MGA</b>		<i>228 µg/m<sup>3</sup></i>		<i>60 µg/m<sup>3</sup></i>	
318574	6254217	1	5	14.4	0.8	2.2
319152	6256283	2	12	30.4	1.0	2.8
319267	6256088	3	12	35.5	1.1	3.0
319456	6256003	4	11	35.3	1.1	3.0
316840	6255957	5	9	24.6	1.1	3.9
316823	6255785	6	9	25.2	1.2	4.1
316783	6255539	7	7	21.5	1.1	3.9
316777	6255247	8	7	19.3	1.1	3.7

\* see **Figure 1** for location of receptors

Note:

(a) Existing operations were modelled using variable CEMS emission data.

(b) Proposed operations were modelled using the maximum allowable emission rate that ensures compliance with the assessment criteria.

**Table 30: Maximum predicted SO<sub>3</sub> ground-level concentrations at discrete receptor due to cumulative operations (mg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>0.018 mg/m<sup>3</sup></i>	
<b>Receptor location</b>			<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m)</b>	<b>Y (m)</b>	<b>ID</b>		
<b>MGA</b>	<b>MGA</b>			
318574	6254217	1	2.07E-03	1.86E-03
319152	6256283	2	1.81E-03	1.66E-03
319267	6256088	3	1.95E-03	1.67E-03
319456	6256003	4	1.88E-03	1.60E-03
316840	6255957	5	1.62E-03	1.47E-03
316823	6255785	6	1.68E-03	1.52E-03
316783	6255539	7	1.59E-03	1.46E-03
316777	6255247	8	1.62E-03	1.47E-03

**Table 31: Maximum predicted PAH (as BaP equivalent) ground-level concentrations at discrete receptor due to cumulative operations (mg/m<sup>3</sup>)**

<i>Averaging period</i>			<i>1-hour</i>	
<i>Impact assessment criteria</i>			<i>0.0004 mg/m<sup>3</sup></i>	
<b>Receptor location</b>			<b>Existing operations</b>	<b>Proposed operations</b>
<b>X (m)</b>	<b>Y (m)</b>	<b>ID</b>		
<b>MGA</b>	<b>MGA</b>			
318574	6254217	1	9.57E-10	1.04E-09
319152	6256283	2	9.72E-10	1.01E-09
319267	6256088	3	1.02E-09	1.09E-09
319456	6256003	4	9.81E-10	1.04E-09
316840	6255957	5	1.03E-09	1.06E-09
316823	6255785	6	1.03E-09	1.07E-09
316783	6255539	7	1.02E-09	1.10E-09
316777	6255247	8	1.03E-09	1.21E-09

**Table 32: Predicted ground-level concentrations of metals at discrete receptor due to existing cumulative operations (mg/m<sup>3</sup>)**

Pollutant		Goal (mg/m <sup>3</sup> )	Residence ID							
			1	2	3	4	5	6	7	8
			Existing operations							
			99.9 <sup>th</sup> percentile 1-hour average concentrations (mg/m <sup>3</sup> )							
Antimony		9.00E-03	1.38E-06	1.21E-06	1.25E-06	1.25E-06	1.23E-06	1.29E-06	1.20E-06	1.21E-06
Arsenic		9.00E-05	1.04E-06	7.10E-07	7.18E-07	7.04E-07	7.66E-07	8.17E-07	7.71E-07	7.80E-07
Beryllium		4.00E-06	2.81E-07	2.50E-07	2.56E-07	2.55E-07	2.51E-07	2.64E-07	2.44E-07	2.50E-07
Cadmium		1.80E-05	1.58E-07	1.40E-07	1.45E-07	1.43E-07	1.43E-07	1.49E-07	1.39E-07	1.44E-07
Chromium	Cr VI	1.34E-05	2.18E-06	1.93E-06	1.99E-06	1.97E-06	1.95E-06	2.05E-06	1.92E-06	1.94E-06
	Cr III	9.00E-03								
Cobalt		-	1.22E-07	1.35E-07	1.47E-07	1.44E-07	1.03E-07	1.06E-07	1.00E-07	1.01E-07
Manganese		1.30E-02	1.91E-06	1.84E-06	1.92E-06	1.92E-06	1.71E-06	1.79E-06	1.67E-06	1.67E-06
Mercury	organic	1.27E-05	1.58E-06	1.68E-06	1.82E-06	1.67E-06	1.15E-06	1.17E-06	1.10E-06	1.08E-06
	inorganic	1.80E-03								
Nickel		1.80E-04	2.28E-06	2.23E-06	2.32E-06	2.33E-06	2.07E-06	2.18E-06	2.04E-06	2.03E-06
Selenium		-	5.78E-07	4.98E-07	4.98E-07	4.90E-07	5.01E-07	5.18E-07	4.92E-07	4.90E-07
Tin		-	1.52E-05	9.03E-06	9.23E-06	9.17E-06	9.51E-06	1.03E-05	9.79E-06	1.01E-05
Vanadium		-	2.07E-07	2.20E-07	2.41E-07	2.27E-07	1.60E-07	1.71E-07	1.58E-07	1.66E-07
Pollutant		Goal (mg/m <sup>3</sup> )	Annual average (mg/m <sup>3</sup> )							
Lead		5.00E-04	4.21E-08	5.71E-08	6.16E-08	6.08E-08	7.66E-08	8.20E-08	7.54E-08	7.28E-08

<b>Table 33: Predicted ground-level concentrations of metals at discrete receptor due to proposed cumulative operations (mg/m<sup>3</sup>)</b>										
<b>Pollutant</b>		<b>Goal (mg/m<sup>3</sup>)</b>	<b>Proposed operations</b>							
			<b>99.9<sup>th</sup> percentile 1-hour average concentrations (mg/m<sup>3</sup>)</b>							
Antimony		9.00E-03	1.57E-06	1.49E-06	1.44E-06	1.46E-06	1.34E-06	1.40E-06	1.31E-06	1.33E-06
Arsenic		9.00E-05	1.07E-06	7.80E-07	7.72E-07	7.81E-07	8.24E-07	8.61E-07	8.21E-07	8.26E-07
Beryllium		4.00E-06	3.28E-07	2.91E-07	2.88E-07	2.87E-07	2.80E-07	2.93E-07	2.73E-07	2.80E-07
Cadmium		1.80E-05	1.84E-07	1.78E-07	1.67E-07	1.72E-07	1.60E-07	1.67E-07	1.54E-07	1.59E-07
Chromium	Cr VI	1.37E-08	2.51E-06	2.37E-06	2.31E-06	2.33E-06	2.17E-06	2.27E-06	2.13E-06	2.15E-06
	Cr III	9.00E-03								
Cobalt		-	1.29E-07	1.36E-07	1.39E-07	1.33E-07	1.07E-07	1.11E-07	1.07E-07	1.04E-07
Manganese		1.30E-02	2.19E-06	2.03E-06	2.00E-06	2.05E-06	1.85E-06	1.95E-06	1.82E-06	1.88E-06
Mercury	organic	1.24E-05	1.56E-06	1.64E-06	1.74E-06	1.64E-06	1.24E-06	1.24E-06	1.16E-06	1.17E-06
	inorganic	1.80E-03								
Nickel		1.80E-04	3.36E-06	2.98E-06	2.88E-06	2.95E-06	2.86E-06	3.00E-06	2.80E-06	2.86E-06
Selenium		-	5.62E-07	4.33E-07	4.40E-07	4.43E-07	4.63E-07	4.86E-07	4.60E-07	4.57E-07
Tin		-	1.52E-05	9.47E-06	9.36E-06	9.55E-06	1.01E-05	1.07E-05	1.02E-05	1.04E-05
Vanadium		-	2.09E-07	2.15E-07	2.23E-07	2.19E-07	1.67E-07	1.67E-07	1.66E-07	1.56E-07
<b>Pollutant</b>		<b>Goal (mg/m<sup>3</sup>)</b>	<b>Annual average (mg/m<sup>3</sup>)</b>							
Lead		5.00E-04	4.31E-08	5.56E-08	5.88E-08	5.76E-08	7.77E-08	8.31E-08	7.73E-08	7.41E-08

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## 8. CONCLUSIONS

AUSPLUME dispersion modelling has been used to assess the potential for impacts on local air quality due to emissions from the existing and proposed operations of the FCCU (Boiler No. 8 stack) and Boiler 7/9 at the Shell Refinery site at Clyde.

The AUSPLUME cumulative impact including emissions from all the stack sources shows compliance with all the impact assessment criteria.

On the basis of the AUSPLUME dispersion modelling results of the proposed changes to the operations at the site, it is unlikely that there would be any significant impact on air quality at the nearby residential areas.

Shell has identified that due to upset temporary conditions there may be occasions when the FCCU (Boiler No.8) in-stack concentration of TSP may exceed the POEO standard of 50 mg/Nm<sup>3</sup>. The dispersion modelling has demonstrated that the impact of the elevated concentrations will have a minimal impact on local air quality and would not result in an exceedance of the impact assessment criteria. The maximum predicted annual average TSP concentrations under upset conditions is 0.09 µg/m<sup>3</sup>, which is equal to 0.1 % of the impact assessment criteria of 90 µg/m<sup>3</sup>. This proposal to replace the critical components of FCCU's Reactor and Regenerator will result in a much lower likelihood of the occurrence of upset conditions owing to the improved operating conditions.

## 9. RECOMMENDATIONS

As there is currently no monitoring data in the local area with which to validate the dispersion modelling results, and based on the large differences between the results from the two models (AUSPLUME and CALPUFF), there needs to be further investigations undertaken to determine the source of the discrepancies.

Shell will commit to monitoring SO<sub>2</sub> and SO<sub>3</sub> concentrations in the ambient air for a period of 12 months to facilitate the validation of the dispersion modelling and provide assurance that there are no detrimental impacts on the local community.

If the ambient monitoring detects an exceedance of the SO<sub>2</sub> or SO<sub>3</sub> impact assessment criteria, Shell will commit to improve operational conditions to ensure that there are no future exceedances.

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## **Appendix A: Basis of air quality goals**

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## Particulate matter

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, that is those greater than 10  $\mu\text{m}$ , generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing, which increases during exercise. The very fine particles can be deposited in the pulmonary region and it is these that are of particular concern.

The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulfur dioxide.

Much of the recent concern over the health effects of fine particulate matter is based on investigations carried out in the United States, with the view to quantifying the health risks associated with both long-term and short-term exposure to airborne particulate matter. The study is colloquially referred to as "The Six Cities Study" from the original work by **Dockery et al. (1993)**, which determined a relationship between fine particulate matter (defined as particles smaller than 2.5  $\mu\text{m}$  in diameter) in the air and mortality in six United States cities.

The basic finding of the Six Cities Study is that there is an increase in mortality with increasing concentrations of fine particulate matter. The conclusions appear to be robust and have been supported by subsequent studies and, as far as can be determined, are not confounded by other known variables. However, subsequent analysis of the Six Cities Study data (**HEI, 2000**) suggests that the increase in mortality is not as large as previously thought.

In May 2003, NEPC released advisory reporting standards for  $\text{PM}_{2.5}$  in a variation to the NEPM (**NEPC, 2003**). The advisory reporting standards are a 24-hour average of 25  $\mu\text{g}/\text{m}^3$  and an annual average of 8  $\mu\text{g}/\text{m}^3$ . There is no time line for compliance. The goal is to gather sufficient data nationally to facilitate the review of the Air Quality NEPM scheduled to commence in 2005. The variation includes a protocol setting out monitoring and reporting requirements for particles as  $\text{PM}_{2.5}$ .

The US EPA has not changed its  $\text{PM}_{10}$  (particles less than 10  $\mu\text{m}$  in diameter) goal but has introduced new goals for very fine particles ( $\text{PM}_{2.5}$ ) with a 24-hour limit of 65  $\mu\text{g}/\text{m}^3$  and an annual limit of 15  $\mu\text{g}/\text{m}^3$ . The DEC has historically noted the US EPA 24-hour air quality standard of 150  $\mu\text{g}/\text{m}^3$  and annual average standard of 50  $\mu\text{g}/\text{m}^3$  for  $\text{PM}_{10}$ . It now adopts the NEPM 24-hour standard of 50  $\mu\text{g}/\text{m}^3$ , and references an annual average of 30  $\mu\text{g}/\text{m}^3$  as a long-term reporting goal. The current proposal will be assessed using the NEPM standards, adopted by the DEC.

## Oxides of Nitrogen

Oxides of nitrogen ( $\text{NO}_x$ ) are produced in most combustion processes and are formed during the oxidation of nitrogen in the fuel and nitrogen in the air. Generally during high-temperature processes a number of nitrogen oxides are formed including nitric oxide (NO) and nitrogen dioxide ( $\text{NO}_2$ ). Generally at the point of emission NO will comprise the greatest proportion of emission and typically constitute 95% by volume of the  $\text{NO}_x$  and  $\text{NO}_2$  will comprise 5%. The presence of  $\text{NO}_x$  emissions can be of concern in urban environments where the control of photochemical smog is important. From the point of view of impacts on human health, it is  $\text{NO}_2$  which is of greatest concern.

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Ultimately however all nitric oxides emitted into the atmosphere are oxidised to NO<sub>2</sub> and to other higher oxides of nitrogen. The rate at which this oxidation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low it is unimportant that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO<sub>2</sub> can occur.

Generally, for plumes impacting close to the source the time interval for oxidation is not sufficient to have converted a large proportion of the plume to the more harmful NO<sub>2</sub>.

The DEC has not set any air quality goals for nitric oxide, however it has set 1-hour and annual average goals for nitrogen dioxide. It has adopted the NEPM standard of 0.12 ppm or 246 µg/m<sup>3</sup>. It has also adopted the WHO 1-hour goal of 0.11 ppm or 200 µg/m<sup>3</sup> as a long term reporting goal.

### **Sulfur dioxide**

Sulfur dioxide (SO<sub>2</sub>) is an acid gas which can have harmful effects on the respiratory system as well as on vegetation and building materials. The 1-hour average air quality goal for SO<sub>2</sub> is 570 µg/m<sup>3</sup>.

### **Sulfur trioxide**

Sulfur trioxide (SO<sub>3</sub>) is a corrosive chemical and contact can severely irritate and burn the skin and eyes with possible eye damage. Breathing SO<sub>3</sub> can irritate the nose and throat and lungs.

When it combines with water it forms sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) which is an oily liquid that is highly corrosive. Breathing sulfuric acid mist can irritate the lungs; high levels can cause death through a dangerous build-up of fluid in the lungs (pulmonary oedema). Contact can severely burn the skin and eyes. Repeat exposure can cause erosion and pitting of the teeth, stomach upset, nose bleeds, tearing of the eyes, emphysema, and bronchitis. NSW DEC has set a 1-hour average glc criteria (at the 99.9<sup>th</sup> percentile) of 18 µg/m<sup>3</sup>.

### **Air toxics**

Air Toxics are gaseous, aerosol or particulate pollutants which are present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life. Air toxics include the following general categories of compounds: VOCs, PAHs, heavy metals and aldehydes.

There is a growing international recognition of the potential health risks associated with exposure to air toxics and of the need for action to minimise these risks. There is evidence that cancer, birth defects, genetic damage, immunodeficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of air toxics.

Monitoring by the NSW DEC has shown that levels of air toxics are currently low and well below current international standards and benchmarks (**NSW EPA, 2002**).

In August 2005, the NSW DEC report "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" was released (**NSW DEC, 2005a**). This sets ground-level impact assessment criteria for a number of toxic air pollutants, including benzene, PAHs (as benzo[a]pyrene) and a range of metals.

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**Appendix B: Joint Wind Speed, Wind Direction and Stability Class Frequency Tables  
for Shell Clyde Refinery**



STATISTICS FOR FILE: C:\Jobs\Shell\_Clyde\Met\Clyde\_data\2004\Clyde04.aus  
 MONTHS: All  
 HOURS : All  
 OPTION: Frequency

PASQUILL STABILITY CLASS 'A'

WIND SECTOR	Wind Speed Class (m/s)								TOTAL
	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	
NNE	0.002618	0.002618	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005237
NE	0.002505	0.001708	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004212
ENE	0.003188	0.003529	0.000683	0.000000	0.000000	0.000000	0.000000	0.000000	0.007400
E	0.003529	0.002505	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.006375
ESE	0.002049	0.002277	0.000455	0.000000	0.000000	0.000000	0.000000	0.000000	0.004781
SE	0.001708	0.002049	0.001138	0.000228	0.000000	0.000000	0.000000	0.000000	0.005123
SSE	0.001935	0.004326	0.001821	0.000114	0.000000	0.000000	0.000000	0.000000	0.008197
S	0.001480	0.001594	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.003301
SSW	0.003643	0.003074	0.000569	0.000000	0.000000	0.000000	0.000000	0.000000	0.007286
SW	0.002163	0.001594	0.000683	0.000000	0.000000	0.000000	0.000000	0.000000	0.004440
WSW	0.001821	0.001708	0.000569	0.000000	0.000000	0.000000	0.000000	0.000000	0.004098
W	0.002732	0.002960	0.000911	0.000000	0.000000	0.000000	0.000000	0.000000	0.006603
WNW	0.003188	0.003871	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.007286
NW	0.004212	0.003643	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.008197
NNW	0.002391	0.001366	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003757
N	0.002846	0.001594	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004440
CALM									0.017987
TOTAL	0.042008	0.040414	0.007969	0.000342	0.000000	0.000000	0.000000	0.000000	0.108720

MEAN WIND SPEED (m/s) = 1.57  
 NUMBER OF OBSERVATIONS = 955

PASQUILL STABILITY CLASS 'B'

WIND SECTOR	Wind Speed Class (m/s)								TOTAL
	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	
NNE	0.000228	0.001708	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.002163
NE	0.001025	0.002391	0.001252	0.000000	0.000000	0.000000	0.000000	0.000000	0.004668
ENE	0.001252	0.002505	0.000455	0.000000	0.000000	0.000000	0.000000	0.000000	0.004212
E	0.000342	0.002846	0.001252	0.000000	0.000000	0.000000	0.000000	0.000000	0.004440
ESE	0.000342	0.002277	0.002960	0.000114	0.000000	0.000000	0.000000	0.000000	0.005692
SE	0.001025	0.005464	0.013320	0.003301	0.000000	0.000000	0.000000	0.000000	0.023110
SSE	0.000342	0.004212	0.007514	0.001025	0.000000	0.000000	0.000000	0.000000	0.013092
S	0.000228	0.001594	0.002163	0.000455	0.000000	0.000000	0.000000	0.000000	0.004440
SSW	0.000000	0.001935	0.000455	0.000114	0.000000	0.000000	0.000000	0.000000	0.002505
SW	0.000569	0.002049	0.002505	0.000455	0.000000	0.000000	0.000000	0.000000	0.005578
WSW	0.000569	0.001935	0.002277	0.001480	0.000000	0.000000	0.000000	0.000000	0.006261
W	0.000342	0.001594	0.001025	0.000455	0.000000	0.000000	0.000000	0.000000	0.003415
WNW	0.000797	0.003985	0.001252	0.000228	0.000000	0.000000	0.000000	0.000000	0.006261
NW	0.001594	0.003757	0.000683	0.000114	0.000000	0.000000	0.000000	0.000000	0.006148
NNW	0.000228	0.000797	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.001366
N	0.000455	0.001366	0.000455	0.000000	0.000000	0.000000	0.000000	0.000000	0.002277
CALM									0.007172
TOTAL	0.009335	0.040414	0.038138	0.007741	0.000000	0.000000	0.000000	0.000000	0.102801

MEAN WIND SPEED (m/s) = 2.84  
 NUMBER OF OBSERVATIONS = 903

PASQUILL STABILITY CLASS 'C'

WIND SECTOR	Wind Speed Class (m/s)								TOTAL
	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	
NNE	0.000114	0.000797	0.000569	0.000000	0.000000	0.000000	0.000000	0.000000	0.001480
NE	0.000911	0.001366	0.001025	0.000342	0.000000	0.000000	0.000000	0.000000	0.003643
ENE	0.000797	0.003529	0.004098	0.002163	0.000000	0.000000	0.000000	0.000000	0.010587
E	0.000228	0.003871	0.010246	0.002960	0.000000	0.000000	0.000000	0.000000	0.017304
ESE	0.000114	0.003415	0.010474	0.003529	0.000000	0.000000	0.000000	0.000000	0.017532
SE	0.000114	0.001366	0.001821	0.000683	0.000000	0.000000	0.000000	0.000000	0.003985
SSE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
S	0.000114	0.000569	0.001252	0.001366	0.000000	0.000000	0.000000	0.000000	0.003301
SSW	0.000911	0.002277	0.001935	0.000911	0.000000	0.000000	0.000000	0.000000	0.006034
SW	0.000455	0.002846	0.005920	0.003188	0.000000	0.000000	0.000000	0.000000	0.012409
WSW	0.000114	0.001025	0.001366	0.001025	0.000000	0.000000	0.000000	0.000000	0.003529
W	0.000228	0.001708	0.001821	0.002163	0.000000	0.000000	0.000000	0.000000	0.005920
WNW	0.002049	0.007969	0.003188	0.001935	0.000000	0.000000	0.000000	0.000000	0.015141
NW	0.001025	0.006148	0.002732	0.001480	0.000000	0.000000	0.000000	0.000000	0.011384
NNW	0.000683	0.001594	0.001138	0.001025	0.000000	0.000000	0.000000	0.000000	0.004440
N	0.000455	0.002049	0.001594	0.000114	0.000000	0.000000	0.000000	0.000000	0.004212
CALM									0.007969
TOTAL	0.008311	0.040528	0.049180	0.022883	0.000000	0.000000	0.000000	0.000000	0.128871
MEAN WIND SPEED (m/s) = 3.21									
NUMBER OF OBSERVATIONS = 1132									

PASQUILL STABILITY CLASS 'D'

WIND SECTOR	Wind Speed Class (m/s)								TOTAL
	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	
NNE	0.000683	0.000797	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001480
NE	0.001025	0.001480	0.001935	0.000114	0.000000	0.000000	0.000000	0.000000	0.004554
ENE	0.007400	0.013434	0.013661	0.010018	0.000683	0.000000	0.000000	0.000000	0.045196
E	0.007855	0.013206	0.008766	0.000569	0.000000	0.000000	0.000000	0.000000	0.030396
ESE	0.001252	0.007741	0.004668	0.000683	0.000114	0.000000	0.000000	0.000000	0.014458
SE	0.000569	0.003415	0.007969	0.000455	0.000114	0.000000	0.000000	0.000000	0.012523
SSE	0.000000	0.000455	0.003301	0.000569	0.000000	0.000000	0.000000	0.000000	0.004326
S	0.000569	0.001708	0.002391	0.000114	0.000000	0.000000	0.000000	0.000000	0.004781
SSW	0.002277	0.005351	0.002391	0.000569	0.001480	0.000114	0.000000	0.000000	0.012181
SW	0.000342	0.010474	0.013889	0.003188	0.000342	0.000000	0.000000	0.000000	0.028233
WSW	0.000114	0.002391	0.002846	0.000342	0.000683	0.000000	0.000000	0.000000	0.006375
W	0.000000	0.004326	0.003188	0.002732	0.001935	0.000455	0.000228	0.000000	0.012864
WNW	0.003301	0.025159	0.012523	0.004781	0.003415	0.001138	0.000569	0.000000	0.050888
NW	0.008652	0.033242	0.009563	0.002732	0.000911	0.000228	0.000000	0.000000	0.055328
NNW	0.005806	0.007969	0.006375	0.001594	0.000342	0.000000	0.000000	0.000000	0.022086
N	0.000797	0.002732	0.001594	0.000569	0.000000	0.000000	0.000000	0.000000	0.005692
CALM									0.027550
TOTAL	0.040642	0.133880	0.095059	0.029030	0.010018	0.001935	0.000797	0.000000	0.338912
MEAN WIND SPEED (m/s) = 2.85									
NUMBER OF OBSERVATIONS = 2977									

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001366	0.000797	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002163
NE	0.002049	0.002505	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004554
ENE	0.005351	0.003985	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009335
E	0.004668	0.002960	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007628
ESE	0.004326	0.004212	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.008652
SE	0.002277	0.006944	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009221
SSE	0.001594	0.005237	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.007172
S	0.001935	0.003985	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005920
SSW	0.003074	0.004440	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007514
SW	0.001025	0.004326	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005351
WSW	0.001025	0.003188	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004212
W	0.002391	0.002846	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005237
WNW	0.003757	0.005464	0.000228	0.000000	0.000000	0.000000	0.000000	0.000000	0.009449
NW	0.009563	0.008083	0.000569	0.000000	0.000000	0.000000	0.000000	0.000000	0.018215
NNW	0.004668	0.001025	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005692
N	0.001594	0.000342	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.001935
CALM									0.020150
TOTAL	0.050660	0.060337	0.001252	0.000000	0.000000	0.000000	0.000000	0.000000	0.132400

MEAN WIND SPEED (m/s) = 1.54  
NUMBER OF OBSERVATIONS = 1163

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002846	0.000455	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003301
NE	0.004212	0.001366	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005578
ENE	0.003871	0.000797	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004668
E	0.003188	0.000797	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003985
ESE	0.002049	0.000455	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002505
SE	0.002960	0.006148	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009107
SSE	0.006375	0.008424	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.014800
S	0.003415	0.003415	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006831
SSW	0.004326	0.001935	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006261
SW	0.006489	0.003188	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009677
WSW	0.006831	0.003415	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.010246
W	0.006717	0.003074	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009791
WNW	0.009904	0.002846	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.012750
NW	0.013092	0.002277	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.015369
NNW	0.007286	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007400
N	0.002846	0.000114	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002960
CALM									0.063069
TOTAL	0.086407	0.038821	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.188297

MEAN WIND SPEED (m/s) = 1.04  
NUMBER OF OBSERVATIONS = 1654

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50	1.50	3.00	4.50	6.00	7.50	9.00	GREATER	TOTAL
	TO 1.50	TO 3.00	TO 4.50	TO 6.00	TO 7.50	TO 9.00	TO 10.50	THAN 10.50	
NNE	0.007855	0.007172	0.000797	0.000000	0.000000	0.000000	0.000000	0.000000	0.015824
NE	0.011726	0.010815	0.004212	0.000455	0.000000	0.000000	0.000000	0.000000	0.027209
ENE	0.021858	0.027778	0.018898	0.012181	0.000683	0.000000	0.000000	0.000000	0.081398
E	0.019809	0.026184	0.020606	0.003529	0.000000	0.000000	0.000000	0.000000	0.070128
ESE	0.010132	0.020378	0.018670	0.004326	0.000114	0.000000	0.000000	0.000000	0.053620
SE	0.008652	0.025387	0.024249	0.004668	0.000114	0.000000	0.000000	0.000000	0.063069
SSE	0.010246	0.022655	0.012978	0.001708	0.000000	0.000000	0.000000	0.000000	0.047587
S	0.007741	0.012864	0.006034	0.001935	0.000000	0.000000	0.000000	0.000000	0.028575
SSW	0.014230	0.019012	0.005351	0.001594	0.001480	0.000114	0.000000	0.000000	0.041781
SW	0.011043	0.024476	0.022996	0.006831	0.000342	0.000000	0.000000	0.000000	0.065688
WSW	0.010474	0.013661	0.007058	0.002846	0.000683	0.000000	0.000000	0.000000	0.034722
W	0.012409	0.016507	0.006944	0.005351	0.001935	0.000455	0.000228	0.000000	0.043830
WNW	0.022996	0.049294	0.017418	0.006944	0.003415	0.001138	0.000569	0.000000	0.101776
NW	0.038138	0.057149	0.013889	0.004326	0.000911	0.000228	0.000000	0.000000	0.114640
NNW	0.021061	0.012864	0.007855	0.002618	0.000342	0.000000	0.000000	0.000000	0.044740
N	0.008994	0.008197	0.003643	0.000683	0.000000	0.000000	0.000000	0.000000	0.021516
CALM									0.143898
TOTAL	0.237363	0.354394	0.191598	0.059995	0.010018	0.001935	0.000797	0.000000	1.000000

MEAN WIND SPEED (m/s) = 2.24  
NUMBER OF OBSERVATIONS = 8784

FREQUENCY OF OCCURENCE OF STABILITY CLASSES

A : 10.9%  
B : 10.3%  
C : 12.9%  
D : 33.9%  
E : 13.2%  
F : 18.8%

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0125	0079	0162
02	0000	0000	0000	0123	0089	0154
03	0000	0000	0000	0145	0085	0136
04	0000	0000	0000	0129	0077	0160
05	0000	0000	0000	0129	0091	0146
06	0021	0015	0020	0130	0075	0105
07	0050	0047	0063	0108	0037	0061
08	0094	0070	0083	0107	0004	0008
09	0090	0071	0104	0101	0000	0000
10	0120	0076	0102	0068	0000	0000
11	0131	0098	0104	0033	0000	0000
12	0134	0103	0095	0034	0000	0000
13	0125	0100	0103	0038	0000	0000
14	0088	0104	0126	0048	0000	0000
15	0063	0100	0137	0066	0000	0000
16	0021	0070	0133	0121	0012	0009
17	0014	0046	0053	0216	0022	0015
18	0004	0003	0009	0256	0059	0035
19	0000	0000	0000	0231	0082	0053
20	0000	0000	0000	0198	0099	0069
21	0000	0000	0000	0154	0094	0118
22	0000	0000	0000	0142	0086	0138
23	0000	0000	0000	0141	0087	0138
24	0000	0000	0000	0134	0085	0147

-----  
 STABILITY CLASS BY MIXING HEIGHT  
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Mixing height	A	B	C	D	E	F
<=500 m	0140	0109	0182	0815	1116	1617
<=1000 m	0445	0334	0446	1077	0012	0012
<=1500 m	0370	0460	0504	0985	0035	0025
<=2000 m	0000	0000	0000	0088	0000	0000
<=3000 m	0000	0000	0000	0012	0000	0000
>3000 m	0000	0000	0000	0000	0000	0000

-----  
 MIXING HEIGHT BY HOUR OF DAY  
 -----

Hour	0000 to 0100	0100 to 0200	0200 to 0400	0400 to 0800	0800 to 1600	1600 to Greater than 3200
01	0163	0086	0016	0036	0063	0002 0000
02	0156	0097	0015	0052	0044	0002 0000
03	0137	0094	0020	0057	0056	0002 0000
04	0161	0088	0010	0057	0049	0001 0000
05	0197	0074	0011	0040	0044	0000 0000
06	0116	0106	0088	0028	0027	0001 0000
07	0102	0059	0120	0077	0008	0000 0000
08	0000	0066	0119	0181	0000	0000 0000
09	0000	0000	0096	0190	0080	0000 0000
10	0000	0000	0000	0225	0141	0000 0000
11	0000	0000	0000	0143	0223	0000 0000
12	0000	0000	0000	0092	0274	0000 0000
13	0000	0000	0000	0000	0366	0000 0000
14	0000	0000	0000	0000	0366	0000 0000
15	0000	0000	0000	0000	0366	0000 0000
16	0000	0000	0000	0000	0366	0000 0000
17	0002	0011	0000	0010	0336	0007 0000
18	0019	0049	0004	0022	0261	0011 0000
19	0057	0079	0013	0039	0167	0011 0000
20	0078	0088	0026	0053	0117	0004 0000
21	0121	0095	0025	0029	0093	0003 0000
22	0137	0093	0010	0038	0081	0007 0000
23	0142	0088	0019	0040	0070	0007 0000
24	0149	0087	0019	0042	0066	0003 0000

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**Appendix C: AUSPLUME – variable emissions file**



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## **Appendix D: CALPUFF modelling results**

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## Dispersion modelling using CALPUFF

The NSW DECC requested that dispersion modelling also be completed using CALPUFF as well as AUSPLUME. This section compares the results of the two models for the proposed cumulative operations.

### CALPUFF compared with AUSPLUME

In the last decade there has been a significant improvement in the capability of dispersion models. A limitation of common Gaussian plume dispersion models (such as AUSPLUME) is that they assume that the meteorological conditions are the same spatially over the entire modelling domain for any given hour. However, the meteorological conditions can be more accurately represented using wind field and puff models.

The CALPUFF model makes use of wind fields generated by the CALMET model. CALMET generates a three-dimensional wind field on an hourly basis by taking observations of winds at selected locations and interpolating these to produce information on wind speed and direction at a grid of regularly spaced points covering the area of interest. Modifications that are imposed on this interpolated wind field (by topography and differential heating and differential roughnesses) are then applied to the winds at each grid point to develop a final wind field.

The final wind field reflects the effect of local topography and the effects of different temperatures experienced by water bodies and land surfaces as well as different surface roughnesses that arise because of changes in vegetation or other variations in land use such as the presence of towns, agricultural land and forest land, etc.

In the model simulations made using the CALPUFF model, a wind field has been generated for each hour of the 2004 calendar year using data collected on the Shell Refinery site.

Given information on the local landuse and terrain features, the CALMET model has used the data from these sites to determine wind patterns over the entire modelling domain. Cloud cover data were taken from the Bureau of Meteorology site located at Sydney Airport, which is situated approximately 20 km from the site. Upper air information on higher altitude winds and temperature profiles were extracted via CSIRO's prognostic model (The Air Pollution Model, TAPM). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia (from 1997 onwards) based on synoptic information determined from the six hourly Limited Area Prediction System (LAPS) (**Puri et al., 1997**). The model is discussed further in the accompanying user manual (see **Hurley, 2002**).

A summary of the data and parameters used as part of the meteorological component of this study are shown in **Table C1**.

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**Table C1: Meteorological parameters used for this study**

<b>TAPM (v 3.0)</b>	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	25 x 25 x 25
Year of analysis	2004
Centre of analysis	Shell Clyde Refinery (33°49.5' S, 151°2.5' E)
<b>CALMET (v 6.212)</b>	
Meteorological grid domain	10 km x 10 km
Meteorological grid resolution	0.2 km
Surface meteorological stations	BoM Sydney Airport ➤ Cloud cover On-site station – Wind speed – Wind direction – Temperature TAPM – Ceiling height – Relative humidity – Pressure
Upper air meteorological stations	Data extracted from TAPM

## **CALPUFF settings**

### ***Terrain influence***

CALPUFF requires terrain adjustments other than those provided by the wind field model (CALMET). The wind field transports a puff along the surface of the terrain, but never causes its height above the surface to change. Hence, puffs may be channelled or deflected by the terrain, but a simple terrain treatment is required to more accurately reflect the effect of the terrain.

Three terrain adjustment methods are available in CALPUFF, the first two are incorporated into existing dispersion models:

1. ISC Terrain Treatment
  - The original terrain adjustment used in ISC (US EPA dispersion model, Industrial Source Complex) – this option is not intended for use in situations where any receptors are placed on terrain that exceeds the height of the stack, it was therefore not used in this assessment.
2. Plume Path Coefficient Treatment
  - In the plume path coefficient treatment, the height of the plume at a receptor depends on the height of the plume over level terrain (which is taken to the height of the plume above the elevation at the base if the stack from which the plume is released), the receptor height (above the base of the stack), and a plume path coefficient (which depends on stability class). The maximum predicted concentrations presented in **Table 12** were estimated using this option.
3. CALPUFF Strain-based approach to Terrain Adjustment
  - This method adjusts the properties of the puff in the basis of the local strain to the flow imparted by the underlying terrain. The effective spread of the puff in the vertical may be altered by the terrain, thereby increasing ground-

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level concentrations in the region where the height of the puff is approximately equal to the vertical plume height

For the purposes of this assessment the CALPUFF terrain adjustment method was selected.

In addition, the option to calculate the dispersion coefficients using micrometeorological variables was selected together with the PDF option for convective conditions.

***Comparison of results***

As presented in **Table C2**, the maximum predicted concentrations using CALPUFF comply with the impact assessment criteria for all the pollutants, except 10-minute and 1-hour average SO<sub>2</sub> and the 1-hour average 99<sup>th</sup> percentile concentration for SO<sub>3</sub>.

The predicted concentrations from the CALPUFF model show large and significant variations to the predicted concentrations using AUSPLUME. Discussions between technical experts about the complexities of the CALPUFF model have not been able to determine the cause of such large discrepancies. It has been noted by the DECC that other recent projects in NSW have experienced similar discrepancies in the results between the models, with CALPUFF overpredicting ground-level concentrations. It is also noted that in the USA, CALPUFF is typically used for far-field investigations (i.e. for large distances such as up to 150km) with complex terrain, whereas the predicted area of impact around the Refinery is considered localised (i.e. within 10 km of the site).

**Table C2: AUSPLUME and CALPUFF predicted cumulative impacts compared**

Pollutant	Assessment criteria		Averaging time	Scenario	Concentration	
					AUSPLUM E	CALPUF F
Carbon monoxide (CO)	30	mg/m <sup>3</sup>	1-hour maximum		0.55	1.03
	10	mg/m <sup>3</sup>	8-hour maximum		0.13	0.93
Nitrogen dioxide (NO <sub>2</sub> )	246	mg/m <sup>3</sup>	1-hour maximum		49	160
	62	mg/m <sup>3</sup>	Annual Mean		0.46	4.09
Particulate matter < 10 µm (PM <sub>10</sub> )	50	ug/m <sup>3</sup>	24-hour maximum	Normal operations	0.61	3.36
				Upset operations	0.84	4.96
	30	ug/m <sup>3</sup>	Annual mean	Normal operations	0.06	0.57
				Existing operations	0.08	0.77
TSP	90	ug/m <sup>3</sup>	Annual mean	Normal operations	0.10	0.84
				Existing operations	0.12	1.12
Sulfur dioxide (SO <sub>2</sub> )	712	mg/m <sup>3</sup>	10-minute maximum		685	1133
	570	mg/m <sup>3</sup>	1-hour maximum		483	897
	228	mg/m <sup>3</sup>	1 day		49.8	332.2
	60	mg/m <sup>3</sup>	Annual average		4.9	45.3
Sulfuric Acid (as SO <sub>3</sub> )	1.80E-02	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		7.15E-03	2.68E-02
PAHs (as B[a]P)	4.00E-04	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		2.32E-08	4.89E-08
Arsenic	9.00E-05	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		3.85E-06	1.23E-05
Beryllium	4.00E-06	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		1.32E-06	1.69E-06
Cadmium	1.8E-05	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		7.07E-07	1.19E-06
Cobalt	-				5.75E-07	9.54E-07
Chromium VI	9.00E-05	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		1.01E-05	1.73E-05
Mercury (organic)	1.80E-04	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		6.47E-06	1.39E-05
Manganese	1.30E-02	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		9.41E-06	1.81E-05
Nickel	1.80E-04	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		1.40E-05	1.60E-05
Antimony	9.00E-03	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		6.27E-06	1.85E-05
Selenium	9.00E-03	mg/m <sup>3</sup>	1-hour 99.9 <sup>th</sup> percentile		2.24E-06	5.89E-06
Tin	-		1-hour 99.9 <sup>th</sup> percentile		4.44E-05	1.78E-04
Vandadium	-		1-hour 99.9 <sup>th</sup> percentile		8.82E-07	1.60E-06
Lead	5.00E-04	mg/m <sup>3</sup>	Annual Mean		9.18E-08	8.60E-07

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**Appendix B**  
**Statement of Commitments**

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## Statement of Commitments

### **SOC 1 Statutory Commitments**

SOC 1.1 Shell will obtain all licenses, permits and approvals and maintain them as required throughout the life of the development. Copies of all relevant licenses, permits and environmental approvals will be available on site at all times during the construction and operation of the Project.

### **SOC 2 Project Compliance**

SOC 2.1 Shell will be responsible for the Project and the environmental impacts that may result, and will update its environmental management system governing the conduct of all persons on the site, including contractors, subcontractors and visitors.

SOC 2.2 Reasonable steps will be taken so that employees, contractors and sub-contractors are trained and are made aware of, and comply with, the conditions of the DoP's consent relevant to their respective activities. In addition, all employees, contractors and sub-contractors will be made aware of HS&E responsibilities and potential consequences of departure from procedure.

SOC 2.3 In accordance with any Conditions of Consent issued by the DoP, Shell will certify in writing to the satisfaction of the Director-General that it has complied with those Conditions of Consent relating to activities including the following:

- The performance of any physical works associated with the project.
- Re-commissioning of the FCCU.

SOC 2.4 Any update reports with regard to compliance with all, or any part of, the conditions of consent will be supplied upon request. Any such update will meet the requirements of the Director-General and be submitted within such period as the Director-General may agree.

### **SOC 3 Management of Key Issues**

#### **Air Quality Impacts**

SOC 3.1 Shell will monitor SO<sub>2</sub> and SO<sub>3</sub> concentrations in the ambient air for a period of ~15 months to facilitate the validation of the dispersion modeling and provide assurance that there are no detrimental impacts on the local community. Monitoring will include periods before, during and after the major Refinery shut-down proposed in the second quarter of 2008.

- SOC 3.1.1     **Monitoring Plan** On or before 31 January 2008, the Shell will submit a written report to the Manager Sydney Industry, DECC, PO Box 668 Parramatta NSW 2124, on the proposed locations for the ambient monitor(s). The following will be taken into account:
- The results of dispersion modelling, which includes all sources of SO<sub>2</sub> and SO<sub>3</sub> at the premises and other sources of SO<sub>2</sub> and SO<sub>3</sub> in the local area surrounding the premises
  - Meteorological patterns in the local area
  - The locations of sensitive receptors most likely to be exposed to high, short-term SO<sub>2</sub> and SO<sub>3</sub>/H<sub>2</sub>SO<sub>4</sub> emissions from the site.
- SOC 3.1.2     **Monitoring Stations** On 31 December 2007, Shell will establish the ambient monitoring network for SO<sub>2</sub> and SO<sub>3</sub>/H<sub>2</sub>SO<sub>4</sub>, in accordance with SoC 3.1.1. Monitoring must be undertaken for nominally 3 months prior to and a minimum 12 months after completion of the upgrades to the FCCU. The ambient monitoring will log concentrations over a 10-minute averaging period and will be undertaken in accordance with the methodologies set out in the *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*
- SOC 3.1.3     **Monitoring report:** Within approximately 18 months after completion of the FCCU upgrade, Shell will submit a written report to the Manager Sydney Industry, DECC, PO Box 668 Parramatta NSW 2124, detailing the results of ambient monitoring. The report will be prepared to the satisfaction of the DECC and include, but not be limited to, the following:
- Details of the results of ambient monitoring
  - A comparison of the monitoring data with the results of both Calpuff and Ausplume dispersion modelling data.
  - Update and recalibration of the site wide air emissions model using information collected during from the monitoring program as well as from the FCCU stack continuous emissions monitoring system.
  - Comparison between modeling results of two or more suitable air dispersion models.
  - Detailed discussion on the investigations conducted and on what was done to provide reliably accurate predictions of air quality impacts from the site at off-site receptors.
- SOC 3.1.5     **Reliable continuous emissions monitoring system:** By 31 March 2008, Shell will submit a report to the Manager Sydney Industry, DECC, PO Box 668 Parramatta NSW 2124, detailing the results of works undertaken to ensure its continuous emissions monitoring system for SO<sub>2</sub> or H<sub>2</sub>SO<sub>4</sub>/SO<sub>3</sub> emissions

monitoring from point 9 is providing reliable results. This should include, but not limited to:

- Calibration of the system
- Relativity Accuracy test conducted in accordance with CEM-2 (US EPA Performance Specification 2)
- Confirmation that the equipment is operating to the requirements of CEM-2.

SOC 3.1.6 If the ambient monitoring detects an exceedance of the SO<sub>2</sub> or SO<sub>3</sub> impact assessment criteria, Shell will commit to undertake a Pollution Reduction Program (PRP) to mitigate these impacts, in consultation with the DECC. Further, if in exceedance, Shell commits to defining appropriate emission limits for the FCCU stack in relation to SO<sub>2</sub> and H<sub>2</sub>SO<sub>4</sub>/SO<sub>3</sub> (as SO<sub>3</sub> equivalent) to ensure compliance with the DECC's assessment criteria for SO<sub>2</sub> and H<sub>2</sub>SO<sub>4</sub> and reflect proper and efficient operation of the plant.

SOC 3.2 Shell commits to Group 6 concentration limits for Point 9 (FCCU Stack) for species as outlined for Petroleum Refining Activities, specifically being Nitrogen Oxides, solid particles, Hydrogen Sulphide, VOC's, and Smoke.

#### **Construction Traffic**

SOC 3.3 Transportation of wide loads or heavy/large equipment will be scheduled to off-peak periods with appropriate controls measures in place during transportation. Transportation plans will be developed and submitted for approval for all oversized equipment//loads by the respective contractor.

#### **Noise Impacts**

SOC 3.4 During the demolition, construction and operation phase of this project, Shell will conduct activities in accordance with the NSW INP and other regulatory limits.

#### **Soil and Water Quality Impacts**

SOC 3.5 Surface water and stormwater will be managed via the existing drainage system which collects and transports water to the waste water treatment plant for decontamination.

SOC 3.6 Risks to groundwater contamination will continue to be managed by Shell via the implementation of its environmental management systems and procedures.

SOC 3.7 Section 120 of the *Protection of the Environment Operations Act, 1997* (prohibition of pollution of waters) will be complied with in connection with the carrying out of the development.

SOC 3.8 Any activity in Parramatta River will incorporate mitigative measures to reduce any potential impact and will be undertaken in accordance with a Part 7 permit, which may be required under the *Fisheries Management Act, 1994*.

**Hazards and Risk Impacts**

- SOC 3.9 Prior to the commencement of works, Shell will submit for the approval of the Director-General, a Hazard and Operability Study (HAZOP) of the development (and related systems). The Study will be chaired by an independent, qualified person or team, approved by the Director-General, and will be carried out in accordance with the Department's publication Hazardous Industry Planning Advisory Paper No. 8 - HAZOP Guidelines.
- SOC 3.10 Prior to the commencement of works, Shell will submit for the approval of the Director-General, a Construction Safety Study for the development, prepared in accordance with the Department's Hazardous Industry Planning Advisory Paper No. 7 - Construction Safety Study Guidelines. The Study will specifically identify and address potential hazards associated with the construction of the development and its interaction with other parts of the Refinery, while the works permitted under this consent are undertaken. This will be split into two phases, pre-turnaround construction and turnaround construction.

**Waste Generation and Management**

- SOC 3.11 A waste management plan will be prepared to outline the treatment and/or beneficial reuse of waste materials associated with the development. The plan will enable the minimisation of temporary storage of waste on the site and minimisation of waste volumes requiring disposal by maximising recycling of metal from the old equipment.
- SOC 3.12 Shell will not cause, permit or allow any waste generated outside the site to be received at the site for storage, treatment, processing, reprocessing, or disposal on the site, except as expressly permitted by an EPL issued under the *Protection of the Environment Operations Act, 1997* and in accordance with its provisions.
- SOC 3.13 Where possible, waste types will be identified prior to the commencement of construction. Depending on the waste classification of material to be removed, the use of licensed waste transporters will be used.
- SOC 3.14 Any PCB contaminated waste will be handled and disposed of in accordance with the PCB CCO and Shell's EPL 570.

**SOC 4 Community Information, Consultation and Involvement****Community Complaints**

- SOC 4.1 Prior to the commencement of works, Shell will provide the following and make available for community complaints:
- A telephone number on which complaints about the development may be registered
  - A postal address to which written complaints may be sent
  - An email address to which electronic complaints may be transmitted.

The telephone number, the postal address and the email address will be provided in a letterbox drop prior to the commencement of construction.

SOC 4.2 Details of all complaints received via the methods listed in SOC 4.1 as well as complaints received in person either at the Refinery or elsewhere will be recorded in an up-to-date Complaints Register. The Register will record, but not necessarily be limited to:

- The date and time, where relevant, of the complaint
- The means by which the complaint was made (telephone, mail, email or in person)
- Any personal details of the complainant that were provided, or if no details were provided, a note to that effect
- The nature of the complaint
- Any action(s) taken in relation to the complaint, including any follow-up contact with the complainant
- If no action was taken in relation to the complaint, the reason(s) why no action was taken.

SOC 4.3 The Complaints Register will be made available for inspection by the Director-General upon request. Summaries of the Register, without details of the complainants, will be made available to the public for inspection upon request.

SOC 4.4 All monitoring, including recording and reporting of monitoring results, as required by the DoP's consent and as may be specified in an Environment Protection License applicable to the development will be undertaken. Such records will be retained on site in a legible format and will be made available to authorized persons upon request.

## **SOC 5 Environmental Management and Reporting**

### **Construction Environmental Management Plan**

SOC 5.1 A Construction and Environmental Management Procedure (CEMP) will be prepared and implemented to outline environmental management practices and procedures to be followed during the construction phase of the Project. A copy will be submitted to the Director-General prior to the commencement of any construction works. This CEMP will be split into two packages, i.e. pre-construction and construction.

### **Operational Environmental Management**

SOC 5.2 Prior to the re-commissioning of the FCCU, Shell will demonstrate to the satisfaction of the Director-General that it has updated environmental and safety management systems for the Refinery to reflect any necessary modifications.

**Incident Reporting**

SOC 5.3 The site has an incident reporting and investigation system that will be utilised if an incident occurred. This is a detailed and comprehensive system to monitor incidents but also the remedial response.

**Environmental Auditing**

SOC 5.4 After completion of the construction phase, Shell will formalise an audit program in accordance with ISO 19011 and will undertake internal audits in accordance with the program to assess compliance with any Conditions of Consent including construction management plans associated with the proposed project. The level of compliance with Conditions of Consent will be documented and any observations would be noted, actioned as appropriate and documented.

**SOC 6 Validation of Commitment**

## SOC 6.1

Such commitments as identified above remain current for the life of the project to the extent that they do not become subject to change as a result of some other form of subsequent agreement with recognised authorities, or where they may contradict a legal or other requirement currently or subsequently imposed on the project or Shell, that was not known at the time of making this commitment.

This commitment is made under authority of the following person, who is legally empowered to make this undertaking on behalf of Shell Refining (Australia) Pty Ltd:

Name	David W. Johnston
Position	Refinery Manager
Signature	<i>David Johnston</i>
Date	14/11/07







Shell Refining (Australia) Pty Ltd

Clyde FCCU R&R Project

## SHELL CLYDE REFINERY

### FCCU R&R Rejuvenation Project

Doc. No. MC.01200.G.102

# Event Waste Management Plan



<b>Revision</b>	<b>Description</b>	<b>By</b>	<b>Date</b>
0	Draft	M. Daniels	24/08/07
1	Added Doc Number	M Daniels	12/09/07
2	Issued for Approval	G Pitstock	02/10/07
3	Further Review by M.watts/S.Symons	S.Symons	13/11/07

SHELL REFINING (AUSTRALIA) PTY LTD  
CLYDE REFINERY

HSE REFINERY PROCEDURE

FCCU R&R Rejuvenation Project

CLYDE REFINERY

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## 1. Introduction

Clyde Refinery creates waste, which can be reused on site, treated on site, disposed of offsite for reuse, recycling or disposal to an authorised waste disposal location.

The objective of this Waste Management Plan is to:

- Reduce waste created
- Reuse waste
- Recycle waste
- Ensure Hazardous, Industrial and Group A (HIGA) wastes are tracked in compliance with the POEO (Waste) Regulation 2005.
- Ensure waste disposed offsite complies with requirements detailed in the Shell Clyde Environmental Protection Licence(No.570).

## 2. Roles and Responsibilities

All solid waste must follow the "Solid Waste Disposal – Clyde Refinery" process decision making flowchart as outlined in Section 3.

### All employees are to:

- Segregate recyclable material from waste streams and store it in the containers provided for this purpose.
- Ensure waste is identifiable, traceable, segregated, stored and disposed off in accordance with requirements of this Waste Management Plan, the POEO (Waste) Regulation 2005 and relevant conditions within Environmental Protection Licence No.570.
- Waste generated in their area of responsibility is removed in a timely manner. They should liaise with Focal Point Person to arrange for removal of wastes.

### Contract Resources' Environmental Coordinator:

- Identify wastes in area
- Arrange sampling and testing
- Maintain waste holding areas in an orderly manner
- Ensure waste is tracked in accordance with the POEO (Waste) Regulation 2005 and Environmental Protection Licence No.570
- Ensure all HIGA wastes are tracked using the "NSW EPA On-Line Tracking" system and have a valid consignment number and transport certificate
- Where a waste stream is not listed, Shell Clyde Environmental Advisor is to be contacted to define an appropriate re-use, recycle or disposal procedures.

Note: Only trained Shell personnel may sign the EPA Waste Data Form for HIGA classified wastes.

### Shell Clyde Environmental Advisor is responsible for:

- Maintaining this procedure
- Liaison with the DECC to approve alternative waste disposal routes identified as potential re-use or recycling opportunities.
- Ensuring monitoring is conducted in accordance with this procedure (frequency and method)
- Reporting to the DECC in accordance with requirements of EP Licence No.570.
- Reporting to Shell HSSE MIS

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- Ensure focal points are trained in accordance with waste management in this procedure

**General Management Controls**

In general principles, the following management controls process will be implemented:

- Identify waste
- Collect waste in separate locations
- Store waste in identified areas only
- Sample wastes which maybe contaminated
- Ensure all wastes are weighed
- Move waste off site as soon as possible
- Collect waste receipts
- Ensure all waste is reported
- Ensure all waste receipts are returned to Shell Clyde Environmental Advisor.

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<b>TYPE OF WASTES GENERATED</b>	<b>EXPECTED VOLUME</b>	<b>PROPOSED ON-SITE STORAGE AND TREATMENT FACILITIES</b>	<b>WASTE CONTRACTOR</b>	<b>DESTINATION</b>
Contaminated soils	Varies	Adjacent to new blast pad area As specified on drawing number CLR07264; Refinery Layout	Innova Soil Technology	Kooragang Island
Process liquid wastes	Varies	Directed Vac trucks/other collection vessels to slops system for reprocessing	Contract Resources / Shell operations	Oil phase recovered and reprocessed through refinery slops system. Water phase processed through Refinery Biotreater. Other disposed as liquid waste disposal (e.g. Collex Grand Avenue), with options depending on calorific value of the waste. Also under controlled conditions to Trade Waste Service Liquid waste disposal (Collex Grand Ave)
Spilt Fuel / Solvents	Unknown	Labelled Drums	Contract Resources / Shell operations	As per above.
Refractory	25 T	Dedicated skip adjacent to Reactor V301 As specified on drawing number CLR07264; Refinery Layout	Shutdown Contractor	Offsite disposal to licensed landfill
Spent Catalyst	100 T	Segregated catalyst is sampled and bagged / open skips As specified on drawing number CLR07264; Refinery Layout	Catalyst Team	Offsite disposal as per existing specification
Coke	280 T	Segregated coke sampled and contained in dedicated skips As specified on drawing number CLR07264; Refinery Layout	Cracker Unit Team	Offsite disposal as Refuse Derived Fuel into power generation
Rashig Rings	5 T	Segregated and washed rings sampled and contained in dedicated skips As specified on drawing number CLR07264; Refinery Layout	Catalyst Team	Ceramic rashig rings offsite disposal via licensed land fill. Metal rashig rings disposed cleaned and recused if not damaged, recycled if damaged.
Dust	Nil	Captured by good housekeeping	Shutdown contractors	On site management See FCCU Environment Management Plan MC.01200.G.090; Appendix "K"
Rust scale	Varies	Scale is incorporated in collected blast pad sediment and stored in sludge bays	Contract Resources / Shutdown contractors	Offsite disposal to licensed landfill

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<b>TYPE OF WASTES GENERATED</b>	<b>EXPECTED VOLUME</b>	<b>PROPOSED ON-SITE STORAGE AND TREATMENT FACILITIES</b>	<b>WASTE CONTRACTOR</b>	<b>DESTINATION</b>
Asbestos / Insulation	Unknown	Dedicated bins provided for segregated asbestos / insulation	Shutdown contractors / Sita	Offsite special landfill operations
Broken concrete	30 m3	Clean concrete is segregated As specified on drawing number CLR07264; Refinery Layout	Sita	Concrete Recyclers Eastern Creek
Metal fabrication	Varies	To be washed on the wash pad To be tagged by inspection for recycle. Dedicated scrap metal bins	Metal Recyclers	Offsite – BHP Port Kembla
Electrical Wastes	Varies	Dedicated bins provided for Electrical wastes recyclable / non recyclable	Shutdown Contractors / Sita	Offsite disposal for resource recovery or general waste to landfill
Blasting Grit	20 T	Dedicated skip bins provided , product sampled	Contract Resources	Offsite disposal depending on contaminants Awaiting negotiations
Used Gaskets	3 m3	Contaminated General Waste Bins	Sita	Offsite disposal depends on contamination Awaiting negotiations
Cardboard Packaging	Varies	Dedicated 3 or 5 m3 Wire bins As specified on drawing number CLR07264; Refinery Layout	Visy Recycling	Regular offsite disposal to Smithfield Mill Or disposal to licensed landfill
Mercury	Varies	Dedicated skips for contaminated sludges where sampling has indicated Mercury presence	Transpacific Industries	Kooragang Island
PCB contaminated material	Low volumes	Dedicated labelled drums after sampling identifies presence	TBD (authorised PCB destruction and disposal service provider. In accordance with EPL No.570 Condition U5 (PRP NO.13))	TBD through EPL No570 Condition U5 (PRP No.13 – PCB Removal Program).
Waste timber offcuts	Low volumes	Uncontaminated skips and contaminated product skips	Sita	Green waste recycling at Eastern Creek Specialised landfills as specified by waste tracking
Flare Sludges	100 m3	20K Isocontainer (pyrophoric)	Transpacific Industries	Kooragang Island

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<b>TYPE OF WASTES GENERATED</b>	<b>RESPONSIBILITY</b>	<b>METHOD</b>	<b>REDUCE</b>	<b>REUSE</b>	<b>RECYCLE</b>	<b>PREFERRED DISPOSAL</b>	<b>COMPLIANCE INDICATORS</b>
Contaminated soils	Plant Controller for area within which waste has been generated (ie Process West, Process East, Utilities or Movements).	See FCCU Environment Management Plan MC.01200.G.090 Appendix "B"	No other options available	No other options available	No other options available	Thermal Desorption Resulting soil used as inert fill	<ul style="list-style-type: none"> <li>• Sampling Results</li> <li>• Online Waste Tracking category</li> <li>• CA &amp; TC against License 570</li> </ul>
Process liquid wastes	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "D"	Refinery slops system	Refinery slops system for reuse	Refinery slops system for reuse	Refinery slops system for reuse	<ul style="list-style-type: none"> <li>• Waste sampling</li> <li>• TWS specification</li> <li>• Slops system ullage</li> </ul>
Spilt Fuel / Solvents	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "E"	Refinery slops system	Refinery slops system for reuse	Refinery slops system for reuse	Refinery slops system for reuse	<ul style="list-style-type: none"> <li>• Waste sampling</li> <li>• Storage levels</li> <li>• Contaminants</li> <li>• Slops system ullage</li> </ul>
Refractory	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "G"	No other options available	No other options available	No other options available	Offsite disposal to licensed landfill	<ul style="list-style-type: none"> <li>• Waste sampling</li> <li>• Waste Tracking CA and TC</li> <li>• Waste audits</li> </ul>
Spent Catalyst	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "H"	No other options available	Incorporate into cement clinker production	Recover precious metals through reprocessing	Boral Cement Road base	<ul style="list-style-type: none"> <li>• Boral specification</li> <li>• RTA Specification</li> <li>• Waste Audits</li> </ul>
Coke	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "I"	No other options available	Refuse Derived Fuel	No other options available	Boral Cement Macquarie Power Station Bluescope Steel Licensed landfill	<ul style="list-style-type: none"> <li>• Boral Specification</li> <li>• EPA Waste Tracking</li> <li>• Sampled contaminants</li> </ul>

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<b>TYPE OF WASTES GENERATED</b>	<b>RESPONSIBILITY</b>	<b>METHOD</b>	<b>REDUCE</b>	<b>REUSE</b>	<b>RECYCLE</b>	<b>PREFERRED DISPOSAL</b>	<b>COMPLIANCE INDICATORS</b>
Rashig Rings	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "J"	No other options available	Reuse unbroken rings in reactor	No other options available	Use on site in reactor Dispose through Waste Tracking or metal recycle	Sampling Unbroken ceramics
Dust	Plant Controller for area within which waste has been generated (ie Process East)	On site management See FCCU Environment Management Plan MC.01200.G.090 Appendix "K"	Limit activities in high wind periods  Enclose area while using HPW or HP Blasting	Not Applicable	Not Applicable	Wet to prevent movement  Minimise site effects using water spray	<ul style="list-style-type: none"> <li>• OH&amp;S Act 2000</li> <li>• Regulations 2001</li> <li>• Shell's QIR System</li> </ul>
Rust scale	Plant Controller for area within which waste has been generated (ie Process East)	On site management See FCCU Environment Management Plan MC.01200.G.090 Appendix "L"	Use of better coatings when sealing metal tank / equipment surfaces	No other options available	No other options available	Licensed landfill	<ul style="list-style-type: none"> <li>• Sampling process</li> <li>• Contaminants</li> <li>• Licensed landfill</li> </ul>
Asbestos / Insulation	Plant Controller for area within which waste has been generated (ie Process East)	Offsite special landfill operations See FCCU Environment Management Plan MC.01200.G.090 Appendix "M"	Replace Asbestos with alternate products	No other options available	No other options available	Licensed landfill	<ul style="list-style-type: none"> <li>• EPA Waste Tracking</li> <li>• Blue / Yellow stickers</li> <li>• OH&amp;S Audits</li> </ul>
Broken concrete	Plant Controller for area within which waste has been generated (ie Process East)	Concrete Recyclers See FCCU Environment Management Plan MC.01200.G.090 Appendix "N"	Onsite Planning Processes	Grind and reuse in concrete process	Grind and reuse in concrete process	Concrete batching Road base sealant	<ul style="list-style-type: none"> <li>• Type of contaminants</li> <li>• Roadbase specification</li> <li>• Waste audits</li> </ul>

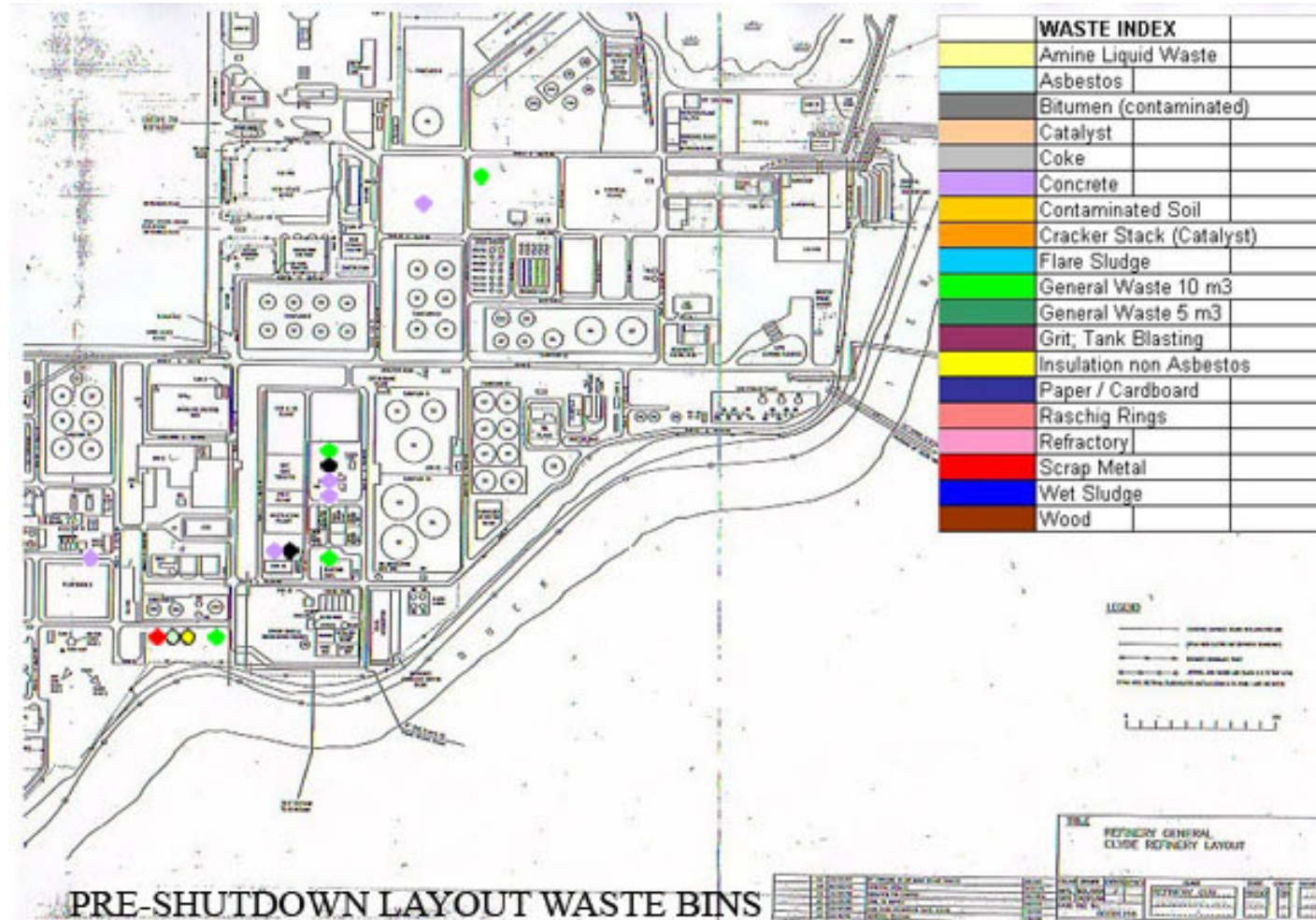
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<b>TYPE OF WASTES GENERATED</b>	<b>RESPONSIBILITY</b>	<b>METHOD</b>	<b>REDUCE</b>	<b>REUSE</b>	<b>RECYCLE</b>	<b>PREFERRED DISPOSAL</b>	<b>COMPLIANCE INDICATORS</b>
Metal fabrication	Plant Controller for area within which waste has been generated (ie Process East)	Offsite – Recycled Metal See FCCU Environment Management Plan MC.01200.G.090 Appendix "O"	Not Applicable	Not Applicable	Recycle in Steel Furnaces	BHP Steelmaking	<ul style="list-style-type: none"> <li>Recycled metas specification</li> <li>Contaminants</li> <li>Waste audits</li> <li>Weighbridge dockets</li> </ul>
Electrical Wastes	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "P"	Forward Planning	Excess materials can be reused on site for other applications	Metals can be recovered if segregated  Plastics can be used in Waste From Energy Technology	Segregated wastes Minimise disposal costs through recycling centres	<ul style="list-style-type: none"> <li>Waste audits</li> <li>Weighbridge dockets</li> </ul>
Blasting Grit	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "Q"	Use of alternate abrasives	Grit reuse depending on specification	Grit recovery through processing	Immobilisation in road base or concrete manufacture  Use in fill materials including road base	<ul style="list-style-type: none"> <li>Sampling</li> <li>Grit specification</li> <li>Contaminants present</li> </ul>
Used Gaskets	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "R"	No other options available	No other options available	No other options available	Disposal as contaminated waste to licensed landfill	<ul style="list-style-type: none"> <li>Waste Tracking CA &amp; TC</li> <li>Waste audits</li> </ul>

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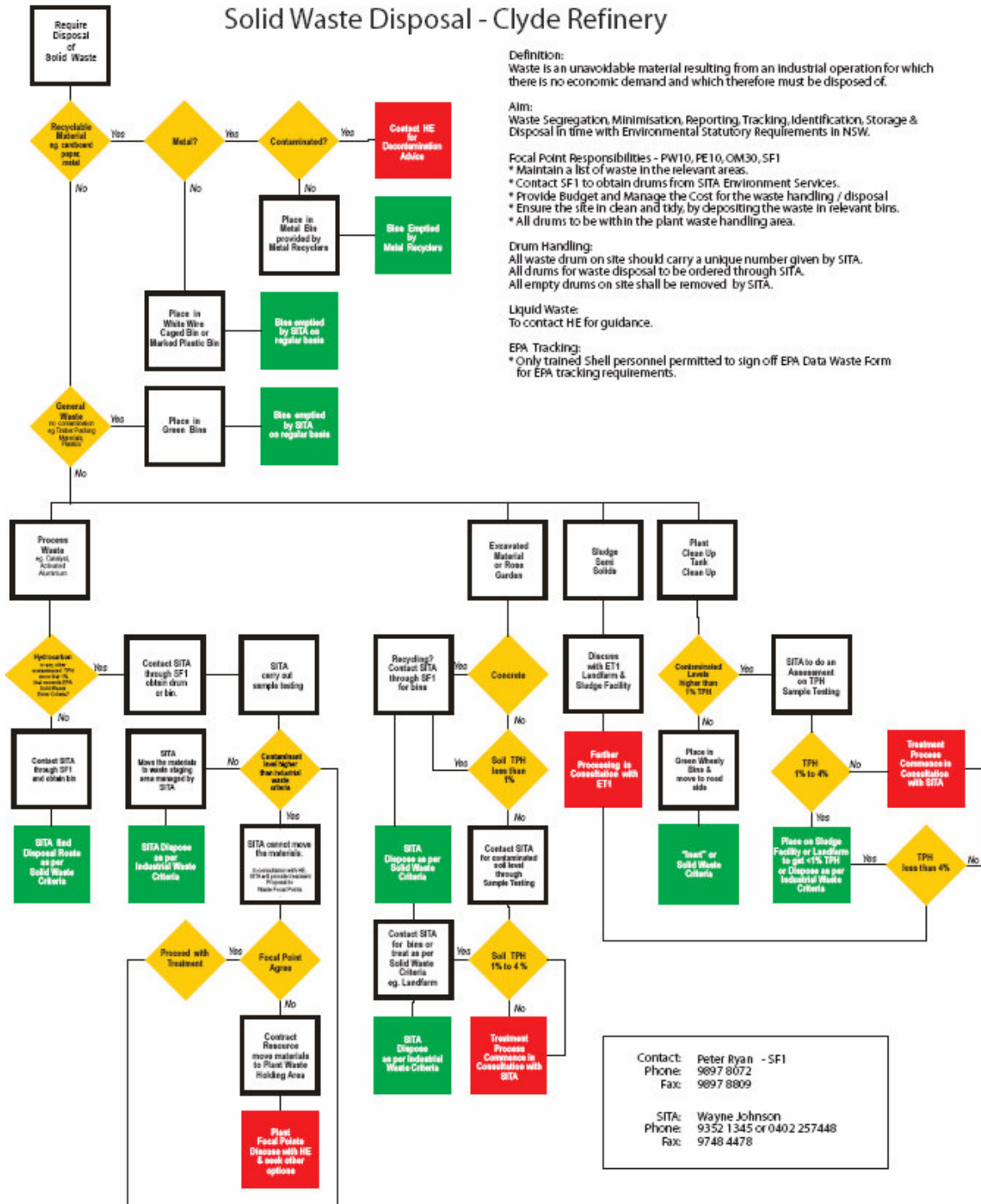
<b>TYPE OF WASTES GENERATED</b>	<b>RESPONSIBILITY</b>	<b>METHOD</b>	<b>REDUCE</b>	<b>REUSE</b>	<b>RECYCLE</b>	<b>PREFERRED DISPOSAL</b>	<b>COMPLIANCE INDICATORS</b>
Cardboard Packaging	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "S"	National Packaging Covenant objectives	Reuse packaging for storage or transport instead of virgin material	Segregate and meet recycling specification	Visy Mill APPM Landfill if contaminated	<ul style="list-style-type: none"> <li>Recyclers specification</li> <li>Sufficient bins in use</li> <li>Waste Audits</li> </ul>
Mercury	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "T"	New Technology	No other options available	Mercury recycling facility, Sydney if possible.	Transpacific Kooragang Island  Alternate disposal meeting EPA requirements	<ul style="list-style-type: none"> <li>Sampling</li> <li>OH&amp;S Act 2000</li> <li>Weighbridge docketts</li> <li>Waste Tracking CA and TC</li> </ul>
PCB's	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "V"	Not now in new transformer liquid insulation	Off-site treatment of transformer oil, regeneration of oil and re-use.	No other options available	Per waste disposal route identified under EPL No.570 Condition U5.	<ul style="list-style-type: none"> <li>Sampling</li> <li>OH&amp;S Act 2000</li> <li>Weighbridge docketts</li> <li>Waste Tracking CA and TC</li> <li>Manufacturer's specification</li> </ul>
Waste timber offcuts	Plant Controller for area within which waste has been generated (ie Process East)	See FCCU Environment Management Plan MC.01200.G.090 Appendix "W"	Non purchase of CCA impregnated timber  Use of other materials	Use for similar applications on site or in transport	Green waste processing if not contaminated	Green waste recycling at Eastern Creek  If contaminated Specialised landfills	<ul style="list-style-type: none"> <li>Greenwaste specification</li> <li>Weighbridge docketts</li> <li>Waste Audits of bins</li> <li>Contaminated Waste tracking CA and TC</li> </ul>

### 3. Skip Bin Placement – PRE SHUTDOWN



## 4. Management of Solid Wastes

### 4.1 Management Strategy

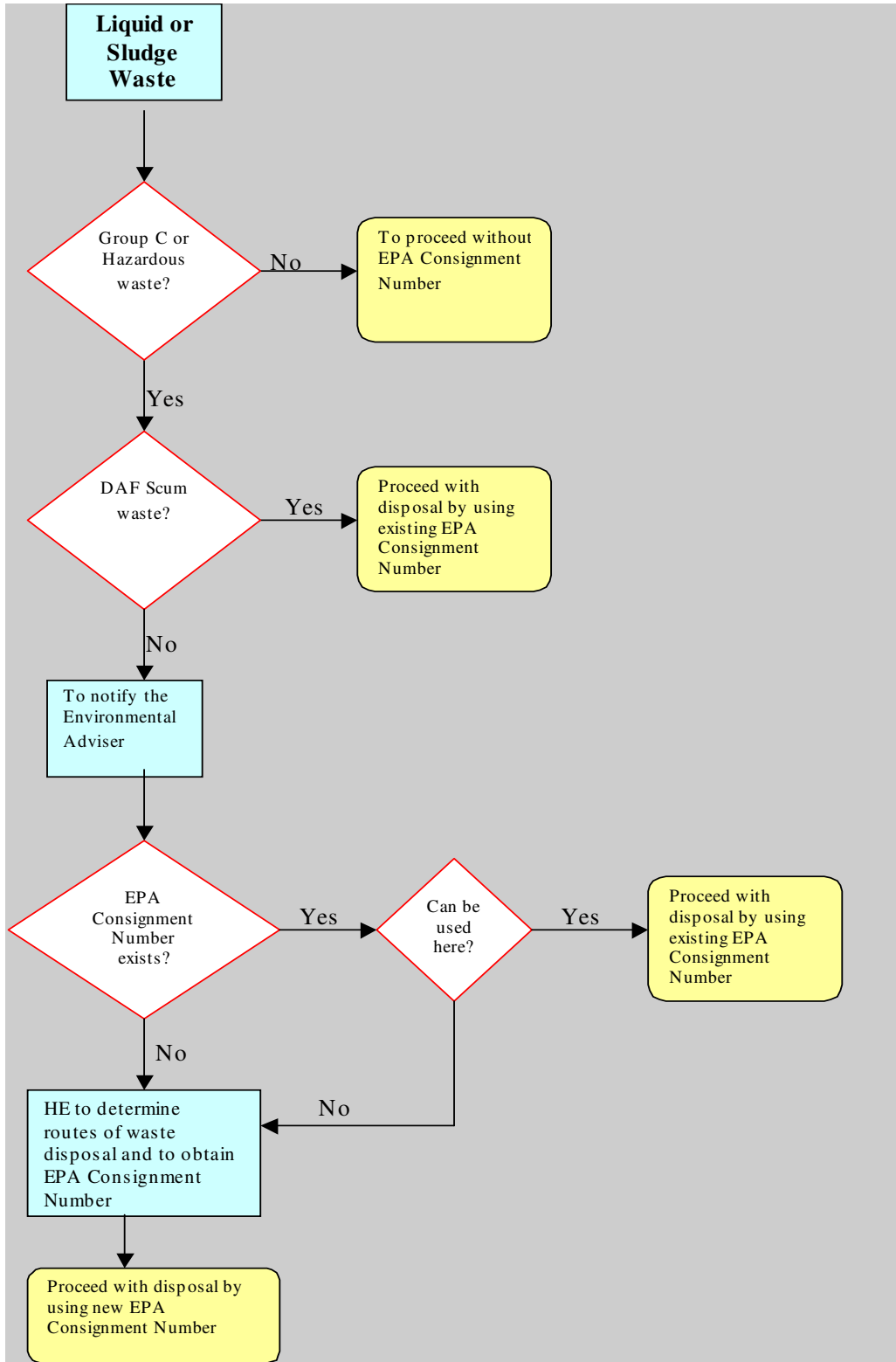


### 4.2 Monitoring

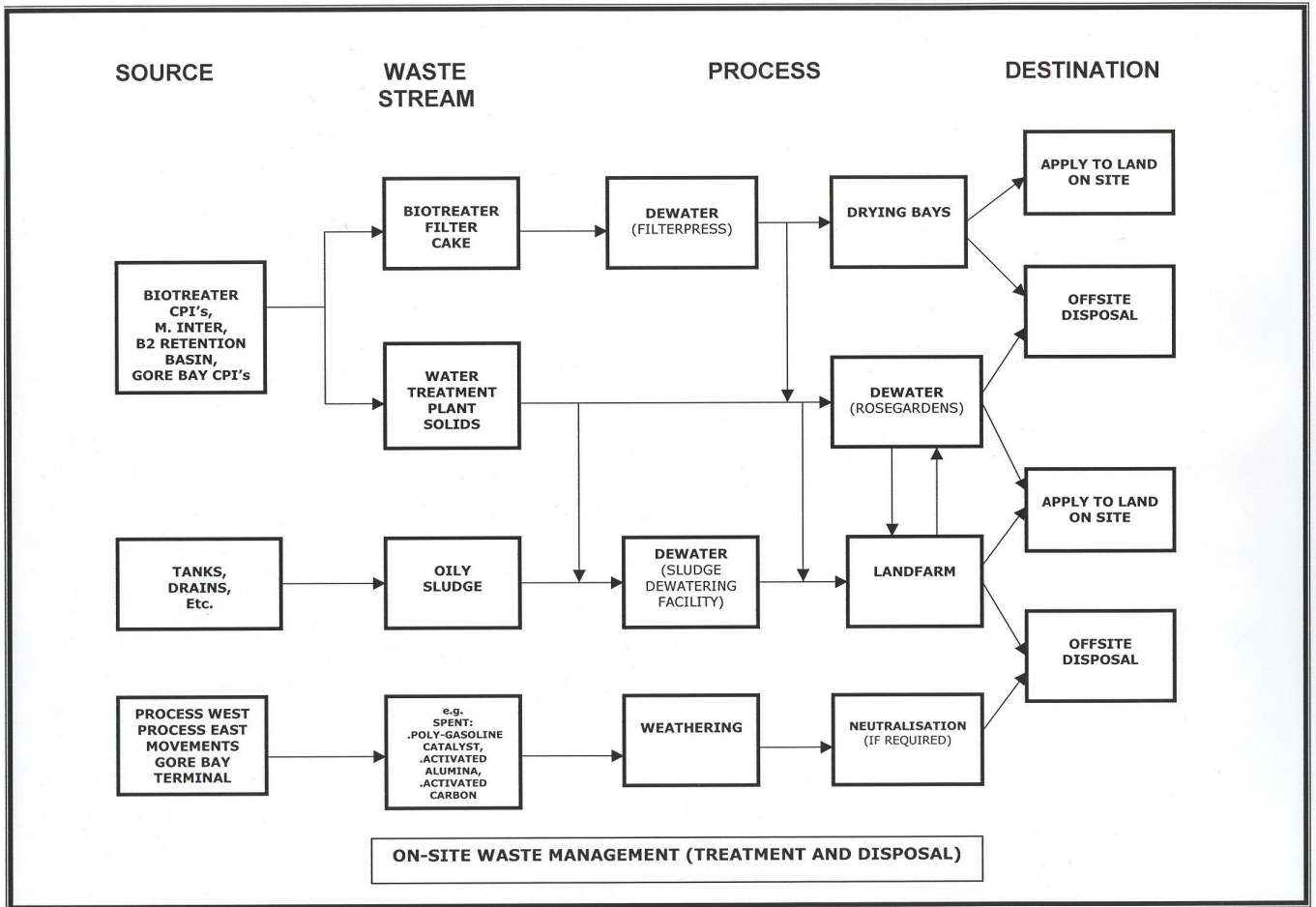
All soils or sludges being removed off site must be tested by a NATA accredited laboratory for a minimum suite of metal and hydrocarbons

## 5. Liquid & Sludge Waste Disposal

### Liquid and Sludge Waste Disposal – Clyde Refinery



## 6. On-site Waste Management (Treatment and Disposal)



## **APPENDIX A - Definitions of Waste Streams**

### **DEFINITIONS OF WASTE STREAMS**

#### **Spoil**

Solid material of a "natural" origin such as excavated soil and rock, brick, concrete, asphalt and road base but excluding asbestos in all forms. Where any doubt exists as to whether a particular quantity of material is in fact spoil, it should be treated as solid waste until tests prove otherwise.

#### **Solid Waste**

Solid material of process origin such as spent carbon and tank bottom sludges. Solid wastes may be wet but must be of a spadeable consistency. Solid waste must pass EPA leachate and other testing.

#### **Asbestos Waste**

Solid waste containing asbestos. It is classified in three categories:-

- Category 1 Waste asbestos-based thermal or acoustic insulation.
- Category 2 Asbestos-containing dust waste.
- Category 3 Waste materials containing asbestos in a bonded matrix such as asbestos cement or CAF gasket.

#### **Recyclable Paper**

Waste paper as defined by Australian Paper Manufacturers as being recyclable.

#### **General Solid Waste**

This is the waste material accumulated in working areas and meal rooms and includes used plastic cups, empty milk cartons, cardboard boxes, wrapping material and food scraps. This also includes paper that is not recyclable.

#### **Scrap Metal**

Metallic waste including piping offcuts, redundant rolled steel sections, redundant tanks, empty drums and sheet cladding of lagging.

#### **Spent Carbon**

Used activated carbon from the odour adsorption unit at the LPG gantry

#### **Waste Oil/Water, Hydrocarbon/Water Mixtures or Emulsions**

Liquid waste arising from activities throughout the Refinery such as emptying slops tanks, servicing interceptors, interceptor and drain clean outs, tank cleaning operations and after cleaning up losses of containment. Waste water which cannot be discharged to storm water or to trade waste is classified within this category.

### **Soils Contaminated With Controlled Waste**

Such soils arising from cleaning up after losses of containment, construction projects and remediation type projects throughout the Refinery.

### **Leaded Sludge**

Leaded sludge and scale resulting from tank cleaning activities, where the product stored in the tank prior to cleaning has contained lead. Includes solid material removed from tanks, pumps, filters and piping in systems handling leaded Mogas or lead alkyls.

### **Recyclable Oil**

Off grade oil, which can be recycled by a waste oil contractor eg. re-used as a lower grade oil, or used as a part constituent of cement kiln fuel.

### **Containers and Drums Contaminated With Residues Of Substances Referred In Appendix 1 EPL No.570**

Includes containers with more than 20 mls of oily residue per container, heavily oil soaked rags or other heavily oil soaked absorbent material.

### **Excavation Material (but not soil)**

Solid material of a "natural" origin such as excavated rock, brick, concrete, asphalt and road base but excluding asbestos in all forms. Where any doubt exists as to whether a particular quantity of materials is in fact uncontaminated excavation material it should be treated as solid industrial waste until it can be proved otherwise.

### **Spent Catalysts**

Used catalysts mainly from CCU but also including HDS, HDT and other catalysts, activated alumina drying agents and molecular sieves.

### **Biosludge or Biotreater Filter Cake**

Solid organic material produced as a by-product of the activated sludge process in the Biotreater.

### **Spent Caustic**

Caustic soda solution after having been used in treating processed for purifying LPG components and gasoline. It contains sulphides, mercaptans and, in the case of treating catalytic cracked gasoline, alkyl phenols.

### **PCBs**

Polychlorinated Biphenyls are organic compounds containing large amounts of chlorine and are listed under the Environmentally Hazardous Chemicals Act. They were used for many years in the electrical industry either pure or as an additive in mineral oil for filling transformers and capacitors.