January 2015

DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Environmental Impact Assessment (EIA) for the Proposed Vopak-Reatile Terminal Richards Bay Bulk Liquid Storage and Handling Facility

Submitted to:
For client review

DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014

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REPORT

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ACRONYMS

Acronym	Description
AEL	Atmospheric Emissions Licence
AIA	Approved Inspection Authority
BA	Basic Assessment
BAT	Best Available Techniques
BIL	Background Information Letter
BLEVE	Boiling Liquid Expanding Vapour Explosion
CPP	Clean Petroleum Products
DAEA	KwaZulu-Natal Department of Agriculture and Environmental Affairs
DAFF	Department of Agriculture, Forestry and Fisheries
DEDTEA	KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs
DSR	Draft Scoping Report
DWA	Department of Water Affairs
DWS	Department of Water Affairs and Sanitation
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EAPSA	Environmental Assessment Practitioners of South Africa
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EKZNW	Ezemvelo KwaZulu-Natal Wildlife
EMF	Environmental Management Framework
EMP	Environmental Management Plan
EMS	Environmental Management System
EPRP	Emergency Preparedness Response Plan
GNR	Government Notice
I&AP	Interested and Affected Party
IFR	Internal Floating Roof
IUCN	International Union for Conservation of Nature
IVS	Island View Storage

JBS	Joint Bunker Services
LPG	Liquid Petroleum Gas
LSD	Low Sulphur Diesel
m^3	Cubic metres
m^3/h	Cubic metres per hour
MHI	Major Hazardous Installation
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (Act No. 39 of 2004)
NEM:BA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NEM:WA	National Environmental Management: Waste Act (Act No. 59 of 2008)
NERSA	National Energy Regulator of South Africa
OHSA	Occupational Health and Safety Act (Act No. 85 of 1993)
PP(P)	Public Participation (Process)
RBCT	Richards Bay Coal Terminal
S&EIA	Scoping and Environmental Impact Assessment
S&EIR	Scoping and Environmental Impact Report
SACNASP	South African Council of Natural Scientific Professions
SANAS	South African National Accreditation System
SANS	South African National Standard
SDF	Spatial Development Framework
SHE	Safety, Health and Environmental
SHEQ	Safety, Health, Environment and Quality
ToR	Terms of Reference
TNPA	Transnet National Ports Authority
ULSD	Ultra Low Sulphur Diesel

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TERMINOLOGY

Term	Explanation
AIA	An approved inspection authority (AIA) is defined in the Major Hazard Installation Regulations (July 2001)
ALARP	The UK Health and Safety Executive developed *the risk ALARP triangle*, in an attempt to account for risks in a manner similar to those used in everyday life. This involved deciding: Whether a risk is so high that something must be done about it; Whether the risk is, or has been made, so small that no further precautions are necessary; If a risk falls between these two states that it has been reduced to levels As Low As Reasonably Practicable (ALARP*)*. Reasonable practicability involves weighing a risk against the trouble, time and money needed to control it.
Asphyxiant	An asphyxiant is a gas that is non-toxic but may be fatal, if it accumulates in a confined space and is breathed at high concentrations, since it drives out oxygen-containing air.
BLEVE	Boiling liquid expanding vapour explosions result from the sudden failure of a vessel containing liquid at a temperature above its boiling point. A BLEVE of flammables results in a large fireball.
Bunds or Bund Walls	There are walls built around tanks as a pollution control measure. Should spillage occur, the bunds will contain the fuel and prevent it from escaping into the receiving environment. The facility design includes a bund that is capable of containing the entire volume of the largest tank within the bund, plus an additional 10%. The bunds and the floor on which the tank is located are built with impervious concrete such that fuels thus cannot leak through them.
Construction Phase	The phase of a project preceding the Operations Phase, during which project facilities and infrastructure are assembled and installed on their foundations, and connected and tested, to ensure that they operate as designed.
Emergency Plan	An emergency plan is a plan in writing that, on the basis of identified potential incidents at the installation together with their consequences, describes how such incidents and their consequences should be dealt with, both on site and off site.
Explosion	An explosion is a release of energy that causes a pressure discontinuity or blast wave.
Flammable Limits	Flammable limits are a range of gas or vapour amounts in the air that will burn or explode if a flame or other ignition source is present. The lower point of the range is called the Lower Flammable Limit. Likewise, the upper point of the range is called the Upper Flammable Limit.
Flammable Liquid	The Occupational Health and Safety Act 85 of 1993 defines a flammable liquid as any liquid which produces a vapour that forms an explosive mixture with air and includes any liquid with a closed-cup flash point of less than 55ºC.

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Term	Explanation
	Flammable products have been classified according to their flash points and boiling points, which ultimately determines the propensity to ignite. Separation distances described in the various codes are dependent on the flammability classification. Class Description 0 Liquefied Petroleum Gas IA Liquids that have a closed-cup flash point of below 23 °C and boiling point below 35 °C IB Liquids that have a closed-cup flash point of below 23 °C and boiling point of 35 °C or above IC Liquids that have a closed-cup flash point of 23 °C and above, but below 38 °C II Liquids that have a closed-cup flash point of 38 °C and above, but below 60.5 °C IIA Liquids that have a closed-cup flash point of 60.5 °C and above, but below 93 °C
Frequency	The frequency is the number of times an outcome is expected to occur in a given period of time.
Ignition Source	An ignition source is a source of temperature and energy sufficient to initiate combustion.
Individual Risk	Individual Risk Individual risk is the probability that in one year a person will become a victim of an accident if the person remains permanently and unprotected in a certain location. Often the probability of occurrence in one year is replaced by the frequency of occurrence per year.
Internal Floating Roof	The internal floating roof is used in the tank structure and is floating on the liquid stored in the tank; it rises and falls with the liquid level within the tank achieving a no vapour zone. The purpose of the floating roof is to minimise the vapour emissions on products with a high vapour pressure.
Isopleth	See Risk Isopleth
Jet	The jet is the outflow of material emerging from an orifice with significant momentum.
Jet Fire/Flame	The jet fire/flame is the combustion of material emerging from an orifice with a significant momentum
Liquid Tight Floors	These are impermeable floors used to prevent seepage of petroleum products into the ground.
Local Government	Local government is defined in Section 1 of the Local Government Transition Act, 1993 (Act No. 209 of 1993)

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Term	Explanation
Loss of Containment	Loss of containment is the event resulting in a release of material into the atmosphere.
Major Hazard Installation	Major Hazard Installation means an installation: (a) Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily;(b) Where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident (the potential of which will be determined by the risk assessment).
Major Incident	A major incident is an occurrence of catastrophic proportions, resulting from the use of plant or machinery or from activities at a workplace. When the outcome of a risk assessment indicates that there is a possibility
Material Safety Data Sheet	According to ISO-11014, a material safety data sheet (MSDS) is a document that contains information on the potential health effects of exposure to chemicals, or other potentially dangerous substances and on safe working procedures when handling chemical products. It is an essential starting point for the development of a complete health and safety program. It contains hazard evaluations on the use, storage, handling and emergency procedures related to that material. The MSDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure and what to do if such incidents occur.
Operation Phase	The phase of a project during which the newly constructed tanks, pipelines, gantries and associated facilities are operated.
PADHI	PADHI (planning advice for developments near hazardous installations) is the name given to the methodology and software decision support tool developed and used in the HSE. It is used to give land-use planning (LUP) advice on proposed developments near hazardous installations. PADHI uses two inputs into a decision matrix to generate either an 'Advise Against' or 'Don't Advise Against' response: The zone in which the development is located of the three zones that HSE sets around the major hazard: The inner zone (> 1x10^{-5} fatalities per person per year); The middle zone (1x10^{-5} to 1x10^{-6} fatalities per person per year); The outer zone (1x10^{-6} to 3x10^{-7} fatalities per person per year); The 'sensitivity level' of the proposed development which is derived from an HSE categorisation system of 'development types' (see the 'Development type tables' in Appendix I (of the Risk Specialist Report))
Public Participation (Consultation)	The process of involving all affected parties in the design, planning and operation of a project. The process requires that the proponents give the parties to be consulted notice of the matter in sufficient form and detail to allow them to prepare their views on the matter. They are also given a reasonable

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Term	Explanation
	amount of time to prepare their views and an opportunity to present their views to the proponents, who consider the views presented, fully and impartially
Quantitative Risk Assessment	The quantitative risk assessment is the process of hazard identification, followed by a numerical evaluation of effects of incidents and consequences, probabilities and their combination into overall measure of risk.
Risk	Risk is the measure of the consequence of a hazard and the frequency with which it is likely to occur. Risk is expressed mathematically as: Risk = Consequence x Frequency of Occurrence
Risk Assessment	The risk assessment is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a major hazard installation, and the measures required to remove, reduce or control the potential causes of such an incident.
Vapour Cloud Explosion	The explosion resulting from ignition of a pre-mixed cloud of a flammable vapour, gas, or spray with air, in which flames accelerate to sufficiently high velocities to produce significant overpressure.

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1.0 INTRODUCTION AND OVERVIEW

Royal Vopak is the world's largest independent operator of bulk liquid storage tanks, specializing in the storage and handling of liquefied chemicals, gases, petrochemicals, biofuels, vegetable oils and oil products. Royal Vopak operates a total of 84 terminals in 31 countries worldwide with a combined storage capacity of approximately 29.9 million m³. In South Africa Royal Vopak has four sites which operate as a singular terminal in Durban, KwaZulu-Natal, namely the Vopak Terminal Durban. These sites are situated within and adjacent to the Cutler Complex, Island View. The Cutler Complex is an area of national importance (a National Key Point) designated for the bulk storage of petroleum and chemical products. The Vopak Terminal Durban has a combined storage capacity of approximately 130,000 m³, while efficiency projects are currently underway to increase this storage capacity. In addition to the Vopak Terminal Durban, Vopak received Environmental Authorisation (EA) from the Gauteng Department of Agriculture and Rural Development (GDARD) for the Vopak Terminal Lesedi proposed at Jameson Park, Heidelberg in Gauteng. The Lesedi project is intended to provide approximately 300,000 m³ of petrochemical storage capacity to the Gauteng region.

The projected economic growth for South Africa, and the associated increasing demands for petroleum products, has now resulted in Vopak South Africa Developments (Pty) Ltd. (VSAD), a joint venture between Royal Vopak and Reatile Resources proposing the development of a bulk liquid storage and handling facility known as the Vopak-Reatile Terminal Richards Bay (the proposed Terminal), in the South Dunes Precinct of the Port of Richards Bay, KwaZulu-Natal.

The proposed Terminal will occupy a footprint of approximately 15.8 Ha and will consist of 45 storage tanks which will store Liquid Petroleum Gas (LPG), and a mix of Clean Petroleum Products (CPP) and Chemicals. The storage capacity of the tanks envisaged for the proposed Terminal range from 1,000 m³ to 20,000 m³. The proposed Terminal will be developed in a phased manner with the initial phase providing approximately 36,000 m³ of storage capacity, and further phases providing up to 264,000 m³ additional storage capacity. Once completed, the proposed Terminal will have a total storage capacity of approximately 300,000 m³. The final storage capacity of the proposed Terminal would be based on future growth and demand in the market. In addition to the storage tanks, the proposed Terminal will provide associated infrastructure which includes a liquid shipping line; manifolds, stenching equipment, a marine loading arm, road loading bays, rail loading bays, weighbridges for road and rail loading, mass flow meters, and buildings and utilities.

Golder Associates Africa (Pty) Ltd. (Golder) has been appointed as the independent Environmental Assessment Practitioner (EAP) responsible for undertaking the Environmental Impact Assessment (EIA) process required in accordance with the National Environmental Management Act (Act No. 107 of 1998) (NEMA) and the NEMA EIA Regulations of 18 June 2010 published in Government Notice GNR 543. An Application for Environmental Authorisation (EA) for the proposed Terminal was lodged with the Provincial KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs (DEDTEA), previously known as the KwaZulu-Natal Department of Agriculture and Environmental Affairs (DAEA). Following the submission of the application, and a meeting with Mr. Muzi Mdamba of DEDTEA, VSAD made the decision to split the EA process for the proposed Terminal into two separate EA processes, namely a Basic Assessment (BA) process to obtain EA for site clearing and preparation activities, and a full EIA process to obtain EA for the construction and operation of the proposed Terminal.

Separate Applications for EA were lodged with DEDTEA as follows:

Table 1: Applications for Environmental Authorisation submitted to DEDTEA.

Application	DEDTEA Reference Number
Environmental Impact Assessment (EIA) for the Vopak-Reatile Terminal Richards Bay Bulk Liquid Storage and Handling Facility	DC28/0001/2014 KZN/EIA/0001388/2014
Basic Assessment (BA) for Site Clearing and Site Preparation Activities on Lots 4 and 5 of Portion 3 of Erf 11478 in the South Dunes Precinct of the Port of Richards Bay, KwaZulu-Natal	DC28/0004/2014 KZN/EIA/0001439/2014

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The decision to split the EA process into separate BA and EIA processes was taken following a review of the existing information, specifically the Final BA Report (FBAR) and supporting Terrestrial Ecology, and Wetland Delineation, specialist studies compiled on behalf of the Transnet National Ports Authority (TNPA) for the provision of Services to the South Dunes Lease Sites. TNPA's FBAR and supporting specialist studies determined that although the South Dunes Precinct is highly transformed, it does host important vegetation communities and species, and important faunal species (Geomeasure Group and ACER Africa, 2013). The decision to conduct a separate BA process for site clearing and preparation activities was therefore taken to determine upfront the possibility of any threatened or protected species occurring onsite, which may require separate authorisations in addition to that required under NEMA. These include:

- Licenses Regarding Protected Trees from the Department of Agriculture, Forestry and Fisheries (DAFF) in accordance with Section 15 (1) of the National Forests Act (Act No. 84 of 1998) (NFA) as amended;
- Permits for Carrying Out of a Restricted Activity in Relation to a Listed Threatened or Protected Species (TOPS) from Ezemvelo KwaZulu-Natal Wildlife (EKZNW) in accordance with the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA); and/or
- A Water Use License (WUL) from the Department of Water Affairs and Sanitation (DWS) in accordance with Chapter 4 of the National Water Act (Act No. 36 of 1998) (NWA).

A single Public Participation (PP) process was conducted for the BA and EIA processes. The Draft BA Report (DBAR) for site clearing and preparation activities, and the Draft Scoping Report (DSR) for the construction and operation of the proposed Terminal were released in parallel for a 40 day comment period. The split approach to applying for an EA, and the contents of the DBAR and DSR were presented at a single Public Meeting. A Final BAR (FBAR) and Final Scoping Report (FSR) were prepared for the respective applications and released in parallel for a 21 day comment period. This was done to ensure uniformity in the approach to the PP process being conducted, and to provide Interested and Affected Parties (I&APs) with the opportunity to comment on both EA processes in a transparent and holistic manner.

In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, including those of DEDTEA, VSAD made the decision to reintegrate the two processes into a single EIA process. This Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal. The remainder of this EA process will therefore be managed under a single Application, namely: the Application for EA for the Vopak-Reatile Terminal Richards Bay (DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014).

In addition to obtaining an EA under NEMA for the proposed Terminal, VSAD will also require the following: a WUL from DWS in accordance with the NWA; an Atmospheric Emissions License (AEL) from the uThungulu District Municipality in accordance with the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA); a License regarding Protected Trees from DAFF in accordance with the NFA; and a Permit for carrying out a restricted activity in relation to a listed Threatened or Protected Species (TOPS) from EKZNW in accordance with NEM:BA.

1.1 Purpose of an EIA

The main purpose of an EIA is to provide the relevant authorities with sufficient information on a proposed project to allow them to make an informed decision on whether or not the listed activities should be authorised. The EIA process includes a number of phases. This DEIAR presents the information gathered during the Impact Assessment Phase of EIA.

EIAs are normally undertaken to:

- Facilitate the application of project approval processes;

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- Incorporate the best environmental option by considering environmental impacts in the planning and design stage of development;
- Manage risk and avoid project delays, by engaging stakeholders and responding to their concerns and expectations in a timely manner, so as to gain a social license to operate;
- Facilitate effective planning and reduce the potential for the creation of liabilities;
- Ensure impacts, benefits and mitigation plans are identified; and
- Improve project design and execution in respect of all of the above.

The objectives of this EIA are to:

- Conduct a program of stakeholder engagement as part of the impact assessment process;
- Establish the baseline conditions of the proposed Terminal's area of influence prior to construction and operation;
- Systematically identify and assess material environmental and social impacts that may result from the construction, operation and closure of the proposed Terminal;
- Develop a set of recommended mitigation measures to avoid negative impacts, and, where that is not possible, to reduce the effects of negative impacts and provide enhancement measures where the proposed Terminal can provide positive benefits;
- Fully integrate these measures into the design, engineering, planning and execution of the proposed Terminal; and
- Include an evaluation and assessment of alternatives, including a "no project" alternative.

1.2 The purpose of a WUL

A Water Use License (WUL) is required in accordance with the National Water Act (Act No. 36 of 1998) (NWA). The main purpose of a WUL is to register listed water uses with the Department of Water Affairs and Sanitation (DWS) (previously known as the Department of Water Affairs (DWA)) in order to ensure that everyone has access to sufficient water, that the environment is protected, and that water is reallocated to advance previously disadvantaged communities. WULs are therefore used to control water use through regulating the way water can be used.

WULs provide water users with formal authorisation to use water for productive and beneficial purposes, and specify the conditions under which water can be used to ensure that the water use authorised by the WUL does not have a negative impact on the water resource or other water users.

1.3 The purpose of an AEL

An Atmospheric Emissions License (AEL) is required from the uThungulu District Municipality in accordance with the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA). The main purpose of an AEL is to license activities which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage. AELs are therefore used to prevent pollution and ecological degradation of the atmosphere, promote conservation, and secure ecologically sustainable development and use of natural resources, and improve air quality through the minimisation of pollution through vigorous control, cleaner technologies and cleaner production practices.

1.4 Purpose of a License regarding Protected Trees

A License regarding Protected Trees is required from the Department of Agriculture, Forestry and Fisheries (DAFF) in accordance with Section 15 (1) of the National Forests Act (Act No. 84 of 1998) (NFA). The main purpose of a License regarding Protected Trees is to provide for the conservation and development of natural forests and woodlands according to the principles of sustainable management, and to allow for the protection of sensitive species.

1.5 Purpose of a Permit for Carrying out a Restricted Activity

A Permit for carrying out a restricted activity in relation to a listed Threatened or Protected Species (TOPS) is required from the Ezemvelo KwaZulu-Natal Wildlife (EKZNW) in accordance with the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA). The main purpose of a Permit for Carrying out a Restricted Activity in related to a listed TOPS is to amongst others, provide for the management and conservation of South Africa's biodiversity within the framework of NEMA, provide for the protection of species and ecosystems that warrant national protection; provide for the sustainable use of indigenous biological resources; and to provide for the fair and equitable sharing of benefits arising from bio prospecting involving indigenous biological resources.

1.6 The Proponent

VSAD, a joint venture between Royal Vopak and Reatile Resources, is the project proponent for the proposed Terminal. Once developed, Royal Vopak will have 70% ownership of the proposed Terminal and Reatile Resources will have 30% ownership. The Terminal is proposed on Lots 4 and 5 of Portion 3 of Erf 11478 of the South Dunes Precinct of the Port of Richards Bay. VSAD signed a lease agreement with the Transnet National Ports Authority (TNPA) for Lots 4 and 5 on 28 March 2012.

For the purposes of this EIA, the following people may be contacted at VSAD:

Table 2: Proponents Contact Details

Item	Description	
Contact Person	David Bent	Carla Manion
Company Name	Vopak South Africa Developments (VSAD)	Vopak South Africa Developments (VSAD)
Address	105 Taiwan Road Island View Durban 4052	105 Taiwan Road Island View Durban 4052
Telephone	011 887 4236 / 031 466 9260	031 466 9221
Cell phone	083 325 4394	084 440 6761
Email	david.bent@vopak.com	carla.manion@vopak.com

1.7 Details of Environmental Assessment Practitioner

Golder Associates Africa (Pty) Ltd. (Golder) is a member of the world-wide Golder Associates Corporation (GAC) group of companies, offering a variety of specialised engineering and environmental services. Employee owned since its formation in 1960, GAC employs more than 8,000 people who operate from more than 180 offices located throughout Africa, Asia, Australasia, Europe, North America and South America. Golder Associates Africa has offices in South Africa, Botswana, Mozambique and Ghana. Golder Associates Africa has more than 350 skilled employees and is able to source additional professional skills and inputs from other Golder offices around the world.

Golder is experienced in environmental management and assessment and is familiar with the EIA requirements for bulk liquid petro-chemical storage and handling facilities. The company is well known for its integrity and independence, as well as for its skill in assisting I&APs to participate in the EIA and associated PP processes.

Golder declares its independence in accordance with the NEMA EIA Regulations of 18 June 2010 (GNR 543), and has no vested interest in the proposed Terminal.

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For purposes of this EIA, the following persons may be contacted at Golder:

Table 3: EAP Contact Details.

Contact Persons	**Rob Hounsome**	**Sasha Slogrove-Saayman**
Purpose	Technical	Public Participation
Address	P.O. Box 29391 Maytime 3624	P.O. Box 6001 Halfway House 1685
Telephone	031 717 2777	011 254 4966
Fax	031 717 2791	086 582 1561
Cell phone	082 889 3507	082 258 4880
Email	RHounsome@golder.com	SSaayman@golder.co.za

This EIA is being directed by Mr Rob Hounsome from Golder. Rob is registered as an Environmental Assessment Practitioner (EAP) with the Certification Board for Environmental Assessment Practitioners of South Africa (EAPSA) (Registration Number: 0077/06) and as a Professional Natural Scientist (Pri.Sci.Nat) with the South African Council for Natural Scientific Professions (SACNASP) (Registration Number: 400065/07). He has more than 18 years' experience as a consulting environmental scientist and EIA Project Manager. The Project Manager for this EIA is Mr Ed Perry. Ed is registered as an Environmental Auditor with the Institute of Environmental Management and Assessment (IEMA) and as a Lead Auditor with the International Cyanide Management Institute. Ed has worked in environmental consultancy for over eighteen years for a wide range of public and private sector clients, and is the Divisional Leader for Golder's Environmental Services in Africa.

The EIA project team including specialists are listed in Table 4 below.

Table 4: Project team

Team member	**Role**
Project Director	Rob Hounsome
Project Manager	Ed Perry
Risk Specialist	Mike Oberholzer
Air Quality Specialists	Adam Bennett, Lance Coetzee and Candice Allan
Hydrology Specialist	Trevor Coleman and Amanda Cassa
Ecology Specialist	Warren Aken and Andrew Zinn
Traffic Specialists	Seniel Pillay
Social Specialist	Pierre Gouws and Priya Ramsaroop
Public Participation Specialists	Sasha Slogrove-Saayman and Mfundo Ndlovu

1.8 Structure of the Report

The NEMA EIA Regulations of 18 June 2010 (GNR 543) state that an EIA Report must contain all information that is necessary for the competent authority, in this instance DEDTEA, to consider the application and to reach a decision on whether to grant or refuse EA. Table 5 provides an overview of the requirements of an EIA Report as contained in Regulation 31 (2) of the NEMA EIA Regulations (GNR 543), and indicates where in the report the respective requirements can be found.

Table 5: Requirements of an Environmental Impact Assessment Report as determined by the NEMA EIA Regulations (GNR 543).

Regulation	Description	Location in the Report
31 (2) (a) (i)	Details of the EAP who compiled the report	Section 1.0
31 (2) (a) (ii)	Details of the expertise of the EAP to carry out an environmental impact assessment	Section 1.0
31 (2) (b)	A detailed description of the proposed activity	Section 2.0
31 (2) (c)	A description of the property on which the activity is to be undertaken and the location of the activity on the property, or if it is:	Section 2.0
31 (2) (c) (i)	A linear activity, a description of the route of the activity	N/A
31 (2) (c) (ii)	An ocean-based activity, the coordinates where the activity is to be undertaken	N/A
31 (2) (d)	A description of the environment that may be affected by the activity and the manner in which the physical, biological, social, economic and cultural aspects of the environment may be affected by the proposed activity	Section 3.1.4 Section 6.0
31 (2) (e)	Details of the public participation process conducted in terms of Sub regulation (1), including :	Section 5.0
31 (2) (e) (i)	Steps undertaken in accordance with the plan of study	Section 5.0 Section 6.0
31 (2) (e) (ii)	A list of persons, organisations and organs of state that were registered as interested and affected parties	APPENDIX B
31 (2) (e) (iii)	A summary of comments received from, and a summary of issues raised by registered interested and affected parties, the date of receipt of these comments and the response of the EAP to those comments	APPENDIX C
31 (2) (e) (iv)	Copies of any representations and comments received from registered interested and affected parties	APPENDIX C
31 (2) (f)	A description of the need and desirability of the proposed activity	Section 2.0
31 (2) (g)	A description of identified potential alternatives to the proposed activity, including advantages and disadvantages that the proposed activity or alternatives may have on the environment and the community that may be affected by the activity	Section 2.0 Section 6.0
31 (2) h)	An indication of the methodology used in determining the significance of potential environmental impacts	Section 6.0
31 (2) (i)	A description and comparative assessment of all alternatives identified during the environmental impact assessment process	Section 2.0 Section 6.0
31 (2) (j)	A summary of the findings and recommendations of any specialist report or report on a specialised process	Section 6.0 Section 6.7.5
31 (2) (k)	A description of all environmental issues that were identified during the environmental impact assessment process, an assessment of the significance of each issue and an indication of the extent to which the issue could be addressed by the adoption of mitigation measures	Section 6.0
31 (2) (l)	An assessment of each identified potentially significant impact, including:	Section 6.0
31 (2) (l) (i)	Cumulative impacts	Section 6.0
31 (2) (l) (ii)	The nature of the impact	Section 6.0
31 (2) (l) (iii)	The extent and duration of the impact	Section 6.0
31 (2) (l) (iv)	The probability of the impact occurring	Section 6.0
31 (2) (l) (v)	The degree to which the impact can be reversed	Section 6.0
31 (2) (l) (vi)	The degree to which the impact may cause irreplaceable loss of resources	Section 6.0
31 (2) (l) (vii)	The degree to which the impact can be mitigated	Section 6.0
31 (2) (m)	A description of any assumptions, uncertainties and gaps in knowledge	Section 6.0
31 (2) (n)	A reasoned opinion as to whether the activity should or should not be authorised, and if the opinion is that it should be authorised, any	Section 8.0

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Regulation	Description	Location in the Report
	conditions that should be made in respect of that authorisation	
31 (2) (o)	An environmental impact statement which contains:	Section 6.0
31 (2) (o) (i)	A summary of the key findings of the environmental impact assessment	Section 6.0
31 (2) (o) (ii)	A comparative assessment of the positive and negative implications of the proposed activity and identified alternatives	Section 6.0
31 (2) (p)	A draft environmental management programme containing the aspects contemplated in Regulation 33	Section 6.7.5
31 (2) (q)	Copies of any specialist reports and reports on specialised processes complying with Regulation 32	APPENDIX E APPENDIX F APPENDIX G APPENDIX H APPENDIX I
31 (2) (r)	Any specific information that may be required by the competent authority	N/A
31 (2) (s)	Any other matters required in terms of Sections 24(4)(a) and (b) of the Act	N/A

2.0 PROJECT DESCRIPTION

2.1 Location of the Proposed Terminal

The proposed Terminal is located in the South Dunes Precinct of the Port of Richards Bay, KwaZulu-Natal (see Figure 3 and Figure 4 below). The South Dunes Precinct constitutes an island surrounded by areas of fresh and salt water. It is connected to the mainland via a narrow strip of land which was constructed as a berm wall in the 1970's to separate the original Mhlathuze Estuary into the Port of Richards Bay estuary in the north; and the Richards Bay Game Reserve and remaining Mhlathuze Estuary in the south. The South Dunes Precinct is bordered by the Port of Richards Bay to the west, the harbour mouth to the north, the Indian Ocean to the east, and the Indian Ocean and Richards Bay Game Reserve to the south. The South Dunes Precinct is used primarily for liquid chemical and petroleum storage facilities (DAERD, 2011). Current tenants include the Richards Bay Coal Terminal (RBCT), Island View Storage (IVS) (see Figure 1), Joint Bunker Services (JBS) (see Figure 2), and Transnet Rail Engineering (TRE).

Figure 1: Photo of the IVS Storage Facility in the Port of Richards Bay South Dunes Precinct.

Figure 2: Photo of the JBS Storage Facility in the Port of Richards Bay South Dunes Precinct.

RBCT constitutes the world's largest coal export terminal, with capacity to export 66.5 million tons of coal to the international market per year. RBCT exports coal derived from the Mpumalanga coalfields and can handle 3,000 84-ton coal wagons per day and fill an average of 700 ships per year (CSIR, 2002).

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IVS is a bulk liquid storage and handling facility which handles a wide range of liquefied gases and hazardous liquids; including propylene, butane, butadiene, ammonia, hexane, octane and acetone (CSIR, 2002).

JBS is a joint bunker service provider and provides storage of fuels for Caltex Oil (SA) (Pty) Ltd., Engen Petroleum Limited, BP Southern Africa (Pty) Ltd., Shell Oil South Africa (Pty) Ltd. and Total Oil South Africa (Pty) Ltd. (CSIR, 2002).

The South Dunes Precinct has a total of 8 berths. Berths 301 to 306 are coal berths which are used by RBCT, while Berths 208 and 209 are bulk liquid berths and are used by JBS and IVS. The eChwebeni Natural Heritage Site situated in the northern extent of the South Dunes Precinct adjacent to Berth 208 is a site of conservation significance and is managed by EKZNW. It consists of ecologically sensitive mangrove area and is one of few places in the country which contains *Rhizophora mucronata* (red mangrove), *Bruguiera gymnorrhiza* (black mangrove), and *Avicennia marina* (white mangrove) (Transnet, 2011).

Access to the South Dunes Precinct is obtained via Harbour Arterial Road, while Hardwick Road, Eleanor Road, Dune Road and Mundra Road provide additional access within the area. Railway lines including those used by RBCT and TRE are also present.

TNPA have made a total of 16 lease sites available in the South Dunes Precinct and is in the process of applying for EA from the National Department of Environmental Affairs (DEA) for the provision of services to the 16 lease sites (DEA Reference Number: 14/12/16/3/3/1/582). Proposed services include the construction of rail infrastructure, extension of road infrastructure, water reticulation, storm water channel and service culverts. TNPA initiated the EA process with the intention of improving infrastructure within the South Dunes Precinct prior to the establishment of terminal operations within the area (Geomeasure Group, 2013).

Vopak-Reatile have entered into a lease agreement with TNPA for Lots 4 and 5 of Portion 3 of Erf 11478 which occupy a combined land area of approximately 15.8 Ha (158,525 m^2). It is anticipated that the site will be adequate to accommodate the anticipated storage terminal of 300,000 m^3 and associated on-site infrastructure. The site will be developed in a phased manner with the initial phase providing approximately 36,000 m^3 of storage capacity, and further phases providing up to 264,000 m^3 additional storage capacity.

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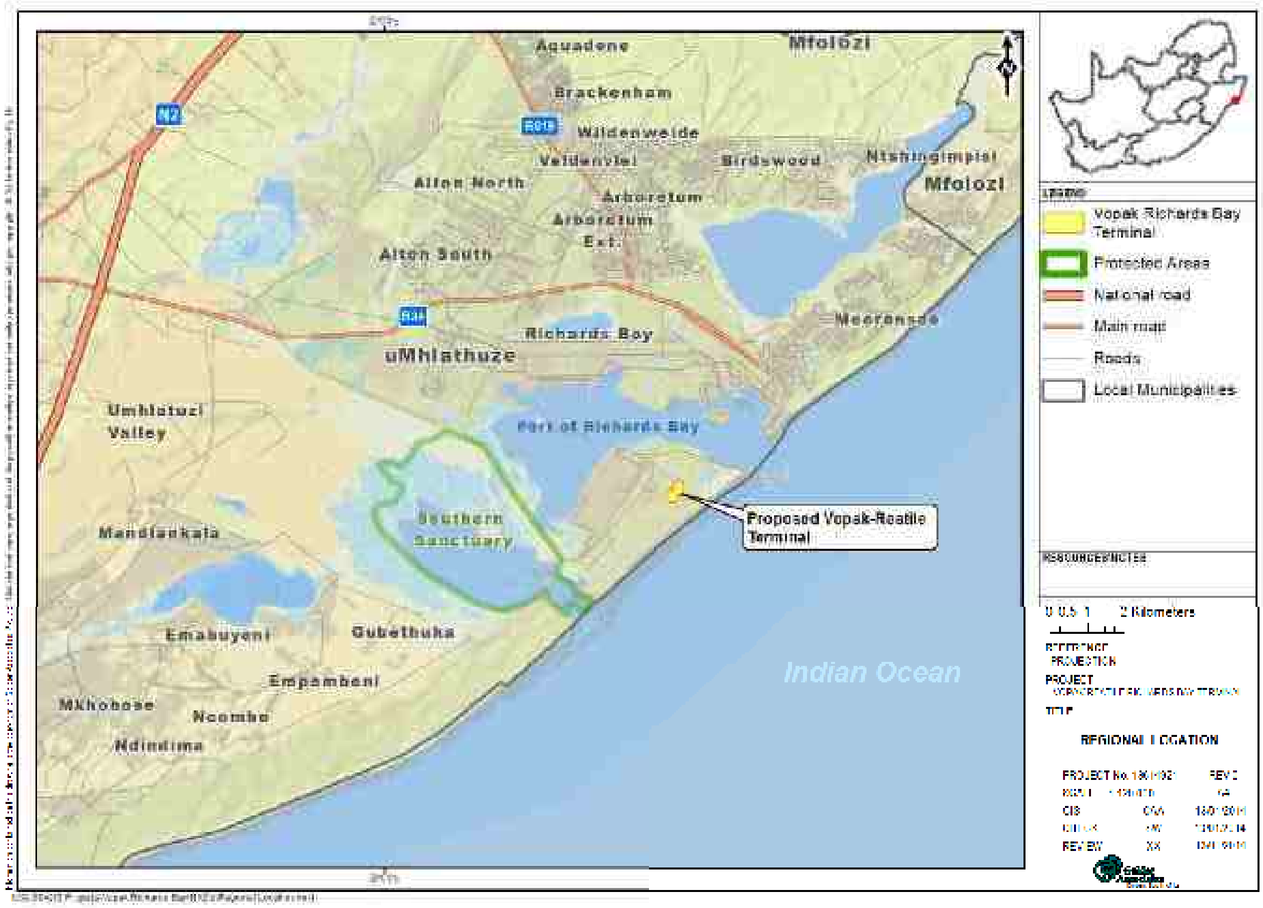

Figure 3: Regional view of the proposed Terminal Lease Sites.

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Figure 4: Local View of the Proposed Terminal Lease Sites.

2.2 Storage Capacity and Products

The proposed Terminal constitutes a greenfield site (i.e. the site has not been developed previously), and will be developed in phases. All phases form part of the scope of this EIA. Once completed, the total combined storage capacity would be approximately 300,000 m³. The proposed Terminal will comprise the following:

- An initial phase with a total storage capacity of approximately 36,000 m³; and
- Further phases with a total storage capacity of up to an additional 264,000 m³.

A list of products envisaged for storage at the proposed Terminal is provided in Table 6. The list provided is indicative with the quantity and type of products dependent on the requirements of VSAD's customers. The list provided in Table 6 is a worst case scenario regarding the quantity and hazard of the products stored, such that the impacts assessed within the specialist studies based on this list of products are conservative providing a high level of confidence that the impacts and risks associated with the CPP stored are likely to be less than those described.

Table 6: Proposed Products to be Stored at the Vopak-Reatile Terminal Richards Bay.

Product	Volume (mt/yr)	Logistics		Tank Size (m³)	Number of Tanks	Total Tankage (m³)
		Import	Export			
Acetone	7,000			1,500	1	1,500
Bitumen	80,000	✓		5,000	2	10,000
Bright stock	1,600	✓	✓	1,000	1	1,000
Butyl Acrylate	59,000			5,000	2	10,000
Caustic soda	216,000	✓	✓	20,000	2	40,000
DEA	414	✓		1,000	1	1,000
Diesel	120,000	✓		10,000	1	10,000
Ethanol	12,000		✓	1,500	1	1,500
Ethyl Acetate	5,000	✓	✓	1,000	1	1,000
Ethyl Acrylate	21,000		✓	1,500	1	1,500
Ethylol 95	10,000		✓	1,000	1	1,000
Ethylol 99	10,000		✓	1,000	1	1,000
Fuel Oil 360	320,000	✓		20,000	2	40,000
GAA(Glycol Acrylic Acid)	2,400		✓	1,000	1	1,000
Iso-Butanol	5,800		✓	1,000	1	1,000
LPG	100,000	✓		7,200	3	21,600
Lube SN150	3,200	✓		1,000	1	1,000
Lube SN500	4,800	✓		1,500	1	1,500
MEK	3,000		✓	1,000	1	1,000
MIBK	48,000		✓	5,000	2	10,000
N-Butanol	89,000		✓	5,000	2	10,000
N-paraffin	7,200		✓	1,000	1	1,000
Petrol	120,000	✓		10,000	1	10,000
PGI	3,576	✓		1,000	1	1,000
Sabutol	2,300		✓	1,000	1	1,000
Styrene	60,000	✓		5,000	1	5,000
Sulphuric Acid	240,000	✓	✓	20,000	3	60,000
TDI	3,422	✓		1,000	1	1,000

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Product	Volume (mt/yr)	Logistics		Tank Size (m^3)	Number of Tanks	Total Tankage (m^3)
		Import	Export			
TEA	2,892	✓		1,000	1	1,000
TEA (Commercial)	1,421	✓		1,000	1	1,000
Voralux 106	3,850	✓		1,000	1	1,000
Voralux HL 109	2,892	✓		1,000	1	1,000
Voranol 4701	856	✓		1,000	1	1,000
Voranol CP 6001	856	✓		1,000	1	1,000

2.3 Proposed Terminal Infrastructure

The following infrastructure is proposed for the proposed Terminal:

- Shipping liquid line;
- Marine loading arm;
- Road loading bays;
- Rail loading bays;
- Weighbridges for road and rail loading;
- Utilities; and
- Buildings, including;
  - An admin block;
  - Guard house;
  - Truckers rest building;
  - Workshop area;
  - LV and MV substation building;
  - Firewater pump house; and
  - Firefighting station building.

The storage tanks will be designed to appropriate local and international standards according to the latest versions of:

- SANS 10089-1:2008: ‘Storage and distribution of petroleum products in above-ground bulk installations’;
- Tank design Manual (Vopak International Standard);
- API 650: ‘Welded Steel Tanks for Oil Storage’; and
- EEMUA 190 Guide for the Design, Construction and Use of Mounded Horizontal Cylindrical Steel Vessels for Pressurised Storage of LPG at Ambient Temperatures.

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2.4 Proposed Terminal Layout

The indicative layout for the proposed Terminal is presented in Figure 5. The final internal layout of the proposed Terminal may change due to a number of reasons including the following: the findings from the specialist studies; comments raised during the stakeholder engagement process; engineering requirements; and/or site conditions established during the site clearance/construction phase. Although the exact location of the various tanks etc. may change, all of the necessary components have been included and due to the methodologies used for the specialist studies the exact locations within the proposed Terminal site of the various elements will not change the conclusions of the specialist studies and impact assessments.

Existing rail tracks utilised by RBCT border the site to the north, south and east. All new rail tracks / siding access constructed as part of the proposed Terminal will be located on the western side of the terminal, and will be spaced a minimum of 15 m from any construction. The provision of rail infrastructure to the proposed Terminal is the responsibility of TNPA and has been included in the scope of the BA currently being conducted on TNPA's behalf (DEA Reference Number: 14/12/16/3/3/1/582). Rail infrastructure proposed by TNPA will be constructed according to the S410 Specification for railway earthworks (2006) and the Geotechnical Service Handbook (1986). The design criterion is aimed at slow moving trains with 20 ton axle loads (Geomeasure Group, 2013).

The provision of road access to the proposed Terminal is also the responsibility of TNPA and has been included in the scope of TNPA's BA. Access currently exists to the boundary of the proposed Terminal via Mundra Road. TNPA propose extending Mundra Road by 1 km in length and 7 m in width to provide access to the site (Geomeasure Group, 2013). The proposed Terminal will have only one entrance for truck movement, which will be located in the north-western extent of the site. A second gate will be provided for safety purposes, and will function as an emergency exit only. Parking space for trucks will be provided inside the proposed Terminal facility.

Liquid shipping lines will be constructed from Berths 208 and 209 to the proposed Terminal. The construction of shipping liquid lines require a way-leave application be completed and submitted to TNPA for approval.

All buildings including the main office building and canteen, cabins, firefighting station, lab and control room and maintenance workshop will be located in the same vicinity in the northern extent of the proposed Terminal.

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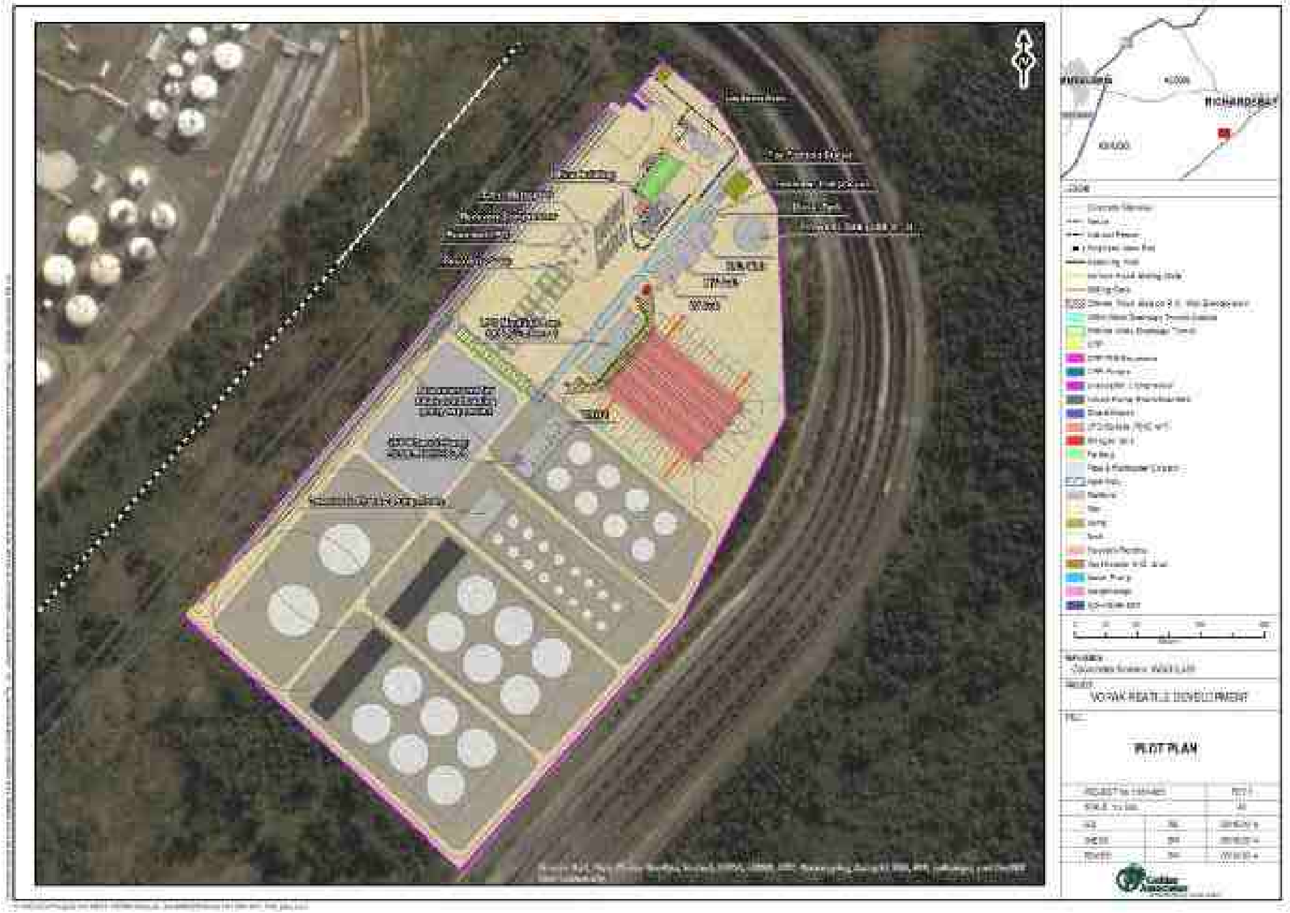

Figure 5: Plot Plan for the proposed Vopak-Reatile Terminal Richards Bay.

2.5 Activities and Operational Services

The following standard activities, operational services and functions are required and/or will take place at the proposed Terminal:

- Ship unloading of fuel (from ship to terminal tanks; and/or ship to railcar/truck tanks);
- Ship loading of fuel (from terminal tanks to ship);
- Railcar unloading of fuel (from railcar to terminal tanks);
- Railcar loading of fuel (from terminal tanks to railcar);
- Truck unloading of fuel (from truck to terminal tanks);
- Truck loading of fuel (from terminal tanks to truck);
- Internal tank-to-tank transfer;
- Tank measurement on site;
- Tank water draining activities/services;
- Tank cleaning and emptying activities/services;
- Separate line pigging, cleaning and purging;
- Full firefighting facility;
- Jetty and loading bay occupation;
- Parking of vehicles at loading bay; and
- Petrol vapour treatment.

2.6 Construction Activities

2.6.1 Construction

Construction activities will include building new tanks, constructing manifolds, liquid shipping lines, road and rail loading bays, all the utilities, offices, and associated infrastructure. During the construction phase a temporary warehouse will be built to store the construction equipment required. Since this is a new plot, it will be ensured that enough space is allocated in the plot plan, for additional pipe racks, extensions to structures, changes in operation, automation and maintenance philosophies.

Raw materials required during construction include sand, mixed concrete, steel plates, steel rods, steel beams and steel pipes. Water required to meet the construction water demands will be sourced from the uMhlathuze Municipality or the local Water Service Provider, Mhlathuze Water. Additional electricity will be produced by diesel generators. Mechanical and electronic equipment required during the construction phase will include cranes, trucks, earth-moving equipment, welding machines, diesel generators and compactors.

Local contractors will be sourced for the construction phase employment requirements.

The initial phases of development include site preparation, construction and then terminal commissioning and start-up.

These activities can be broken down as follows:

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Site Preparation:

Site clearing and preparation activities include the removal of vegetation and relocation of sensitive species where necessary; the removal and stockpiling of the first layer of soil; cutting and filling of soil together with replacing of soil as required; levelling to the required elevations; and setting-up of construction facilities such as construction camp and site offices. All site clearing activities will be conducted in accordance with SANS 2001-BS1: Site Clearance.

Vegetation clearing as part of site clearing will be kept to a minimum. Trees and bushes (complete with roots), other vegetation, and all other material that might interfere with the construction of the works will be removed and disposed of. Invasive alien vegetation will be removed, and any plant bulbs found within disturbed ground will be conserved for replanting in landscaped areas. All litter, building rubble, rocks and/or boulders that may be present on site or exposed during site clearing operations will be cleared and removed from site. All organic matter arising from site clearing will be transported off site to a licensed landfill facility. No material will be burned or buried on the site.

Re-usable materials including topsoil and material identified as suitable for bulk backfill and structural compacted fill will be removed and stacked for later use. Topsoil will be conserved and will be carefully removed and stored for future landscaping use, as well as future use over the LPG bullet mounds. Topsoil will be stacked near the area from which it is removed in a manner that will not cause obstructions during subsequent site works. Beach sand which occurs on site has been determined as being suitable for bulk backfill and engineered fill layers. This sand will also be used for the future earth mounds to be built around the LPG bullets.

In the event that any hardened areas are encountered on site, these will be scarified, loosened and broken up by ripping or excavation to a depth of 300 mm.

Construction:

Construction activities include the following:

1) General civil works;
2) Structural and mechanical erection of facilities;
3) Piping fabrication and installation;
4) Electrical installations;
5) Instrumentation installations;
6) Painting and insulation; and
7) Pre-commissioning.

Completion and Commissioning:

Completion and commissioning activities include:

1) Completion of warehouse, maintenance workshop and control room;
2) Completion of main office, administration building, changing room, fire station and medical station;
3) Completion of operator cabins, traffic office including waiting room for truck drivers and car park shed;
4) Completion of fire water pump house and power generator building; and
5) Commissioning of utilities and electrical substations.

Start-up

Start-up is a result of commissioning of all of the above and occurs as a result of successful commissioning.

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2.7 Operational Activities

2.7.1 Pipelines

Product pipelines will be used to transport CPP products and LPG between the Berths 208 and 209 and the proposed Terminal. Dedicated pipelines will be provided for LPG, while the remaining pipelines would transport a variety of products. It is anticipated that pipelines will operate with an operating pressure of 10 bar and will have a maximum flow rate of 1,000 m^3/h for LPG and 1,200 m^3/h for CPP products. Product pipelines will run above-ground on pipe racks. Space will be reserved on the pipe racks for future pipelines. Both liquid and vapour pipelines will be provided for shipping operations. All road and rail loading and unloading lines will generally stay full of liquid. Loading lines will only be emptied for maintenance purposes. Thermal relief valves will protect the pipes against overpressure due to solar heating.

2.7.2 Manifolds and Pumps

Dedicated LPG road tanker, railcar tank loading, ship loading, and tank-to-tank transfer loading pumps will be installed. The pump capacity will be 250 m^3/h with a maximum operating pressure of 10 bar. All tanks will be connected to one line that will lead to the various loading pumps. Each storage tank will therefore have a pump inlet line to the pump manifold.

The following pumps will be installed:

- Pumps for terminal tanks to rail loading;
- Pumps for terminal tanks to road loading;
- Pumps for terminal tanks to ship loading; and
- Pumps for tank to tank transfer.

The following pumps will also be installed for vapour return:

- Pump from railcar tanks to vapour return tank
- Pump from tank for stench LPG; and
- Small pump from vapour recovery tank to a road tanker (to allow for vapour return to be removed from site).

2.7.3 Ship Loading and Unloading

LPG products will be imported via ship with provision made for loading into road and rail tankers as well as small ships. Liquid shipping lines will be installed to load product from terminal tanks to ships via Berths 208 and 209, and to unload product from ships to terminal tanks. After each grade of product is discharged from the ship, berth lines will be blown through with vapour to remove any liquid residue.

2.7.4 Road and Rail Loading and Unloading

Various combinations and sizes of trucks will be loaded. These could be single trucks or 17 ton isotainers. All trucks will have bottom loading connections, and road isotainer transport equipment will be equipped with standardized manifolds at the back side of the truck. The road loading bays will be equipped with loading arms for bottom loading and a vapour connection to collect product vapours.

Railcar tanks will have top loading connections. The rail loading bays will be equipped with loading arms, which will enable the connection of both product and vapour lines in one handling.

Road and rail loading bays will be fully automated for loading LPG. The loading rate at the road and rail loading bays will be limited to 80 m^3/h. The proposed Terminal will have a single weighbridge at the entrance for checking laden and unladen LPG road tanker weights, and a rail weigh bridge will be installed for custodial use.

A vapour recovery vessel will be used to collect liquefied stenched LPG vapours.

2.7.5 Waste and Wastewater Treatment

The products handled at the proposed Terminal may contain a range of hazardous and non-hazardous substances with differing risk profiles. VSAD govern and manage the waste that they generate according to internal best practice procedures and relevant waste management legislation, including the National Environmental Management: Waste Act (Act No. 59 of 2008) (NEM:WA) with associated schedules and/or norms and standards including the Minimum Requirements for Waste Disposal, as set by the then Department of Water Affairs and Forestry (DWAF, 1998). VSAD applies the principles of reducing, re-using and recycling wastes wherever possible following which VSAD will ensure that all waste generated at the proposed Terminal is disposed of safely via an appropriately authorised facility. All certificates of cleanliness and safe disposal will be kept on file.

Rainwater recovered by drain from the road loading area and internal roads will be collected, passed through an oil/water separator, and collected in a sump before being treated or released. The sump may also include soiled water from septic tanks.

2.7.5.1 Storm Water and Waste Water

Wastewater or spills may be generated from the operational (pump and manifold) and loading areas. While LPG is not classified as a pollutant, and spills and releases of LPG will eventually evaporate, the associated risk pertains to Vapour Cloud Explosion (VCE) or Pool Fire. Released LPG vapours can travel downhill or be blown by wind. LPG may therefore accumulate in unprotected drains which can then transmit LPG away from safe zones to hazardous areas. Any drains that could come into contact with LPG will be protected with water traps to prevent the accumulation of LPG.

Water/spills from the loading area will be collected in a collection pit/separator. Clean water can be discharged, while polluted water will be treated.

2.8 Health, Safety and Environment (HSE) Controls

VSAD's international standards and local legislation on Health, Safety and Environment (HSE) will be used to guide the design and operational philosophy of the proposed Terminal. Examples of how this philosophy is applied during design include:

- Storage vessels for liquids (as in accordance with NEM:AQA):

True vapour pressure of contents at storage temperature	**Type of tank or vessel**
Up to 14 kPa	Fixed roof tank vented to atmosphere
Above 14 kPa up to 91 kPa	External floating roof tank with primary and secondary rim seals for tank diameter larger than 20 m, or fixed roof tank with internal floating deck fitted with primary seal, or fixed roof tank with vapour recovery system.
Above 91 kPa	Pressure vessel

- Petrol tanks will be equipped with Internal Floating Roof (IFR);
- Liquid products with vapour pressure above 14 kPa will be loaded/unloaded using bottom loading;

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- Vapours expelled during loading operations will be returned to the loading tank where they will be stored prior to vapour recovery;
- For road and rail loading - vapour recovery/treatment units will be installed;
- Liquid tight floors with tank leak detection at all tanks;
- All tanks to be mounded to prevent any fires;
- Overfill protection with high level switches with independent emergency valves shut-off at all tanks;
- Emergency shut-down systems;
- Secondary containment;
  - Slop tanks will be provided for on-site wastewater/liquid waste.
- Communications and Alarms;
  - General fire alarms;
  - Automatically triggered alarm (e.g. by fire sensors); and
  - General evacuation alarm.
- Oil and water separator and waste water treatment; and
- Firefighting infrastructure and emergency equipment as required. Including the provision of fire water tanks.

2.9 Development Sequence

The phases include the installation of storage tanks, manifolds, road and rail loading bays and pipelines, and ship lines.

The initial phase will include all the utilities, offices, storage and support infrastructure (i.e. firefighting station, workshops etc.) required to accommodate all phases.

Further phases will include the construction of additional storage tanks and road and rail loading bays. Since this is a new plot, during engineering for the initial phase, it will be ensured that enough space is kept for additional pipe racks, extensions to structures, changes in operation, automation and maintenance philosophies.

2.10 Project Alternatives

VSAD has considered alternative layout design, product groupings as well as tank design options to international standards.

2.10.1 Alternative Land Options

It is critical that the proposed Terminal site be located in close proximity to a point of import/export, transportation infrastructure, and within close enough proximity to primary users in the Gauteng and KwaZulu-Natal regions. The proposed Terminal site is situated in the South Dunes Precinct of the Port of Richards Bay, as this was the only suitable land available within the Port of Richards Bay and within proximity of the liquid fuel berths, Berth 208 and 209.

In terms of the Environmental Management Framework (EMF) for the Richards Bay Port Expansion Area and Industrial Development Zone (2011) the dune cordon area is primarily used for port related and various liquid chemical and petroleum storage facilitates. The area has been earmarked to advance port-related

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developments, and is under strict manangement control due to the hazardous nature of current and proposed facilities (EMF, 2011). Furthermore, access to the area is restricted which presents opportunities for the establishment of high secure facilities such as the proposed Terminal.

The proposed Terminal site was identified as being the most feasible for the establishment of a bulk liquid storage and handling facility. The Port of Durban is the only other Port with the appropriate infrastructure situated within close enough proximity of primary users in the Gauteng and KwaZulu-Natal regions. The development of a new bulk liquid storage facility at the Port of Durban is restricted due to the limited space available within the Port. The Port of Durban is also heavily congested as a result of previous poor planning.

The South Dunes Precinct has been identified by TNPA in its Port Development Framework as future terminals/lease sites specifically for liquid and dry bulk. The area is therefore planned for future development in terms of TNPA's future port expansion areas. The development of the South Dunes Precinct for bulk liquid terminals is also reflected in the Environmental Management Framework (EMF) Report for the Richards Bay Port Expansion Area and Industrial Development Zone (2011) which was developed as a joint initiative between the National DEA, the KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development (DAERD), and the City of uMhlathuze.

In terms of development priorities, and given the degree of transformation in the area, the EMF report makes the recommendation that the area be used to advance port-related development. Furthermore the EMF report also states that the area could also be considered as a potential exclusion zone, meaning that specified activities may be excluded from environmental authorisation subject to prescribed norms and standards (EMF Desired State of Environment Report: Thornhill and van Vuuren, 2009).

Environmental Management guidelines identified in terms of development priorities for the area state that:

> *The interest of the port and industrial development must be advanced in the central dune area by:*
>
> - *Encouraging activities that are directly related and dependent on the port;*
> - *Encouraging activities that are compatible with the prevailing land use activities such as chemical and fuel storage activities; and*
> - *Implementing measures to avoid visual impacts such as buffers, appropriate construction and design layout, and directional lighting.*

The implementation of the proposed Terminal within the South Dunes Precinct of the Port of Richards Bay is therefore aligned with TNPA and Departmental planning and development frameworks, as well as in terms of TNPA's proposed port expansion plans. As a result this is the only locatin assessed for impacts associated with the proposed development.

2.10.2 Alternative Layout Design Options

The site layout plan provided by VSAD is preliminary in nature and will be optimized based on the findings from the specialist studies; comments during the stakeholder engagement process; engineering requirements; site conditions established during the site clearance/ construction phase.

2.10.3 Alternative Tank Design Options

Tanks planned for the proposed Terminal, will be in accordance with relevant international best practice guidelines and all other applicable legislation. The final tank designs will therefore be confirmed during the final layout design process.

2.10.4 The "No-Project" Alternative

The "no-project" alternative would result in the current status quo regarding limited provision of strategic bulk storage and handling facilities remaining unchanged. As a result consumers are likely to be faced with shortages and possible interruptions in supply amidst increasing demand. As demand increases additional

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pressure is placed on existing facilities and infrastructure such as loading facilities, storage tanks and handling facilities; which can result in negative implications for the provision of such services. The proposed Terminal will result in the provision of strategic bulk liquid storage capacity for LPG, Chemicals and CPP products within close proximity of major consumers, and will also present additional opportunities for the import and export of product. Both imports and exports present economic benefits in the form of taxation for imports, and revenue generation for exports.

There are a number of benefits associated with the proposed Terminal. The following benefits can cause negative economic impacts should the proposed Terminal not proceed.

2.10.4.1 Improved Bulk Liquid Supply and Distribution

The construction of the proposed Terminal would provide for the import and distribution of bulk liquids including LPG, CPP and Chemicals within close proximity of major consumer regions such as Gauteng and KwaZulu-Natal. The lack of land available at the Port of Durban, and Richards Bay's position within close proximity to the consuming markets justifies the need for an additional Terminal and point of import/export at the Port of Richards Bay. The proposed Terminal is therefore required to ensure surety of supply of LPG, CPP and Chemical products to consumers.

The proposed Terminal will also be aligned with the Department of Energy's (DoE's) 20-Year Liquid Fuels Infrastructure Plan which is in the process of being developed. The infrastructure plan is intended to provide a framework for ensuring security of supply of liquid fuels in the short, medium and long term; and will also assist in determining the capabilities and capacity for local refining, storage, handling and logistics.

2.10.4.2 Business Opportunities

The need for strategic storage has been identified as a key motivating factor for the proposed Terminal. As demand for bulk liquid products continue to increase the market will be faced by shortages of supply which has negative implications for the economy. Similarly there will be limited opportunity for South Africa to grow and develop its bulk liquid fuels markets. There will also be no opportunity for additional export capacity via the proposed Terminal and the Port of Richards Bay, or for potential newcomers to enter the bulk liquid fuels market.

2.10.4.3 Job Creation

The proposed Terminal would have a beneficial impact on the regional economy through the creation of new employment opportunities during the construction phase of development.

Both skilled and unskilled employment opportunities would be created through the proposed Terminal. In a developing country such as South Africa, following a "no-project" option would have potential adverse impacts on a local and regional employment scale.

2.11 Need and Desirability

The need and desirability of the proposed Terminal can be assessed against the DEA's Draft Guideline on Need and Desirability in terms of the NEMA EIA Regulations (GNR 543) published in Government Gazette No. 35746 on 5 October 2012.

The Guidelines indicate that while the concept of need and desirability relates to the *type* of development being proposed, need and desirability can be explained in terms of the general meaning of its two components where "need" refers to "time", and "desirability" to "place". The need and desirability of a development therefore needs to consider whether it is the right time and right place for locating the type of land-use/activity being proposed. Need and desirability is therefore equated to the wise use of land, and should be able to answer the question of what the most sustainable use of land is.

According to the DEA's Draft Guidelines the need and desirability of an application must be addressed separately and in detail by answering, inter alia, the following questions:

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NEED (“timing”):

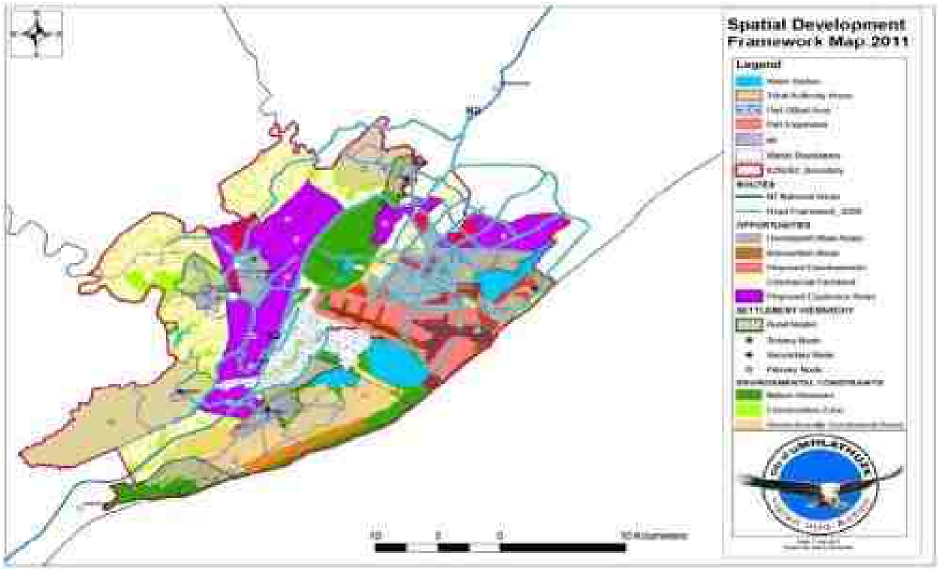
Question 1:	**Is the land use (associated with the activity being applied for) considered within the timeframe intended by the existing approved Spatial Development Framework (SDF) agreed to by the relevant environmental authority (i.e. is the proposed development in line with the projects and programmes identified as priorities within the credible IDP?).**
Answer:	Yes
Explanation:	The Spatial Development Framework Map: 2011 compiled as part of the Draft Review of the uMhlathuze SDF and contained in the City of uMhlathuze’s Integrated Development Plan (IDP) 2012/2017 identified the South Dunes Precinct as an area of Opportunities for Proposed Developments (see Figure 6). The compilation of the uMhlathuze SDF Draft Review was informed by a range of information sources including the TNPA’s Port Master Plan.  *Figure 6: Draft Review of the uMhlathuze Spatial Development Framework (SDF).* In terms of the development timeframe, Lots 4 and 5 are reflected in the current layout of the Port of Richards Bay provided in TNPA’s Port Development Framework Plans 2014 (see Figure 7), while Lots 2 and 3 and the remaining South Dunes Lease Sites are only reflected TNPA’s medium term (2042) and long term layouts (see Figure 9 and Figure 10).

Figure 7: Port of Richards Bay Current Layout (2013).

Figure 8: Port of Richards Bay Short-Term Layout (2019).

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Figure 9: Port of Richards Bay Medium-Term Layout (2042).

Figure 10: Port of Richards Bay Long-Term Layout.

The development of the proposed Terminal is therefore aligned with the current planning framework of the SDF and is intended for at this point in time.

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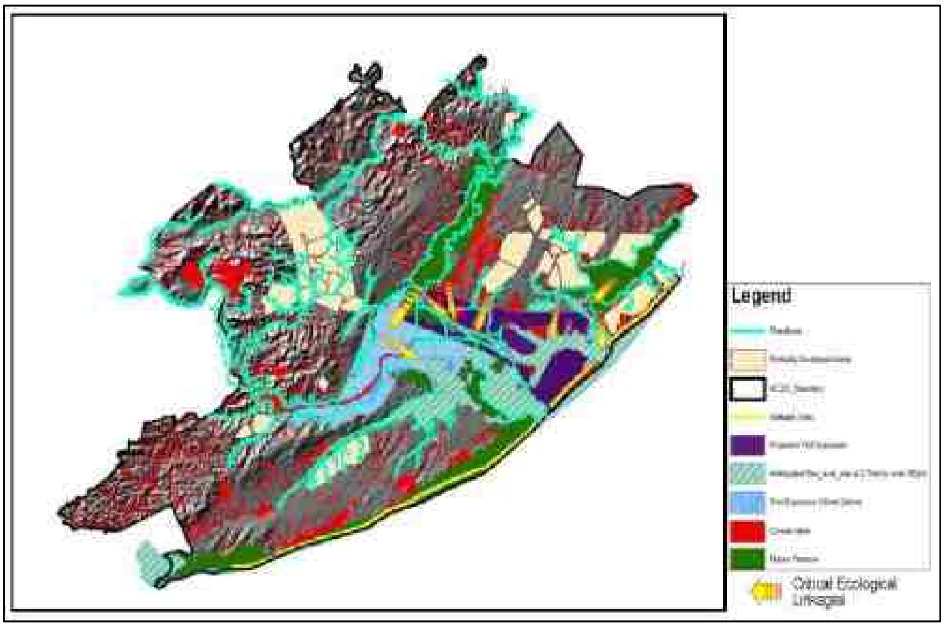
Question 2:	**Should development, or if applicable, expansion of the town/area concerned in terms of this land use (associated with the activity being applied for) occur here at this point in time?**
Answer:	Yes
Explanation:	The proposed Terminal is proposed in the South Dunes Precinct of the Port of Richards Bay. The South Dunes Precinct has been identified in the Environmental Management Framework (EMF) for the Richards Bay Port Expansion Area and Industrial Development Zone (2011) as a proposed Port Expansion area. The composite map compiled as a result of the EMF was subsequently used to inform the Draft Review of the uMhlathuze SDF and compilation of the uMhlathuze Spatial Development Framework Map: 2011 (see Figure 11).  *Figure 11: EMF Composite Map.* The implementation of the proposed Terminal would allow for the development of designated port land within an area which has been identified specifically as a Port Expansion Area. The proposed Terminal would not result in an expansion of the Port of Richards Bay, but would allow for optimal use to be made of port land which has been zoned for industrial use.

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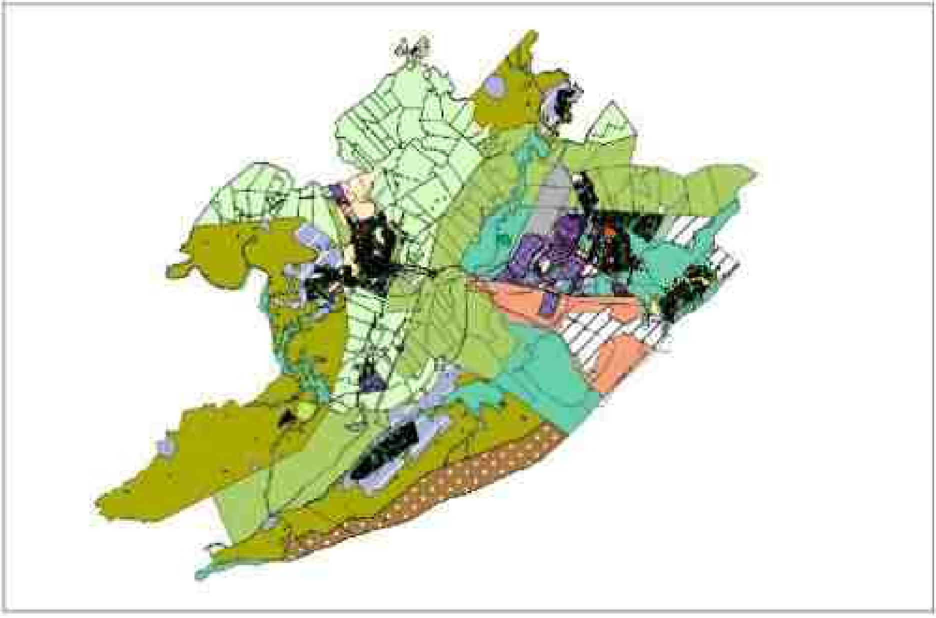

Figure 12: uMhlathuze Land Use Scheme.

The uMhlathuze Land Use Scheme was developed as part of the Municipality's Land Use Management System (LUMS) and came into effect on 7 January 2014. In terms of the uMhlathuze Land Use Scheme the project area is situated within the Harbour Use Zone. The Statement of Intent of this Zone is the provision of land for harbour purposes managed in terms of legislation related to the National Ports Authority. Harbours may include land for administrative purposes, customs, industrial uses, and areas for bulk storage, terminals, custom posts, limited commercial activity, social, health and recreational activities for employees. The proposed development of a bulk liquid storage terminal within the South Dunes Precinct is therefore in accordance with the "Harbour Zone" LUMS.

Question 3:	**Does the community/area need the activity and the associated land use concerned (is it a societal priority)? This refers to the strategic as well as local level (e.g. development is a national priority, but within a specific local context it could be inappropriate).**
Answer:	Yes
Explanation:	The proposed Terminal is proposed on Lots 4 and 5 of the Port of Richards Bay. The sites have an industrial land use zoning and have been identified by TNPA in its Port Planning Framework as future terminal sites. The proposed Terminal is therefore aligned with the existing zoning and proposed future land use.

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Question 4:	**Are the necessary services with adequate capacity currently available (at the time of application), or must additional capacity be created to cater for the development?**
Answer:	No
Explanation:	TNPA has applied for EA from the National DEA for the provision of services to the South Dunes Lease Sites (DEA Reference No.: 14/12/16/3/3/1/582). Services proposed by TNPA include the construction of rail infrastructure, extension of road infrastructure, water reticulation, storm water channel and service culverts (see Figure 13). The purpose of the development is to allow an efficient storm water management system, and improve access and service delivery to the sixteen South Dunes Lease Sites. TNPA has undertaken to improve infrastructure within the area prior to the establishment of actual terminal operations.  *Figure 13: Site Plan for proposed Transnet Service Infrastructure (Source: Geomeasure Group, 2013).*

Question 5:	**Is this development provided for in the infrastructure planning of the municipality, and if not what will the implication be on the infrastructure planning of the municipality (priority and placement of services and opportunity costs)?**
Answer:	No
Explanation:	The proposed Terminal will have no impact on the City of uMhlathuze's infrastructure planning. In addition, TNPA has applied for an EA from the National DEA for the provision of services including the construction of rail infrastructure, extension of the road infrastructure, water reticulation, storm water channel and service culverts to the South

	Dunes Lease Sites (DEA Reference No.: 14/12/16/3/3/1/582).

Question 6:	**Is this project part of a national programme to address an issue of national concern or importance?**
Answer:	No
Explanation:	The development of the proposed Terminal would provide strategic bulk liquid fuel storage and handling. The proposed Terminal would allow for the import and export of product which would assist in strengthening the local market, and ensuring surety of supply while reducing shortages or interruptions.

DESIRABILITY (“placing”):

Question 1:	**Is the development the best practicable environmental option for this land/site?**
Answer:	Yes
Explanation:	The proposed Terminal is on land which has been zoned for industrial use and port related development. The site comprises land which has been highly developed and practically all ecosystems have been transformed and severely degraded as a result of past disturbances. These include the relocation of surface soils due to infrastructure development; the removal of primary vegetation, and alien invasive plant species transforming available habitats on site. The implementation of a suitable Environmental Management Programme (EMP) as part of the proposed Terminal would therefore provide for the proper protection and management of any species of special concern which may exist on site, while also providing for the removal and control of alien invasive vegetation.

Question 2:	**Would the approval of this application compromise the integrity of the existing approved and credible municipal IDP and SDF as agreed to by the relevant authorities?**
Answer:	No
Explanation:	The proposed Terminal is proposed in accordance with the City of uMhlathuze’s Integrated Development Plan (IDP) 2012/2017 and Draft Review of the uMhlathuze SDF. The IDP and SDF identified the project area as an area of Opportunities for Proposed Developments.

Question 3:	**Would the approval of this application compromise the integrity of the existing environmental management priorities for the area (e.g. as defined in EMFs), and if so, can it be justified in terms of sustainability considerations?**
Answer:	No
Explanation:	The EMF for the Richards Bay Port Expansion Area and Industrial Development Zone (2011) identified the South Dunes Lease sites as Zone 4: Dune Cordon (see Figure 14).

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Figure 14: Dune Cordon.

In terms of the EMF the central dune cordon is primarily used for port related and various liquid chemical and petroleum storage facilitates. The EMF further states that the only opportunity for development within the dune cordon is in the central dune area where access is restricted, and this presents opportunities for the establishment of highly secure facilities.

In terms of the Desired State of Environment presented in the EMF, given the degree of transformation the central dune area must be used to advance port-related development.

Furthermore Management Guidelines for Development Priorities in the Dune Cordon, state that the interest of the port and industrial development must be advanced in the central dune area by:

- Encouraging activities that are directly related and dependent on the port;
- Encouraging activities that are compatible with the prevailing land use activities such as chemical and fuel storage activities; and
- Implementing measures to avoid visual impacts such as buffers, appropriate construction and design layout, and directional lighting.

The proposed Terminal is therefore aligned with the EMF. Furthermore, approval of the proposed Terminal would not compromise the integrity of existing environmental management priorities for the area as defined in the EMF for the Richards Bay Port Expansion Area and Industrial Development Zone (2011).

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Question 4:	**Do location factors favour this land use (associated with the activity applied for) at this place (this relates to the contextualisation of the proposed land use on this site within its broader context).**
Answer:	Yes
Explanation:	The project site for the proposed Terminal is situated on port land and has an industrial land use zoning. The site has been identified for future terminal sites given their location within the Port and access to import and export facilities and supporting infrastructure. Furthermore the development of the site is supported by the City of uMhlathuze's Municipal IDP, SDF and EMF. The site is situated within proximity of the liquid berths (Berth 208 and 209) through which product will be imported and exported (see Figure 15). The berths have direct road access, while EA for the provision of additional services in the form of rail infrastructure, an extension of road infrastructure, water reticulation, storm water channel and service culverts is being applied for by TNPA (DEA Reference Number: 14/12/16/3/3/1/582). The proposed Terminal is therefore strongly favoured by location factors.  *Figure 15: Location of Liquid Berths in relation to the project site.*

Question 5:	**How will the activity or the land use associated with the activity applied for, impact on sensitive natural and cultural areas (built and rural/natural environment)?**
Answer:	The proposed Terminal will not impact on any sensitive natural and/or cultural areas. The impacts associated with the development of the proposed Terminal will be confined to occurring onsite. The construction and operation of the proposed Terminal will be managed in strict accordance with the projects EMP as well as with TNPA's applicable Environmental Management Programmes and Frameworks. Nearby sensitive areas such

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	as the eChwebeni Natural Heritage Site situated north-west of the project site and the Richards Bay Game Reserve and Estuary situated south-west of the project site will therefore not be impacted on. TNPA as part of its port planning has identified areas of open space within the Port environment (see Figure 7 to Figure 10) for the purpose of protecting sensitive habitats and environmental features. In the South Dunes Precinct the open space area includes dune habitat and coastal vegetation which are situated on the seaward side of TRE's railway line. Areas situated within the railway loop generally comprise disturbed habitats which are fragmented as a result of the raised railway line which forms a barrier between habitats.

Question 6:	**How will the development impact on people's health and wellbeing (e.g. in terms of noise, odours, visual character and sense of place, etc.)?**
Answer:	The proposed development will have minimal impact on people's health and wellbeing. **Noise:** The construction and operation of the proposed Terminal would result in an increase in ambient noise levels. However, the Terminal is proposed within an access controlled Port environment, and is therefore located away from potential sensitive receptors. The proposed Terminal will therefore not impact on the general public or any residential areas. **Odours:** The construction and operation of the proposed Terminal may result in an increase in some odour emissions. These will however be minimal and will be localised to the project site which is located away from any sensitive receptors. **Visual Character:** The visual character of the project site would be altered as a result of the proposed Terminal. However given the projects location within an access controlled Port environment, away from any residential areas or public spaces the change in visual character is not likely to impact on people's health and/or wellbeing. **Sense of Place:** The proposed Terminal would result in a change in the sense of place of the site. However this would occur within a Port environment which has been earmarked for future development. The impact of the proposed project on the areas sense of place is therefore expected to be minimal.

Question 7:	**Will the proposed activity or the land use associated with the activity applied for, result in unacceptable opportunity costs?**
Answer:	No
Explanation:	The area has been specifically identified for the future development and expansion of the Port of Richards Bay and more specifically for the implementation of dry bulk and liquid terminals.

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Question 8:	**Will the proposed land use result in unacceptable cumulative impacts?**
Answer:	No
Explanation:	The proposed Terminal is proposed in an area which has been earmarked for bulk liquid storage terminals. Existing bulk liquid storage facilities within the South Dunes Precinct include the JBS and IVS facilities. Potential cumulative impacts associated with the proposed Terminal have been addressed in the specialist studies where applicable, and are reported on in Section 6.0 of this DEIAR.

3.0 LEGAL DESCRIPTION AND OTHER REQUIREMENTS

This section summarises the policy, legal, and administrative framework within which the EIA, WUL and AEL will be carried out. This includes a summary of relevant South African regulations as well as VSAD's Health, Safety and Environment (HSE) policy. In addition, this section introduces the regulatory authorities responsible for reviewing this DEIAR.

3.1 Regulatory Framework

3.1.1 National Environmental Management Act (Act No. 107 of 1998) (NEMA)

The National Environmental Management Act (Act No. 107 of 1998) (NEMA) contains a set of principles that govern environmental management and against which environmental impact assessment and all environmental management plans and actions are measured. These principles include sustainable development, protection of the natural environment, waste minimisation, public consultation, and the right to a clean and healthy environment and a general duty of care.

The EIA Regulations of 18 June 2010 (GNR 543) promulgated under Section 24 of NEMA specify two broad categories for undertaking an EA process for an activity, namely a BA (as described in Regulations 21 to 25 of GNR 543) or a full Scoping and Environmental Impact Assessment (S&EIA) process (as described in Regulations 26 to 35 of GNR 543). Projects which trigger activities identified in Listing Notice 1 (GNR 544) and Listing Notice 3 (GNR 546) require EA subject to a BA process, while projects which trigger any activities identified in Listing Notice 2 (GNR 545) require EA subject to a full S&EIA process.

Listed activities associated with the proposed Terminal for which EA is being applied for are listed in Table 7 below.

Table 7: Project related activities listed in terms of GNR 544, 545 and 546.

The number and date of the relevant notice:	**Activity Number**	**Description of the listed activity**
GNR 544 of 18 June 2010 (Listing Notice 1)	18	The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock from (i) a watercourse; but excluding where such infilling, depositing, dredging, excavation, removal or moving (a) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority;

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The number and date of the relevant notice:	Activity Number	Description of the listed activity
		or (b) occurs behind the development setback line. **Applicability to the project:** A “watercourse” as defined by the NEMA EIA Regulations Listing Notice 1 of 18 June 2010 (GNR 544) is defined as “a river or spring; a natural channel or depression in which water flows regularly or intermittently; a wetland, lake or dam into which, or from which, water flows; any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse as defined in the National Water Act, 1998 (Act No. 36 of 1998) and a reference to a watercourse includes, where relevant, its bed and banks.” While a “wetland” is defined as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports, or would support vegetation typically adapted to life in saturated soil.” The proposed Terminal has the potential to result in the infilling, depositing or moving of more than 5 m³ of material into and/or from a watercourse.
GNR 545 of 18 June 2010 (Listing Notice 2)	3	The construction of facilities or infrastructure for the storage, or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of more than 500 m³. **Applicability to the project:** The proposed Terminal will result in the construction of storage tanks with a combined capacity of approximately 300,000 m³ for the storage of dangerous goods including LPG, and a mixture of CPP and Chemicals.
GNR 545 of 18 June 2010 (Listing Notice 2)	5	The construction of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case that Act will apply. **Applicability to the project:** The proposed Terminal requires an AEL in accordance with NEM:AQA (Act No. 39 of 2004) for the release of emissions into the atmosphere.
GNR 545 of 18 June 2010 (Listing Notice 2)	26	Commencing of an activity, which requires an atmospheric emission license in terms of section 21 of the National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004). **Applicability to the project:** The proposed Terminal requires an AEL in accordance with Section 21 of NEM:AQA (Act No. 39 of 2004) for the release of emissions into the

The number and date of the relevant notice:	Activity Number	Description of the listed activity
		atmosphere.
GNR 546 of 18 June 2010 (Listing Notice 3)	13	The clearance of an area of 1 hectare or more of vegetation where 75% or more of the vegetative cover constitutes indigenous vegetation, except where such removal of vegetation is required for (1) the undertaking of a process or activity included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), in which case the activity is regarded to be excluded from this list. (2) the undertaking of a linear activity falling below the Thresholds mentioned in Listing Notice 1 in terms of GN No. 544 of 2010 (c) In Eastern Cape, Free State, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape and Western Cape: (iii) In urban areas, the following: (cc) Areas seaward of the development setback line; (dd) Areas on the watercourse side of the development setback line or within 100 metres from the edge of a watercourse where no such setback line has been determined **Applicability to the project:** “Indigenous vegetation” as defined by the NEMA EIA Regulations Listing Notice 3 of 18 June 2010 (GNR 546) refers to “vegetation consisting of indigenous plant species occurring naturally in an area, regardless of the level of alien infestation and where the topsoil has not been lawfully disturbed during the preceding ten years.” The development of the proposed Terminal can be expected to result in the clearance of an area greater than 1 Ha of vegetation which in some instances would occur within 100 m of the edge of a watercourse.

Whereas activities listed in GNR 544 (Listing Notice 1) and GNR 546 (Listing Notice 3) were originally applied for under a separate BA process (KZN DEDTEA Reference Number: DC28/0004/2014 KZN/EIA/0001439/2014), these have now been reintegrated into the current consolidated EIA process (KZN DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014).

3.1.1.1 Public Participation (PP) Process

The principles that determine communication with society at large are included in the principles of NEMA and are elaborated upon in General Notice 657, titled *“Guideline 4: Public Participation”* (Department of Environmental Affairs and Tourism, 19 May, 2006), which states that:

“Public participation process means a process in which potential I&APs are given an opportunity to comment on, or raise issues relevant to, specific matters”.

PP is an essential and regulatory requirement for any EA process, and must be undertaken in terms of Regulations 54 to 57 of the NEMA EIA Regulations (GNR 543). PP is a process that is intended to lead to a joint effort by stakeholders, technical specialists, the authorities and the project proponent/developer who work together to produce better decisions than if they had acted independently. As such, the EIA will meet the requirements stipulated in GNR 543 and DEA's guidelines on PP, published in May 2006 as GNR 657.

For the purposes of the proposed Terminal a single integrated PP process is being conducted for the EA and associated licensing application processes.

3.1.1.2 Regulatory Authority

The competent authority in respect of activities listed under Listing Notices 1, 2 or 3 (GNR 544, 545 and 546) of the NEMA EIA Regulations (GNR 543) is defined as: "*the environmental authority in the province in which the proposed activities area to be undertaken*", in this instance the KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs (DEDTEA).

3.1.1.3 Specific Environmental Management Acts (SEMAs)

NEMA constitutes South Africa's overarching framework environmental legislation with regards to environmental management. In addition to NEMA, a number of Specific Environmental Management Acts (collectively referred to as "SEMAs") were promulgated to deal with specific areas of the environment. These include:

- The National Environmental Management: Protected Areas Act (Act No. 57 of 2003) (NEM:PAA);
- The National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA);
- The National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA);
- The National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008) (NEM:ICM); and
- The National Environmental Management: Waste Act (Act No. 59 of 2008) (NEM:WA).

Any activities which require licensing or authorisation from the relevant competent authority under the SEMAs are required to conduct an environmental assessment process as stipulated under the NEMA EIA Regulations (GNR 543). An application for an AEL in terms of NEM:AQA is therefore subject to the same environmental assessment process detailed above in addition to any other processes which may be stipulated within the respective SEMA legislation. This includes conducting a PP Process as described in Chapter 6 (Regulations 54 to 57) of the NEMA EIA Regulations (GNR 543).

3.1.2 National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA)

The National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA) is a piece of framework legislation developed as a SEMA under NEMA which deals with the management of air quality in South Africa. The NEM:AQA has shifted the approach of air quality management from source based control to the control of the receiving environment. The NEM:AQA also devolved the responsibility of air quality management from the national sphere of government to the local municipal sphere of government (district and local municipal authorities). District and Local Municipalities are thus tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objectives of the act are to protect the environment by providing reasonable legislative and other measures that:

- Prevent pollution and ecological degradation;
- Promote conservation; and

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- Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

3.1.2.1 Emissions standards

NEM:AQA makes provision for the setting and formulation of national ambient air quality and emission standards. On a provincial and local level, these standards can be set more stringently if the need arises. The control and management of emissions in NEM:AQA relates to the listing of activities that are sources of emission and the issuing of Atmospheric Emission Licences (AEL). In terms of Section 21 of NEM:AQA, a listed activity is an activity which “results in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage”.

The proposed Terminal is a new facility which will trigger listed activity Category 2. Subcategory 2.4: Storage and Handling of Petroleum Products. An AEL application process is thus being run in parallel with the EIA process.

Category 2: Petroleum Industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass

Subcategory 2.4: Storage and Handling of Petroleum Products

Description:	Petroleum product storage tanks and product transfer facilities, except those used for liquefied petroleum gas		
Application:	All permanent immobile liquid storage tanks larger than 500 m^3 cumulative tankage capacity at a site.		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa.**
Common name	**Chemical symbol**		
Total volatile organic compounds from vapour recovery/destruction units.	N/A	New	150
		Existing	150
Total volatile organic compounds from vapour recovery/destruction units (Non-thermal treatment) (Thermal treatment).	N/A	New	40
		Existing	40

According to *Subcategory 2.4: Storage and Handling of Petroleum Products*: the following transitional arrangement shall apply for the storage and handling of raw materials, intermediate and final products with a vapour pressure greater than 14 kPa at operating temperature:

i) Leak detection and repair (LDAR) program approved by licensing authority to be instituted, by 01 January 2014.

ii) The following special arrangements shall apply for control of total VOCs from storage of raw materials, intermediate and final products with a vapour pressure of up to 14 kPa at operating temperature except during loading and offloading. (Alternative control measures that can achieve the same of better results may be used).

   a) Storage vessels for liquids shall be of the following type (Table 8):

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  b) The roof legs, slotted pipes and/or dipping well on floating roof tanks shall have sleeves fitted to minimise emissions.

  c) Relief valves on pressurised storage should undergo periodic checks for internal leaks. This can be carries out using portable acoustic monitors or if venting to atmosphere with an accessible open end, tested with a hydrocarbon analyser as part of an LDAR programme.

i) The following special arrangements shall apply for control of total VOCs from the loading and unloading (excluding ships) of raw materials, intermediate and final products with a vapour pressure of greater than 14 kPa a handling temperature. (Alternative control measures that can achieve the same or better results may be used).

  a) All installations with a throughput of greater than 50,000 m³ per annum of products with a vapour pressure greater than 14 kPA, must be fitted with vapour recovery/ destruction units. Emission limits are set out in Table 9.

  b) For road tanker and rail car loading/ offloading facilities where the throughput is less than 50,000 m³ per annum, and where ambient air quality is, or is likely to be impacted, all liquid products shall be loaded using bottom loading, or equivalent with the venting pipe connected to a vapour pressure balancing system. Where vapour balancing and/or bottom loading is not possible, a recovery system utilizing absorption, condensation or incineration of the remaining VOCs with a collection efficiency of at least 95%, shall be fitted.

Table 8: Types of storage vessels for liquids

Application	All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1,000 m³
True vapour pressure of contents at product storage temperature	**Type of tank or vessel**
Type 1: Up to 14 kPa	Fixed-roof tank vented to atmosphere, or as per Type 2 and 3
Type 2: Above 14 kPa and up to 91 kPa with a throughput of less than 50,000 m³ per annum	Fixed roof tank with Pressure Vacuum Vents fitted as a minimum to prevent “breathing” losses, or as per Type 3
Type 3: Above 14 kPa and up to 91 kPa with a throughput greater than 50,000 m³ per annum	1) External floating-roof tank with primary rim seal and secondary rim seal for tank with a diameter of greater than 20 m, or 2) Fixed-roof tank with internal floating deck / roof fitted with primary seal, or 3) Fixed-roof tank with vapour recovery system
Type 4: Above 91 kPa	Pressure vessel

Table 9: Emissions limits for vapour recovery units

Description	Vapour Recovery Units		
Application	All loading / offloading facilities with a throughput greater than 50 000 m³		
Substance or mixture of substances		**Plant status**	**mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Total volatile organic compounds from vapour recovery / destruction units using **thermal treatment**	N/A	New	150
		Existing	150
Total volatile organic compounds from vapour recovery/ destruction units using **non-thermal**	N/A	New	40,000
		Existing	40,000

Description	Vapour Recovery Units		
treatment			

3.1.2.2 *The relationship between the EIA and AEL process*

The legislated process to obtain an AEL under NEM:AQA is via one of two routes:

- Route 1: An AEL is to run parallel with a BA/EIA process; or
- Route 2: An AEL can run independently without the need of a BA/EIA.

The Route 1 process is applicable if:

- The proposed facility is a new facility which involves a listed activity;
- Is a new listed activity in an existing facility; or
- When there are changes to emission rates and/or raw materials which may increase emission levels of key pollutants.

The Route 1 process uses the BA/EIA process to inform the AEL process and thus there are several crucial linkages between the BA/EIA/AEL processes.

The Route 2 process is applicable when:

- There are basic change of “descriptive information” relating to the existing activity and there are no changes in the emissions and air quality impact (i.e. Transfer to new owners);
- A renewal of an existing AEL is being undertaken when there are no substantive changes, variations and/or amendments to the AEL; or
- Transition from APPA provisional/registration certificate to provisional AEL as long as there is no change in the emission and air quality impact i.e. non-substantive changes.

Since the proposed Terminal is a new facility the AEL is being applied for in alignment with Route 1.

3.1.2.3 Public Participation (PP) for the AEL

Chapter 5 Section 38 of the NEMA:AQA *Procedures for Licence Applications* specifies the minimum requirements for PP required in support of an AEL. The AEL process is to be run in collaboration with the EIA process and thus the EIA and AEL PP processes are to be run as one collaborative process to prevent duplication. The PP process to be undertaken will be in alignment with the standard EIA PP process as required by the NEMA EIA Regulations (GNR 543) as well as the specific requirements under NEMA:AQA.

3.1.2.4 Regulatory Authority

Metropolitan and district municipalities constitute the licensing authorities charged with implementing the AEL system referred to under Section 22 of NEM:AQA. The uThungulu District Municipality is therefore the AEL licensing authority for the proposed Terminal.

3.1.2.5 Applicable Air Quality Standards, Legislation and Guidelines

Ambient Air Quality Standards

The South African Ambient Air Quality Standards for common pollutants prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area (Table 10). In the event that the standards are exceeded, the ambient air quality is defined as poor and potential adverse health impacts are likely to occur.

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Table 10: South African Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
NO_2 [(a)]	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM_{10} [(b)]	24 hour	120	-	4	Immediate – 31 December 2014
	24 hour	75	-	4	1 February 2015
	1 year	50	-	0	Immediate – 31 December 2014
	1 year	40	-	0	1 February 2015
O_3 [(c)]	8 hours (running)	120	61	11	Immediate
Lead (Pb) [(d)]	1 year	0.5	-	0	Immediate
CO [(e)]	1 hour	30,000	26,000	88	Immediate
	8 hour (1 hourly average)	10,000	8,700	11	Immediate
Benzene (C_6H_6) [(f)]	1 year	10	3.2	0	Immediate – 31 December 2014
	1 year	5	1.6	0	1 February 2015
SO_2 [(g)]	10 minute	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hours	125	48	4	Immediate
	1 year	50	19	0	Immediate
$PM_{2.5}$ [(h)]	24 hours	65		4	Immediate – 31 December 2015
	24 hours	40		4	1 January 2016 – 31 December 2029
	24 hours	25		4	1 January 2030
	1 year	25		0	Immediate – 31 December 2015
	1 year	20		0	1 January 2016 – 31 December 2029
	1 year	15		0	1 January 2030

Notes:

a. *The reference method for the analysis of NO_2 shall be ISO 7996*
b. *The reference method for the determination of the particulate matter fraction of suspended particulate matter shall be EN 12341*
c. *The reference method for the analysis of ozone shall be the UV photometric method as described in ISO 13964*
d. *The reference method for the analysis of lead shall be ISO 9855*
e. *The reference method for analysis of CO shall be ISO 4224*
f. *The reference methods for benzene sampling and analysis shall be either EPA compendium method TO-14 A or method TO-17*
g. *The reference method for the analysis of SO_2 shall be ISO 6767*
h. *The reference method for the analysis of $PM_{2.5}$ shall be EN14907*

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Dust Fallout Standards

On 1 November, 2013, the National Dust Control Regulations were promulgated under the NEM:AQA and published in the Government Gazette No. 36974. The dust fall standard defines acceptable dust fall rates in terms of the presence of residential areas (Table 11).

Table 11: Acceptable dust fall rates

Restriction areas	Dust fall rate (mg/m²/day over a 30 day average)	Permitted frequency of exceedance
Residential areas	Dust fall < 600	Two per annum (not in sequential months)
Non-residential areas	600 < Dust fall < 1200	Two per annum (not in sequential months)

Proposed Environmental Assessment levels

According to the International Finance Corporation (IFC) Environmental, Health, and Safety (EHS) Guidelines (2007) on air emissions and ambient air quality, projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current World Health Organization (WHO) Air Quality Guidelines.

In the absence of local standards and guidelines, applicable WHO and other international air quality guidelines are used to assess the predicted emissions from a proposed facility.

Internationally, it is generally accepted that, in the absence of any ambient reference standards available, it is acceptable to make use of either 1/50th (for non-carcinogens) or 1/100th (for carcinogens) of the relevant Occupational Exposure Limits. In the absence of reliable toxicological data, this methodology has been used to set numerous ambient standards including those published by the UK Environment Agency/ European Commission.

Table 12: Proposed Environmental Assessment Levels (EALs) for the Vopak-Reatile Terminal

Product	Short term (1 hour) EAL (µg/m³)	Long term (annual) EAL (µg/m³)	Reference
Acetone	362,000	18,100	UK Environment Agency (2011)[a]
Acrylic acid	6,000	300	UK Environment Agency (2011) [a]
Butanol	3,000	-	150 mg/m³ NIOSH REL[b]
Butyl Acrylate	1,100	-	55 mg/m³ NIOSH REL[b]
Diethanolamine	324	7.8	UK Environment Agency (2011)[a]
Ethanol	38,000	-	1900 mg/m³ NIOSH REL[b]
Ethyl Acetate	28,000	-	1400 mg/m³ NIOSH REL[b]
Ethyl Acrylate	6,200	210	UK Environment Agency (2011) [a]
Methyl ethyl ketone	11,800	-	590 mg/m³ NIOSH REL[b]
Methyl isobutyl ketone	4,100	-	205 mg/m³ NIOSH REL[b]
Propanol	10,000	-	500 mg/m³ NIOSH REL[b]
Propylene glycol	500	-	25 mg/m³ NIOSH REL[b]
Styrene	800	800	WHO (2000)[c]
Triethanolamine	100	-	5 mg/m³ ACGIH TLV[d]
Ethylbenzene	55,200	4,410	UK Environment Agency (2011) [a]

Product	Short term (1 hour) EAL (µg/m³)	Long term (annual) EAL (µg/m³)	Reference
Toluene	8,000	1,910	UK Environment Agency (2011) [a]
Xylenes	66,200	4,410	UK Environment Agency (2011) [a]
Total VOC	10,000	-	European Parliament (2000) [e]

Notes:

a) UK Environment Agency (2011) H1 Environmental Risk Assessment Framework. Annex F - Air Emissions. Bristol, United Kingdom. GEHO0410BSIL-E-E v2.2

b) National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL)

c) World Health Organisation (WHO), Air quality guidelines 2000, EAL derived from values for 24 hour reference period

d) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)

e) European Parliament (2000) Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the Incineration of Waste. Official Journal of the European Communities. L332/91

3.1.3 National Water Act (Act No. 36 of 1998) (NWA)

The National Water Act (Act No. 36 of 1998) (NWA) is the law relating to water resources and provides for the regulation of water use in South Africa. The NWA acknowledges Government's overall responsibility for and authority over South Africa's water resources and their use, and provides for the protection of the quality of water resources, and the equitable allocation of water for beneficial use.

Chapter 4 Section 21 of the NWA lists water uses which require licensing in accordance with the Act. Section 21 water uses which may be applicable to the development and operation of the proposed Terminal include:

c) Impeding or diverting the flow of water in a watercourse

i) Altering the bed, banks. course or characteristics of a watercourse

In terms of the NWA, a watercourse means:

(a) a river or spring;

(b) a natural channel in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse,

and a reference to a watercourse includes, where relevant, its bed and banks:

Any infrastructure located within a watercourse as defined by the NWA or within 500 m from its edge will thus require a WUL and letters of approval from the City of uMhlathuze and uThungulu District Municipality.

3.1.3.1 Regulatory Authority

The responsible authority in terms of NWA and the licensing of Section 21 Water Uses is defined as the Regional Office of the Department of Water Affairs and Sanitation (DWS), in this instance the KwaZulu-Natal DWS. The process of applying for a Water Use License (WUL) is separate from the EIA process, and is therefore being applied for separately of the current EIA process.

3.1.4 National Environmental Management: Waste Act (Act No. 59 of 2008) (NEM: WA)

The National Environmental Management: Waste Act (Act No. 59 of 2008) (NEM:WA) is a piece of framework legislation developed as a SEMA under NEMA which deals with the management of waste in South Africa. In terms of this Act a Waste Management License (WML) must be obtained for any waste management activities as contained in the List of Waste Management Activities That Have, or are Likely to

Have a Detrimental Effect on the Environment (GNR 921). Waste management activities are divided into Category A, B and C activities. Category A waste management activities, require a BA process be conducted as part of the WML application, while Category B activities require a full S&EIA process. Category C activities require compliance with relevant requirements or standards as determined by the Minister.

In terms of NEM:WA, waste is defined as follows:

***"waste"** means any substance, whether or not that substance can be reduced, re-used, recycled and recovered –*

(a) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;

(b) which the generator has no further use of for the purposes of production;

(c) that must be treated or disposed of; or

(d) that is identified as a waste by the Minister by notice in the Gazette, and includes waste generated by the mining, medical or other sector, but –

(i) a by-product is not considered waste; and

(ii) any portion of waste, once re-used, recycled and recovered, ceases to be waste.

The proposed Terminal does not trigger any of the waste management activities listed in GNR 921, and therefore does not require a WML.

3.1.5 National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA)

According to the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA), a person may not carry out a restricted activity involving a specimen of a listed Threatened or Protected Species (TOPS), without a permit issues in terms of Chapter 7 of NEM:BA. Restricted activities in relation to a specimen of a listed TOPS include, among others, hunting, catching, capturing or killing; as well as gathering, collecting, damaging or destroying any threatened or protected species.

In addition to requiring a permit to carry out a restricted activity involving a specimen of a listed TOPS, a person may also not carry out a restricted activity involving a specimen of an alien species without a permit issued in terms of Chapter 7 of NEM:BA. Restricted activities in relation to a specimen of an alien species include, among others, having in possession or exercising physical control over, conveying, moving or otherwise translocating any specimen of an alien of listed invasive species.

According to the NEM:BA Regulations, exotic species can be listed into one of four categories; 1a, 1b, 2 and 3. In respect of Government Notice 1, the following restrictions are relevant to listed plant species:

NEM:BA Category 1a and 1b

The propagation, release, conveying or allowing the spread of any species listed as Category 1a and 1b is prohibited.

NEM:BA Category 2

A permit is required to be in possession of, propagate, release, spread or allow the spread of any species listed as Category 2.

NEM:BA Category 3

The propagation and release of Category 3 species is prohibited, however an exemption is made to be in possession of, or allow the spread of these species.

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3.1.5.1 *Regulatory Authority*

The licensing authority in terms of NEM:BA and the permitting of restricted activities is Ezemvelo KwaZulu-Natal Wildlife (EKZNW) or the Department of Agriculture, Forestry and Fisheries (DAFF). The process of applying for a permit in accordance with Chapter 7 of NEM:BA is separate from the EIA process, and will therefore be applied for separately from the current EIA process.

3.1.6 Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA)

The Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA), as amended, provides for control over the utilization of natural agricultural resources. Section 6 of CARA makes provision for control measures to be applied in order to achieve the objectives of the Act, these measures relate to, among others: utilization and protection of wetlands; the regulating of the flow pattern of run-off water; the utilization and protection of vegetation; the control of weeds and invader plants; and the restoration or reclamation of eroded land or land which is disturbed or denuded.

The 2001 revision of the CARA recognises three categories of invasive plant, namely: Category 1 - declared weeds, Category 2 - declared invader plants with a commercial or utility value, and Category 3 - ornamental plants. These are listed in Regulations 15 and 16 of CARA. The regulations pertaining to each category are summarised below:

CARA Category 1: Declared weeds

Category 1 listed plants have no economic value and possess characteristics harmful to humans, animals or the environment. These species tend to produce high volumes of seed, are wind or bird dispersed, or have efficient vegetative reproduction, and are thus highly invasive causing substantial environmental degradation. As such, Category 1 listed plants may not be planted or propagated in rural and urban areas, and the trade in their seeds, cuttings and other propagatory material is prohibited. Moreover, it is recommended that active measures be taken to control and eradicate populations of these species (ARC, 2010, internet).

CARA Category 2: Declared invader plants with commercial or utility value

Although Category 2 listed plants are invasive species, they do have beneficial properties and general utility. They are permitted in demarcated areas (as granted by the Executive Officer) under controlled conditions, and in bio control reserves. Seed and propagative material may only be sold to, and acquired by land users of areas demarcated for that particular species, as determined by the Executive Officer. These species may not occur within 30 m of the 1:50 year flood line of a water course or wetland, except under authorisation in terms of the NWA (ARC, 2010, internet).

CARA Category 3: Mostly ornamental plants

These are exotic plants that are generally popular ornamental and garden species but show high invasive potential and frequently encroach into natural areas. Existing plants may remain provided they do not occur within 30 m from the 1:50 year flood line of a water course or wetland, and provided all reasonable steps are taken to limit the further spread of that species. No further planting or trade in propagative material is permitted (ARC, 2010, internet).

3.1.7 Integrated Coastal Management Act (Act No. 24 of 2008)

The Integrated Coastal Management Act (Act No. 24 of 2008) (ICMA) emanates from the White Paper for Sustainable Coastal Development in South Africa and proposes inter alia establishing a system of integrated coastal and estuarine management. This legislation firmly establishes integrated coastal management as the preferred vehicle for the promotion of sustainable coastal development in South Africa. This is promoted through directives in terms of the conservation and maintenance of the natural attributes of the coastal environment concomitant with development that is both sustainable, and socially and economically justifiable. It defines the rights and responsibilities of all coastal stakeholders including those of organs of state and gives effect to South Africa’s international responsibilities in respect of coastal pollution. The ICMA

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aims to facilitate the implementation of the principles and guidelines presented by the White Paper and have a number of objectives including:

- The provision of a legal and administrative framework to promote cooperative, coordinated and integrated coastal management;
- The protection of the natural coastal environment as a national heritage;
- The management of coastal resources in the interests of the whole community;
- The promotion of equitable access to the resources and benefits provided by the coast; and
- The fulfilment of South Africa’s obligations under international law.

In accordance with the Ports Act, all waste contractors must be licensed by the Port. As such Vopak will ensure that all its waste contractors are licensed accordingly.

3.1.7.1 Occupational Health and Safety Act (Act No. 85 of 1993) (OHSA) and its Major Hazard Installation (MHI) Regulations

The Occupational Health and Safety Act (Act No. 85 of 1993) (OHSA) and its Major Hazard Installation (MHI) Regulations (July 2001) require employers, self-employed persons and users, who have on their premises, either permanently or temporarily, a MHI or a quantity of a substance which may pose a risk that could affect the health and safety of employees and the public, to conduct a risk assessment in accordance with the OHSA and MHI Regulations. Further to this, the Department of Labour (DoL) requires a MHI risk assessment to be undertaken prior to construction by an organisation approved by the DoL.

In accordance with the OHSA, a "major hazard installation" means an installation-

a) Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or

c) Where any substance is produced, processed, used, handled or stored in such a form and quantity that it has the potential to cause a major incident;

MHI Risk Assessments undertaken in terms of the OHSA must cover a mandatory list of elements covered in the MHI Regulations.

The MHI Regulations are applicable to risks posed and not merely consequences. As such, both the consequences and likelihood of an incident occurring need to be evaluated, with the classification of an installation determined by the risk posed to both the employees and the public.

In accordance with the legislation, the risk assessment must be done by an Approved Inspection Authority (AIA) who is registered with the DoL and accredited by the South African Accreditation Systems (SANAS).

4.0 BASELINE CONDITIONS

This chapter describes the proposed Terminal’s baseline environmental conditions according to available information. The main sources of information for the baseline conditions include the TNPA FBAR for the construction of a Storm Water Channel and Associated Infrastructure within the South Dunes Lease Site (DEA Reference 14/12/16/3/3/1/582) (Geomeasure Group, 2013) and supporting specialist studies which include the Proposed Provision of Services at the Dune Area, Port of Richards Bay: Terrestrial Ecological Assessment (ACER Africa, 2013a), and the Proposed Provision of Services at the Dune Area, Port of Richards Bay: Wetland Delineation (ACER Africa, 2013b); the EMF Report for Richards Bay Port Expansion Area and IDZ (DAERD, 2011); the Strategic Environmental Assessment (SEA): Port of Richards Bay, State of the Environment Report (CSIR, 2005a); the SEA: Port of Richards Bay, Sustainability Framework (CSIR, 2005b); the uMhlathuze Local Municipality: IDP Review 2013/2014 (uMhlathuze, 2013); the City of

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uMhlathuze Revision of SDF (uMhlathuze, 2007); the uMhlathuze Municipality Revision of the uMhlathuze Spatial Framework Plan (SFP): Status Quo Report (SiVEST Selatile Moloi, 2007); and the specialist studies conducted as part of the current EIA process.

4.1 Topography

Richards Bay is located within a large coastal plain which varies in altitude from 0 metres above mean sea level (mamsl) (i.e. sea level) at the coast to approximately 200 mamsl 20 km inland from the coast at Empangeni (see Figure 16). The coastline is characterized by a steep sandstone ridge and a strip of 1 to 4 dune ridges up to approximately 1 km wide which run parallel to the coast, and reach a height of approximately 100 m. The entrances to the Richards Bay Harbour and Richards Bay Estuary constitute the only breaks within the coastal dune ridge.

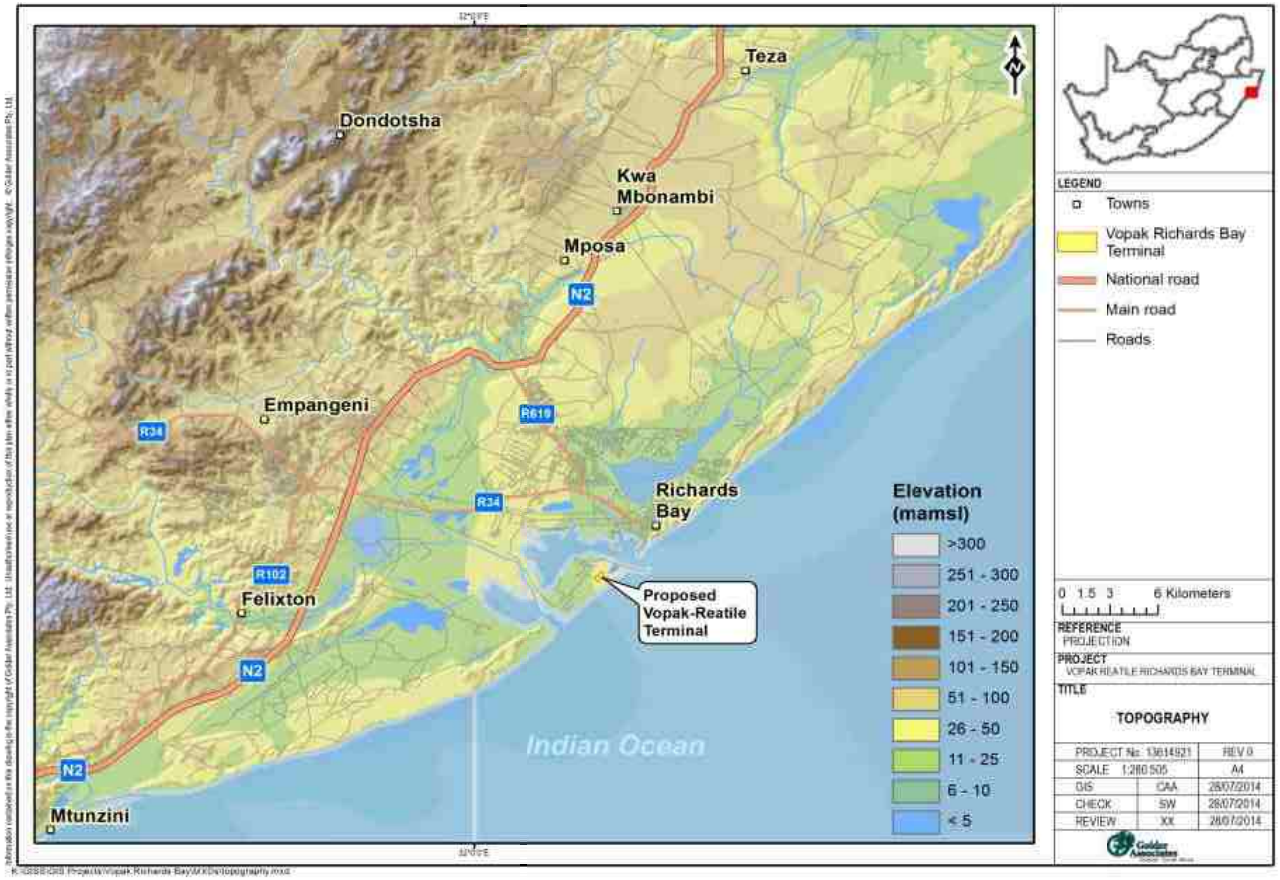

Figure 16: Regional Topography of the Greater Richards Bay Area.

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4.2 Regional Climate

Richards Bay is situated within the subtropical high pressure belt. The mean circulation of the atmosphere over the subcontinent is anticyclonic throughout the year (except for near the surface) (Preston-Whyte and Tyson, 1997). The synoptic patterns affecting the typical weather experienced in the region owe their origins to the subtropical, tropical and temperate features of the general atmospheric circulation over Southern Africa (Figure 17).

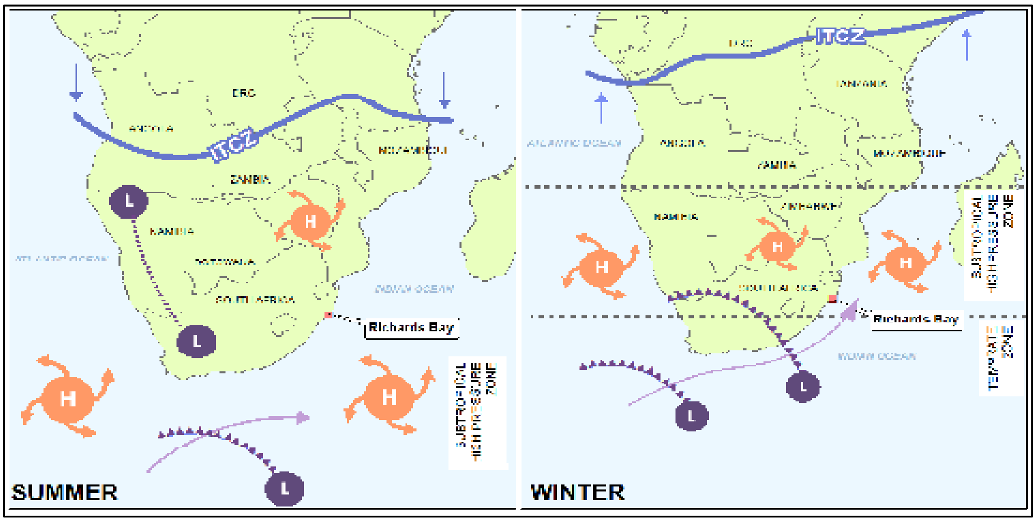

Figure 17: Seasonal Circulation Patterns Affecting the Regional Climate.

The subtropical control is brought via the semi-permanent presence of the South Indian Anticyclone (HP cell), Continental High (HP cell) and the South Atlantic Anticyclone (LP cell) in the high pressure belt located approximately 30° S of the equator (Preston-Whyte and Tyson, 1997). The tropical controls are brought via tropical easterly flows (LP cells) (from the equator to the southern mid-latitudes) and the occurrence of the easterly wave and lows (Preston-Whyte and Tyson, 1997). The temperature control is brought about by perturbations in the westerly wave, leading the development of westerly waves and lows (LP cells) (i.e. cold fronts from the polar region, moving into the mid-latitudes) (Preston-Whyte and Tyson, 1997).

Seasonal variations in the positioning and intensity of the HP cells determine the extent to which the westerly waves and lows impact the atmosphere over the region. In winter, the high pressure belt intensifies and moves northward while the westerly waves in the form of a succession of cyclones or ridging anticyclones move eastwards around the South African coast or across the country. The positioning and intensity of these systems are thus able to significantly impact the region. In summer, the anticyclonic HP belt weakens and shifts southwards and the influence of the westerly wave and lows weakens.

Anticyclones (HP cells) are associated with convergence in the upper levels of the troposphere, strong subsidence throughout the troposphere, and divergence near the surface of the earth. Air parcel subsidence, inversions, fine conditions and little to no rainfall occur as a result of such airflow circulation patterns (i.e. relatively stable atmospheric conditions). These conditions are not favourable for air pollutant dispersion, especially in regards to those emissions emitted close to the ground.

Westerly waves and lows (LP cells) are characterised by surface convergence and upper-level divergence that produce sustained uplift, cloud formation and the potential for precipitation. Cold fronts, which are associated with the westerly waves, occur predominantly during winter. The passage of a cold front is characterised by pronounced variations in wind direction and speed, temperature, humidity, pressure and distinctive cloud bands (i.e. unstable atmospheric conditions). These unstable atmospheric conditions bring about atmospheric turbulence which creates favourable conditions for air pollutant dispersion.

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The tropical easterlies and the occurrence of easterly waves and lows affect Southern Africa mainly during the summer months. These systems are largely responsible for the summer rainfall pattern and the north easterly wind component that occurs over the region (Schulze, 1986; Preston-Whyte and Tyson, 1988).

The convective activity associated with the easterly and westerly waves disturbs and hinders the persistent inversion which sits over Southern Africa. This allows for the upward movement of air pollutants through the atmosphere leading to improved dispersion and dilution of accumulated atmospheric pollution.

4.2.1 Precipitation

Richards Bay is located in the summer rainfall region of South Africa and thus receives most of its rainfall during the period of October to March, with peak rainfall occurring in the late summer months of January and February. Rainfall is not uncommon in winter when it is associated with the passage of low pressure frontal weather systems from the south-west (i.e. cold fronts). Long term (1970 – 1990) precipitation trends for Richards Bay are presented in Figure 18.

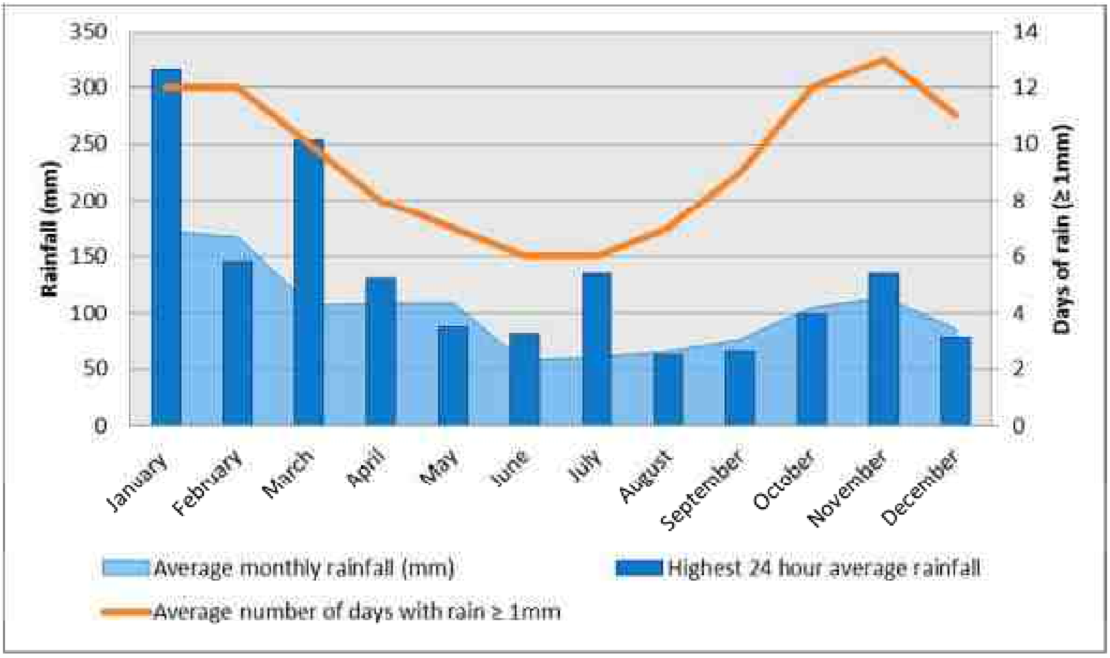

Figure 18: Long Term Precipitation Trends in Richards Bay, based on the South African Weather Service Long Term Data Record (1970 - 1990) (www.weathersa.co.za).

4.2.2 Temperature

Air temperatures in Richards Bay are warm, to hot, for most of the year and summers are humid. In summer the average daily maximum temperature is 29 °C with extremes exceeding 40 °C, while in winter the average maximum temperature is 23 °C with extremes in the region of 34 °C. Extreme temperatures frequently occur due to berg wind conditions. Annual average relative humidity levels are 82% (08:00) and 67% (14:00), respectively. Long term (1970 – 1990) temperature trends for Richards Bay are presented in Figure 19.

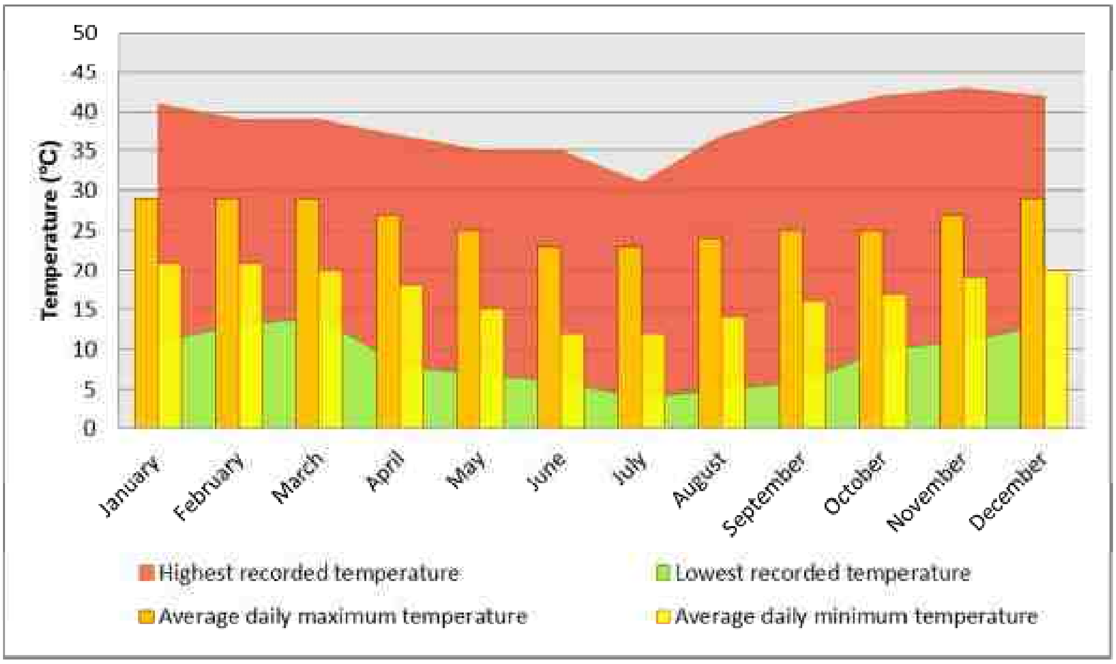

Figure 19: Long Term Temperature Trends in Richards Bay, based on the South African Weather Service Long Term Data Record (1970 - 1990) (www.weathersa.co.za).

4.2.3 Wind Speed and Direction

Wind roses summarize the occurrence of winds at a specified location by representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction. Each cardinal branch is divided into segments of different colours which represent different wind speed classes.

4.2.3.1 Wind Rose for the Modelled Period

The annual wind rose for the proposed Terminal is presented in Figure 20. The average wind speed for the period 2011 to 2013 was 4.24 m/s. Clear dominant wind axes are evident, with winds predicted to originate from the north-north-east (11% of the time) and north-east (10% of the time), followed by south-south-west (9%) and south-west (9%). Winds are moderate, with 3.56% calms (<1m/s).

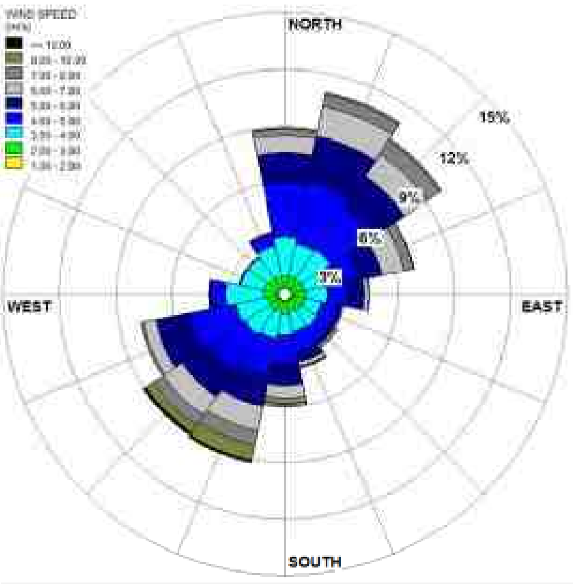

Figure 20: MM5 Wind Rose and Wind Frequency Distribution for the proposed Terminal for the Period 2011 to 2013.

4.2.4 Diurnal Wind Roses

A diurnal variation is apparent in Figure 21, with the west-south-westerly land breeze (off shore winds) dominant in the early hours (00:00 – 06:00) and the north-north-easterly sea breeze dominant in the afternoons (12:00 – 18:00). Mornings (06:00 – 12:00) tend to be dominated by high speed south-westerly winds (>10 m/s).

4.2.5 Seasonal Wind Roses

A seasonal variation can be seen in Figure 22, with north-easterly and east-north-easterly winds dominating in summer and spring; and south-westerly and west-south-westerly winds dominating in autumn and winter. The highest frequency of calms is noted in winter (4.08%).

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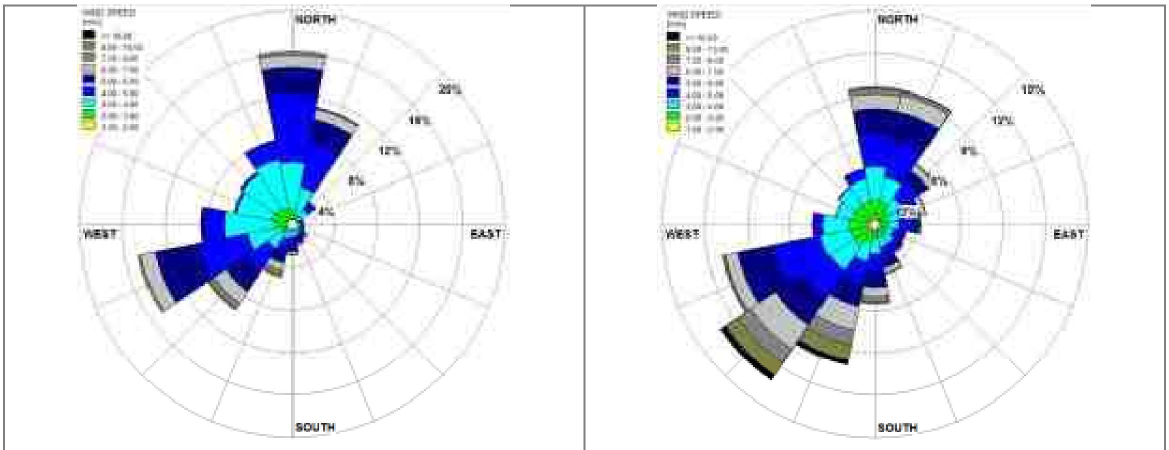
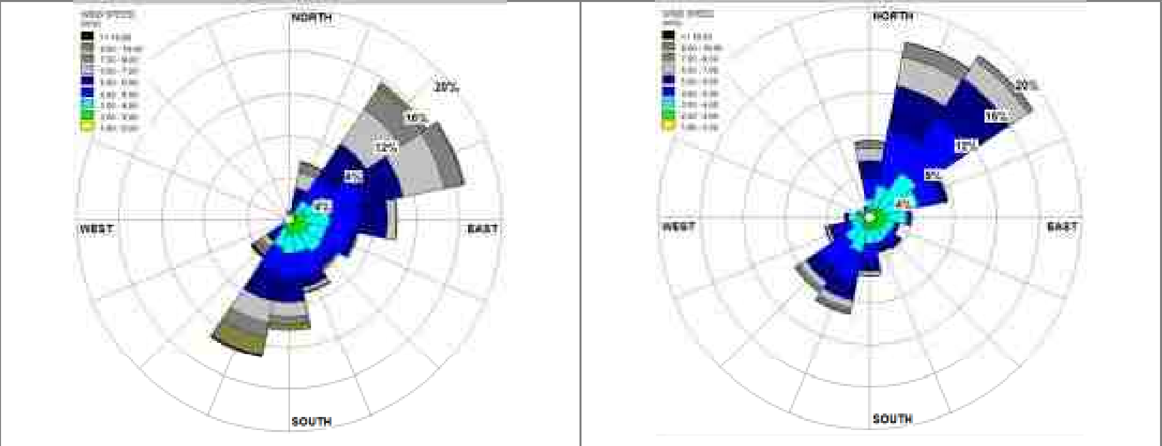


00:00 to 05:59
N 16% of the time
WSW 15% of the time
Calms: 2.65%

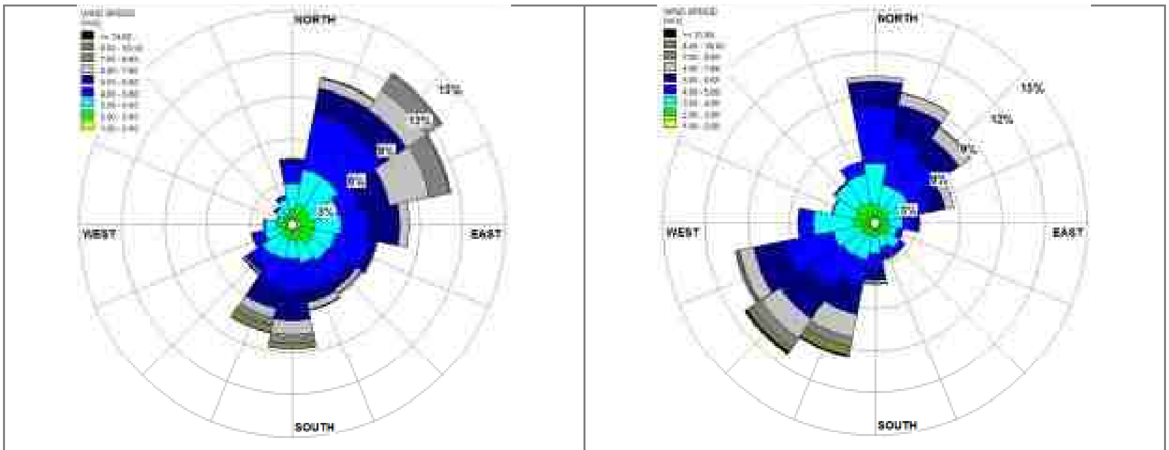
06:00 to 11:59
SW 13% of the time
SSW & WSW 11% of the time
Calms: 6.18%



12:00 to 17:59
ENE 17% of the time
NE 15.5% of the time
Calms: 2.83%

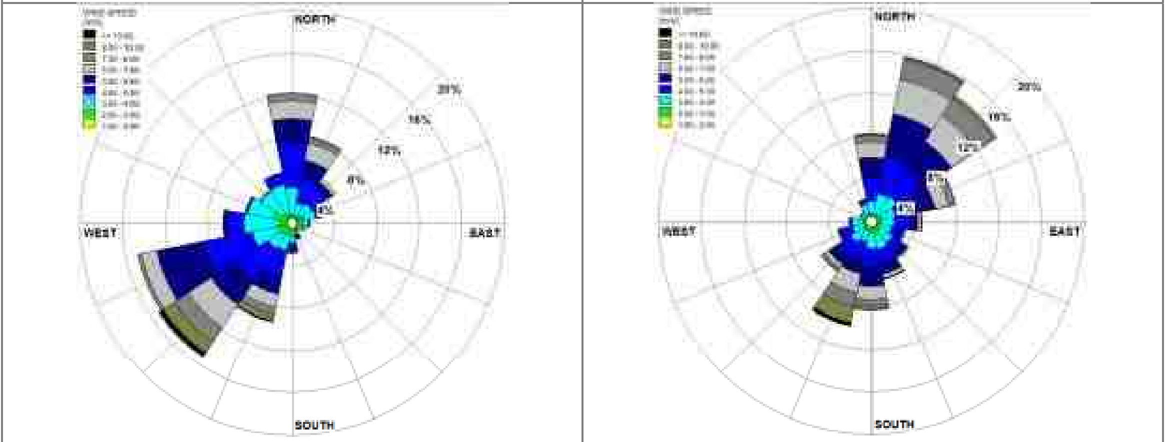
18:00 to 23:59
NE 18.5% of the time
NNE 17% of the time
Calms: 2.52%

Figure 21: MM5 Diurnal Wind Rose and Wind Frequency Distribution for the proposed Terminal for the Period 2011 to 2013.



Summer (DJF)
NE 13% of the time
ENE 11.5% of the time
Calms: 3.63%

Autumn (MAM)
SW 11% of the time
N & WSW 10% of the time
Calms: 4.18%



Winter (JJA)
SW 15% of the time
WSW 14.75% of the time
Calms: 4.08%

Spring (SON)
NNE 15.5% of the time
NE 14% of the time
Calms: 2.35%

Figure 22: Modelled Seasonal Wind Rose and Wind Frequency Distribution for the proposed Terminal for the Period 2011 to 2013.

4.2.6 Land Use and Sensitive Receptors

The proposed Terminal is located within the South Dunes Precinct of the Port of Richards Bay which is bordered by the Richards Bay harbour to the west, the small craft harbour to the north, the harbour mouth to the north-east, the Indian Ocean to east, and the Richards Bay Game Reserve to the south. The South Dunes Precinct is used primarily for liquid chemical and petroleum storage facilities (DAERD, 2011). Tenants include the RBCT, IVS, JBS, and TRE.

The Grindrod dry bulk terminal is located approximately 4 km north of the proposed Terminal, and handles coal, heavy minerals (i.e. phosphate rock and metal ores), sulphur (and other phosphates), and other dry bulk commodities.

The suburb of Meerensee is located approximately 2 – 5 km north-east of the proposed Terminal, and is home to the boat club, shopping malls, churches, schools, guesthouses, hotels and residences. The suburb comprises many potential sensitive receptors.

Numerous industrial activities exist within 5 – 10 km of the proposed Terminal, specifically in the Alton Industrial area, north-west of the proposed Terminal site (Figure 23). Major industries include, but are not limited to:

- Hillside smelters;
- Foskor fertiliser plant;
- Mondi Richards Bay pulp and paper mill;
- Tata Steel;
- RBCT; and
- Richards Bay Minerals Mine and Smelter Complex.

Numerous potential sensitive receptors, including nature reserves, residents, schools, hospitals and clinics are also present within this band and are located within the following suburbs:

- Gubethuka and Esikhawini to the south-west; and
- Brackenham, Wildenweide, Veldenvlei, Birdswood, Arboretum (and Extension) to the north.

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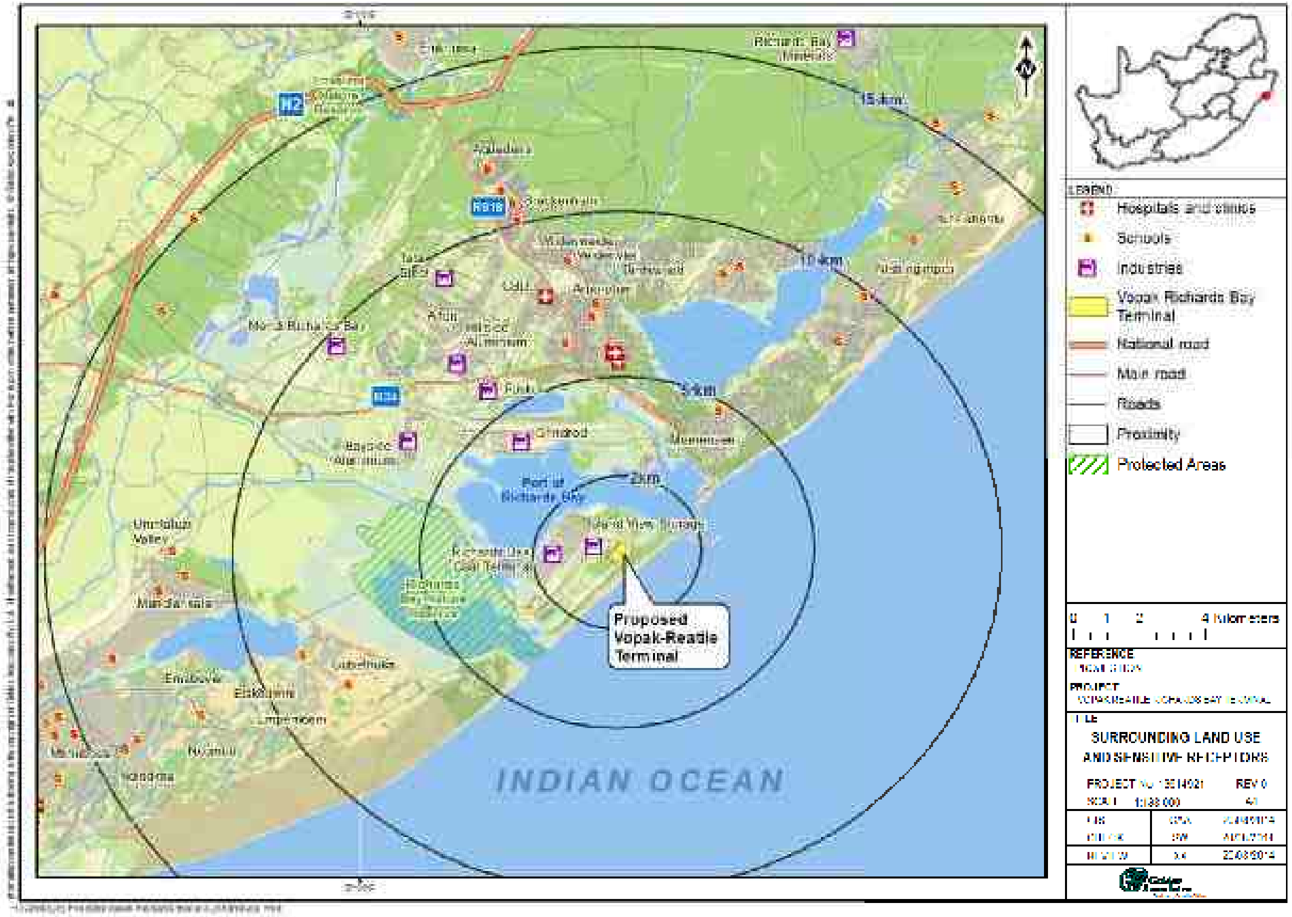

Figure 23: Land Use and Sensitive Receptors in the Vicinity of the proposed Terminal.

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4.3 Ecology

4.3.1 Regional Environment

The proposed Terminal is situated within the KwaZulu-Cape Coastal Forest Mosaic ecoregion (AT0116) (WWF, 2014). This ecoregion extends along the eastern coast of South Africa, and represents the southernmost African distribution of tropical fauna and flora. It is characterised by a mix of forest interspersed with thornveld. The topography of the KwaZulu-Cape Coastal Forest Mosaic ecoregion varies from steeply rolling hills and ridges in the north to coastal platforms and gorges in the south (WWF, 2014). The climate of the ecoregion is generally tropical, with summer temperatures ranging from 15 °C to 24 °C and winter temperature from 10 °C to 15 °C. Rainfall is between 900 to 1,500 mm per year, with the north receiving rain in the summer and the south in winter (WWF, 2014).

Soils within the region are typically poorly developed and are characterised by deep, medium to coarse-grained calcareous sands that are alkaline in nature (WWF, 2014). The geology of the region is defined mostly by sediments of the Karoo sequence with elements of the Natal Group sandstones and basement rocks (WWF, 2014).

The proposed Terminal falls within the Maputaland-Pondoland-Albany hotspot of biodiversity. The region is defined by high biological endemism and diversity, and extends below the Great Escarpment from the Eastern Cape, through KwaZulu-Natal into Mpumalanga Province (Conservation International, 2008). The floristic richness of the region is second only to the Cape Floristic Region in Africa. Approximately 8,100 plant species are present, of which, 1,900 are strict endemics (Conservation International, 2008). The region also has remarkable fauna diversity, with 540 birds, 200 mammals, over 200 reptiles and 72 amphibians recorded (Conservation International, 2008).

According to Conservation International (2008) an estimated 20% of the original extent of the Maputaland-Pondoland-Albany hotspot has been transformed. Both commercial and subsistence agriculture are major agents of transformation, as are commercial forestry, urbanisation and mining. As a large proportion of the hotspot is also under communal ownership, large areas that aren't necessarily transformed *per se*, are nonetheless severely overgrazed (Conservation International, 2008).

Anthropogenic activity throughout the ecoregion has resulted in the fragmentation and transformation of much the KwaZulu-Cape Coastal Forest Mosaic, with little over half the historic extent remaining (WWF, 2014). Although large forest patches do occur, most forest areas are confined to small, isolated pockets set in a modified landscape matrix. Forest patches occur on private and tribal land, and in conservancies and protected areas. Those not in formal conservation areas are often subject to intense utilisation, with the WWF (2014) indicating that forests are harvested for building material, traditional medicine, food and water. Forest patches are cleared to make way for agriculture and grazing, with sugar cane and forestry being major land use drivers. Other common threats to forests in KwaZulu-Natal include mining, urban and recreational developments, alien plant species encroachment and unrestricted vehicle access (WWF, 2014).

4.3.2 Regional Vegetation Types

According to Mucina & Rutherford (2006) the sub-regional environment encompasses two vegetation types namely Northern Coastal Forest (FOz 7) and Maputaland Coastal Belt (CB1). At a provincial level, Scott-Shaw & Escott (2011) have refined and updated Mucina & Rutherford's (2006) work in an attempt to represent the pre-transformation extent of KwaZulu-Natal's vegetation types. These authors refer to Mucina & Rutherford's (2006) Northern Coastal Forest vegetation type as KwaZulu-Natal Dune Forest: Maputaland Dune Forest.

The characteristics of the relevant vegetation types are based on Mucina & Rutherford (2006) descriptions; however the delineations as shown in Figure 24 reflect the pre-transformation vegetation types as determined by Scott-Shaw & Escott (2011):

4.3.2.1 The Northern Coastal Forest (FOz 7)

The Northern Coastal Forest vegetation type, also referred to as KwaZulu-Natal Dune Forest: Maputaland Dune Forest by Scott-Shaw & Escott (2011), occurs in KwaZulu-Natal, particularly along the Indian Ocean

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seaboard and in Maputaland. It also occurs to a very small extent in the Eastern Cape Province. It occurs at low altitudes of between 10 – 150 mamsl (Mucina & Rutherford, 2006).

Vegetation Unit

The vegetation unit is characterized by species rich, tall/medium height subtropical coastal forests on rolling coastal plains and stabilized coastal dunes. Forests of the coastal plains are dominated by *Drypetes natalensis, Englerophytum natalense, Albizia adianthifolia, Diospyros inhacaensis* etc. The low tree and shrubby understoreys are species rich and comprise many taxa of subtropical origin. On dunes, these forests have well-developed tree, shrub and herb layers. *Mimusops caffra, Sideroxylon inerme, Dovyalis longispina, Acacia kosiensis* and *Psydrax obovata* are the most common constituents of the tree layer. *Brachylaena discolor, Chrysanthemoides monilifera, Carissa bispinosa, Euclea natalensis, Euclea racemosa, Eugenia capensis, Gymnosporia nemorosa, Kraussia floribunda, Peddiea africana, Strelitzia nicolai* and *Dracaena aletriformis* are frequent in the understorey. The herb layer usually contains *Asystasia gangetica, Isoglossa woodii, Microsorium scolopendrium, Zamioculcas zamiifolia* and *Oplismenus hirtellus.* Herbaceous vines and woody climbers are important structural determinants in these forests, including *Acacia kraussiana, Artabotrys monteiroae, Dalbergia armata, Landolphia kirkii, Monanthotaxis caffra, Rhoicissus tomentosa, Rhus nebulosa, Scutia myrtina, Uvaria caffra, Gloriosa superba* (Mucina & Rutherford, 2006).

Conservation Status

About 68% of this vegetation unit is statutorily conserved in a range of reserves mostly under the management of EKZNW. The original extent of these forests has been diminished by agriculture (mainly sugarcane and fruit orchards), timber plantations, urban sprawl and tourist-related development of the KwaZulu-Natal coast. Illegal clearing for small-scale agriculture is also a threat. In addition, these subtropical forests are sensitive to alien plant invasion, particularly *Chromolaena odorata* (Mucina & Rutherford, 2006).

4.3.2.2 Maputaland Coastal Belt (CB1)

The Maputaland Coastal Belt vegetation unit is found in KwaZulu-Natal, continuing into southern Mozambique, with a 35 km broad strip along the coast of the Indian Ocean stretching from the Mozambique border in the north to Mtunzini in the south. Altitude varies from about 20 – 120 mamsl (Mucina & Rutherford, 2006).

Vegetation Unit

Dry land vegetation types are dominated by grassland or *Syzigium* savanna where fire has been frequent, but tend toward shrub land where the fire regime has been disrupted. Lack of fire and disturbance has promoted the invasion of alien trees and shrubs to the extent that distinct patches of these invaded grasslands can be recognized. In some instances self-sustaining stands of pines, eucalypts or gums have established, with an understory of usually grassland. Areas of hard geology may support grassland but also commonly support *Acacia karroo* savanna or woodland. As with vegetation of marine sands, a decrease in fire frequency or increased disturbance has promoted the establishment of alien shrubs and trees. In addition, preclusion of fire may promote thickening of woody vegetation such that *A. karroo* thickets may develop (Mucina & Rutherford, 2006).

Conservation Status

The Maputaland Coastal Belt vegetation type is classified as Vulnerable, with a conservation target of 25%, whereas only 15% is currently statutorily conserved in the Greater St Lucia Wetland Park as well as in Sileza, Enseleni and Amatikulu Nature Reserves. More than 30% has been transformed for plantations and cultivation and by urban sprawl. Alien invasive species include scattered populations of *Chromolaena odorata* and *Lantana camara*. Erosion levels are mostly very low. The Maputaland Coastal Belt vegetation type has a relatively high number of plant taxa at the southernmost and northernmost limits of their distribution range. The occurrence of widely disjunctive or outlier populations increases the conservation value of the Maputaland Coastal Belt vegetation type (Mucina & Rutherford, 2006).

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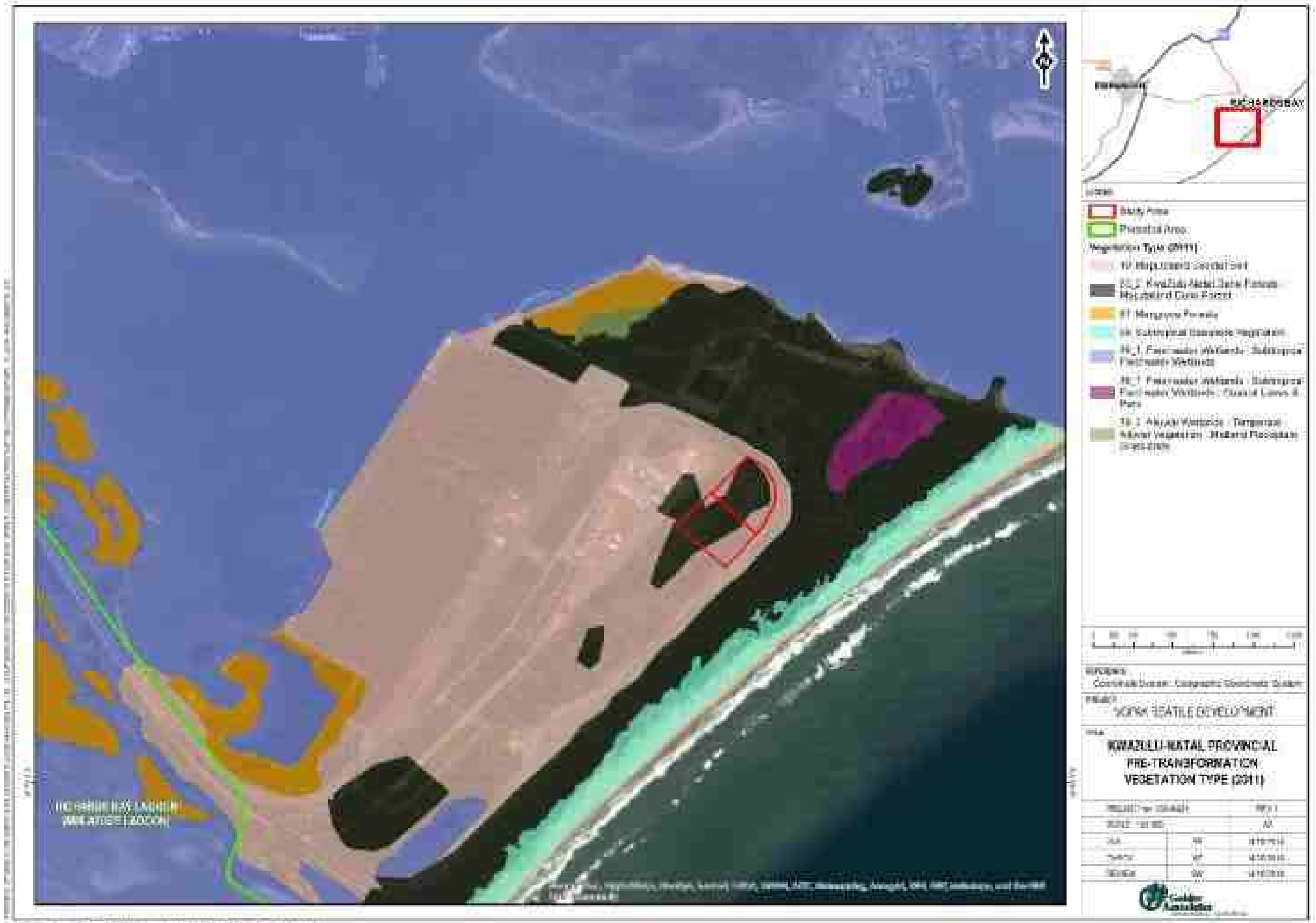

Figure 24: Map showing the proposed Terminal in relation to Scott-Shaw & Escott (2011) Vegetation Types.

4.3.3 National and Provincial Conservation Considerations

The Richard's Bay Nature Reserve constitutes an important protected area in the greater Richard's Bay area. The reserve is 1,192 Ha in extent and is located less than 3 km west and south-west of the proposed Terminal. The Richard's Bay Nature Reserve is formally recognised as a 'nature reserve' (Category IV, Site Code 13307) by the International Union for Conservation of Nature (IUCN) and was created by the construction of a 4 km long causeway across the Richard's Bay estuary (BirdLife International, 2013), creating what is now termed the Mhlathuze Estuary. Three rivers drain into the estuary at this point creating a shallow tidal lagoon fringed by mangroves (*Rhizophoraceae*), papyrus and other reeds and sedges (BirdLife International, 2013). Remnant climax coastal dune forests grow on the eastern side of the sanctuary, with savanna making up the remaining terrestrial habitat (BirdLife International, 2013).

The estuary and surrounding marginal vegetation are critical estuarine habitat for a complex community of water birds and water-associated birds. As a result the Richard's Bay Nature Reserve is recognised by BirdLife International (2013) as an Important Bird Area (IBA) (ZA079).

The main Richard's Bay harbour is situated beyond the peninsula on which the proposed Terminal is located. Despite its active use, the harbour continues to function as an estuary and like the adjacent Mhlathuze Estuary, contains important and diverse marine habitats, including intertidal and shallow sub-tidal mudflats and sandbanks, deep-water basins and channels (CRUZ 2012).

The South African National Biodiversity Institute's (SANBI) list of threatened ecosystems identifies much of the land around the Richard's Bay harbour as Critically Endangered and small pockets as Endangered (Figure 25). A closer examination of the spatial data however, indicates that SANBI adopted a course-grain delineation of this ecosystem as large areas designated as Critically Endangered are in fact completely transformed or already highly disturbed.

Habitat modelling by EKZNW highlights that the greater Richards Bay harbour area may comprise potential habitat for two species of conservation importance, namely the millipede *Centrobolus richardi* and the frog *Hyperolius pickersgilli* (Figure 26).

Figure 25: Delineation of Threatened Ecosystems (SANBI 2009).

Figure 26: Ecological Irreplaceability Map.

4.4 Hydrology (Surface Water)

Regionally the proposed Terminal is located in the Mhlatuze River catchment or Drainage Region W. Locally the area falls entirely within quaternary catchment W12F. The proposed Terminal is situated in the eastern extent of the W12F quaternary catchment. Quaternary catchment W12F covers an area of 39,900 Ha. No water courses cross the proposed Terminal site and the area is covered in dense bush. Therefore run-off from the site will flow to the northeast towards the harbour mouth.

4.4.1 Climate Data

Rainfall data downloaded from the DWS website (Department of Water Affairs, 2008) in the area around the proposed Terminal is presented in Table 13 and shown in Figure 28.

Table 13: Rainfall Station in the Richard's Bay Area.

Station	Name	Distance (km)	Altitude (mamsl)	From	To	No. of Years	MAP (mm)
W1E009	Arboretum at Msingasi Lake	6.22	10	1976	2014	38	1,310

Figure 27 shows the monthly rainfall distribution for Arboretum taken from the Msingasi Lake Rainfall Station.

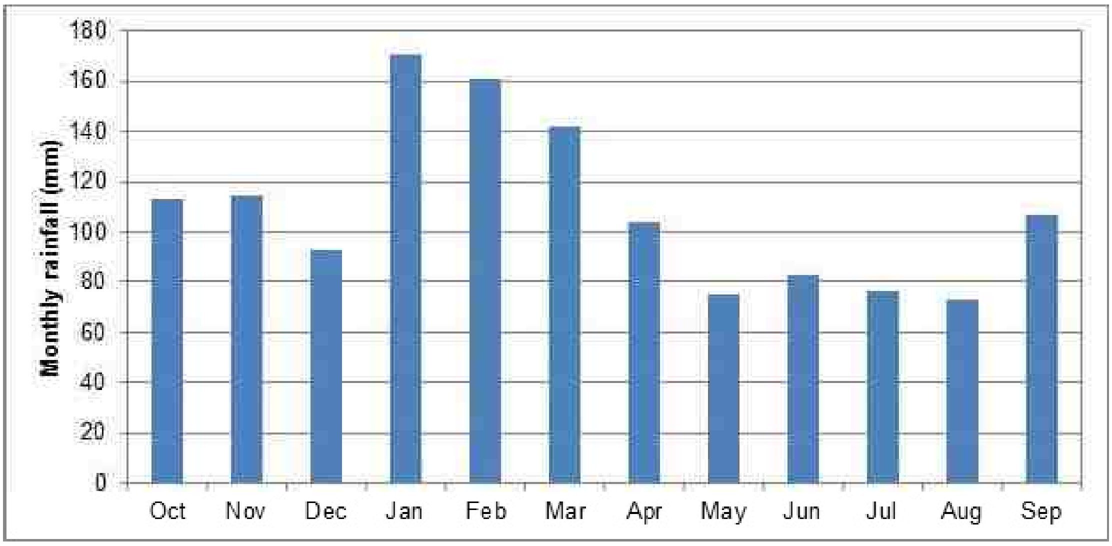

Figure 27: Monthly Rainfall Distribution for Arboretum taken from the Msingasi Lake Rainfall Station.

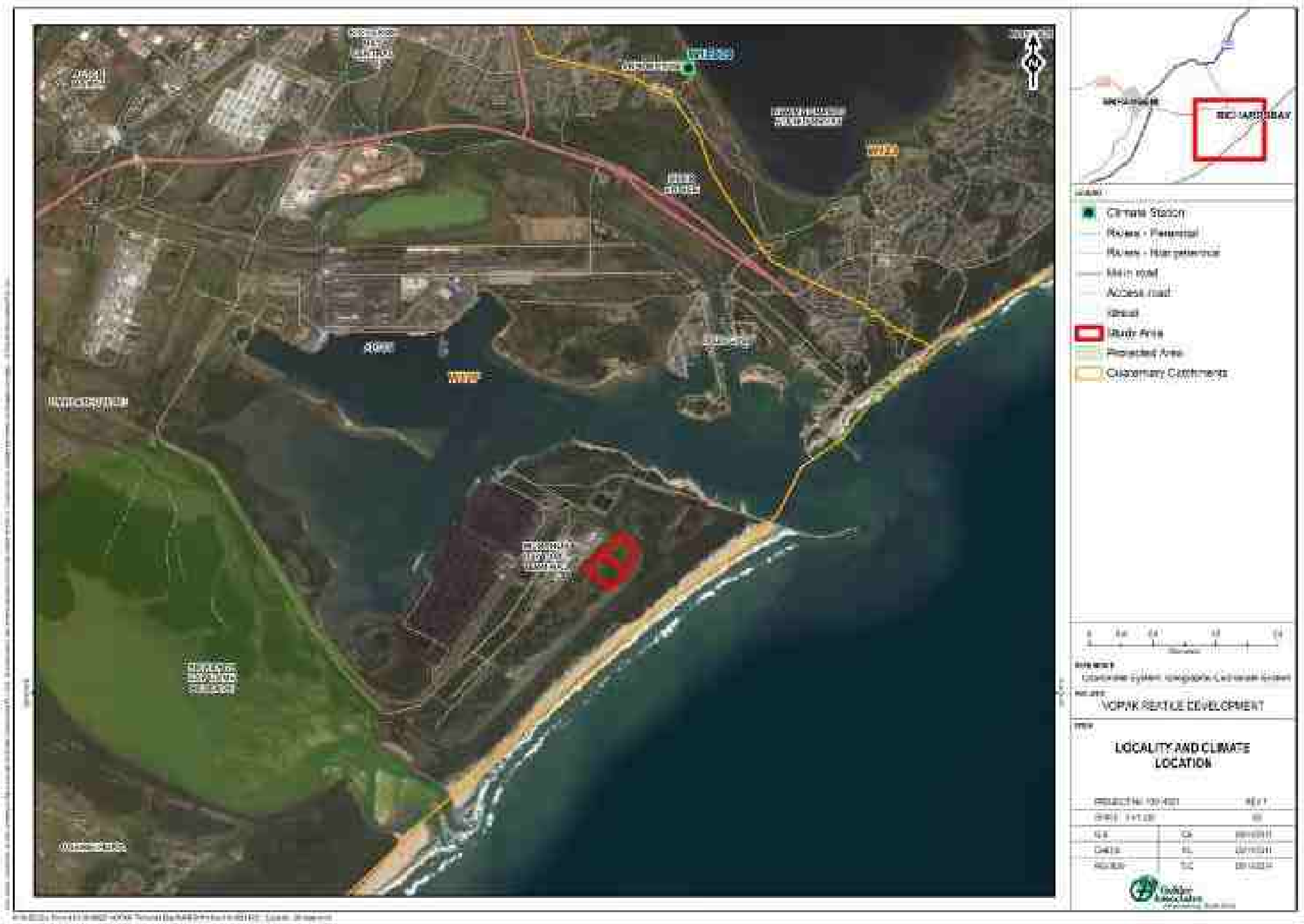

Figure 28: Locality and Climate of the proposed Terminal.

Figure 29 shows the cumulative plot for the Msingasi Lake Rainfall Station. The straightness of the line indicates that there are no anomalies in the data and that the data can therefore be relied upon.

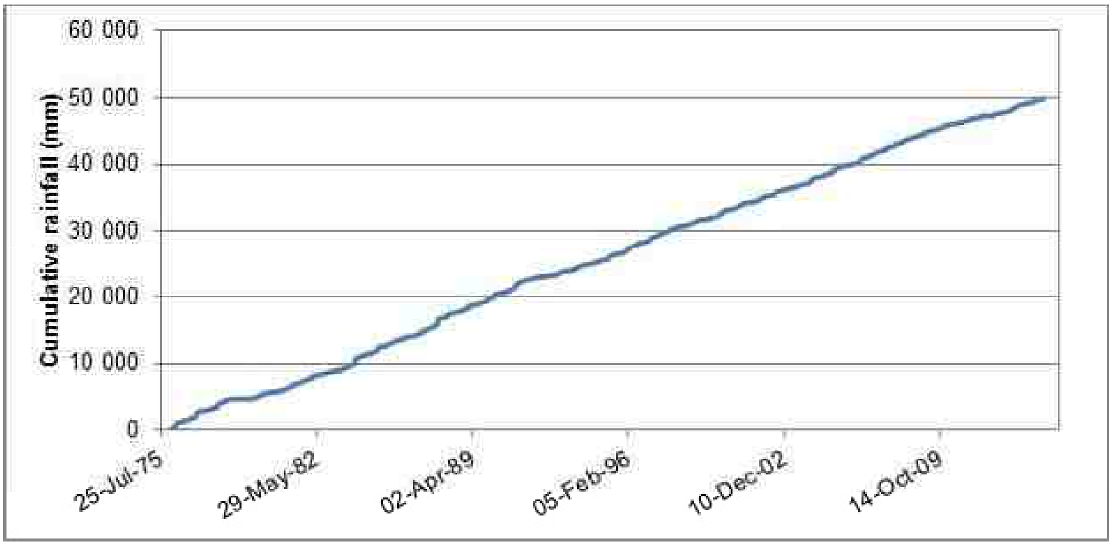

Figure 29: Cumulative rainfall for Aboretum at Msingasi Lake Rainfall Station.

Figure 30 and Figure 31 show the daily and annual rainfall for Arboretum taken from the Msingasi Lake Rainfall Station.

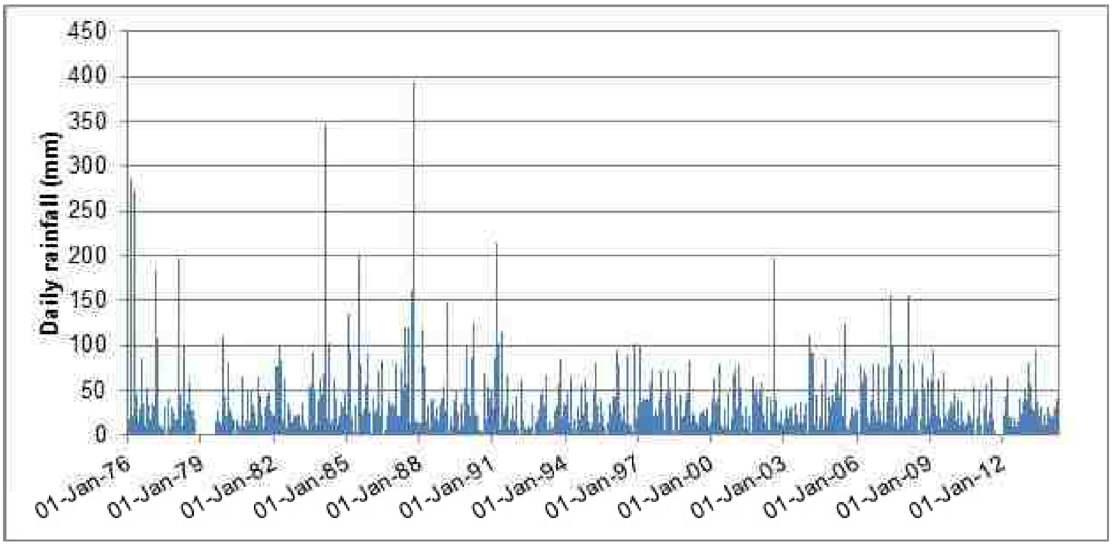

Figure 30: Daily Rainfall for Arboretum taken from the Msingasi Lake Rainfall Station (W1E009)

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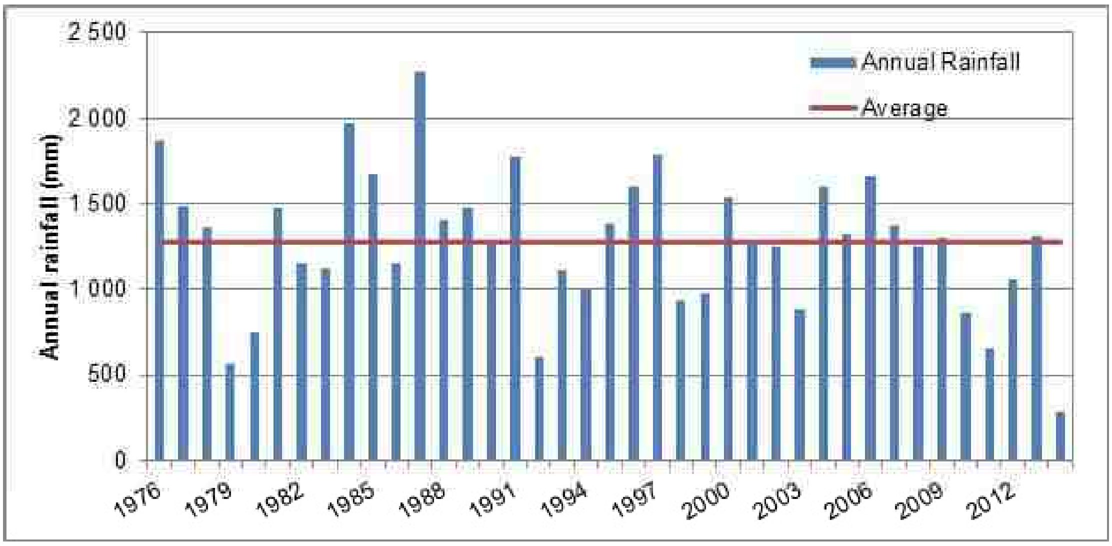

Figure 31: Annual Rainfall for Arboretum taken from the Msingasi Lake Rainfall Station (W1E009)

The mean annual rainfall for Arboretum as taken from the Msingasi Lake Rainfall Station is 1,310 mm. The lowest rainfall year was 1979 with 565.3 mm and the highest rainfall year was 1987 with 2,273.9 mm.

The 5, 50 and 95 percentile of the annual rainfall totals for the Msingasi Lake Rainfall Station are presented in Table 14. Figure 32 shows the annual probability curve for Arboretum taken from the Msingasi Lake Rainfall Station.

Table 14: 5, 50 and 95 Percentile of the Annual Rainfall Totals

Station number	Station name	5%	50%	95%
W1E009	Arboretum at Msingasi Lake	600.49	1,301.20	1,881.57

Table 14 shows there was:

- Less than 600 mm/annum rainfall for 5% of the time;
- Less than 1,301 mm/annum rainfall for 50% of the time; and
- Less than 1,882 mm rainfall for 95% of the time.

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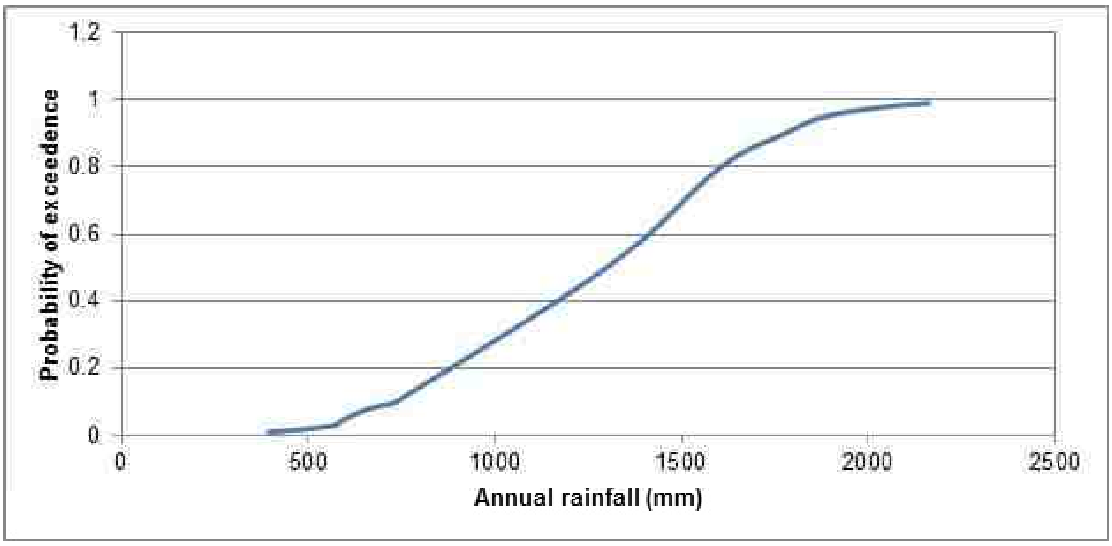

Figure 32: Annual Probability Curve for Arboretum taken from the Msingasi Lake Rainfall Station.

The Msingasi Lake Rainfall Station measured 33 rainfall events of more than 100 mm/day, and 6 rainfall events of more than 200 mm/day during the data period.

Table 15: High rainfall events

Maximum recorded daily rainfall (mm)	**Date of maximum rainfall**
286	26 January 1976
271	20 March 1976
346	31 January 1984
202	23 June 1985
395	28 September 1987
214	18 February 1991

From Table 15 it is evident that the proposed Terminal will experience high rainfall events (of frequently over 100 mm/d and occasionally 200 mm/d).

The 24-hour rainfall depths for the 1:2, 1:5, 1:10, 1:20, 1:50, 1:100 and 1:200 recurrence intervals at the station were calculated from the data available. In order to determine the likely magnitude of storm events, a statistical approach, using the Reg Flood program (Alexander, van Aswegen, & Hansford, 2003) was applied, to the available recorded daily rainfall depths. The maximum 24 hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit is the Log Pearson distribution which resulted in the 24 h storm rainfall depths summarised in Table 16.

Table 16: Computed 24 hour rainfall depths for different recurrence intervals in mm/day

Recurrence interval (years)	**1:2**	**1:5**	**1:10**	**1:20**	**1:50**	**1:100**	**1:200**
24 hour rainfall depth (mm)	103	168.47	218	280	378	466	570

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4.4.2 Potential Evaporation

The proposed Terminal falls within evaporation zone 22A (Midgley, Pitman, & Middleton, 1994). The mean annual S-pan evaporation depth in the area is between 1,300 and 1,400 mm/a. Table 17 summarises the average monthly evaporation values using Arboretum taken from the Msingasi Lake Rainfall Station. The monthly average evaporation depths for the station are shown in Figure 33.

Table 17: Average monthly evaporation (mm)

Month	**W1E009 Arboretum at Msingasi Lake Rainfall Station**
Oct	100.9
Nov	118.6
Dec	139.0
Jan	142.4
Feb	127.6
Mar	123.3
Apr	94.6
May	69.2
Jun	54.9
Jul	57.5
Aug	72.7
Sep	86.1
Annual Evaporation (mm)	**1,186.9**

Figure 33: Average Monthly Evaporation Values for Station W1E009 (S-pan)

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4.5 Sub-Regional Land cover in the Surrounds

A total of ten land cover units were identified within the regional area surrounding the proposed Terminal. These include:

- Forest and Woodland;
- Grassland;
- Urban/Built-up;
- Wetlands;
- Water bodies;
- Mines/Quarries; and
- Bare Rock and Soil (Natural).

Additional vegetation and land cover occurring in the regional vicinity of the proposed Terminal are depicted in Figure 34. These include:

- Cultivated;
- Degraded Forest and Woodland; and
- Plantations.

According to Figure 34, the proposed Terminal appears to be located in Forest and Woodland, and Grassland. Areas surrounding the proposed Terminal site also comprise of Forest and Woodland, and Grassland units. Grassland in the immediate surroundings corresponds with RBCT's and TRE's existing railway lines. The IVS facility is characterised by the Urban/Built-up Land cover unit, while the RBCT is characterised by the Mines/Quarries unit. A wetland area identified in the north-eastern extent of the South Dunes Precinct corresponds with an existing wetland area.

Vegetation within the South Dunes Precinct comprises Mangrove Forest, Maputaland Coastal Belt, Northern Coastal Forest, Subtropical Dune Thicket and Subtropical Seashore Vegetation. A small section of KwaZulu-Natal Coastal Forest which has been listed as an endangered ecosystem in the NEM:BA TOPS list occurs in the southern extent of the IVS Storage Facility. However, according to EKZNW's MINSET data for the area this section of Forest is completely transformed (ACER Africa, 2013a).

The majority of the South Dunes Precinct has been transformed. Past disturbances encountered on site include: relocation of surface soils due to infrastructure development; removal of primary vegetation, with subsequent succession taking place; and alien invasive plant species transforming available habitats on site (ACER Africa, 2013a). The Richards Bay Game Reserve which borders the South Dunes Precinct to the south, and the eChwebeni Natural Heritage Site situated in the northern extent of the South Dunes Precinct contain primary (untransformed) plant communities and ecosystems and, provide prime foraging, roosting and breeding habitat for many fauna species (ACER Africa, 2013a).

The Port of Richards Bay constitutes a built up area interspersed with areas of forest and woodland, and to a lesser extent grassland, and bare rock and soil.

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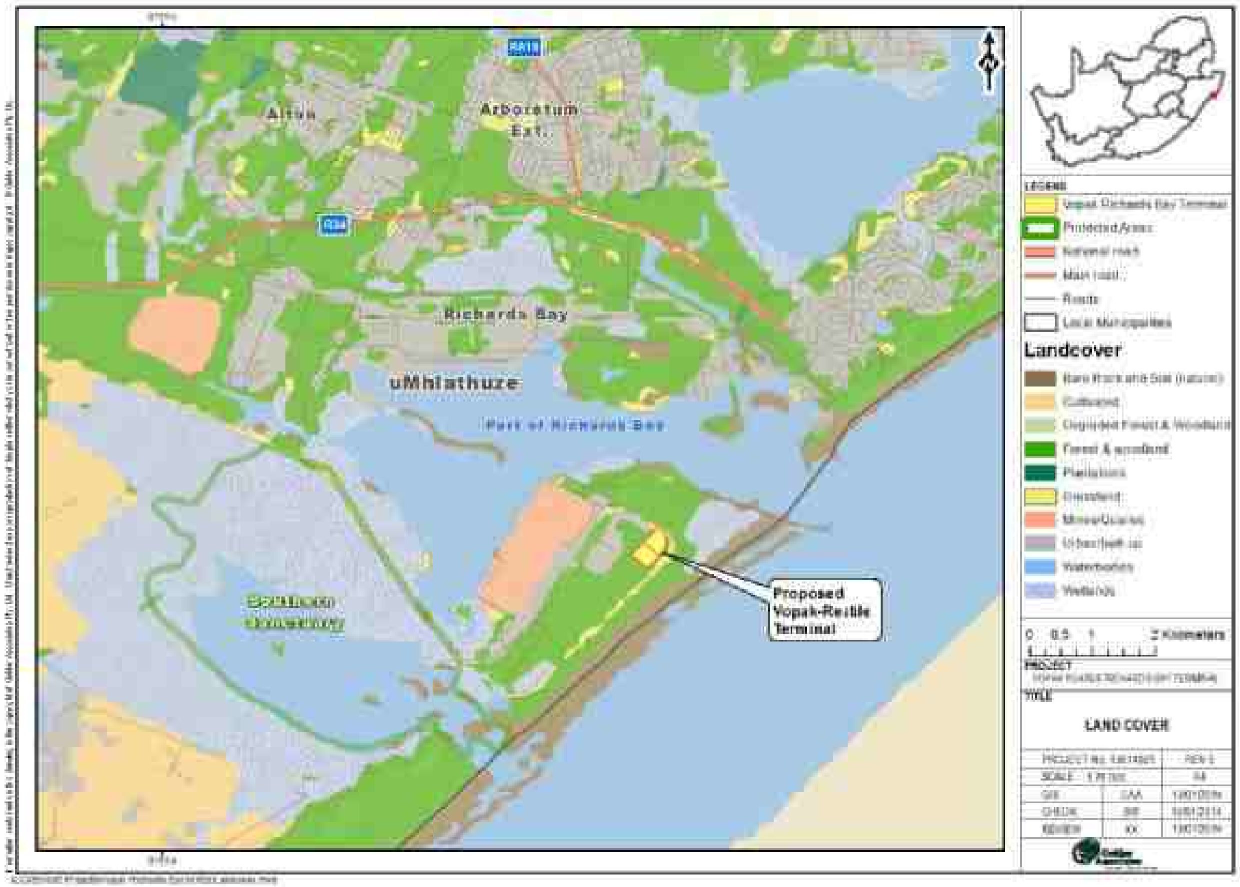

Figure 34: Regional Land Cover of the proposed Terminal and Surrounds.

4.6 Social Baseline

4.6.1 Sub-regional and Site Context

The City of uMhlathuze Local Municipality is situated on the north-eastern coast of KwaZulu-Natal, approximately 180 km north-east of Durban. It is one of six Local Municipalities which form part of the uThungulu District. It is bordered to the north by the Mbonambi Municipality, to the north-west by the Ntambanana Municipality, to the west by the uMlalazi Municipality, and to the east and south by the Indian Ocean.

The City of uMhlathuze Municipality covers an area of approximately 795 km² and is the third largest Municipality in KwaZulu-Natal. The Municipality includes the formal towns of Richards Bay, Empangeni, eSikhawini, Ngwelezane, eNseleni, Felixton and Vulindlela; as well as rural areas which comprise the Dube, Mkhwananzi, Khoza and Zungu (Madlebe) Traditional Authorities. Figure 35 shows the sub-regional area in which the proposed Terminal will be situated. Main access to the area is obtained via the N2 National Road which traverses the area in a north-east to south-west direction, and the R34 which traverses the area in an east-west direction, connecting the towns of Empangeni and Ntambanana in the west with Richards Bay in the east. Railway lines are also prevalent in the municipal area but these provide a commercial/industrial service only and not a passenger service (uMhlathuze Local Municipality: IDP Review 2013/2014).

4.6.2 Population and Demography

The City of uMhlathuze Municipality is the most populated municipality within the uThungulu District. According to the 2011 Census the population of the City of uMhlathuze Municipality was 334,459 (Census, 2011). The Municipal population has increased on average by 1.45% per annum since the 2001 census was undertaken, when the population size was 289,189. Similarly the number of households within the Municipality increased from 67,127 in 2001 to 86,609 in 2011; however the average household size has remained unchanged at 3.9 between 2001 and 2011.

4.6.3 Economic Overview

The towns of Richards Bay and Empangeni constitute the industrial and commercial hubs of the Municipality respectively. Key sectors in the City of uMhlathuze Municipality include trade, tourism, coastal recreation, commerce, industry, forestry and agriculture. The Municipality is home to pioneering industries, and includes two world class aluminium smelters as well as the world's largest export coal terminal (i.e. RBCT). The main industrial plants located within the immediate surroundings include: BHP Billiton (i.e. Bayside and Hillside Aluminium Smelters); Mondi Kraft; Sappi; Bell Equipment, Central Timber Company; Silvacel; Foskor; TNPA; Tronox (formerly known as Exxaro Sands); RBM; Tata Steel and RBCT.

4.6.4 Settlement Pattern

Settlement densities are highest in the formal urban areas of Empangeni, Richards Bay, eSikhawini, Ngwelezane, eNseleni, Vulindlela and Felixton. While historically the peri-urban areas located directly adjacent to the formal urban areas experienced increasing settlement densification, this trend has changed in the Traditional Council areas of the Municipality. As a result areas of denser settlement in the rural (Traditional Council) areas have developed at further distances from the formal urban areas (uMhlathuze, 2013). The two primary nodes of the Municipal area are Richards Bay and Empangeni, while eSikhawini is an emerging primary node. The towns of Ngwelezane, Vulindlela and Felixton are secondary nodes while Nseleni has been classified as a tertiary node.

4.6.5 General Land Uses and Zoning

The urban areas of the City of uMhlathuze Municipality are dominated by residential and industrial land uses. The highest residential densities of single residential units are observed in Aquadene, Esikhaleni, Brackenham and Nseleni. The areas with the highest percentage of land zoned for general residential purposes are Arboretum, Brackenham, Empangeni, Esikhaleni, Meerensee, Veldenvlei and Wildenweide. Within the City of uMhlathuze Municipality land zoned for special residential accounts for approximately 20% of the total zoned land area, while land zoned for industrial uses accounts for approximately 21% of the total zoned land area. Other land use zonings include land zoned for conservation, open spaces, municipal purposes and community type facilities or services. Land zoned for commercial use accounts for less than 2% of the zoned land.

The proposed Terminal is situated within the area identified as the central dune cordon in “Zone 4: Dune Cordon” as identified in the EMF Report for the Richards Bay Port Expansion Area and IDZ (DAERD, 2011). The central dune cordon is used primarily for port-related activities. Activities encouraged within this area include development which is directly related and dependent on the port. The location of the proposed Terminal within this area is therefore in accordance with the recommendations of the EMF Report (DAERD, 2011).

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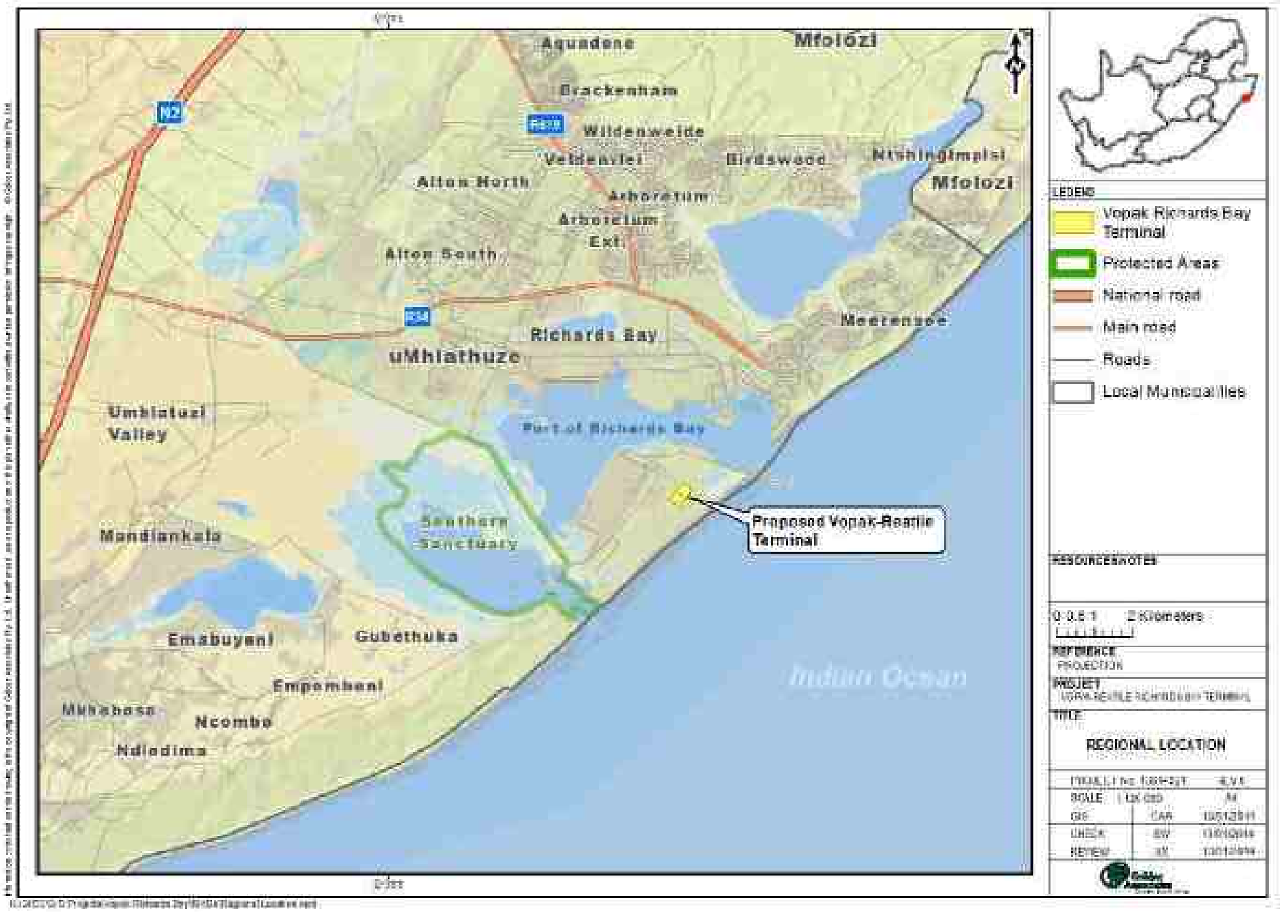

Figure 35: Sub Regional Area in which the proposed Terminal will be Situated.

4.7 Geotechnical Profile

4.7.1 Site Soils

The soil profile of the proposed Terminal comprises a shallow and deep profile. These soil profiles can generally be describes as follows:

Shallow Soil Profile:

On average the top 200 mm of soil consists of loose/very loose topsoil of aeolian origin (i.e. windblown). Underlying this to a depth of at least 1.0 m (but up to 1.7 m in parts) are Quaternary fine sands of loose consistency. The Quaternary profile improves in consistency from loose to, loose to medium-dense below the aeolian topsoil layer. Groundwater is encountered at a depth of between 0.9 m and 1.5 m across the proposed Terminal site (SRK, 2013).

Deep Soil Profile:

Quaternary silty sands of variable consistency (but on average at least medium-dense within approximately 3 m of the surface, becoming dense to very dense soon thereafter) dominate the profile from 12 m to 19 m. Occasional thin horizons of loose soils do occur, but these are by no means dominant. Underlying this, variable horizons of Quaternary silty sands (generally at least medium-dense, but dense on average) and estuarine deposits of clayey silt and silty clay (generally at least firm, but stiff on average) occur. Quaternary silty sands are dominant in the upper profile in the south/south-western portion of the proposed Terminal, but clayey silt and silty clay become more prominent in the profile moving north on the proposed Terminal site (SRK, 2013).

4.7.2 Groundwater Table

Groundwater occurs within 1.5 m of the surface, but at the surface in the dune slack wetland areas (i.e. low lying areas between dunes). The groundwater table is near surface on the proposed Terminal site, and as such dewatering will be a requirement in almost all excavations. The non-cohesive nature of the soils near the surface (i.e. aeolian soils) will support effective dewatering during construction.

4.8 General Geology and Hydrogeology

The proposed site is underlain by Quaternary Sediment (Qs) of the Kalahari Group from the Cenozoic Era. A geological map of the area surrounding the proposed Terminal is provided in Figure 36.

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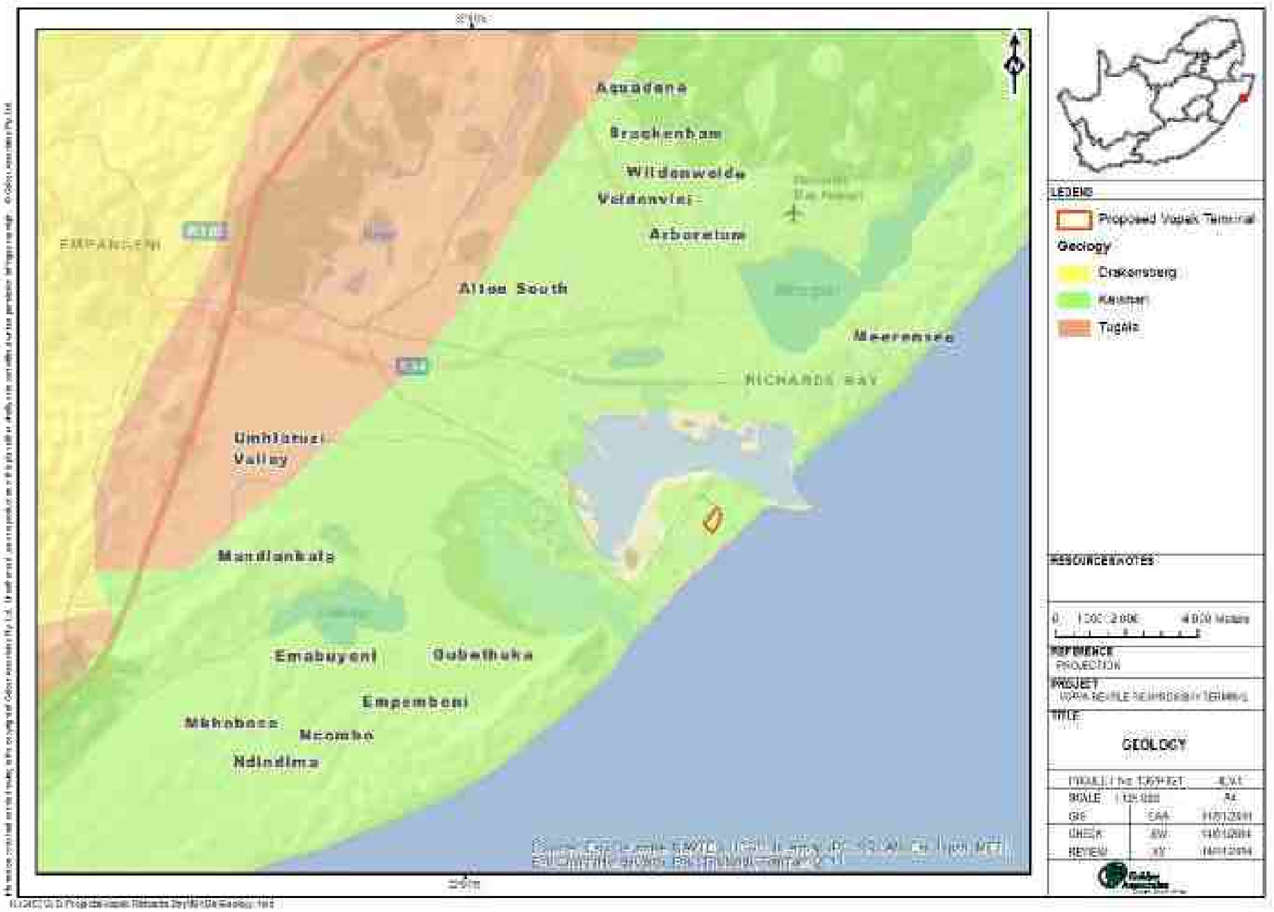

Figure 36: Geological Map of the Area surrounding the proposed Terminal.

4.9 Waste

Wastes generated at the proposed Terminal will comprise of wastewater and solid waste streams.

4.9.1 Wastewater Streams

The following main liquid waste streams will be generated by the proposed Terminal:

- Non-contaminated rainwater;
- Oily/hydrocarbon/organic waste;
- Rainwater from tank pits;
- Tank cleaning waste;
- Spills/Off spec Product; and
- Sanitary Waste.

4.9.1.1 Non-contaminated Rainwater

The proposed Terminal’s sub-catchments are all classified as clean water catchments. The only catchment where run-off could potentially be polluted is the truck loading area, which could potentially be contaminated with oil and grease. Non-contaminated/clean water run-off (i.e. rainwater from roof structures etc.) will run into the onsite stormwater drainage system. Stormwater run-off will be collected onsite in two sumps before being disposed of via TNPA’s proposed stormwater channel.

4.9.1.2 Oily / Hydrocarbon / Organic Waste

This liquid waste consists of different streams, namely:

- Diluted tank cleaning waste;
- Contaminated rainwater from the manifold areas;
- Contaminated rainwater from the loading areas; and
- Rainwater from the main road between the tank pits.

Run-off from areas which have the potential to be contaminated by oils, hydrocarbons or organic waste will be collected and stored for collection, treatment and disposal by a registered offsite facility as required.

4.9.1.3 Rainwater from Tank Pits

Rainwater from tank pits is considered to be non-contaminated rainwater. All tank pits are designed as closed systems, to ensure minimal possibility of contamination on site. However in the case of a leakage or spill this will no longer be the case. In the event of a spill, this would be treated as an incident. If no contaminants are present then the rainwater can be discharged to stormwater drains. If contaminants are present in the rainwater, it needs to be stored appropriately before being collected for treatment and disposal at a registered offsite facility.

4.9.1.4 Tank Cleaning Waste

Initial tank cleaning waste will be pumped directly to vacuum trucks to be exported for processing at a registered offsite facility. Further tank cleaning waste will be re-used, recycled or sent for disposal as per legal requirements.

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4.9.1.5 Spills/Off Spec Product

Large spills and off spec product will be pumped directly to vacuum trucks for offsite processing at a registered facility. The number and size of vacuum trucks required would be dependent on the amount of spilled or off-spec product.

4.9.1.6 Sanitary Waste

Sanitary waste consists of wastewater coming from sanitary facilities such as showers, wash basins and toilets but also wastewater coming from the office facilities. Wastewater will be passed through to the TNPA sewer system. Should this not be available a septic tank system will be installed.

4.9.1.7 Tank and Line Washings

Liquid waste generated during tank and line washing is considered to be hazardous, and will be re-used, recycled or treated at a registered offsite facility which is capable of handling the volumes of washings produced. Washings will be decanted and stored in slop tanks or waste tubes until such time as they are collected and disposed of by a suitable waste contractor. Upon collection waste will be pumped from the slop tanks into a permitted contractor’s tanker for collection and disposal. Certificates of cleanliness and safe disposal will be kept on file.

4.9.1.8 Slops

The quality criteria for products being stored, particularly for chemicals, are very specific. Product can therefore be considered “off-spec” during normal product transfer processes. End of line samples will be done prior to loading a vessel or tank and if the product is considered to be “off specification”, the survey or customer may request a certain volume to be slopped whereby the initial incoming product is transferred into drums for temporary storage, re-use, recycling or disposal as determined by the customer.

During the slopping of incoming product, tests are administered to determine the quality of incoming product. Once the tests being administered verify that the incoming product is above the applicable quality threshold (i.e. the product is “on-specification”), the product is loaded into the intended tank or vessel for storage. The respective customer will then remove the slop drums from the proposed Terminal for re-use back into the production process, recycling or disposal as required.

Samples taken during the movement and storage of product to ensure that it is “on-specification” constitute a source of waste. This waste is disposed into slop drums as “draining’s” and removed by an approved waste contractor. Samples taken by independent surveyors are handled and disposed by themselves.

4.9.1.9 Emergency Waste

Spills

The possibility exists for unanticipated spills to occur at the proposed Terminal in the form of tank and tanker overfills. In the event of a spills or leak of manageable volume occurring, action will be taken to stop the source of the spill/leak, and to contain the spill/leak making use of spill equipment. If there is a risk of fire or a need to control vapours, foam may be used to blanket the spill. Absorbents and neutralizers will be used as required in responding to a spill. Once the spill has been confirmed to be safe, VSAD’s spill response equipment will be used to pump the spilled product into a mobile slop drum, which will be stored onsite until it is removed by a registered contractor. As part of VSAD’s emergency response plan a spill response company will be kept on standby to ensure that large scale events are prepared for. Where quality specifications permit, spilt product may be recovered. However if foam, neutralizers or absorbents were used to handle the spill, recycling is not feasible, and the waste will need to be treated and disposed of in the appropriate manner. Records of all spills will be kept as part of the HSE Key Performance Indicator (KPI) requirements.

Major Incidents

In the event of a major incident occurring, spilt product would collect in the bunded area surrounding the tank, thereby preventing the lateral spread of the spilt product. If a major incident in the form of a tank fire or the loss of containment were to occur, the Emergency Response Procedure would be activated to bring the

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situation under control. Firefighting and/or inter-bund drainage may be required. In both cases significant amounts of waste would be produced (product mixed with firewater). Liquid waste removal contractors would be brought in to remove the waste from the proposed Terminal and undertake the necessary treatment. The waste generated would be treated offsite at a facility with sufficient capacity to treat such large volumes.

4.9.2 Solid Waste

The main types of solid waste to be generated as a result of the proposed Terminal include:

- Paper waste and similar wrapping materials generated by offices, storage and infrastructure;
- Material waste such as contaminated cloth towelling generated during the construction phase and thereafter by maintenance and sanitation; and
- Food and domestic waste from kitchens and waste bins.

Solid wastes will be sorted, collected, and despatched via containers. The containers will be clearly sign posted and colour coded to denote the type of waste.

4.9.2.1 Paper Waste

Paper waste and similar wrapping materials will be generated by offices, storage and infrastructure. This waste will be deposited into dedicated bins and then transferred to waste skips located in a defined area. The skip will be removed on a weekly basis by a recognised waste disposal company for off-site recycling. During construction the skip may require removal more frequently when packaging materials are disposed of and this will be on demand.

4.9.2.2 Cloth Waste

Material waste such as contaminated cloth towelling generated during the construction phases and thereafter by maintenance and sanitation, will be collected in dedicated bins located strategically around the construction site. The bins will be emptied into a waste skip located adjacent to the construction site, and thereafter adjacent to the main workshop area. The skip will be removed on a weekly basis by a recognised waste disposal company for off-site disposal/incineration.

4.9.2.3 Domestic Waste

Food and domestic waste generated from the kitchens, canteen and office waste bins will be collected in bins then transferred to skips located in a defined area. The skip sizes will decrease in size from construction to operation. The skip will be removed on a bi-weekly basis by a recognised waste disposal company for off-site recycling.

4.9.3 Vapour Handling

In order to prevent unnecessary discharge of vapours to atmosphere the following preventative measures are being taken. The venting in general occurs at the following locations:

- Storage tanks containing petroleum products for both 93 octane (ULP93), and unleaded 95 octane (ULP95);
- Road tanker loading facility; and
- Rail Tanker Car loading facility.

4.9.3.1 Storage Tanks

The tanks containing petroleum products will be fitted with internal floating roof systems. This will inhibit vapour loss during the filling and emptying of the tanks hence no vapour handling system would be required.

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4.9.3.2 Road Tanker Loading

A vapour recovery system will be installed at the truck loading to treat the vapour emissions during loading of trucks.

The vapour treatment unit will be located close to the loading gantry and will include storage vessels for the recovered fuel. The recovered product fuel is returned to the respective storage tank. Vapour recovery is not required for diesel loading, however, since the top hatches will not be opened prior to loading, the air displaced from the diesel road tankers will be evacuated via the vapour recovery line. This philosophy also mitigates the risk that a diesel road tanker might have just recently been used for petrol. Also this philosophy prevents operators from having to access the top hatch on the road tanker at the loading bays.

4.9.3.3 Rail Tanker Car (RTC) Loading

A vapour recovery system will be installed at the RTC loading to treat the vapour emissions during loading. As noted for the road tanker loading vapour recovery is not required for diesel loading.

The vapour treatment unit will be located close to the loading gantry and include storage vessels for the recovered fuel. This fuel is returned to the respective product storage tank.

5.0 EIA AND PUBLIC PARTICIPATION PROCESS

A full EIA process essentially has four phases as follows:

- **The Scoping Phase**, during which key issues and concerns regarding the development are identified for further evaluation. The Scoping Report should also discuss the EIA Phase and illustrate how this phase is carried out;
- **The Impact Assessment Phase**, the relevant issues identified during Scoping are assessed by environmental specialists to determine their possible impact on the environment and to recommend ways to reduce the negative impacts and enhance the positive impacts;
- **The Environmental Impact Report Phase**, the findings of the specialist reports are combined into an Environmental Impact Assessment Report, which is then made available for comment by stakeholders; and
- **The Decision-Making Phase**, based on the findings in the EIA Report, the DEDTEA will decide whether the proposed project may proceed or not. This is the final phase of the EIA and requires that an Environmental Management Plan (EMP) is finalised and submitted to the authorities for review.

The full EIA process is shown in Figure 37.

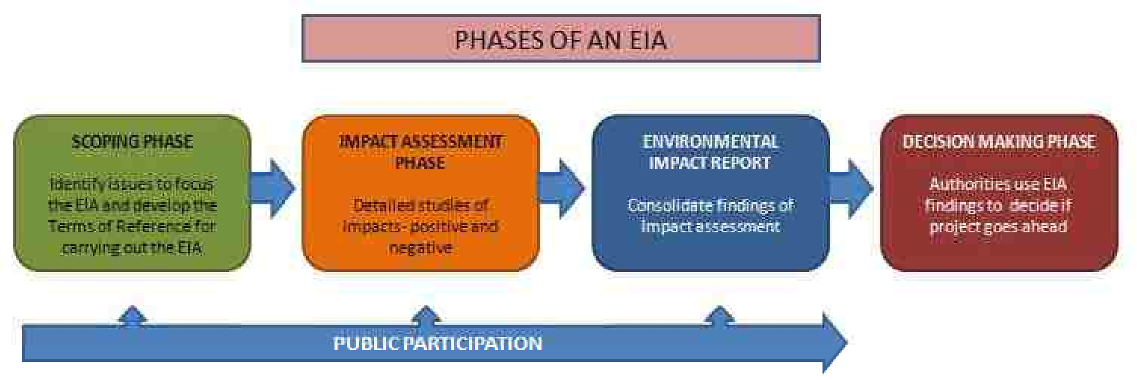

Figure 37: EIA Process Flow Diagram

A Public Participation (PP) process runs concurrent with the EIA process. From the beginning to the end of the EIA process, the PP process plays a pivotal role in the overall ‘effectiveness’ and validity the EIA itself.

5.1 Public Participation Process

The principles that govern communication with society at large are embodied in the principles of NEMA (Chapter 1), South Africa’s overarching environmental law. PP is also an essential and regulatory requirement for any EA process, and is guided by Regulations promulgated under NEMA and NEM:AQA, specifically the NEMA EIA Regulations (GNR 543), and Chapter 5, Section 38, *Procedures for Licence Applications* of NEMA:AQA. For VSAD to meet NEMA/NEMA:AQA requirements a full Scoping, Environmental Impact Reporting and Atmospheric Emission Licencing (AEL) process are being completed, including the legislated extensive Public Participation Process (PPP).

5.1.1 Objectives of Public Participation in an EIA/AEL process

PP is an essential and regulatory requirement for an EA and AEL process. The NEMA EIA Regulations (GNR 543) state that: “Public participation process” means a process in which potential interested and affected parties (I&APs) are given an opportunity to comment on, or raise issues relevant to, specific matters”.

The PPP is designed to provide sufficient and accessible information to I&APs in an objective manner to assist them to:

During the Scoping Phase

- Raise issues of concern and suggestions for enhanced benefits;
- Verify that their issues have been recorded;
- Assist in identifying reasonable alternatives; and
- Contribute relevant local information and traditional knowledge to the environmental assessment.

During the Impact Assessment Phase

- Contribute relevant information and local and traditional knowledge to the environmental assessment;
- Verify that their issues have been considered in the environmental investigations; and
- Comment on the findings of the environmental assessments.

During the Decision-making Phase

- Advise I&APs of the outcomes, i.e. the authority decisions on the EIA and AEL, and how and by when the decisions can be appealed.

Documents are made available at various stages during the EIA process to provide I&APs with information and opportunities to identify issues of concern and suggestions for enhanced benefits, to verify that the issues raised have been considered and to comment on the Scoping and EIA Reports. Following the completion of the EIA and PP processes, the Final EIA Report will be submitted to DEDTEA for decision making.

5.1.2 Identification of Interested and Affected Parties

In terms of the NEMA EIA Regulations (GNR 543), stakeholders are required to formally register as stakeholders/Interested and Affected Parties (I&APs) for the EIA. Golder’s PP team started this process by developing an initial stakeholder list of I&APs and advised stakeholders of the opportunity to register as I&APs for the EIA by addressing letters to them personally.

I&APs were also identified through a process of networking and referral; obtaining information from Golder’s existing stakeholder database; liaison with potentially affected parties in the study area; newspaper advertisements; and a registration process which involved the completion of an I&AP registration and comment sheet. In addition, I&AP registration and comment sheets encouraged I&APs to indicate the names of their colleagues and friends who may also be interested in participating in the EIA.

5.1.2.1 Registration of I&APs

The NEMA EIA Regulations (GNR 543) distinguish between I&APs and registered I&APs as follows:

I&APs, as contemplated in Section 24(4)(d) of NEMA include: (a) any person, group of persons or organisation interested in or affected by the activity; and (b) any organ of state that may have jurisdiction over any aspect of the activity.

In terms of the EIA Regulations (GNR 543) "*registered interested and affected parties*" means:

"An interested and affected party whose name is recorded in the register opened for that application".

For that purpose, an EAP managing an application must open and maintain a register which contains the names, contact details and addresses of:

(a) All persons who: have submitted written comments or attended meetings with the applicant or EAP;
(b) All persons who: have requested the applicant or EAP managing the application, in writing, for their names to be placed on the register; and
(c) All organs of state which have jurisdiction in respect of the activity to which the application relates.

5.2 Public Participation during the Scoping Phase

The public participation process followed during the Scoping Phase of EIA is summarised in Table 18 below.

Table 18: Summary of Public Participation process during Scoping Phase

Date	**Description**
Draft Scoping Report (DSR)	
March 2014	The commencement of the EIA process and the opportunity to participate will be announced by way of: ■ A Background Information Letter (BIL) (27 March 2014) (Appendix B) was addressed to all stakeholders on the database (Appendix C), informing them of the availability of the Draft Scoping Report (DSR) for comment, providing details of the Open House to be held, and inviting them to register as I&APs for the project. ■ An advertisement inviting I&APs to register as stakeholders and to comment on the DSR was published in English in the Zululand Observer Newspaper (28 March 2014) and in Zulu in the Ilanga Newspaper (27 March 2014) (Appendix D) ■ Placing site notices (2 English and 2 Zulu) at locations accessible and visible to the public (Appendix E); and ■ Posting the invitation letter and comment sheet on the Golder website at www.golder.com/public on **27 March 2014**. The DSR was made available for a 40 day public review period from **27 March to 12 May 2014**. The DSR and its supporting documents were distributed for public review and comment as follows: ■ Placed in the following public places: ▪ Richards Bay Library

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	▪ Golder Associates Africa, Midrand ■ Mailed/e-mailed to I&APs who request copies of the report; ■ Distributed at the Open House (see below); and ■ Posted on Golder’s website: www.golder.com/public. I&APs were invited to comment in the following ways: ■ By attending the Open House; ■ By completing and submitting the comment sheets made available with the BIL and with the DSR at the public places; and By submitting additional written comments to the Public Participation Office by e-mail or fax, or by telephone.

Open House	
April 2014	An Open House to discuss the content of the DSR, was held as follows: ▪ Date: Wednesday, 16 April 2014 ▪ Time: 14:00 to 17:00 ▪ Venue: Protea Hotel – Richards Bay Corner Davidson and Launder Lanes Meerensee, Richards Bay The purpose of the Open House was: ■ To present the contents of the DSR and Plan of Study for Impact Assessment to I&APs; and ■ To provide I&APs with an opportunity to contribute issues of concern and suggestions for enhanced benefits. Information was displayed visually and on detailed maps. Copies of the DSR and its supporting documents were made available in hard copy and on CD. Relevant legislation, guidelines and other publications were also made available for I&APs' easy reference. Comments and suggestions raised at the Open House meeting were recorded and captured in a Comment and Response Report (CRR) (Appendix F).
Final Scoping Report (FSR)	
July 2014	The DSR was updated at the end of the public review period. The Final Scoping Report (FSR) was made available to the public for 21 days in accordance with the NEMA EIA Regulations of 2010 and more recent guidance on comment periods**. The opportunity to participate has been announced by way of:** ■ A letter sent to all I&APs announcing the availability of the FSR for comment. The FSR and its supporting documents were made available as follows: ■ Posted on Golder's website: www.golder.com/public. The FSR and its supporting documents were then submitted to the lead authority, the DEDTEA for a decision on whether the Impact Assessment phase of EIA may proceed.
September 2014	DEDTEA acknowledged receipt of, and accepted the FSR on 25 September 2014.

5.3 Public Participation during the Impact Assessment Phase

PP during the Impact Assessment Phase revolves around a review of the findings of the EIA as presented in this Draft EIA Report, which contains the Specialist Studies and the Draft EMP. These reports have been made available for public review and comment for a 40 day period from 23 January 2015 to 4 March 2015. I&APs are also invited to a Public Meeting, scheduled for Wednesday, 11 February 2015.

I&APs have been invited to comment on this Draft EIA Report and supporting reports in any of the following ways:

- By raising comments during the Public Meeting where the findings of the specialist studies will be presented;

- By completing I&AP comment sheets provided with the reports at the public places and submitting additional written comments by e-mail or fax, or by telephone, to the PP team; and
- The Draft EIA Report and its accompanying reports, have been distributed to public places in the project area, and have been posted on the Golder website: www.golder.com/public for I&APs to comment.

All issues raised during the public review and comment period on the Draft EIA Report and its supporting reports will be incorporated into the Comment and Response Report (CRR) that will accompany the Final EIA Report to be submitted to the decision-making authorities.

The Final EIA Report and EMP will be made available to the public for 21 days in accordance with the NEMA EIA Regulations (GNR 543).

The public participation process to be followed during the Impact Assessment Phase of EIA is summarised in Table 19 below.

Table 19: Summary of Public Participation process during Impact Assessment Phase

Date	Description
Draft EIA Report	
January 2015	A letter announcing the availability of the Draft EIA Report for public comment, together with an I&AP comment sheet was mailed to all registered I&APs in January 2015 to: ■ Inform them of the availability of the Draft EIA Report for public comment; ■ Invite them to request copies of the documents should they so wish; and ■ Invite them to the Public Meeting on Wednesday, 11 February 2015.
Public Meeting	
January 2015	The Public Meeting will be held on Wednesday, 11 February 2015. The objectives of the Public Meeting are: ■ To provide I&APs with an overview of the proposed project, the environmental impacts and the recommended mitigation and monitoring measures; ■ For I&APs to comment on the findings of the impact assessment studies and to raise further issues of concern and suggestions for enhanced benefits; and ■ For I&APs to comment on the technical and public participation processes of the EIA.
Final EIA Report	
January 2015	■ All issues, comments and suggestions raised during the public comment period on the Draft EIA Report will be included in the CRR and the EIA Report will then be finalised; ■ The Final EIA Report will be made available to registered I&APs for comment for a period of 21 days, in early 2015; and ■ The Final EIA Report will then be submitted to DEDTEA for decision-making.

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5.4 Impact Assessment Phase

5.4.1 Technical Assessment

During the Impact Assessment Phase specialist studies and relevant documentation was reviewed to investigate the issues of concern raised during the Scoping Phase. A review of these documents was expected to address the issues raised, therefore not necessitating further specialist studies to be conducted.

5.5 Environmental Authorisation

Stakeholders will be advised in writing and by way of advertisements placed in two local newspapers of DEDTEA's decision on the EIA, in other words, on whether EA has been granted or refused for the proposed project, and if granted, the conditions of the authorisation. I&APs will also be advised that the decision may be appealed, and will be provided with guidance on how to do so.

5.6 Consultation Conclusion

Contributions to the EIA process by a wide range of stakeholders and the authorities assist in enhancing the findings and recommendations of the EIA. A range of issues will be raised and reflected in the CRR that will accompany the Final EIA Report thus strengthening the recommendations of the EIA and the provisions of the EMP.

6.0 IMPACT IDENTIFICATION AND ASSESSMENT

6.1 Approach to Impact Assessment

This EIA complies with the requirements of NEMA. Principles contained in NEMA, South Africa's overarching environmental legislation, serve as guidelines for interpreting and implementing the requirements of the project.

Key principles contained in NEMA include:

- Sustainability – development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs;
- Mitigation hierarchy – avoidance of environmental impact, or where this is not possible, minimising the impact and remediating the effects of the impact; and
- Developers have a duty of care towards the environment.

An assessment of the impacts associated with the proposed Terminal was conducted within the context provided by these principles and objectives.

The impact assessment comprised a number of specialist studies. The findings of the specialist studies were then integrated into this DEIAR and the impacts were ranked using the methodology as shown in Section 6.2 that compares the significance of each impact.

The following specialist studies were undertaken as part of this EIA process:

- Air quality Impact Assessment;
- Terrestrial Ecology Impact Assessment;
- Hydrology (Surface Water) Impact Assessment;
- Risk Impact Assessment; and
- Traffic Impact Assessment.

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6.2 Impact Assessment Methodology

The methodology and approach followed during this EIA is described below.

Each specialist undertook an impact assessment, and prepared an impact assessment report as supporting documentation to the EIA. Each impact assessment report included:

- An Executive Summary;
- Introduction;
- Brief project description;
- Methodology including guidelines and standards used in the study;
- Baseline description of the environment;
- Identification of potential impacts associated with the project;
- An assessment of the significance of each potential impact of the project; and
- Recommendations for mitigation/management of impacts.

Impacts were assessed using information gathered during the baseline assessment in combination with previously collected data and the detailed project plan.

The significance of the identified impacts was determined using the approach outlined in Table 20. This incorporates two aspects for assessing the potential significance i.e. occurrence and severity, which are further sub-divided as indicated. The impact ranking is described for both pre and post implementation of mitigation/management measures conditions.

Table 20: Impact Classification for Impact Assessment

	Occurrence			Severity				Environmental Consequence	
Impact	Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation

Occurrence:

- Direction of an impact may be positive, neutral or negative with respect to the particular impact (e.g., a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative).
- Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40 % to 60 % chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

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- Duration refers to the length of time over which an environmental impact may occur: i.e. transient (less than 1 year), short-term (0 to 5 years [construction]), medium-term (5 to 15 years [operational]), long-term (greater than 15 years with impact ceasing after closure of the project) or permanent.

Severity:

- Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as: negligible: no measurable effect (<1%) from current conditions; low: <10% change from current conditions; moderate: 10 to 20% change from current conditions; and high: >20% change from current conditions. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. Each specialist study will attempt to quantify the magnitude and outline the rationale used.
- Scale/Geographic extent refers to the area that could be affected by the impact and is classified as site; local: effect restricted to the LSA; regional: effect extends beyond the LSA into the RSA; and beyond regional: effect extends beyond the RSA site.
- Reversibility allows for the impact to be described as reversible or irreversible.
- Frequency may be low: occurs once; medium: occurs intermittently; or high: occurs continuously.

Environmental Consequence:

- Environmental Consequence: The overall residual consequence for each effect will be classified as one of: no impact, low, moderate or high by evaluation of the rankings for magnitude, geographic extent and duration Table 21.

Table 21: Categories describing Environmental Significance

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur. In the case of adverse impacts, there is no possible mitigation that could offset the impact, or mitigation is difficult, expensive, time-consuming or some combination of these. Social, cultural and economic activities of communities are disrupted to such an extent that these come to a halt. In the case of beneficial impacts, the impact is of a substantial order within the bounds of impacts that could occur.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. In the case of adverse impacts, mitigation is both feasible and fairly easily possible. Social, cultural and economic activities of communities are changed, but can be continued (albeit in a different form). Modification of the project design or alternative action may be required. In the case of beneficial impacts, other means of achieving this benefit are about equal in time, cost and effort.
Low	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts, mitigation is either easily achieved or little will be required, or both. Social, cultural and economic activities of communities can continue unchanged. In the case of beneficial impacts, alternative means of achieving this benefit are likely to be easier, cheaper, more effective and less time-consuming.
No impact	Zero impact

Source: Integrated Environmental Management Information Series, 2002

Prediction Confidence

Although not explicitly included in the criteria tables, there is uncertainty associated with the information and methods used in an EIA because of its predictive nature. The certainty with which an impact analysis can be completed depends on a number of factors including:

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- Understanding of natural/ecological and socio-economic processes at work now and in the future; and
- Understanding of present and future properties of the affected resource.

When there are questions about the factors reviewed above the level of prediction confidence for an impact analysis will be discussed. Where the level of prediction confidence makes a prediction of the impact problematic, a subjective assessment is made based on the available information, the applicability of information on surrogates and on professional opinion.

The level of prediction confidence may be sufficiently low in some cases that an estimate of environmental consequence cannot be made with a sufficient degree of confidence. In such instances, undetermined ratings are accompanied by recommendations for research or monitoring to provide more data in the future.

Development of Mitigation Measures

A common approach to describing mitigation measures for critical impacts is to specify a range of targets with a predetermined acceptable range and an associated monitoring and evaluation plan. To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute. The following summarize the different approaches that may be used in prescribing and designing mitigation measures:

- Avoidance: e.g. mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site;
- Minimization: mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact;
- Rectification: mitigation through the restoration of environments affected by the action;
- Reduction: mitigation by taking maintenance steps during the course of the action; and
- Compensation: mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

6.3 Air Quality Impact Assessment

The Air Quality Impact Assessment specialist report is attached as APPENDIX E.

6.3.1 Scope of Work

The Scope of work for the Air Quality Impact Assessment included the following:

- Baseline assessment:
  - Literature review;
  - Identification of sensitive receptors;
  - Meteorological data analysis;
  - Review of legislation, policies and standards; and
  - Identification of the potential health effects.
- Emissions inventory:
  - Identification of emission sources; and
  - Calculation of emissions rates.
- Impact Assessment:

  - Dispersion modelling; and
  - Impact assessment.
- Mitigation and monitoring:
  - Recommendation of measures to control and/or mitigate the impact of emissions; and
  - Recommendations for monitoring protocols.

6.3.2 Methodology

6.3.2.1 Baseline Air Quality and Meteorology

The baseline air quality assessment included:

- A review of applicable legislation, policy and standards;
- A description of the receiving environment including: topography, land use and sensitive receptors;
- The characterisation of regional climate patterns and analysis of site-specific meteorological data;
- The identification of local emission sources; and
- The identification and discussion of the potential health effects associated with key atmospheric emissions.

An emissions inventory comprises the identification of sources of emission, and the quantification of each source's contribution to ambient air pollution concentrations. The establishment of an emissions inventory therefore forms the basis for the assessment of the impacts of the proposed Terminal on the receiving environment.

Air pollution emissions may typically be obtained using actual sampling at the point of emission, estimating it from mass and energy balances or emission factors which have been established at other, similar operations.

6.3.2.2 Dispersion Modelling

Dispersion modelling is used as a tool to predict the ambient atmospheric concentration of pollutants emitted to the atmosphere from a variety of processes. The AERMOD View modelling software was used to determine likely ambient air pollutant concentrations from the proposed Terminal. AERMOD View is an air dispersion modelling package which incorporates the following United States Environmental Protection Agency (USEPA) air dispersion models into one integrated interface:

- AERMOD;
- ISCST3; and
- ISC-PRIME.

These USEPA air dispersion models are used extensively internationally to assess pollution concentration and deposition from a wide variety of sources.

The AERMET[1] pre-processor was used to process MM5 modelled regional meteorological data for input into ISC-AERMOD. Input to a dispersion model includes prepared meteorological data, source data, information on the nature of the receptor grid and emissions input data.

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[1] AERMET is a pre-processor that organizes and processes meteorological data and estimates the necessary boundary layer parameters for dispersion calculations in AERMOD

6.3.3 Specialist Findings

6.3.3.1 Key Pollutants and Associated Health Effects

Table 22 summarises the health effects associated with the main pollutants affecting the regional air quality, as well as those associated with the proposed Terminal

Table 22: Key Pollutants and Associate Health Effects

Pollutant	Health Effects
Carbon Monoxide	Severe hypoxia Headaches, nausea & vomiting Muscular weakness Shortness of breath Long term exposure can lead to Neurological deficits and damage
Hydrogen Sulphide	Irritation to the eyes, nose, or throat Difficulty in breathing for some asthmatics Loss of consciousness Headaches, poor attention span, poor memory, and poor motor function In extreme cases, death Does not accumulate in the body, therefore there are no long term effects.
Nitrogen dioxide	Effects on pulmonary function, especially in asthmatics Increase in airway allergic inflammatory reactions Increase in mortality
Particulate matter (TSP, PM_{10} and $PM_{2.5}$)	Airway allergic inflammatory reactions & a wide range of respiratory problems Increase in medication usage related to asthma, nasal congestion and sinuses problems Adverse effects on the cardiovascular system Increase in mortality
Sulphur dioxide	Reduction in lung function Respiratory symptoms (wheeze and cough) Increase in mortality
Volatile organic compounds (BTEX)	Adverse effects on the cardiovascular system and central nervous system Increase in mortality Long term exposure can lead to Neurological and cardiovascular system damage and Increased prevalence of carcinomas in the community
Acetone	Slight irritation to nose and pharynx at high concentration (about 1000 ppm). Concentration higher than 2000 ppm may induce sleep, nausea, vomiting, feeling of intoxication and dizziness. Concentration higher than 10000 ppm may induce unconsciousness and death. Daily exposure of 3 hours at 1000 ppm concentration for 7 to 15 years will result in nose and pharynx irritation, disorientation and weakness.
Acrylic acid	Hazardous in case of inhalation (lung corrosive). Causes nose and eye irritation, lung haemorrhage. Tests involving acute exposure of rats, mice, and rabbits have demonstrated acrylic acid to have moderate acute toxicity by inhalation or ingestion, and high acute toxicity by dermal exposure.
Butyl Acrylate	Exposure to butyl acrylate mists or vapours at levels above the recommended exposure limits may cause irritation to the respiratory tract. High exposure could result in pulmonary edema. Inhalation of mists or aerosols could result in irritation, drowsiness and headache.
Diethanolamine	Harmful if inhaled. Irritating to the nose and throat and respiratory system. Over exposure may cause coughing, difficulty in breathing and chest pains. Low inhalation hazard due to low vapour pressure unless material is heated or a mist or spray is generated.

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Pollutant	Health Effects
Ethanol	Vapours may be irritating to the eyes, nose and throat. Inhalation may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of the respiratory tract, and loss of consciousness.
Ethyl Acetate	Vapour may be irritating, experienced as nasal discomfort and discharge, with headache, nausea, dizziness, unconsciousness, liver and kidney damage, and pulmonary edema.
Ethyl Acrylate	Vapours may be irritating to the eyes, nose and throat. Inhalation may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of the respiratory tract, and loss of consciousness.
Butanol	Headaches and irritation of the eyes, nose and throat
Propanol	High vapour concentrations may cause irritation of eyes and respiratory tract.
Methyl ethyl ketone	Nasal and respiratory irritation, dizziness, weakness and fatigue
Methyl isobutyl ketone	Headaches, dizziness, nausea, decreased blood pressure, changes in heart rate and cyanosis may result from over-exposure to vapour or skin exposure. Prolonged inhalation may be harmful.
Propylene glycol	A single prolonged (hours) inhalation exposure is not likely to cause adverse effects. Mists are not likely to be hazardous.
Styrene	Vapours may cause mucous membrane irritation and upper respiratory tract discomfort. High concentrations may result in headache, nausea, insensibility and other central nervous system effects. Repeated exposure to high concentrations may cause liver and kidney damage.
Triethanolamine	Vapours may cause coughing and difficulty breathing. Repeated exposure to high concentrations may cause liver and kidney damage.

6.3.3.2 Emissions Inventory

Emissions from the proposed Terminal were based on Australian National Pollutant Inventory (NPI) emission factors for similar facilities. An emission factor is a tool that is used to estimate emissions to the environment, and this relates the quantity of substances emitted from a source to some common activity associated with those emissions, in this case emissions from the handling and storage of various liquids.

Emissions from the handling and storage of various liquids can be categorised as working and standing losses:

- Working losses are the combined loss from filling and emptying a tank. As the liquid level increases, the pressure inside the tank increases and vapours are expelled from the tank. A loss during emptying occurs when air drawn into the tank becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.
- Standing losses occur through the expulsion of vapour from a tank due to the vapour expansion and contraction as a result of changes in temperature and barometric pressure. This loss occurs without any change in the liquid level in the tank.

A list of possible products handled and stored at the proposed Terminal as well as throughputs are provided in the table below (Table 23) (NPI, 2012).

Table 23: Products Handled and Stored

Product	CAS	Throughput (T/Annum)
Acetone	00067-64-1	7,000
Bitumen	08052-42-4	80,000
Bright stock	64742-54-7	1,600
Butyl Acrylate	00141-32-2	59,000
Caustic soda	01310-73-2	216,000
Di-ethanolamine	00111-42-2	414
Diesel	68334-30-5	120,000
Ethanol	00064-17-5	12,000
Ethyl Acetate	00141-78-6	5,000
Ethyl Acrylate	00140-88-5	21,000
Ethylol 95	09003-99-0	10,000
Ethylol 99	00064-17-5	10,000
Fuel Oil 360	68476-33-5	320,000
Acrylic acid	00079-10-7	2,400
Iso-Butanol	00078-83-1	5,800
Iso-Propylol	00067-63-0	25,000
LPG (propane / butane)	68476-85-7	100,000
Lube SN150	72623-86-0	3,200
Lube SN500	72623-86-0	4,800
Methyl ethyl ketone	00078-93-3	3,000
Methyl isobutyl ketone	00108-10-1	48,000
N-Butanol	00071-36-3	89,000
N-paraffin (kerosene)	64771-72-8	7,200
Petrol (ULP)	08006-61-9	120,000
Propylene glycol	00057-55-6	3,576
Sabutol	00071-23-8	2,300
Styrene	00100-42-5	60,000
Sulphuric Acid	07664-93-9	240,000
TDI	66071-12-3	3,422
Triethanolamine	00102-71-6	2,892
Triethanolamine	00102-71-6	1,421
Voralux 106	09082-00-2	3,850
Voralux HL 109	09082-00-2	2,892
Voranol 4701	25322-69-4	856
Voranol CP 6001	25322-69-4	856

Emissions associated with the handling and storage of the products at the proposed Terminal are presented in Table 24.

Table 24: Vopak-Reatile Emissions Rates

Product	Emission (T/Annum)	Emission (g/s)
Acetone	7.00	0.22
Acrylic acid	0.08	0.00
Butanol	2.82	0.09
Butyl Acrylate	1.87	0.06
Di-ethanolamine	0.01	0.00
Ethanol	1.02	0.03
Ethyl Acetate	0.16	0.01
Ethyl Acrylate	0.67	0.02
Methyl ethyl ketone	0.10	0.00
Methyl isobutyl ketone	1.52	0.05
Propanol	0.79	0.03
Propylene glycol	0.11	0.00
Styrene	1.90	0.06
Triethanolamine	0.14	0.00
Benzene	0.33	0.01
Ethylbenzene	0.06	0.00
Toluene	0.35	0.01
Xylenes	0.27	0.01
Total VOC	55.88	1.77

In calculating the emissions, the following assumptions were made:

- Liquids are stored in standard vertical fixed roof (domed) tanks;
- Liquefied gasses are stored in pressurized horizontal mounded bullets;
- The storage tanks are:
    - In good condition;
    - Well maintained; and
    - Best practice is followed in filling and extracting;
- A default maximum emission rate was used for products without emission factors;
- The vapour recovery unit for petrol is assumed to have a control efficiency of 95%;
- Emissions of LPG are accounted as part of Total VOC emissions; and
- Although small quantities of sulphur oxides are emitted from storage tank vents and tank car and tank truck vents during loading operations, from sulphuric acid concentrators, and through leaks in process equipment these emissions are not significant.

The emission inventory has the following limitations:

It was not possible to estimate the quantity of LPG and sulphuric acid that is likely to be handled by the facility and therefore the emission values were unable to be calculated. However, this does not affect the area affected by the emissions as shown in Figure 38 and Figure 39.

6.3.3.3 Dispersion Modelling

Dispersion modelling for the operation of the proposed Terminal is presented as follows:

- Maximum hourly average concentrations for all pollutants(Figure 38); and
- Maximum annual average concentrations for all pollutants (Figure 39).

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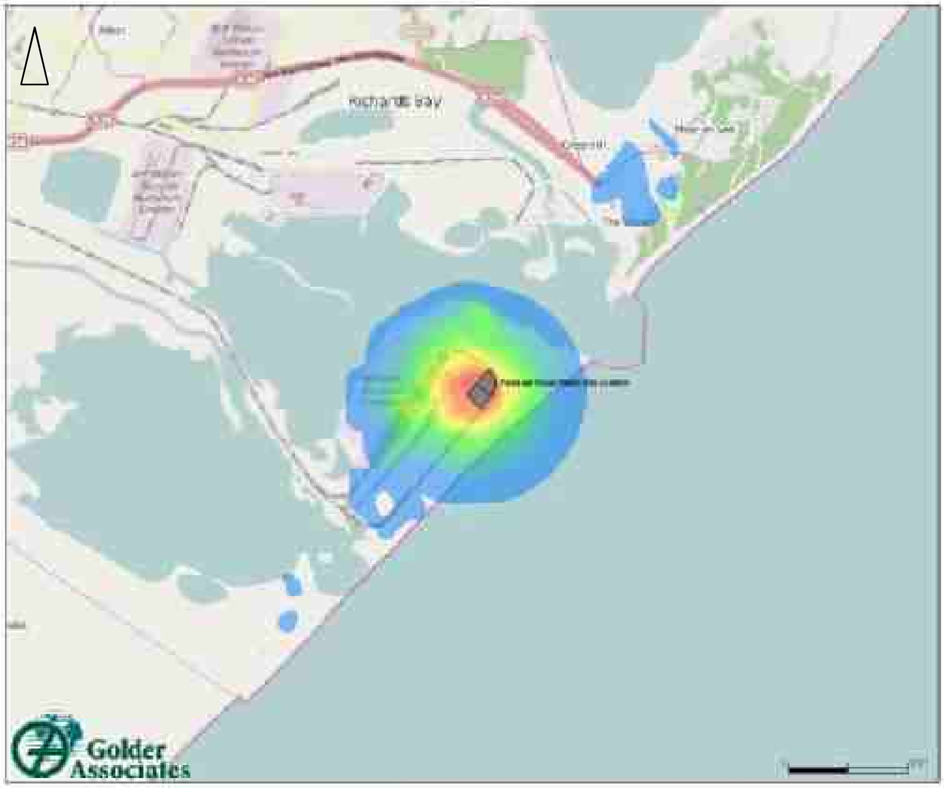
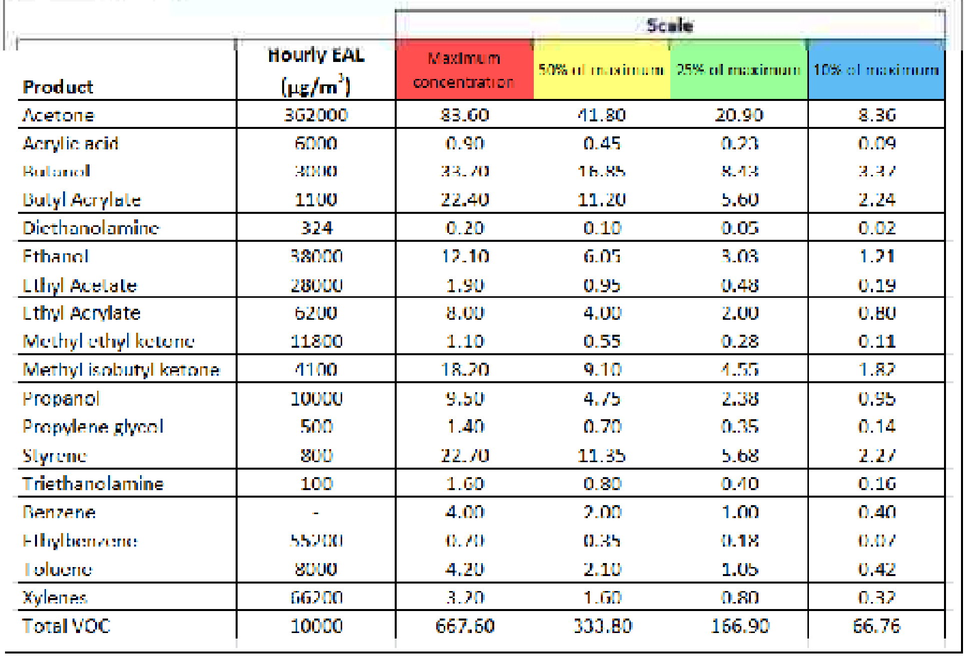
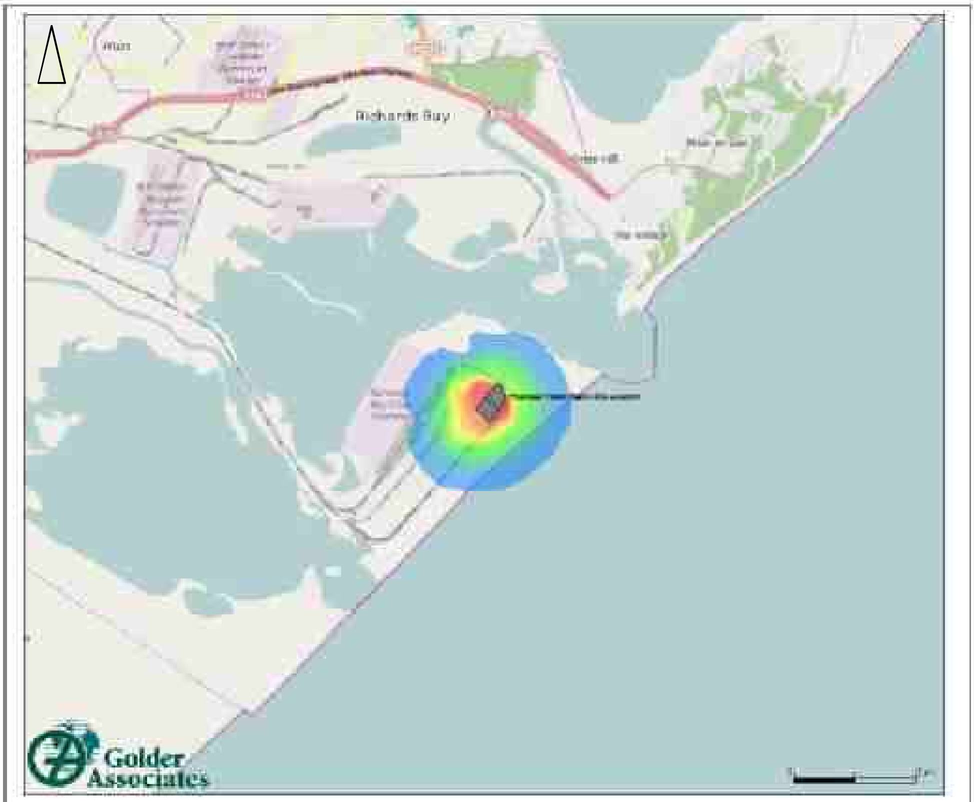




Product	Hourly EAL ($\mu g/m^3$)	Scale			
		🟥 Maximum concentration	🟨 50% of maximum	🟩 25% of maximum	🟦 10% of maximum
Acetone	362000	83.60	41.80	20.90	8.36
Acrylic acid	6000	0.90	0.45	0.23	0.09
Butanol	3000	33.70	16.85	8.43	3.37
Butyl Acrylate	1100	22.40	11.20	5.60	2.24
Diethanolamine	324	0.20	0.10	0.05	0.02
Ethanol	38000	12.10	6.05	3.03	1.21
Ethyl Acetate	28000	1.90	0.95	0.48	0.19
Ethyl Acrylate	6200	8.00	4.00	2.00	0.80
Methyl ethyl ketone	11800	1.10	0.55	0.28	0.11
Methyl isobutyl ketone	4100	18.20	9.10	4.55	1.82
Propanol	10000	9.50	4.75	2.38	0.95
Propylene glycol	500	1.40	0.70	0.35	0.14
Styrene	800	22.70	11.35	5.68	2.27
Triethanolamine	100	1.60	0.80	0.40	0.16
Benzene	-	4.00	2.00	1.00	0.40
Ethylbenzene	55200	0.70	0.35	0.18	0.07
Toluene	8000	4.20	2.10	1.05	0.42
Xylenes	66200	3.20	1.60	0.80	0.32
Total VOC	10000	667.60	333.80	166.90	66.76

Figure 38: Maximum Hourly Average Dispersion Simulations for the Operation of the proposed Terminal.



Product	Annual EAL (µg/m³)	Scale Maximum concentration	50% of maximum	25% of maximum	10% of maximum
Acetone	18100	1.31	0.65	0.33	0.13
Acrylic acid	300	0.01	0.01	0.00	0.00
Butanol		0.53	0.26	0.13	0.05
Butyl Acrylate		0.35	0.17	0.09	0.03
Diethanolamine	7.8	0.00	0.00	0.00	0.00
Ethanol		0.19	0.09	0.05	0.02
Ethyl Acetate	-	0.03	0.01	0.01	0.00
Ethyl Acrylate	210	0.17	0.06	0.03	0.01
Methyl ethyl ketone	-	0.02	0.01	0.00	0.00
Methyl isobutyl ketone		0.28	0.14	0.07	0.03
Propanol	-	0.15	0.07	0.04	0.01
Propylene glycol		0.02	0.01	0.01	0.00
Styrene	800	0.35	0.18	0.09	0.04
Triethanolamine	-	0.03	0.01	0.01	0.00
Benzene	5	0.18	0.09	0.05	0.02
Ethylbenzene	4410	0.03	0.01	0.01	0.00
Toluene	1910	0.29	0.14	0.07	0.03
Xylenes	4410	0.13	0.06	0.03	0.01
Total VOC		41.29	20.64	10.32	4.13

Figure 39: Maximum Annual Average Dispersion Simulations for the Operation of the proposed Terminal.

The results of the simulations were compared with relevant standards and are summarised in Table 25

Table 25: Summary of Results from the Dispersion Simulations

Product	Short term (1 hour average)			Long term (annual average)		
	EAL* (µg/m^3)	**Maximum concentration**	**% of EAL**	**EAL* (µg/m^3)**	**Maximum concentration**	**% of EAL**
Acetone	362,000	83.6	0.02%	18,100	0.95	0.01%
Acrylic acid	6,000	0.9	0.02%	300	0.01	0.00%
Butanol	3,000	33.7	1.12%		0.38	
Butyl Acrylate	1,100	22.4	2.03%		0.25	
Diethanolamine	324	0.2	0.05%	7.8	0.00	0.02%
Ethanol	38,000	12.1	0.03%		0.14	
Ethyl Acetate	28,000	1.9	0.01%		0.02	
Ethyl Acrylate	6,200	8.0	0.13%	210	0.09	0.04%
Methyl ethyl ketone	11,800	1.1	0.01%		0.01	
Methyl isobutyl ketone	4,100	18.2	0.44%		0.21	
Propanol	10,000	9.5	0.09%		0.11	
Propylene glycol	500	1.4	0.27%		0.02	
Styrene	800	22.7	2.84%	800	0.26	0.03%
Triethanolamine	100	1.6	1.64%		0.02	
Benzene	-	4.0	-	5	0.04	0.90%
Ethylbenzene	55,200	0.7	0.00%	4,410	0.01	0.00%
Toluene	8,000	4.2	0.05%	1,910	0.05	0.00%
Xylenes	66,200	3.2	0.00%	4,410	0.04	0.00%
Total VOC	10,000	667.6	6.68%		7.57	

** See Section 3.1.2.5*

The results of the dispersion simulations indicated that:

- Maximum offsite long term (annual) and short term (hourly) concentrations for all pollutants did not exceed 10% of their respective guideline or standard;
- Maximum offsite long term (annual) and short term (hourly) concentrations for all pollutants occurred within 250 m of the proposed Terminal's fence line; and that
- Concentrations of pollutants decreased by 50% within 500 m, and by 75% within 1 km of the proposed Terminal's fence line.

6.3.4 Impact Assessment

6.3.4.1 Construction Phase

Site clearing and construction activities are significant sources of fugitive dust emissions that may have a substantial, but temporary impact on the local air quality in the vicinity of the proposed Terminal. The following possible sources of fugitive dust and particulate emissions were identified as activities which could potentially generate significant quantities of particulate matter and TSP (dust) during site clearing and construction activities:

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- Site Clearing and Preparation activities:
  - Debris removal;
  - Removal of obstacles such as boulders, trees, etc.;
  - Truck loading, transport and unloading of debris;
  - Earthworks;
  - Vehicular traffic (exhaust emissions and entrainment of dust on unpaved roads);
  - Bulldozing, excavating and scraping;
  - Loading and unloading excavated material;
  - Dumping of fill material, road base, or other materials; and
  - Compacting and grading.
- Construction activities:
  - Particulate matter (soot) and gaseous emissions such as carbon monoxide, sulphur oxides, nitrogen oxides and organic compounds including polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) emissions, including:
    - Vehicle exhaust emissions associated with the operation of heavy machinery and related equipment for earthmoving and construction purposes (excavators, bulldozers, cranes, etc.) and the engines associated with such machines;
    - Exhaust emissions associated with the diesel generators required for additional electricity generation;
  - Dust and finer, fugitive particulate matter emissions associated with the following:
    - Erection of structures using steel, concrete, brick, glass, timber, and other materials;
    - Mechanical activities including grinding, hammering and drilling;
    - Metal joining and finishing including welding, brazing, soldering and other techniques;
    - Generation of solid wastes and debris, their stockpiling, transfer, and loading onto trucks or into skips;
    - Transport of building materials and supplies onto the site, and transport of wastes off site; and
    - Movement of vehicles along unpaved roadways and paths, in and out of the site and within the site, together with any establishment and maintenance of the roadways (e.g. grading).
  - Odour generation through the release of VOCs, associated with extensive applications of paints, sealants, caulking compounds, adhesives and waterproofing agents over large surface areas.

Emissions to the atmosphere from construction sites also include smoke and odour.

The quantities of dust will vary according to the intensity of activity, the type of operation and the meteorological conditions. Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive industries and aesthetics.

These impacts will however have a short duration and will be limited to the proposed Terminal site. IVS employees, located adjacent the proposed site, are not likely to suffer health effects however the dust may become a nuisance during periods of increased activity or wind speeds. It is for these reasons; the environmental consequence of the impact is anticipated to be moderate.

The implementation of mitigation measures will reduce the magnitude of this impact, thus reducing the significance of the impact to low.

Similarly, the magnitude and duration of the degeneration of the ambient air quality due to an increase in gases (CO, NO_x, SO_x, and VOCs) and particulate matter (soot) associated with vehicle exhaust emissions is anticipated to be low.

The magnitude, duration and environmental consequence of impacts associated with the erection of structures, mechanical activities (drilling, grinding etc.), metal joining and finishing and applications of paints, sealants, adhesives etc. is anticipated to be low.

6.3.4.2 Operational Phase

The significance of the proposed Terminal's operational impacts on the ambient air quality was simulated and quantitatively assessed. Based on this assessment, the proposed Terminal will have a negative impact on the existing ambient air quality, for the duration of its operations. The magnitude of the impact is however predicted to be low (< 10% from current conditions) and limited to the proposed Terminal site. The impact is therefore likely to have a low environmental consequence.

6.3.4.3 Decommissioning Phase

Similarly to land clearing and site preparation, decommissioning activities are likely to constitute significant, yet short lived sources of fugitive dust emissions that may have substantial, but temporary impact on the local air quality in the vicinity of the proposed Terminal. Of particular significance would be dust and particulate emissions associated with the following:

- Generation of solid wastes and debris, their stockpiling, transfer, and loading onto trucks or into skips;
- Transport of wastes off site; and
- Movement of vehicles along unpaved roadways and paths, in and out of the proposed Terminal site and within the site itself.

Particulate matter (soot) and gaseous emissions such as carbon monoxide, sulphur oxides, nitrogen oxides and organic compounds including polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) emissions are also likely to result from heavy vehicle/machinery exhausts emissions.

Air quality impacts are, however limited to the 'active' phases of the proposed Terminal. Provided the proposed Terminal site is rehabilitated and potential sources of wind erosion (such as stockpiles and open/exposed areas) are re-vegetated, there will be no long term residual impact on the ambient air quality. The impact is therefore likely to have a low environmental consequence.

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Table 26: Rating of Potential Air Quality Impacts Associated with the Proposed Terminal.

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Demolition and debris removal (including transportation, loading and unloading)	Fugitive dust and PM emissions	Negative	Definite	Transient	Medium	Site	Reversible	Medium	Moderate	Low
Earthworks	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Vehicular traffic	Fugitive vehicle exhaust emissions (CO, SO_x, NO_x, PM and VOCs)	Negative	Definite	Short term	Low	Site	Reversible	Medium	Low	Low
	Fugitive dust and PM emissions from travelling on unpaved roads	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Vehicle and generator	Exhaust emissions	Negative	Definite	Short term	Low	Site	Reversible	Medium	Low	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
exhaust emissions	(CO, SO_x, NO_x, PM and VOCs)									
Erection of structures	Fugitive dust and PM emissions	Negative	Definite	Transient	Low	Site	Reversible	Medium	Low	Low
Mechanical activities (drilling, grinding etc.)	Fugitive dust and PM emissions	Negative	Definite	Transient	Low	Site	Reversible	Low	Low	Low
Stockpiling, transfer, and loading of waste and building material	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Metal joining and finishing	Fugitive PM emissions	Negative	Medium	Transient	Low	Site	Reversible	Low	Low	Low
Movement of vehicles along roadways (i.e. dust entrainment on unpaved roads	Fugitive dust and PM emissions from travelling on unpaved	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
	roads								🟧	🟩
Extensive applications of paints, sealants, adhesives etc.	Odour and VOCs	Negative	Medium	Transient	Low	Site	Reversible	Low	Low	Low
Storage losses from tanks	Volatile gas emissions	Negative	Definite	Medium term	Low	Site	Reversible	Medium	Low	Low
Working losses during product handling	Volatile gas emissions	Negative	Definite	Medium term	Low	Site	Reversible	Medium	Low	Low
Demolition of structures	Fugitive dust and PM emissions	Negative	Definite	Transient	High	Local	Reversible	Low	Moderate	Low
Stockpiling, transfer, and loading of waste	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Movement of vehicles along unpaved roadways	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Re-vegetation	Reduction	Positive	High	Long term	Low	Site	Reversible	High	No Impact	No Impact

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
post closure	in fugitive dust and PM emissions									

6.3.5 Specialist Conclusions

Based on the available data; the construction and operation of the proposed Terminal will impact negatively on local ambient air quality. The overall significance of this impact is however predicted to be low, as the proposed Terminal is predicted to comply with local (South African) source emission and ambient air quality standards and guidelines. As a result, there should be no detrimental impacts on sensitive receptors in the vicinity of the proposed Terminal.

Since the type, volume and throughput of chemicals stored at the proposed Terminal will be dependent on market conditions, the parameters assessed in the Air Quality Impact Assessment may change. The assessment has been undertaken based on the list of products provided in Table 6. This is thought to be a worst case scenario for the quantity and hazardous nature of products that are likely to be stored on site. However if the quantity and type of products stored were to significantly increase in volume or hazard this assessment may need to be reviewed.

6.4 Terrestrial Ecology Impact Assessment

The Terrestrial Ecology Impact Assessment specialist report is attached as APPENDIX F.

6.4.1 Scope of Work

The scope of work for the Terrestrial Ecology Impact Assessment included the following:

- Present a description of the study area’s existing flora and fauna characteristics;
- Identify sites and species of conservation importance that occur, or potentially occur, in the study area, or that may be affected by the proposed project;
- Identify and assess potential negative ecological impacts associated with the proposed project; and
- Recommend management measures to mitigate negative ecological impacts.

6.4.2 Methodology

The terrestrial ecology assessment included an ecological characterisation phase, followed by an impact assessment phase. The ecological characterisation phase comprised a desktop literature review component, as well as a field programme that included fauna and flora sampling. The impact assessment was informed by the findings of the ecological characterisation, and the significance of potential impacts were assessed.

6.4.2.1 Literature Review

Vegetation

Mucina and Rutherford (2006) and ACER (2013), as well as other relevant literatures sources were consulted to develop an understanding of the broader vegetation characteristics of the Richards Bay area and the harbour peninsula on which the proposed Terminal is located. Vegetation data for the 2832CC quarter degree grid square as presented on SANBI’s SIBIS (Version 2) database and the EKZNW database (2011b) were obtained to develop plant species lists for the site.

Arthropoda

A list of expected arthropod species list was compiled by consultation of a number of literature sources relevant to the study area including the EKZNW database data for the 2832CC quarter degree grid square (EKZNW, 2011b). Field guides such as Picker *et al* (2002) were also consulted during the compilation of the expected species list.

Reptiles

An expected reptile species list was compiled by consultation of a number of literature sources relevant to the study area, including the EKZNW database data (EKZNW, 2011b) and ACER (2013). Field guides such as Branch (1996), as well as the MSc. thesis by Maritz (2007), were consulted during the compilation of the expected species list.

Amphibians

An expected amphibian species list was compiled by consulting the EKZNW database data (EKZNW, 2011b), ACER (2013), Du Preez and Carruthers (2009), and the MSc Thesis by Maritz (2007).

Birds

A list of expected bird species was compiled by consulting the EKZNW database (EKZNW, 2011b), Harrison, et al. (1997a), Sinclair et al. (2002) and ACER (2013).

Mammals

A list of expected mammal species was compiled by consulting the EKZNW database (EKZNW, 2011b) and literature sources such as Smithers (1983), ACER (2013), and the field guide by Stuart and Stuart (2007)

6.4.2.2 Field Methodology

6.4.2.2.1 Vegetation Surveys

Satellite imagery of the area was consulted as a first approximation of the plant communities within the proposed Terminal site. Plant communities were roughly delineated based on the satellite imagery and previous studies were consulted in order to determine the vegetation type. In order to study the vegetation in greater detail relevés (sample plots) were selected according to vegetation types identified. Relevé data was collected in the field by means of point transects (for species occurring in the herbaceous layer) and belt transects (for tree and shrub species and lianas).

Species that were not identified in the field were sampled or photographed for identification at a later stage by consulting literature sources. Vegetation data was collected by Golder from 10 – 14 March 2014 and by ACER from 9 – 11 September 2014.

6.4.2.2.2 Fauna Surveys

Fauna sampling sites were selected on completion of the initial vegetation assessment in order to encompass all of the possible habitats found on the proposed Terminal site, as well as concentrate on sites which will either be directly affected by the proposed Terminal, or be likely to host increased diversity or protected / Red Data species. Field work was conducted on site by Golder for 5 days from the 10 – 14 March 2014 and by ACER from 9 – 11 September 2014.

Arthropoda

Surveying techniques for anthropods included the following:

- Pitfall traps were set out in a 10 m x 10 m grid within each of the selected sites;
- Sweep netting was conducted where vegetation was appropriate for this technique. Transects of 50 m were swept for arthropods at each site.
- Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching in suitable habitats (rocks, logs, artificial cover, leaf litter, artificial litter, bark, leaf axils, etc.), and scanning sites where specimens were likely to be found.

Reptiles

The following survey techniques were used to sample for reptiles:

- Roads and paths on the site were traversed during the day. Emphasis was placed on attempting to find *Bradypodion setaroi* (Setaro's Dwarf Chameleon), which may occur in the area; and
- Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching all suitable habitats (rocks, logs, artificial cover, leaf litter, artificial litter, bark, leaf axils, etc.), and scanning basking sites and places where specimens were likely to be found.

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Amphibians

Amphibian sampling included active searchers, which was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching suitable habitat types (leaf litter, artificial litter, pools, streams, etc.), and scanning basking sites and places where specimens were likely to be found.

Birds

The avian surveys were conducted by means of point counts of 15 minutes each (Bibby et al, 1993). During the survey, bird species were identified, and where necessary, identifications were verified using Sasol Birds of Southern Africa, 3rd ed. (Sinclair *et al*. 2002). Particular attention was paid to suitable roosting, foraging and nesting habitats for Red Data species.

Mammals

Small mammals were trapped by means of 10 Sherman traps placed in a single grid, at each of the fauna survey sites. The data collected during Sherman trapping was augmented by surveys of tracks, signs and other evidence of small or large mammal activity.

The mammal sensitivity assessment was based on the suitability of available habitat for species of particular conservation concern. The sensitivity of the mapped habitats was then assessed in terms of how the potential impacts of the proposed project would alter the state of the habitat and therefore the continued presence of the particular species.

6.4.3 Specialist Findings

6.4.3.1 Vegetation Assessment

The proposed Terminal is situated on an island that is surrounded by water and connected to the main land through a narrow land bridge. Two vegetation communities occur at the proposed Terminal site (ACER pers. comm. 2014):

- *Brachylaena discolor – Apodytes dimidiata* short thicket community; and
- *Phragmites australis – Typha capensis* wetlands.

Brachylaena discolor – Apodytes dimidiata Short Thicket Community

The *Brachylaena discolor – Apodytes dimidiata* short thicket community is a degraded representation of the Maputaland Coastal Belt vegetation type. This community is a mosaic of coastal thickets, secondary coastal thickets and *Imperata cylindrica* as well as *Typha* wetlands. In places, the topography is sharply undulating (ACER pers. comm. 2014).

Where fast drainage of water occurs, *Imperata* wetlands are found, and where the water drains away slowly, *Typha* wetlands are found. This community was severely disturbed in the past by the invasive alien species, Horsetail tree (*Casuarina equisetifolia*), however, recently, the Horsetail trees were cut down in an effort to control alien invasive species (ACER pers. comm. 2014). This has allowed indigenous vegetation to return to the proposed Terminal site, and at present this plant community is in various stages of succession. The community to the south-western corner of Lot 5 is still in good ecological condition, albeit slightly disturbed by common Lantana (*Lantana camara*) (ACER pers. comm. 2014).

Adenia gummifera var. *gummifera, Ficus trichopoda, Sideroxylon inerme* and *Mimusops caffra* are some of the woody plant species recorded in the *Brachylaena discolor – Apodytes dimidiata* short thicket community. *Adenia gummifera* var. *gummifera* is listed as Declining (IUCN(2014.2) – Regional Status, while *Ficus trichopoda, Sideroxylon inerme* and *Mimusops caffra* are listed as protected according to both the National Forest Act (No. 84 of 1998) and Schedule 7 of the KwaZulu-Natal Nature Conservation Management Amendment Act (No. 5 of 1999).

Phragmites australis – Typha capensis Wetlands

The *Phragmites australis – Typha capensis* wetlands are permanently inundated with water and occur in depressions that allow for the accumulation of surface water. The high water table which is encountered at a

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depth of between 0.9 and 1.5 m across the proposed Terminal site and at surface in the dune slack wetland areas (SRK, 2013) provides a significant groundwater contribution to the wetlands (ACER pers. comm. 2014).

The deep water zone is dominated by *Typha capensis* and *Phragmites australis*. The seasonal zone is dominated by *Cyclosorus interruptus* and *Leersia hexandra*. Several *Cyperus* species are abundant and *Juncus kraussii* can also be found. *Ficus sur* and *Ficus trichopoda* are found outside the deep water zone (ACER pers. comm. 2014). The alien plant *Casuarina equisetifolia* invades this wetland from the edge of the temporary zone (ACER pers. comm. 2014).

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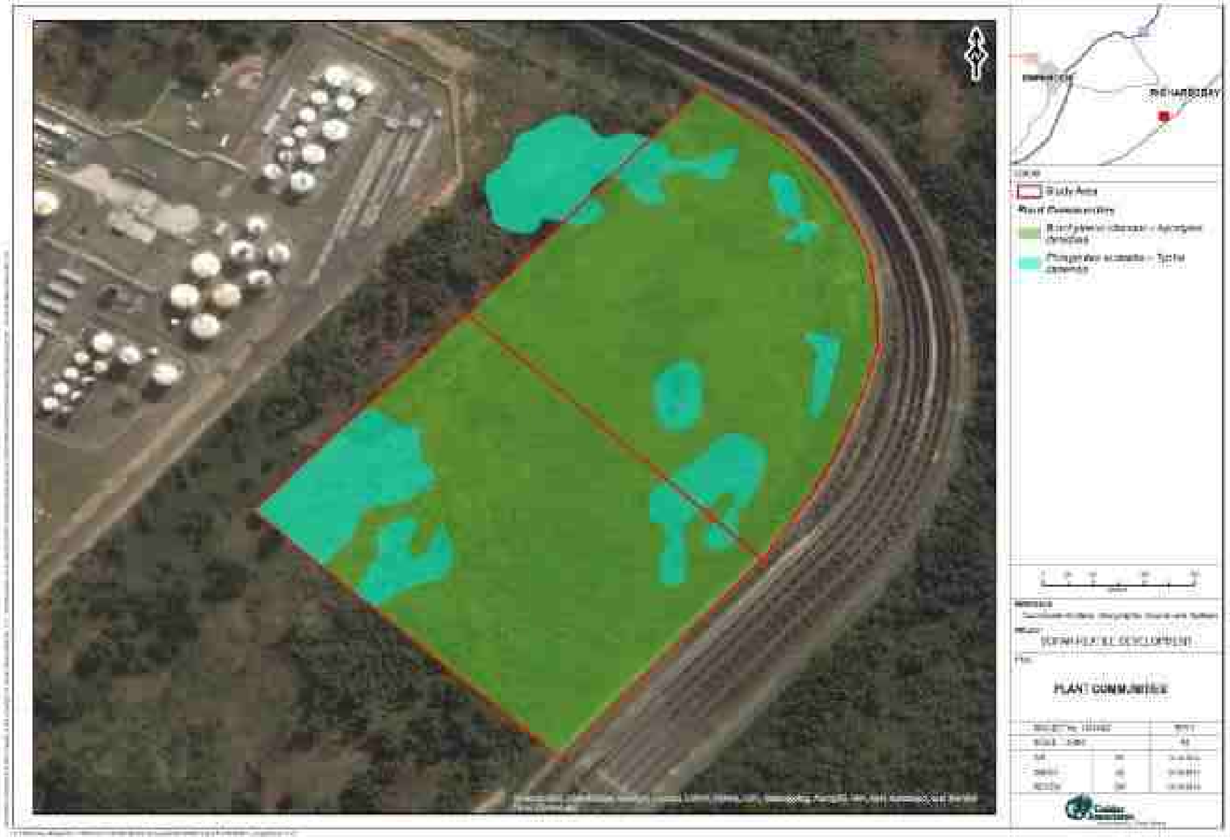

Figure 40: Plant Communities Identified in the proposed Terminal.

6.4.3.2 *Fauna Assessment*

Arthropoda

A total of 56 arthropod species, comprising 45 families and 15 orders, were recorded during on the proposed Terminal site. All of the species recorded during the survey are common savanna species and none are listed as species of conservation importance. Apart from the possible presence of millipedes of conservation importance, such as *Centrobolus richardi,* there is little literature regarding other Red Data arthropod species occurring in the area.

Reptiles

Six reptile species were recorded during the March 2014 survey. None of the recorded species are restricted in terms of habitat and distribution, or classified as Red Data species. Sixty nine reptile species potentially occur in the region in which the proposed Terminal is located.

Amphibians

Five amphibian species were recorded in or adjacent to the proposed Terminal site. These are the Common river frog (*Amieta angolensis*), Guttural toad (*Amietophrynus gutturalis*), Mozambique rain frog (*Breviceps mossambicus*), Tinker reed frog (*Hypercolius tuberilinguis*) and Argus reed frog (*Hyperolius argus*) (ACER, 2013). None of the recorded species are restricted in terms of habitat and distribution, or classified as Red Data species. Based on available literature, 51 frog species are expected to occur within the proposed Terminal region.

Birds

Twenty eight bird species were recorded in the proposed Terminal site during the March 2014 field survey. The lack of perennial water bodies on site and rivers excludes waterfowl and other water related avian species from the project area and contributed to the reduced species diversity. Based on the South African Bird Atlas Project, 329 bird species have been recorded in the quarter degree grid cell (QDGC) 2832CC in which the proposed Terminal is situated.

Mammals

Seven mammal species were recorded during the March 2014 field survey. Recorded mammals are common species that occur in a wide range of habitats. None are listed as Red Data/protected species. Ninety two mammals historically occur in the region as per Stuart and Stuart (2006).

6.4.3.3 *Habitat Sensitivity Analysis*

Ecological Integrity

Connectivity between the natural plant communities inside the proposed Terminal site and those outside is very limited. The railway and road system in place effectively isolate the proposed Terminal from surrounding habitats.

The *Brachylaena discolor – Apodytes dimidiata* short thicket community is degraded, having been disturbed in the past by the invasive alien species. In the south-western corner of Lot 5, vegetation is generally in good ecological condition. The ecological integrity of *Brachylaena discolor – Apodytes dimidiata* short thicket community is therefore considered low-moderate. The ecological integrity of the *Phragmites australis – Typha capensis* wetlands is considered moderate.

Conservation Importance

Despite the harbour peninsula being largely disturbed and disconnected from the mainland, the proposed Terminal site and its surrounds does provide habitat for flora and fauna, some of which, are species of conservation importance. Four plant species of conservation importance have been recorded within the proposed Terminal site, namely *Adenia gummifera var. gummifera, Ficus trichopoda, Sideroxylon inerme, Mimusops caffra* (ACER pers. comm. 2014). An additional species of conservation importance (*Dioscorea sylvatica)* has also previously been recorded adjacent to the proposed Terminal (ACER, 2013).

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The *Brachylaena discolor* – *Apodytes dimidiata* short thicket community is considered to have a moderate conservation importance, while the *Phragmites australis* – *Typha capensis* wetlands are of high conservation importance.

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Figure 41: Ecological Integrity of Vegetation Communities in the proposed Terminal.

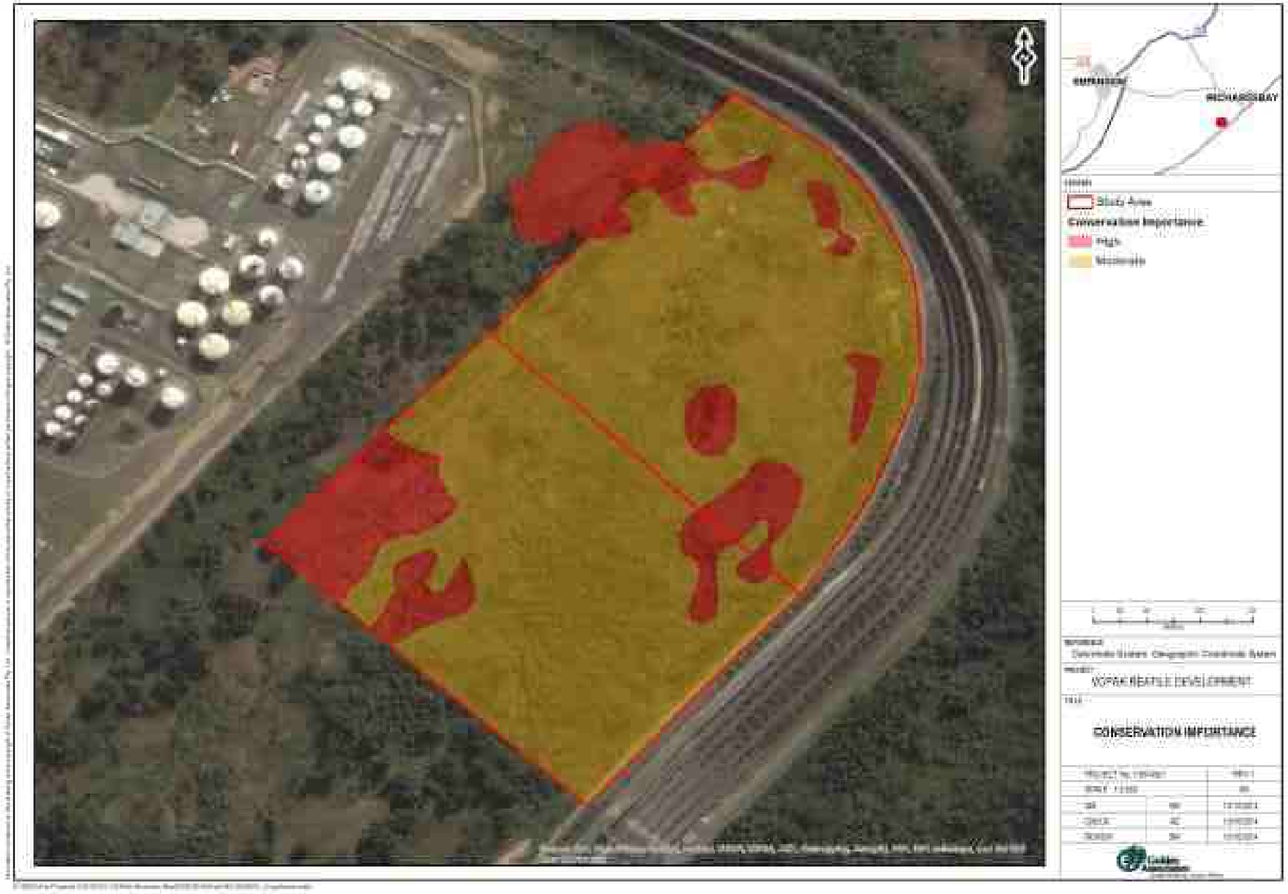

Figure 42: Conservation Importance of Vegetation Communities in the proposed Terminal.

6.4.4 Impact Assessment

6.4.4.1 Construction Phase

The main impacts on flora and fauna will be during the construction phase due to the site clearance and loss of habitat.

Habitat Loss as a Result of Vegetation Clearing

Habitat loss refers to the removal of natural habitat. In terrestrial ecosystems habitat loss occurs primarily through the clearing of indigenous vegetation or through the homogenisation of available habitat. This results not only in the immediate destruction of individual plants and some fauna species, but may also lead to a loss of biodiversity and a contingent breakdown in ecosystem functioning.

Although habitat loss and degradation are normally associated with the immediate vegetation clearing and earth works that precede construction activities, the impacts can be long term, persisting throughout the operational and closure phases. In certain instances, these impacts can be ameliorated by successful rehabilitation of the site.

Vegetation clearing is likely to be the greatest direct impact on the ecology within the proposed Terminal site. Vegetation clearing will commence during the construction phase and will lead to the permanent removal of natural/semi-natural habitat in the proposed Terminal footprint. This will negatively affect on-site flora and fauna communities.

Loss of Plant Species of Conservation Importance

During initial vegetation clearing and earth works, flora and fauna of conservation importance such as Red Data and protected species may be killed, injured or damaged. Moreover, habitat loss and degradation may result in sensitive species being disturbed.

Vegetation clearing may also result in the removal of plant species of conservation importance. These are *Adenia gummifera var. gummifera, Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra*.

Spread of Alien Invasive Species

Clearing of natural vegetation may create conditions conducive to the establishment and colonisation of exotic and/or declared NEM:BA and CARA listed invader plants in those parts of the site that are not covered with hardstanding, which is likely to be greater than 90%. Most exotic, invasive species if left uncontrolled will suppress or replace indigenous plants leading to a concomitant reduction in fauna species diversity and abundance (Bromilow, 2010). However the site clearance will already have led to a reduction in species diversity and abundance with the majority of the site covered in hardstanding to prevent any contamination of the underlying ground.

Encroachment by exotic invasive species may initially occur during construction facilitated by vegetation clearing. If not controlled, the scale and magnitude of infestation will rapidly increase and may persist for the entire lifecycle of the proposed Terminal.

Several CARA and NEM:BA listed alien invasive plant species were recorded in the proposed Terminal site. Alien invasive plants can out-compete indigenous vegetation, creating large almost monospecific exotic vegetation stands. Construction activities can facilitate the further establishment and spread of alien invasive species into adjacent areas if not adequately controlled.

Killing or Injuring of Fauna

Forest areas in South Africa provide habitat for a number of fauna species. It is likely that upon commencement of construction activates many larger and more agile species will move-off to avoid disturbance. A number of smaller and less mobile species however, may be trapped and killed /injured during all phases of the proposed Terminal e.g. invertebrates.

During the construction phase fauna may be killed or injured as a result of earth works, vehicle activity and poaching. This impact is unlikely to be of concern during the operational and decommissioning phases. No species of conservation importance were found on the site during the fauna surveys.

Habitat Degradation Due to Dust

The clearing of vegetation for construction coupled with increased vehicular traffic and the establishment of top soil and waste stockpiles, will result in the increased potential for dust entrainment. Dust settling on plant material can affect photosynthesis, respiration, transpiration rates, and allow for the penetration of phototoxic gaseous pollutants into plant tissue (Farmer, 1993). These impacts can result in decreased plant productivity which may lead to alterations in plant community structure and composition, and consequent changes in herbivore diversity and abundance (Farmer, 1993).

Dust may also directly affect fauna. In arthropods for example, exposure to dust may lead to the smothering of adults and larvae and the disrupting of chemical cues used for mating (Talley et al. 2006), while mammals exposed to dust may show respiratory afflictions (Borm & Tran, 2002).

Dust will be generated during vegetation clearing, earthworks, from top-soil stockpiles, and as a result of vehicle activity. These activities mainly occur during the construction phase, but dust generation may persist during the operational and decommissioning phases if undeveloped areas that have been cleared of vegetation are not rehabilitated.

6.4.4.2 Operational Phase

Spread of Alien Invasive Species

Encroachment by exotic invasive species may initially occur during construction, however if this is left uncontrolled, the scale and magnitude of infestation will rapidly increase and may persist for the entire lifecycle of the proposed Terminal in areas which are not covered by hard standing, which is likely to be less than 10% of the site.

Several CARA and NEM:BA listed alien invasive plant species were recorded within the proposed Terminal site. Alien invasive plants can out-compete indigenous vegetation, creating large almost monospecific exotic vegetation stands. Construction activities are likely to facilitate the establishment and spread of alien invasive species into adjacent areas, and if not adequately controlled, alien invasive vegetation can continue to spread during the operational and decommissioning phases.

Habitat Degradation Due to Dust

Dust will be generated during vegetation clearing, earthworks, from top-soil stockpiles, and as a result of vehicle activity. Dust generation may persist during the operational and decommissioning phases if undeveloped areas that have been cleared of vegetation are not rehabilitated.

6.4.4.3 Decommissioning Phase

Spread of Alien Invasive Species

Alien invasive plants can out-compete indigenous vegetation, creating large almost monospecific exotic vegetation stands. Construction activities are likely to facilitate the establishment and spread of alien invasive species into adjacent areas. If not adequately controlled, alien invasive vegetation can continue to spread during the operational and decommissioning phases.

Habitat Degradation Due to Dust

Dust will be generated during vegetation clearing, earthworks, from top-soil stockpiles, and as a result of vehicle activity. Dust generation may persist during the operational and decommissioning phases if undeveloped areas that have been cleared of vegetation are not rehabilitated.

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Table 27: Rating of Potential Ecology Impacts Associated with the Proposed Terminal.

Impacts	Occurrence			Severity				Environmental Consequence	
	Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Loss of habitat as a result of vegetation clearing	Negative	Definite	Permanent	High	Local	Irreversible	Low	High	Moderate
Loss of plant species of conservation importance	Negative	Highly probable	Short-term	High	Local	Irreversible	`Low	High	Moderate
Spread of alien invasive species	Negative	Highly probable	Long term	Moderate	Local	Reversible	High	Moderate	Low
Killing or injuring of fauna	Negative	Medium probability	Short-term	High	Local	Irreversible	Low	Moderate	Low
Habitat degradation due to dust	Negative	Highly probable	Short-term	Moderate	Local	Reversible	Medium	Low	Low

6.4.5 Specialist Conclusions

The vegetation of the study area comprises two vegetation communities, namely *Brachylaena discolor – Apodytes dimidiata* short thicket community and *Phragmites australis – Typha capensis* wetlands. Both communities have localised sites of disturbance, mostly from the establishment of alien invasive plant species, such as Lantana (*Lantana camara*) (ACER pers. comm. 2014).

Four plant species of conservation importance were recorded at the proposed Terminal site. These are *Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra* (ACER pers. comm. 2014), both of which are listed as protected according to the NFA and the KwaZulu-Natal Nature Conservation Management Amendment Act (Act No. 5 of 1999), and *Adenia gummifera var. gummifera* which is listed as Declining (IUCN 2014.2, Regional Status). Moreover, *Dioscorea sylvatica* which is listed as Vulnerable (IUCN 2014.2, Regional Status) was previously recorded by ACER (2013) on a site immediately adjacent to the proposed Terminal and therefore has a high probability of occurring on-site.

Despite its disturbed nature the proposed Terminal site does comprise habitat for a variety of fauna, with several taxa recorded during the field survey. None of the recorded taxa are Red List or protected species; however no survey can ensure that every species on a site has been observed and therefore there is the potential for species of conservation importance to occur in the study area.

There is the possibility that during the clearing of vegetation for the proposed Terminal that there is a likelihood that there will be impact upon the flora and fauna in the vicinity of the construction site, and to this end the management measures that are proposed for the relocation of flora and the vigilance in capturing and relocating of fauna should be closely monitored.

Vegetation clearing and associated construction activities will also increase the potential for the establishment and spread of invasive plant species. It is thus important that the management measures outlined for the proposed Terminal are incorporated into the EMP and strictly adhered to.

6.5 Hydrology (Surface Water) Impact Assessment

The Hydrology Impact Assessment specialist report is attached as APPENDIX G.

6.5.1 Scope of Work

The scope of work for the Hydrology Impact Assessment included the following:

- Collect hydrology data to describe the baseline hydrological situation in the area;
- Assess the site wide water management plan. The water management plan includes the management of stormwater from clean and dirty water catchments;
- Assess the sizes of the water management infrastructure including diversion berms, dirty water collection drains and pollution control dams;
- Conduct a surface water impact assessment; and
- Develop a monitoring programme.

6.5.2 Methodology

The following activities were undertaken as part of the Hydrology (Surface Water) Impact Assessment:

- Available daily rainfall data was collected, updated, reviewed and analysed. The available data was used to patch a daily rainfall record for use in determining rainfall statistics. The rainfall data analysis included trends, monthly averages and 24 hour rainfall depths for the 1:2, 1:5, 1:10, 1:20, 1:50 and 1:100 year recurrence interval storms;
- The available climate data was collected and reviewed to produce monthly potential evaporation;
- A regional hydrology assessment of the catchment area was undertaken;

- The stormwater management plan for the proposed Terminal was assessed to determine clean and dirty water separation and the capacity of the drainage system. The PCSWMM model was used to conduct this assessment;
- An assessment of the impacts of the proposed Terminal on the surface water hydrology was undertaken using the impact ranking system; and
- A surface water monitoring programme was developed for the proposed Terminal. The monitoring programme was based on the results of the hydrology impact assessment. The plan indicates the location of sampling points and lists the water quality variables to be measured and the sampling frequency.

6.5.3 Specialist Findings

6.5.3.1 Clean and Dirty Water Sub-catchments

The proposed Terminal was discretised based on the topography of the site. These sub-catchments were then classified as either clean or dirty water catchments based on the land usage. The sub-catchments are shown in Figure 43. The sub-catchments are all classified as clean; the only catchment where the run-off could be potentially polluted is the truck loading area that could be potentially contaminated with oil and grease.

6.5.3.2 Proposed Stormwater Management Plan

The stormwater drainage system will be constructed in the initial phase and is designed to accommodate the run-off from the initial and further phases of development.

The proposed stormwater management strategy is as follows:

- The proposed Terminal site is sloping towards the north-east. Stormwater run-off will be collected into two sumps SU1 and SU2 (see Figure 44);
- The LPG Bullet laydown and staging area (sub-catchments S3 – S8) will be surrounded by trenches that drain to the south-east and will discharge to the main drain (C1 – C4) that runs along the southern boundary of the proposed Terminal. The main drain reports to SU1;
- The run-off from the south-east area of the proposed Terminal (S11 and S9) will report to the main drain. The water will then be pumped into TNPA’s stormwater channel to be constructed for the South Dunes Lease Sites which will then drain east to the harbour;
- The northern part of the proposed Terminal (S12 and S10) will be serviced by a pipe and rainwater culvert that will drain into sump SU1; and
- The remaining catchments (S13 – S17) will be serviced by pipes running east along the northwest boundary of the proposed Terminal and draining into sump SU2. This sump will then also be pumped into TNPA’s stormwater channel to be constructed for the South Dunes Lease Sites which will then drain to the harbour; and
- Measures will be taken by the security wall or berms to prevent stormwater run-off from entering the proposed Terminal site.

6.5.3.3 Modelling the Stormwater Management Conduit System

The PCSWMM model was used as the flood analysis model. PCSWMM is a dynamic rainfall-run-off simulation model used for single event or long-term simulation of run-off quantity. This model was set up for the proposed Terminal and used to size the conveyance structures for separation of clean and dirty stormwater run-off.

Figure 43: Sub-catchments of the proposed Terminal.

Figure 44: Stormwater Management Plan Layout for the proposed Terminal.

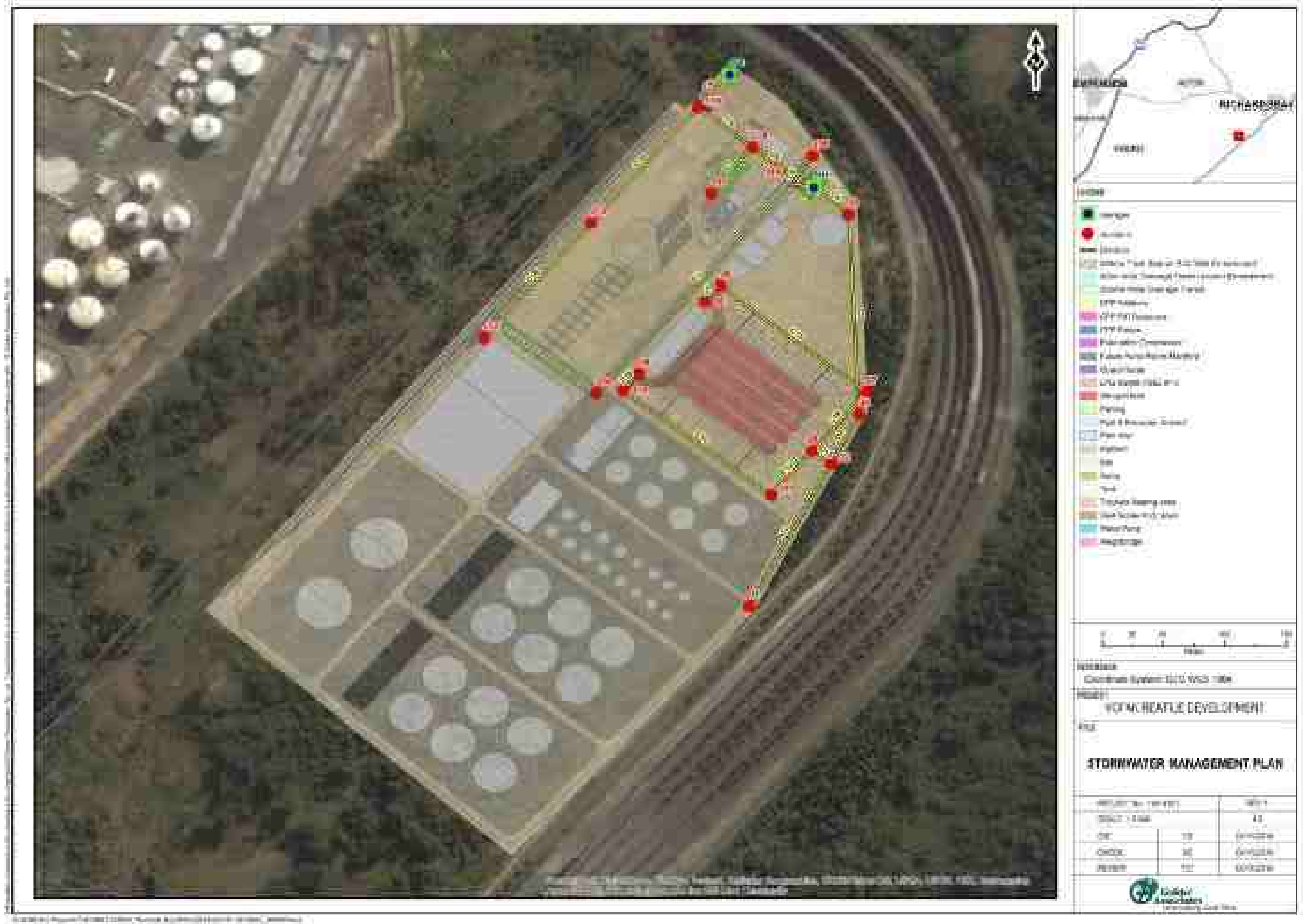

Figure 45: Stormwater Management Plan Layout for the proposed Terminal.

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6.5.3.4 Sub-catchment Characteristics

The parameters which were used to model the overland and channel flow are provided in Table 28. The Manning's 'n' coefficient used in the model for the impervious areas and pervious areas was 0.015 and 0.15 respectively.

The soils were identified as being in the sand group. The model uses these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The infiltration parameters for the sand soil group are a suction head of 49.5 mm, a hydraulic conductivity of 235.6 mm/hr and an initial soil moisture deficit of 0.346. Most of the proposed Terminal will be covered with either concrete paving or engineered gravel road with only a small area being left for landscaping thus the run-off generated onsite will be high. The catchment areas, slopes and percent of impervious areas together with the total run-off volume and the flood peaks for the 1:20 and 1:50 year storm events are presented in Table 28.

6.5.3.5 Channel Characteristics

The diversion channel layout is shown in Figure 44 and Figure 45. The Manning's roughness assumed for the concrete drains was 0.012 and for the concrete trenches was 0.015 (Webber, 1971). The dimensions, slope and maximum velocity of the channels are listed in Table 29.

6.5.3.6 Stormwater Management Discussion

Based on the drawings provided by VSAD, the PCSWMM model was used to determine the recurrence interval storm that the proposed stormwater management system could accommodate.

The findings indicated that channels C1, C2, C6, C18, C13 and trenches C11 and C12 will be flooded if a 1:50 year storm event occurs. Channels C1, C2 and C13 and trench C12 will be flooded if a 1:20 year storm event occurs. These areas are deemed clean and thus there is no need to resize the drains if VSAD find the flood risk to be acceptable for the construction and operation of the proposed Terminal.

The stormwater management system was found to be unable to convey the 1:2 year storm event due to Channel C2 being undersized. If Channel C2 is changed to a 900 mm *Φ* ROCLA pipe instead of a 600 mm *Φ* ROCLA pipe as is currently proposed, the 1:2 year storm event can be accommodated by the system.

Vopak will provide this information to the facility design team to ensure the facility can cope with a 1:50 year storm event. It is recommended that an oil trap be placed at the truck loading area to filter out any oil and grease that may spill from the loading trucks and contaminate the stormwater. If an oil trap is installed this will filter through any oil or grease and the water can be considered clean and can then be drained through the proposed Terminal site and disposed of as proposed.

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Table 28: Catchment Areas, Slopes, Computed Run-off Volumes and Flood Peaks for the 1:20 and 1:50 Year Storm

Name	Area (Ha)	Slope (%)	Impervious area (%)	24h storm depth (mm)	Total run-off volume per 24h (Megalitres) 2y	2y Peak Run-off (L/s)	Total run-off volume per 24h (Megalitres) 20y	20y Peak Run-off (L/s)	Total run-off volume per 24h (Megalitres) 50y	50y Peak Run-off (L/s)
S1	4.29	0.01	50	279.88	2.13	201.24	5.87	700.65	7.95	1,030.87
S2	2.35	0.01	50	279.88	1.17	116.24	3.22	403.59	4.37	597.07
S3	0.12	0.19	100	279.88	0.12	26.37	0.33	82.47	0.45	114.69
S4	0.38	0.26	100	279.88	0.39	91.35	1.06	275.55	1.43	379.43
S5	0.11	0.19	100	279.88	0.11	24.62	0.31	76.9	0.42	106.9
S6	0.40	0.29	100	279.88	0.41	100.39	1.13	298.6	1.52	409.72
S7	0.15	0.22	100	279.88	0.15	34.03	0.42	105.41	0.57	146.19
S8	0.20	0.24	100	279.88	0.21	47.64	0.57	145.73	0.77	201.41
S9	1.15	0.005	10	279.88	0.12	27.7	0.32	84.06	0.44	117.49
S10	0.23	0.01	90	279.88	0.22	42.03	0.59	136.77	0.8	195.04
S11	0.20	0.005	25	279.88	0.05	10.53	0.14	33.57	0.19	48.03
S12	1.84	0.01	50	279.88	0.91	78.78	2.5	279.54	3.39	404.49
S13	1.92	0.01	50	279.88	0.95	91.06	2.62	316.1	3.55	466.73
S14	0.39	0.005	50	279.88	0.2	40.73	0.54	130.53	0.73	186.7
S15	0.62	0.005	100	279.88	0.63	87.72	1.72	307.59	2.33	443.8
S16	0.143	0.005	5	279.88	0.01	2.03	0.02	5.65	0.03	8.16
S17	0.22	0.005	20	279.88	0.04	10.64	0.12	31.89	0.16	44.51

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Table 29: Dimensions of Run-off Diversion Channels and the Flows and Velocities Associated with the 1:20 and 1:50 Year Storms

Name	Inlet Node	Outlet Node	Length (m)	Rough ness	Cross-Section	Height/ Diameter (m)	Bottom width (m)	Slope (m/m)	Max. flow (L/s) 2y	Max. velocity (m/s) 2y	Max. flow (L/s) 20y	Max. velocity (m/s) 20y	Max. flow (L/s) 50y	Max. velocity (m/s) 50y
C1	J1	J2	129.15	0.012	Circular	0.585	0	0.0025	200.05	1.23	336.13	1.38	336.4	1.38
C2	J2	J4	44.56	0.012	Circular	0.585	0	0.0024	597.7*	1.59*	329.82	1.33	329.88	1.33
C3	J4	J3	161.78	0.012	Circular	0.853	0	0.00247	597.85	1.62	344.81	1.46	350.34	1.45
C4	J3	SU1	28.29	0.012	Circular	0.853	0	0.00159	617.5	1.35	416.35	1.25	461.48	1.28
C6	J15	SU2	30.3	0.012	Circular	0.853	0	0.00297	215.28	1.32	748.53	1.81	987.5	1.9
C7	J17	J18	48.1	0.012	Circular	0.585	0	0.00848	40.01	1.23	128.52	1.73	184.06	1.91
C8	J18	J15	51.06	0.012	Circular	0.853	0	0.00787	41.56	1.16	132.94	1.64	190.61	1.82
C9	J19	J18	34.46	0.012	Circular	0.585	0	0.00749	1.96	0.48	5.51	0.65	7.99	0.73
C10	J9	J10	17.53	0.015	Rectangular	1	0.4	0.01	26.17	0.93	81.93	1.32	113.93	1.44
C11	J10	J11	136.26	0.015	Rectangular	1	0.4	0.01	220.66	1.68	739.02	2.03	807.68	2.05
C12	J11	J8	46.52	0.015	Rectangular	1	0.4	0.01	251.61	1.71	807.68	2.03	807.68	2.03
C13	J8	J2	16.7	0.012	Circular	0.585	0	0.005	414.61	1.86	473.26	1.91	474.84	1.91
C14	J5	J6	17.04	0.015	Rectangular	1	0.4	0.01	24.43	0.91	76.4	1.29	106.19	1.41
C15	J6	J7	135.84	0.015	Rectangular	1	0.4	0.01	119.49	1.48	360.29	1.88	496.06	1.98
C16	J7	J8	61.19	0.015	Rectangular	1	0.4	0.01	163.24	1.57	493.58	1.93	680.04	2.01
C18	J12	J13	120	0.012	Circular	0.585	0	0.003	90.53	1.07	316.72	1.45	368.51	1.51
C19	J13	J15	120.49	0.012	Circular	0.853	0	0.00299	172.81	1.25	600.09	1.73	774.65	1.83
C5	J16	SU1	26.94	0.015	Rectangular	1	5	0.0052	0	0	0	0	0	0
C17	J14	SU1	220.39	0.015	Rectangular	1	5	0.00392	109.35	0.52	383.93	0.84	563	0.98

*This flow and velocity are based on Pipe C2 being a 900 mm Φ ROCLA pipe and not a 600 mm Φ ROCLA pipe.

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6.5.4 Impact Assessment

The potential direct and indirect hydrology impacts associated with the proposed Terminal include:

- Changes in surface water quality; and
- Change in surface water run-off and erosion.

The surface water quality impacts will ultimately impact on the downstream water users, including the provision of irrigation water when the water make becomes feasible for such use.

The main impacts associated with the proposed Terminal can be described as follows:

Changes in Surface Water Catchment Areas

- Catchment areas are reduced due to the erecting of pump rooms and bullet laydown areas.

Changes in Surface Water Quality

- The mobilisation of sediments in the borrow pit area during construction;
- Spillage from equipment during construction; and
- Pollution from gas leakages during operations.

Change in Surface Water Run-off

- Run-off impacts due to Terminal footprint during operation and closure; and
- Potential flooding of railway during construction, operation and decommission.

6.5.4.1 Construction Impacts

Impacts associated with the construction phase of the proposed Terminal include impacts on run-off water quality, and run-off peak flows.

Impacts on Run-off Water Quality:

- Stripping of vegetation and topsoil have the potential to result in the expose of a barren site. In the event of high flood peaks occurring, high run-off would occur from the proposed Terminal site during construction
- Spillage of fuels, lubricants, oil and grease required during construction activities have the potential to negatively impact on the quality of run-off water.
- Construction equipment, vehicles and temporary workshop areas have the potential to constitute non-point sources of pollution during the construction phase.

Impacts on Run-off Peak Flows:

- Stripping of vegetation and topsoil have the potential to result in the expose of a barren site. In the event of high flood peaks occurring, high run-off would occur from the proposed Terminal site during construction. This high run-off volume has the potential to affect neighbouring properties during the construction period.

6.5.4.2 Operational Impacts

Impacts associated with the operational phase of the proposed Terminal include impacts associated with the pollution of stormwater.

Impacts on Pollution of Stormwater:

- Spillages of fuels, lubricants, oil and grease and gas leaks during the operational phase of the proposed Terminal have the potential to result in the pollution of stormwater.

- During operations, vehicles have the potential to constitute a non-point source of pollution at the proposed Terminal site.

6.5.4.3 Decommissioning Impacts

Impacts associated with the decommissioning phase of the proposed Terminal include impacts associated with run-off.

Impacts on Run-off:

- Demolition activities which may be required as part of the decommissioning phase of development have the potential to create large barren areas that may increase erosion, which might increase the amount of suspended solids flowing towards neighbouring properties.

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Table 30: Rating of Potential Hydrology (Surface Water) Impacts Associated with the Proposed Terminal.

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Run-off water quality during construction	Stripping of vegetation and topsoil to expose a barren site. High flood peaks lead high run-off from this area during construction	Negative	Medium / Low	Medium-term	Moderate	Site	Reversible	Medium	Moderate	Low
	Spillage of fuels, lubricants, oil and grease	Negative	Medium / Low	Medium-term	Moderate	Site	Reversible	Medium	Moderate	Low
	Construction equipment, vehicles and temporary workshop areas will be likely sources of pollution as a non-point source.	Negative	Medium / Low	Medium-term	Moderate	Site	Reversible	Medium	Moderate	Low
Run-off peak flows during construction	Stripping of vegetation and topsoil to expose a barren site. High flood peaks lead high run-off from this area during	Negative	High	Medium-term	Moderate	Local	Reversible	Medium	Moderate	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
	construction									
Pollution of stormwater during operation	Potential pollution of stormwater from spillage of fuels, lubricants, oil and grease and gas leaks	Negative	Low	Long-term	Moderate	Site	Reversible	Medium	Moderate	Low
	Vehicles will be a likely source of pollution as a non-point source.	Negative	Low	Long-term	Moderate	Site	Reversible	Medium	Moderate	Low
Run-off during decommissioning	Decommissioning may leave large barren areas that may increase erosion, which might increase the amount of suspended solids flowing towards neighbouring properties.	Negative	Medium / Low	Short-term	High	Site	Reversible	Low	Moderate	Low

6.5.5 Specialist Conclusions

The following conclusions were drawn from the Hydrology Impact Assessment:

- This proposed Terminal will be subjected to high rainfall events as shown by the rainfall analysis;
- The stormwater system as currently proposed cannot accommodate a 1:2 year storm event. The information will be provided to the site designers who will design the site to accommodate a 1:50 year storm event;
- A monitoring programme has been proposed to ensure the quality of the water exiting the proposed Terminal site is to standard; and
- The impacts are largely related to surface water run-off and preventing the neighbouring properties being affected. Impacts were ranked as having medium environmental significance but with the implementation of appropriate mitigation measures can be reduced to low environmental significance.

6.6 Risk Impact Assessment

Golder appointed RISCOM (Pty) Ltd (RISCOM) to conduct a Risk Impact Assessment for the proposed Terminal. The Risk Impact Assessment was conducted strictly for the purposes of this EIA and is not intended to replace a MHI Risk Assessment required in accordance with the OHSA and MHI Regulations. The Risk Impact Assessment only covers acute events and sudden ruptures and not chronic and on-going releases, such as fugitive emissions. A copy of the Risk Impact Assessment specialist report compiled by RISCOM is attached as APPENDIX H.

6.6.1 Scope of Work

The main aim of the Risk Impact Assessment was to quantify the potential risks associated with the proposed Terminal to employees and neighbours. The scope of work for the Risk Impact Assessment included the following:

- The development of accidental spill and fire scenarios for the proposed Terminal;
- The determination of the probability of each accident scenario using generic failure rate data (tanks, pumps, valves, flanges, pipework, gantry, couplings, etc.);
- The determination of the consequences (thermal radiation, domino effect, toxic cloud formation, etc.) for each of the developed incidents; and
- The calculation of maximum individual risk (MIR) values taking into account all accidents, meteorological conditions and lethality.

6.6.2 Methodology

RISCOM made use of the methodologies and criteria described in the internationally recognised CPR 18E (Purple Book) and RIVM (2009) for the purposes of the Risk Impact Assessment. The CPR 18E (Purple Book) and RIVM (2009) are legal requirements for conducting Quantitative Risk Assessments (QRAs) in the Netherlands and form the basis of commercially available software.

The evaluation of the acceptability of risks was then extended to the ALARP (As Low As Reasonably Practicable) criteria of the Health and Safety Executive (HSE) of the United Kingdom, which clearly explains and covers land use based on determined risks.

The QRA process is summarised with the following steps:

1) The identification of components that are flammable, toxic, reactive or corrosive and that have the potential to result in a major incident from fires, explosions or toxic releases;
2) The development of accidental loss-of-containment scenarios for equipment containing hazardous components (including the release rate, location and orientation of release);

3) For each incident developed in Step 2, the determination of the consequences (thermal radiation, domino effects, toxic-cloud formation, etc.); and

4) For scenarios with off-site consequences (i.e. greater than 1% fatality off-site), the calculation of the Maximum Individual Risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

6.6.2.1 Hazard Identification

As a first step, of the Risk Impact Assessment all hazards were identified. Cut-off or threshold values were used to determine the significance of each hazard and the merits of investigating them further. Hazards were assessed in terms of the risk they presented to employees and the neighbouring community in terms of their probability and/or consequence.

During the identification of hazards, the following factors were taken into consideration:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- The type and design of containers, vessels or pipelines;
- The quantity of material that could be involved in an airborne release; and
- The nature of the hazard most likely to accompany hazardous materials spills or releases, e.g. airborne toxic vapours or mists, fires or explosions, large quantities in storage and certain handling conditions of processed components.

6.6.2.2 Scenario Selection

A series of scenarios that characterise the release mechanisms that determine the nature and extent of consequences or impacts were analysed. Impacts that did not extend beyond the boundary of the proposed Terminal (determined by the 1% fatality) were excluded from the risk assessment.

The selection of release scenarios ultimately determines the accuracy of the risk assessment and therefore must cover both low and high frequency events. It should also be noted that a particular scenario may produce more than one major consequence. In such cases, the consequences are evaluated separately and assigned failure frequencies in the risk analysis.

6.6.2.3 Modelling Software

The physical consequences were calculated with TNO's EFFECTS v. 9.0.20 and the data derived was entered into TNO's RISKCURVES v. 9.0.23.

6.6.2.4 Physical and Consequence Modelling

In order to establish the impacts following an accident, it is necessary first to estimate: the physical process of the spill (i.e. rate and size); the spreading of the spill; the evaporation from the spill; the subsequent atmospheric dispersion of the airborne cloud; and, in the case of ignition, the burning rate and resulting thermal radiation from a fire and the overpressures from an explosion.

The second step is then to estimate the consequences of a release on humans, fauna, flora and structures. This illustrates the significance and extent of an impact in the event of a release. The consequences would be due to toxic and asphyxiant vapours, thermal radiation or explosion overpressures. The consequences may be described in various formats. The simplest methodology follows a comparison of predicted concentrations (or thermal radiation or overpressures) to short-term guideline values. Alternatively consequences may be determined using a dose-response analysis. Dose-response analysis aims to relate the intensity of the phenomenon that constitutes the hazard to the degree of injury or damage that it can cause. Probit analysis is the method mostly used to estimate probability of death, hospitalisation or structural damage. The probit is a lognormal distribution and represents a measure of the percentage of the vulnerable

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resource that sustains injury or damage. The probability of injury or death (i.e. risk level) is in turn estimated from this probit (risk characterisation).

Consequence modelling gives an indication of the extent of an impact for selected events and is used primarily for emergency planning. A consequence that would not cause irreversible injuries would be considered insignificant, and no further analysis would be required.

This subsection addresses the impact of releases without taking into account the probability of occurrence. This merely illustrates the significance and the extent of the impact in the event of a release.

Each processing unit was assessed in terms risk by selecting the scenario and completing outflow and conducting consequence modelling. Consequences with possible impacts which extend beyond the boundary of the proposed Terminal were retained for the risk analysis of the unit. Finally, the risk of the proposed Terminal in its entirety was determined as a combination of the risks calculated for each unit.

Consequences or impacts were evaluated using six representative weather classes each with certain wind speed and stability conditions. Two weather classes represented conditions during the day, two represented conditions during both the day and the night and two represented conditions during only the night. The furthest distance to the 1% fatality for each impact scenario would be retained for risk analysis.

If the distance to the 1% fatality extended beyond the boundary of the proposed Terminal so that the potential existed for both workers and the public to be involved in a major incident, then there would be a possibility of the proposed Terminal being classified as a Major Hazard Installation (MHI). A risk assessment would be required to determine this.

6.6.3 Specialist Findings

6.6.3.1 Transport Pipelines from Berthed Ship to Terminal

Transport pipelines will be used to carry CPP products and LPG between Berths 208 and 209 and the proposed Terminal. The consequences in this section relate to the failure of the pipeline as it enters the harbour area.

6.6.3.1.1 Hazard Identification

Flammable or Combustible Components to be Stored, Transported or Processed

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. The pipelines, other than those for LPG, would transport a variety of products. Of all the CPP products, petrol has the lowest flashpoint, and was therefore used as the worst case scenario for consequence modelling.

6.6.3.1.2 Consequence Modelling

Pool Fires

A failure of a transport pipeline would form a pool that would spread until it could spread no more, or until it was contained by natural barriers. The maximum area of a spill is assumed to be 3,000 m² (RIVM 2009). A full-bore rupture as well as a leak from a hole of 50 mm would both produce a flammable pool limited to 3,000 m². Figure 46 shows the extent of a pool fire, at a single point, from a loss of containment of petrol from the pipeline. The solid lines represent the extent of the impacts during a westerly wind, while the dashed lines indicate the extent of the impact from all wind directions.

The 1% fatality is represented by the 10 kW/m² thermal radiation isopleth. Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m² isopleth was reached.

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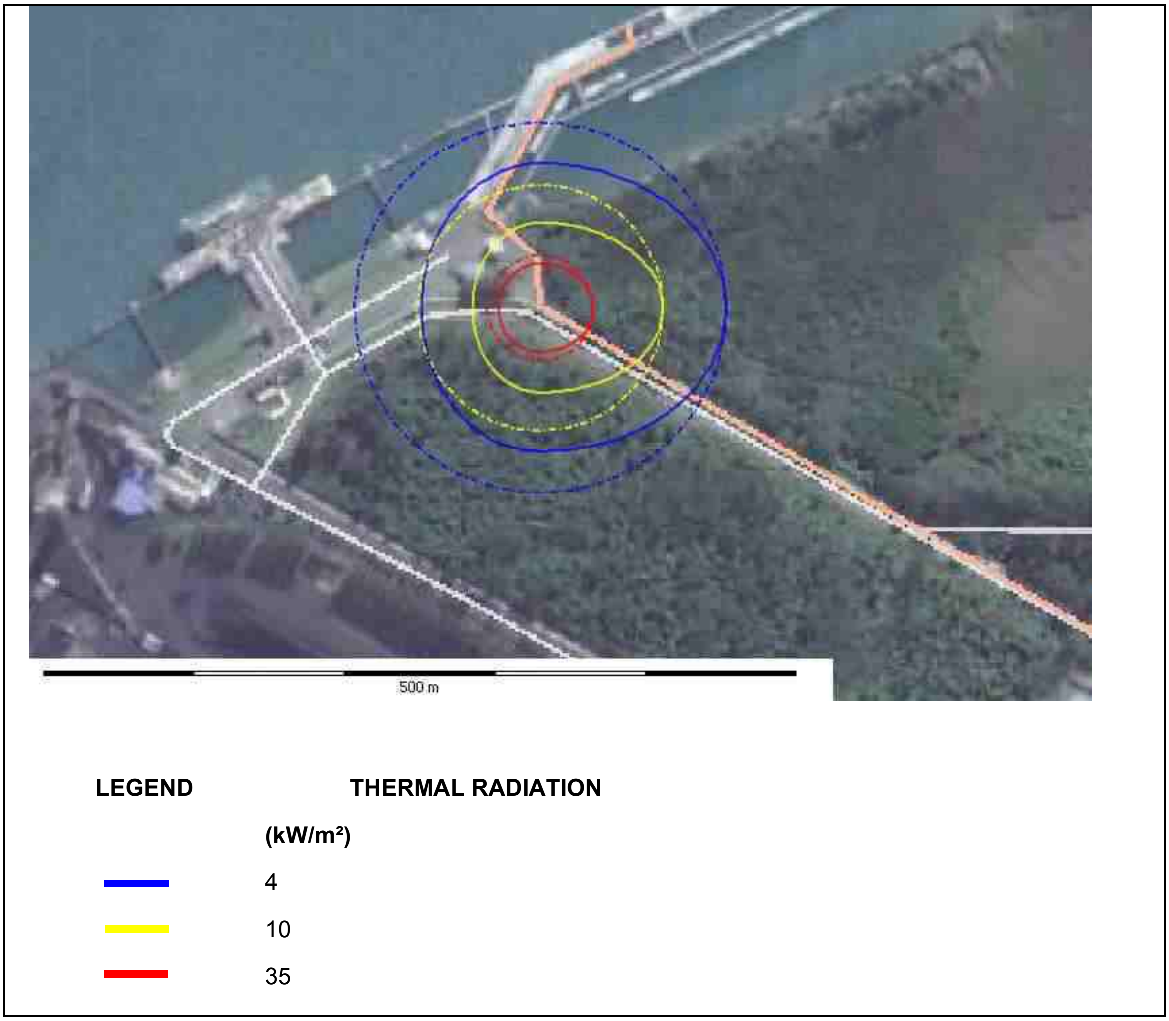

Figure 46: Thermal-radiation Isopleths from Petrol Pool Fires Resulting from a Pipeline Failure.

Jet Fires

A release of LPG under pressure could result in a jet fire. The simulations assumed the jet fire to be in the worst orientation i.e. horizontal for aboveground pipelines.

Full-bore Rupture

The worst-case release orientation would be in the horizontal plane producing a flame length of 135 m. The edge of the flame would have over 209 kW/m² of thermal radiation and could cause severe damage to equipment, as well as result in fatalities, within a short time and short distance from the flame.

Figure 47 provides the thermal radiation for a full-bore rupture of a pipeline at a single point, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations. While the effect zone appears large, the actual damage at high thermal radiation would be limited to a relatively small area.

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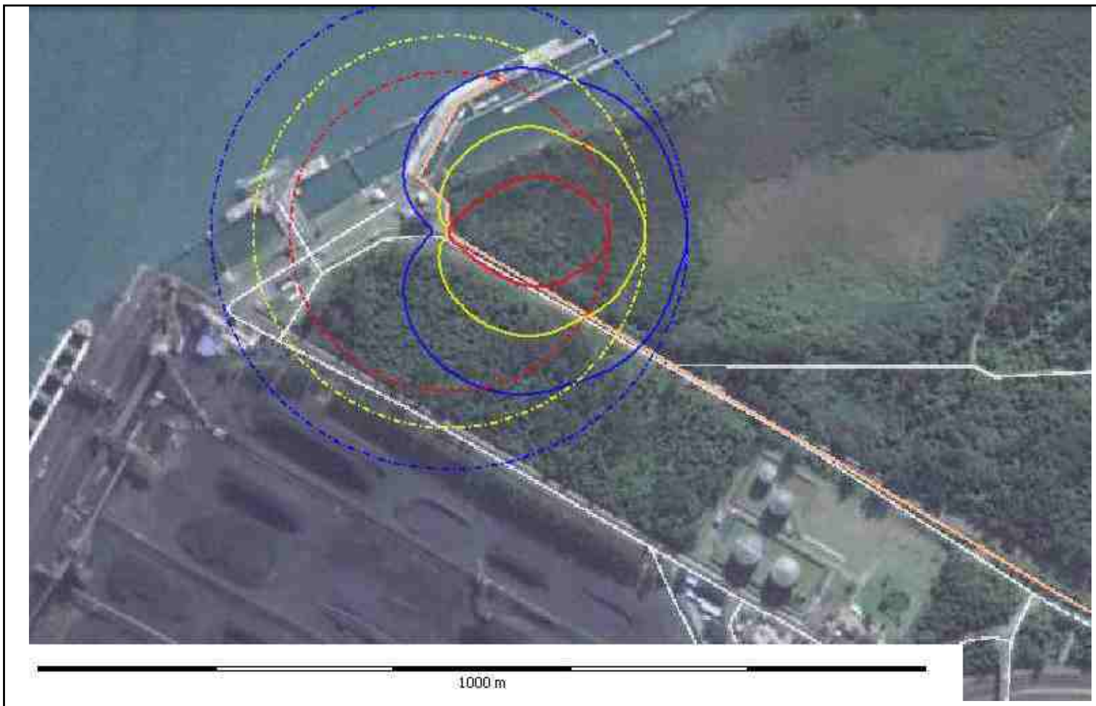

LEGEND	THERMAL RADIATION (kW/m²)
🟦	4
🟨	10
🟥	35

Figure 47: Thermal Radiation for a Jet Fire from a Full-bore Rupture of the LPG Pipeline.

A 25 mm Hole

A 25 mm hole represents approximately 10% of the possible pipeline diameter. The worst-case release orientation would be in the horizontal plane producing a flame length of 34 m in still air. The edge of the flame would have over 207 kW/m² of thermal radiation and could cause severe damage to equipment as well as result in fatalities, within a short time and a short distance from the flame.

Figure 48 gives the thermal radiation at a single point, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations.

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LEGEND	THERMAL RADIATION (kW/m²)
🟦	4
🟨	10
🟥	35

Figure 48: Thermal Radiation for a Jet Fire from a Release from a 25 mm Hole in the LPG Pipeline.

In either scenario, an accidental jet fire from the LPG gas pipeline could have considerable reach and, depending on the orientation and point of release, could damage surrounding pipelines and equipment.

Flash Fires

A flash fire would extend to the Lower Flammable Limit (LFL) but could extend beyond this limit, due to the formation of pockets. It is assumed that people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed.

Flash fires from a LPG pipeline failure are the dominant scenarios and could extend 291 m from a single point of release as shown in Figure 49. The solid lines represent the extent of the impacts as indicated by the LFL during a westerly wind, while the dashed lines indicate the extent of the impact from all wind directions.

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Figure 49: The Extent of a Flash Fire from a LPG Pipeline Failure as Indicated by the LFL.

Vapour Cloud Explosions (VCEs)

A Vapour Cloud Explosion (VCE) from a LPG release would have endpoint distances for overpressures of 0.1 bar (representing the 1% fatality and partial damage to buildings) extending up to 326 m from the point of release, shown in Figure 50. In the scenario modelled, the vapours drifted to an ignition point before detonating. This is referred to as a ‘late explosion’. The solid lines indicate the overpressures from vapours drifting during a south-westerly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions. While the effect zone appears large, the actual explosion damage at high overpressures would be limited to a relatively small area.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. The effects of the blast could damage nearby pipelines, the LPG installation at the proposed Terminal or ships in the harbour, with cascading consequences.

VCEs from petrol or Avgas spills would be more localised.

LEGEND **BLAST OVERPRESSURE**

	(bar)
🟦	0.03
🟨	0.1
🟩	0.3
🟥	0.7

Figure 50: Blast Overpressures from a Large LPG Pipeline Release Resulting in a VCE.

Summary of Impacts

Releases from pipelines can result in more than one undesirable consequence, with certain consequences having an endpoint larger than the 1% fatality. The maximum distances to the 1% fatality isopleth for releases from the transport pipelines, including all the types of scenarios, are given in Table 31.

Table 31: Summary of Impacts from LPG Releases.

Scenario	**Max. Distance to the 1% Fatality Isopleth (m)**	**NEMA Section 30 Incident[2]**
LPG failure	230	No
Petrol rupture	95	Yes Pollution detrimental to the environment
Diesel rupture	85	Yes Pollution detrimental to the environment

---

[2] Section 30 of the NEMA deals with the control of emergency incidents where an "incident" is defined as an "unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed".

Scenario	Max. Distance to the 1% Fatality Isopleth (m)	NEMA Section 30 Incident[2]
LPG leak	50	No
Petrol leak	30	Yes Pollution detrimental to the environment
Diesel leak	28	Yes Pollution detrimental to the environment

6.6.3.1.3 Maximum Individual Risk (MIR)

The MIR for the transport pipelines is shown in Figure 51. The risks are dominated by the flash fire and VCE risks. However, the risk of 1x10^{-6} fatalities per person per year isopleth follows the pipeline and always remains within the port area. As a result there is no risk to the public.

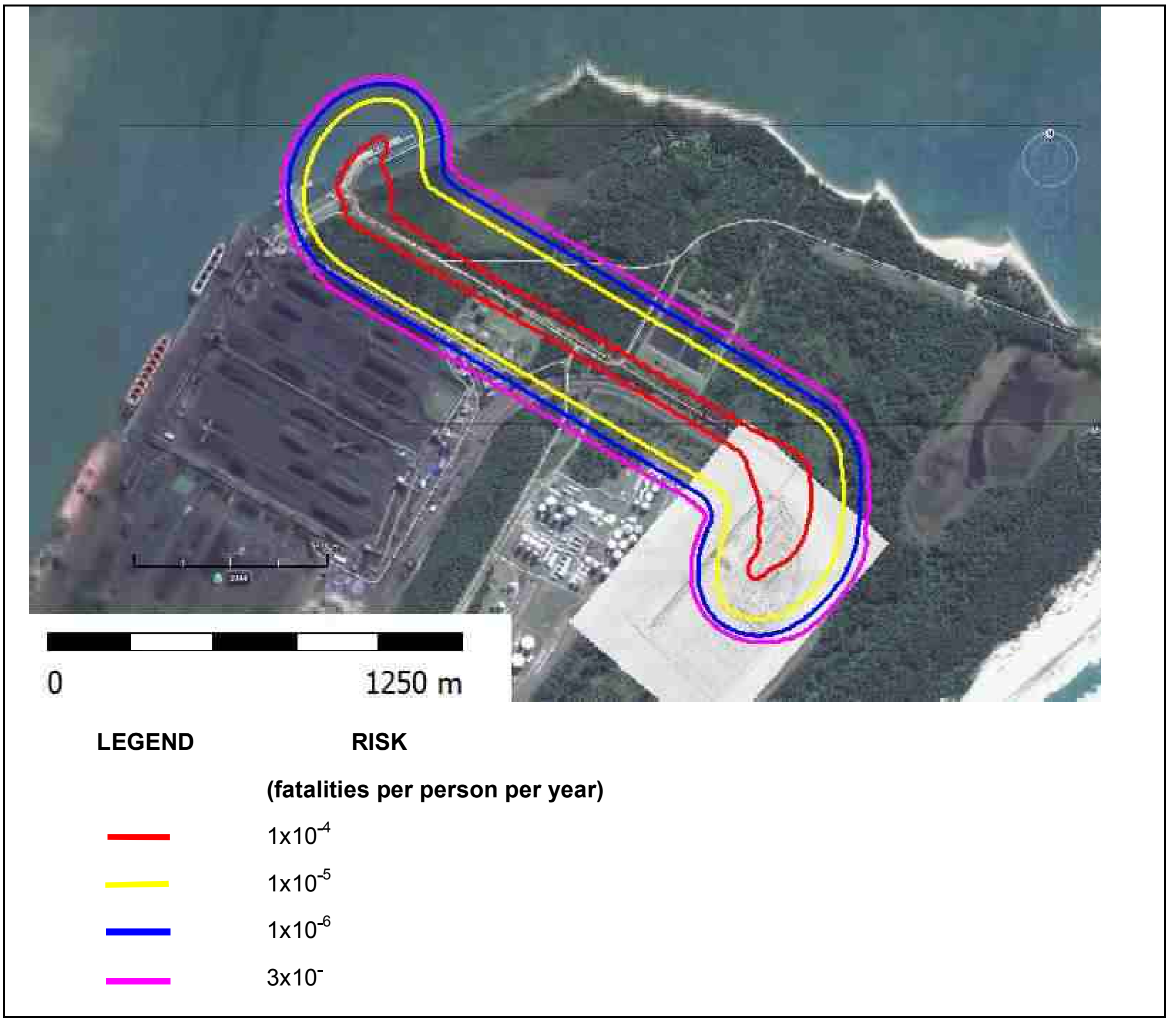

Figure 51: Combined Risks for the Transport Pipelines.

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6.6.3.2 LPG Bulk Storage and Gantries

LPG would be transported from ships to the LPG storage vessels from there, LPG would be loaded into road or rail tankers for distribution. The consequences in this section relate to incidents are the Initial Phase Storage and LPG Storage Vessels.

6.6.3.2.1 Hazard Identification

Notifiable Substances

More than 25 t of LPG will be stored in a single vessel during both the initial and further phases of development. LPG would be classified as a notifiable substance and automatically the proposed Terminal would be classified as a MHI.

Flammable or Combustible Components to be Stored, Transported or Processed

LPG is considered to be an extremely flammable component but is not considered acutely toxic.

6.6.3.2.2 Consequence Modelling

Pool Fires

No pool fires would be expected as released LPG would flash into the vapour state with liquid LPG droplets evaporating rapidly. Furthermore LPG tanks will be mounded thereby preventing the formation of flammable LPG pools below the storage vessels.

Jet Fires

A release of LPG under pressure could result in a jet fire. The simulations assume the jet fire to be in the worst orientation i.e. horizontal for all releases except a Pressure Safety Valve (PSV) release which would be in the vertical orientation.

10 mm Hole

A 10 mm hole would be typical of a small hole or flange gasket failure. The worst-case release orientation would be in the horizontal plane producing a flame length of 20 m in still air. The edge of the flame would have over 51 kW/m² of thermal radiation and could cause severe damage to equipment as well as result in fatalities, within a short time and a short distance from the flame.

Figure 52 provides the thermal radiation for a single vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The contours indicate the flame from a single release orientation.

The 1% fatality, represented by the 10 kW/m² thermal radiation isopleth, remains within the boundary of the proposed Terminal. As no external consequences from this scenario are expected, no further analysis would be required.

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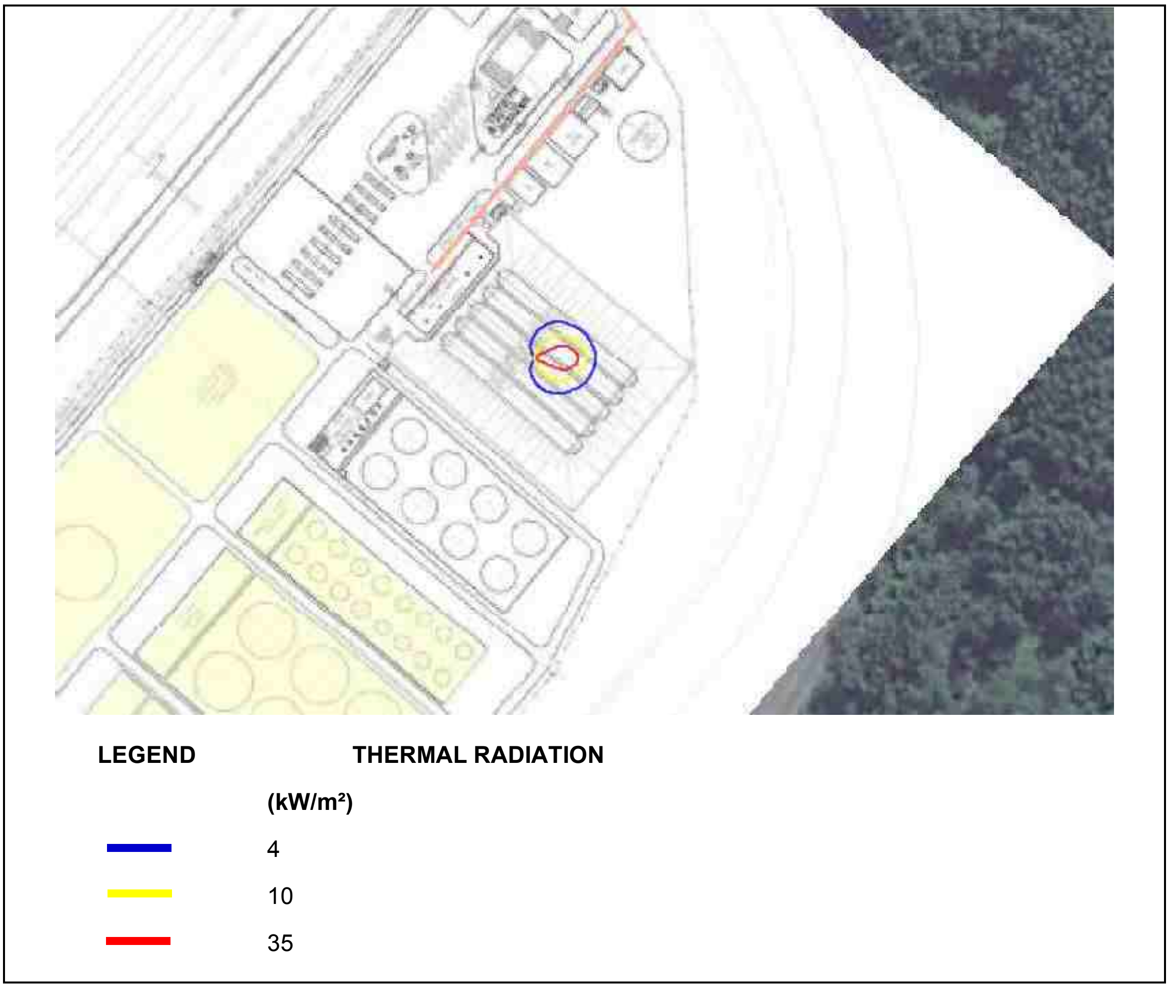

Figure 52: Thermal Radiation of a LPG Jet Fire from a 10 mm Hole at the Initial Phase Storage.

Pressure Safety Valve (PSV) Failure

A Pressure Safety Valve (PSV) is a statutory requirement to protect storage vessels in the event of overpressure and will be provided on all LPG tanks. A failure of the PSV would result in a vertical release. A strong wind could tilt the flame giving the largest distance for ground thermal radiation.

A PSV release from an 8 inch opening would be in the vertical plane producing a flame length of 95 m in still air. The edge of the flame would have over 208 kW/m² of thermal radiation and could cause damage to an adjacent unprotected LPG vessel.

Figure 53 provides the thermal radiation for a single LPG storage vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations. While the effect zone appears large, the actual damage at high thermal radiation would be limited to a relatively small area.

The 1% fatality, represented by the 10 kW/m² thermal radiation isopleth, extends beyond boundary of the proposed Terminal but not beyond port land.

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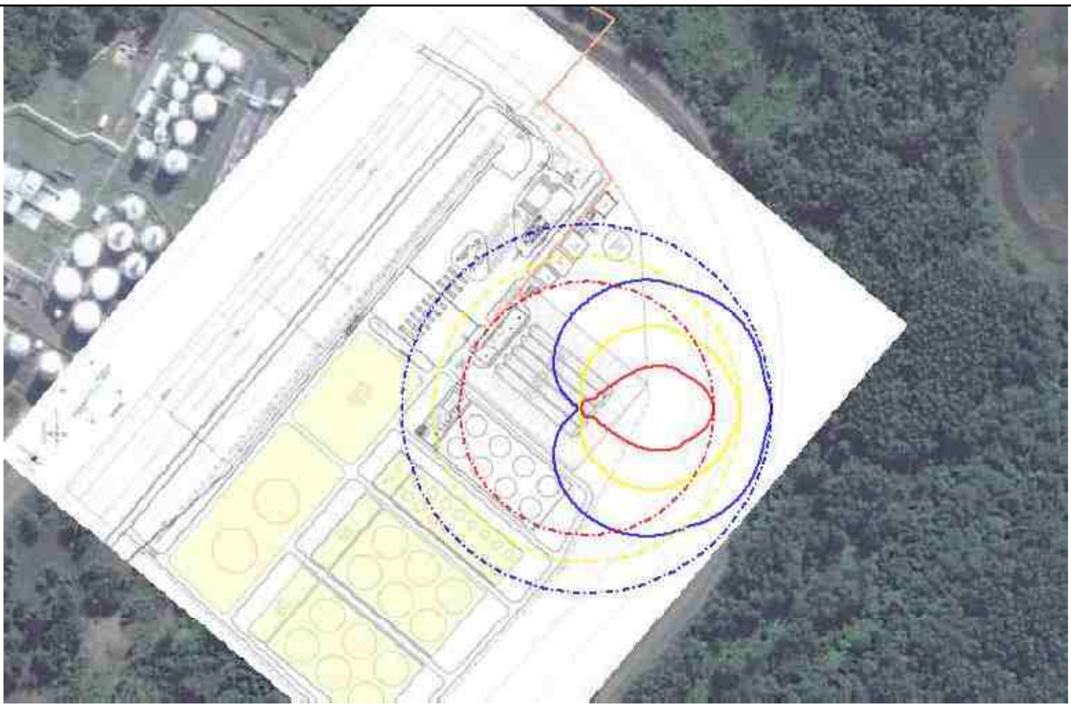
Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m² isopleth, could extend a distance with potential to damage surrounding LPG and liquid fuel tanks with cascading effects.



LEGEND **THERMAL RADIATION**

	(kW/m²)
🟦	4
🟨	10
🟥	35

Figure 53: Thermal Radiation of a LPG Jet Fire from a PSV Failure at the Initial Phase Storage.

Vessel Empties in 10 Minutes

The design of the mounded LPG tanks would determine if a jet fire from a vessel failure could be a plausible scenario. Assuming the mound covers the lower portion of the vessel only, a 7,882 m³ LPG vessel that empties in 10 minutes would have a mass flow of 5,890 kg/s producing a flame length of 656 m for a short duration. The edge of the flame would have over 346 kW/m² of thermal radiation that could cause damage to an adjacent unprotected LPG vessel.

Figure 54 provides the thermal radiation for a single vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations.

The 1% fatality, represented by the 10 kW/m² thermal radiation isopleth, extends beyond the boundary of the proposed Terminal but not beyond port land.

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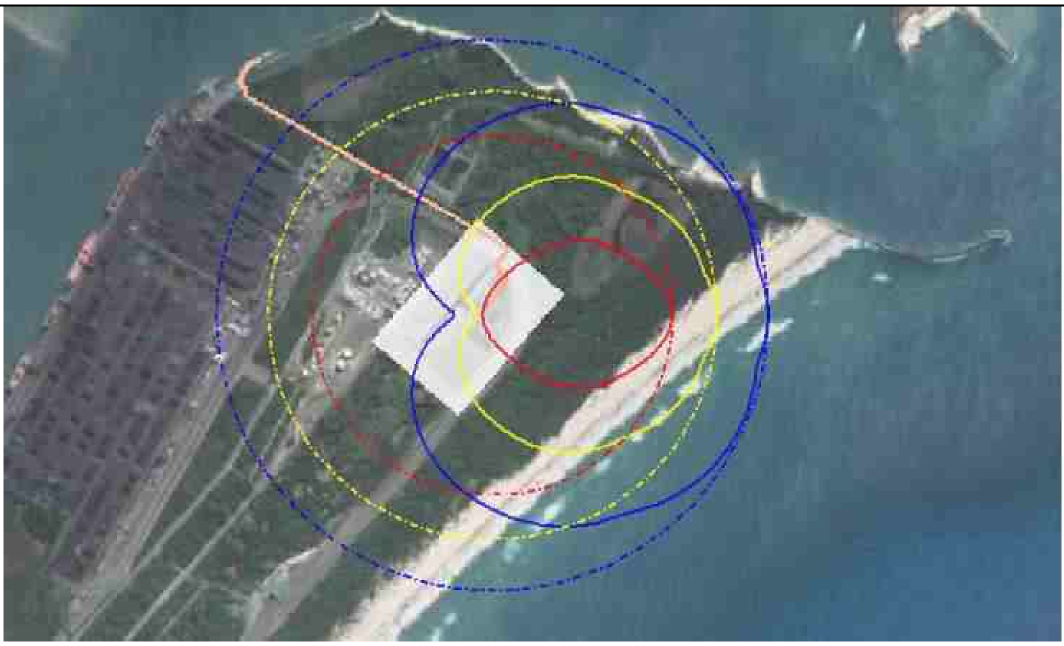
Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m² isopleth, could extend a considerable distance with potential to damage surrounding LPG and liquid fuel tanks with cascading effects.



LEGEND	**THERMAL RADIATION**
	(kW/m²)
🟦	4
🟨	10
🟥	35

Figure 54: Thermal Radiation of a LPG Jet Fire from a Fixed Duration Release at the Initial Phase Storage.

Flash Fires

A flash fire would extend to the LFL but could extend beyond this limit, due to the formation of pockets. It is assumed that unprotected people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed.

The dominant flash fire scenario is the failure of a single 7,882 m³ storage vessel, as shown in Figure 55. Off-site impacts are indicated by the LFL, which in the worst-case scenario can extend 3.3 km downwind of the release. The extent of a flash fire from the 90 m³ stenched vessel is shown for comparison.

In the worst conditions, a flash fire from a loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas.

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LEGEND	FLASH-FIRE SCENARIO	
🟨	LPG storage vessel (7,882 m^3):	Empties in 10 min
🟦	LPG storage vessel (7,882 m^3):	Catastrophic failure
🟥	LPG stenched vessel (90 m^3):	Catastrophic failure
🟪	LPG stenched vessel (90 m^3):	Empties in 10 min

Figure 55: Maximum Extent of the Impact from LPG Flash Fires at the Initial Phase Storage.

Vapour Cloud Explosions (VCEs)

Figure 56 indicates the off-site blast overpressures of 0.1 bar (representing the 1% fatality and partial damage to buildings) due to loss of containment of LPG vapours from a single 7,882 m^3 storage vessel in the worst meteorological conditions. The VCE from a loss of containment of the 90 m^3 stenched vessel is shown for comparison.

In the modelled scenario, vapours drifted to an ignition point before detonating. This is referred to as a 'late explosion'. The solid lines indicate the overpressures from vapours drifting during a westerly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions. While the effect zone appears large, the actual explosion damage at high overpressures would be limited to a relatively small area.

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LEGEND	FLASH-FIRE SCENARIO	
🟨	LPG storage vessel (7,882 m³):	Empties in 10 min
🟦	LPG storage vessel (7,882 m³):	Catastrophic failure
🟥	LPG stenched vessel (90 m³):	Catastrophic failure
🟪	LPG stenched vessel (90 m³):	Empties in 10 min

Figure 56: Maximum Distances to the 0.1 Bar Overpressure for LPG VCEs at the Initial Phase Storage.

The worst-case blast overpressures would be the fixed duration release of a single LPG storage vessel, as shown in Figure 57. The solid lines indicate the overpressures from vapours drifting during a westerly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. A large release of LPG could result in extensive damage and fatalities up to 1.4 km downwind of the release.

No lethal effects are expected below 0.1 bar overpressure for people in the open. In the worst conditions, a VCE from a loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas.

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LEGEND **BLAST OVERPRESSURE**

(bar)

🟦	0.1
🟨	0.3
🟥	0.7

Figure 57: Blast Overpressures for the Worst-case Vapour Cloud Explosion from a Release from a Single 7,882 m³ LPG Storage Vessel.

Boiling Liquid Expanding Vapour Explosions (BLEVEs)

A BLEVE could occur if a flame impinges on a LPG pressure vessel, particularly in the vapour space region where cooling by evaporation of the contained LPG does not occur.

The major consequences of a BLEVE are intense thermal radiation from the fireball, a blast wave and fragments from the shattered vessel. These fragments may be projected to considerable distances. Analyses of the travel range of fragment missiles from a number of BLEVEs suggest that the majority land within 700 m from the incident. A blast wave from a BLEVE is fairly localised but can cause significant damage to immediate equipment.

A BLEVE would not be expected at the proposed Terminal as the tanks would be mounded to prevent LPG pooling below the tank. However, a BLEVE could be formed at the LPG stenched vessel or at the LPG road and rail tankers. The characteristics of these BLEVEs are indicated in Table 32.

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Table 32: Characteristics of LPG BLEVEs at the Stenched Vessel or at the Road and Rail Tankers

Parameter	Stenched Vessel (90 m³)	Rail Tanker (56 m³)	Road Tanker (50 m³)
Initial mass in vessel (kg)	44,623	27,766	24,791
Duration of the fire ball (s)	13.1	11.6	11.3
Maximum diameter of the fire ball (m)	205.7	175.6	169.1
Maximum height of the fire ball (m)	308.6	263.4	253.7
Distance to 1% fatality (m)	293.5	241.2	230.3
Distance to10% fatality (m)	248.2	203.4	194.0
Distance to 50% fatality (m)	199.4	162.8	155.2
Distance to 90% fatality (m)	156.9	127.4	121.2

The 1% fatality from LPG BLEVEs at the stenched vessel or road and rail tankers is shown in Figure 58. While the impacts from LPG BLEVEs could extend beyond the proposed Terminal, no fatalities would be expected outside of port land.

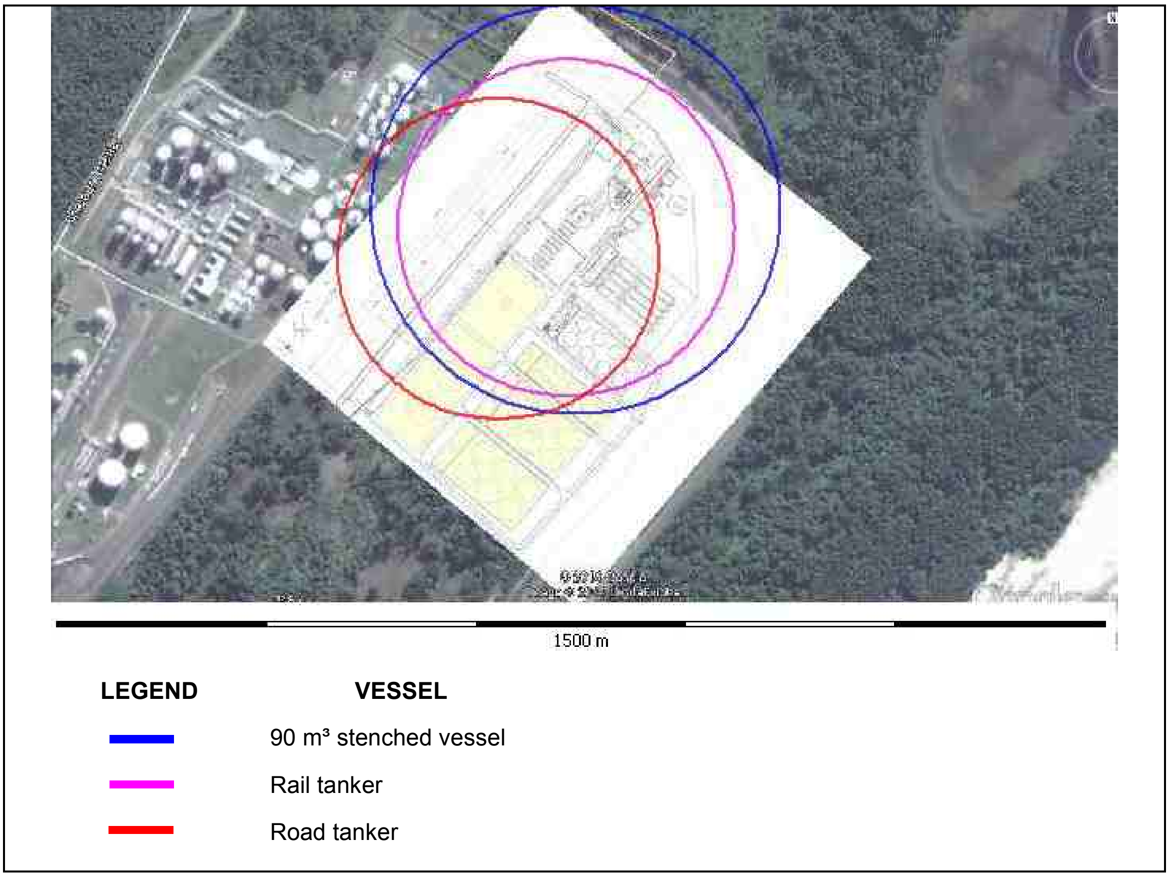


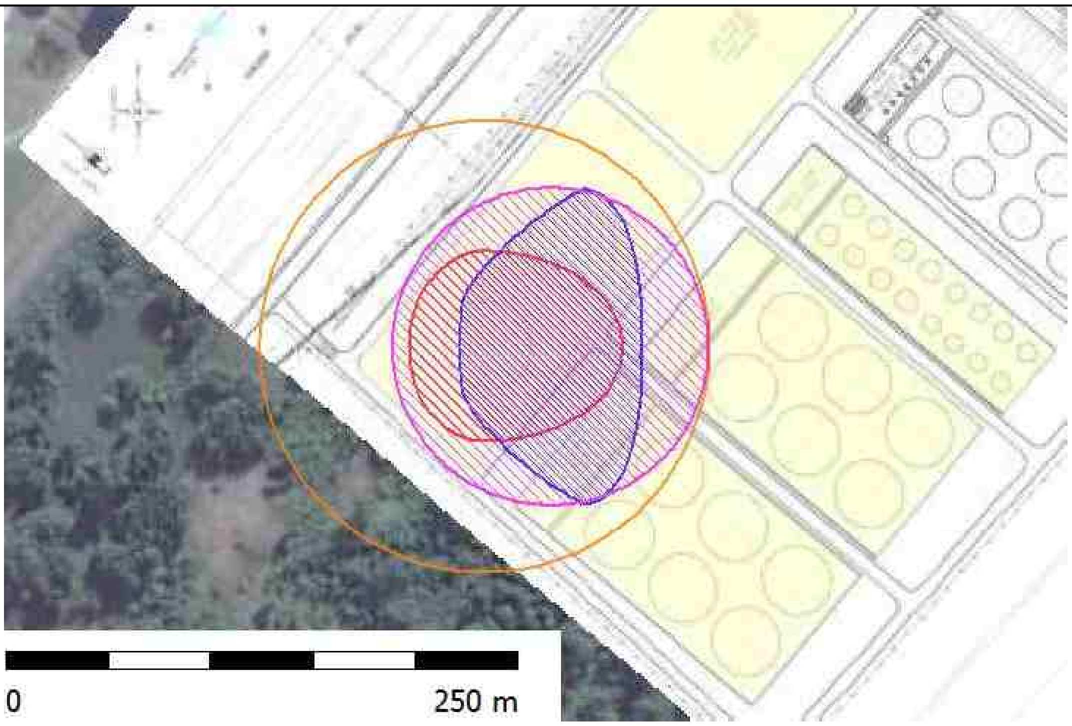
Figure 58: The 1% Fatality from LPG BLEVEs at the Stenched Vessel or at the Road and Rail Tankers.

Further Phases

Further phases envisaged for the proposed Terminal may include the construction of two spherical vessels of 34,000 m³ each containing refrigerated LPG.

The extent of the 1% fatality from a loss of containment from a single refrigerated LPG sphere is shown in Figure 59. The shaded areas indicate the extent of impacts from particular scenarios during a westerly wind, while the single line shows maximum distance to the 1% fatality isopleth from all wind directions.

A VCE would produce the greatest distance to the 1% fatality isopleth that could extend beyond the boundary of the proposed Terminal but not beyond port land.



LEGEND	RISK	
—	Vapour cloud explosion	(0.1 bar overpressure)
—	Pool fire	(10 kW/m²)
—	Flash fire	(LFL)
—	Maximum distance to the 1% fatality isopleth	

Figure 59: The Extent of the 1% Fatality from a Loss of Containment of the Proposed LPG Sphere.

Summary of Impacts

Loss of containment of LPG can result in more than one undesirable consequence, with certain consequences having an endpoint larger than the 1% fatality. The maximum distances to the 1% fatality isopleth from all LPG release scenarios are given in Table 33.

Table 33: Summary of Impacts from LPG Releases at Bulk Storage or the Gantries

Scenario	Max. Distance to the 1% Fatality Isopleth (m)	NEMA Section 30 Incident[3]
Future LPG Storage (34,000 m³)		No
Catastrophic failure	110	
Fixed duration release	109	
LPG Rail Gantry		No
Rail tanker (56 m³) failure	344	
Rail tanker loading arm failure	188	
Rail tanker loading arm leak	25	
LPG Road Gantry		No
Road tanker (50 m³) failure	332	
Road tanker loading arm failure	188	
Road tanker loading arm leak	25	
LPG Storage (7,882 m³)		Yes Reaches the public
Fixed duration release	3,385	
Pump failure	3,160	
Vessel failure	2,201	
Overfill	383	
PSV failure	150	
10 mm hole	37	
LPG Stenched Vessel (90 m³)		No
Pump failure	557	
Vessel failure	406	
Fixed duration release	272	
PSV failure	149	
Overfill	88	
10 mm hole	37	

6.6.3.2.3 Maximum Individual Risk (MIR)

The risks for LPG bulk storage and gantries for the initial and further phases of development are shown in Figure 60. The risk of $3x10^{-7}$ fatalities per person per year isopleth, representing trivial risk, extends about 2.9 km downwind from the release into the harbour area but not into the residential areas. The risk of $1x10^{-6}$ fatalities per person per year isopleth would extend beyond port land into unoccupied ocean. Thus,

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[3] Section 30 of the NEMA deals with the control of emergency incidents where an “incident” is defined as an “unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed”.

the risk due to the proposed Terminal would be considered acceptable provided that the PADHI land use restrictions are applied.

LEGEND	RISK (fatalities per person per year)
🟥	1x10^{-4}
🟨	1x10^{-5}
🟦	1x10^{-6}
🟪	3x10^{-7}

Figure 60: Risk Contours for LPG Releases at the Bulk Storage and Gantries.

6.6.3.3 Bulk Atmospheric Storage and Gantries

The proposed Terminal would receive CPP liquid fuels and other components that would be stored in bulk tanks and dispatched by ship, road or rail. The consequences in this section relate to incidents are the CPP storage.

6.6.3.3.1 Hazard Identification

Notifiable Substances

Liquid fuels are not considered notifiable substances.

Flammable or Combustible Components to be Stored, Transported or Processed

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic.

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A number of chemicals could be stored on and transported onto the proposed Terminal site during further project phases. Given that the full chemical inventory could change, calculations were done on a conservative basis using petrol in all scenarios.

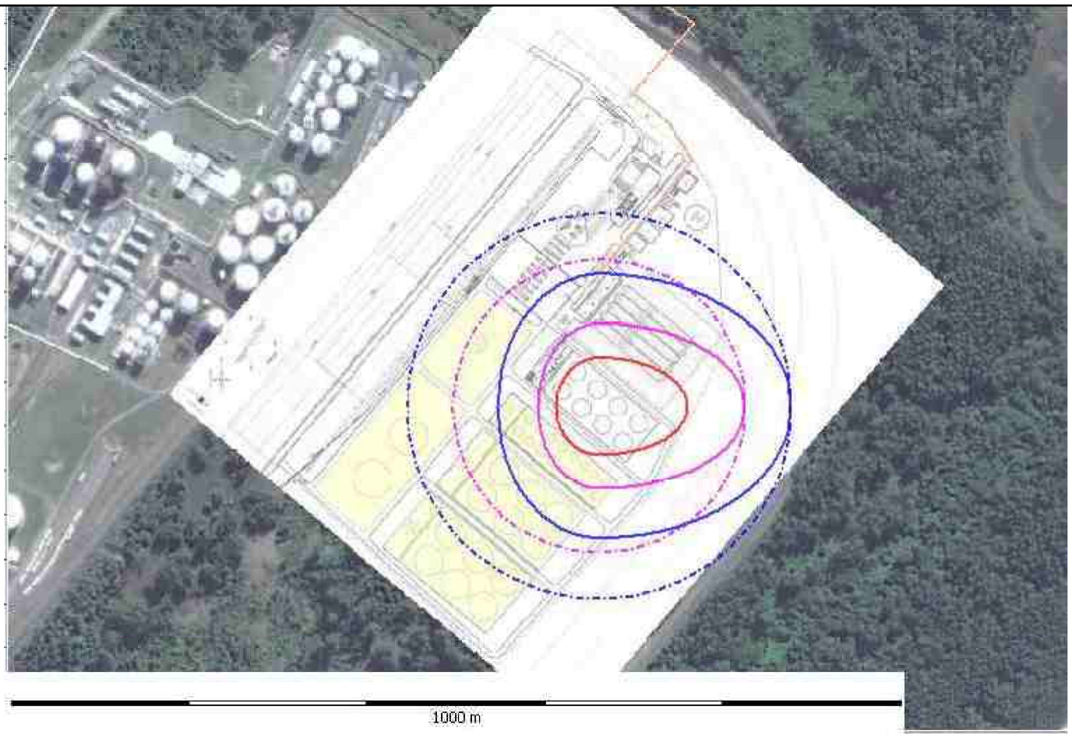
6.6.3.3.2 Consequence Modelling

Bund and Pool Fires

Pool fires would occur with a loss of containment of flammable or combustible material followed by an ignition.

In the event of a pool fire the flames would tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of the impacts of thermal radiation. In the event of a large release from a tank or associated piping, the spilt material would be contained within the bunded area. The extent of pool fires, under strong wind conditions, is shown in Figure 61. The solid lines indicate a westerly wind, while the dashed lines indicate a wind from all directions.

The 1% fatality, represented by the 10 kW/m² thermal radiation isopleth, extends beyond the boundary of the proposed Terminal but not beyond port land.



LEGEND	THERMAL RADIATION (kW/m²)
🟦	4
🟪	10
🟥	35

Figure 61: The Extent of Thermal Radiation from a Large Bund Fire for the Initial Phase of CPP Storage.

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Releases from the road and railway gantries would be collected in the sump. As a result, all major fires would occur at the sump, producing the thermal radiation shown in Figure 62.

Impacts from pool fires at the sump would not extend beyond the boundary of the proposed Terminal, and therefore no further analysis would be required.

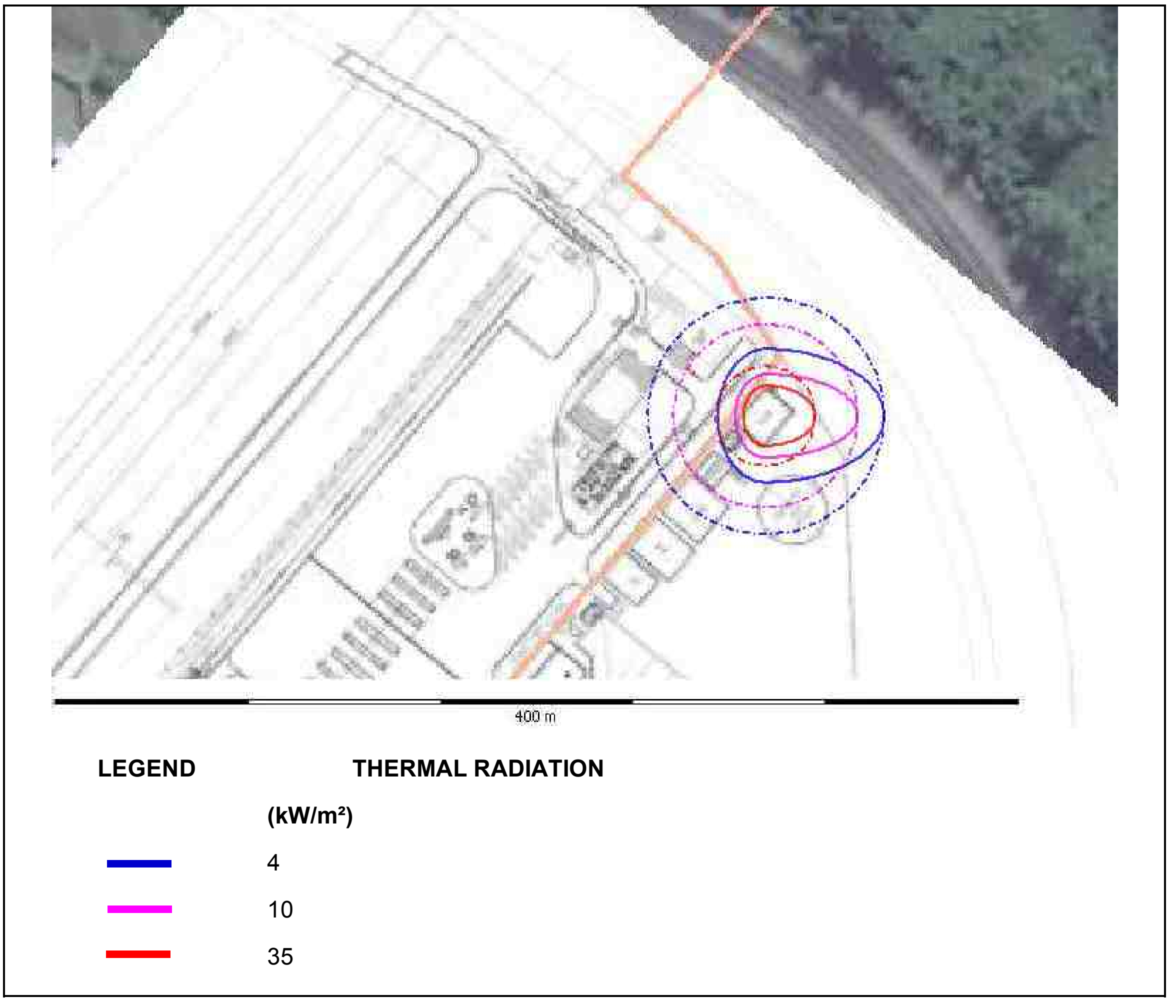

Figure 62: The Extent of Thermal Radiation a Large Pool Fire at the Sump of the Gantries.

Tank-top Fires

A tank-top fire would occur if the flammable vapours above the stored liquid ignite. The resulting fire would be contained within the tank but could cascade into a bund fire with the collapsing of the tank.

The thermal-radiation isopleths from a single tank-top fire, representing the largest tank, are shown in Figure 63.

The 1% fatality, represented by the 10 kW/m² thermal radiation isopleth, remains within the boundary of the proposed Terminal. As no external consequences from this scenario are expected, no further analysis would be required.

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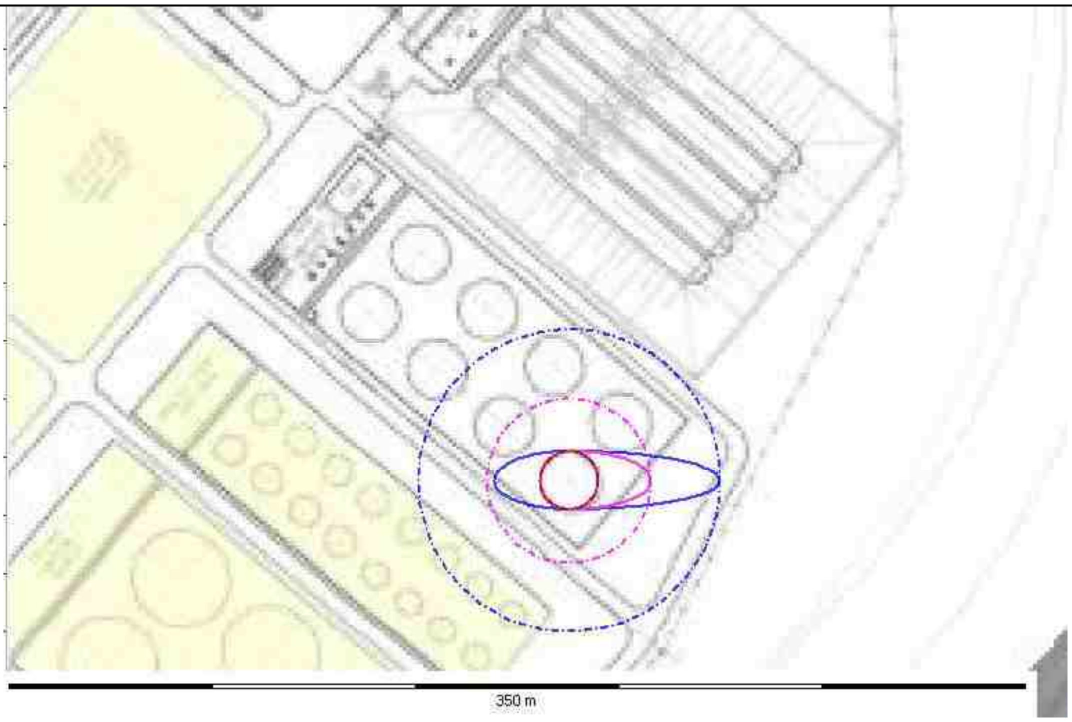

LEGEND **THERMAL RADIATION**

(kW/m²)

🟦	4
🟪	10
🟥	35

Figure 63: Thermal Radiation from Tank-top Fires for the Initial Phase of CPP Storage.

Flash Fires

A flash fire would extend to the LFL but could extend beyond this limit, due to the formation of pockets. It is assumed that unprotected people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed.

Flash fires from large bund spillages of petrol are illustrated in Figure 64. The thin line shows the flammable cloud shape during a northerly wind, while the dashed line shows the effect zone from all wind directions.

Flash fires would remain within the boundary of the proposed Terminal and would only pose a threat to workers in the immediate vicinity. As flash fires would not extend beyond the boundary of the proposed Terminal, no further action would be required.

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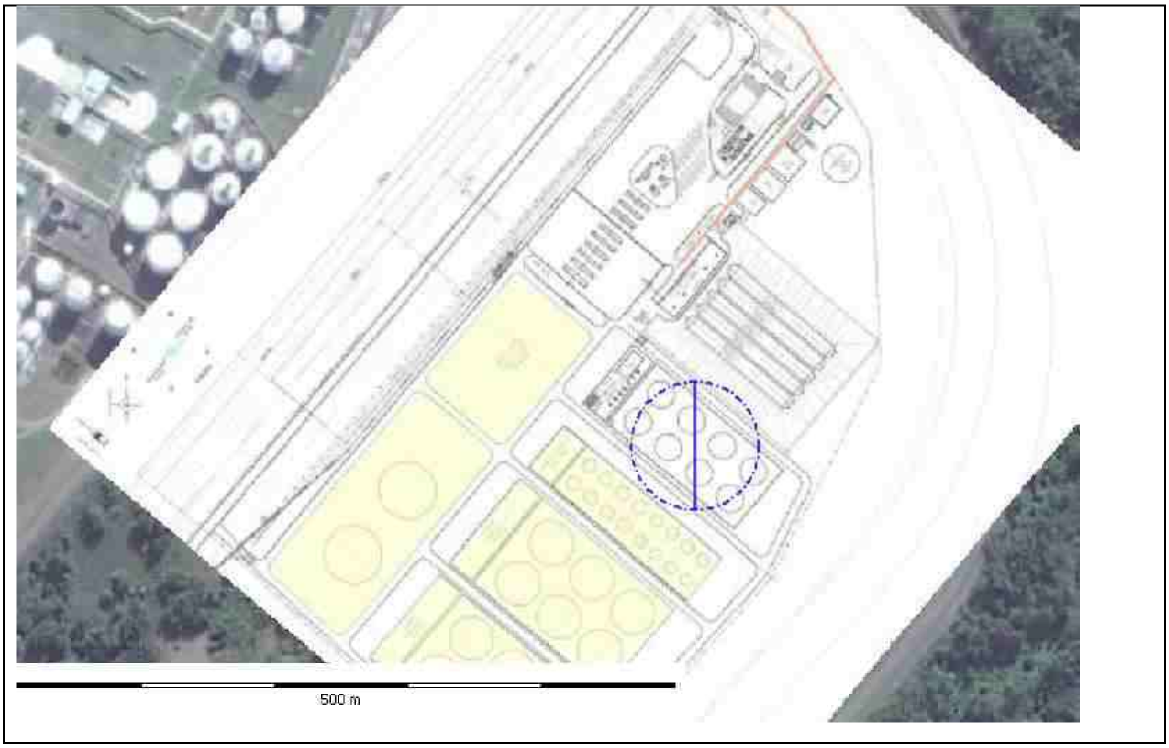


Figure 64: Flash Fires from Loss of Containment within the Initial Phase of CPP Storage.

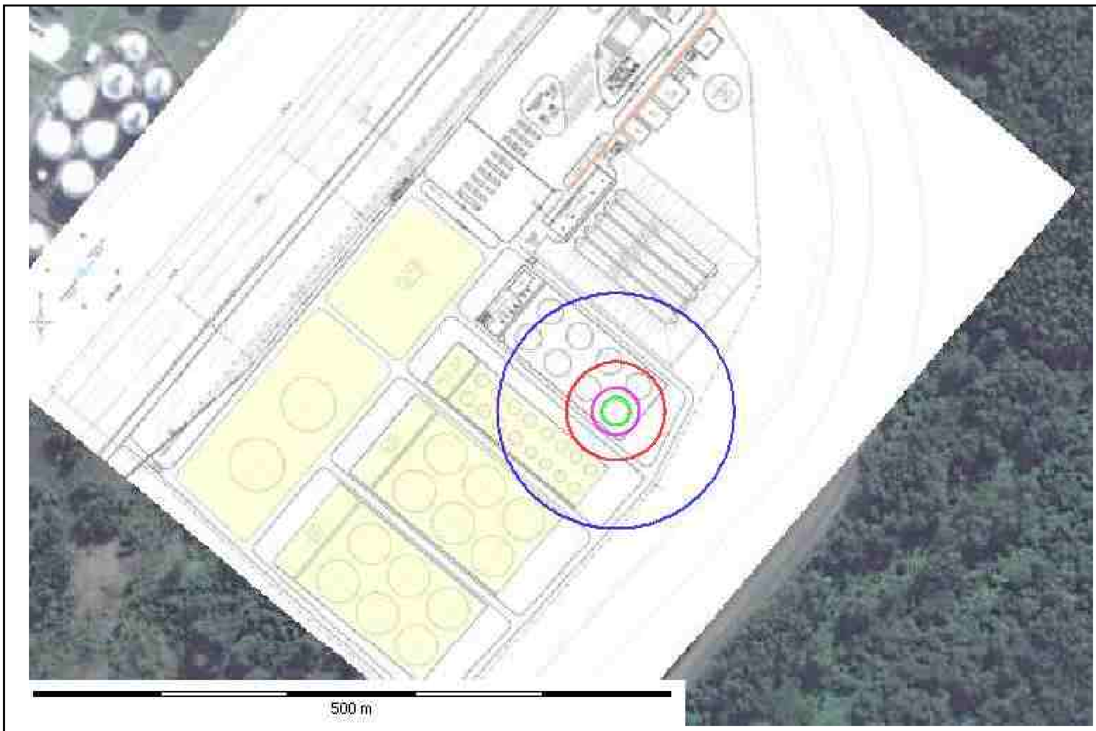
Fixed-roof Tank Explosions

Petrol tanks will be fitted with internal floating roofs, thereby eliminating the formation of flammable clouds above the liquid levels. However, the floating roof rests on legs approximately 1.8 m above the base of the tank. Under certain conditions when the tank is almost empty flammable vapours can occupy the space below the floating roof. The mass used in the explosion calculations is the volume of flammable material at its lower flammability limit.

The blast overpressures from a fixed-roof explosion at a single petrol storage tank for the initial phase is shown in Figure 65.

The 0.1 bar overpressure isopleth, representing the 1% fatality and partial damage to buildings, would not extend beyond the boundary of the proposed Terminal. As a result there would be no off-site consequences from fixed-tank explosions.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. A large explosion may damage the storage tank as well as surrounding tanks with cascading effects.



LEGEND		TANK EXPLOSION
	(bar)	
🟦	0.03	Glass breaks, minor injuries
🟥	0.1	1% fatality, some walls destroyed
🟪	0.3	100% fatality, major structural damage
🟩	0.7	Almost total destruction

Figure 65: Blast Overpressures for a Single Fixed-roof Tank Explosion at the Initial Phase of CPP Storage.

Vapour Cloud Explosions (VCEs)

Figure 66 indicates the expected blast overpressures from a large release of petrol into the bund. Bund blast impacts would remain on site without potential injuries to the public.

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LEGEND	(bar)	VCE
🟦	0.03	Glass breaks, minor injuries
🟥	0.1	1% fatality, some walls destroyed
🟪	0.3	100% fatality, major structural damage
🟩	0.7	Almost total destruction

Figure 66: Vapour Cloud Explosions from Bund Spillages at the Initial Phase of CPP Storage.

Boiling Liquid Expanding Vapour Explosions (BLEVEs)

A BLEVE could occur if a flame impinges on a petrol road or rail tanker, particularly in the vapour space region where cooling by evaporation of the contained petrol does not occur.

Spillages at the road and rail gantry would be directed to the sump, thereby making BLEVEs of road and rail tankers an implausible scenario.

6.6.3.3.3 Maximum Individual Risk (Initial and Further Phases)

Each vessel would have two level transmitters that would signal the level to the control system. At high level an alarm would be activated in the control room for remedial action. The level transmitters would be independent and would not suffer common mode failure. The failure rate of the level controllers has not been given, and thus the lowest SIL value of 1 (0.1 failure per annum) was assigned.

A level switch would signal to the emergency shutdown (ESD) system to close the valve on the incoming line. The failure rate of the level switch has not been given, and thus the lowest SIL value of 1 was assigned. The level controls and level switch would also be independent.

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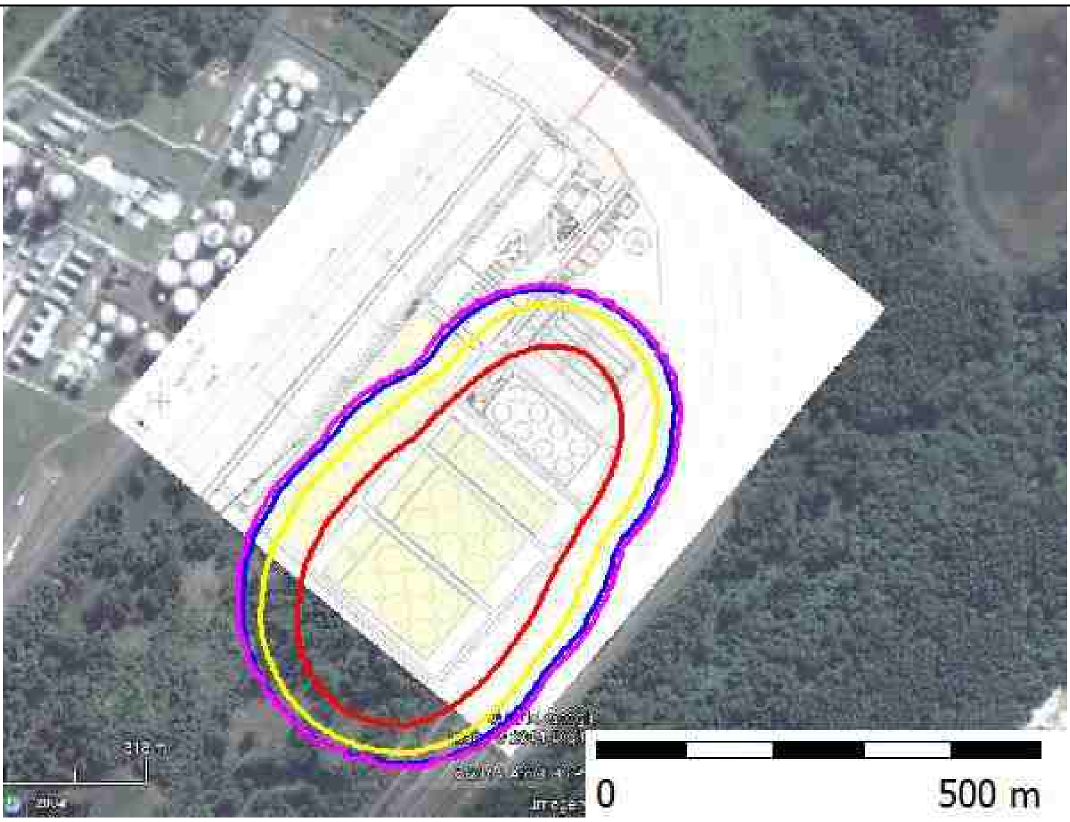
The risk isopleths for the proposed Terminal after completion of the further phases are indicated in Figure 67. The risk of 1x10^{-4} fatalities per person per year is close in value to the risk of 3x10^{-7} fatalities per person per year, as the risk drops rapidly from the point of release. The risk of 1x10^{-4} fatalities per person per year extends beyond the boundary of the proposed Terminal on the southern and eastern sides but would not extend beyond port land. Thus, the risks to the public would be considered acceptable.

As the components to be stored in the tanks of the further phases have not been fully described, the risk assessment assumed the worst case being petrol. In the event that the tanks would contain higher flashpoint materials, the risk isopleths may diminish in size.



LEGEND	RISK (fatalities per person per year)
🟥	1x10^{-4}
🟨	1x10^{-5}
🟦	1x10^{-6}
🟪	3x10^{-7}

Figure 67: Risk Isopleths for the Initial and Further Phases of the Bulk Atmospheric Storage.

6.6.3.4 Consolidated Risks

The consolidated risk is combined from the MIRs and is shown in Figure 68 for the initial phase of the proposed Terminal, with the contributions from each hazardous area on the proposed Terminal site.

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The risk of 1×10^{-4} fatalities per person per year isopleth (generally considered the upper limit of tolerable) remains within port land and does not enter areas used by the general public.

Similarly, the risk of 1×10^{-6} fatalities per person per year isopleth, representing the lower limit of tolerable, does not extend into areas used by the general public. Risks less than 3×10^{-7} fatalities per person per year would be considered trivial and acceptable for land use by vulnerable populations, such as hospitals, nursery schools, retirement homes, etc.

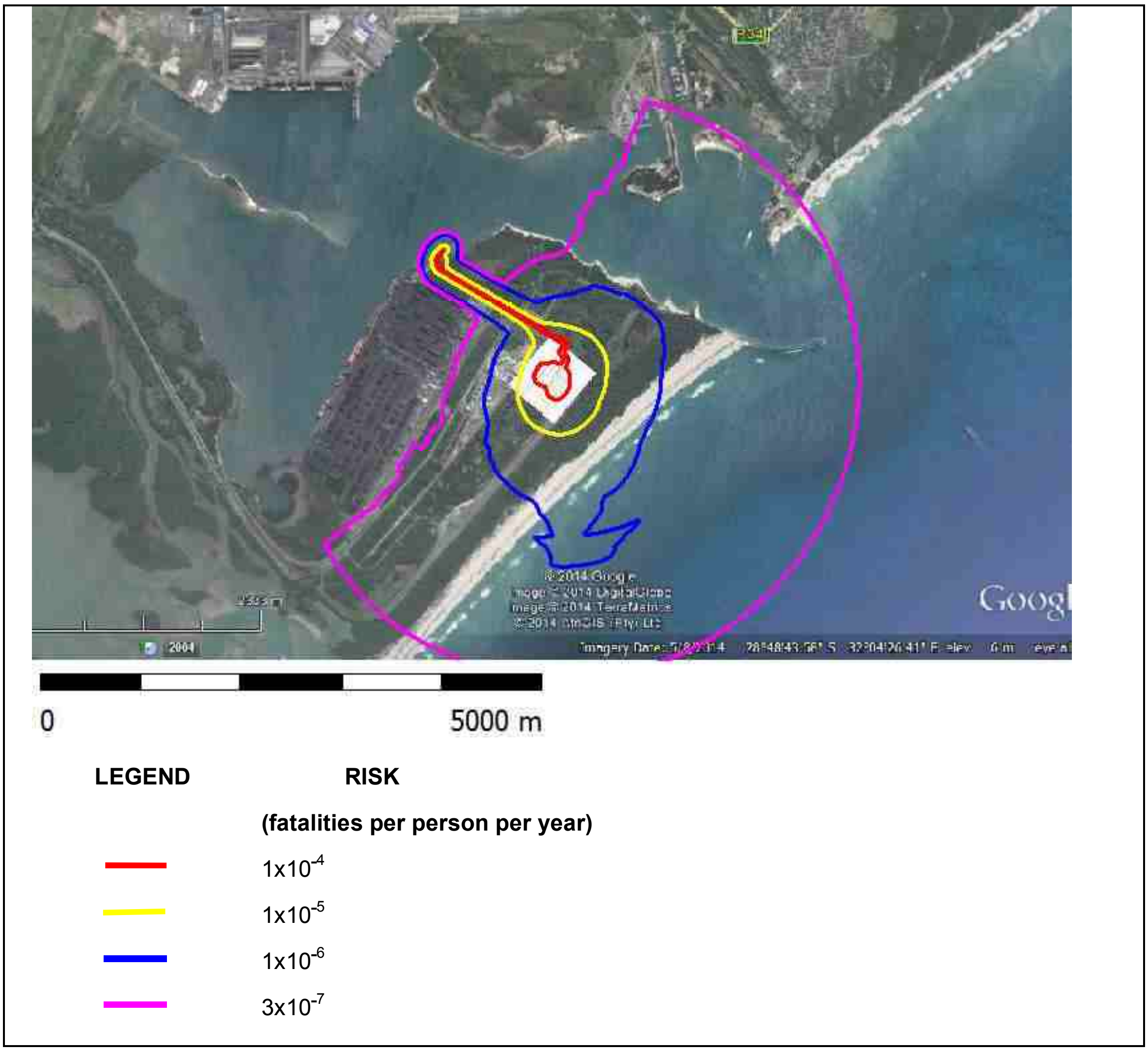

Figure 68: Combined risks for the Initial and Further Phases of the proposed Terminal.

The combined risks for the initial and further phases of the proposed Terminal are shown in Figure 69. The addition of the further phases would increase the extent of the risk of 1×10^{-6} fatalities per person per year isopleth but would have little effect otherwise.

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LEGEND	RISK
	(fatalities per person per year)
🟥	1x10^{-4}
🟨	1x10^{-5}
🟦	1x10^{-6}
🟪	3x10^{-7}

Figure 69: Combined Risks for the Initial and Further Phases of the proposed Terminal.

6.6.4 Impact Assessment

The following impacts have been identified for the proposed Terminal from a Risk perspective.

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Table 34: Rating of Potential Risks Associated with the Proposed Terminal.

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Transport pipelines	Fires and explosions due to loss of containment with an ignition	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Moderate	Low
	Fires and explosions due to a loss of containment of LPG pipeline from the berths to the terminal	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Moderate	Low
	Fires and explosions due to a loss of containment of CPP pipeline from the berths to the terminal	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Moderate	Low
	Soil and	Negative	Improbable	Short-term	High	Local	Reversible	Low	Moderate	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
	water contamination due to a loss of containment of CPP pipeline from the berths to the terminal									
LPG bulk storage and gantries	Fires and explosions due to loss of containment with an ignition	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Moderate	Low
	Fires and explosions due to a loss of containment at the gantries	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Moderate	Low
Atmospheric bulk storage and gantries	Fires and explosions due to loss of containment	Negative	Improbable	Short-term	High	Local	Irreversible	Low	Moderate	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
	with an ignition									
	Fires and explosions due to a loss of containment at the gantries	Negative	Improbable	Short-term	High	Local	Irreversible	Low	Moderate	Low

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6.6.5 Specialist Conclusions

The Risk Impact Assessment undertaken by RISCOM was conducted on the assumption that the proposed Terminal is maintained to an acceptable level and that all statuary regulations are applied. It also assumed that the detailed engineering designs would be correctly specified for the intended duty. For example, it assumed that the tank wall thicknesses would have been correctly calculated, that the vents have been sized for emergency conditions, that the instrumentation and electrical components comply with the specified electrical area classification, and that the material of construction is compatible with the products, etc. It remains the responsibility of VSAD and their appointed contractors to ensure that all engineering designs have been completed by competent persons and that all equipment has been installed correctly. All designs should be in full compliance with (but not limited to) the OHSA and its regulations, the National Buildings Regulations and the Buildings Standards Act (Act No. 107 of 1977) as well as all applicable local bylaws.

A number of incident scenarios were simulated, taking into account prevailing meteorological conditions.

Hazardous Components

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic. Nitrogen is an inert gas but can replace air and act as an asphyxiant. The nitrogen inventory has not been specified, and it is assumed that nitrogen would be generated on site with minimal inventory.

Notifiable Substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances requires any employer who has a substance equal to or exceeding the quantity as listed in the regulations to notify the divisional director. A site is classified as a MHI if it contains one or more notifiable substances or if the off-site risk is sufficiently high. Petrol, diesel, Avgas and nitrogen are not listed as notifiable products. More than 25 t of LPG would be stored in a single vessel during the initial and further phases of development. LPG will be classified as a notifiable substance and automatically the proposed Terminal would be classified as a MHI.

Transport Pipelines from Berthed Ship to Terminal

Transport pipelines would be used to carry CPP products and LPG between Berths 208 and 209 and the proposed Terminal. Petrol was used to reflect the worst case scenario for all modelling for the CPP pipelines. Impacts from petrol pool fires as well as LPG jet fires, flash fires and VCEs, due to a release from a single point on the relevant pipeline with an ignition, could extend various distances from that pipeline. The worst case of the failure of the LPG pipeline could extend 230 m to the 1% fatality but would not constitute a NEMA Section 30 incident, as it would not reach an area used by the general public or cause pollution to the environment. The worst case of the failure of the CPP pipeline could extend 95 m to the 1% fatality and would constitute a NEMA Section 30 incident as it could cause pollution to the environment.

The risks are dominated by the flash fire and VCE risks. However, the risk of $1x10^{-6}$ fatalities per person per year isopleth follows the pipeline and always remains within port land; therefore, there is no risk to the public.

LPG Bulk Storage and Gantries

LPG would be transported from ships to the LPG storage vessels, and from there would be loaded into road or rail tankers. The 1% fatality for jet fires, due to the release from a single mounded vessel in the initial phase followed by ignition, could extend beyond the boundary of the proposed Terminal but not beyond port land. In the worst conditions, a flash fire or VCE from a similar loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas. This would constitute a NEMA Section 30 incident as it could reach the public. A BLEVE would not be expected at the bulk storage tanks during the initial phase of development as the tanks would be mounded to prevent LPG pooling below the tank. However, a BLEVE could be formed at the LPG stenched vessel or at the LPG road and rail tankers.

While the impacts could extend beyond the boundary of the proposed Terminal, no fatalities would be expected outside of port land. Further phases of development may include two LPG spherical vessels. A VCE would produce the greatest distance to the 1% fatality isopleth, which could extend beyond the boundary of the proposed Terminal but not beyond port land. The risk of $3x10^{-7}$ fatalities per person per year isopleth, representing trivial risk, could extend about 2.9 km downwind from the release into the harbour area but not into the residential areas.

The risk of $1x10^{-6}$ fatalities per person per year isopleth could extend beyond port land into unoccupied ocean. Thus, the risk due to the proposed Terminal would be considered acceptable provided that the PADHI land use restrictions are applied.

Bulk Atmospheric Storage and Gantries

The proposed Terminal would receive CPP liquid fuels and other components that would be stored in bulk tanks and dispatched by ship, road or rail. Petrol was used to reflect the worst case scenario for all modelling. The 1% fatality due to pool fires at the initial phase's bulk storage could extend beyond the boundary of the proposed Terminal but not beyond port land. Releases from the road and railway gantries would be collected in the sump. Impacts from pool fires at the sump would not extend beyond the boundary of the proposed Terminal. Impacts at the initial phase's bulk storage from tank-top fires, flash fires, fixed-roof tank explosions and VCEs would not extend beyond the boundary of the proposed Terminal. Spillages at the road and rail gantry would be directed to the sump, making BLEVEs of road and rail tankers an implausible scenario.

The risk of $1x10^{-4}$ fatalities per person per year isopleth, representing the upper limit of tolerable, extends beyond the boundary of the proposed Terminal on the southern and eastern sides but would not extend beyond port land. Thus, the risks to the public are considered acceptable.

Consolidated Risks

The consolidated risk was combined from the contributions of each hazardous area on site for the initial phase of development for the proposed Terminal. The risk of $1x10^{-4}$ fatalities per person per year isopleth (generally considered the upper limit of tolerable) remains within port land and does not enter areas used by the general public. Similarly, the risk of $1x10^{-6}$ fatalities per person per year isopleth, representing the lower limit of tolerable, does not extend into areas used by the general public. Risks less than $3x10^{-7}$ fatalities per person per year would be considered trivial and acceptable for land use by vulnerable populations, such as hospitals, nursery schools, retirement homes, etc. The addition of further phases would increase the extent of the risk of $1x10^{-6}$ fatalities per person per year isopleth but would have little effect otherwise. As the components to be stored in the tanks of the further phases of development have not been full described, this Risk Impact Assessment assumed petrol as the worst case scenario. In the event that the tanks would contain higher flashpoint materials, the risk isopleths may diminish in size.

Major Hazard Installation

The Risk Impact Assessment concluded that the proposed Terminal, including the transportation pipelines and the terminal, would be considered a MHI as more than 25 t of LPG would be stored in a single vessel during the initial and further phases of development. LPG would thereby be classified as a notifiable substance.

The Risk Impact Assessment does not replace the need to conduct a MHI Risk Assessment which is to be conducted in accordance with the OHSA and MHI Regulations. Once detail designs have been finalised for the proposed Terminal the MHI Risk Assessment should be completed prior to construction to determine the acceptability of the risks posed to the public.

6.7 Traffic Impact Assessment

Golder appointed Iliso Consulting (Pty) Ltd (Iliso Consulting) to conduct a Traffic Impact Assessment in support of the EIA for the proposed Terminal. A copy of the Traffic Impact Assessment specialist report is attached as APPENDIX I.

6.7.1 Scope of Work

The scope of work for the Traffic Impact Assessment included the following:

- Quantify the transportation demands as a result of the proposed project, with particular emphasis on road based transport;
- Assess the impact of the additional road based transportation demand on the surrounding road network and infrastructure; and
- Propose mitigation measures, if required, to the road network and infrastructure to support the proposed development.

6.7.2 Methodology

The primary movement of traffic to and from the proposed Terminal is expected to be to/from Durban and Johannesburg via the N2. The logical route that will be followed to gain access to the proposed Terminal from the N2 is thus via John Ross Highway, along Ferro Close and finally Harbour Arterial.

Based on the above routing, traffic counts were undertaken at the three primary intersections leading to the proposed Terminal as shown in Figure 70. These are:

- Intersection 1: The intersection of Harbour Arterial and the proposed Terminal;
- Intersection 2: The intersection of Ferro Close and Harbour Arterial; and
- Intersection 3: The intersection of John Ross Highway and Ferro Close.

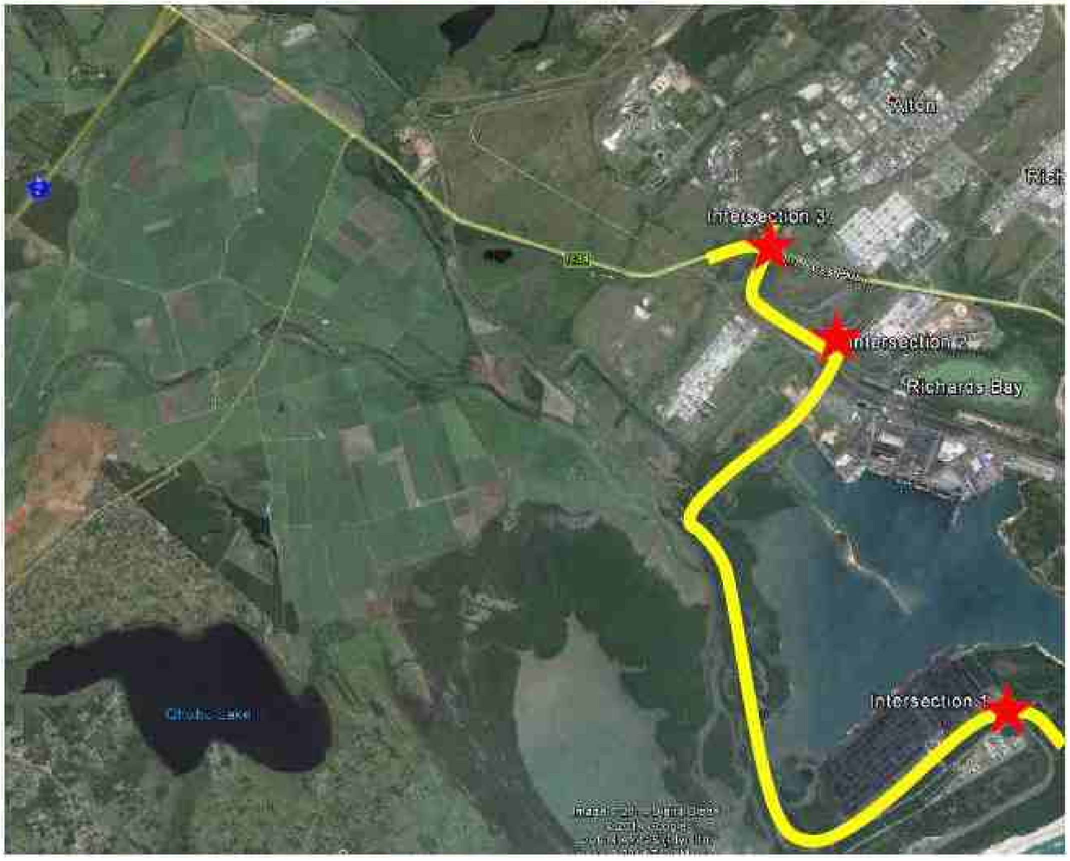

Figure 70: Intersections 1, 2 and 3.

A 12 hour count was conducted from 06:00 to 18:00 at the three identified intersections. It was found that 06:45 to 07:45 is typically the morning (AM) peak hour and 15:45 to 16:45 is typically the afternoon (PM) peak hour for all three intersections. Figure 71 shows the existing conditions in the AM as well as the PM peak hours for the three intersections which provide the main access to the proposed Terminal.

Intersections 2 and 3 constitute existing signalised intersections. Intersection 1 is a priority controlled Intersection. Table 35 shows the results of the existing (2014) conditions derived using SIDRA Intersection Analysis software.

Table 35: Intersection Analysis, Background Traffic – 2014.

Approach	**Road Name**	**John Ross Highway / Ferro Close**		**Ferro Close / Harbour Arterial**		**Harbour Arterial / Road A**	
		AM	**PM**	**AM**	**PM**	**AM**	**PM**
East	LOS	B	B	B	B	B	B
	Delay (s)	18.4	17.4	13.4	16.1	10.6	11.6
	V/C	0.874	0.501	0.025	0.016	0.001	0.002
	Queue Length (m)	114.2	59.3	2	1.2	0.1	0.1
West	LOS	A	B	C	C	x	x
	Delay (s)	9.8	16.1	21.8	22.7	x	x
	V/C	0.288	0.532	0.403	0.154	x	x
	Queue Length (m)	50	63.6	34.3	11	x	x
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	24.9	11.7	10.1	10.5	4.2	0.9
	V/C	0.163	0.165	0.116	0.396	0.001	0.02
	Queue Length (m)	21.3	19.3	9.8	38.1	0	1
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	28	15.9	12.3	11.1	4.1	0.1
	V/C	0.298	0.537	0.384	0.138	0.001	0.083
	Queue Length (m)	32.3	42.3	36.3	12.3	0	0
Overall Intersection Performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	16.3	16.2	15.1	11.8	6.3	0.3
	V/C	0.874	0.537	0.403	0.396	0.001	0.083
	Queue Length (m)	114.2	63.6	36.3	38.1	0.1	1

The summarised results reveal that all of the three intersections are currently operating at an acceptable Level of Service (LOS) (deemed to be LOS D or better) during the AM as well as the PM peak hour.

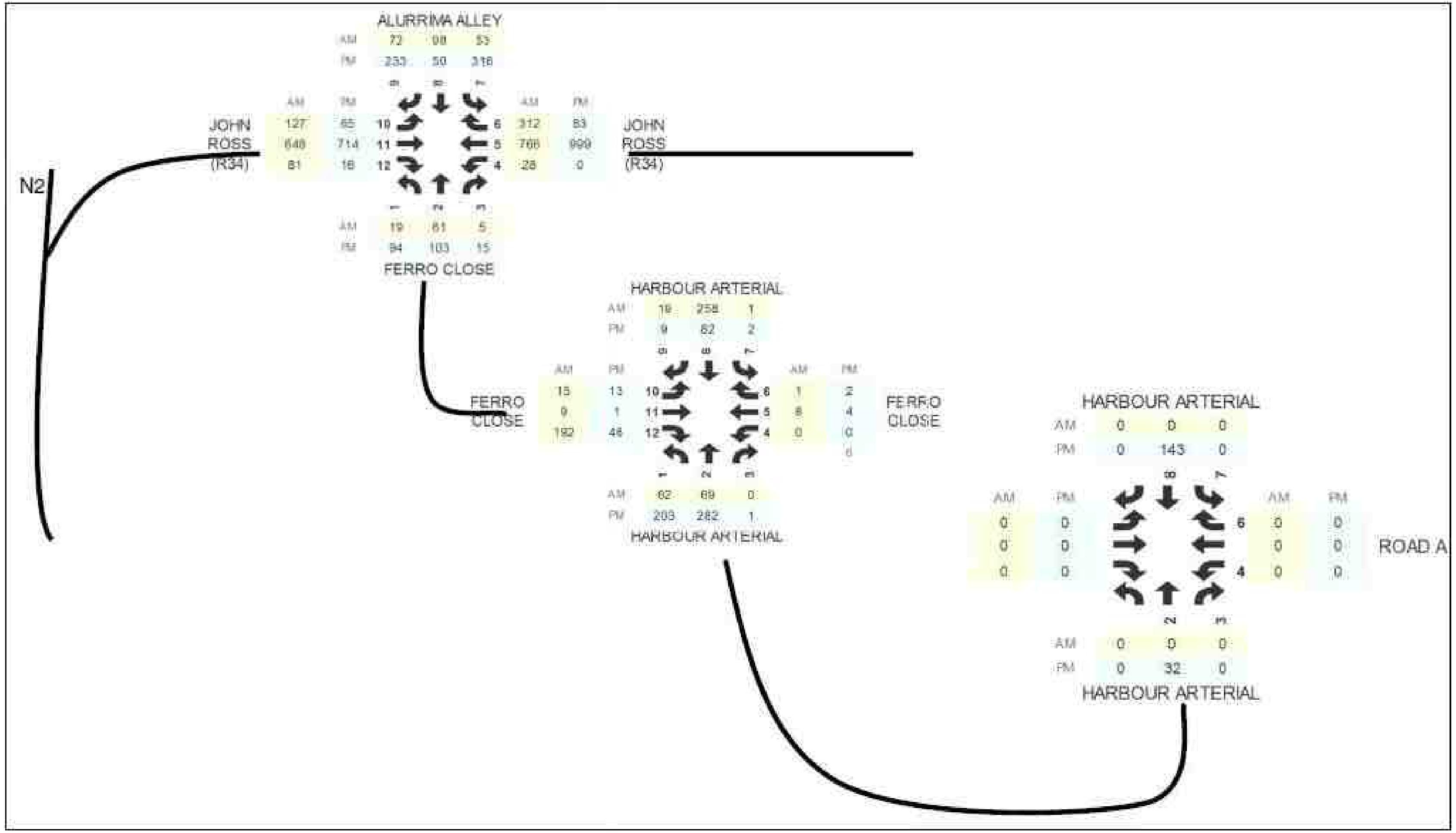

Figure 71: Weekday AM/PM Peak Hour Volumes.

6.7.3 Specialist Findings

6.7.3.1 Trip Generation

Heavy Goods Vehicles (HGV) Trip Generation

Whilst the proposed Terminal is anticipated to have impacts on shipping, rail and road operations, the focus of the Traffic Impact Assessment are the impacts on the road network and supporting road infrastructure. The road gantry loading capacity of the proposed Terminal was utilised to determine the trip generation of the proposed Terminal, and hence the impacts on the road network. Table 36 shows the anticipated Heavy Goods Vehicle (HGV) volumes for the Initial and Further Phases of development.

Table 36: Anticipated HGV Volumes.

	Initial Phase	Further Phases
Loading Bays	9	9
Average Truck Load (m^3)	25	25
Maximum Pump Rate (m^3/h)	102.5	102.5
Clearance Time Coefficient	50%	50%
HGV Volumes	18	18

The calculation of HGV volumes was based on the following criteria:

- Number of loading bays (i.e. 9 loading bays for the Initial Phase of development and a further 9 loading bays for Further Phases of development);
- The average pump rate of 102.5 m^3/h, being the average pump rate of 125 m^3/h for CPP and 80 m^3/h for LPG; and
- The average truck load of 25 m^3, based on trucks being between 17 m^3 and 40 m^3.

Light Vehicle (LV) Trip Generation

The staff trips were estimated based on the following criteria:

- 120 general workers would be employed at the proposed Terminal, who would utilise public transport in the form of mini-bus taxis; and
- 12 supervisory/management staff who would utilise private vehicles.

Public Transport (PT) trips were estimated at 10 trips in the peak hour based on a vehicle (taxi) capacity of 12 passengers, whilst Private Vehicle (PV) trips were estimated at 12 trips in the peak hour based on a vehicle occupancy of 1 person.

Table 37: Public Transport (PT) and Private Vehicle (PV) Trips.

Trip Type	People	Vehicle Capacity	Trips	In / Out
PT Trips	120	12	10	100/100
PV Trips	12	1	12	80/20

Total Trips Generated

The total volumes for all trips for the Initial and Further Phases of development are shown in Table 38 below:

Table 38: Total Vehicle Volumes – Initial Phase.

Development Phase	Vehicle Type	Total In	Total Out
Initial Phase	HGV	18	17
	PT	10	10
	PV	10	2
Further Phases	HGV	37	33
	PT	10	10
	PV	10	2

* A reverse haul (loaded on entry and exit) percentage of 10% was assumed

6.7.3.2 Trip Distribution and Assignment

The total forecasted traffic for the Initial Phase of the proposed Terminal, which includes background traffic, a 2.5% per annum (p.a.) growth rate from 2014, and development traffic for the 2015 analysis years is shown in Figure 72. The total forecasted traffic for the Further Phases of the proposed Terminal, which includes background traffic, a 2.5% p.a. growth rate from 2014, and development traffic for the 2020 analysis year is shown in Figure 73.

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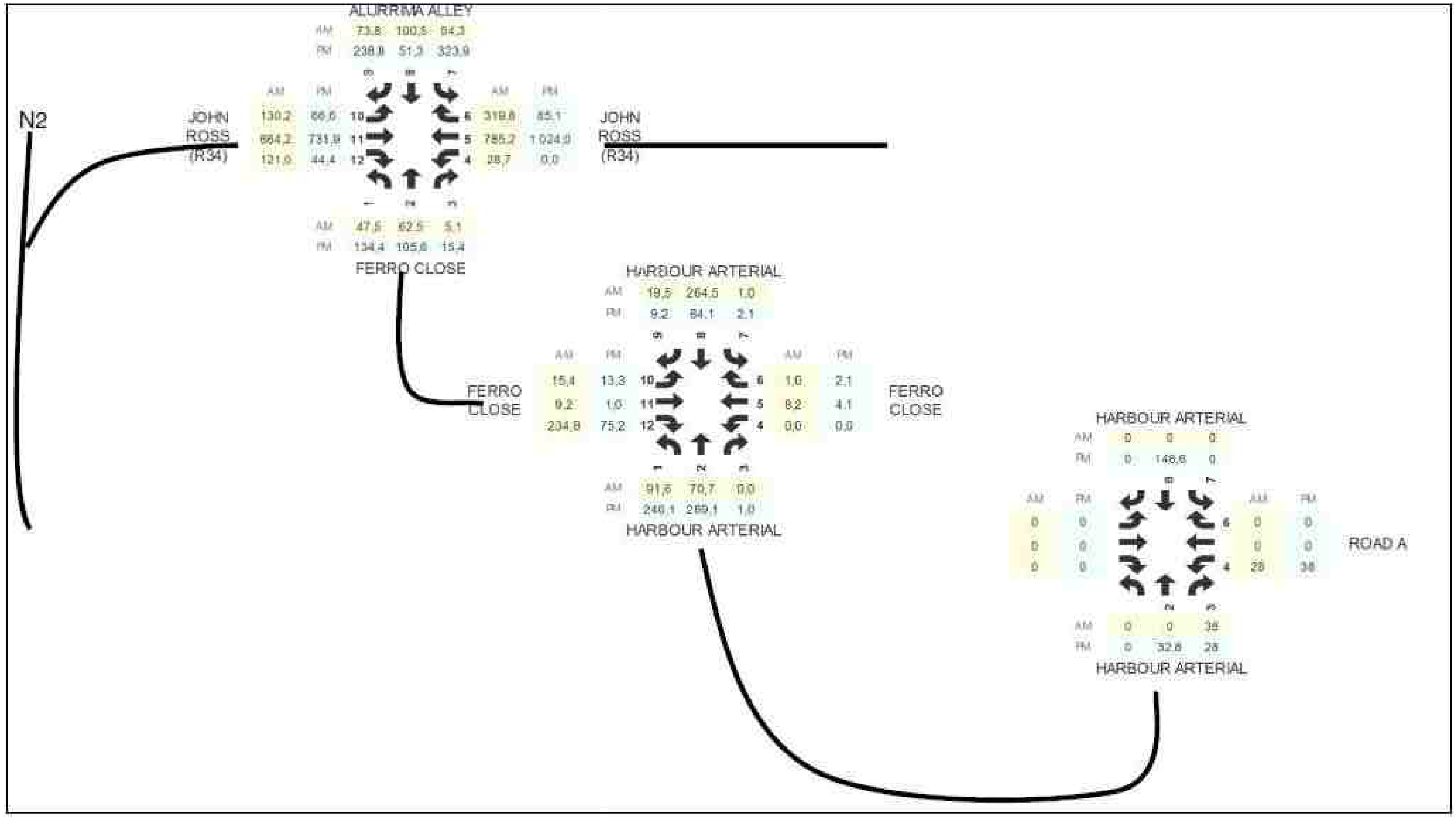

Figure 72: 2015 Total Forecasted Traffic.

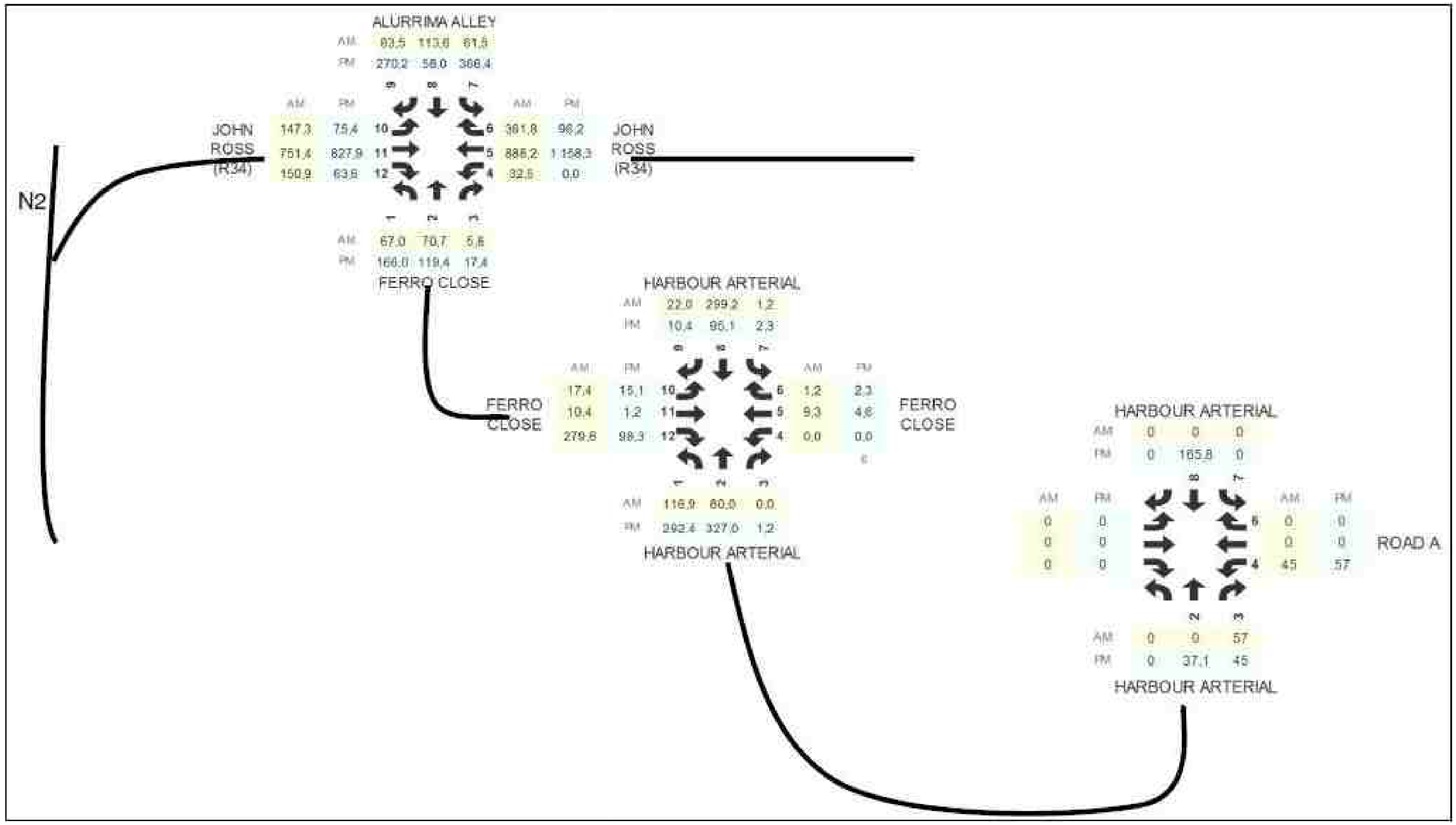

Figure 73: 2020 Total Forecasted Traffic.

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6.7.4 Impact Assessment

6.7.4.1 Traffic Analysis

Intersection Analysis

The three main intersections identified along the main access route to the proposed Terminal were analysed utilising SIDRA Intersection Analysis software, to determine their operational characteristics for the 2015 and 2020 analysis years respectively. The results from the traffic analysis are summarized in Table 39 and Table 40 for the expected morning (AM) and afternoon (PM) peak hour traffic loadings on all the intersections for 2015 and 2020 analysis years respectively.

Initial Phase Intersection Analysis

Table 39: 2015 Initial Phase Intersection Analysis.

Approach	**Road Name**	**John Ross Highway / Ferro Close**		**Ferro Close / Harbour Arterial**		**Harbour Arterial / Road A**	
		AM	**PM**	**AM**	**PM**	**AM**	**PM**
East	LOS	B	B	B	B	B	C
	Delay (s)	17.4	17.5	12	16	14	15.3
	V/C	0.870	0.513	0.023	0.017	0.028	0.047
	Queue Length (m)	114.2	61.1	1.9	1.2	1.8	2.7
West	LOS	B	B	C	C	x	x
	Delay (s)	10.5	16.9	20.9	23.4	x	x
	V/C	0.429	0.545	0.459	0.234	x	x
	Queue Length (m)	51.5	65.6	41.8	17.3	x	x
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	21.4	17.5	10.7	10.5	10.1	6.8
	V/C	0.167	0.513	0.132	0.406	0.035	0.056
	Queue Length (m)	21.8	61.1	10.7	39.3	1.9	3.7
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	28.1	16	14.1	11.2	4.1	0.1
	V/C	0.306	0.552	0.437	0.141	0.001	0.085
	Queue Length (m)	33.2	43.7	40	12.7	0	0
Overall Intersection Performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	16	16.5	15.8	12.2	11.5	4.1
	V/C	0.870	0.552	0.459	0.406	0.035	0.085
	Queue Length (m)	114.2	65.6	41.8	39.3	1.9	3.7

The analysis revealed that all three intersections identified would operate at an acceptable LOS for the 2015 analysis year.

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Table 40: 2020 Further Phases Intersection Analysis.

Approach	Road Name	John Ross Highway / Ferro Close		Ferro Close / Harbour Arterial		Harbour Arterial / Road A	
		AM	PM	AM	PM	AM	PM
East	LOS	B	B	B	B	B	C
	Delay (s)	14.2	15.5	11.3	16.1	15	17.4
	V/C	1	0.515	0.025	0.019	0.05	0.086
	Queue Length (m)	127.9	65.4	2.1	1.3	3.5	5.4
West	LOS	B	B	C	C	x	X
	Delay (s)	11.8	15.8	21.0	24.2	x	x
	V/C	0.714	0.715	0.542	0.315	x	x
	Queue Length (m)	59.8	70.4	52.4	24	x	x
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	23.8	13.8	11.2	10.7	10.9	9
	V/C	0.252	0.372	0.158	0.459	0.059	0.091
	Queue Length (m)	28.6	24.8	12.6	45.8	3.6	6.5
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	33.0	18.7	15.3	11.3	4.1	0
	V/C	0.367	0.641	0.524	0.16	0.001	0.096
	Queue Length (m)	43.6	58.3	48.1	14.4	0	0
Overall Intersection Performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	15.5	16.1	16.4	12.6	12.5	5.7
	V/C	1	0.715	0.542	0.459	0.059	0.096
	Queue Length (m)	127.9	70.4	52.4	45.8	3.6	6.5

The analysis revealed that all three of the identified intersections would operate at an acceptable LOS for the 2020 analysis year.

6.7.4.2 Construction Phase

Traffic impacts associated with the construction phase of the proposed Terminal would primarily deal with the delivery of construction materials and the removal of waste from site. Consequently, construction activities are not expected to have a major impact on the surrounding road network. However, a traffic accommodation plan would be required during the construction phase which would mitigate any adverse impacts.

6.7.4.3 Operational Phase

Traffic impacts associated with the operational phase would primarily deal with the transportation of product from the proposed Terminal. Based on the assessment undertaken for the proposed Terminal the operational phase is not expected to have any significant impacts on the surrounding road network and would therefore not require any mitigation measures.

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Table 41: Rating of Potential Traffic Impacts Associated with the Proposed Terminal.

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Additional traffic generated by the proposed Terminal	Increase in noise and air pollution (carbon emissions)	Negative	High	Permanent	Low	Local	Reversible	Medium	Low	Low
	Traffic safety hazards	Negative	Medium	Permanent	Low	Local	Reversible	Medium	Low	Low
Traffic Impacts	Road network (construction activities)	Negative	Medium	Short-term	Moderate	Local	Reversible	Medium	Low	Low
	Road network (operational activities)	Negative	Medium	Medium-term	Moderate	Regional	Reversible	Medium	Low	Low

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6.7.5 Specialist Conclusions

The Traffic Impact Assessment for the proposed Terminal revealed the following:

- For the initial phase of development, the proposed Terminal would generate approximately 38 inbound vehicle trips (comprising 18 HGVs and 20 LMVs) and 29 outbound vehicle trips (comprising 17 HGVs and 12 LMVs) in the AM Peak hour, with reverse flows in the PM peak hour.
- For the further phases of development, the proposed Terminal would generate approximately 57 inbound vehicle trips (comprising 37 HGVs and 20 LMVs) and 45 outbound vehicle trips (comprising 33 HGVs and 12 LMVs) in the AM Peak hour, with reverse flows in the PM peak hour.
- The intersection analysis for the 2015 (Initial Phase) and 2020 (Further Phases) analysis years revealed that all three of the identified intersections would operate at an acceptable LOS with the proposed Terminal in place.
- In light of the road network performing at an acceptable LOS, no mitigation measures are required.

The proposed Terminal does not have a significant impact on the operational performance or safety of the surrounding road network and it is therefore recommended that the proposed Terminal be approved from a transportation perspective.

7.0 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

7.1 Introduction

This Environmental Management Plan (EMP), as detailed in Section 7.8, is based on the results of the Environmental Impact Assessment (DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014) and addresses the management and mitigation measures of the environmental impacts resulting from the proposed Terminal. The EMP has been prepared in accordance with the requirements of NEMA and the NEMA EIA Regulations (GNR 543).

7.2 Implementation of the EMP

The mitigation measures referred to in this EMP shall be incorporated with the mitigation measures as stated in Section 6.0 above. It will also be integrated with VSAD's existing Environmental Management System (EMS). Relevant monitoring measures will also be implemented and reported on where required.

7.3 Objectives of the EMP

The key objectives of the EMP are:

- To facilitate compliance with applicable acts, regulations and guidelines;
- To recognise that social responsibility and environmental management are among the highest corporate priorities;
- To assign clear accountability and responsibility for environmental protection and social responsibility to management and employees;
- To facilitate environmental and social planning through project life cycle;
- To provide a process for achieving targeted performance levels;
- To provide appropriate and sufficient resources, including training, to achieve targeted performance levels on an on-going basis; and
- Evaluate environmental performance and social responsibility against VSAD's environmental and other policies, objectives and targets and seek improvement where appropriate.

7.4 Finalisation of the EMP

This EMP is a “living document” and information contained in this version of the EMP, will be reviewed and updated annually. The findings and recommendations of periodic assessments (annually or more frequently) by internal/external auditors will be used to update the current version at the time, if required. The EMP is structured to address the impacts identified in the EIA. A formal management system will be implemented.

7.5 VSAD’s Responsibility for EMP Implementation

Primary responsibility for implementation of the EMP rests with VSAD, typically the Safety, Health, Environment and Quality (SHEQ) Manager. In addition, VSAD must ensure that all relevant contracting companies tendering for work receive a copy of the EMP and understand their responsibility to operate within the framework of the measures defined in the EMP. When adjudicating relevant tenders, VSAD will ensure that contractors have made appropriate allowance for the management of environmental matters. VSAD will include adherence to the EMP as a contractual condition in all agreements with contractors. To this end, VSAD will:

1) Educate its personnel, contractors and visitors with regards to the SHE requirements applicable in general to VSAD’s sites;

2) Provide professional staff to give effect to its SHE management commitments;

3) Appoint a competent Project Manager to oversee all aspects of the construction phase;

4) Appoint a competent Environmental Management Officer (EMO) (which might be the SHE Coordinator) prior to the commencement of construction. The EMO will perform regular inspections to monitor compliance with the construction EMP, provide the appropriate level of management within VSAD with monthly reports on environmental compliance and performance and provide guidance on the remediation of any unplanned environmental impacts. The EMO will also motivate and draft any amendments to the EMP as and when they become necessary;

5) Undertake monthly internal EMP compliance inspections by the EMO and annual audits by a suitably qualified and competent auditor during the operational phase. These inspections and audits will include all activities associated with the proposed Terminal in its entirety, including activities undertaken by VSAD’s contractors and agents;

6) Undertake internal EMP compliance inspections by the EMO at weekly intervals and external audits by a suitably qualified and competent independent auditor at three-monthly intervals during the decommissioning and construction phases of development; and

7) Monitor, evaluate and report performance on SHE protection to the relevant management level within VSAD.

7.5.1 Responsibility of Contractors

All relevant contracting companies will receive a copy of the EMP at the time of tender. Contractors shall familiarise themselves with the EMP mitigation measures for the site and ensure that contracting prices allow for environmental management costs.

Upon appointment each contractor must have a copy of the EMP in their place of work. It is the responsibility of the contractor to ensure that all staff personnel are aware of the measures applicable to their area of work on site. It is the responsibility of the contractor to bring to the attention of the VSAD Environmental Team or relevant VSAD staff member, any environmental incident or breach of the conditions of the EMP within 24 hours of occurrence of such event, through the company’s Incident Reporting System, or at a relevant timeframe as stipulated in VSAD’s EMS.

The contractors shall:

1) Be required to enter into a contractual commitment with VSAD to adhere to the requirements of the EMP and the environmental guidelines and standards contained therein;

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2) Familiarise themselves with the undertakings and requirements relevant to the construction, operational and decommissioning phase contained in this EMP, educate their personnel accordingly and ensure that such undertakings and requirements are adhered to;

3) Prepare method statements describing the methods through which compliance with environmental standards will be guaranteed and submit them to VSAD for approval. Although VSAD may comment on any inadequacies in these statements, the contractor is solely and exclusively responsible in cases of non-compliance with the standards contained in this EMP document;

4) Employ techniques, practices and methods that ensure the fulfilment of these requirements, with specific reference to the control of waste and pollution, the prevention of loss or damage to natural resources and the minimisation of adverse effects on users and holders of neighbouring land and the public in general;

5) Take cognisance of the basic information provided in this EMP, but shall also verify the accuracy of any information provided, report any inaccuracies or omissions to VSAD's Management and appointed EMO and, irrespective of any inaccuracies or omissions, comply with the intentions of the requirements stated in this EMP;

6) Undertake any remedial measures within a reasonable period of time following the receipt of a written instruction from VSAD to do so;

7) Take all reasonable and prudent measures to prevent the occurrence of accidents that may compromise the integrity of the environment and/or the health and safety of all persons on site, of all persons on neighbouring land and of the general public;

8) Report all incidents to VSAD or its representative including but not limited to environmental damage, injuries and/or loss of or damage to VSAD's physical assets or corporate image;

9) In the event of an incident as described above occurring, present a detailed plan to:
   a) Restore the environmental conditions, in so far as it is possible to do so, to a state similar to that existing before the incident;
   b) Address any injuries caused in a manner satisfactory to the injured party or parties and VSAD; and
   c) Prevent the future occurrence of similar incidents.

10) Cooperate in periodic EMP compliance audits by VSAD, its auditors and/or relevant government bodies and provide the necessary information to this effect; and

11) Should the government authorities be of the opinion that any activities executed by the contractor cause unacceptable environmental damage, or are inadequate to mitigate environmental damage; the contractor shall immediately consult the competent government authorities and VSAD, and reach an agreement about the remedial measures to be implemented. The measures agreed upon shall be implemented as soon as possible, so as to avoid the occurrence of further damage and to repair any damage that may have occurred. The contractor will be responsible for all relevant costs related to the applicable environmental damage.

7.5.2 Monitoring Plan

A monitoring plan must be established and integrated with VSAD's existing monitoring plan before the proposed Terminal is executed. The conditions of the monitoring plan must be agreed upon by VSAD and adhered to throughout the life span of the proposed Terminal. The monitoring plan must be aligned with the requirements of this EMP. The monitoring plan must state:

- Who is responsible for what monitoring tasks;
- When monitoring must take place;

- How the monitoring must take place;
- How the monitoring results will be distributed and communicated; and
- What avenues of corrective actions will be taken should EMP stipulations be found ‘non-compliant’.

7.5.3 Environmental Incidents and Breaches of EMP Conditions

The designated person will bring to the attention of the SHEQ Manager any significant environmental incidents or breaches of the conditions of the EMP, within 24 hours of occurrence of such event (unless stated otherwise in the existing EMS). The Site Manager will notify the controlling authority within 48 hours of such an incident, if the environmental incident constitutes a reportable breach of any permit or licence condition.

The designated person will monitor employees and contractor’s adherence to the EMP by conducting regular EMP compliance audits throughout each phase of the operation and will issue the contractor with a notice of non-compliance whenever transgressions are observed. The designated person will record the nature and magnitude of the non-compliance in a register, the actions taken to discontinue the non-compliance, the actions taken to mitigate its effects and the results of the actions. The contractor should act immediately when a notice of non-compliance is received and implement the agreed corrective action.

Any avoidable non-compliance with the EMP by contractors will be considered sufficient grounds for the imposition of a penalty. The value of the penalty to the contractor must equal twice the cost of corrective action. Set penalties should be enforced. Penalties shall be specified in the contract with the Contractor.

7.5.4 Complaints Management

Complaints management shall be implemented as per the requirements of the existing EMS. This may entail that complaints received regarding activities on the site pertaining to the environment should be recorded in a register and the response noted with the date and action taken. This record should be submitted with the monthly reports and a verbal report should be given at regular site meetings.

7.6 Emergency Preparedness and Response Plan

All emergencies shall be handled according to the existing Vopak Emergency Plan. VSAD’s Emergency Response Team shall provide immediate response to any significant incident, and the emergency contingency plan will also be integrated with that of the City of uMhlathuze Local Municipality, if required.

Personnel will be designated and trained to activate and implement the VSAD Emergency Preparedness and Response Plan (EPRP) in reaction to onsite and offsite accidental releases, or other environmental emergencies that may occur. In addition to a designated Incident Officer and Emergency Response Team members, other key staff involved in the implementation of the EPRP includes the Operations, Environmental, Safety and Security supervisory personnel. Contractors performing work for VSAD will be required to be appropriately trained and have ready access to equipment and supplies that would allow them to contain and control an accidental release until the arrival of an Emergency Response Team.

In general, the EPRP will endeavor to ensure:

- A safe environment for all employees, contractors, visitors and neighbours;
- That all activities are conducted in an environmentally responsible manner consistent with environmental regulations, guidelines and best practice;
- The identification and management of all significant environmental risks;
- The existence of a comprehensive system for managing emergencies and a high degree of emergency preparedness;
- That the response to emergencies is predicated primarily on the preservation of human life and the safety of emergency response personnel;

- The containment of emergencies and their effects within the boundaries of the proposed Terminal;
- Cooperation with external emergency response organizations; and
- A safe return to normal operations.

Implementation of the EPRP will be the responsibility of the Health, Safety and Security Department or equivalent.

7.6.1 Emergency Plan Preparation and Implementation

When preparing additional measures for emergency, the following aspects will be taken into account:

- An evacuation procedure which includes the consideration of shelter in the case of accidental releases;
- Detail of the method for identifying and accounting for the number of persons on site at all times;
- All employees, contractors and visitors will be made aware of/trained on the contents of the EPRP;
- Ensure that the EPRP aspects are included in the proposed Terminal's EMS.
- Frequency of revision and update of the EPRP;
- Distributing copies to individuals designated by the Terminal Manager and placing others at strategic locations, and ensuring that all copies are maintained as current;
- Training of staff to manage onsite emergencies; in general emergency notification and evacuation procedures at the time of their employment and annually thereafter;
- Allocated responsibilities and specific action details;
- A procedure for activating the emergency plan;
- An Emergency Control Centre (ECC) available on site, complete with:
  - Copies of the most recent version of the emergency plan and the most recent version of the site layout and location plans/maps;
  - Diagrams of those service facilities, communications, fire hydrants, safety refuges, building emergency exits and muster points required in an emergency;
  - Relevant equipment for both internal and external communications;
  - A readily available means of recording messages and communications in chronological order; and
  - Sufficient room to accommodate the emergency management personnel.
- Emergency resources including but not limited to:
  - Onsite first aid services and facilities are available;
  - A vehicle, suitable for the transport of casualties, is available onsite at all times;
  - Fixed location firefighting equipment (extinguishers, host reels, etc.) is distributed and located where necessary, accordingly to a risk analysis and maintained in accordance with manufacturer's instructions; and
  - A fire water main system, which would include a fire water source.
- Maintaining all emergency equipment, materials and supplies available and in good working order;

- An incident command protocol must be drawn up and agreed upon by the local Fire Service to avoid conflict when they arrive onsite for large incidents or additional assistance, and
- A Mutual Aid corporation agreement with TNPA should be negotiated. This agreement should address all relevant factors, such as financial contributions by both parties, maintenance of equipment, emergency response plan shared between the two sites, location of emergency response vehicles, training etc.

7.7 VSAD’s Commitments

Table 42 presents a summary of VSAD’s Environmental Commitments as presented in the EIA. This is a summary of the environmental commitments based on the project design measures, mitigation actions, monitoring and follow-up, and community consultation.

Table 42: Summary of VSAD's Environmental Commitments

No.	Description	Commitment
1	Stormwater management	VSAD will construct a stormwater management system consisting of a series of surface trenches and drains which ultimately feed into two sumps before being pumped into TNPA’s proposed stormwater channel to be constructed for the South Dunes Lease Sites.
2	Effluent discharge	Wastewater will be passed through to the TNPA sewer system. Should this not be available a septic tank system will be installed.
3	Tanks and tank installation	The tanks to be constructed on the site will be designed and erected to comply with the latest relevant SANS/API Standards and Procedures.
4	Occupational Health and Safety Act (83 of 1993)	VSAD will comply with the requirements of the OHSA which are applicable to the proposed Terminal. In addition, VSAD also has over 75 operational, maintenance, and SHE standards which ensure procedures and protocols are in place to manage, as a minimum, compliance with the OSHA as a minimum, and alignment with the principles of international best practise.

7.8 EMP during Construction, Operation and Decommissioning Phases

7.8.1 Air Quality Mitigation Measures

The following mitigation measures have been identified to reduce air quality impacts which may be associated with the proposed Terminal:

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Construction Phase

Construction Phase		Responsibility
Objectives	■ To comply with the requirements of NEM:AQA; and ■ To reduce discomfort or nuisance effects on receptors.	***Site Manager***
Impacts:	■ Fugitive dust and PM emissions associated with: ▪ Demolition and debris removal (including transportation, loading and unloading); ▪ Earthworks; ▪ Stockpiling, transfer, and loading of waste and building material; ▪ Vehicular traffic on unpaved roads; and ▪ Material stockpiles.	
Mitigation measure(s):	■ Training the workforce in awareness of air emissions should be carried out at all levels (workers, foremen, managers) and should be included in site induction courses. Training should focus on promoting understanding as to why mitigation measures are in place; ■ Reduce unnecessary traffic volumes by developing plans to optimise vehicle usage and movement; ■ Employ wet suppression on construction access roads using water and a suitable dust palliative to achieve the 95% control efficiency (water alone will only achieve a 75% control efficiency); ■ Institute rigorous speed control and traffic calming measures to reduce vehicle entrainment of dust. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads; ■ Use temporary windbreaks in open exposed areas and stockpiles prone to wind erosion to reduce wind speed through sheltering; and ■ Employ good housekeeping both inside and outside the construction site, including: cleaning up rubbish and debris, sweeping, hosing down stockpiles or roadways, repairing tears in hessian or shade cloth used for dust attenuation.	
Performance criteria	■ Vehicle use and movement optimisation plan; ■ Evidence of wet suppression on access roads and stockpiles; ■ Evidence of speed control (e.g. speed bumps or speed limit signage); ■ Housekeeping schedule; and ■ Use of temporary windbreaks.	

Construction Phase		Responsibility
Monitoring/ Measurement	■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

Operational Phase

Operational Phase		Responsibility
Objectives	■ To comply with the requirements of NEM:AQA; ■ Put measures in place to align the operations with the provisions of South African guidelines on air quality; and ■ To reduce discomfort or nuisance effects on receptors.	***Environmental Control Officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Fugitive volatile gas emissions from storage tanks and handling.	
Mitigation measure(s):	■ All installations with a throughput of greater than 50,000 m³ per annum of products with a vapour pressure greater than 14 kPa, will be fitted with vapour recovery/destruction units. This is considered to be a conservative approach as vapour recovery system control efficiencies typically range from 90 – 97%.	
Performance criteria	■ Compliance with the Atmospheric Emissions Licence (AEL).	
Monitoring/ Measurement	■ Monitoring should be in compliance with the Atmospheric Emissions Licence (AEL); and ■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

Decommissioning Phase

Decommissioning Phase		Responsibility
Objectives	■ To comply with the requirements of NEM:AQA; and ■ To reduce discomfort or nuisance effects on receptors.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Fugitive dust and PM emissions associated with: ▪ Stockpiling, transfer, and loading of waste and rubble; ▪ Vehicular traffic on unpaved roads; and ▪ Material stockpiles.	
Mitigation measure(s):	■ Training the workforce in awareness of air emissions should be carried out at all levels (workers, foremen, managers) and should be	

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Decommissioning Phase		Responsibility
	included in site induction courses. Training should focus on promoting understanding as to why mitigation measures are in place; ■ Reduce unnecessary traffic volumes by developing plans to optimise vehicle usage and movement; ■ Employ wet suppression on construction access roads using water and a suitable dust palliative to achieve the 95% control efficiency (water alone will only achieve a 75% control efficiency); ■ Rigorous speed control and traffic calming measures should be instituted to reduce vehicle entrainment of dust. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads; ■ Use temporary windbreaks in open exposed areas and stockpiles prone to wind erosion to reduce wind speed through sheltering; ■ Re-vegetation to minimise wind erosion impacts in the context of establishing self-sustaining ecosystems; and ■ Traffic and movement over stabilised areas should be restricted and controlled, and damage to stabilised areas should be repaired and maintained to the satisfaction of the Environmental Manager.	
Performance criteria	■ Vehicle use and movement optimisation plan; ■ Evidence of wet suppression on access roads and stockpiles; ■ Evidence of speed control (e.g. speed bumps or speed limit signage); ■ Housekeeping schedule; ■ Use of temporary windbreaks; and ■ Rehabilitation and closure plan.	
Monitoring/ Measurement	■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

7.8.2 Terrestrial Ecology Mitigation Measures

The following mitigation measures have been identified to reduce impact on ecology and biodiversity which may be associated with the proposed Terminal:

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Construction Phase

Construction Phase		**Responsibility**
Objectives	■ To minimise the vegetation clearing and impacts on vegetation associated with the development. The impact of vegetation clearing is likely to be a long term impact; ■ To limit the number of plant species of conservation importance that are cleared during construction, and obtain clearing permits for those where clearing is unavoidable; ■ To control and prevent the spread of alien invasive species into adjacent undeveloped natural/semi-natural areas; ■ To reduce the likelihood that fauna occurring in the will be killed or injured during construction activities; and ■ To minimise the effects of dust on terrestrial fauna and flora.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Clearing of vegetation in the development footprint will lead to a loss of habitat for flora and fauna and a likely reduction in on-site biodiversity; ■ Loss of plant species of conservation importance; ■ Establishment and spread of alien invasive species; ■ Killing and injuring of fauna; and ■ Habitat degradation due to dust.	
Mitigation measure(s):	■ The total footprint area to be disturbed / developed will be kept to a minimum by demarcating the construction areas and restricting construction to these areas only; ■ Develop and implement a rehabilitation programme, encompassing active revegetating using indigenous plant species, of all areas exposed during construction. The ECO should be responsible for overseeing the rehabilitation programme; ■ Where possible, infrastructure should be sited so as to avoid clearing protected plant species; ■ Where clearing is unavoidable, clearance permits must be obtained from the relevant authorities to clear Red List and protected plants - *Adenia gummifera* var. *gummifera, Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra*.; ■ An alien invasive species control programme that includes regular monitoring and follow-up treatments, must be developed and implemented to reduce the establishment and spread of exotic invasive species in and to the study area; ■ It is recommended that the ECO be responsible for monitoring the nature and extent of on-site exotic, invasive plants; ■ A suitably trained ECO needs to be appointed to manage fauna,	

Construction Phase		Responsibility
	such as reptiles and amphibians, that are found in the project footprint and that do not readily disperse during construction activities. These fauna should be handled correctly and relocated to adjacent undisturbed natural areas; ■ Educate all construction personnel about the presence of fauna on-site and the need to protect them; ■ Dust suppression on roads must be applied using water bowsers; and ■ Exposed excavations, disturbed ground surfaces, stockpiles and unpaved traffic areas must be maintained in a moist condition.	
Performance criteria	■ Evidence that construction areas and areas to be cleared are clearly demarcated; ■ Rehabilitation Programme; ■ Clearance permits have been obtained where required and are available onsite; ■ Alien Invasive Species Control Programme; ■ Evidence that dust suppression is being employed on roads; and ■ Evidence that exposed excavations, disturbed ground surfaces, stockpiles and unpaved traffic areas are being kept moist.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

Operational Phase

Operational Phase		Responsibility
Objectives	■ Continue controlling alien invasive species in the study area; and ■ To minimise the effects of dust on terrestrial fauna and flora.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Establishment and spread of alien invasive species; and ■ Habitat degradation due to dust.	
Mitigation measure(s):	■ Conduct regular monitoring and follow-up treatments, as per the alien invasive species control programme; and ■ Revegetate exposed surfaces, as per the rehabilitation programme.	
Performance criteria	■ Alien Invasive Species Control Programme; and ■ Rehabilitation Programme.	

Operational Phase		Responsibility
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

Decommissioning Phase

Decommissioning Phase		Responsibility
Objectives	■ To control and prevent the spread of alien invasive species into adjacent undeveloped natural/semi-natural areas.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Establishment and spread of alien invasive species.	
Mitigation measure(s):	■ Conduct regular monitoring and follow-up treatments, as per the alien invasive species control programme.	
Performance criteria	■ Alien Invasive Species Control Programme; and ■ Rehabilitation Programme.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

7.8.3 Hydrology (Surface Water) Mitigation Measures

The following mitigation measures have been identified to reduce impacts on surface water which may be associated with the proposed Terminal:

Construction Phase

Construction Phase		Responsibility
Objectives	■ Maintain run-off water quality during construction activities; ■ Prevent the pollution of run-off as a result of construction equipment and areas; ■ Minimise high run-off peak flows during construction; and	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Run-off water quality: ▪ High flood peaks lead to high run-off from barren construction areas during the construction phase; ▪ Spillage of fuels, lubricants, oil and grease can negatively impact on run-off water quality; and ▪ Construction equipment, vehicles and temporary workshop areas will be likely sources of pollution as a non-point source. ■ Run-off peak flows: ▪ High flood peaks may result in high run-off from barren	

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Construction Phase		**Responsibility**
	construction areas which may affect neighbouring properties.	
Mitigation measure(s):	■ Bunded areas to store chemicals and/or fuel; ■ Clean-up of spills as soon as they occur; ■ Keep construction activities away from the Mhlatuze River mouth and Richards Bay harbour as much as possible; ■ In order to minimise impacts, construction needs to take place during the dry season (winter months); ■ Consider also placing an outer berm around the site to divert any run-off away from any construction activities; and	
Performance criteria	■ All chemicals and/or fuel are stored in bunded areas, and no storage of chemicals and/or fuels is occurring outside of bunded areas; ■ Spill kits are readily available onsite, and there is no evidence of any spills having occurred onsite; ■ There is no evidence of construction activities are occurring within proximity of the Mhlatuze River mouth or Richards Bay Harbour; ■ No construction activities are occurring during the dry season (winter months); and ■ No pooling of run-off is occurring near construction activities.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Surface water quality should also be monitored in accordance with the Surface Water Quality Monitoring Programme developed for the proposed Terminal.	

Operational Phase

Operational Phase		**Responsibility**
Objectives	■ To control and prevent the potential for flooding as a result of excess run-off; and ■ To control and prevent the potential for pollution of stormwater to occur.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Pollution of stormwater from spillage of fuels, lubricants, oil and grease and gas leaks etc.	
Mitigation measure(s):	■ Implement the stormwater management plan identified for the proposed Terminal;	

Operational Phase		**Responsibility**
	■ Use the oil trap in truck loading area; ■ Bunded areas to store chemicals and/or fuel; ■ Clean-up of spills as soon as they occur; ■ Stop pumping stormwater into Transnet drains until spill has been cleaned.	
Performance criteria	■ No evidence of flooding occurring onsite; ■ No chemicals/fuels stored outside of bunded areas; and ■ No evidence of spills onsite.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Surface water quality should also be monitored in accordance with the Surface Water Quality Monitoring Programme developed for the proposed Terminal.	

Decommissioning Phase

Decommissioning Phase		**Responsibility**
Objectives	■ To control and prevent the potential for erosion to occur as a result of stormwater run-off.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Increased run-off over barren areas during the decommissioning phase has the potential to increase the amount of suspended solids flowing towards neighbouring properties.	
Mitigation measure(s):	■ Return the topography of the area to its pre-construction state; and ■ Re-vegetate disturbed areas to limit the surface water flow regime to primarily seepage.	
Performance criteria	■ Evidence of re-vegetation and rehabilitation occurring onsite.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Surface water quality should also be monitored in accordance with the Surface Water Quality Monitoring Programme developed for the proposed Terminal.	

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7.8.3.1 Water Quality Monitoring Programme

A surface water quality monitoring programme has been developed for the proposed Terminal. The monitoring programme was based on the results of the hydrology impact assessment. The plan indicates the location of sampling points and lists the water quality variables to be measured and the sampling frequency.

Water Quality Monitoring Programme		Responsibility
Objectives	■ To identify possible contaminated water on the proposed Terminal site; and ■ To address the contamination of water exiting the proposed Terminal site.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Monitoring/ Measurement	The three main areas that have been identified for water quality monitoring appear in Figure 74. These are mainly at the two sumps that collect the stormwater before pumping to TNPA's proposed stormwater channels and the oil trap that has been recommended to filter out any oil and grease that may be spilt from the truck loading area. The monitoring of these three site should take place monthly and additional monitoring should take place when pumping to TNPA's proposed stormwater channel i.e. if pumping to TNPA's stormwater channel takes place over three days then a daily sample should be taken for those three day to ensure knowledge of what is exiting the proposed Terminal site. Since the proposed Terminal site should be free of most contaminants the stormwater should be tested for oil and grease that could leak from the trucks at the loading bay. The general limit is 2.5 mg/l as set out by DWS (Department of Water Affairs, 2013). The basic system variables of pH and EC should also be included in the monitoring programme.	

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Figure 74: Water quality monitoring at the Vopak-Reatile Terminal.

7.8.4 Risk Mitigation Measures

The following mitigation measures have been identified to reduce risks which may be associated with the proposed Terminal:

Risk Mitigation Measures		**Responsibility**
Objectives	■ To ensure that the proposed Terminal is designed and operated in such a manner that reduces the risk impact associated with it to acceptable levels.	***VSAD, Engineers, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Fires; ■ Explosions; and ■ Flammable atmospheres.	
Mitigation measure(s):	■ The proposed Terminal must comply with all statutory requirements, i.e. pressure vessel designs; ■ The proposed Terminal must comply with applicable SANS codes, i.e. SANS 10087, SANS 10089, SANS 10108, etc.; ■ Applicable guidelines or equivalent international recognised codes of good design and practice must be incorporated into the designs; ■ A recognised process hazard analysis (such as a HAZOP study, FMEA, etc.) must be completed for the proposed Terminal prior to construction to ensure that design and operational hazards have been identified and adequate mitigation measures are put in place; ■ The proposed Terminal must comply fully with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent to ensure that adequate protective instrumentation is included in the design and would remain valid for the full life cycle of the proposed Terminal: ▪ The designer must demonstrate that sufficient and reliable instrumentation would be specified and installed at the proposed Terminal; ■ A safety document detailing safety and design features which reduce the impacts from fires, explosions and flammable atmospheres must be prepared and issued to the MHI assessment body at the time of the MHI assessment: ▪ The safety document must include compliance to statutory laws, applicable codes and standards and world's best practice; ▪ The safety document must include the listing of statutory and non-statutory inspections, giving frequency of inspections; ▪ The safety document must include the auditing of the built facility against the safety document; ▪ The safety document must note that codes such as IEC 61511 can be used to achieve these requirements;	

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Risk Mitigation Measures		**Responsibility**
	■ VSAD and their contractors must demonstrate that the final designs would reduce the risks posed by the proposed Terminal to internationally acceptable guidelines; ■ All terminal designs must be signed by a professional engineer registered in South Africa in accordance with the Professional Engineers Act, who takes responsibility for suitable designs; ■ An emergency preparedness and response document must be completed for on-site and off-site scenarios prior to initiating the MHI risk assessment. This must include input from local authorities; ■ Permission should not be granted for any increases to the product list or product inventories without redoing part of or the full EIA; ■ Final acceptance of the facility risks with an MHI risk assessment that must be completed in accordance to the MHI regulations: ▪ Basing such a risk assessment on the final design and including engineering mitigation.	
Performance criteria	■ The proposed Terminal complies with all statutory requirements, i.e. pressure vessel designs; ■ The proposed Terminal complies with applicable SANS codes, i.e. SANS 10087, SANS 10089, SANS 10108, etc.; ■ The proposed Terminal design has incorporated applicable guidelines or equivalent international recognised codes of good design and practice; ■ A HAZOP study has been completed prior to construction and is available onsite; ■ The proposed Terminal complies with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent; ■ Sufficient and reliable instrumentation has been specified and installed at the proposed Terminal; ■ A safety document detailing safety and design features has been prepared and has been issued to the MHI assessment body at the time of the MHI assessment: ■ All terminal designs are signed by a professional engineer registered in South Africa in accordance with the Professional Engineers Act; and ■ An EPR document including input from local authorities has been completed for on-site and off-site scenarios prior to the MHI Risk Assessment.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

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Transport Pipelines from Berthed Ship to Terminal

Transport Pipelines from Berthed Ship to Terminal		**Responsibility**
Objectives	■ To minimise risks associated with transportation pipelines from the berth to the proposed Terminal.	***VSAD, Engineers, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Failure of the LPG pipeline. ■ Fires and explosions due to loss of containment with an ignition ; ■ Fires and explosions due to a loss of containment of the LPG pipeline from the berths to the terminal; ■ Fires and explosions due to a loss of containment of the CPP pipeline from the berths to the terminal; and ■ Soil and water contamination due to a loss of containment of the CPP pipeline from the berths to the terminal.	
Mitigation measure(s):	■ Codes and standards: ▪ A number of international codes are available for the design, manufacture and maintenance of cross-country pipelines, such as the ASME B31 range covering both gas and liquid pipelines. It is recommended that the transport pipelines be fully compliant with ASME B31 or an equivalent. ■ Buried pipeline: ▪ The major contribution to the pipeline risks is gas transmission. The risk assessment assumes a horizontal release of gas as the worst orientation for aboveground pipelines. Burying the pipeline to a depth required by the standards would reduce the risks by ensuring that the release is in the vertical plane as well as fire and explosion distances. ■ Pressure surges: ▪ A sudden closure of a valve along a pipeline produces a pressure surge that could break supporting pipeline structures or exceed the pressure rating of the pipeline, resulting in a possible loss of containment of the transported material. It is recommended that the designers of the pipeline demonstrate that pressure surges would not occur during the operation of the pipeline or that maximum pressure surges have been incorporated into the design such that the pipeline or associated equipment would not be damaged and there would not be loss of containment. ■ Reverse flow: ▪ The risk assessment assumed that a loss of containment along the pipeline would be from the pumping operation and that there would be no reverse flow of material from storage containment to the point of release. It is thus recommended that the pipeline designs ensure that reverse flow from the storage containment	

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Transport Pipelines from Berthed Ship to Terminal		**Responsibility**
	is not a plausible scenario.	
Performance criteria	■ Compliance with ASME B31 codes or an equivalent; ■ Transport pipelines from berthed ship to the proposed Terminal are buried; ■ Transport pipelines and associated equipment have been designed to withstand maximum pressure surges; and ■ Transport pipelines have been designed so that no reverse flow is possible from the storage containment to the point of release.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

LPG Bulk Storage and Gantries

LPG Bulk Storage and Gantries		**Responsibility**
Objectives	■ To minimise risks associated with LPG bulk storage and gantries.	***VSAD, Engineers, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Overfilling of storage vessels; ■ Loss of containment from a pump casing failure; ■ Fires and explosions due to loss of containment with an ignition ; and ■ Fires and explosions due to a loss of containment at the gantries. Comparison of the risk of 1x10^{-6} fatalities per person per year isopleths for the combined risk and the scenarios of overfilling of storage vessels and pump failure is shown in Figure 75. The pump failure, represented by pump casing failure, would release the storage vessel contents via the connecting pipeline. The rate of release is determined by the vessel pressure and the size of the pump suction inlet .Thus, improving the risk of overfilling and of loss of containment from a pump casing failure would be the most significant mitigation in risk reduction.	

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LPG Bulk Storage and Gantries | **Responsibility**

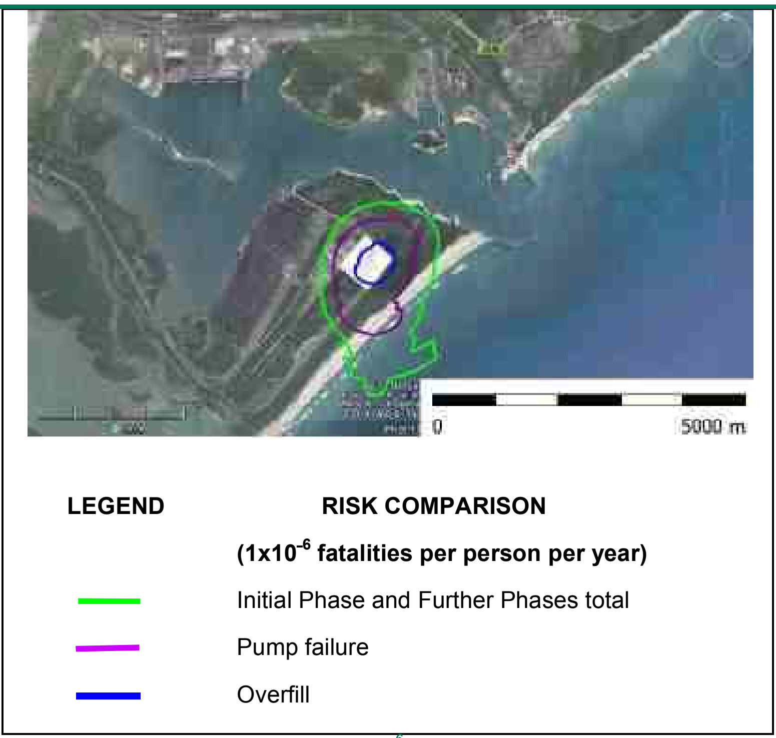

Figure 75: Comparison of the risk of 1x10^{-6} fatalities per person per year isopleths.

Mitigation measure(s):

- Codes and standards:
  - The applicable standard for the design would be SANS 10087. This is an acceptable standard and *full compliance* with this standard would be expected. Full compliance with SANS 10108, covering the types of electrical instrumentation required for a process in order to reduce ignition sources, would also be mandatory.
- Safety instrumented systems:
  - IEC 61508/11 (Safety Instrumented Systems) are codes specifically related to the instrumentation requirements to ensure adequate protection from the hazards in chemical plants and is applicable to the life cycle of the proposed Terminal. These codes are aimed at reducing risks to acceptable levels to surrounding populations.

    Designs would be evaluated against the criteria of the code and instrumentation with specific failure rates would be specified as well as minimum periods of checking. Thus, the selection of instrumentation is not based on price alone. Furthermore, instrumentation cannot be reduced or changed without reviewing the code. The specification of this code means that designs presented at EIA and MHI evaluations cannot be altered at construction for the purposes of reducing costs. Moreover, the

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LPG Bulk Storage and Gantries		**Responsibility**
	code ensures that the proposed Terminal would continue to maintain the safety functions for the life cycle of the Terminal, retaining a safe working environment for both workers and the public.	
Performance criteria	■ Compliance with the IEC 61508/11.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Monitoring should also be in compliance with the requirements and provision of the IEC 61508/11.	

Bulk Atmospheric Storage and Gantries

Bulk Atmospheric Storage and Gantries		**Responsibility**
Objectives	■ To minimise the risks associated with bulk atmospheric storage and gantries.	***VSAD, Engineers, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Fires and explosions due to loss of containment with an ignition ; and ■ Fires and explosions due to a loss of containment at the gantries.	
Mitigation measure(s):	■ Codes and standards: ▪ The applicable standard for the design would be SANS 10087. This is an acceptable standard and *full compliance* with this standard would be expected. Full compliance with SANS 10108, covering the types of electrical instrumentation required for a process in order to reduce ignition sources, would also be mandatory. ■ Safety instrumented systems: ▪ IEC 61508/11 (Safety Instrumented Systems) are codes specifically related to the instrumentation requirements to ensure adequate protection from the hazards in chemical plants and is applicable to the life cycle of the proposed Terminal. These codes are aimed at reducing risks to acceptable levels to surrounding populations. Designs would be evaluated against the criteria of the code and instrumentation with specific failure rates would be specified as well as minimum periods of checking. Thus, the selection of instrumentation is not based on price alone. Furthermore, instrumentation cannot be reduced or changed without reviewing the code. The specification of this code means that designs presented at EIA and MHI evaluations cannot be altered at construction for the purposes of reducing costs. Moreover, the code ensures that the proposed Terminal would continue to	

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Bulk Atmospheric Storage and Gantries		Responsibility
	maintain the safety functions for the life cycle of the Terminal, retaining a safe working environment for both workers and the public. ■ Buncefield Recommendations (specific to operators of Buncefield-type sites): ▪ The Competent Authority and operators of Buncefield-type sites must develop and agree on a common methodology to determine Safety Integrity Level (SIL) requirements for overfill prevention systems in line with the principals set out in Part 3 of BS EN 61511. This methodology should take into account: 1) The existence of nearby sensitive resources or populations; 2) The nature and intensity of the proposed Terminal's operations; 3) Realistic reliability expectations for tank gauging systems; and 4) The extent/rigour of operator monitoring. Application of the methodology should be clearly demonstrated in safety reports submitted to the Competent Authority. ▪ Operators of Buncefield-type sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. This should include, but not be limited to reviews of the following: 1) The arrangements and procedures for periodic proof testing of storage tank overfill prevention systems to minimise the likelihood of any failure that could result in loss of containment; any revisions identified pursuant to this review should be put into immediate effect; and 2) The procedures for implementing changes to equipment and systems to ensure any such changes do not impair the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response. ▪ Operators of Buncefield-type sites should protect against loss of containment of petrol and other highly flammable liquids by fitting a high integrity, automatic operating overfill prevention system (or a number of such systems, as appropriate) that is physically and electrically separate and independent from the tank gauging system. Such systems should meet the requirements of Part 1 of BS EN 61511 for the required safety integrity level, as determined by the agreed methodology. Where independent automatic overfill prevention systems are already provided, their efficacy and reliability should be reappraised in line with the principles of Part 1 of BS EN 61511 and for the required safety integrity level, as	

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Bulk Atmospheric Storage and Gantries		Responsibility
	determined by the agreed methodology. ▪ The overfill prevention system (comprising means of level detection, logic/control equipment and independent means of flow control) should be engineered, operated and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of the recognised industry standard for 'safety instrumented systems', Part 1 of BS EN 61511. ▪ All elements of an overfill prevention system should be proof tested in accordance with the validated arrangements and procedures sufficiently frequently to ensure the specified safety integrity level is maintained in practice in accordance with the requirements of Part 1 of BS EN 61511. ▪ Operators of Buncefield-type sites should introduce arrangements for the systematic maintenance of records to allow a review of all product movements together with the operation of the overfill prevention systems and any associated facilities. The arrangements should be fit for their design purpose and include, but not be limited to, the following factors: 1) The records should be in a form that is readily accessible by third parties without the need for specialist assistance; 1) The records should be available both on site and at a different location; 2) The records should be available to allow periodic review of the effectiveness of control measures by VSAD and the Competent Authority, as well as for root cause analysis should there be an incident; and 3) A minimum period of retention of one year. ▪ Operators of Buncefield-type sites should review the classification of places where explosive atmospheres may occur and their selection of equipment and protective. This review should take into account the likelihood of undetected loss of containment and the possible extent of an explosive atmosphere following such an undetected loss of containment. Operators should also consider such a review, to take account of events at Buncefield. ▪ Operators of Buncefield-type sites should evaluate the siting and/or suitable protection of emergency response facilities such as fire-fighting pumps, lagoons or manual emergency switches. ▪ Operators of Buncefield-type sites should employ measures to detect hazardous conditions arising from loss of primary containment, including the presence of high levels of flammable vapours in secondary containment. Operators should without delay undertake an evaluation to identify suitable and appropriate measures. This evaluation should include, but not	

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Bulk Atmospheric Storage and Gantries		Responsibility
	be limited to, consideration of the following: 1) Installing flammable gas detection in bunds containing vessels or tanks into which large quantities of highly flammable liquids or vapour may be released; 2) The relationship between the gas detection system and the overfill prevention system. Detecting high levels of vapour in secondary containment is an early indication of loss of containment and so should initiate action, for example through the overfill prevention system, to limit the extent of any further loss; 3) Installing CCTV equipment to assist operators with early detection of abnormal conditions. Operators cannot routinely monitor large numbers of passive screens, but equipment is available that detects and responds to changes in conditions and alerts operators to these changes. ■ Operators of new Buncefield-type sites or those making major modifications to existing sites (such as installing a new storage tank) should introduce further measures including, but not limited to, preventing the formation of flammable vapour in the event of tank overflow. Consideration should also be given to modifications of tank top design and to the safe rerouting of overflowing liquids. ■ Revised standards should be applied in full to new build sites and to new partial installations. On existing sites, it may not be practicable to fully upgrade bunding and site drainage. Where this is so operators should develop and agree with the Competent Authority risk-based plans for phased upgrading as close to new plant standards as is reasonably practicable.	
Performance criteria	■ Compliance with the IEC 61508/11.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Monitoring should also be in compliance with the requirements and provision of the IEC 61508/11.	

7.8.5 Traffic Mitigation Measures

The following mitigation measures have been identified to reduce traffic impacts which may be associated with the proposed Terminal:

Traffic Mitigation Measures		Responsibility
Objectives	■ To minimise the impact of the proposed Terminal on existing road users and infrastructure; and	***VSAD, Environmental***

Traffic Mitigation Measures		**Responsibility**
	■ To ensure the road network performs at an acceptable LOS.	***control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Construction vehicles have the potential to impact on existing road users; and ■ An increase in the number of road tankers has the potential to impact on the road network during the operational phase of development.	
Mitigation measure(s):	■ Develop and implement a traffic accommodation plan to mitigate any adverse impacts on road users during the construction phase of development; and ■ In light of the road network performing at an acceptable LOS, no mitigation measures are required for the operational phase of development.	
Performance criteria	■ The road network continues to perform at an acceptable LOS.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

7.8.6 Noise

The following mitigation measures have been identified to reduce noise impacts which may be associated with the proposed Terminal:

Construction Phase

Construction Phase		**Responsibility**
Objectives	■ Minimise noise impacts associated with the construction of the proposed Terminal to acceptable levels.	***VSAD, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Construction activities have the potential to result in an increase in ambient noise levels which may have the potential to impact negatively and create a nuisance for surrounding land users	
Mitigation measure(s):	■ Noisy activities will where possible be restricted to daytime working hours (i.e. 07:00 – 17:00). If construction activities are required outside these hours noisy activities will be kept to a minimum. ■ Unnecessary revving of engines should be avoided and equipment should be switched off when not required or in use; ■ The drop height of materials should as far as possible be minimised; ■ Audible reversing warning systems on vehicles should have a minimum noise impact on neighbouring receptors. The use of conventional audible reversing alarms has the potential to cause annoyance due to the tonal component. It should be noted that alternatives, such as “white-noise” type alarms, are available which	

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Construction Phase		**Responsibility**
	are generally considered to be less annoying; ■ Vehicles must undergo regular maintenance and be kept in good working order; ■ Where possible rubber liners should be used to reduce noise impacts, for example in chutes and dumpers; ■ Equipment must undergo regular maintenance and be kept in good working order according to manufacturer's specifications. Rattling noises for example can be controlled by tightening loose parts and by fixing resilient material (such as rubber) between the surfaces in contact; ■ Wherever economically possible the quietest equipment that can undertake the work should be selected; and ■ Mufflers and other noise suppression devices must undergo regular maintenance and be kept in good working order according to the manufacturers specifications.	
Performance criteria	■ The construction of the proposed Terminal does not result in any noise complaints from surrounding land users; and ■ The construction of the proposed Terminal does not result in any nuisance factors to surrounding land users.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Any noise complaints will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

Operational Phase

Operational Phase		**Responsibility**
Objectives	■ Minimise noise impacts associated with the operation of the proposed Terminal to acceptable levels; and ■ Minimise any increases in ambient noise levels.	***VSAD, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Operational activities have the potential to result in an increase in ambient noise levels which may have the potential to impact negatively and create a nuisance for surrounding land users	
Mitigation measure(s):	■ Noise suppression devices must undergo regular maintenance and be kept in good working order according to the manufacturers specifications; and ■ Noise-generating equipment must undergo regular maintenance and	

Operational Phase		**Responsibility**
	be kept in good working order according to the manufacturers specifications to avoid upset.	
Performance criteria	■ The operation of the proposed Terminal does not result in any noise complaints from surrounding land users; and ■ The operation of the proposed Terminal does not result in any nuisance factors to surrounding land users.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Any noise complaints will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

7.8.7 Light Impact Mitigation Measures

The following mitigation measures have been identified to reduce light impacts which may be associated with the proposed Terminal:

Operational Phase

Operational Phase		**Responsibility**
Objectives	■ To minimise light impacts associated with the proposed Terminal on surrounding land users while providing sufficient lighting for lighting and security purposes.	***VSAD, Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ The proposed Terminal has the potential to result in light pollution which may negatively impact on surrounding land users.	
Mitigation measure(s):	During the Operational Phase of development, careful planning of lighting requirements should be undertaken to ensure that lighting meets the needs to keep the locations secure and safe, without resulting in excessive illumination. The following general lighting requirements have been identified for the project: ■ The height from which floodlights are fixed should be reduced as far as possible whilst still maintaining the required levels of security illumination. Area lighting on tall masts should be confined to the lower landform elevations. ■ Zones of high and low lighting requirements should be identified with the focus on only illuminating areas to the minimum extent possible to allow safe operations at night and security surveillance. Buildings that are typically not used at night such as offices and workshops should be fitted with sensors that switch off lights in empty rooms, to prevent them from inadvertently being left on. ■ Up-lighting of structures should be avoided. Light should be directed downwards and focused on the object requiring illumination.	

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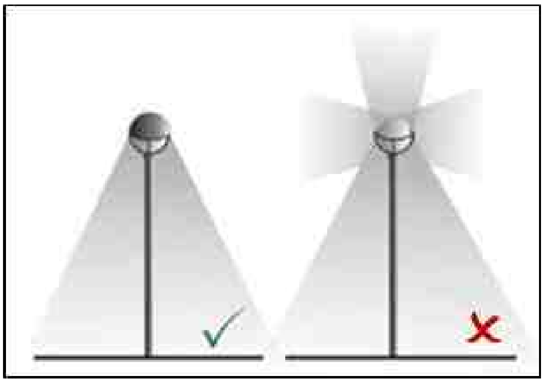
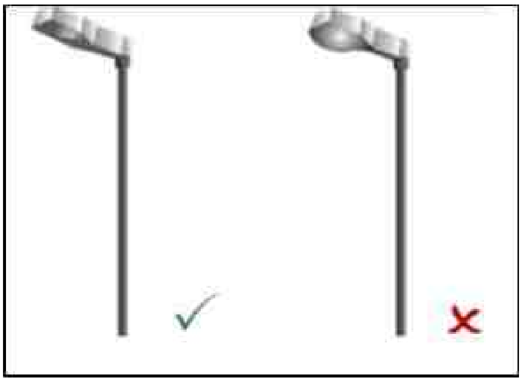
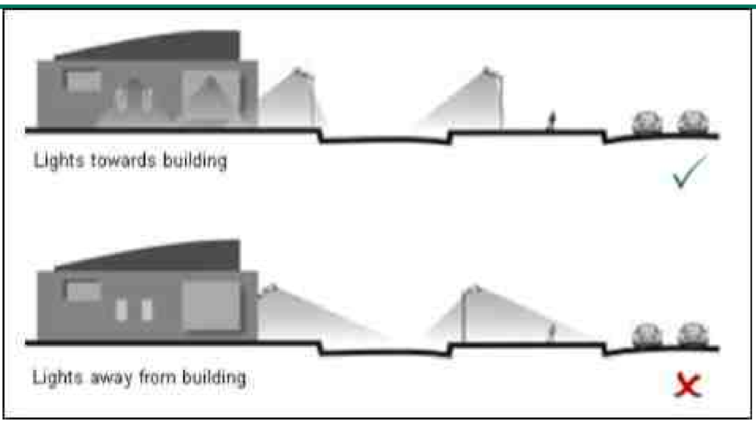
Operational Phase		Responsibility
	Directing the light towards the direction from where it would be most experienced by external receptors should also be avoided (Figure 76). ■ Light spill must be minimised. All security lighting shall have ‘blinkers’ or be specifically designed to ensure light is directed downwards while preventing side spill. Light fixtures of this description are commonly available for a variety of uses and should be used to the greatest extent possible. This may require that the number of light poles is increased to give the required illumination on the ground (Figure 77). ■ Lighting for security and safety purposes must be directed downwards and towards buildings and plant, to reduce light spill beyond the property boundary (Figure 78).  *Figure 76: Avoid up-lighting of structures, but rather direct the light downwards and focused on the object to be illuminated (CKA, 2008).*  *Figure 77: All security lighting shall have ‘blinkers’ or be specifically designed to ensure light is directed downwards while preventing side spill (CKA, 2008).*	

Operational Phase		Responsibility
	 *Figure 78: Lighting for security and safety must be directed downwards and towards buildings and plant (CKA, 2008).*	
Performance criteria	■ No complaints are received regarding the proposed Terminal's lighting; ■ Lighting which is provided is sufficient for the purposes of which it is intended, including security reasons; and ■ The proposed Terminal does not result in any light spill or light pollution which may impact on surrounding land users.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA; and ■ Any complaints which may be received which are associated with light pollution will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

7.8.8 Waste

The following mitigation measures have been identified to reduce waste impacts which may be associated with the proposed Terminal:

Construction phase

Construction Phase		Responsibility
Objectives	■ To prevent erosion and loss of stored soil material until it will be used to restore and rehabilitate the site during decommissioning; ■ To minimise the generation of general waste where possible, if not possible, to ensure waste is separated and recycled to limit quantities requiring disposal at landfill; ■ To minimize the generation of hazardous waste where possible, to	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ)***

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Construction Phase		Responsibility
	recycle or re-use or if possible return to the supplier; and ■ To minimise the generation of food waste and to recycle wherever possible.	***Manager***
Impacts:	■ Excavated earth material including the removal of topsoil, overburden, vegetation and other waste; ■ Generation and management of general (non-hazardous) industrial waste materials during construction; ■ Generation and management of hazardous waste materials during construction; and ■ Generation of general domestic food waste from the kitchen, offices and temporary staff facilities during construction.	
Mitigation measure(s):	■ Excavations and removal of overburden and topsoil will be minimized as far as possible; ■ Some of the topsoil and overburden material removed during the pre-construction phase will be used for backfilling; ■ These stockpiles will be sloped and capped to prevent erosion and loss of material. The integrity and aesthetics of the capping layer will further be enhanced by vegetating it with suitable natural plants indigenous to the area; ■ Storm and run-off water management systems will be implemented to divert storm and run-off water away from these stockpiles; ■ Prevent and minimise business/industrial waste generation as far as possible; ■ Provide suitable containers and temporary storage areas as close to the point of generation as practical possible; ■ Re-use waste during construction where possible; ■ Separate waste at source and recycle wherever possible; ■ Recycle waste via credible recycling contractors, e.g. metal salvagers; ■ Ensure unusable waste is disposed of in an environmentally responsible manner at licensed disposal facilities only (“Cradle to grave” responsibility); ■ Minimise hazardous waste at source wherever possible; ■ Separate hazardous waste streams for re-use or to recycle; ■ Recycle or treat waste via licensed waste contractors; ■ Return waste to the supplier if possible;	

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Construction Phase		Responsibility
	■ As a last option to pre-treat and dispose at a nearby suitably licensed waste facility for hazardous waste; ■ Sufficient food waste containers will be provided as close to the generation source as possible; ■ Food waste will be collected regularly to prevent any nuisances at these facilities; and ■ Landfilling of food waste will only be employed as a last option.	
Performance criteria	■ No evidence of erosion occurring onsite; ■ Measures with which to minimise waste generation are evident on site; ■ Separate waste containers have been provided onsite; and ■ Safe disposal certificates are obtained and kept on file.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

Operational phase

Operational Phase		Responsibility
Objectives	■ To ensure all general waste materials generated at the proposed Terminal are managed and disposed of in an environmentally acceptable manner to prevent any impacts to the health and safety of the community and environment; ■ To prevent hazardous waste generated at the proposed Terminal from impacting the surrounding environment or causing injury to human health; ■ To ensure all solid domestic waste generated at the proposed Terminal, workshops and offices is managed and disposed of in an environmentally acceptable manner; ■ To prevent hazardous waste generated at the proposed Terminal from entering the natural environment and causing injury to human health; and ■ To ensure all waste materials generated at the proposed Terminal are managed, and to prevent illegal waste disposal in the surrounding area.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Generation of general waste during operations; ■ Generation of hazardous waste during operations; ■ Storage of general waste;	

Operational Phase		**Responsibility**
	■ Storage of hazardous waste; ■ Spillage of hazardous waste during transport to the off-site landfill site / treatment facility; and ■ Unauthorised disposal of waste to the environment.	
Mitigation measure(s):	■ Appropriate collection, storage, transport, minimisation and disposal of all wastes generated at the proposed Terminal; ■ Demarcated areas with suitable waste bins will be provided for general waste; ■ Waste will be separated and recycled at source as far as possible to minimise volumes requiring landfilling; ■ Employees and the community will be educated to ensure the objectives of the waste aspect of the EMP are achieved; ■ Appropriate collection, storage, transport, minimisation, treatment and disposal of all hazardous wastes generated at the proposed Terminal; ■ Demarcated collection/storage areas with suitable waste bins for hazardous waste will be provided at strategic places; ■ Hazardous waste streams will be labelled and stored separately and recycled as far as possible to minimise volumes requiring landfilling; ■ Where possible hazardous waste will be returned to the suppliers; ■ Non-hazardous solid waste including paper, cloth and domestic waste will be handled as follows: ▪ Sufficient storage and waste bins will be provided as close to the point of generation as possible; ▪ Suitably designed central sorting and storage area (salvage yard) for general domestic and packaging wastes (not containing any hazardous wastes or chemicals) will be provided; and ▪ Employees and the community will be educated to ensure the objectives of the strategy are achieved. ■ All hazardous waste streams will be identified (inventory) and classified to ensure their hazardous properties (in accordance with the Waste Management and Classification Regulations) are known and to ensure it is managed and disposed of in a safely manner; ■ Hazardous wastes will be stored in sealed containers constructed of a suitable material and will be labelled as required by the Waste Management and Classification Regulations and best international practices; ■ All hazardous waste will be stored, transported, and disposed of in compliance with the relevant Waste Management and Classification	

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Operational Phase		**Responsibility**
	Regulations for hazardous waste; ■ Hazardous waste storage areas on site will be positioned away from any storm water drains and watercourses and away from moving vehicles and equipment to prevent accidental spills; on impermeable surface and bunded appropriately; ■ The storage/sorting site will at least comply with the following: ▪ The area will have a capacity less than 80 m³ of hazardous waste at any one time; and ▪ The migration of any accidental spillage of hazardous liquids or materials into the soil and groundwater regime around the storage area will be prevented. ■ Different and incompatible wastes will be clearly labelled and stored separately to prevent any chemical reactions such as combustion and fire hazards from occurring; ■ Drums will not be overfilled and different wastes types not be mixed; ■ Unless watertight, containers of dry waste will be stored on pallets or similar; ■ Waste containers or tanks whilst on site will be clearly labelled with the words “Hazardous Waste”. ■ Liquid or semi-liquid hazardous waste in will be kept in appropriate containers (closed drums or similar) and under cover; ■ Only trained persons should handle hazardous wastes; ■ Vehicles transporting waste should be purposed built and all required Haz-chem signage and emergency contact details should be displayed on these vehicles; ■ Strict speed limits should be imposed on hazardous waste vehicles; ■ Only trained and informed persons should transport hazardous wastes; ■ Regular environmental audits and inspections of the surrounding area will be undertaken to identify any environmental concerns and take action to rectify them; and ■ Workers and the community will be educated and trained to ensure the environment is kept clean and a reporting system will be implemented to report transgressors.	
Performance criteria	■ Separate waste containers have been provided onsite; and ■ Safe disposal certificates are obtained and kept on file.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued	

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Operational Phase		**Responsibility**
	by DEDTEA.	

Decommissioning Phase

Decommissioning Phase		**Responsibility**
Objectives	■ To limit the storage time and volumes of waste on the proposed Terminal site after decommissioning; and ■ To ensure waste materials are sorted and recycled wherever possible, minimising the need for landfilling.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Impacts:	■ Existing industrial structures will be removed and the topography will be returned (as far as possible) to its pre-development state; and ■ Temporary storage of dismantled used infrastructure materials, steel works, equipment, building rubble, contaminated soil and other waste.	
Mitigation measure(s):	■ All re-usable materials and equipment will be recycled as far as possible; ■ Natural vegetation of the area will be re-introduced on the proposed Terminal site; ■ Hazardous waste that cannot be recycled will be disposed of via the existing off-site disposal system at the time; ■ Dismantled and used materials will be sorted at source; ■ Hazardous and contaminated waste will be disposed of at a suitably licenced facility; ■ Landfilling of any waste will be implemented only as a last resort; and ■ Any deviations from set environmental requirements and standards during this phase will be addressed immediately.	
Performance criteria	■ Separate waste containers have been provided onsite; and ■ Safe disposal certificates are obtained and kept on file.	
Monitoring/ Measurement	■ Monitoring should be in compliance with the EMP and any conditions of authorisation that may be contained in the EA issued by DEDTEA.	

Additional Mitigation Measures

Waste hierarchy

The waste management hierarchy is an internationally accepted guide to prioritise waste management options and aims to achieve optimal environmental results. VSAD's main priority should be to prevent the

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generation of waste wherever possible. Where the prevention of waste generation is not possible, waste should as far as possible be minimised or re-used (see Figure 79).

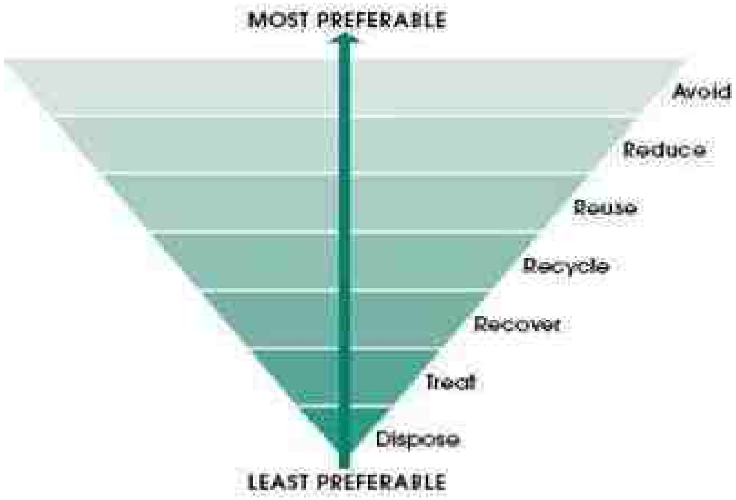

Figure 79: Waste Hierarchy

Realistic targets and time frames within which to reduce the generation of waste should be developed, and measures for more environmentally friendly waste management practices should be identified and implemented.

To further promote the minimisation of hazardous waste generation, VSAD should develop and implement a “Green Procurement Policy” wherein only environmentally friendly products are acquired and used in their operations. The quality and type of the input materials and resources determines the output and waste streams that can be expected.

8.0 OPINION OF THE ENVIRONMENTAL ASSESSMENT PRACTITIONER (EAP)

The potential environmental impacts associated with the proposed Terminal have been identified through the EIA, and where necessary, specialist studies have been undertaken to analyse particular aspects of the proposed Terminal’s development and operation.

The most pertinent issues identified during the EIA, are the issues relating to ecology, air quality, surface water, risk and traffic. No fatal flaws have been identified for the construction, operation or decommissioning of the proposed Terminal Provided.

The Environmental Management Plan (EMP) (see Section 7.8) generally proposes a number of management measures to mitigate identified impacts and to enhance identified positive benefits of the proposed project.

In our opinion, should these measures for the management and monitoring of impacts identified in this EIA be appropriately implemented, the potential negative impacts of the proposed Terminal should become acceptable.

With the exception of two ecology impacts the majority of impacts identified as having either a “High” or “Moderate” Environmental Significance can successfully be reduced to “Low” Environmental Significance granted that the mitigation measures identified within this EIA are implemented, and appropriate monitoring or the mitigation measures in accordance with the environmental objectives against performance criteria takes place. The loss of habitat as a result of vegetation clearing will remain high after mitigation, whereas the loss of plant species of conservation importance can be reduced from high to moderate environmental significance. This is due to the fact that there is a likelihood that there will be impact upon the flora and fauna in the vicinity of the construction site, and to this end the management measures that are proposed for the relocation of flora and the vigilance in capturing and relocating of fauna should be closely monitored. It is thus important that the management measures outlined for the proposed Terminal are incorporated into the EMP and strictly adhered to.

In addition it is also recommended that once the project description and final product portfolio has been determined that the Air Quality Impact Assessment and Risk Impact Assessments are updated / rerun as necessary.

GOLDER ASSOCIATES AFRICA (PTY) LTD.

Ed Perry Project Manager	Rob Hounsome Project Director

SW/EP/sw

Reg. No. 2002/007104/07
Directors: SA Eckstein, RGM Heath, SC Naidoo, GYW Ngoma

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APPENDIX A

Document Limitations

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APPENDIX B

List of Stakeholders

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STAKEHOLDER DATABASE

Name	Company	City
Acker-Pritchard, Cherise	Wildlife and Environment Society of South Africa (WESSA)	Mtunzini
Addison, Russel	uMhlathuze Valley Sugar Company Limited	Empangeni
Anderson, Mark	Bird Life South Africa	Beaconsfield
Aspinall, Louise	Wildcall	London
Baker, Dwayne	City of uMhlathuze	Richards Bay
Ballot, Chris	Exxaro Arnot Coal	Rietkuil
Barnes, Rusty	KwaMbonambi Timber and Cane Growers Association	
Basson, John	Transnet National Ports Authority	Waterfront
Berry, Sheila	uBuhle Bemvelo Environmental Group	Howick
Bhengu, Sicelo	Richards Bay Minerals	Richardsbay
Bhungane, Phindile	Department of Agriculture, Forestry and Fisheries (DAFF)	Pietermaritzburg
Bigwood, Taryn	iSimangaliso Wetland Park	St Lucia
Biyela, Bonginkosi	uThungulu District Municipality	Richards Bay
Biyela, T M	Mbonambi Municipality	Kwambonambi
Black, Venessa	Earthlife eThekwini	Durban
Blackie, Annette	Zululand Chamber of Commerce and Industry	
Blackmore, Andy	Ezemvelo KZN Wildlife	Cascades
Bodasing, Marilyn	Botanical Society of South Africa	Mayville
Bodenstein, Johan	Indiflora CC Environmental Services	Mayville
Boshoff, Michelle	Richards Bay Minerals	Richards Bay
Bosman, F G	Democratic Alliance (DA)	Meer En See
Botes, Vic	Mhlathuze Water	Richards Bay
Botha, Mark	WWF SA	Claremont
Breen, Terry	Breen Properties	Richards Bay
Brett, Dymock	Khanya Kude Sugar Estate	Nyoni
Brokhorst, B G	Sokhulu Tribal Authority	
Brown, Sally	Global Environmental Trust	Hillcrest
Brudvig, Ryan	Department of Water Affairs (DWA)	Howick
Bukhosini, Raphael	Mandlazini Agri-Village	Richards Bay
Buller, Rob	Mhlathuze Water	Richards Bay
Burchmore, Chris	Mondi Forests	Pietermaritzburg
Burger, Francois	Wildcall	Vryheid
Burger, Hannetjie	Honorary Officers Vryheid Group	Vryheid
Burger, Willem	Honorary Officers Vryheid Group	Vryheid
Buthelezi, J E	Sokhulu Tribal Authority	
Buthelezi, Nora	Sokhulu Tribal Authority	
Buthelezi, Thembi	iSimangaliso Authority	St Lucia
Buthelezi, Zinhle	Esikhawini Public Library	Esikhawini
Camminga, Sandy	Richards Bay Clean Air Association	Richards Bay

Name	Company	City
Carbutt, Clinton	Ezemvelo KZN Wildlife	
Castis, Terri	iSimangaliso Wetland Park	St Lucia
Cele, J N	African National Congress (ANC)	Esikhaleni
Cele, N R	African National Congress (ANC)	Esikhaleni
Cele, Phumzile		Esikhawini
Cele, Silas	Induna	Esikhawini
Cele, Thenjiwe		Esikhawini
Chetty, Cheryl	uThungulu District Municipality	Richards Bay
Chili, F B	Nduna Village	Esikhawini
Chili, M P	Dube Village	
Chili, S.	Dube Village	
Chili, Zandile	Dube Traditional Council	Esikhawini
Chilli, Charles	Dube Traditional Council	Esikhawini
Chilli, T H		Empangeni
Clark, Rosanne	Wilderness Foundation	Himeville
Condon, Tim	Zululand Wildlife Forum	
Cook, Pete	Grantleigh School	Kwambonambi
Cooke, Lindsay	Sea Escapes Scuba Diving	Sodwana Bay
Cooper, Debbie	iSimangaliso Authority	St Lucia
Cottrell, Michael	Wildlife and Environment Society of South Africa (WESSA)	Westville
Craigie, Francis	Department of Environmental Affairs (DEA)	
Cuthbertson, Janet	Suni Ridge Environmental Centre	Hluhluwe
Cyrus, D P	Coastal Research Unit	Empangeni
Cyrus, Digby	Zululand Environmental Alliance (ZEAL)	
Danisa, L M	African National Congress (ANC)	Esikhaleni
Davidson, William	Nseleni Nurseries	Kwambonambi
Dawood, A S	African National Congress (ANC)	Brackenham
de Beer, Elna	SRK Consulting	Johannesburg
de Beer, Gerhard	Spoornet	Wierda Park
de Lange, B J	Democratic Alliance (DA)	Empangeni
Demont, Lynton	Transnet (Protekon)	
Denton, A.	Richards Bay Minerals	Richardsbay
Dickens, Chris	Institute of Natural Resources	Scottsville
Dladla, Nelisa	Richards Bay Minerals	Richardsbay
Dlamini, Duduzile		Esikhawini
Dlamini, Mnyamezile	Regional Land Claims Commission	Pietermaritzburg
Dlamini, Nkosinathi Shadrack	City of uMhlathuze	Richards Bay
Dlamini, Philani		Enseleni
Dlamini, Samke		Esikhawini

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Name	Company	City
Dlamini, Sikhosiphi	KZN Department of Home Affairs	Richards Bay
Dlamini, Zanele		Esikhawini
Dlungwana, Thembile	Department of Agriculture, Forestry and Fisheries (DAFF)	Pietermaritzburg
Dodkins, Janice		Sodwana Bay
Doerner, Ulf	Wilderness Foundation	Munich
Domingo, Garth	TRONOX	
Drinkwater, T W		Hillcrest
Drodskie, Peggy	South African Chamber of Business	Saxonwold
Drummond, Ryan	River Willow Farm	Kwambonambi
du Toit, C E	KwaMbonambi Primary School	Kwambonambi
du Toit, Francois	African Conservation Trust	Link Hills
Dube, Alfred	Dube Traditional Council	Esikhawini
Dube, Cebisile Rejoice		Esikhawini
Dube, D.	Sokhulu Tribal Authority	
Dube, E J B	African National Congress (ANC)	Kwadlangezwa
Dube, Jowel	Dube Traditional Council	
Dube, K J		Esikhawini (Mkhobosa)
Dube, K M		
Dube, M N	Sokhulu Tribal Authority	
Dube, Nombulelo		Esikhawini
Dube, S M		
Dube, Sarah	Dube Tribal Authority	Esikhawini
Dube, T B		
Dube, T M		Esikhawini (Madlankala)
Dube, Zodwa		Esikhawini
Duigan, Helen	Rhenosterspruit Nature Conservancy	Bryanston
Duncan, Greg	Exec Properties	Meer En See
Dunjwa, Virginia		Empangeni
Dunne, Tania	Foskor (Pty) Limited	Richards Bay
Durow, Neville	Sacred Earth Network	Ashburton
Dutton, Paul	Dutton Environmental	Salt Rock
Edwards, Tony	KwaMbonambi Indigenous Plants CC	Kwambonambi
Elliott, Felicity	Ezemvelo KZN Wildlife	Cascades
Esterhuizen, Roy	Silvacel	Richards Bay
Ewing, Andrew	Magqubu Ntombela Foundation	Yellowwood Park
Fanner, Mary Anne	Compu-accounting	Cascades
Findlay, Ken	Earthwatch/UCT	Rondebosch
Fourie, L C M	Democratic Alliance (DA)	Empangeni
Fourie, Louis	Afrikaanse Handel Instituut Zoeloeland and uThungulu	Empangeni

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Name	**Company**	**City**
	Strategic Development Comm	
Fowles, Edward		Portugal
Frazee, Sarah	Conservation SA	Claremont
Friedman, Warren	Palmiet Nature Reserve	
Galliers, Chris	Game Rangers Association of Africa – KZN Region	Howick
Gazu, Gugu	City of uMhlathuze Local Municipality	Richards Bay
Gear, Simon	Birdlife South Africa	Randburg
Golding, Desmond	Department of Economic Development	Pietermaritzburg
Gopalkista, Rita	SA Portal Operation	
Govender, Neil	Kennedy & Donkin Africa (Pty) Ltd	Richards Bay
Govender, Sharin	uMhlathuze Local Municipality	Richards Bay
Govender, Thamen	Richards Bay Minerals	Meer En See
Govender, Troyd	Eskom	New Germany
Govender, Vishnu	Cooperative Governance and Traditional Affairs (COGTA)	Durban
Graham, Theo	Mhlathuze Water	Richards Bay
Grant, Andrew	KwaMbonambi Farmers Association	Kwambonambi
Grant, Stephen	Matambo Farm	Kwambonambi
Green, Kevin	Ezemvelo KZN Wildlife	Meer En See
Greyling, Anique	Endangered Wildlife Trust (EWT)	Parkview
Guldemond, Robert	University of Pretoria	Hatfield
Gumbi, N V	African National Congress (ANC)	Esikhaleni
Gumbi, Sbusiso	KwaZulu-Natal Department of Transport	Pietermaritzburg
Gumbi, Zethu	uMhlathuze Local Municipality	Esikhawini
Gumede, Constance		Empangeni
Gumede, E N	Sokhulu Tribal Authority	Richards Bay
Gumede, Elima		Kwaphefeni
Gumede, F N	Sokhulu Tribal Authority	
Gumede, Jabulani		Esikhawini
Gumede, Themhihle		Esikhawini
Gumede, Timothy	uMhlathuze Local Municipality	Esikhawini
Gwala, Zanele	Department of Mineral Resources (DMR)	Durban
Hammer, Marion	Global Nature Fund	Radolfzell
Hancock, Mike	Moyamara Residential Country Club	Kwambonambi
Hardev, Trenisha	Richards Bay Minerals	Richardsbay
Harrison, Ian	Kwambo Conservancy	Kwambonambi
Harry, Connie	Zululand Observer	
Heaney, Martine	uMhlathuze Municipality	Richards Bay
Hlatshwayo, B J	Enseleni High School	Richards Bay
Hlela, Sabelo	City of uMhlathuze	Richards Bay
Hlengwa, T D		Esikhawini

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Name	Company	City
Hlope, S N	uMhlathuze Local Municipality	Richards Bay
Hodgson, Joy		
Hoole, Ross	Department of Land Affairs (DLA)	Pietermaritzburg
Jenkinson, Ron	Jengro Estates	Kwambonambi
Jones, Roy	Ezemvelo KZN Wildlife	Meer En See
Jordan, Brenda Strachan	City of uMhlathuze	Richards Bay
Joseph, L S	uMhlathuze Local Municipality	Richards Bay
Kelbe, Bruce	University of Zululand	Mtunzini
Kelbe, Dudley		Richards Bay
Kelly, Syd	Richards Bay IDZ	Richards Bay
Keswa, Vuyo	Transnet National Ports Authority	Richards Bay
Kewley, Howard	Mapelane Ski Boat Club	Mtunzini
Khakoza, M J		Esikhawini
Khambuke, Judas Moses		Empangeni
Khanyile, Mangausa		Barkley East
Khathi, Nozipho	uThungulu District Municipality	Richards Bay
Khoza	Bhejane Tribal Authority	Empangeni
Khoza, Lindani	uMhlathuze Municipality	Richards Bay
Khoza, M.	Inkatha Freedom Party	
Khoza, S P	National Freedom Party	Enseleni
Khozi, Sfiso		Empangeni
Khulu, Mthoko		Richards Bay
Khulu, Phumlani		Richards Bay
Khuluse, Nkosingiphile	uThungulu District Municipality	Richards Bay
Khumalo, Dumisani	Enseleni Senior Secondary School	Richards Bay
Khumalo, M R	African National Congress (ANC)	
Khumalo, Morin		Esikhawini
Khumalo, Nonkululeko	Department of Mineral Resources (DMR)	Durban
Khumalo, Sizwe	Zululand Chamber of Business	Richards Bay
Khumalo, Wiseman	Mandlazini Comminity	Richards Bay
Khuzwayo, Sakah	Sokhulu Tribal Authority	
Khuzwayo, Silondiwe		Pietermaritzburg
Klopper, Johan	Afrikaanse Sakekamer	Richards Bay
Kok, Naomi	Felixton Canegrowers Association	Empangeni
Kormos, Cyril	International Union for the Conservation of Nature - World Commission on Protec	Berkeley
Kuluse, Nkosinkuphile	uThungulu District Municipality	Richards Bay
Kwela, P N	National Freedom Party	Birdswood
Kweyama, C S	Kwa-Dube Tribal Authority	Esikhaleni

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Name	Company	City
Langa, Duncan	Mandlazini Community	Richards Bay
Larkan, Stan	uThungulu District Municipality	Richards Bay
Larsen, Paul	Silver Oak Estate	Kwambonambi
Lax, Ilan	Wilderness Action Group	Pietermaritzburg
Lemmer, David	Pulp United	Pietermaritzburg
Lipalesa, Sissie Matela	Environmental and Rural Solutions	Matatiele
Liptrot, Mark	Richmond Marianhill Conservancy	Kloof
Litsoane, Masina	Department of Environmental Affairs (DEA)	Pretoria
Locke, Harvey	Conservation Strategy and the WILD Foundation	Boulder Colorado
Longmore, Jenny	Ezemvelo KZN Wildlife	Cascades
Lourens, M.	African National Congress (ANC)	Veld-En-Vlei
Louw, Hendrik		Meer En See
Luthuli, Baghelile		Esikhawini
Luthuli, Zama	RBCT	Richards Bay
Maary, Dorry	Pipetec	Empangeni
Mabale, Dolphin	AMAFA KwaZulu/Natal	
Mabaso, Sikhumbuzo	Dube Village	Eskihawini
MacFarlane, John	uThungulu Strategic Development Committee	Meer En See
Macgregor, Murray	SAC & ES	Strubens Valley
Machaka, Tebatjo Lesetja		Kwambonambi
Madondo, N M	African National Congress (ANC)	Mandlanzini
Madonsela, Nicosinathi	uMhlathuze Local Municipality	Esikhawini
Magagula, Audrey		Esikhawini
Magagula, Themba	Abathombenics	Mereensee
Magubane, Modise	Mbonambi Municipality	Mbonambi
Magutshwa, Thandeka		Esikhawini
Maharaj, Manisha	Department of Water Affairs (DWA)	Durban
Mahunu, Khanyile	Dube Tribal Authority	
Majola, Ntombenhle		Esikhawini
Majola, Siza	Rio Tinto	
Makatini, M T	Inkatha Freedom Party	Kwadlangezwa
Makhanya, Sello	AMAFA KwaZulu/Natal	Pietermaritzburg
Makhoba, Xolile	Richards Bay Minerals	Richards Bay
Makka, Anoshka	uThungulu Tourism	Richards Bay
Manipersadh, Pravesh	Ingonyama Trust	Pietermaritzburg
Mankowski, Patty	Westville Conservancy	Westville
Manning, Jenni		Gillits
Marais, Elitza	uThungulu District Municipality	Richards Bay

Name	Company	City
Margot, Bruce	Corporate Governance & ISC	Pietermaritzburg
Markham, Rob		Pietermaritzburg
Martin, Vance	World Commission on Protected Areas, IUCN	Boulder Colorado
Masango, Z.	City of uMhlathuze	Richards Bay
Maseko, Nkosazana	Department of Mineral Resources (DMR)	Durban
Mashaba, Thulani	African National Congress (ANC)	Empangeni Rail
Masilo, Tokoloho	Mhlathuze Water	Richards Bay
Masinga, Rose		Kwaphefeni
Mathaba, B.		Empangeni
Mathenjwa, M P	African National Congress (ANC)	Empangeni
Mathenjwa, Sikhali	KZN Department of Agriculture & Environmental Affairs	Empangeni
Mathie, Alistair	Spider Club of South Africa	Sloane Park
Mavimbela, C P	National Freedom Party	Enseleni
May, Nicole	Toprock Museum	Ashburton
Mazibuko, Lethiwe	Empangeni Public Library	Empangeni
Mbambo, Gugu		Esikhawini
Mbambo, Thoko		Esikhawini
Mbambo, Zazi	Nduna Village	Esikhawini
Mbanjwa, N.	African National Congress (ANC)	Esikhaleni
Mbanjwa, Z.	Department of Agriculture, Environmental Affairs and Rural Development (DAEARD)	Richards Bay
Mbatha, E F	uMhlathuze Local Municipality	Esikhawini
Mbatha, Elphas	uMhlathuze Local Municipality	Richards Bay
Mbatha, Nozipho		Empangeni
Mbatha, P T	African National Congress (ANC)	
Mbokazi, Jabulani	Canaan School	Kwambonambi
Mbokazi, M M	uMhlathuze Local Municipality	Empangeni
Mbuede, Z J		Esikhawini
Mbunakazi, M S		
Mbunyasi, Tholaleke		Esikhawini
Mbuyazi, Mandla Enerst	Ntoyeni Resettlement Committee	Empangeni
Mcartney, Garth	CV Personnel and uThungulu Strategic Development Committee	Zimbali
Mchunu, Thendeka	uThungulu District Municipality	Richards Bay
McKelvey, Bianca	Wildlife and Environment Society of South Africa (WESSA)	Durban
McKenzie, Ashleigh	iSimangaliso Wetland Park	Mtunzini
McMurtry, Shaun	Grantleigh School	Kwambonambi
Mdakane, S.	Infrastructure and Technical Services	Richards Bay
Mdamba, Muzi	Department of Agriculture and Environmental Affairs (DAEA)	Empangeni
Mdlalose, Nompumelelo	Department of Water Affairs (DWA)	Durban

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Name	Company	City
Mdlaose, M D	Sokhulu Tribal Authority	
Mdletshe, Enock		Empangeni
Mdletshe, M.		Empangeni
Mdlovana, Kirteanav		Empangeni
Menne, Wally	Timberwatch Coalition	Mayville
Merryweather, D.	Democratic Alliance (DA)	Arboretum
Mhlongo, M E	African National Congress (ANC)	
Mhlongo, Mthokozisi	uMhlathuze Municipality	Durban
Mhlongo, Nomsa		Esikhawini
Mhlongo, T.	Sokhulu Tribal Authority	
Mhlungu, Silindile	Department of Agriculture, Forestry and Fisheries (DAFF)	Pietermaritzburg
Milburn, Ria		Lyndhurst
Millard, Rick		Westville
Mjadu, Vusimuzi	Dube Village	Esikhawini
Mkhabela	Vondlo Junior School	Empangeni Rail
Mkhaliphi, Lawrence	Biowatch South Africa	Mthubhathubha
Mkhize, M R	Inkatha Freedom Party	Ngwelezane
Mkhize, S G	African National Congress (ANC)	Ngwelezane
Mkhize, Senzo	Sappi Forests	Cascades
Mkhwanazi, Fanyana	Dube Village	Esikhawini
Mkhwanazi, Thula	uThungulu Strategic Development Committee	Meer En See
Mkize, G M	African National Congress (ANC)	Empangeni
Mlaba, N.	National Freedom Party	Kwadlangezwa
Mlambo, Busisiwe	South African National Roads Agency Limited (SANRAL)	Scottsville
Mlambo, Sifiso		Esikhawini
Mlondo, Ntombizabo		Esikhawini
Mlondo, Petros		Empangeni
Mncube, Siphiwe		Esikhawini
Mngadi, Khanyisile		Kwambonambi
Mngadi, Mayvis		Kwambonambi
Mngadi, Otalia Ruth Rainie	Dube Traditional Authority	Esikhawini
Mngoma, William	Department of Agriculture and Environmental Affairs (DAEA)	Richards Bay
Mngomezulu, A P	Inkatha Freedom Party	Esikhaleni
Mngomezulu, Jerry	Richards Bay Minerals	Richards Bay
Mngomezulu, Mandla	Congress of South African Trade Unions (COSATU)	Meer En See
Mnguni, B.	Dube Village	Esikhawini
Mnguni, Dudu		Esikhawini
Mnguni, Fano		Empangeni
Mnguni, Mdubuzi	Dube Village	Esikhawini

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Name	Company	City
Mnqayi, M S	African National Congress (ANC)	Ngwelezane
Mnqayi, Zakhele	uMhlathuze Municipality	Richards Bay
Mnyungula, Ayanda	Department of Agriculture, Forestry and Fisheries (DAFF)	Pietermaritzburg
Mohajane, Patle	National Nuclear Regulator (NNR)	Centurion
Mohamed, Hanis	Mondi Forests	Richards Bay
Moodley, Karoon	Department of Mineral Resources (DMR)	Durban
Moodley, Nivi	Exxaro KZN Sands	Empangeni
Moonsamy, Coleen	Department of Water Affairs (DWA)	Durban
Moonsamy, Colleen	Department of Water Affairs (DWA)	Durban
Moonsamy, Gino	The National Nuclear Regulator	Centurion
Morgan, Gareth	Democratic Alliance (DA)	Cape Town
Moss, Alan	City of uMhlathuze	Richards Bay
Mostert, Theo	University of Zululand	Mtunzini
Motsepe, Nthabiseng	Rio Tinto	Richards Bay
Mpangase, Douglas		Esikhawini
Mpanza, Caesar	Eskom	Empangeni
Mpanza, Nelsiwe		Esikhawini
Mpanza, P D		Esikhawini
Mphofu, Wisdom	uThungulu District Municipality	Richards Bay
Mpikayise, Cebekhulu	Ntoyeni Resettlement Committee	Empangeni
Mpofu, Philphane		Esikhawini
Mponzo, Thulani	Nduna Village	Esikhawini
Mpungose, Irene		Esikhawini
Mpungose, Khumbulani		Empangeni
Mpungose, Ntombi		Esikhawini
Mpungose, R T	uMhlathuze Local Municipality	Esikhawini
Mpungose, Skhumbuzo	Department of Agriculture and Environmental Affairs (DAEA)	Empangeni
Mpungose, Thembi		Esikhawini
Msomi, Bheki		Esikhawini
Msomi, Busani	City of uMhlathuze	Richards Bay
Msomi, Doreen	Department of Health	Empangeni
Msomi, M R	uThungulu District Municipality	Richards Bay
Msweli, B A		Empangeni
Msweli, Fanele Antony		Kwambonambi
Mtambo, Laurence	KwaZulu-Natal Department of Transport	Pietermaritzburg
Mthembu, A H	African National Congress (ANC)	Hillview
Mthembu, B C	African National Congress (ANC)	Esikhaleni
Mthembu, Babhekile	uMhlathuze Local Municipality	Esikhawini
Mthembu, K.		Esikhawini

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Name	Company	City
Mthembu, M.		Kwambonambi
Mthembu, Muntukathenjwa		Empangeni
Mthembu, Nokuthula	Mhlathuze Water	Richards Bay
Mthembu, Phinah		Esikhawini
Mthembu, Slindo	Department of Transport	Empangeni
Mthemthwa, Mjojeni		Empangeni
Mthenjana, M W	African National Congress (ANC)	Esikhaleni
Mthethwa, B V	uThungulu District Municipality	Richards Bay
Mthethwa, B.	Sokhulu Tribal Authority	
Mthethwa, Emelina		Empangeni
Mthethwa, K N	Inkatha Freedom Party	
Mthethwa, M C		Kwambonambi
Mthethwa, M E	Mbonambi Municipality	Kwambonambi
Mthethwa, Mkusawabathethwa	Mhlana Tribal Authority	Kwambonambi
Mthinyane, Nikeziwe	Sokhulu Traditional Authority	Kwambonambi
Mthiyane, B D	Sokhulu Tribal Authority	
Mthiyane, B M	uMhlathuze Local Municipality	Pietermaritzburg
Mthiyane, B T	African National Congress (ANC)	Madlebe Tribal Authority
Mthiyane, B Z		Esikhawini
Mthiyane, B.	Sokhulu Tribal Authority	
Mthiyane, Inkosi	Sokhulu Tribal Authority	
Mthiyane, J.	Sokhulu Tribal Authority	
Mthiyane, M M	Sokhulu Tribal Authority	
Mthiyane, M.	Sokhulu Tribal Authority	
Mthiyane, Menzi		Esikhawini
Mthiyane, Mholeni	Sokhulu Tribal Authority	
Mthiyane, N B	Sokhulu Tribal Authority	
Mthiyane, N.	Sokhulu Tribal Authority	
Mthiyane, P B	Sokhulu Tribal Authority	
Mthiyane, Phakama	Sokhulu Tribal Authority	
Mthiyane, Philangekosi		Esikhawini
Mthiyane, Phineas	Sokhulu Tribal Authority	
Mthiyane, Simon	Sokhulu Tribal Authority	Mtubatuba
Mthiyane, Sipho	uMhlathuze Local Municipality	Esikhawini
Mthiyane, T.	Sokhulu Tribal Authority	
Mthiyane, Zanele	RBCT	Richards Bay
Mthunyane, Bheka	uMhlathuze Local Municipality	Richards Bay
Mtshali, Dumisani	Department of Agriculture and Environmental Affairs (DAEA)	Richards Bay

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Name	Company	City
Mtslali, Eslinah Bhekiwe		Empangeni
Muir, Andrew	Wilderness Foundation	Centrahil
Muller, Wendy	BHP Billiton Middelburg Mines (BECSA)	
Musgrave, Lylie		Waterfall
Mvubu, Thulisiwe		Esikhawini
Mzimela, N B	African National Congress (ANC)	Madlebe Tribal Authority
Mzimela, N.	Mbonambi Local Municipality	Kwambonambi
Naduma, U.		Empangeni
Naylor, Gladys	Mondi Kraft and Business Paper	Richards Bay
Ncinga, Nokuthola	National Ports Authority	Richards Bay
Ncube, Perceverance	Lifeline	Richards Bay
Ncube, S L	Sokhulu Tribal Authority	
Ncube, Tulisiwe	Dube Traditional Authority	Esikhawini
Ndebele, Amos	Insika Rural Development Trust	Empangeni
Ndimande, D J	African National Congress (ANC)	Enseleni
Ndlela, Khanyisile		Esikhawini
Ndlovana, Israel		Empangeni
Ndlovana, Pano Eric		Empangeni
Ndlovana, Philipine		Empangeni
Ndlovana, Thulisiwe		Kwambonambi
Ndlovu, Bongiwe	Department of Transport	Pietermaritzburg
Ndlovu, C H		Esikhawini
Ndlovu, Khonzi	Democratic Alliance (DA)	Esikhaleni
Ndlovu, Mfundo	Golder Associates	Maytime
Ndlovu, Mthokozisi	Inzinyembezi Zendlovu Construction & Services	Kwambonambi
Ndlovu, Nontobeko H		Richards Bay
Ndlovu, S Z		Esikhawini
Ndlovu, Thembheka	Department of Land Affairs (DLA)	Richards Bay
Ndlovu, Vumani	Transnet National Ports Authority	Richards Bay
Ndwandwe, G P	City of uMhlathuze	Richards Bay
Nel	Zenith Estates	Kwambonambi
Nembula, Monde	SRK Consulting	Esikhawini
Nene, Johannes		Kwadlangezwa
Ngcobo, Basil	Transnet	Richards Bay
Ngcobo, Philemon	Dube Tribal Authority	Meer En See
Ngcobo, T B	National Freedom Party	Enseleni
Ngcobo, Vusi	SABS Mining and Minerals	Richards Bay
Ngcobo, Zakhele	Wildlands Conservation Trust	Empangeni
Ngeleka, P S	National Ports Authority	Richards Bay

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Name	Company	City
Ngema, B F		Empangeni
Ngema, Dorcas	National Union of Mine Workers of South Africa (NUMSA)	Richards Bay
Ngema, Londiwe		Esikhawini
Ngidi, Comfort	Sokhulu Tribal Authority	
Ngobese, Mwandile		Esikhawini
Ngwenya, Ntokozo		Esikhawini
Ngwenya, S N		Esikhawini
Nkabinde, B A		Esikhawini
Nkomo, Dennis	Ikusasa Construction	Esikhawini
Nkosi, B L	Department of Social Development	Pietermaritzburg
Nkosi, G A	African National Congress (ANC)	Esikhaleni
Nkosi, Mandla	Mbonambi Municipality	Kwambonambi
Nkosi, Maphumzane	Democratic Alliance (DA)	Esikhaleni
Nogmann, Weg	Alfluorco	
Nordal, Matthew	Wilderness Foundation	
Nsele, Lenadi		Esikhawini
Nsibande, S M		Mjabuliseni
Nsomi, Simangele		Kwa Dlange
Ntanzi, P M	African National Congress (ANC)	Ngwelezane
Nthombela, M.	Sokhulu Tribal Authority	
Ntikinca, Tandaza	Department of Human Settlements	Pietermaritzburg
Ntombela, Mirriam	Sokhulu Tribal Authority	
Ntshangase, P S		
Ntuli, B R	African National Congress (ANC)	Ngwelezane
Nxumalo, D A	City of uMhlathuze	Richards Bay
Nxumalo, Lucky	Mbonambi Municipality/Mfolozi Municipality	Kwambonambi
Nxumalo, Thembeni		Empangeni
Okello, Nick	Richards Bay Mining	Richards Bay
Ott, Theresia	Richards Bay Minerals	Richards Bay
Outhwaite, Peter	Birdlife Zululand	
Pakkies, Duncan	Ingonyama Trust	Pietermaritzburg
Palmer, E A	African National Congress (ANC)	Empangeni
Pascoe, Digs	Space for Elephants Foundations	Eshowe
Pather, Prash	Department of Health	Pietermaritzburg
Patterson, Mike	Zululand Chamber of Business and uThungulu Strategic Development Committee	Empangeni
Pawandiwa, Bernadet	AMAFA/Heriatage KwaZulu-Natal	Pietermaritzburg
Phelps, J M	Zululand Environmental Alliance (ZEAL)	Kwambonambi
Pheshe, Zipho		Esikhawini
Phillips, Fred	City of uMhlathuze	Richards Bay

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Name	Company	City
Pietersen, Antoinette	Golder Associates	Halfway House
Pietersen, Toni	Golder Associates	Halfway House
Porter, Roger		Hilton
Pountney, Charmayne	Zululand Chamber of Commerce and Industry	
Pretorius, Jason		Richards Bay
Qhaya, Nomonde	Department of Mineral Resources (DMR)	Durban
Qobile	KwaMbonambi Traditional Authority	
Queripel, Rob	Department of Land Affairs (DLA)	
Radebe, Malusi	Richards Bay Public Library	Richards Bay
Radebe, W M	African National Congress (ANC)	Enseleni
Rapuleng, Magugu	Zululand Chamber of Business	Richards Bay
Raymond, Suzi		Mtunzini
Reddy, Christina	Port of Richards Bay	Richards Bay
Redinger, Pierre	Crystal Holdings	Empangeni
Reid, Lynne	Birdlife South Africa	Meyerton
Resch, Jurgen	Deutsche Umwelthilfe e.V.	Radolfzell
Rielly, Arthur	Natural Moments Bush Camp	
Rivers-Moore, Maryann		Hilton
Roberts, Jo	Wilderness Foundation	
Rozani, Wiseman	Department of Agriculture, Forestry and Fisheries (DAFF)	Pietermaritzburg
Sabelo, L S	National Freedom Party	Esikhaleni
Sanders, Larry	Department of Cooperative Governance and Traditional Affairs	Pietermaritzburg
Sandu, Jeremy	Grantleigh School	Bothas Hill
Savides, Dave	Zululand Observer	
Scheepers, Jan		Meer En See
Scheepers, Nelius	Golder Associates	Maytime
Schwegman, Carolyn	Wildlife and Environment Society of South Africa (WESSA)	Pennington
Scott-Shaw, R D	Ezemvelo KZN Wildlife	Cascades
Sebayana, Athalia	Department of Water Affairs (DWA)	Durban
Selby, Franz	TATA Steel KZN (Pty) Ltd	
Senogles, Jean	Primates Africa	Westville
Shandu, Happy	Department of Agriculture, Environmental Affairs and Rural Development (DAEARD)	Richards Bay
Shangase, L B	African National Congress (ANC)	Ngwelezane
Shaw, Lize	SiyaQubeka Forests (Mondi Business Paper)	Kwambonambi
Shozi, Sifiso		Empembeni
Sibiya, Ntombi		Esikhawini
Sibiya, Shiso		Empangeni
Sibiya, Thina		Empangeni
Sibiya, Thulani		Empangeni

Name	Company	City
Sigwaza, G C	Sokhulu Tribal Authority	
Simelana, Thembinkosi	Mhlana Tribal Authority	Empangeni
Simelane, Bernard	Eskom	Empangeni
Simmadhri, S S	Inkatha Freedom Party	Wildenweide
Sithole, Ndumiso	Ezemvelo KZN Wildlife	
Sithole, S T	Sokhulu Tribal Authority	
Sithole, Sithembiso		Empangeni
Sithole, Totozi	Community Committee	Empangeni
Skepe, Pumeza	Department of Environmental Affairs (DEA)	Pretoria
Skosana, Edmund	Vuka Environments	Richards Bay
Smit, Danie	Department of Environmental Affairs (DEA)	
Smith, Debbie	Zululand Environmental Alliance (ZEAL)	Kwambonambi
Smith, Hennie	uThungulu District Municipality	Richards Bay
Smith, Jeremy	Richards Bay Rate Payers Association	Meer En See
Solomons, Milicent	Department of Environmental Affairs (DEA)	Pretoria
Sookroo, M.	African National Congress (ANC)	Empangeni
Sosibo, Mayo	Department of Land Affairs (DLA)	Pietermaritzburg
Soutar, Bruce David		Musgrave
Stacey, Jonathan	Bird Life International	
Strachan, Brenda	uMhlathuze Local Municipality	Esikhawini
Strachan, Marie	Mercury	
Stuart, Ian	KwaMbonambi Ratepayers Association	Kwambonambi
Sukreben, Kevin	Umhlathuze Municipality	Empangeni
Sutherland, Tracy		Sodwana Bay
Swaine, John	Mondi Forests	Richards Bay
Swan, Nick	Isithunzi Consulting	Hillcrest
Swanepoel, Kyla		
Tait, Anita	uThungulu District Municipality	Richards Bay
Taylor, Martin	Birdlife South Africa	Richards Bay
Tembe, J D		Esikhawini
Terblanche, Ciska		
Terry, Beverley	National Association for Clean Air	
Thameu, Dinesree	Ezemvelo KZN Wildlife	Cascades
Thandeka, Mngadi		Esikhawini
Thango, Phiwo	Zululand Chamber of Business and uThungulu Strategic Development Committee	Meer En See
Themba, S S	Sokhulu Tribal Authority	
Thusi, N T		Empangeni
Thusi, Sphiwe	uMhlathuze Municipality	Richards Bay
van de Venter-	AMAFA/Heriatage KwaZulu-Natal	Pietermaritzburg

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Name	Company	City
Radford, Annie		
van der Walt, Frans	uThungulu Strategic Development Committee	Meer En See
van der Westhuizen, Chris	Richards Bay High School	Richards Bay
van Eeden, Danie	Mbonambi Municipality/Mfolozi Municipality	Kwambonambi
van Heerden, Frans	Mine Workers Union (MWU)	Richards Bay
van Huyssteen, Marius	SRK Consulting	Westville
van Kraayenburg, Marita	Emgangeni Public Library	Empangeni
van Loggerenberg, Carl	Sappi Forests	Kwambonambi
van Rooyen, Magnus		Baynesfield
van Vuuren, James	AMAFA KwaZulu/Natal	Pietermaritzburg
van Zyl, J L		Meer En See
van Zyl, Stefan	Sappi Forests	Sappi Forests
Venter, Andrew	Wildlands Conservation Trust	Hilton
Viljoen, A.		Birdswood
Viljoen, Alem	Zoeloeland AHI	Richards Bay
Volschenk, Vernon		Kwambonambi
von Abo, Ethel	KwaZulu-Natal Agricultural Union	Scottsville
Ward, Mark	Wildlife and Environment Society of South Africa (WESSA)	Howick
Ward, Roddy	Private Consultant	Mayville
Webb, Candice	Mondi Richards Bay	Richards Bay
Whitakker, Dave	Zululand Chamber of Business Foundation	
Wieners, Dominic	Ezemvelo KZN Wildlife	Cascades
Williams, Bronwyn	CLS Consulting Services	
Wilson, Stewart	National Roads Agency (NRA)	Scottsville
Wilson-Browne, Murray	Sappi Forests	Kwambonambi
Woods, Mike		Kwambonambi
Wright, Bernadie	uMhlathuze Tourism	Mereensee
Wright, Chris	GCS (Pty) Ltd	
Xaba, S B		Enseleni
Xulu, D J		Kwadlangezwa
Young, Alison	KwaZulu-Natal Conservancies Association	Umlaas Road
Zaloumis, Andrew	iSimangaliso Wetland Park	St Lucia
Zikhali, Dumsani		Kwambonambi
Zikhali, Thafanqa Sipho		Esikhawini
Zondi, Busisiwe		Empangeni
Zondo, Moses		Kwambonambi
Zulu, Lithe	Sokhulu Tribal Authority	

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Name	Company	City
Zulu, Nelisiwe		Richards Bay
Zulu, Nonhlanhla		Empangeni
Zulu, Peter		Richards Bay
Zulu, S H		Mkhamango Reserve
Zulu, Shadracle	uMhlathuze Local Municipality	Empangeni
Zungu, Mandisa	Department of Cooperative Governance and Traditional Affairs	Durban
Zungu, Wilson	Mkhwanazi Traditional Council	Richards Bay

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APPENDIX C

Comments and Response Report

January 2015
Report No. 13614921-13289-4

January 2015

COMMENT AND RESPONSE REPORT

Environmental Impact Assessment (EIA) for the Proposed Vopak-Reatile Terminal Richards Bay Bulk Liquid Storage and Handling Facility

Submitted to:
Public Review

DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014

REPORT

Report Number. 13614921

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COMMENT AND RESPONSE REPORT

Purpose of this document

This document records comments, issues of concern, questions and suggestions for enhanced benefits raised by stakeholders to date on the Draft and Final Scoping Reports for the Environmental Impact Assessment (EIA) and the Atmospheric Emission License (AEL) for the proposed Vopak-Reatile Terminal Richards Bay bulk liquid storage and handling facility.

Comments include those raised in response to advertisements placed in local papers and letters that were e-mailed and posted to stakeholders, and include comments recorded at the Open House / Public Meeting held on Wednesday, 16 April 2014.

The issues were categorised as follows:

- Environmental – Specialist Studies:
  - Air quality;
  - Ecology;
  - Hydrology – Surface Water and Groundwater;
  - Wetlands;
  - Soils;
  - Rehabilitation and Closure; and
  - Other.
- Socio-Economic:
  - Community Health and Safety; and
  - Business opportunities and Employment.
- General:
  - EIA Process;
  - Public participation;
  - Infrastructure; and
  - Other.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
ENVIRONMENTAL – SPECIALIST STUDIES				
Air quality				
The Air Quality Study should include the following: Modelling of cumulative impacts (including worst case scenario) – study to include all chemical and petroleum facilities currently located in the South Dunes Precinct. The impact of establishing an additional Major Hazardous Installation (MHI) facility next to existing chemical storage facilities needs to be understood.	Ms Sandy Camminga	RBCAA EIA Committee	Comment sent via email on 20 May 2014	The Air Quality Impact Assessment provides an assessment of the direct, indirect and cumulative air quality impacts associated with the proposed Terminal. Baseline air quality information obtained for the area includes information on other bulk liquid and chemical storage facilities in the vicinity. This baseline information was then used to determine the impact of the proposed Terminal in combination with existing bulk liquid storage facilities. The impact of establishing an MHI near existing chemical storage facilities has been addressed as part of the Risk Impact Assessment conducted for the proposed Terminal.
Ecology				
According to your posters, the site is classified as a coastal forest. How will the rehabilitation of this forest be carried out to ensure that it is returned to its original state?	Ms Thembile Belebese	Department of Agriculture, Forestry and Fisheries (DAFF): Forest regulation and support	Open house meeting, Wednesday 16 April 2014, Richards Bay	According to the Vegetation Map of South Africa, Lesotho and Swaziland the proposed Terminal site is characterised as the Northern Coastal Forest (FOz7) and Maputaland Coastal Belt (CB1) vegetation units (Mucina and Rutherford, 2006). Northern Coastal Forest and Maputaland Coastal Belt are regional vegetation units which occur across large portions of KwaZulu-Natal. However a field survey conducted by the Terrestrial Ecology Specialist in April 2014 determined that the proposed Terminal site is severely degraded as a result of previous

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				disturbances caused by or produced by humans, which included the removal of primary vegetation, the relocation of surface soils and the creation of depressions, as well as the introduction and proliferation of exotic species. The project site is therefore more accurately characterised by Phragmites australis – Typha capensis tall closed hygrophilous grassland (grassland growing in damp conditions); *Brachylaena discolor* – *Apodytes dimidiata* short thicket community; and Cleared secondary vegetation community than Coastal Forest. Site rehabilitation, should it be required, would be conducted in accordance with the Environmental Management Plan (EMP) prepared for the project. A copy of this EMP has been made available as part of the Draft EIA Report to I&APs for a 40 day comment and review period.
Site clearing should not be undertaken until the EIA is approved. The department will require the EIA ROD to issue a clearing licence or permit.	Ms Thembile Belebese	DAFF: Forest regulation and support	Open house meeting, Wednesday 16 April 2014, Richards Bay	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
Coastwatch is of the opinion that a holistic approach must be taken for the establishment of the Vopak-Reatile Terminal and we would support a single assessment process which – ■ Identifies the ecological impacts of the removal of vegetation from the site and considers the impact in context of municipal environmental planning initiatives and provincial conservation plans. This phase of the project could well be guided by the ecological findings of the South Dunes Lease Site infrastructure project.	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
Hydrology – Surface water and groundwater				
Coastwatch is of the opinion that a holistic approach must be taken for the establishment of the Vopak-Reatile Terminal and we would support a single assessment process which – ■ Identifies the potential hydrological impacts which may result from vegetation clearing and earthworks which could affect the remainder of the dune vegetation and dune stability.	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
Wetlands				
The existing wetlands were identified in the biological report of the scoping document (and are well described and delineated in the Richards Bay EMF of 2011) but are regarded as not significant. According to your document it is planned just to fill in the wetland with no rehabilitation or even offset created. The wetlands are described in section 4.4.1 under Aquatic Ecosystems. The layout of the site must take this into consideration and the Department of Water Affairs must be involved in the whole process.	Dr Pieter Aucamp	Ptersa Environmental Consultants	Comments received via email on 6 May 2014	According to the Terrestrial Ecology Specialist Study conducted as part of the EIA for the Vopak-Reatile Terminal Richards Bay (DAEA Reference Number: DC28/0001/2014: KZN/EIA/0001388/2014) none of the areas within the project site are considered as being of high conservation importance. The project site has been severely transformed in the past. As a result perceived wetland areas which do occur on site are as a result of previous disturbances caused by or produced by humans, which included the removal of primary vegetation, the relocation of surface soils and the creation of depressions, as well as the introduction and proliferation of exotic species. Depression areas present on site have since been colonised by indigenous wetland species and exotic invasive plant species, such as the horsetail tree (*Casuarina equisetifolia*) and slash pine (*Pinus elliottii*). Rehabilitation and mitigation measures associated with infilling are provided in the Environmental Management Plan (EMP) prepared as part of the Draft Environmental Impact Assessment (EIA) Report. Vopak are in the process of initiating a Water Use License Application (WULA) for the proposed project. The Department of Water and Sanitation (DWS) is registered as an I&AP for the

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				project and have been provided with copies of the Draft EIA Report for their review and comment.
The DWA acknowledges that there are wetlands within close proximity to the proposed development. Has a wetland study been conducted? The wetlands should be delineated and a buffer zone must be created away from the temporary wet zone and any activity must be confined outside the buffer zone. A Functional Assessment must be carried out to determine an appropriate buffer so that the wetland is not impacted by the development. A licence must be applied for in terms of Section 21 (c) and (i) of the National Water Act (Act 36 of 1998) if the applicant wishes to develop on the wetland/ riparian zone or within the 500m buffer.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Wetland Studies have been conducted in the area as part of the BA for the Provision of Services to the South Dunes Lease Site (DEA Reference Number: 14/12/16/3/3/1/582), and the EIA for the Proposed Richards Bay Port Expansion Programme (DEA Reference Number: 14/12/16/3/3/3/103). Site Clearing and Preparation activities are proposed within 500 m of a wetland. VSAD are therefore in the process of initiating a Water Use License Application (WULA) and supporting Integrated Water and Waste Management Plan (IWWMP) to obtain authorisation from the Department of Water Affairs (DWA) in accordance with Section 21 (c) and (i) of the National Water Act (Act No. 36 of 1998) (NWA).
Soils				
Soil erosion on site must be prevented at all times, i.e. pre-, during- and post construction activities.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted. Mitigation measures with which to minimise soil erosion pre, during and post construction activities have been provided in an Environmental Management Plan prepared as part of the Draft EIA Report.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
Erosion control measures should be implemented in areas sensitive to erosion such as water supply points, edges of sloped etc. These measures could include sand bags, hessian sheets, retention or replacement of vegetation.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted. Mitigation measures with which to minimise soil erosion pre, during and post construction activities have been provided in the Environmental Management Plan prepared as part of the Draft EIA Report.
Rehabilitation and closure				
There is mention of rehabilitating the site to its original state if the EIA is not approved. Why not wait for the approval of the EIA?	Ms Thembile Belebese	DAFF: Forest regulation and support	Open house meeting, Wednesday 16 April 2014, Richards Bay	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
Other				
The report (Draft Scoping Report) makes mention that the terminal will store chemicals – we need to know what chemicals are intended to be stored.	Ms Sandy Camminga	The Richards Bay Clean Air Association (RBCAA) EIA Committee	Comment sent via email on 20 May 2014	The types of chemicals likely to be stored at the terminal site are dependent on the final client base secured for the project. In order to properly assess the impact of such chemicals, a worst case scenario approach will be adopted. As a result, and for the purposes of assessment, the types of chemicals likely to be stored onsite have been assumed to be hazardous.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
The RBCAA requires confirmation that the only radiation present at the site will come from thermal radiation.	Ms Sandy Camminga	RBCAA EIA Committee	Comment sent via email on 20 May 2014	The only radiation present at the site will come from thermal radiation.
On page 43 the report states: "*Generally, during the EIA phase there is insufficient detailed information to conduct a MHI (major* hazardous installation) risk assessment in accordance with the MHI regulations. For example emergency plans have not been developed and final designs have not been completed. Under *such circumstances the risk assessment is conducted generally in accordance with the prescribed* topics of the MHI regulations." The RBCAA disagrees with this recommendation. Instead, we recommend that an MHI Risk Assessment is undertaken as part of the specialist studies due to the size, volume and proximity to a similar operation and fuel (RBCT coal stockpiles). A highly detailed and effective Emergency Response Plan must form part of the MHI assessment, which needs to tie into the City of Mhlathuze's Emergency Response Plan. Although the probability for an explosion / leak might be low, the impact	Ms Sandy Camminga	RBCAA EIA Committee	Comment sent via email on 20 May 2014	In South Africa, risk assessments are conducted under two separate pieces of legislation. Namely: ■ The National Environmental Management Act (Act No. 107 of 1998) (NEMA) and the NEMA EIA Regulations of 18 June 2010 (as amended); and ■ The Occupational Health and Safety Act (Act No. 85 of 1993) (OHSA) and its Major Hazardous Installation (MHI) Regulations. A Risk Assessment Specialist Study has been conducted as part of the Impact Assessment phase of EIA. This Risk Assessment Specialist Study was undertaken in accordance with the NEMA and the EIA Regulations, and identifies and assesses the potential impacts, and proposes mitigation measures, and determines whether there are any fatal flaws to the project from a risk perspective. The Risk Assessment Specialist Study provides information on whether or not the project is likely to be considered an MHI, and if it is likely to be an MHI whether it would meet the requirements of the MHI Regulations and whether the risks identified as part of the assessment could be engineered or managed to acceptable levels.

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
will be significant with dire consequences. The Assessment should include the risks associated with a total power outage, as recently experienced at Island View Storage, and the management thereof detailed in the Emergency Response Plan.				Conversely an MHI Risk Assessment is conducted in accordance with the Occupational Health and Safety Act, 1993 (OHSA) and its MHI Regulations, and is required to determine whether a project can be constructed and operate with risks to employees and the public at an acceptable level. In accordance with the OHSA and the MHI Regulations, the MHI Risk Assessment must be undertaken by a specialist which is an accredited Approved Inspection Authority (AIA) for MHI Risk Assessments, and the MHI Risk Assessment must be undertaken on behalf of the Department of Labour (DoL). MHI Risk Assessments undertaken in terms of the OHSA are required to cover a mandatory list of elements as contained in the MHI Regulations, and require sufficient detailed information including detailed Emergency Response Plans, which have been developed specifically for a proposed project and which have been based on final project designs, which include final details on the types and quantities of materials to be stored. Due to the fact that the types and quantities of materials likely to be stored at the Vopak-Reatile Terminal Richards Bay are currently unknown, it is not possible to successfully conduct an MHI Risk Assessment as part of the Specialist Studies for EIA.
Solid waste that is generated from the	Ms N P S Mdlalose	DWA	Written comments	Solid waste generated by the project will be

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
activities at the development is required to be disposed of at a permitted waste disposal site. Ms C Moonsamy of the DWA must be contacted if any other disposal route is to be followed.	Ms N Govender		dated 26 May 2014	stored onsite before being collected by a registered waste disposal service provider and disposed of at a licensed waste disposal facility such as the uThungulu Regional Landfill Site.
Contaminated soil or other hazardous material must be disposed of at a permitted hazardous landfill site that is authorised to accept the said material.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Contaminated soil or other hazardous material will be collected by a registered waste disposal service provider and disposed of at a waste disposal facility which is licensed to accept hazardous waste. Safe Disposal Certificates will also be obtained from the registered waste disposal service provider and kept on file.
Please provide the DWA with spill contingency plans including storage of materials, chemicals, fuels etc. during the construction and operational phase.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	A Spill Contingency Plan will be prepared based on VSAD's Emergency Response Plans and will be kept onsite as part of the Environmental Management Plan (EMP).
Spillages occurring at the dispensing area must be contained and channelled to a separator. Fuels/oils must not be allowed to be discharged into stormwater pipes or drains and sewage manholes/pipes.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Information on the manner in which product spills will be managed and cleaned up is provided in the Environmental Impact Assessment and EMP reports.
Product spills within the bunded area must be cleaned up and material used in the clean-up process must be disposed of correctly.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Information on the manner in which product spills will be managed and cleaned up is provided in the Environmental Impact Assessment and EMP reports.
It is important that any significant	Ms N P S Mdlalose	DWA	Written comments	A spill contingency plan will be prepared and

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
spillages of chemicals, fuels, etc. during the construction phase are reported to the DWA and other relevant authorities.	Ms N Govender		dated 26 May 2014	included in the Environmental Management Plan (EMP) to be kept onsite.
The storage of oils, materials, chemicals, fuels etc. to be used during the construction phase must not pose a risk to the surrounding environment. Such storage areas must be located out of the 1:100 year floodline of any river and unauthorised access to these areas must be controlled. Temporary bunds must be constructed around chemical or fuel storage areas to contain possible spillages.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	No storage areas will be located within the 1:100 year floodline of any river or watercourse within the surrounding area. The storage of materials will be strictly monitored in accordance with the EMP prepared for the project.
No forms of secondary pollution should arise from the disposal of sewage and refuse. The contractor must be clearly briefed on the method of disposal of such waste and compliance must be ensured/ monitored. Any pollution problems arising from the proposed development is to be addressed immediately by the Applicant.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted.
How will sewage be disposed of? The EIA reports states that the "sump may also include soiled water from septic tanks". If this is the preferred method of	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Sewage generated onsite will be collected and stored in a conservancy tank system. The conservancy tank has been designed for 10 days storage for 7 people (150l/day), and will be pumped by a registered service provider as

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
disposal the following conditions regarding this method of sewage management must be adhered to: 1) Percolation tests must be conducted on the site where the septic tank and soakaway evapo-transpiration area is located. The suitability of the method of sewage disposal for the site must be determined. 2) Surface stormwater, subsoil seepage and local groundwater conditions shall be taken into account when positioning, designing and constructing the soakaway and evapo-transpiration. 3) Ideally the field should be 5m above any impermeable layer and/ or water table and 100m away from any surface water body. The distance from a ground water supply point should be 100m. 4) All wastewater disposal sites/ effluent treatment and disposal systems/ septic tank systems must be located above the 100 year floodline or more than 100 meters from the edge of a water resource which includes dams or boreholes which are utilised for drinking water				required every few days. As a result the proposed project would not require soakaway or evapo-transpiration systems or areas. Mitigation measures with which to minimise the proposed projects impact on groundwater resources have been provided as part of the Environmental Management Plan (EMP) which forms part of the Draft EIA Report.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
or stock watering. 5) The developer must follow acceptable construction, maintenance and operational practices to ensure the consistent, effective and safe performance of the wastewater disposal system. All reasonable measures must be taken to prevent wastewater overflowing from the wastewater disposal system. 6) The retention capacity of the septic tank, the storage and infiltration area of the soak away and the evapo-transpiration area must be calculated according to design effluent loading which is based upon the maximum occupancy of residences. 7) No stormwater from roof down pipes or pool backwash systems may be connected to the septic tank/soakaway. The soakaway specifically for stormwater shall not be located within or up slop of the evapo-transpiration area. 8) The French drains and evapo-transpiration area must be regularly maintained.				

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
9) The evapo-transpiration area must be maintained with vegetation and must not be surfaced. The planting of indigenous deep rooted trees over the evapo-transpiration area will be beneficial in removing excess moisture from the system.				
10) To ensure minimal impact on the groundwater resources suitable mitigation measures must be implemented through the environmental management plan.				
11) Soakaway must not be constructed in area of shallow soils. Sitting of the septic tank must be done with access for desludging taken into consideration.				
12) Sewage sludge must be removed from any wastewater and the resulting sludge disposed of according to the requirements of any relevant law and regulation. The disposal of wastewater to an on-site disposal facility is regarded as a water use according to the National Water Act 1998 (Act 36 of 1998). Therefore a water use licence/authorisation under section 21 (g) of the National Water Act 1998 (Act 36 of 1998) may need to				

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
be applied for from the DWA prior to development commencing. 13) Septic tanks system must not impact on any water resources either on-site or off site. Any accident that may occur from septic tanks system must instantly be reported to the DWA. 14) The design of septic tank soakaway systems must include fat and grease traps and all effluent from kitchens must pass through a grease trap prior to discharge to the septic tank. 15) The municipality must approve all plans for the septic tank soakaway system. The septic tank soakaway system on completion must be inspected by the officials from the municipality for their approval. 16) The system must not impact on any water resource or any other person's water use, property or land. 17) The system must not be detrimental to the health and safety of the public.				
The Draft Scoping Report (DSR) report states the rainwater will be collected, passed through an oil/water separator	Ms N P S Mdlalose	DWA	Written comments dated 26 May	Information on the quantity, quality, and treatment method for water collected in the collection pit from the loading areas is provided in

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
and collected in a sump before being treated or released - the quantity and quality, the treatment method and where the water will be released must be provided to the DWA.	Ms N Govender		2014	the Draft EIA Report and as part of the Surface Water (Hydrological) Specialist Study conducted for the project. No septic tanks are envisioned as part of the project. Once operational the proposed Terminal will make use of a conservancy tank system which will be emptied by a registered service provider and disposed of at a licensed disposal facility on a regular basis. The opportunity exists for clean stormwater to be discharged into the Stormwater channel proposed by the Transnet National Ports Authority (TNPA)
The DSR also states that water/spills from the loading area will be collected in a collection pit/separator. Clean water can be discharged, while polluted water will be treated. Please clarify this. Please provide quantity and quality of water that would be collected, the treatment method and where the clean water will be discharged.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Information on the quantity, quality, and treatment method for water collected in the collection pit from the loading areas is provided in the Draft EIA Report and as part of the Surface Water (Hydrological) Specialist Study conducted for the project. The opportunity exists for clean stormwater to be discharged into the Stormwater channel proposed by the Transnet National Ports Authority (TNPA)
SOCIO-ECONOMIC				
Community Health and Safety				
What safeguards are in place to prevent accidents similar to the recent oil spill?	Ms Mia Moorcroft	Zululand Observer	Open house meeting,	Vopak operate to International Best Practice in addition to having a number of their own

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
			Wednesday 16 April 2014, Richards Bay	standards that all Vopak operations worldwide have to comply with, e.g. back up electricity for all safety mechanisms such as the high level alarms on the tanks as well as various other controls. In addition Vopak assess risks associated with their operations and take appropriate actions to reduce the risks associated with the Environment, Health, MHI, etc.
Vopak needs to be aware that the local community has been sensitised about issues at the Richards Bay Terminal. This includes the power failures that have been experienced at the Island view Site as well as an oil spill that occurred within the complex some time back.	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	Thank you for your comment.
Business opportunities and Employment				
Are there opportunities for local enterprises to conduct business with Vopak when work resumes?	Mr Phiwokuhle Thango	MCE	Open house meeting, Wednesday 16 April 2014, Richards Bay	Yes, there will be opportunities for local business. It should be understood that when Vopak say “local contractors” it does not necessarily mean that the contractors are going to specifically come from Richards Bay, but they might come from South Africa, depending on the services that are offered, as well as their proven track record.
Is there a database that is being formulated to register local goods and service providers?	Mr Phiwokuhle Thango	MCE	Open house meeting, Wednesday 16 April 2014, Richards Bay	There is already a database in existence. It is centred at the main Vopak offices at Island View. Contact should be made through Vopak’s Procurement Manager at Vopak Terminal

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				Durban, 105 Taiwan Road, Durban, 4052.
Who do we speak to at Vopak to ensure that they have our names on the database for future job opportunities?	Mr Phiwokuhle Thango	MCE	Open house meeting, Wednesday 16 April 2014, Richards Bay	Job seekers with experience in the Petrochemical Industry should contact the Vopak's HR department at Vopak Terminal Durban, 105 Taiwan Road, Durban, 4052. Job seekers without experience should refer to advertisements in the local media.
Is Vopak planning to advertise for companies to become part of the suppliers' database?	Ms Slindo Mthembu	KZN Department of Transport	Open house meeting, Wednesday 16 April 2014, Richards Bay	Vopak appreciates proactive local business, where local businesses approach Vopak to register as suppliers. For instance, Vopak has a list of suppliers for their Lesedi operations, but work is not going to commence just yet. So Vopak is not yet in a position to call for suppliers to register on their database
The Chamber of Commerce has developed a database that comprises a list of local SMMEs. This list could be made available to companies procuring local business.	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	Thank you very much for this comment. We will forward the suggestion to Vopak who will then liaise with the Chamber directly.
Has Vopak already appointed consultants for the civil engineering work?	Mr Theo Pillay	J & P Projects	Open house meeting, Wednesday 16 April 2014, Richards Bay	Vopak, at risk, has appointed design consultants that are working on the designs of the operations in the Richards Bay Terminal.
Please can you consider local people from Richards Bay for jobs at the proposed Vopak-Reatile Terminal?	Ms Brenda Delport	Express Employment Professionals	Open house meeting, Wednesday 16 April 2014,	Local people are always considered if they have the right skills, experience, or requisite capabilities. Job seekers with experience in the Petrochemical Industry should contact Vopak's

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
			Richards Bay	HR department at Vopak Terminal Durban, 105 Taiwan Road, Durban, 4052. Job seekers without experience should refer to advertisements in the local media.
Is Vopak planning to advertise the various jobs and services that they will be requiring?	Ms Slindo Mthembu	KZN Department of Transport	Open house meeting, Wednesday 16 April 2014, Richards Bay	Jobs and service requirements would be advertised on a requirement basis in the local media.
GENERAL				
EIA process				
It remains a challenge for the public to contribute meaningfully to an EIA process at their own cost and time. It should be considered that a percentage of the company's proposed development cost should be made available in an independent fund to assist NGOs and other stakeholders to contribute meaningfully, as is the case in the USA.	Ms Janet Cuthbertson	Suni-Ridge Environmental Centre	Email correspondence. Thursday, 27 March 2014	Public participation is one of the most important aspects of the environmental authorisation process. People have the right to be informed about potential decisions that may affect them and be afforded an opportunity to influence those decisions. Effective public participation also facilitates informed decision-making by the competent authority and may result in better decisions as the views of all parties are considered. According to the National Environmental Management Act, 1998 (Act No. 107 of 1998): Environmental Impact Assessment Regulations: GN R 543 of June 2010: Section 17. An Environmental Assessment Practitioner (EAP) appointed in terms of regulation 16 (1) must – (a) Be independent;

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				(b) Have expertise in conducting EIA's (c) Perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant; The NEMA regulations in South Africa are silent on the developer's requirement to finance stakeholder participation, as is the case in the USA. This certainly warrants further dialogue in future. The Public Participation Guidelines GG 807 of October 2012 only state that: The applicant or EAP must give notice to I&APs by: (e) Using reasonable alternative methods as agreed to by the competent authority to accommodate people who wish to, but cannot participate due to illiteracy, disability or any other disadvantage. (Section 4. Notification of I&APs and land owners 4.1 Method of notification). The consultants are happy to meet with individuals and organisations that are not in a position to attend a Public Meeting.
Can the BA and the EIA be linked somehow? Although the specialist studies will only form part of the EIA, the ecological study will be required for a	Ms Thembile Belebese	DAFF: Forest regulation and support	Open house meeting, Wednesday 16 April 2014,	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
decision on the BA.			Richards Bay	process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
The Richards Bay Clean Air Association (RBCAA) is confused by the approach to separate the assessment of the proposed Vopak-Reatile Terminal 2 environmental processes. The process being applied is resulting in fragmented information being presented. This makes it difficult for stakeholders to follow the process and provide meaningful input. We request that a single assessment be undertaken for the proposed establishment of the Vopak-Reatile Terminal.	Ms Sandy Camminga	RBCAA EIA Committee	Comment sent via email on 20 May 2014	Thank you for your comment. In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
Coastwatch finds that the approach being taken for establishing the Vopak-Reatile Terminal is confusing and undesirably fragmented. Coastwatch fails to find good reason and strong motivation for the separation of site clearing and earth moving activities (the basic assessment)	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	Thank you for your comment. In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
from the remainder of the activities.				supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
Does the Basic Assessment process take into consideration that the EIA might not be successful?	Mr Franz Schmidt	Tata Steel	Open house meeting, Wednesday 16 April 2014, Richards Bay	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.
Vopak and Golder need to be aware that EIAs in Richards Bay tend to drag on for longer than anticipated.	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	Thank you for your comment.
The City of Richards Bay has adopted a new Land Use Management System (LUMS). This should be considered in the EIA.	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	Thank you for your comment.

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
Your project description needs to be careful about alternative sites. Regulations indicate that project alternatives should be presented and the lack of such alternatives could cause a delay in authorisation.	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	No alternative sites have been considered as part of the EIA due to the fact that Vopak have been granted an operational lease for Lots 4 and 5 of Portion 3 of Erf 11478 specifically. The development of a Bulk Liquid Storage Facility at this site is aligned with local development planning.
Vopak needs to be aware of future developments in the road and rail industry and when these are to take place as it will affect the timing of the project	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	Thank you for your comment.
The assessment is fatally flawed since the public participation regulation (R543 section 54) is not followed. An incomplete Draft Scoping Report is used to convey the information. This can be assumed to be the “final draft” by unsuspecting and less informed I&APs.	Dr Pieter Aucamp	Ptersa Environmental Consultants	Comments received via email on 6 May 2014	The Draft Scoping Report was titled as such and is referred to as a Draft Report in the body of the Report. The Public Participation and Scoping and EIA processes were explained in Section 5.0 of the DSR. English and Zulu Site Notice Boards, and Newspaper Advertisements were placed around the site, announcing the proposed project and the availability of the DSR for comment. I&APs were also provided with a Background Information Letter (BIL) which announced the availability of the DSR for comment, and which also outlined the Public Participation and Scoping and EIA processes being followed. The DSR and Public Participation processes were also presented at the Open House meeting during which time I&APs in attendance were invited to ask questions or raise comments on

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				the report.
Not all activities are identified. The following must be added: GNR 545 of 18 June 2010 (Listing Notice 2) *Activity 5 applies:* *The construction of facilities or infrastructure for any process or activity which re-quires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case that Act will apply.* A water use license is needed according to Regulation 1199 of 18 December 2009, section 6(b) since the activity takes place within 500m of an identified wetland.	Dr Pieter Aucamp	Ptersa Environmental Consultants	Comments received via email on 6 May 2014	The list of Listed Activities for which Environmental Authorisation is being applied for will be updated and amended throughout the EIA process as additional information becomes available. Vopak are in the process of initiating a Water Use License Application (WULA) for the proposed project. No development will take place within 500 m of a wetland or watercourse prior to a WUL being obtained from the Department of Water and Sanitation (DWS).
We reiterate that we find the separation of the site clearance / preparation activities from facility construction and operation problematic and to illustrate our confusion cite the following objectives as set out in the section 1.1 –	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	In response to concerns raised by stakeholders regarding VSAD's decision to follow a split approach to obtaining EA, a decision was made to reintegrate the two processes into a single EIA process. The Draft EIA Report (DEIAR) and supporting specialist studies have been prepared

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
■ Establish baseline conditions of the Project area of influence prior to construction and operation; ■ Systematically identify and assess material environmental and social impacts that may result from the construction, operation and closure of the Terminal; ■ Develop a set of recommended mitigation measures to avoid negative impacts, and, where that is not possible, to reduce the effects of negative impacts and provide enhancement measures where the project can provide positive benefits. However, Coastwatch fails to understand how these objectives can be achieved once the site has been cleared of vegetation and prepared for construction? While the following specialist studies are proposed for EIA (DC28/0001/2014) – ■ Risk impact assessment ■ Air quality impact assessment ■ Hydrological impact assessment (surface water)				for the proposed Terminal in its entirety, and include impacts and mitigation measures associated with site clearing and preparation activities which were previously reported on under the BA process, as well as the construction and operation of the proposed Terminal.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
■ Ecological impact assessment ■ Traffic impact assessment Once the site has been cleared of vegetation and the earthworks completed under DC28/0004/2014 (should it receive a positive record of decision) the value of hydrological and ecological studies is surely negated. While finding the basic assessment deficient, Coastwatch supports the approach to assessment as set out in the scoping report, section 6.1, wherein the key NEMA principles are given, however we fail to find how two separate assessments (BA for site clearing and full EIA for, basically, the operational phase) align the Vopak-Reatile Terminal with the principles of Sustainability, Mitigation hierarchy and Duty of Care.				
In addition, the operational phase impacts of risk, air quality, stormwater and waste management, traffic should be identified and managed as set out in the scoping report.	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	Thank you for your comment.
It follows, therefore, that Coastwatch is opposed to two separate assessments being undertaken for different components of the same project and is	Ms Carolyn Schwegman	Coastwatch KZN	Comments received via email on 12 May 2014	Thank you for your comment.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
thus unable to offer meaningful input into the proposed establishment of the Vopak-Reatile Terminal at this stage.				
The DWA notes the content (i.e. responsibilities and conditions) as outlined in the EMPr. Compliance to the approved EMPr must be audited regularly by the designated Environmental Control Officer.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	An Environmental Management Plan (EMP) containing information on the responsibilities of personnel will be prepared and kept onsite. Monitoring compliance with the EMP will be conducted by an Environmental Control Officer (ECO) to be appointed for the project on a regular and ongoing basis during the construction and operational phases of development.
Public participation				
The assessment is fatally flawed since the public participation regulation (R543 section 54) is not followed. The I&AP list does not include the immediate neighbour (IVS) as required by regulation 543 section 54 (b) (iii).	Dr Pieter Aucamp	Ptersa Environmental Consultants	Comments received via email on 6 May 2014	The proposed Terminal site is bordered by a servitude area belonging to Transnet National Ports Authority (TNPA). This portion of land is currently being investigated for the provision of services to the South Dunes Lease Sites (DEA Reference Number: 14/12/16/3/3/1/582). TNPA were notified of the proposed project, and a signed Landowner Notification Form was submitted to the then Department of Economic Development, Tourism and Environmental Affairs (DEDTEA) with the Application for Authorisation Form. Prior to the Open House meeting Miss Silindile Mchunu, Mr Robert Smit, Mr Hendrik Beukes and Ms Gillian Marnewick of Island View Storage (IVS) registered as Interested and Affected Parties (I&APs); and Miss Silindile Mchunu and

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
				Mr Robert Smit attended the Open House Meeting held in Richards Bay on Wednesday, 16 April 2014.
The existing wetlands were identified in the biological report of the scoping document (and are well described and delineated in the Richards Bay EMF of 2011) but are regarded as not significant and it is planned just to fill in the wetland with no rehabilitation or even offset created. The wetlands are described in section 4.4.1 under Aquatic Ecosystems. The layout of the site must take this into consideration and the **Department of Water Affairs must be involved in the whole process.**	Dr Pieter Aucamp	Ptersa Environmental Consultants	Comments received via email on 6 May 2014	Rehabilitation measures have been provided in the Environmental Management Plan (EMP) which has been prepared as part of the Draft Environmental Impact Assessment (EIA) Report. Vopak are in the process of initiating a Water Use License Application (WULA) for the proposed Terminal. The Department of Water and Sanitation (DWS) is registered as an I&AP for the project and has been provided with copies of the Draft EIA Report for their review and comment.
Infrastructure				
Are the tanks, to be used by Vopak, fabricated locally or are they imported?	Mr Walter Maree	PS Projects	Open house meeting, Wednesday 16 April 2014, Richards Bay	Local fabricators are used where the necessary knowledge, experience and skills are proven. There are instances where the tanks due to their size and fabrication complexity are not available locally.
What volumes are expected to be transported through rail and road transport?	Mr Frans van Der Walt	QS2000 Plus	Open house meeting, Wednesday 16 April 2014, Richards Bay	The volumes that are transported by road and rail are a variable and hugely dependent upon client requirement. It is anticipated that approximately 60% will be shipped in this manner with the balance by ship.
What material does Vopak use for their	Mr Walter Maree	PS Projects	Open house	Generally Carbon Steel is used for storage tanks.

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
tanks?			meeting, Wednesday 16 April 2014, Richards Bay	
What are the paint specifications on the tanks?	Mr Walter Maree	PS Projects	Open house meeting, Wednesday 16 April 2014, Richards Bay	Generally epoxy coating is used for storage tanks.
Stormwater on site must be properly managed. Please provide the DWA with a proper Stormwater Management Plan for recommendation. The DWA requires clarity on the Stormwater system design, where the stormwater will be disposed of, and the quantity and quality of stormwater disposed of.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	DWS have been provided with a copy of the Draft EIA Report which contains a copy of the Stormwater Management Plan and provides details on the Stormwater Management Systems envisaged for the implementation at the proposed Terminal.
A stormwater management drainage network must be kept separate from the sewage effluent system. These networks must be designed and constructed in such a manner that stormwater will drain to the stormwater attenuation dams before discharge to the municipal Stormwater System, if supplied	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted. Information on the Stormwater Management Systems being investigated for implementation is provided in the Draft EIA Report and supporting specialist studies. It is anticipated that stormwater generated onsite would feed into TNPA's stormwater channel proposed to service the South Dunes Lease Sites.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
in the area.				
After construction, the site should be graded to ensure free flow of runoff and to prevent ponding of water.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted.
Drainage must be controlled to ensure that runoff from the site will not culminate in off-site pollution or cause water damage to properties further down from the site.	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	Comment noted. Information on site drainage is provided in the Environmental Impact Assessment (EIA) Report and supporting specialist reports.
Aboveground Storage Tanks (AST's): 1) The AST's must comply with SABS or SANS codes of Practice. 2) The installation must comply with local authority bylaws. 3) The AST's must be fitted with an overfill protection device. 4) The condition of the bund wall, tanks, grease traps, valves, pumps and associated piping must be inspected on a regular basis. 5) The tanks must be located on an impermeable surface and must be enclosed by a bund wall, which must be able to contain 110% of the maximum volumes stored in the	Ms N P S Mdlalose Ms N Govender	DWA	Written comments dated 26 May 2014	The Aboveground Storage Tanks (ASTs) will be constructed using the Best Available Technology, and will comply with local and International codes of practice. Where more than one Code of Practice may exist VSAD will ensure compliance with the more stringent of the two. All ASTs will be fitted with overfill protection devices with high level switches with independent emergency shut-off valves. The need to inspect the condition of the project infrastructure including bund walls, tanks, grease traps, valves, pumps and piping will be included in the EMP to be prepared for the project. All tanks will be located on Liquid Tight Floors which are impermeable floors used to prevent seepage of petroleum products into the ground. Bund walls will be built around tanks as a pollution control measure. Should spillage occur,

COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
tanks. 6) The tanks and product lines must be pressure tested prior to commissioning.				the bunds will contain the fuel and prevent it from escaping into the receiving environment. The facility design includes a bund that is capable of containing the entire volume of the largest tank within the bund, plus an additional 10% (i.e. 110%). The bunds and the floor on which the tanks will be located will be built with impervious concrete such that fuels cannot leak through them.
Other				
What is the gas storage industry like in Durban? How is Vopak managing their facilities in Durban? How busy is this industry is in Durban?	Mr Walter Maree	PS Projects	Open house meeting, Wednesday 16 April 2014, Richards Bay	The LPG industry is near capacity in Durban. Vopak do not have LPG in Durban. The industry, due to capacity, is thriving and with a need for expansion.
This EIA does not affect ITB Manufacturing (Pty) Ltd. TRANSNET LTD are the property owners, ITB is situated approximately 10km away from the proposed site.	Mr. Pravesh Manipersadh	Transnet Ltd.	Email correspondence. Tuesday 01 April 2014.	Thank you for your comment.
Should Vopak-Reatile receive authorisation, we strongly recommend that they become members of the Richards Bay Clean Air Association.	Ms Sandy Camminga	RBCAA EIA Committee	Comment sent via email on 20 May 2014	Thank you for your recommendation.
A document has been forwarded to the consultants that are deemed to encourage informed development decision-making by prospective Industrial	Mr Frans Van Der Walt	QS 2000 Plus	Comment received via email on 16 April 2014	Thank you very much for the useful document.

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COMMENTS, ISSUES AND SUGGESTIONS RAISED	COMMENTATOR	ORGANISATION	SOURCE	RESPONSE
and other Developers in the Richard's Bay region. The Integrated Development Planning (IDP) should be expanded and strengthened by means of Coordinated Development Planning, whereby prospective developers, are also made aware of other developments on the cards, be they complimentary or possible competition, all with the view to ensure that the correct Investment Decisions are made, leaving sustainable economic opportunities with no surprises in store as a result of a lack of information.				
What is the timeframe for the construction period? When will operations start?	Ms Brenda Delport	Express Employment Professionals	Open house meeting, Wednesday 16 April 2014, Richards Bay	Construction is proposed to commence in the first quarter of 2015 and will take approximately 18 to 24 months to complete, following which the Vopak-Reatile Terminal Richards Bay will become operational.

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GOLDER ASSOCIATES AFRICA (PTY) LTD.

Erika du Plessis

Sasha Slogrove-Saayman
Public Participation Practitioner

Erika Du Plessis
Senior Stakeholder Engagement Specialist

SSS/EDP/sss

Reg. No. 2002/007104/07
Directors: SA Eckstein, RGM Heath, SC Naidoo, GYW Ngoma

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APPENDIX D

Letter of acknowledgement from DEDTEA

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edtea
Department
Economic Development, Tourism and Environmental Affairs
PROVINCE OF KWAZULU-NATAL

Enquiries :Muzi Mdamba
Imibuzo :
Navrae :

Telephone:035 780 6844
Ucingo :
Telefoon :

Private Bag : X 1048
Isikhwama Seposi : Richards Bay
Privaat Sak : 3900

Reference:
Inkomba :DC28/0001/2014
Verwysing:

Fax :
iFeksi : 035 780 8211
Faks :

Date :
Usuku :
Datum : 25 September 2014

Fax Transmission

Golder Associates Pty (Ltd)
P O. Box 29391
Maytime
3624

Attention: Sarah Watson

Fax no: 031 717 2791

Dear Madam

DC28/0001/2014: ACCEPTANCE OF SCOPING REPORT FOR THE PROPOSED VOPAK-REATILE TERMINAL RICHARDS BAY AT THE PORT OF RICHARDS BAY, KWAZULU NATAL

1. The abovementioned report which was submitted in terms of the EIA Regulations, 2010 and received by the Department on the 25 August 2014 refers.
2. The report has been reviewed by this Department and has been found to be acceptable.
3. However the following issues must be addressed pre and or during the EIA phase:
   - Listed activities that were erroneously omitted in the list of triggered activities applied for must be included in the application form, assessed and their assessment be included in the EIA report.
   - Although this application is for the terminal and not clearing, however commentary from Ezemvelo KZN Wildlife (EKZNW) is important, as there are critical issues of biodiversity importance that requires EKZNW guidance and decision making. Please ensure that their comments are included in the EIA report.
   - Wetland assessments must also be included as a specialist study to be undertaken at an EIA phase by an independent specialist.
   - The issue of bulk services supply and infrastructure (e.g. electricity, water, sewage, storm water management etc.) must be given necessary attention at the EIA phase. Agreements with the relevant authorities in this regard must be included in the EIA report as proof.
   - Although the EIA process for site clearing runs parallel to the EIA for the terminal construction (DC28/0001/2014), the Department would like to emphasize that approval or disapproval of

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one application does not guarantee the approval or disapproval of either application submitted to this Department. Each application is assessed in its own merit. Specialist reports that inform either application must be clearly indicated and must not set to confuse the Interested and Affected Parties. The Department may re-evaluate this process should the need arise.

4. Please contact this Department if you have any queries regarding this correspondence.

Yours faithfully

for: **Head of Department:**
KwaZulu-Natal Department of Economic Development, Tourism and Environmental Affairs

cc: *(Mr. David Bent: Vopak South African Developments, Fax: 031 466 9272)*

APPENDIX E

Air Quality Impact Assessment Specialist Study

January 2015
Report No. 13614921-13289-4

January 2015

AIR QUALITY IMPACT ASSESSMENT

ESIA for the Proposed Vopak-Reatile Terminal Richards Bay Bulk Liquid Storage and Handling Facility

Submitted to:
Public Review

DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014

REPORT

Report Number: 13614921-11897-3

Distribution:

1 x Copy Vopak South Africa Developments (Pty) Ltd
1 x Copy Golder Associates Africa (Pty) Ltd

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Executive Summary

Project overview

Golder Associates Africa (Pty) Ltd. (Golder) was appointed by Vopak South Africa Developments (VSAD) to undertake an environmental authorisation and environmental management programme (EMP) for the proposed Vopak-Reatile Terminal Richards Bay bulk storage facility, located at the Port of Richards Bay, KwaZulu-Natal.

The proposed Vopak-Reatile Terminal will occupy a footprint of approximately 15.8 Ha and will consist of 45 storage tanks which will store Liquid Petroleum Gas (LPG), a mix of Clean Petroleum Products (CPP), and a suite of chemicals. In addition to storage tanks, the proposed terminal infrastructure includes a liquid shipping line; manifolds, stenching equipment, marine loading arm, road loading bays, rail loading bays, weighbridges for road and rail loading, mass flow meters, fire suppression systems, buildings and supporting utilities.

Project location

The proposed site is located in the South Dunes Precinct of the Port of Richards Bay, within the City of uMhlathuze, KwaZulu-Natal.

Surrounding land uses and sensitive receptors

- The site is located within the South Dunes Precinct (SDP)
- Within 2 km of the proposed site:
  - Port of Richards Bay to the west
  - The small craft harbour to the north,
  - The harbour mouth to the north-east
  - The Indian Ocean to east; and
  - Richards Bay Game Reserve to the south.
- Within 2 – 5 km of the proposed site:
  - The Grindrod dry bulk terminal to the north;
  - The suburb of Meerensee to the north-east;
- Within 5 – 10 km of the proposed site:
  - Numerous industrial activities, specifically in the Alton area to the north-west; and
  - Numerous potential sensitive receptors, including nature reserves, residents, schools, hospitals and clinics are also present, located within the following suburbs:
    - Gubethuka and Esikhawini to the south-west; and
    - Brackenham, Wildenweide, Veldenvlei, Birdswood, Arboretum (and Extension) to the north.

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Meteorological conditions

Richard Bay is located in the summer rainfall region of South Africa and therefore receives most of its rainfall during the period of October to March, with peak rainfall occurring in the late summer months of January and February.

Air temperatures in Richards Bay are warm, to hot, for most of the year and summers are humid. In summer the average daily maximum temperature is 29°C with extremes exceeding 40°C, while in winter the average maximum temperature is 23°C with extremes in the region of 34°C.

According to modelled meteorological data (MM5 data) for the period 2011 – 2013, the average wind speed is 4.24 m/s. A clear dominant wind axis is evident, with winds predicted to originate from the north-north-east (11% of the time) and north-east (10% of the time), followed by south-south-west (9%) and south-west (9%). Winds are moderate, with 3.56% calms (<1m/s).

Diurnal variations in wind direction result from land and sea breezes, with the west-south-westerly land breeze (off shore winds) dominant in the early hours (00:00 - 06:00) and the north-north-easterly sea breeze dominant in the afternoons (12:00 – 18:00). Mornings (06:00 – 12:00) tend to be dominated by high speed south-westerly winds (>10 m/s).

A seasonal variation is evident with north-easterly and east-north-easterly winds dominating in summer and spring; and south-westerly and west-south-westerly winds dominating in autumn and winter. The highest frequency of calms is noted in winter (4.08%). Southerly to south-south-westerly winds occur throughout the year and are typically associated with the arrival of coastal low pressure systems (cold fronts and cut off-lows). Coastal lows tend to be more frequent during the summer months.

Baseline air quality

Industrial activities, vehicle exhaust emissions (from the N2 highway and heavy trucks), and sugar cane burning were identified as the main sources of emissions within the municipality (Thornhill and van Vuuren, 2009; SGS Environmental, 2011). The primary air pollutants are sulphur dioxide (SO_2) and fine particulate matter (PM_{10}), while elevated fluoride concentrations have also been identified as a concern.

The Richards Bay Clean Air Association (RBCAA) owns and operates 11 monitoring stations in the greater Richards Bay area, monitoring SO_2, PM_{10} monitoring stations, Total Reduced Sulphide (TRS) and meteorology. The closest air quality-monitoring station to the proposed terminal site is Harbour West which is situated approximately 5.9 km north-west of the site.

The monitoring and data collection network is robust and well maintained. While not currently accredited, the network satisfies South Africa National Accreditation System (SANAS) requirements, thus adding to the confidence and reliability of the data and results. The results captured in the RBCAA 2013 Annual Report revealed the following:

- Current and future annual average PM_{10} NEM:AQA standards were not exceeded during 2013 (Golder Associates, 2014). One exceedance of the current NEM:AQA daily standard (120 µg/m³) and seven exceedances of the future NEM:AQA daily standard (75 µg/m³) were recorded in 2013. Annual average PM_{10} concentrations show an over-all decreasing trend from 2007 - 2013; however 2013 annual average concentrations are higher at the Brackenham and CBD monitoring stations than those recorded in 2012.

- Ten exceedances of the SO_2 NEM:AQA daily average standard (48 ppb), 48 exceedances of the NEM:AQA hourly average standard (134 ppb) and 66 exceedances of the NEM:AQA 10 minute average standard (191 ppb) were recorded during 2013. Annual average SO_2 concentrations showed a marked increase in average annual SO_2 concentrations from 2007 - 2013. However, the NEM:AQA Annual average standard (19 ppb) was not exceeded during 2013.

- 25 exceedances of the World Health Organisation (WHO) 30-minute H_2S guideline (5.0 ppb), 13 exceedances of the Ontario Ministry for the Environment (OME) TRS 10-minute health standard (9.3

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ppb) 163 exceedances of the RBCAA 10-minute target (4.5 ppb) were recorded during 2013. A marked decrease in annual average TRS concentrations is however evident from 2009 - 2013.

Impact assessment summary

Site clearing and construction

Site clearing and construction activities are important sources of fugitive dust emissions that may have substantial temporary impact on the local air quality in the vicinity of the activity. The implementation of mitigation measures will reduce the magnitude of this impact.

Emissions to the atmosphere from construction sites also include vehicle emissions, smoke and odour, however the magnitude and duration of the impact on the ambient air quality is anticipated to be low

Operation

The significance of the operations impact on the ambient air quality was simulated and quantitatively assessed. Based on this assessment, the Terminal will have a negative impact on the existing ambient air quality, for the duration of the operation. The magnitude of the impact is however predicted to be low (< 10% from current conditions) and limited to the Terminal site. The environmental consequence is therefore anticipated to be low.

Decommissioning

Of particular significance are dust and particulate emissions associated with the following:

- Generation of solid wastes and debris, their stockpiling, transfer, and loading onto trucks or into skips;
- Transport of wastes off site; and
- Movement of vehicles along unpaved roadways and paths, in and out of the site and within the site.

Particulate matter (soot) and gaseous emissions such as carbon monoxide, sulphur oxides, nitrogen oxides and organic compounds including polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) emissions are also likely to result from heavy vehicle/machinery exhausts emissions.

Air quality impacts are, however limited to the ‘active’ phases of the proposed terminal. Provided the site is rehabilitated and potential sources of wind erosion (such as stockpiles and open/exposed areas) are re-vegetated, there will be no long term residual impact on the ambient air quality.

Cumulative impacts

Based on the information provided, the cumulative impact of the Terminal is likely to be negligible due to the following factors:

- The site is located at the harbour mouth and is therefore often subject to wind speeds > 5 m/s, favouring dispersion (32% if the time);
- The site is located > 2 km from the nearest residential area; and
- The predicted emissions concentrations resulting from fugitive storage and handling losses is low (i.e. less than 10%.

Recommendations

Based on the available data; site clearing, construction and operation of the proposed Vopak-Reatile Terminal, will impact negatively on local ambient air quality. The overall significance of this impact is however predicted to be low, as the facility is predicted to comply with local (South African) source emission and ambient air quality standards and guidelines. Thus, there should be no detrimental impacts on sensitive receptors in the vicinity of the facility.

Since the type, volume and throughput of chemicals stored at the proposed Terminal will be dependent on market conditions, the parameters assessed in this AQIA are likely to change. It is therefore recommended that Vopak-Reatile re-assess the predicted emissions once the type, volume and throughput of chemicals, as well as vehicle, rail and ship operational details are known.

Contributors

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List of abbreviations and terms

µg	Microgram
$\mu g/m^3$	Micrograms per cubic metre
ACGIH	American Conference of Governmental Industrial Hygienists
AEL	Atmospheric emission license
AQIA	Air quality impact assessment
AQMP	Air quality management plan
ASTMD1739	American Society for Testing and Materials standard method for collection and analysis of windblown dust deposition.
BTEX	Benzene, Ethylbenzene, Toluene & Xylene
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CPP	Clean Petroleum Products
DEA	Department of Environmental Affairs
DJF	December, January, February
E	East
EAL	Environmental Assessment Level
EIA	Environmental impact assessment
EMP	Environmental management plan
EMPR	Environmental management programme report
ENE	East-north-east
ESE	East-south-east
Golder	Golder Associates Africa (Pty) Ltd
H_2	Hydrogen
HAPs	Hazardous air pollutants
ITCZ	Inter-Tropical Convergence Zone
IVS	Island View Storage
JJA	June, July, August
km	Kilometre
km/h	Kilometre per hour
LPG	Liquid Petroleum Gas
MAM	March, April, May

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mg	Milligrams
mg/m^2/day	Milligrams per square metre per day
MM5	Modelled meteorological data
mn^3/h	Normal cubic metres per hour
N	North
NE	North-east
NEM:AQA	National Environmental Management: Air Quality Act (Act no. 39 of 2004)
NNE	North-north-east
NNW	North-north-west
NO_2	Nitrogen dioxide
NOISH	National Institute for Occupational Safety and Health
NO_x	Nitrogen oxides
NW	North-west
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 µm
RBCT	Richards Bay Coal Terminal
REL	Recommended Exposure Limit
S	South
SANS	South African National Standards
SANS 1929	South African National Standard 1929
SAWS	South African Weather Service
SDP	South Dunes Precinct
SE	South-east
SO_2	Sulphur dioxide
SON	September, October, November
SSE	South-south-east
SSW	South-south-west
SW	South-west
TLV	Threshold Limit Value
tonnes/h	Tonnes per hour
UK	United Kingdom
USEPA	United States Environmental Protection Agency
VSAD	Vopak South Africa Developments
W	West

WHO	World health organisation
WNW	West-north-west
WSW	West-south-west

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was appointed by Vopak South Africa Developments (VSAD) to undertake an environmental authorisation and environmental management programme (EMP) for the proposed Vopak-Reatile Terminal Richards Bay bulk storage facility, located at the Port of Richards Bay, KwaZulu-Natal.

The proposed Vopak-Reatile Terminal will occupy a footprint of approximately 15.8 Ha and will consist of 45 storage tanks which will store Liquid Petroleum Gas (LPG), a mix of Clean Petroleum Products (CPP), and a suite of chemicals. In addition to storage tanks, the proposed terminal infrastructure includes a liquid shipping line; manifolds, stenching equipment, marine loading arm, road loading bays, rail loading bays, weighbridges for road and rail loading, mass flow meters, fire suppression systems, buildings and supporting utilities.

This report presents the findings of the Air Quality Impact Assessment (AQIA) undertaken in support of the environmental authorisation and EMP in terms of the National Environmental Management Act: Air Quality Act (Act no. 39 of 2004) (NEMA: AQA).

1.1 Location

The proposed site is located in the South Dunes Precinct of the Port of Richards Bay, within the City of uMhlathuze, KwaZulu-Natal (Figure 1 and Figure 2).

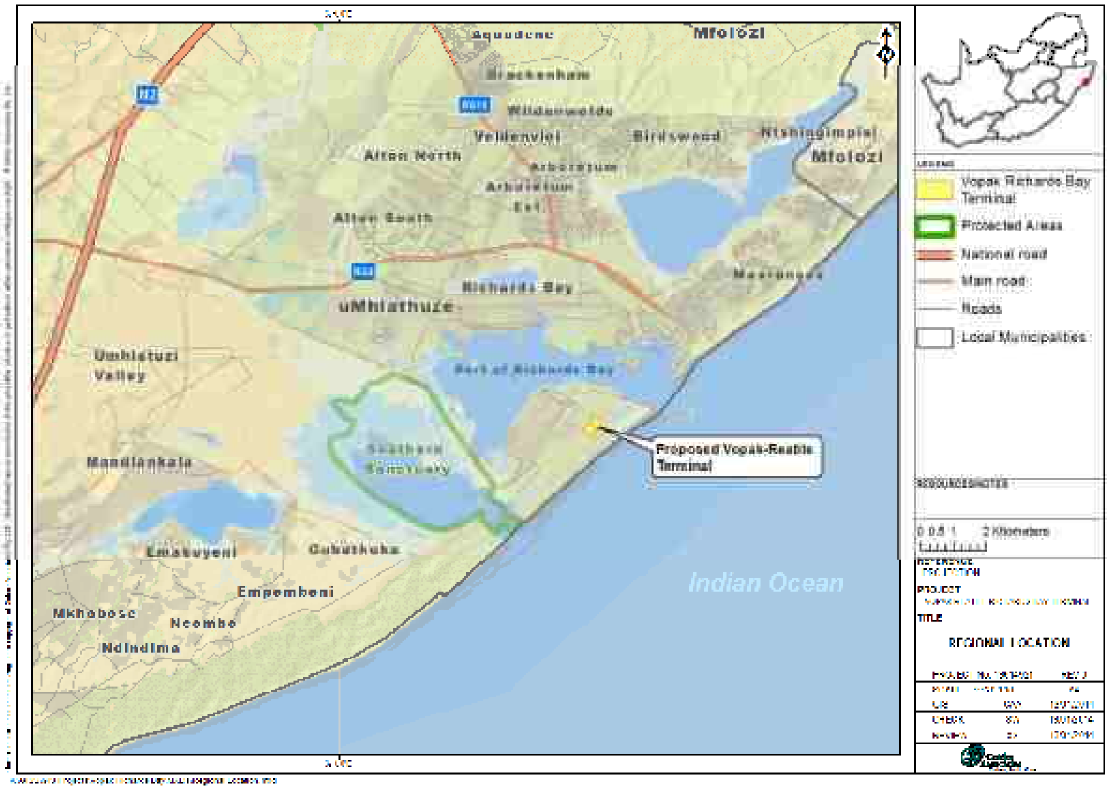

Figure 1: Regional view of the proposed project location/lease sites.

Figure 2: Proposed project location/lease sites.

1.2 Project description

Environmental Authorisation for the Construction, Operation and Decommissioning of the proposed Terminal will be applied for under the EIA process.

1.2.1 Site Clearing and Preparation activities

Site clearing and preparation activities include:

- Vegetation clearing;
- Excavation;
- Site levelling;
- Stripping and stockpiling of soil;
- Importing of soil for levelling purposes;
- Compaction of soil;
- Establishment and demarcation of construction camp;
- Establishment of site offices;
- Establishment of facilities for workers (e.g. ablution facilities etc.);
- Establishment and demarcation of material storage facilities; and

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- Erection of security fencing around the construction camp.

1.2.2 Construction

Construction activities will include building new tanks, construction of manifolds, liquid shipping lines, road and rail loading bays, offices, and all supporting utilities. During the construction phase a temporary warehouse will be built to store the construction equipment required. Since this is a new facility, enough space will be allocated in the plot plan for additional pipe racks, extensions to structures, changes in operation, automation and maintenance philosophies.

Raw materials required during construction include sand, crushed stone, concrete, steel plates, steel rods, steel beams and steel pipes. Electricity will be sourced from the Eskom, and additional electricity will be produced by diesel generators. Mechanical and electronic equipment required during the construction phase will include cranes, trucks, earth-moving equipment, welding machines, diesel generators and compactors.

1.2.3 Proposed terminal layout

The proposed terminal layout is presented in Figure 3. Existing rail tracks utilised by the Richards Bay Coal Terminal (RBCT) border the site to the north, south and east. All new rail tracks and siding access constructed as part of the project will be located on the western side of the terminal, and will be spaced a minimum of 15 m from any construction. The provision of rail infrastructure to the terminal site is the responsibility of Transnet National Ports Authority (TNPA) and has been included in the scope of the Basic Assessment (BA) process initiated by TNPA (DEA Reference Number: 14/12/16/3/3/1/582). Rail infrastructure proposed by TNPA will be constructed according to the S410 Specification for railway earthworks (2006) and the Geotechnical Service Handbook (1986). The design criterion is aimed at slow moving trains with 20 ton axle loads (Geomeasure Group, 2013).

The provision of road access to the terminal lease site is also the responsibility of TNPA and has been included in the scope of TNPA's BA process. Access currently exists to the boundary of the proposed terminal site via Mundra Road. TNPA propose extending Mundra Road by 1 km in length and 7 m in width to provide access to the site (Geomeasure Group, 2013). The site will have only one entrance for truck movement, located in the north-western extent of the site, but for safety purposes a second gate will be provided and will function as an emergency exit only. Parking space for trucks will be provided inside the terminal facility.

Liquid shipping lines will be constructed from Berths 208 and 209 to the site. The construction of shipping liquid lines requires a wayleave application[1] to be completed and submitted to TNPA for approval.

All buildings including the main office building and canteen, cabins, firefighting station, laboratory, control room and maintenance workshop will be located in the same vicinity in the northern extent of the terminal site.

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[1] An application to the local authority requesting permission to install utility services of infrastructure. All parties and their contractors are required to obtain permission from the council to install services or infrastructure on public land.

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Figure 3: Vopak-Reatile Terminal Richards Bay plot plan.

1.2.4 Operation

The following standard activities, operational services and functions are required and/or will take place at the Vopak-Reatile Terminal Richards Bay:

- Ship unloading of fuel (from ship to terminal tanks;
- Ship loading of fuel (from terminal tanks to ship);
- Railcar unloading of fuel (from railcar to terminal tanks);
- Railcar loading of fuel (from terminal tanks to railcar);
- Truck unloading of fuel (from truck to terminal tanks);
- Truck loading of fuel (from terminal tanks to truck);
- Internal tank-to-tank transfer;
- Tank measurement on site;
- Tank water draining activities/services;
- Tank cleaning and emptying activities/services;
- Separate line pigging, cleaning and purging;
- Full firefighting facility;
- Jetty and loading bay occupation;
- Parking of vehicles at loading bay; and
- Vapour recovery and treatment.

1.2.4.1 Storage capacity and products

The Vopak-Reatile Terminal Richards Bay is a greenfield site (i.e. the site has not been developed previously), and will be developed in phases. All phases form part of the scope of the EIA. Once completed, the total combined storage capacity will be approximately 300 000 m^3. The project will comprise the following:

- The initial phase with a total storage capacity of approximately 36 000 m^3; and
- Subsequent phases with a total storage capacity of up to 264 000 m^3.

The proposed products to be stored at the terminal are:

- Liquid Petroleum Gas (LPG);
- Clean Petroleum Products (CPP); and
- A suite of chemicals.

1.2.4.2 Proposed project infrastructure

The project infrastructure proposed for the terminal consists of the following:

- Shipping liquid line;
- Marine loading arm;

- Road loading bays;
- Rail loading bays;
- Weighbridges for road and rail loading;
- Fire suppression systems;
- Buildings; and

1.2.4.3 Supporting utilities

The 45 storage tanks will be designed to appropriate local and international standards according to the latest versions of:

- SANS 10089-1:2008: 'Storage and distribution of petroleum products in above-ground bulk installations';
- Tank design manual (Vopak International Standard);
- API 650: 'Welded Steel Tanks for Oil Storage'; and
- EEMUA 190 Guide for the design, construction and use of mounded horizontal cylindrical steel vessels for pressurised storage of LPG at ambient temperatures.

1.2.5 Project Alternatives

VSAD has considered alternative layout design, product groupings as well as tank design options to international standards.

1.2.5.1 Alternative Land Options

It is critical that the terminal site be located in close proximity to a point of import/export, transportation infrastructure, and within close enough proximity to primary users in the Gauteng and KwaZulu-Natal regions. The terminal site is situated in the South Dunes Precinct within the Port of Richards Bay, as this was the only suitable land available within the Port of Richards Bay and within proximity of the liquid fuel berths, Berth 208 and 209.

In terms of the Environmental Management Framework (EMF) for the Richards Bay Port Expansion Area and Industrial Development Zone (2011) the dune cordon area is primarily used for port related and various liquid chemical and petroleum storage facilitates. The area has been earmarked to advance port-related developments, and is under strict manangement control due to the hazardous nature of current and proposed facilities (EMF, 2011). Furthermore, access to the area is restricted which presents opportunities for the establishment of high secure facilities such as the Vopak-Reatile Terminal Richards Bay.

The implementation of the proposed Vopak-Reatile Terminal Richards Bay within the South Dunes Precinct of the Port of Richards Bay is aligned with TNPA and Departmental planning and development frameworks, as well as in terms of TNPA's proposed port expansion plans. As a result no alternative land options will be considered as part of the EIA process.

1.2.5.2 Alternative Layout Design Options

The site layout plan provided by VSAD is preliminary in nature and will be optimized based on the site specific conditions, and the outcomes of the EIA process, particularly the findings and recommendations of the independent specialist studies.

1.2.5.3 Alternative Tank Design Options

Tanks planned for the proposed terminal, will be in accordance with relevant international best practice guidelines and all other applicable legislation. The final tank designs will therefore be confirmed during the final layout design process.

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1.2.5.4 The "No-Project" Alternative

The "no-project" alternative would result in the current status quo regarding limited provision of strategic bulk storage and handling facilities remaining unchanged. As a result consumers are likely to be faced with shortages and possible interruptions in supply amidst increasing demand. As demand increases additional pressure is placed on existing facilities and infrastructure such as loading facilities, storage tanks and handling facilities; which can result in negative implications for the provision of such services. The Vopak-Reatile Terminal Richards Bay will result in the provision of strategic bulk liquid storage capacity for LPG, a suite of chemicals and CPP products within close proximity of major consumers, and will also present additional opportunities for the import and export of product. Both imports and exports present economic benefits in the form of taxation for imports, and revenue generation for exports.

2.0 TERMS OF REFERENCE

Golder was tasked with compiling an Air Quality Impact Assessment (AQIA) to assess the potential impact of the proposed storage facility on the receiving environment and make recommendations for control and/or mitigation. The methodology used in this assessment is illustrated in Figure 4 and further discussed in the sections that follow.

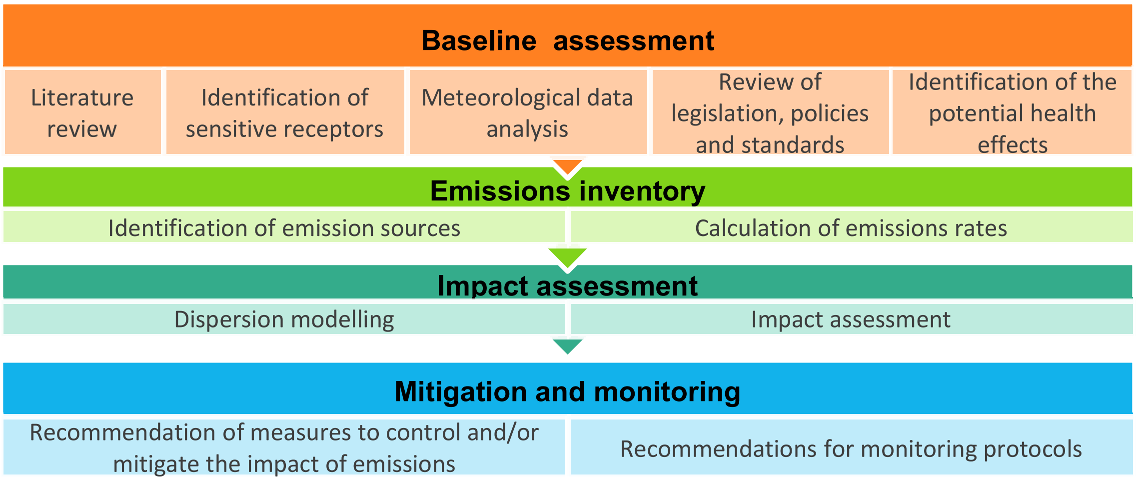

Figure 4: Process followed in the determination of the air quality impacts.

2.1 Baseline assessment

The baseline air quality assessment included:

- A review of applicable legislation, policy and standards;
- A description of the receiving environment including: topography, land use and sensitive receptors;
- The characterisation of regional climate patterns and analysis of site-specific meteorological data;
- The identification of local emission sources; and
- The identification and discussion of the potential health effects associated with key atmospheric emissions.

2.2 Emissions Inventory

An emissions inventory comprises the identification of sources of emission, and the quantification of each source’s contribution to ambient air pollution concentrations. The establishment of an emissions inventory therefore forms the basis for the assessment of the impacts of the proposed storage facility on the receiving environment.

Air pollution emissions may typically be obtained using actual sampling at the point of emission, estimating it from mass and energy balances or emission factors which have been established at other, similar operations (see Box 1).

Emissions from the proposed Vopak-Reatile Terminal were based on Australian National Pollutant Inventory (NPI) emission factors for similar facilities.

Box 1

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors and emission inventories are fundamental tools for air quality management and planning. The emission factors are frequently the best or only method available for estimating emissions produced by varying sources.

2.3 Dispersion modelling

Dispersion modelling is used as a tool to predict the ambient atmospheric concentration of pollutants emitted to the atmosphere from a variety of processes. The AERMOD View modelling software was used to determine likely ambient air pollutant concentrations from the proposed storage facility. AERMOD View is an air dispersion modelling package which incorporates the following United States Environmental Protection Agency (USEPA) air dispersion models into one integrated interface:

- AERMOD;
- ISCST3; and
- ISC-PRIME.

These USEPA air dispersion models are used extensively internationally to assess pollution concentration and deposition from a wide variety of sources.

The AERMET[2] pre-processor was used to process MM5 modelled regional meteorological data for input into ISC-AERMOD. Input to a dispersion model includes prepared meteorological data, source data, information on the nature of the receptor grid and emissions input data.

2.4 Impact assessment

The significance of the identified impacts will be determined using the approach outlined in Table 1. This incorporates two aspects for assessing the potential significance i.e. occurrence and severity, which are further sub-divided as indicated. The impact ranking will be described for both pre and post implementation of mitigation/management measures conditions.

Table 1: Impact Classification for Impact Assessment

Occurrence			**Severity**				**Environmental Consequence**
Direction	**Probability**	**Duration**	**Magnitude**	**Geographic Extent**	**Reversibility**	**Frequency**	

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[2] AERMET is a pre-processor that organizes and processes meteorological data and estimates the necessary boundary layer parameters for dispersion calculations in AERMOD

- **Direction** of an impact may be **positive, neutral or negative** with respect to the particular impact (e.g., a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative).
- **Probability** of occurrence is a description of the probability of the impact actually occurring as **improbable** (less than 5% chance), **low probability** (5% to 40% chance), **medium probability** (40 % to 60 % chance), **highly probable** (most likely, 60% to 90% chance) or **definite** (impact will definitely occur).
- **Duration** refers to the length of time over which an environmental impact may occur: i.e. **transient** (less than 1 year), **short-term** (0 to 5 years [construction]), **medium term** (5 to 15 years [operational]), **long-term** (greater than 15 years with impact ceasing after closure of the project) or **permanent**.
- **Magnitude** is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as: **negligible**: no measurable effect (<1%) from current conditions; **low**: <10% change from current conditions; **moderate**: 10 to 20% change from current conditions; and **high**: >20% change from current conditions. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. Each specialist study will attempt to quantify the magnitude and outline the rationale used.
- **Scale/Geographic extent** refers to the area that could be affected by the impact and is classified as **site**; **local**: effect restricted to the LSA; **regional**: effect extends beyond the LSA into the RSA; and **beyond regional**: effect extends beyond the RSA site.
- **Reversibility** allows for the impact to be described as **reversible** or **irreversible**.
- **Frequency** may be **low**: occurs once; **medium**: occurs intermittently; or **high**: occurs continuously.
- **Environmental Consequence**: The overall residual consequence for each effect will be classified as one of: **negligible**, **low**, **moderate** or **high** by evaluation of the rankings for magnitude, geographic extent and duration Table 2.

Although not explicitly included in the criteria tables, there is uncertainty associated with the information and methods used in an EIA because of its predictive nature. The certainty with which an impact analysis can be completed depends on a number of factors including:

- Understanding of natural/ecological and socio-economic processes at work now and in the future; and
- Understanding of present and future properties of the affected resource.

The level of prediction confidence for an impact analysis will be discussed when there are questions about the factors reviewed above. Where the level of prediction confidence makes a prediction of the impact problematic, a subjective assessment is made based on the available information, the applicability of information on surrogates and on professional opinion.

The level of prediction confidence is sufficiently low in some cases that an estimate of environmental consequence cannot be made with a sufficient degree of confidence. Undetermined ratings are accompanied by recommendations for research or monitoring to provide more data in the future.

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Table 2: Categories describing Environmental Consequence

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur. There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
No Impact	Zero Impact.

2.5 Mitigation and monitoring

Recommendations for potential measures to control and/or mitigate the impact of emissions were provided based on the findings of the impact assessment.

3.0 APPLICABLE LEGISLATION, GIDELINES AND STANDARDS

The National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA) has shifted the approach of air quality management from source based control to the control of the receiving environment. The Act also devolved the responsibility of air quality management from the national sphere of government to the local municipal sphere of government (district and local municipal authorities). District and Local Municipalities are thus tasked with baseline characterisation, management and operation of ambient monitoring networks, licensing of listed activities, and emissions reduction strategies. The main objectives of the act are to protect the environment by providing reasonable legislative and other measures that:

- Prevent pollution and ecological degradation;
- Promote conservation; and
- Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

3.1 Emissions standards

NEMA:AQA makes provision for the setting and formulation of national ambient air quality and emission standards. On a provincial and local level, these standards can be set more stringently if the need arises. The control and management of emissions in NEM:AQA relates to the listing of activities that are sources of emission and the issuing of atmospheric emission licences (AELs). In terms of Section 21 of NEM:AQA, a listed activity is an activity which “results in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions, ecological conditions or cultural heritage”.

The Vopak-Reatile Terminal Richards Bay is a new facility which will trigger a listed activity *(NEM:AQA Category 2. Subcategory 2.4: Storage and Handling of Petroleum Products*). An AEL application process will thus be run in parallel with the environmental authorisation.

According to *Subcategory 2.4: Storage and Handling of Petroleum Products*: the following transitional arrangement shall apply for the storage and handling of raw materials, intermediate and final products with a vapour pressure greater than 14 kPa at operating temperature:

i) Leak detection and repair (LDAR) program approved by licensing authority to be instituted, by 01 January 2014.

ii) The following special arrangements shall apply for control of total VOCs from storage of raw materials, intermediate and final products with a vapour pressure of up to 14 kPa at operating temperature except

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during loading and offloading. (Alternative control measures that can achieve the same of better results may be used).

a) Storage vessels for liquids shall be of the following type (Table 3):

b) The roof legs, slotted pipes and/or dipping well on floating roof tanks (except for domed floating rood tanks or internal floating roof tanks) shall have sleeves fitted to minimise emissions.

c) Relied valves on pressurised storage should undergo periodic checks for internal leaks. This can be carries out using portable acoustic monitors or if venting to atmosphere with an accessible open end, tested with a hydrocarbon analyser as part of an LDAR programme.

iii) The following special arrangements shall apply for control of total VOCs from the loading and unloading (excluding ships) of raw materials, intermediate and final products with a vapour pressure of greater than 14 kPa a handling temperature. (Alternative control measures that can achieve the same or better results may be used).

a) All installations with a throughput of greater than 50 000 m^3 per annum of products with a vapour pressure greater than 14 kPA, must be fitted with vapour recovery/ destruction units. Emission limits are set out in the Table 4.

b) For road tanker and rail car loading/ offloading facilities where the throughput is less than 50 000 m^3 per annum, and where ambient air quality is, or is likely to be impacted, all liquid products shall be loaded using bottom loading, or equivalent with the venting pipe connected to a vapour pressure balancing system. Where vapour balancing and/or bottom loading is not possible, a recovery system utilizing absorption, condensation or incineration of the remaining VOC's with a collection efficiency of at least 95%, shall be fitted.

Table 3: Types of storage vessels for liquids

Application	All permanent immobile liquid storage facilities at a single site with a combined storage capacity of greater than 1 000 cubic meters
True vapour pressure of contents at product storage temperature	**Type of tank or vessel**
Type 1: Up to 14 kPa	Fixed-roof tank vented to atmosphere, or as per Type 2 and 3
Type 2: Above 14 kPa and up to 91 kPa with a throughput of less than 50 000 m^3 per annum	Fixed roof tank with Pressure Vacuum Vents fitted as a minimum to prevent “breathing” losses, or as per Type 3.
Type 3 : Above 14 kPa and up to 91 kPa with a throughput greater than 50 000 m^3 per annum	1) External floating-roof tank with primary rim seal and secondary rim seal for tank with a diameter of greater than 20 m. or 2) Fixed-roof tank with internal floating deck / roof fitted with primary seal, or 3) Fixed-roof tank with vapour recovery system
Type 4: Above 91 kPa	Pressure vessel

Table 4: Emissions limits for vapour recovery units

Description	Vapour Recovery Units		
Application	All loading / offloading facilities with a throughput greater than 50 000 m^3		
Substance or mixture of substances		**Plant status**	**mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa**
Common name	**Chemical symbol**		
Total volatile organic compounds from vapour	N/A	New	150

Description	Vapour Recovery Units		
recovery / destruction units using **thermal treatment**		Existing	150
Total volatile organic compounds from vapour recovery/ destruction units using **non-thermal treatment**	N/A	New	40 000
		Existing	40 000

3.2 Ambient air quality standards

The South African ambient air quality standards for common pollutants prescribe the allowable ambient concentrations of pollutants which are not to be exceeded during a specified time period in a defined area (Table 5). If the standards are exceeded, the ambient air quality is defined as poor and potential adverse health impacts are likely to occur.

If authorised to operate, the proposed storage facility emission contributions to the ambient air quality levels must not exceed or cause exceedances of the ambient air quality standards.

Table 5: South African Ambient Air Quality Standards for Criteria Pollutants

Pollutant	**Averaging Period**	**Limit Value (µg/m^3)**	**Limit Value (ppb)**	**Frequency of Exceedance**	**Compliance Date**
NO_2 (a)	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM_{10} (b)	24 hour	120	-	4	Immediate – 31 December 2014
	24 hour	75	-	4	1 February 2015
	1 year	50	-	0	Immediate – 31 December 2014
	1 year	40	-	0	1 February 2015
O_3 (c)	8 hours (running)	120	61	11	Immediate
Lead (Pb) (d)	1 year	0.5	-	0	Immediate
CO (e)	1 hour	30 000	26 000	88	Immediate
	8 hour (1 hourly average)	10 000	8 700	11	Immediate
Benzene (C_6H_6) (f)	1 year	10	3.2	0	Immediate – 31 December 2014
	1 year	5	1.6	0	1 February 2015
SO_2 (g)	10 minute	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hours	125	48	4	Immediate
	1 year	50	19	0	Immediate
$PM_{2.5}$ (h)	24 hours	65		4	Immediate – 31 December 2015
	24 hours	40		4	1 January 2016 – 31 December 2029
	24 hours	25		4	1 January 2030
	1 year	25		0	Immediate – 31 December 2015

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Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
	1 year	20		0	1 January 2016 – 31 December 2029
	1 year	15		0	1 January 2030

Notes:

a. *The reference method for the analysis of NO_2 shall be ISO 7996*

b. *The reference method for the determination of the particulate matter fraction of suspended particulate matter shall be EN 12341*

c. *The reference method for the analysis of ozone shall be the UV photometric method as described in ISO 13964*

d. *The reference method for the analysis of lead shall be ISO 9855*

e. *The reference method for analysis of CO shall be ISO 4224*

f. *The reference methods for benzene sampling and analysis shall be either EPA compendium method TO-14 A or method TO-17*

g. *The reference method for the analysis of SO_2 shall be ISO 6767*

h. *The reference method for the analysis of $PM_{2.5}$ shall be EN14907*

3.3 Dust fallout standards

On 1 November, 2013, the National Dust Control Regulations were promulgated under the National Environmental Management: Air Quality Act (NEM:AQA), 2004 and published in the Government Gazette No. 36974. The dust fall standard defines acceptable dust fall rates in terms of the presence of residential areas (Table 6).

Table 6: Acceptable dust fall rates

Restriction areas	Dust fall rate (mg/m^2/day over a 30 day average)	Permitted frequency of exceedance
Residential areas	Dust fall < 600	Two per annum (not in sequential months)
Non-residential areas	600 < Dust fall < 1200	Two per annum (not in sequential months)

3.4 Proposed environmental assessment levels

According to the International Finance Corporation (IFC) Environmental, Health, and Safety (EHS) Guidelines (2007) on air emissions and ambient air quality, projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current World Health Organization (WHO) Air Quality Guidelines.

In the absence of local standards and guidelines, applicable WHO and other international air quality guidelines were used to assess the predicted emissions from the proposed Vopak-Reatile Terminal. Where ambient air quality guidelines could not be found, occupational limits were used.

Internationally, it is generally accepted that, in the absence of any ambient reference standards available, it is acceptable to make use of either 1/50th (for non-carcinogens) or 1/100th (for carcinogens) of the relevant Occupational Exposure Limits. In the absence of reliable toxicological data, this methodology has been used to set numerous ambient standards including those published by the UK Environment Agency/ European Commission.

Table 7: Proposed environmental assessment levels (EALs) for the Vopak-Reatile Terminal

Product	Short term (1 hour) EAL ($\mu g/m^3$)	Long term (annual) EAL ($\mu g/m^3$)	Reference
Acetone	362 000	18 100	UK Environment Agency (2011)[a]
Acrylic acid	6 000	300	UK Environment Agency (2011) [a]

Product	Short term (1 hour) EAL (µg/m^3)	Long term (annual) EAL (µg/m^3)	Reference
Butanol	3 000	-	150 mg/m^3 NIOSH REL[b]
Butyl Acrylate	1 100	-	55 mg/m^3 NIOSH REL[b]
Diethanolamine	324	7.8	UK Environment Agency (2011)[a]
Ethanol	38 000	-	1900 mg/m^3 NIOSH REL[b]
Ethyl Acetate	28 000	-	1400 mg/m^3 NIOSH REL[b]
Ethyl Acrylate	6 200	210	UK Environment Agency (2011) [a]
Methyl ethyl ketone	11 800	-	590 mg/m^3 NIOSH REL[b]
Methyl isobutyl ketone	4 100	-	205 mg/m^3 NIOSH REL[b]
Propanol	10 000	-	500 mg/m^3 NIOSH REL[b]
Propylene glycol	500	-	25 mg/m^3 NIOSH REL[b]
Styrene	800	800	WHO (2000)[c]
Triethanolamine	100	-	5 mg/m^3 ACGIH TLV[d]
Ethylbenzene	55 200	4 410	UK Environment Agency (2011) [a]
Toluene	8 000	1 910	UK Environment Agency (2011) [a]
Xylenes	66 200	4 410	UK Environment Agency (2011) [a]
Total VOC	10 000	-	European Parliament (2000) [e]

Notes:

a) *UK Environment Agency (2011) H1 Environmental Risk Assessment Framework. Annex F - Air Emissions. Bristol, United Kingdom. GEHO0410BSIL-E-E v2.2*

b) *National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limit (REL)*

c) *World Health Organisation (WHO), Air quality guidelines 2000, EAL derived from values for 24 hour reference period*

d) *American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)*

e) *European Parliament (2000) Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the Incineration of Waste. Official Journal of the European Communities. L332/91*

3.5 Local Municipal bylaws

As a result of historical ambient air quality problems and the profusion of heavy industries within Richards Bay, the City of uMhlathuze adopted local air quality guidelines that include emission targets and the implementation of air quality buffer zones.

Buffer zones were delineated based on potential health impacts and environmental or nuisance impacts, and were determined by air dispersion modelling and health risk screening assessments. Based on the City of uMhlathuze Spatial Development Framework (2007), the buffer zone delineation (based on all air pollution criteria for ‘current’ operations), the proposed terminal site falls within the Management Zone (Single Health Limit Exceedance) (Figure 5). The Management Zone has been identified as it could result in possible health implications. The recommendation was therefore made that the ambient monitoring network be expanded to ensure representative monitoring within this zone.

The proposed site is also within very close proximity to the Alert Zone (The lowest level at which adverse effects for a specific pollutant have been observed [LOAEL] and Alert Threshold). The main pollutants of concern in the Alert Zone are PM_{10} around the harbour and SO_2 at the Richards bay central business district (CBD) and surroundings. The recommendation was made that further industrial development resulting in PM_{10} and SO_2 pollutants within this zone should be carefully considered since effects may be noticed by sensitive individuals, and actions to reduce these effects may be needed.

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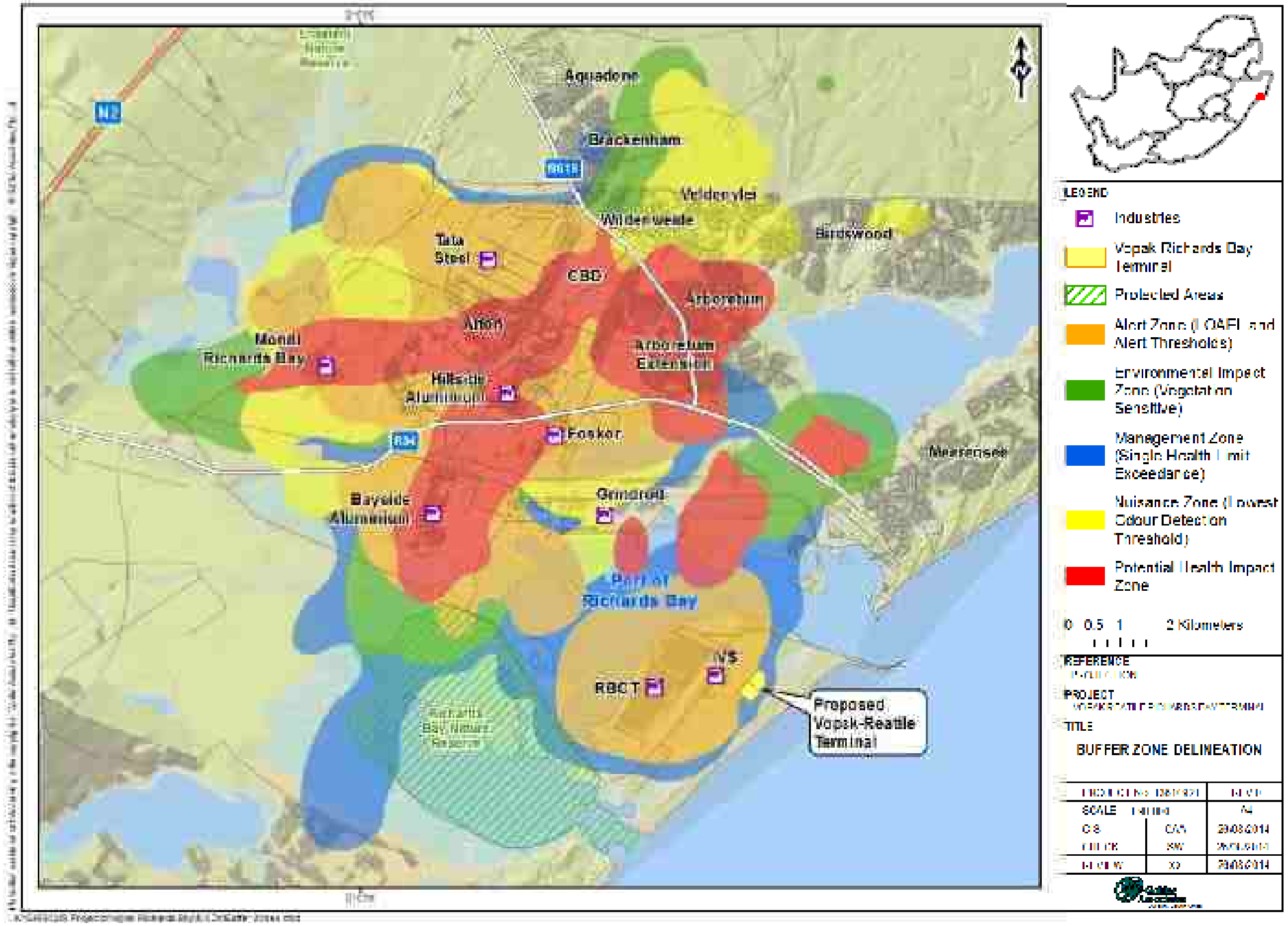

Figure 5: City of uMhlathuze Spatial Development Framework (2007) buffer zone delineation (based on all air pollution criteria for ‘current’ operations).

4.0 BASELINE ASSESSMENT

4.1 Environmental setting

4.1.1 Topography

Richards Bay is located within a large coastal plain varying in altitude from sea level at the coast to 200 m approximately 20 km inland (Empangeni). The coastline is characterized by a steep sandstone ridge and a strip of one to four dune ridges (up to +/- 1 km wide) running parallel to the coast and reaching a height of approximately 100 m. The only break in coastal dune ridge is the harbour and sanctuary entrances.

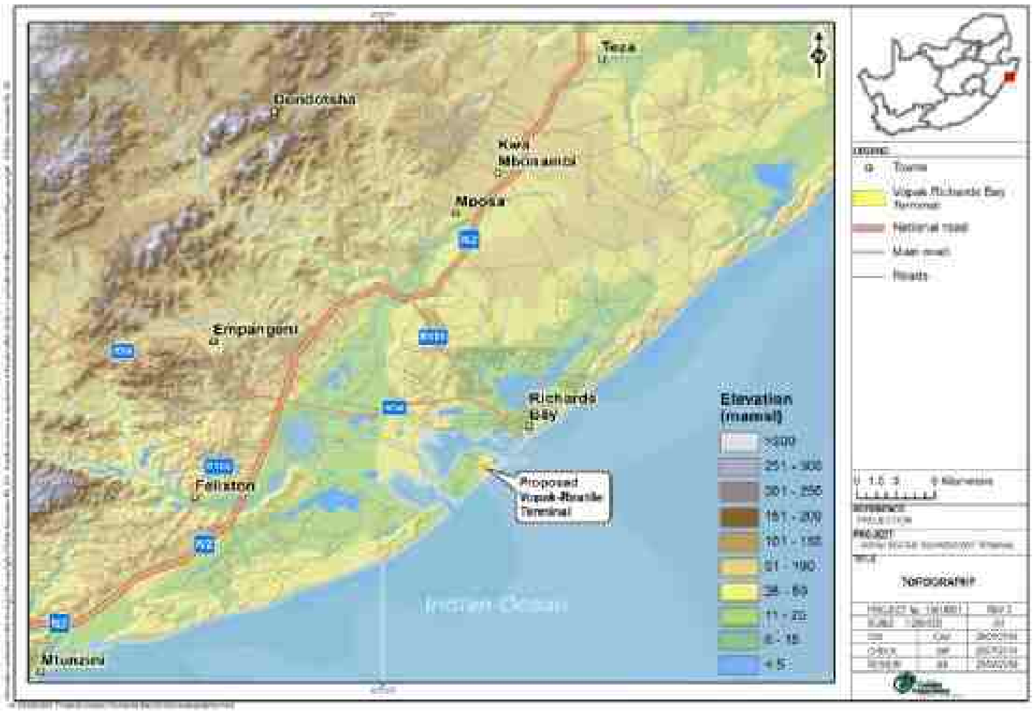

Figure 6: Regional topography of the greater Richards Bay area.

4.1.2 Land use and sensitive receptors

4.1.2.1 Land use and sensitive receptors within 2km of the site

The site is located within the South Dunes Precinct (SDP) which is bordered by the Port of Richards Bay to the west, the small craft harbour to the north, the harbour mouth to the north-east, the Indian Ocean to east, and Richards Bay Game Reserve to the south. The SDP is used primarily for liquid chemical and petroleum storage facilities (DAERD, 2011). Tenants include the Richards Bay Coal Terminal (RBCT), Island View Storage (IVS) (Figure 7), Joint Bunker Services (JBS) (Figure 8), and Transnet Rail Engineering (TRE).

Figure 7: Photo of the IVS Storage Facility

Figure 8: Photo of the JBS Storage Facility

RBCT is the world's largest coal export terminal, with capacity to export 66.5 million tons of coal to the international market per year. RBCT exports coal derived from the Mpumalanga coalfields and can handle 3,000 84-ton coal wagons per day and fill an average of 700 ships per year (CSIR, 2002).

IVS is a bulk liquid storage and handling facility which handles a wide range of liquefied gases and hazardous liquids; including propylene, butane, butadiene, ammonia, hexane, octane and acetone (CSIR, 2002).

JBS is a joint bunker service provider and provides storage of fuels for Caltex Oil (SA) (Pty) Ltd, Engen Petroleum Limited, BP Southern Africa (Pty) (Ltd), Shell Oil South Africa (Pty) Ltd and Total Oil South Africa (Pty) Ltd (CSIR, 2002).

4.1.2.2 Land use and sensitive receptors within 2 – 5 km of the site

The Grindrod dry bulk terminal is located approximately 4 km north of the site. The terminal handles coal, heavy minerals (phosphate rock and metal ores), sulphur (and other phosphates), and other dry bulk commodities.

The suburb of Meerensee is located 2 – 5 km north-east of the site. Home to the boat club, shopping malls, churches, schools, guesthouses, hotels and residences; the suburb comprises many potential sensitive receptors.

4.1.2.3 Land use and sensitive receptors within 5 – 10 km of the site

Numerous industrial activities exist within 5 – 10 km of the proposed site, specifically in the Alton area, north-west of the proposed site (Figure 9), with major industries including (but not limited to):

- BHP Billiton Bayside (now non-operational) and Hillside smelters;
- Foskor fertiliser plant;
- Mondi Richards Bay pulp and paper mill;
- Tata Steel;
- Richards Bay Coal Terminal; and
- Richards Bay Minerals Mine and Smelter Complex.

Numerous potential sensitive receptors, including nature reserves, residents, schools, hospitals and clinics are also present within this band and are located within the following suburbs:

- Gubethuka and Esikhawini to the south-west; and
- Brackenham, Wildenweide, Veldenvlei, Birdswood, Arboretum (and Extension) to the north.

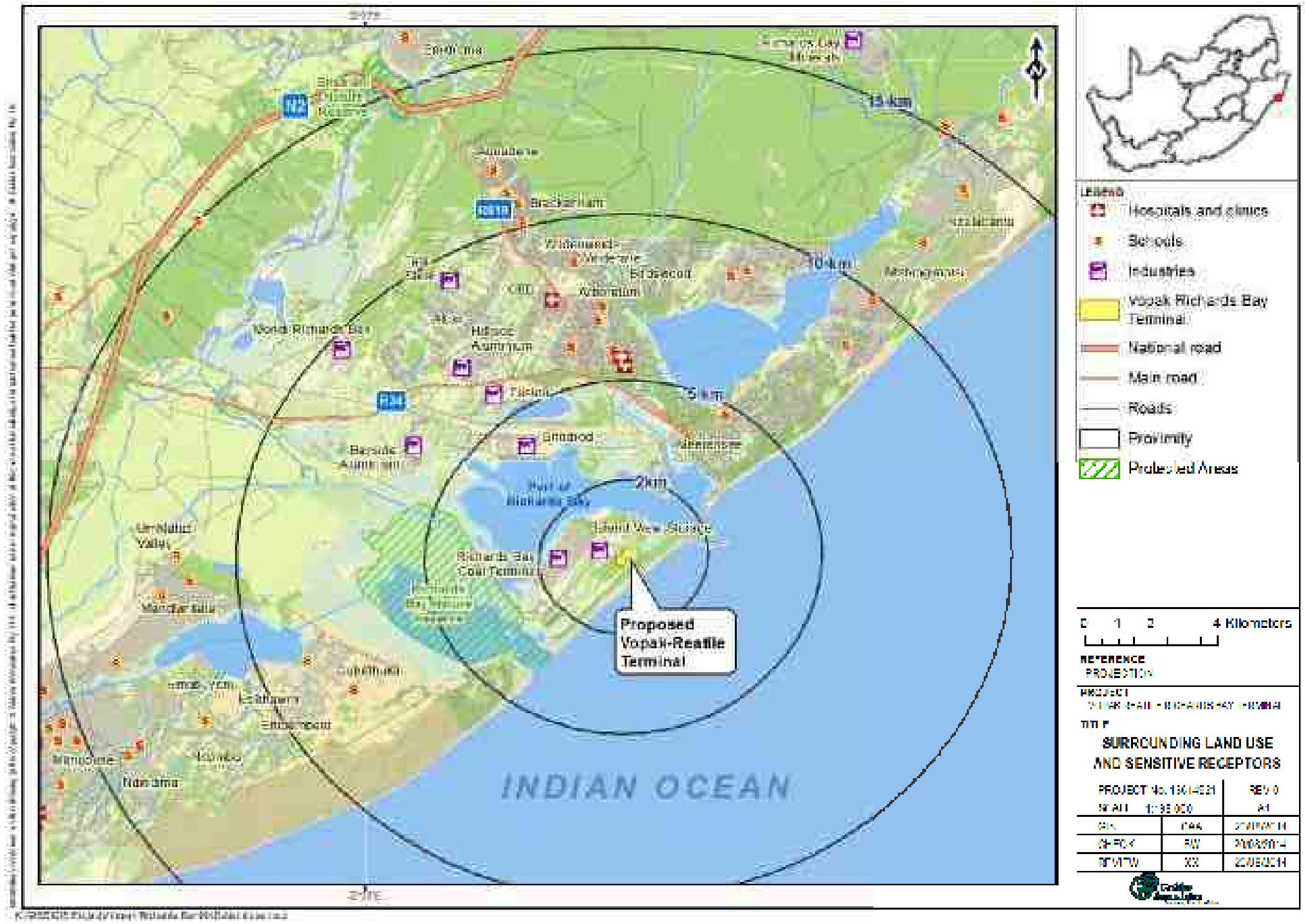

Figure 9: Land use and sensitive receptors in the vicinity of the proposed Terminal.

4.1.3 Regional climate

Richards Bay is situated in the subtropical high-pressure belt. The mean circulation of the atmosphere over the subcontinent is anticyclonic throughout the year (except for near the surface) (Preston-Whyte and Tyson, 1997). The synoptic patterns affecting the typical weather experienced in the region owe their origins to the subtropical, tropical and temperate features of the general atmospheric circulation over Southern Africa (Figure 10).

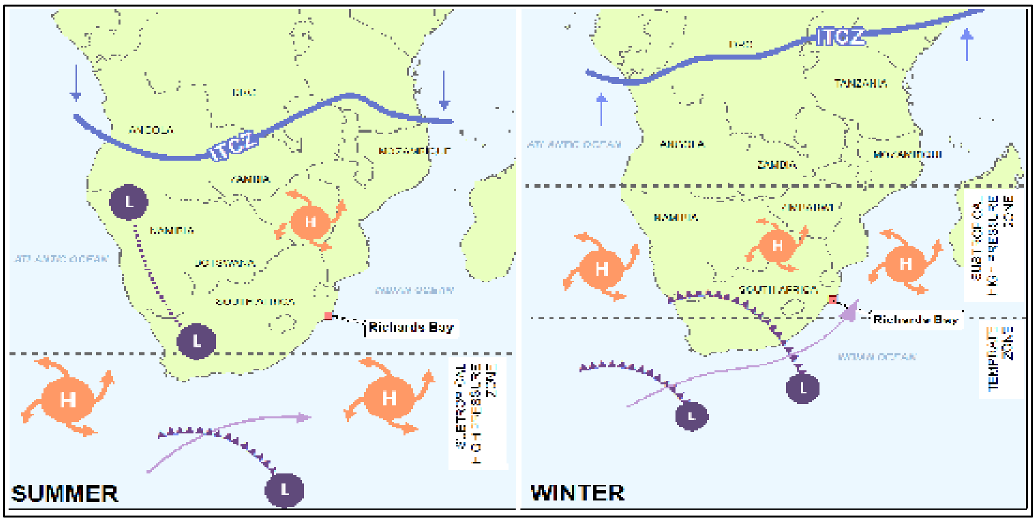

Figure 10: Seasonal circulation patterns affecting the regional climate.

The subtropical control is brought via the semi-permanent presence of the South Indian Anticyclone (HP cell), Continental High (HP cell) and the South Atlantic Anticyclone (LP cell) in the high pressure belt located approximately 30°S of the equator (Preston-Whyte and Tyson, 1997). The tropical controls are brought via tropical easterly flows (LP cells) (from the equator to the southern mid-latitudes) and the occurrence of the easterly wave and lows (Preston-Whyte and Tyson, 1997). The temperature control is brought about by perturbations in the westerly wave, leading the development of westerly waves and lows (LP cells) (i.e. cold front from the polar region, moving into the mid-latitudes) (Preston-Whyte and Tyson, 1997).

Seasonal variations in the positioning and intensity of the HP cells determine the extent to which the westerly waves and lows impact the atmosphere over the region. In winter, the high pressure belt intensifies and moves northward while the westerly waves in the form of a succession of cyclones or ridging anticyclones moves eastwards around the South African coast or across the country. The positioning and intensity of these systems are thus able to significantly impact the region. In summer, the anticyclonic HP belt weakens and shifts southwards and the influence of the westerly wave and lows weakens.

Anticyclones (HP cells) are associated with convergence in the upper levels of the troposphere, strong subsidence throughout the troposphere, and divergence in near the surface of the earth. Air parcel subsidence, inversions, fine conditions and little to no rainfall occur as a result of such airflow circulation patterns (i.e. relatively stable atmospheric conditions). These conditions are not favourable for air pollutant dispersion, especially in regards to those emissions emitted close to the ground.

Westerly waves and lows (LP cells) are characterised by surface convergence and upper-level divergence that produce sustained uplift, cloud formation and the potential for precipitation. Cold fronts, which are associated with the westerly waves, occur predominantly during winter. The passage of a cold front is characterised by pronounced variations in wind direction and speed, temperature, humidity, pressure and distinctive cloud bands (i.e. unstable atmospheric conditions). These unstable atmospheric conditions bring about atmospheric turbulence which creates favourable conditions for air pollutant dispersion.

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The tropical easterlies and the occurrence of easterly waves and lows affect Southern Africa mainly during the summer months. These systems are largely responsible for the summer rainfall pattern and the north easterly wind component that occurs over the region (Schulze, 1986; Preston-Whyte and Tyson, 1988).

In summary, the convective activity associated with the easterly and westerly waves disturbs and hinders the persistent inversion which sits over Southern Africa. This allows for the upward movement of air pollutants through the atmosphere leading to improved dispersion and dilution of accumulated atmospheric pollution.

4.1.4 Boundary layer conditions

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere and is directly affected by the earth's surface. The earth's surface affects the boundary layer through the retardation of air flow created by frictional drag, created by the topography, or as result of the heat and moisture exchanges that take place at the surface.

During the day, the atmospheric boundary layer is characterised by thermal heating of the earth's surface, converging heated air parcels and the generation of thermal turbulence, leading to the extension of the mixing layer to the lowest elevated inversion. These conditions are normally associated with elevated wind speeds, hence a greater dilution potential for the atmospheric pollutants.

During the night, radiative flux divergence is dominant due to the loss of heat from the earth's surface. This usually results in the establishment of ground based temperature inversions and the erosion of the mixing layer. As a result, night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer ranges in depth from a few metres during night-time's to the base of the lowest elevated inversion during unstable, daytime conditions. Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 8.

The atmospheric boundary layer is normally unstable during the day as a result of the turbulence due to the sun's heating effect on the earth's surface. The thickness of this mixing layer depends predominantly on the extent of solar radiation, growing gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. This situation is more pronounced during the winter months due to strong night-time inversions and a slower developing mixing layer. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral.

Table 8: Atmospheric stability classes

Designation	Stability Class	Atmospheric Condition
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies, daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	High winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

For elevated releases, the highest ground level concentrations would occur during unstable, daytime conditions. The wind speed resulting in the highest ground level concentration depends on the plume buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speeds, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it would be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations. In contrast, the highest concentrations for ground level, or near-ground level releases would occur during weak wind speeds and stable (night-time) atmospheric conditions.

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4.1.5 Precipitation

The proposed terminal is located in the summer rainfall region of South Africa and thus receives most of its rainfall during the period of October to March, with peak rainfall occurring in the late summer months of January and February. Rainfall is not uncommon in winter when it is associated with the passage of low pressure frontal weather systems from the south-west (I.e. cold fronts).

Long term (1970 – 1990) precipitation trends for Richards Bay are presented in Figure 11.

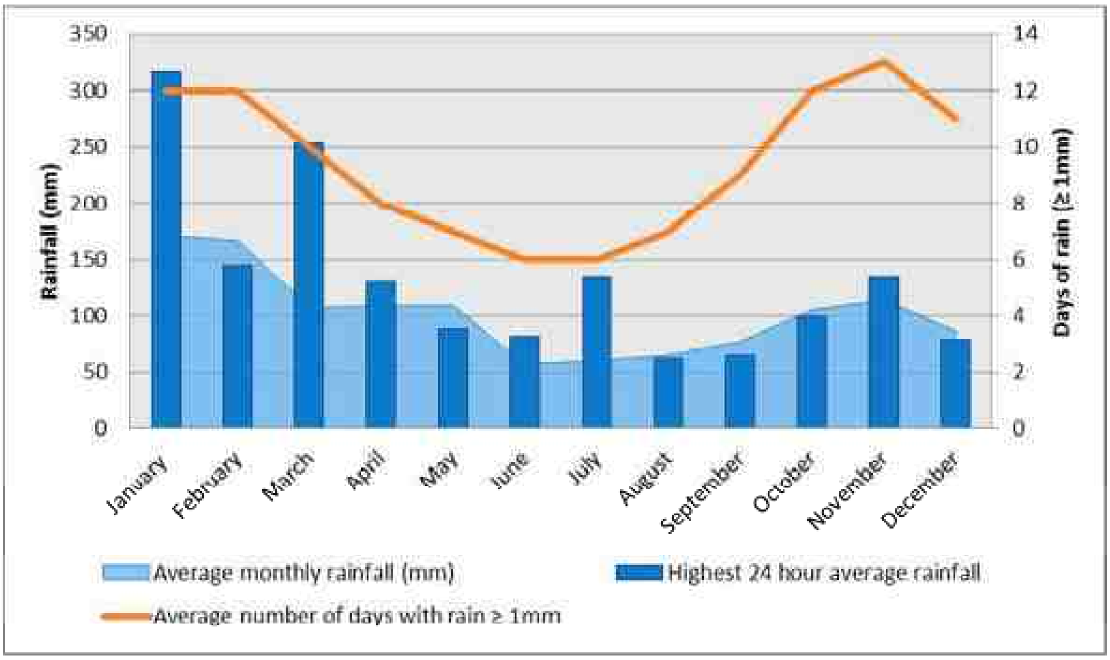

Figure 11: Long term precipitation trends in Richards Bay, based on the South African Weather Service long term data record (1970 - 1990) (www.weathersa.co.za).

4.1.6 Temperature

Ambient air temperature is a key factor affecting both plume buoyancy and the development of mixing and inversion layers. The greater the difference in temperature between the plume and the ambient air, the higher the plume is able to rise.

Air temperatures in Richards Bay are warm, to hot, for most of the year and summers are humid. In summer the average daily maximum temperature is 29°C with extremes exceeding 40°C, while in winter the average maximum temperature is 23°C with extremes in the region of 34°C. Extreme temperatures frequently occur due to berg wind conditions. Annual average relative humidity levels are 82% (08:00) and 67% (14:00), respectively. Long term (1970 – 1990) temperature trends for Richards Bay are presented in Figure 12.

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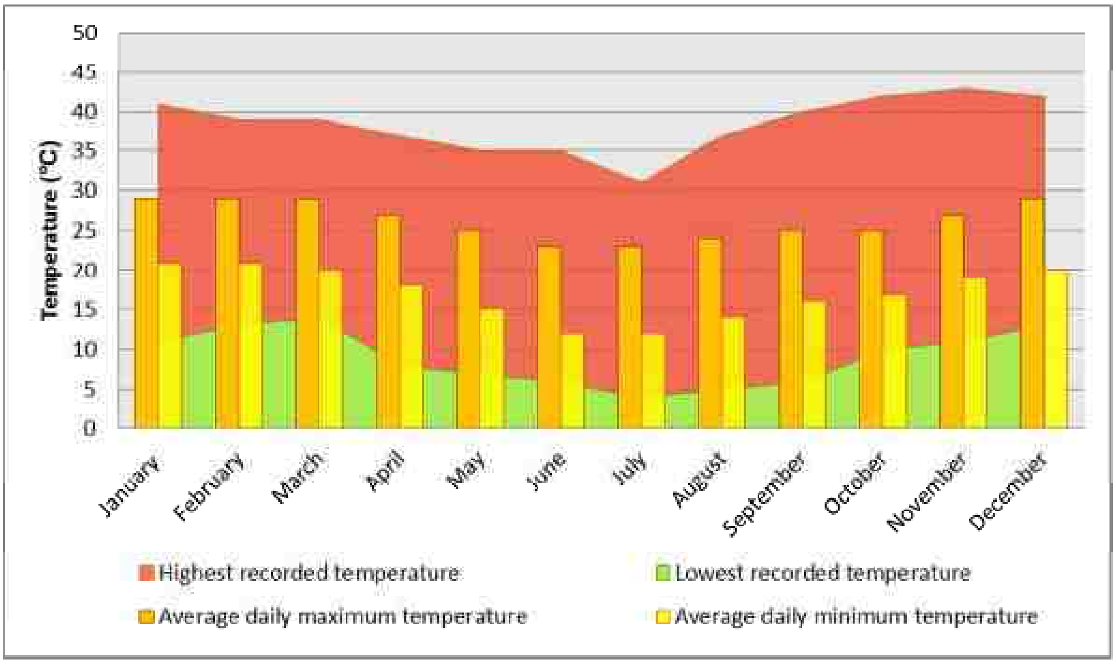

Figure 12: Long term temperature trends in Richards Bay, based on the South African Weather Service long term data record (1970 - 1990) (www.weathersa.co.za).

4.1.7 Wind speed and direction

Wind roses summarize the occurrence of winds at a specified location via representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction (16 cardinal directions). Each cardinal branch is divided into segments of different colours which represent different wind speed classes.

4.1.8 Meteorological overview - MM5 modelled meteorological data

Data for Richards bay for the period January 2011 to December 2013 was acquired from the Pennsylvania State University / National Centre for Atmospheric Research PSU/NCAR meso-scale model (known as MM5) for the dispersion modelling purposes. The meteorological overview for the site was based on the analysis of this MM5 modelled meteorological data. The analysis of the data is assumed and expected to be representative of the actual experienced meteorological conditions on site. A cross check was also undertaken against actual recorded meteorological data to determine if the modelled data has a high or low degree of confidence (Section 4.1.9).

4.1.8.1 Wind rose for the modelled period

The annual wind rose for the proposed terminal is presented in Figure 13. The average wind speed for the period was 4.24 m/s. Clear dominant wind axes are evident, with winds predicted to originate from the north-north-east (11% of the time) and north-east (10% of the time), followed by south-south-west (9%) and south-west (9%). Winds are moderate, with 3.56% calms (<1m/s).

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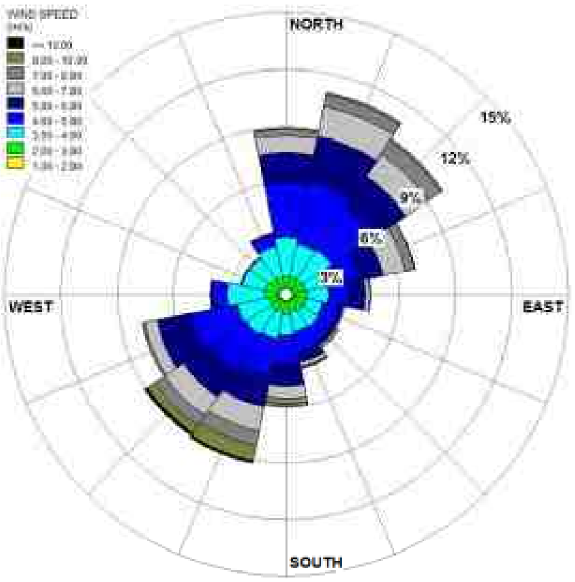

Figure 13: MM5 wind rose and wind frequency distribution for the proposed terminal for the period 2011 to 2013.

4.1.8.2 Diurnal wind roses

A diurnal variation is apparent in Figure 14, with the west-south-westerly land breeze (off shore winds) dominant in the early hours (00:00 - 06:00) and the north-north-easterly sea breeze dominant in the afternoons (12:00 – 18:00). Mornings (06:00 – 12:00) tend to be dominated by high speed south-westerly winds (>10 m/s).

4.1.8.3 Seasonal wind roses

A seasonal variation can be seen in Figure 15, with north-easterly and east-north-easterly winds dominating in summer and spring; and south-westerly and west-south-westerly winds dominating in autumn and winter. The highest frequency of calms is noted in winter (4.08%).

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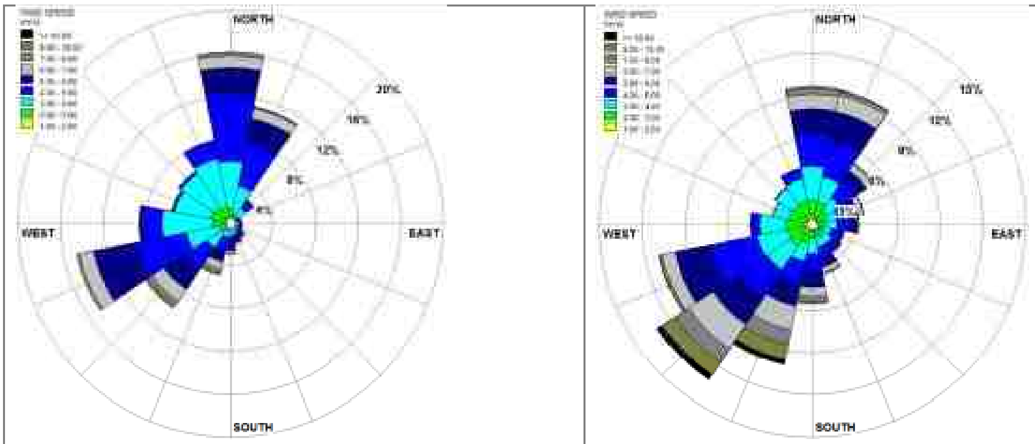
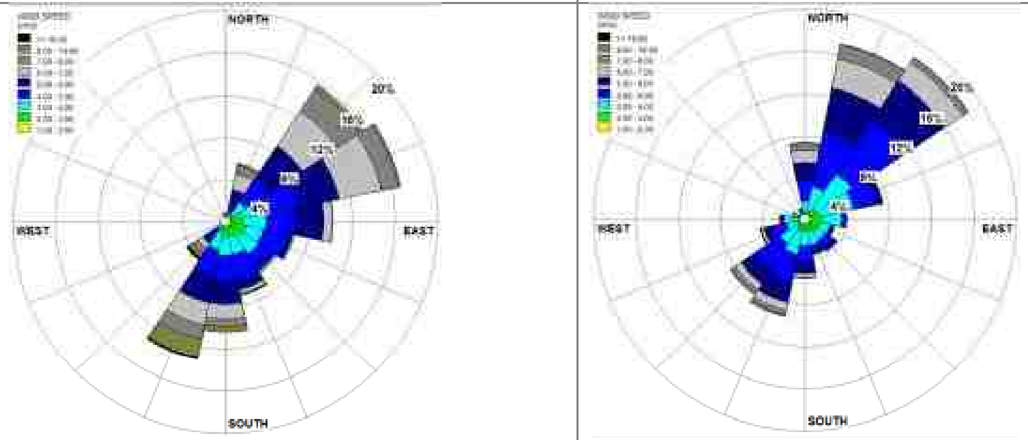


00:00 to 05:59
N 16% of the time
WSW 15% of the time
Calms: 2.65%

06:00 to 11:59
SW 13% of the time
SSW & WSW 11% of the time
Calms: 6.18%



12:00 to 17:59
ENE 17% of the time
NE 15.5% of the time
Calms: 2.83%

18:00 to 23:59
NE 18.5% of the time
NNE 17% of the time
Calms: 2.52%

Figure 14: MM5 diurnal wind rose and wind frequency distribution for the proposed Terminal for the period 2011 to 2013.

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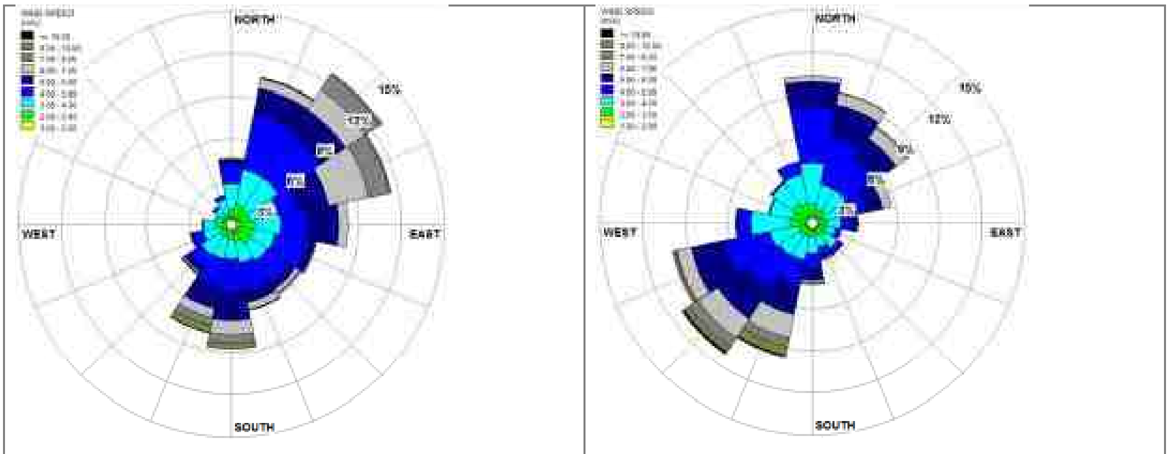
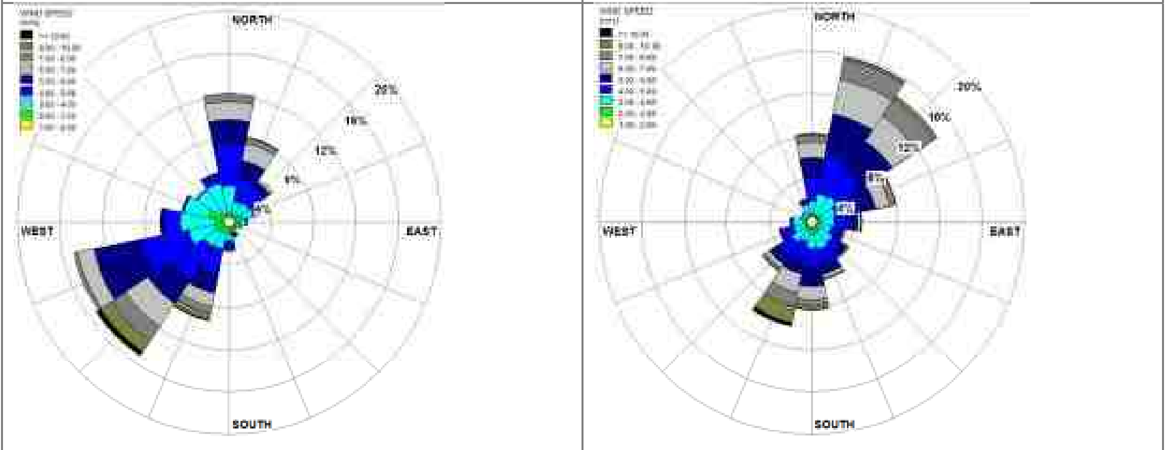


Summer (DJF)
NE 13% of the time
ENE 11.5% of the time
Calms: 3.63%

Autumn (MAM)
SW 11% of the time
N & WSW 10% of the time
Calms: 4.18%



Winter (JJA)
SW 15% of the time
WSW 14.75% of the time
Calms: 4.08%

Spring (SON)
NNE 15.5% of the time
NE 14% of the time
Calms: 2.35%

Figure 15: Modelled seasonal wind rose and wind frequency distribution for the proposed terminal for the period 2011 to 2013.

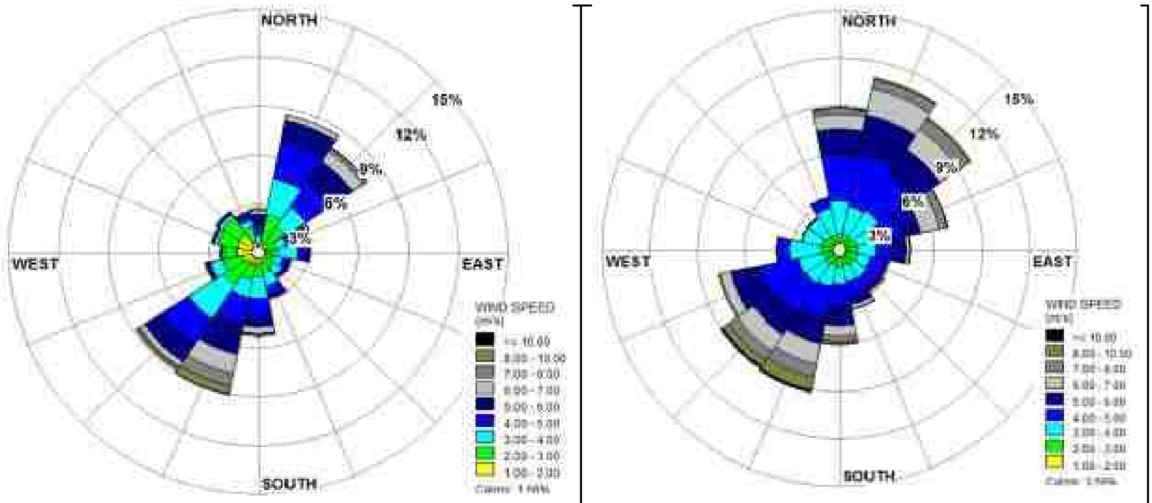
4.1.9 MM5 data cross check and confidence

The annual average wind rose for Richards Bay can be seen in Figure 16. The wind roses were taken from the Richards Bay Clean Air Association (RBCAA) 2013 Annual Report and represent the average wind speed and direction recorded at the Association's Arboretum meteorological station (28° 45' 24.295" S; 32° 3' 52.206" E). The Arboretum Station data capture statistic for 2013 was recorded as 97.5%, exceeding the 90% South Africa National Accreditation System (SANAS) requirement for data use.

The measured data shows that south-south-westerly (9%) and south-westerly (8.8%) winds dominate, followed by north-north-easterly (8.5%) and north-easterly (8%) winds. This clear dominant wind axis is mirrored in the MM5 wind rose, which indicates winds predicted to originate from the north-north-east (11% of the time) and north-east (10% of the time), followed by south-south-west (9%) and south-west (9%).

A difference in the wind class (wind speed) frequency is evident in comparing the wind roses. According to the measured data, the average wind speed recorded during 2013 was 3.54 m/s with 15.7% of winds recorded between 2 – 3 m/s. The MM5 data on the other had has a slightly higher average wind speed of 4.24 m/s with 26.6% of winds modelled between 3 – 4 m/s. The higher average modelled wind speed is however countered by the higher frequency of calms (3.56%), compared to the measured data (1.56% calms).

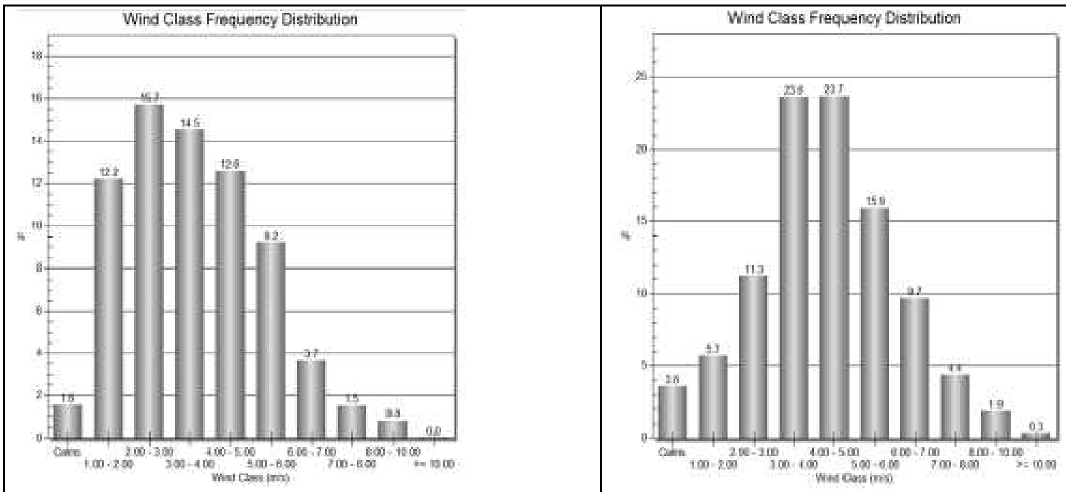
In comparing the results of the local recorded data and MM5 data, it is clear that while there are some variations, the outputs are generally consistent. These variations may be attributable to the comparatively sheltered location of the Arboretum station in Richards Bay, versus the exposed Vopak-Reatile site at the harbour mouth. A relatively high level of confidence is thus instilled in the MM5 modelled data.



Average RBCAA data measured at Arboretum for 2013

MM5 Data average for the period 2011 - 2013

Figure 16: Comparison between the RBCAA measured (2013) and MM5 (average 2011 – 2013) modelled wind rose.



Average RBCAA data recorded at Arboretum for 2013

MM5 Data average for the period 2011 - 2013

Figure 17: Comparison between the RBCAA measured (2013) and MM5 (average 2011 – 2013) wind class frequency distribution

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4.2 Baseline air quality

Industrial activities, vehicle exhaust emissions (from the N2 highway and heavy trucks), and sugar cane burning were identified as the main sources of emissions within the municipality (Thornhill and van Vuuren, 2009; SGS Environmental, 2011). The primary air pollutants are sulphur dioxide (SO_2) and fine particulate matter (PM_{10}), while fluoride has also been identified as a potential threat. The main emissions sources and associated pollutants are summarised in Table 9.

Table 9: Identified emissions sources and common pollutants in the Richards Bay area

Source	**Pollutants**									
	Carbon monoxide	**Carbon dioxide**	**Hydrogen fluoride**	**Hydrogen sulphide / Total Reduced Sulphide**	**Ammonia**	**Nitrogen oxides**	**Particulate matter**	**Sulphur dioxide**	**Sulphur trioxide**	**Volatile organic compounds**
BHP Billiton Hillside smelter	X	X	X			X	X	X		X
Exxaro Hillendale Mine and Central Processing Centre (CPC)	X	X	?			X	X	X		
Foskor fertiliser plant		X	X		X	X	X	X	X	
Island View Storage					X		X			X
Mondi Felixton and Richards Bay pulp mills	X	X		X		X	X	X		X
Richards Bay Coal Terminal (RBCT)							X			
Richards Bay Minerals Mine and Smelter Complex	X	X	?			X	X	X		
Tata Steel	X	X				X	X	X		X
Tongaat Hulett Sugar Mill		X				X	X	X		
Vehicle exhaust emissions	X	X				X	X	X		
Biomass burning (peat fires and sugar cane burning)	X	X				X	X	X		
Domestic fuel burning	X	X				X	X	X		

The Richards Bay Clean Air Association (RBCAA) monitored sulphur dioxide (SO_2) at six, particulates (PM_{10}) at six, Total Reduced Sulphur (TRS) at two and meteorology at nine locations in Richards Bay during 2013 (Figure 18).The monitoring and data collection network is robust and well maintained, with a system in place in alignment with South Africa National Accreditation System (SANAS) requirements, thus adding to the confidence and reliability of the data and results. The following sections present the results RBCAA's monitoring as presented in its 2013 Annual Report (Golder Associates, 2014).

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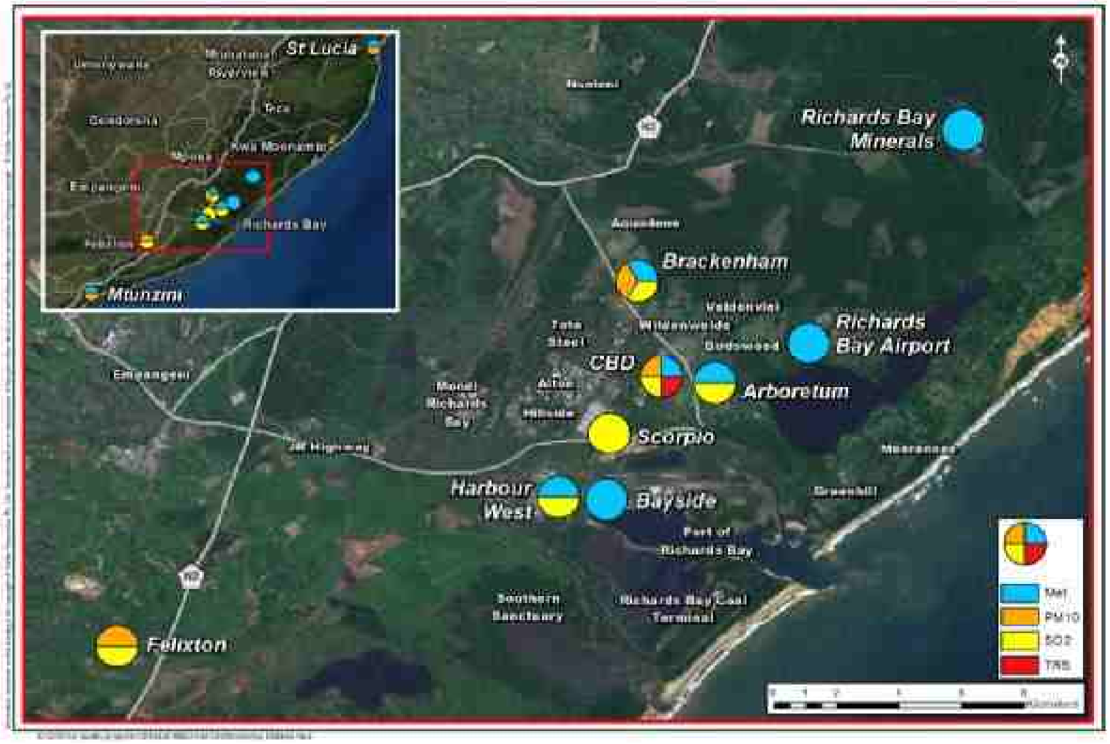

Figure 18: Location of the RBCAA monitoring stations in 2013 (RBCAA 2013 Annual Report, Golder Associates, 2014)[3]

4.2.1 PM$_{10}$

Annual average concentrations dating back to 2007 are illustrated in Figure 19. An over-all decreasing trend is noticeable over the seven year period; however 2013 annual average concentrations are higher at the Brackenham and CBD monitoring stations than those recorded in 2012.

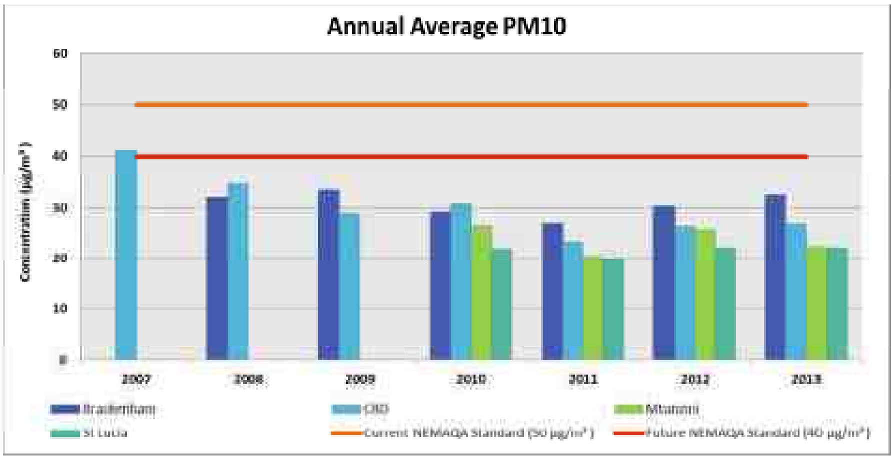

Figure 19: Annual average PM10 concentrations.

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[3] The St Lucia PM10 background monitoring station was decommissioned on 25 June 2014. A new station monitoring PM10, SO$_2$, TRS and meteorology was installed in eSikhaleni in August 2014.

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The seasonal trends in PM_{10} concentrations for 2013 are provided in Figure 20. Peaks are evident during the dry winter months, dropping in the wet summer periods.

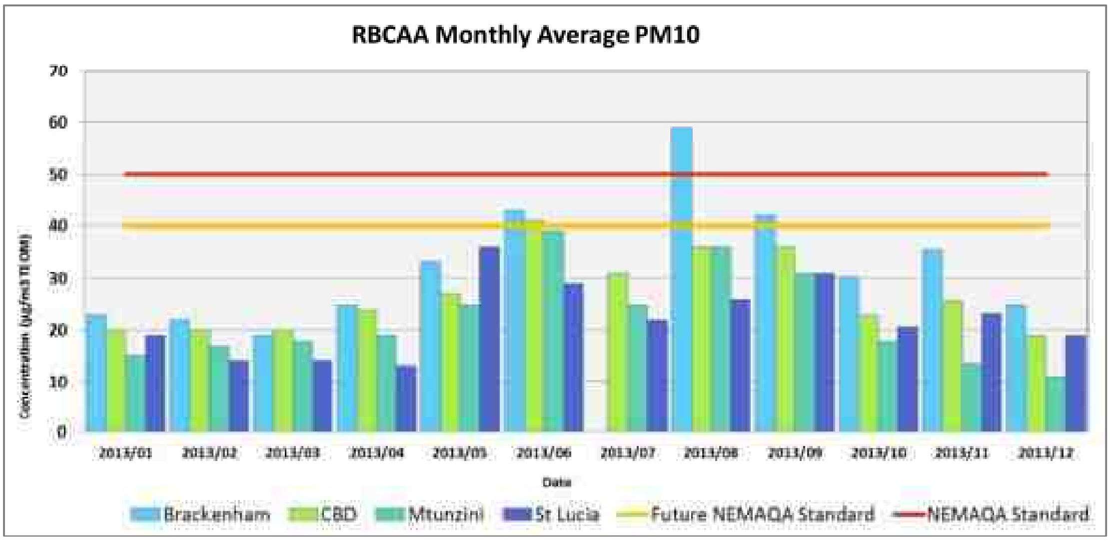

Figure 20: Seasonal trends in PM_{10} (monthly average concentrations for 2013)

Current and future annual average NEM:AQA standards were not exceeded during 2013. One (1) exceedance of the current NEM:AQA daily standard (120 µg/m³) and seven (7) exceedances of the future NEM:AQA daily standard (75 µg/m³) were recorded in 2013.

4.2.2 SO_2

Annual average SO_2 concentrations are illustrated in Figure 21. A marked increase in average annual SO_2 concentrations is evident at Scorpio over the seven year period. Harbour West displays a similar trend although to a lesser extent. The NEM:AQA Annual average standard (19 ppb) was not exceeded during 2013.

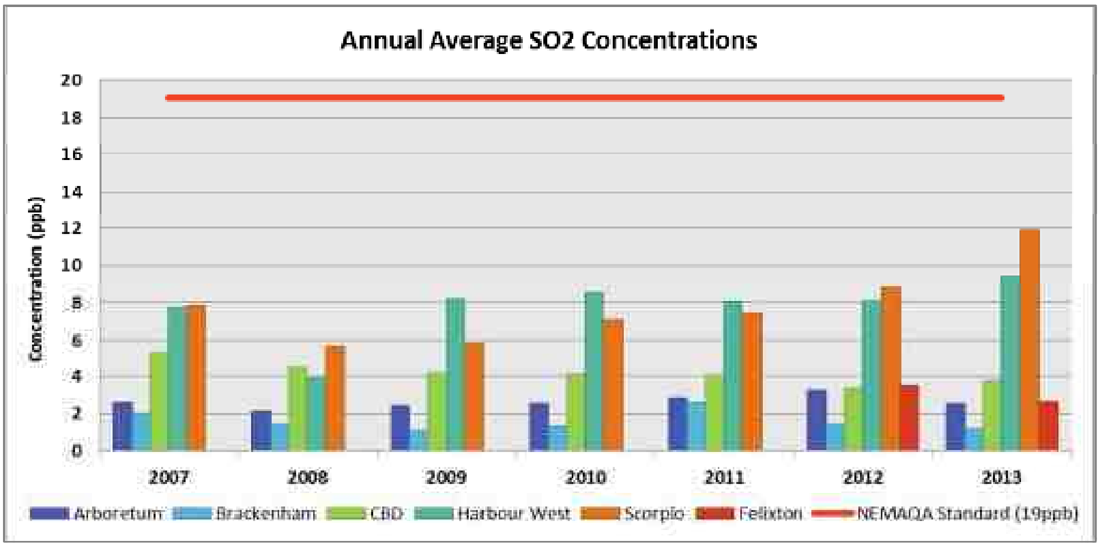

Figure 21:Inter-annual average SO_2 concentrations.

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The seasonal trends in SO_2 concentrations for 2013 are provided in Figure 22. Peaks are evident in the winter months when temperature inversions are common. Concentrations decrease in the summer months.

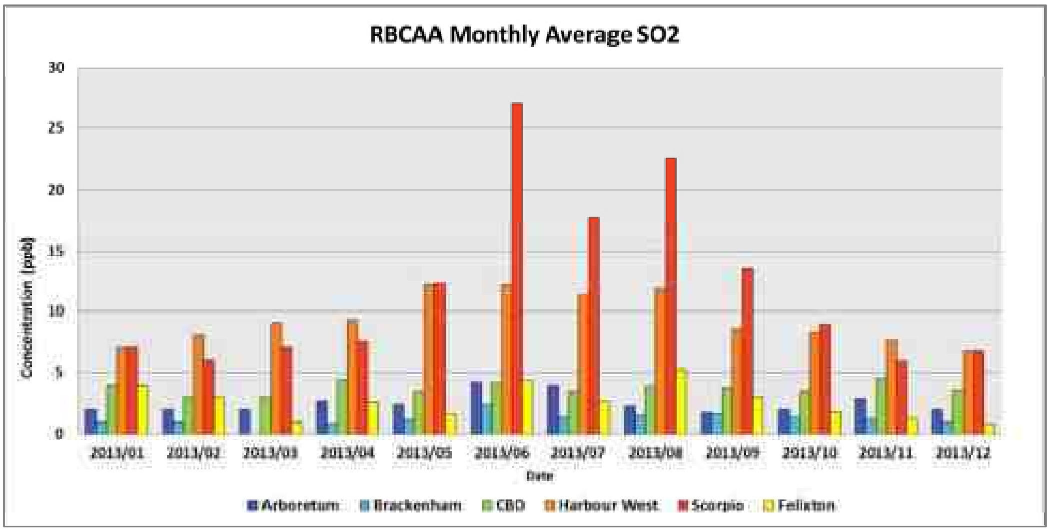

Figure 22: Seasonal trends in SO_2 (monthly average concentrations).

Ten (10) exceedances of the NEM:AQA daily average standard (48 ppb), forty eight (48) exceedances of the NEM:AQA hourly average standard (134 ppb) and sixty six (66) exceedances of the NEM:AQA 10 minute average standard (191 ppb) were recorded during 2013. All exceedances were recorded at the Scorpio Station, with the exception of one (1) which was recorded at Harbour West.

During 2013 the permissible number of exceedances for the daily standard (4) measured at Scorpio were exceeded, the station therefore does not comply with this standard.

4.2.3 TRS

Annual average TRS concentrations are illustrated in Figure 23. A marked decrease in annual average TRS concentrations is evident post 2009. Concentrations increased marginally 2012 and dropped subsequently in 2013. This is likely due to the success of Mondi's odour abatement programme.

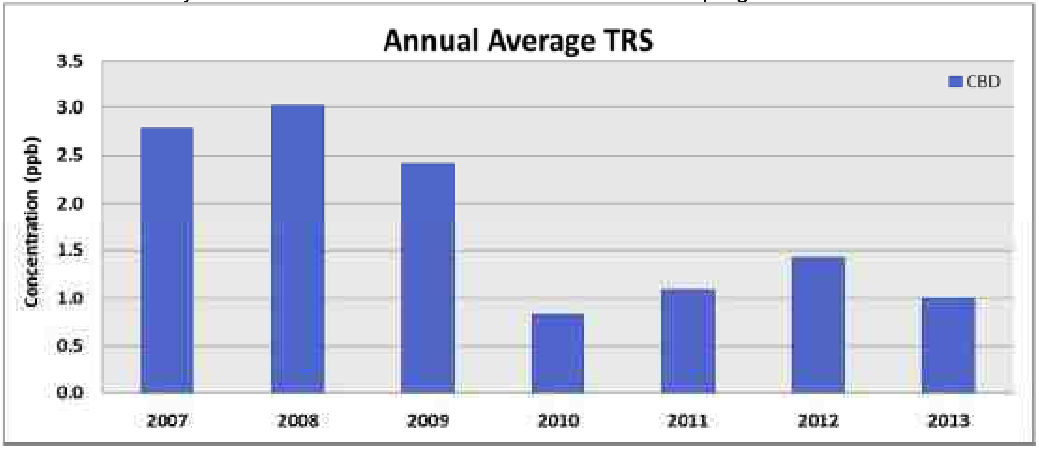

Figure 23: TRS annual average information.

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The seasonal trends for TRS concentrations in 2013 are provided in Figure 24. An over-all decreasing trend is noted in 2013, with the exception of marginally elevated levels recorded in April, May and June. Concentrations returned to baseline levels after the analyser was calibrated in June 2013.

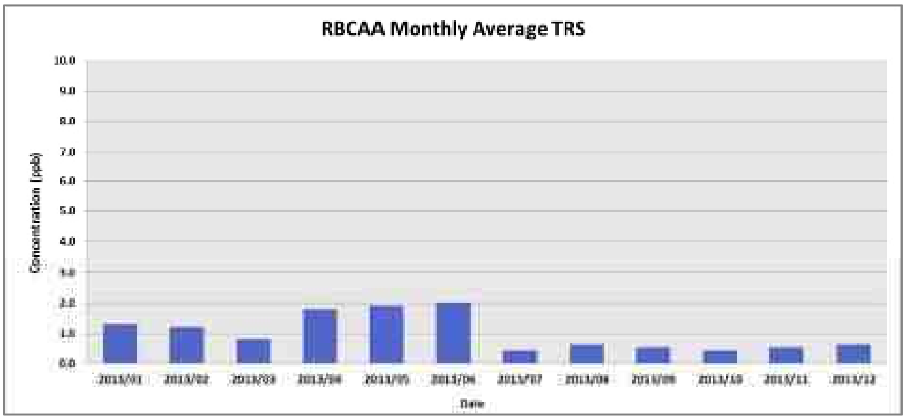

Figure 24: Seasonal trends in TRS (monthly average concentrations)

There were twenty five (25) recorded exceedances of the WHO 30-minute H_2S guideline (5.0 ppb) during 2013.

4.3 Key pollutants and associated health effects

Table 10 summarises the health effects associated with the main pollutants affecting the regional air quality, as well as those associated with the proposed Vopak-Reatile Terminal

Table 10: Key pollutants and associate health effects

Pollutant	Health effects
Carbon Monoxide	Severe hypoxia Headaches, nausea & vomiting Muscular weakness Shortness of breath Long term exposure can lead to Neurological deficits and damage
Hydrogen Sulphide	Irritation to the eyes, nose, or throat Difficulty in breathing for some asthmatics Loss of consciousness Headaches, poor attention span, poor memory, and poor motor function In extreme cases, death Does not accumulate in the body, therefore there are no long term effects.
Nitrogen dioxide	Effects on pulmonary function, especially in asthmatics Increase in airway allergic inflammatory reactions Increase in mortality
Particulate matter (TSP, PM_{10} and $PM_{2.5}$)	Airway allergic inflammatory reactions & a wide range of respiratory problems Increase in medication usage related to asthma, nasal congestion and sinuses problems Adverse effects on the cardiovascular system Increase in mortality
Sulphur dioxide	Reduction in lung function Respiratory symptoms (wheeze and cough) Increase in mortality

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Pollutant	Health effects
Volatile organic compounds (BTEX)	Adverse effects on the cardiovascular system and central nervous system Increase in mortality Long term exposure can lead to Neurological and cardiovascular system damage and Increased prevalence of carcinomas in the community
Acetone	Slight irritation to nose and pharynx at high concentration (about 1000 ppm). Concentration higher than 2000 ppm may induce sleep, nausea, vomiting, feeling of intoxication and dizziness. Concentration higher than 10000 ppm may induce unconsciousness and death. Daily exposure of 3 hours at 1000 ppm concentration for 7 to 15 years will result in nose and pharynx irritation, disorientation and weakness.
Acrylic acid	Hazardous in case of inhalation (lung corrosive). Causes nose and eye irritation, lung haemorrhage. Tests involving acute exposure of rats, mice, and rabbits have demonstrated acrylic acid to have moderate acute toxicity by inhalation or ingestion, and high acute toxicity by dermal exposure.
Butyl Acrylate	Exposure to butyl acrylate mists or vapours at levels above the recommended exposure limits may cause irritation to the respiratory tract. High exposure could result in pulmonary edema. Inhalation of mists or aerosols could result in irritation, drowsiness and headache.
Diethanolamine	Harmful if inhaled. Irritating to the nose and throat and respiratory system. Over exposure may cause coughing, difficulty in breathing and chest pains. Low inhalation hazard due to low vapour pressure unless material is heated or a mist or spray is generated.
Ethanol	Vapours may be irritating to the eyes, nose and throat. Inhalation may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of the respiratory tract, and loss of consciousness.
Ethyl Acetate	Vapour may be irritating, experienced as nasal discomfort and discharge, with headache, nausea, dizziness, unconsciousness, liver and kidney damage, and pulmonary edema.
Ethyl Acrylate	Vapours may be irritating to the eyes, nose and throat. Inhalation may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of the respiratory tract, and loss of consciousness.
Butanol	Headaches and irritation of the eyes, nose and throat
Propanol	High vapour concentrations may cause irritation of eyes and respiratory tract.
Methyl ethyl ketone	Nasal and respiratory irritation, dizziness, weakness and fatigue
Methyl isobutyl ketone	Headaches, dizziness, nausea, decreased blood pressure, changes in heart rate and cyanosis may result from over-exposure to vapour or skin exposure. Prolonged inhalation may be harmful.
Propylene glycol	A single prolonged (hours) inhalation exposure is not likely to cause adverse effects. Mists are not likely to be hazardous.
Styrene	Vapours may cause mucous membrane irritation and upper respiratory tract discomfort. High concentrations may result in headache, nausea, insensibility and other central nervous system effects. Repeated exposure to high concentrations may cause liver and kidney damage.
Triethanolamine	Vapours may cause coughing and difficulty breathing. Repeated exposure to high concentrations may cause liver and kidney damage.

5.0 EMISSIONS INVENTORY

Emissions from the proposed Vopak Reatile Terminal were based on Australian National Pollutant Inventory (NPI) emission factors for similar facilities. An emission factor is a tool that is used to estimate emissions to the environment, and this relates the quantity of substances emitted from a source to some common activity associated with those emissions, in this case emissions from the handling and storage of various liquids.

Emissions from the handling and storage of various liquids can be categorised as working and standing losses:

- Working losses are the combined loss from filling and emptying a tank. As the liquid level increases, the pressure inside the tank increases and vapours are expelled from the tank. A loss during emptying occurs when air drawn into the tank becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space.
- Standing losses occur through the expulsion of vapour from a tank due to the vapour expansion and contraction as a result of changes in temperature and barometric pressure. This loss occurs without any change in the liquid level in the tank.

A list of possible products handled and stored at Vopak Reatile as well as throughputs are provided in the table below (Table 11) (NPI, 2012).

Table 11: Products handled and stored

Product	CAS	Throughput (T/Annum)
Acetone	00067-64-1	7 000
Bitumen	08052-42-4	80 000
Bright stock	64742-54-7	1 600
Butyl Acrylate	00141-32-2	59 000
Caustic soda	01310-73-2	216 000
Di-ethanolamine	00111-42-2	414
Diesel	68334-30-5	120 000
Ethanol	00064-17-5	12 000
Ethyl Acetate	00141-78-6	5 000
Ethyl Acrylate	00140-88-5	21 000
Ethylol 95	09003-99-0	10 000
Ethylol 99	00064-17-5	10 000
Fuel Oil 360	68476-33-5	320 000
Acrylic acid	00079-10-7	2 400
Iso-Butanol	00078-83-1	5 800
Iso-Propylol	00067-63-0	25 000
LPG (propane / butane)	68476-85-7	100 000
Lube SN150	72623-86-0	3 200
Lube SN500	72623-86-0	4 800
Methyl ethyl ketone	00078-93-3	3 000
Methyl isobutyl ketone	00108-10-1	48 000
N-Butanol	00071-36-3	89 000
N-paraffin (kerosene)	64771-72-8	7 200
Petrol (ULP)	08006-61-9	120 000
Propylene glycol	00057-55-6	3 576

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Product	CAS	Throughput (T/Annum)
Sabutol	00071-23-8	2 300
Styrene	00100-42-5	600 00
Sulphuric Acid	07664-93-9	240 000
TDI	66071-12-3	3 422
Triethanolamine	00102-71-6	2 892
Triethanolamine	00102-71-6	1 421
Voralux 106	09082-00-2	3 850
Voralux HL 109	09082-00-2	2 892
Voranol 4701	25322-69-4	856
Voranol CP 6001	25322-69-4	856

Emissions associated with the handling and storage of the products at the proposed Vopak-Reatile Terminal are presented in Table 12.

Table 12: Vopak-Reatile emissions rates

Product	Emission (T/Annum)	Emission (g/s)
Acetone	7.00	0.22
Acrylic acid	0.08	0.00
Butanol	2.82	0.09
Butyl Acrylate	1.87	0.06
Di-ethanolamine	0.01	0.00
Ethanol	1.02	0.03
Ethyl Acetate	0.16	0.01
Ethyl Acrylate	0.67	0.02
Methyl ethyl ketone	0.10	0.00
Methyl isobutyl ketone	1.52	0.05
Propanol	0.79	0.03
Propylene glycol	0.11	0.00
Styrene	1.90	0.06
Triethanolamine	0.14	0.00
Benzene	0.33	0.01
Ethylbenzene	0.06	0.00
Toluene	0.35	0.01
Xylenes	0.27	0.01
Total VOC	55.88	1.77

In calculating the emissions, the following assumptions were made:

- Liquids are stored in standard vertical fixed roof (domed) tanks;
- Liquefied gasses are stored in pressurized horizontal mounded bullets;
- The storage tanks are:
  - In good condition;

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  - Well maintained; and
  - Best practice is followed in filling and extracting;
- A default maximum emission rate was used for products without emission factors;
- The vapour recovery unit for petrol is assumed to have a control efficiency of 95%;
- Emissions of LPG are accounted as part of Total VOC emissions; and
- Although small quantities of sulphur oxides are emitted from storage tank vents and tank car and tank truck vents during loading operations, from sulphuric acid concentrators, and through leaks in process equipment these emissions are not significant.

The emission inventory has the following limitations:

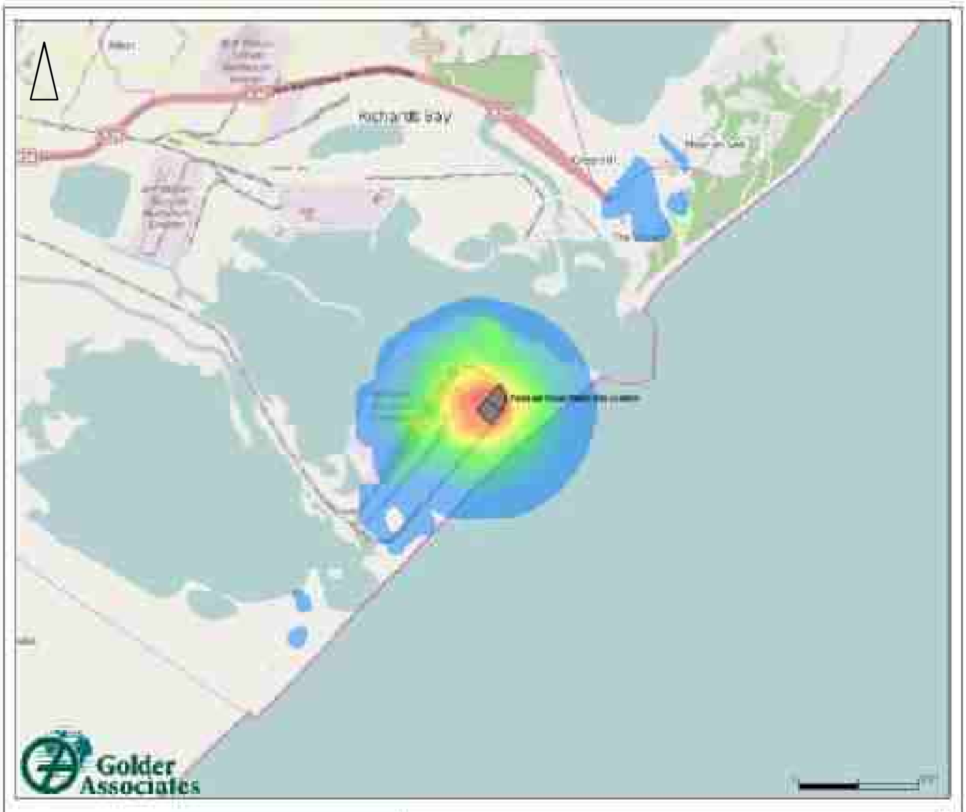
Availability of information on emissions from handling and storage of certain products such as:

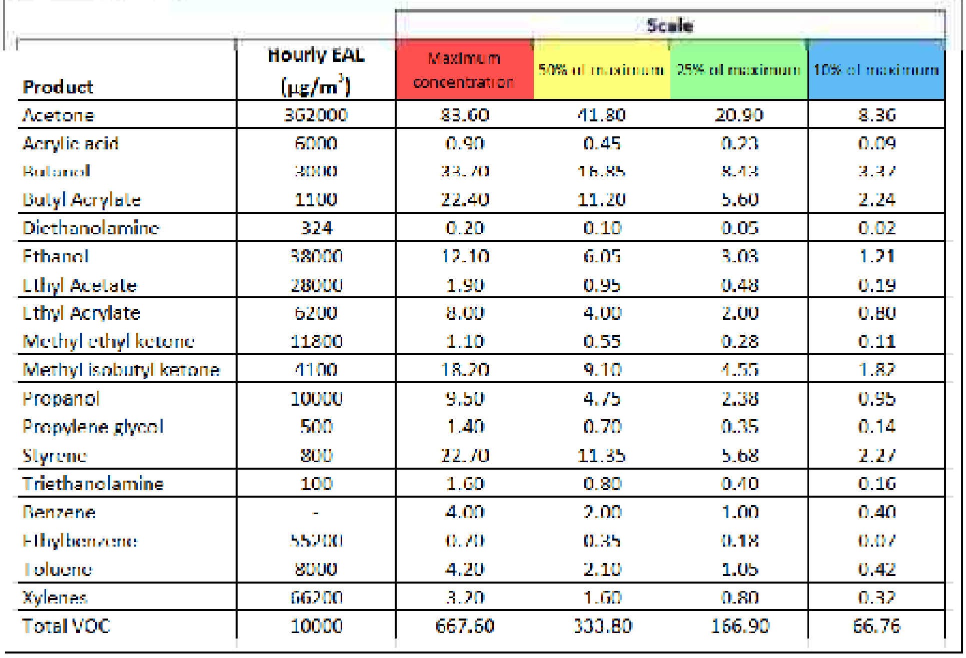
  - LPG; and
  - Sulphuric acid.

6.0 DISPERSION MODELLING

Dispersion modelling for the operation of the proposed Vopak-Reatile Terminal is presented as follows:

- Maximum hourly average concentrations for all pollutants(Figure 25); and
- Maximum annual average concentrations for all pollutants (Figure 26).





Product	Hourly EAL ($\mu g/m^3$)	Scale			
		Maximum concentration	50% of maximum	25% of maximum	10% of maximum
Acetone	362000	83.60	41.80	20.90	8.36
Acrylic acid	6000	0.90	0.45	0.23	0.09
Butanol	3000	33.70	16.85	8.43	3.37
Butyl Acrylate	1100	22.40	11.20	5.60	2.24
Diethanolamine	324	0.20	0.10	0.05	0.02
Ethanol	38000	12.10	6.05	3.03	1.21
Ethyl Acetate	28000	1.90	0.95	0.48	0.19
Ethyl Acrylate	6200	8.00	4.00	2.00	0.80
Methyl ethyl ketone	11800	1.10	0.55	0.28	0.11
Methyl isobutyl ketone	4100	18.20	9.10	4.55	1.82
Propanol	10000	9.50	4.75	2.38	0.95
Propylene glycol	500	1.40	0.70	0.35	0.14
Styrene	800	22.70	11.35	5.68	2.27
Triethanolamine	100	1.60	0.80	0.40	0.16
Benzene	-	4.00	2.00	1.00	0.40
Ethylbenzene	55200	0.70	0.35	0.18	0.07
Toluene	8000	4.20	2.10	1.05	0.42
Xylenes	66200	3.20	1.60	0.80	0.32
Total VOC	10000	667.60	333.80	166.90	66.76

Figure 25: Maximum hourly average dispersion simulations for the operation of the Vopak-Reatile Terminal.

		Scale			
Product	**Annual EAL ($\mu g/m^3$)**	🟥 Maximum concentration	🟨 50% of maximum	🟩 25% of maximum	🟦 10% of maximum
Acetone	18100	1.31	0.65	0.33	0.13
Acrylic acid	300	0.01	0.01	0.00	0.00
Butanol		0.53	0.26	0.13	0.05
Butyl Acrylate		0.35	0.17	0.09	0.03
Diethanolamine	7.8	0.00	0.00	0.00	0.00
Ethanol		0.19	0.09	0.05	0.02
Ethyl Acetate	-	0.03	0.01	0.01	0.00
Ethyl Acrylate	210	0.17	0.06	0.03	0.01
Methyl ethyl ketone	-	0.02	0.01	0.00	0.00
Methyl isobutyl ketone		0.28	0.14	0.07	0.03
Propanol	-	0.15	0.07	0.04	0.01
Propylene glycol		0.02	0.01	0.01	0.00
Styrene	800	0.35	0.18	0.09	0.04
Triethanolamine	-	0.03	0.01	0.01	0.00
Benzene	5	0.18	0.09	0.05	0.02
Ethylbenzene	4410	0.03	0.01	0.01	0.00
Toluene	1910	0.29	0.14	0.07	0.03
Xylenes	4410	0.13	0.06	0.03	0.01
Total VOC		41.29	20.64	10.32	4.13

Figure 26: Maximum annual average dispersion simulations for the operation of the Vopak-Reatile Terminal.

The results of the simulations were compared with relevant standards and are summarised in Table 13

Table 13: Summary of results from the dispersion simulations

Product	**Short term (1 hour average)**			**Long term (annual average)**		
	EAL* (µg/m^3)	**Maximum concentration**	**% of EAL**	**EAL* (µg/m^3)**	**Maximum concentration**	**% of EAL**
Acetone	362 000	83.6	0.02%	18 100	0.95	0.01%
Acrylic acid	6 000	0.9	0.02%	300	0.01	0.00%
Butanol	3 000	33.7	1.12%		0.38	
Butyl Acrylate	1 100	22.4	2.03%		0.25	
Diethanolamine	324	0.2	0.05%	7.8	0.00	0.02%
Ethanol	38 000	12.1	0.03%		0.14	
Ethyl Acetate	28 000	1.9	0.01%		0.02	
Ethyl Acrylate	6 200	8.0	0.13%	210	0.09	0.04%
Methyl ethyl ketone	11 800	1.1	0.01%		0.01	
Methyl isobutyl ketone	4 100	18.2	0.44%		0.21	
Propanol	10 000	9.5	0.09%		0.11	
Propylene glycol	500	1.4	0.27%		0.02	
Styrene	800	22.7	2.84%	800	0.26	0.03%
Triethanolamine	100	1.6	1.64%		0.02	
Benzene	-	4.0	-	5	0.04	0.90%
Ethylbenzene	55 200	0.7	0.00%	4 410	0.01	0.00%
Toluene	8 000	4.2	0.05%	1 910	0.05	0.00%
Xylenes	66 200	3.2	0.00%	4 410	0.04	0.00%
Total VOC	10 000	667.6	6.68%		7.57	

** See Section 3.0*

The results of the dispersion simulations indicated that:

- Maximum offsite long term (annual) and short term (hourly) concentrations for all pollutants did not exceed 10% of their respective guideline or standard;
- Maximum offsite long term (annual) and short term (hourly) concentrations for all pollutants occurred within 250 m of the proposed facility fence line; and that
- Concentrations of pollutants decreased by 50% within 500 m, and 75% within 1 km of the proposed facility fence line.

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7.0 IMPACT ASSESSMENT

7.1 Construction Phase

Site clearing and construction activities are significant sources of fugitive dust emissions that may have a substantial, but temporary impact on the local air quality in the vicinity of the proposed Terminal. The following possible sources of fugitive dust and particulate emissions were identified as activities which could potentially generate significant quantities of particulate matter and TSP (dust) during site clearing and construction activities:

- Site Clearing and Preparation activities:
  - Debris removal;
  - Removal of obstacles such as boulders, trees, etc.;
  - Truck loading, transport and unloading of debris;
  - Earthworks;
  - Vehicular traffic (exhaust emissions and entrainment of dust on unpaved roads);
  - Bulldozing, excavating and scraping;
  - Loading and unloading excavated material;
  - Dumping of fill material, road base, or other materials; and
  - Compacting and grading.
- Construction activities:
  - Particulate matter (soot) and gaseous emissions such as carbon monoxide, sulphur oxides, nitrogen oxides and organic compounds including polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) emissions, including:
    - Vehicle exhaust emissions associated with the operation of heavy machinery and related equipment for earthmoving and construction purposes (excavators, bulldozers, cranes, etc.) and the engines associated with such machines;
    - Exhaust emissions associated with the diesel generators required for additional electricity generation;
  - Dust and finer, fugitive particulate matter emissions associated with the following:
    - Erection of structures using steel, concrete, brick, glass, timber, and other materials;
    - Mechanical activities including grinding, hammering and drilling;
    - Metal joining and finishing including welding, brazing, soldering and other techniques;
    - Generation of solid wastes and debris, their stockpiling, transfer, and loading onto trucks or into skips;
    - Transport of building materials and supplies onto the site, and transport of wastes off site; and
    - Movement of vehicles along unpaved roadways and paths, in and out of the site and within the site, together with any establishment and maintenance of the roadways (e.g. grading).
  - Odour generation through the release of VOCs, associated with extensive applications of paints, sealants, caulking compounds, adhesives and waterproofing agents over large surface areas.

Emissions to the atmosphere from construction sites also include smoke and odour.

The quantities of dust will vary according to the intensity of activity, the type of operation and the meteorological conditions. Large particles settle out near the source causing a local nuisance problem. Fine particles can be dispersed over much greater distances. Fugitive dust may have significant adverse impacts such as reduced visibility, soiling of buildings and materials, reduced growth and production in vegetation and may affect sensitive industries and aesthetics.

These impacts will however have a short duration and will be limited to the proposed Terminal site. IVS employees, located adjacent the proposed site, are not likely to suffer health effects however the dust may become a nuisance during periods of increased activity or wind speeds. It is for these reasons; the environmental consequence of the impact is anticipated to be moderate.

The implementation of mitigation measures will reduce the magnitude of this impact, thus reducing the significance of the impact to low.

Similarly, the magnitude and duration of the degeneration of the ambient air quality due to an increase in gases (CO, NO_x, SO_x, and VOCs) and particulate matter (soot) associated with vehicle exhaust emissions is anticipated to be low.

The magnitude, duration and environmental consequence of impacts associated with the erection of structures, mechanical activities (drilling, grinding etc.), metal joining and finishing and applications of paints, sealants, adhesives etc. is anticipated to be low.

7.2 Operational Phase

The significance of the proposed Terminal’s operational impacts on the ambient air quality was simulated and quantitatively assessed. Based on this assessment, the proposed Terminal will have a negative impact on the existing ambient air quality, for the duration of its operations. The magnitude of the impact is however predicted to be low (< 10% from current conditions) and limited to the proposed Terminal site. The impact is therefore likely to have a low environmental consequence.

7.3 Decommissioning Phase

Similarly to land clearing and site preparation, decommissioning activities are likely to constitute significant, yet short lived sources of fugitive dust emissions that may have substantial, but temporary impact on the local air quality in the vicinity of the proposed Terminal. Of particular significance would be dust and particulate emissions associated with the following:

- Generation of solid wastes and debris, their stockpiling, transfer, and loading onto trucks or into skips;
- Transport of wastes off site; and
- Movement of vehicles along unpaved roadways and paths, in and out of the proposed Terminal site and within the site itself.

Particulate matter (soot) and gaseous emissions such as carbon monoxide, sulphur oxides, nitrogen oxides and organic compounds including polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs) emissions are also likely to result from heavy vehicle/machinery exhausts emissions.

Air quality impacts are, however limited to the ‘active’ phases of the proposed Terminal. Provided the proposed Terminal site is rehabilitated and potential sources of wind erosion (such as stockpiles and open/exposed areas) are re-vegetated, there will be no long term residual impact on the ambient air quality. The impact is therefore likely to have a low environmental consequence.

7.4 Cumulative impacts

Based on the information provided, the cumulative impact of the Terminal is likely to be negligible due to the following factors:

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- The site is located at the harbour mouth and is therefore often subject to wind speeds greater than 5 m/s, favouring dispersion (32% if the time);
- The site is located in excess of 2 km from the nearest residential area; and
- The predicted emissions concentrations resulting from fugitive storage and handling losses is low (i.e. less than 10%).

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Table 14: Air quality impacts

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
Demolition and debris removal (including transportation, loading and unloading)	Fugitive dust and PM emissions	Negative	Definite	Transient	Medium	Site	Reversible	Medium	Moderate	Low
Earthworks	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Vehicular traffic	Fugitive vehicle exhaust emissions (CO, SO_x, NO_x, PM and VOCs)	Negative	Definite	Short term	Low	Site	Reversible	Medium	Low	Low
	Fugitive dust and PM emissions from travelling on unpaved roads	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Vehicle and generator	Exhaust emissions	Negative	Definite	Short term	Low	Site	Reversible	Medium	Low	Low

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Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
exhaust emissions	(CO, SO_x, NO_x, PM and VOCs)									
Erection of structures	Fugitive dust and PM emissions	Negative	Definite	Transient	Low	Site	Reversible	Medium	Low	Low
Mechanical activities (drilling, grinding etc.)	Fugitive dust and PM emissions	Negative	Definite	Transient	Low	Site	Reversible	Low	Low	Low
Stockpiling, transfer, and loading of waste and building material	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Metal joining and finishing	Fugitive PM emissions	Negative	Medium	Transient	Low	Site	Reversible	Low	Low	Low
Movement of vehicles along roadways (i.e. dust entrainment on unpaved roads	Fugitive dust and PM emissions from travelling on unpaved	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
	roads									
Extensive applications of paints, sealants, adhesives etc.	Odour and VOCs	Negative	Medium	Transient	Low	Site	Reversible	Low	Low	Low
Storage losses from tanks	Volatile gas emissions	Negative	Definite	Medium term	Low	Site	Reversible	Medium	Low	Low
Working losses during product handling	Volatile gas emissions	Negative	Definite	Medium term	Low	Site	Reversible	Medium	Low	Low
Demolition of structures	Fugitive dust and PM emissions	Negative	Definite	Transient	High	Local	Reversible	Low	Moderate	Low
Stockpiling, transfer, and loading of waste	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Movement of vehicles along unpaved roadways	Fugitive dust and PM emissions	Negative	Definite	Short term	Medium	Site	Reversible	Medium	Moderate	Low
Re-vegetation	Reduction	Positive	High	Long term	Low	Site	Reversible	High	No Impact	No Impact

Impacts		Occurrence			Severity				Environmental Consequence	
		Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	Before Mitigation	After Mitigation
post closure	in fugitive dust and PM emissions								🟦	🟦

7.5 Assessment of Alternatives

7.5.1 Alternative layout and tanks design options

The site layout plan is preliminary in nature and will be optimized based on the site specific conditions, and the outcomes of the EIA process, particularly the findings and recommendations of the independent specialist studies.

Tanks planned for the proposed terminal, will be in accordance with relevant international best practice guidelines and all other applicable legislation. The final tank designs will therefore be confirmed during the final layout design process.

Whilst care has been taken to assess the potential air pollution impact from the proposed terminal, changes to the current existing designs (specifically tank dimensions), may result in different conclusions. It is therefore recommended that the proposed terminal emissions are re-modelling if and when changes occur.

7.5.2 The “No-Project” alternative

The “no-project” alternative will not alter the ambient air quality from its current state.

8.0 MITIGATION OBJECTIVES

Mitigation objectives in line with the impacts identified are outlined in the following tables:

- Table 15: Recommendations for construction;
- Table 16: Recommendations for operation; and
- Table 17: Recommendations for decommissioning and closure phase.

Recommend attainable mitigation or management actions are also provided which could be included in action plans for implementation by site staff. Quantifiable standards for measuring the effectiveness of mitigation are provided where possible.

Table 15: Recommendations for construction

Construction Phase		**Responsibility**
Objectives	■ To comply with the requirements of NEM:AQA; and ■ To reduce discomfort or nuisance effects on receptors.	***Site Manager***
Impacts:	■ Fugitive dust and PM emissions associated with: ▪ Demolition and debris removal (including transportation, loading and unloading); ▪ Earthworks; ▪ Stockpiling, transfer, and loading of waste and building material; ▪ Vehicular traffic on unpaved roads; and ▪ Material stockpiles.	
Mitigation measure(s):	■ Training the workforce in awareness of air emissions should be carried out at all levels (workers, foremen, managers) and should be included in site induction courses. Training should focus on promoting understanding as to why mitigation measures are in place;	

Construction Phase		**Responsibility**
	■ Reduce unnecessary traffic volumes by developing plans to optimise vehicle usage and movement; ■ Employ wet suppression on construction access roads using water and a suitable dust palliative to achieve the 95% control efficiency (water alone will only achieve a 75% control efficiency); ■ Institute rigorous speed control and traffic calming measures to reduce vehicle entrainment of dust. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads; ■ Use temporary windbreaks in open exposed areas and stockpiles prone to wind erosion to reduce wind speed through sheltering; and ■ Employ good housekeeping both inside and outside the construction site, including: cleaning up rubbish and debris, sweeping, hosing down stockpiles or roadways, repairing tears in hessian or shade cloth used for dust attenuation.	
Performance criteria	■ Vehicle use and movement optimisation plan; ■ Evidence of wet suppression on access roads and stockpiles; ■ Evidence of speed control (e.g. speed bumps or speed limit signage); ■ Housekeeping schedule; and ■ Use of temporary windbreaks.	
Monitoring/ Measurement	■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

Table 16: Recommendations for operation

Operational Phase		
Objectives	■ To comply with the requirements of NEM:AQA; ■ Put measures in place to align the operations with the provisions of South African guidelines on air quality; and ■ To reduce discomfort or nuisance effects on receptors.	***Responsibility***
Impacts:	■ Fugitive volatile gas emissions from storage tanks and handling	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Mitigation measure(s):	■ All installations with a throughput of greater than 50 000 m^3 per annum of products with a vapour pressure greater than 14 kPa, will be fitted with vapour recovery/ destruction units. This is considered to be a conservative approach as vapour recovery system control efficiencies typically range from 90 – 97%.	
Performance criteria	■ Compliance with the Atmospheric Emissions Licence (AEL)	

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Operational Phase		
Monitoring/ Measurement	■ Monitoring should be in compliance with the Atmospheric Emissions Licence (AEL) ■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

Table 17: Recommendations for decommissioning and closure phase

Decommissioning and closure phase		
Objectives	■ To comply with the requirements of NEM:AQA; ■ Put measures in place to align the operations with the provisions of South African guidelines on air quality; and ■ To reduce discomfort or nuisance effects on receptors.	***Responsibility***
Impacts:	■ Fugitive dust and PM emissions associated with: ▪ Stockpiling, transfer, and loading of waste and rubble; ▪ Vehicular traffic on unpaved roads; and ▪ Material stockpiles.	***Environmental control officer (ECO) or Safety Health Environmental and Quality (SHEQ) Manager***
Mitigation measure(s):	■ Training the workforce in awareness of air emissions can be carried out at all levels (workers, foremen, managers) and can be included in site induction courses. Training should focus on promoting understanding as to why mitigation measures are in place; ■ Reduction in unnecessary traffic volumes by developing plans to optimise vehicle usage and movement; ■ Wet suppression on construction access roads with water and a suitable dust palliative to achieve the 95% control efficiency (water alone will only achieve a 75 % control efficiency); ■ Rigorous speed control and the institution of traffic calming measures to reduce vehicle entrainment of dust. A recommended maximum speed of 20 km/h to be set on all unpaved roads and 35 km/h on paved roads; ■ Use temporary windbreaks in open exposed areas and stockpiles prone to wind erosion to reduce wind speed through sheltering; ■ Re-vegetation to minimise wind erosion impacts in the context of establishing self-sustaining ecosystems; ■ Traffic and movement over stabilised areas should be restricted and controlled, and damage to stabilised areas should be repaired and maintained to the satisfaction of the Environmental Manager.	
Performance criteria	■ Vehicle use and movement optimisation plan ■ Evidence of wet suppression on access roads and stockpiles ■ Evidence of speed control (e.g. speed bumps or speed limit signage) ■ Housekeeping schedule	

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Decommissioning and closure phase		
	■ Use of temporary windbreaks ■ Rehabilitation and closure plan	
Monitoring/ Measurement	■ Any complaints as to the management of on-site air quality will be directed to the site management. Complaints and any actions arising from a complaint will be recorded in a complaints register to be maintained by site management.	

9.0 RECOMMENDATIONS

Based on the available data; site clearing, construction and operation of the proposed Vopak-Reatile Terminal, will impact negatively on local ambient air quality. The overall significance of this impact is however predicted to be low, as the facility is predicted to comply with local (South African) source emission and ambient air quality standards and guidelines. Thus, there should be no detrimental impacts on sensitive receptors in the vicinity of the facility.

Since the type, volume and throughput of chemicals stored at the proposed Terminal will be dependent on market conditions, the parameters assessed in this AQIA are likely to change. It is therefore recommended that Vopak-Reatile re-assess the predicted emissions once the type, volume and throughput of chemicals, as well as vehicle, rail and ship operational details are known.

10.0 SUMMARY OF ASSUMTIONS AND LIMITATIONS

10.1 Assumptions

10.1.1 Tanks

- The facility has 41 standard vertical fixed (domed) roof tanks (Table 18).
- The facility has also 3 standard 7 200 m^3 mounded bullets for LPG, with an internal diameter of 10m.
- The total storage capacity of the site is 251 600 m^3.
- The site will be simulated as a volume source.
- The tanks are white and in good condition.
- The maximum liquid height is 90% of shell height and the average liquid level is 75% of shell height.

Table 18: Vertical domed tank dimensions

Tank Size (m³)	Number of tanks	Diameter (m)	Height (m)	Diameter (ft)	Height (ft)
1 000	19	11.2	12.2	36	40
1 500	4	13.4	11.5	44	37
5 000	9	24.4	12.2	80	40
10 000	2	36.6	9.8	120	32
20 000	7	45.7	12.2	150	40

10.1.2 Products

- The products handled at the facility are shown in APPENDIX A;
- Products aren’t mixed and have dedicated tanks;

- The CAS numbers indicated relate to the products handled;
- Certain products have no storage facility and/or throughput (yellow and orange highlight). The throughput indicated is in metric tons per year (mt/yr); and
- The total throughput of the site is 1 592 479 mt/yr.

10.1.3 Mitigation measures

- All installations with a throughput of greater than 50 000 m^3 per annum of products with a vapour pressure greater than 14 kPa, will be fitted with vapour recovery/ destruction units. This is considered to be a conservative approach as vapour recovery system control efficiencies typically range from 90 – 97%;
- Vapour recovery/ destruction units will not exceed the emission limits set out in the Table 19;
- For road tanker and rail car loading/ offloading facilities (where the throughput is less than 50 000 m^3 per annum and where ambient air quality is, or is likely to be impacted) all liquid products will be loaded using bottom loading, or equivalent with the venting pipe connected to a vapour pressure balancing system; and
- Where vapour balancing and/or bottom loading is not possible, a recovery system using absorption, condensation or incineration of the remaining VOC’s with a collection efficiency of at least 95%, will be fitted.

Table 19: Vapour recovery/ destruction emissions limits

Technology	mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa
Total volatile organic compounds from vapour recovery / destruction units using **thermal treatment**	150
Total volatile organic compounds from vapour recovery/ destruction units using **non-thermal treatment**	40 000

10.2 Limitations

- Emissions from road vehicles, trains and ships during loading/ unloading were not considered in this assessment;
- Dispersion models are limited in their inability to account for highly complex rapidly varying spatial and temporal meteorological systems such as calms; coastal fumigation, sea/land breeze recirculation, and mountain and valley winds, especially where complex terrain is involved. The USEPA considers the range of uncertainty to be -50% to 200% for models applied to gently rolling terrain. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions. Dispersion modelling results can be compared with monitored values in order to improve the accuracy of, or “calibrate” models.
- Whilst care has been taken to assess the potential air pollution impact from the proposed Vopak Reatile Terminal, changes to the current existing designs, throughputs, etc. after this assessment may result in different conclusions;
- No site specific monitoring data was available, therefore reliance is placed on regional monitoring data; and
- No emission data from the surrounding industries was available for inclusion in the simulations.

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APPENDIX A

Products Handled

Table A: Products

Product	CAS	Tank Type	Number of Tanks	Volume (m³)	Tank Size (m³)	Throughput (mt/yr)
2-Ethylhexyl acrylate	00103-11-7	-	0	0	1 500	0
Acetone	00067-64-1	Vertical	1	1 500	1 500	7 000
Benzene	68476-50-6	-	0	0	1 500	0
Bitumen	08052-42-4	Vertical	2	10 000	5 000	80 000
Bright stock	64742-54-7	Vertical	1	1 000	1 000	1 600
Butyl Acrylate	00141-32-2	Vertical	2	10 000	5 000	59 000
Caustic soda	01310-73-2	Vertical	2	40 000	20 000	216 000
DEA	00111-42-2	Vertical	1	1 000	1 000	414
Diesel	68334-30-5	Vertical	1	10 000	10 000	120 000
Diethylene glycol	00111-46-6	-	0	0	1 500	0
Ethanol	00064-17-5	Vertical	1	1 500	1 500	12 000
Ethyl Acatate	00141-78-6	Vertical	1	1 000	1 000	5 000
Ethyl Acrylate	00140-88-5	Vertical	1	1 500	1 500	21 000
Ethylol 95	09003-99-0	Vertical	1	1 000	1 000	10 000
Ethylol 99	00064-17-5	Vertical	1	1 000	1 000	10 000
Fuel Oil 360	68476-33-5	Vertical	2	40 000	20 000	320 000
GAA(Glycol Acrylic Acid)	00079-10-7	Vertical	1	1 000	1 000	2 400
Iso-Butanol	00078-83-1	Vertical	1	1 000	1 000	5 800
Isopropylol	00067-63-0	-	0	0	0	25 000
LPG	68476-85-7	Horizontal	3	21 600	7 200	100 000
Lube SN150	72623-86-0	Vertical	1	1 000	1 000	3 200
Lube SN500	72623-86-0	Vertical	1	1 500	1 500	4 800
MEK	00078-93-3	Vertical	1	1 000	1 000	3 000
MIBK	00108-10-1	Vertical	2	10 000	5 000	48 000
N-Butanol	00071-36-3	Vertical	2	10 000	5 000	89 000
N-paraffin	64771-72-8	Vertical	1	1 000	1 000	7 200
Petrol	08006-61-9	Vertical	1	10 000	10 000	120 000
PGI	00057-55-6	Vertical	1	1 000	1 000	3 576
Sabutol	00071-23-8	Vertical	1	1 000	1 000	2 300
Styrene	00100-42-5	Vertical	1	5 000	5 000	60 000
Styrene Monomer	00100-42-5	-	0	0	0	0
Sulphuric Acid	07664-93-9	Vertical	3	60 000	20 000	240 000
TDI	66071-12-3	Vertical	1	1 000	1 000	3 422
TEA	00102-71-6	Vertical	1	1 000	1 000	2 892
TEA (Commercial)	00102-71-6	Vertical	1	1 000	1 000	1 421
Voralux 106	09082-00-2	Vertical	1	1 000	1 000	3 850
Voralux HL 109	09082-00-2	Vertical	1	1 000	1 000	2 892
Voranol 4701	25322-69-4	Vertical	1	1 000	1 000	856
Voranol CP 6001	25322-69-4	Vertical	1	1 000	1 000	856

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APPENDIX B

Document limitations

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APPENDIX F

Terrestrial Ecology Impact Assessment Specialist Study

January 2015

TERRESTRIAL ECOLOGY ASSESSMENT

ESIA for the Proposed Vopak-Reatile Terminal Richards Bay Bulk Liquid Storage and Handling Facility

Submitted to:
Public Review

DEDTEA Reference Number: DC28/0001/2014 KZN/EIA/0001388/2014

REPORT

Report Number: 13614921-13292-5

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd. (Golder) was appointed by Vopak South Africa Developments (VSAD), a joint venture between Royal Vopak and Reatile Resources, to conduct an Environmental Impact Assessment (EIA) for the proposed bulk storage terminal known as the Vopak-Reatile Terminal Richards Bay.

In order to meet Environmental Authorisation requirements for an EIA, amongst others, in terms of the National Environmental Management Act (Act No. 107 of 1998) (NEMA), an ecological impact assessment was required to advise the EIA. Golder's Ecology Division was appointed to conduct the ecological baseline and impact assessment for the project, with additional ecological input from ACER (Africa) Environmental Management Consultants (ACER). This report details the approach, methodology and findings of the study.

1.1 Background information

Golder's understanding of the project is that the Vopak-Reatile Terminal Richards Bay will be a green field's development, situated on land awarded to Vopak Reatile by the Transnet National Ports Authority (TNPA) in 2012. The area under investigation for this study consists of two parcels of land; Lot 4 (covering approximately 7.7 Ha) and Lot 5 (covering approximately 7.8 Ha). Both lots are located on the southern bank of the Richards Bay harbour mouth (Figure 1). The proposed terminal will be developed in phases and will store a combination of LPG, CPP and chemicals.

2.0 PROJECT OBJECTIVES

The objectives of the terrestrial ecosystems assessment are to:

- Present a description of the study area's existing flora and fauna characteristics;
- Identify sites and species of conservation importance that occur, or potentially occur, in the study area, or that may be affected by the proposed project;
- Identify and assess potential negative ecological impacts associated with the proposed project; and
- Recommend management measures to mitigate negative ecological impacts.

2.1 Legal requirements

Environmental legislation and guidelines, applicable to the terrestrial ecosystems assessment, are listed below:

National Environmental Management: Biodiversity Act (Act No. 10 of 2004);

According to the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEM:BA), a person may not carry out a restricted activity involving a specimen of a listed threatened or protected species, without the necessary permit from Ezemvelo KwaZulu-Natal Wildlife (EKZNW) or the Department of Agriculture, Forestry and Fisheries (DAFF). Restricted activities include, among others, hunting, catching, capturing or killing; as well as gathering, collecting, damaging or destroying any threatened or protected species.

National Environmental Management: Air Quality Act (Act No. 39 of 2004);

The National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEM:AQA) approach to air quality management is based on the control of the receiving environment. The main objectives of the Act are to protect the environment by providing reasonable legislative and other measures that (i) prevent air pollution and ecological degradation, (ii) promote conservation and (iii) secure ecologically sustainable development and use of natural resources. Of particular relevance to the proposed project is the National Dust Control Regulations. The dust fall standard defines acceptable dust fall rates in terms of the presence of residential areas.

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Natal Nature Conservation Ordinance (No. 15 of 1974) and the KwaZulu Nature Conservation Act (Act No. 29 of 1992);

In terms of the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu Nature Conservation Act (Act No. 29 of 1992), no person shall, among others: damage, destroy, or relocate any specially protected indigenous plant, except under the authority and in accordance with a permit from EKZNW.

Conservation of Agricultural Resources Act (Act No. 43 of 1983);

The Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA), as amended, provides for control over the utilization of natural agricultural resources. Section 6 of the Act makes provision for control measures to be applied in order to achieve the objectives of the Act, these measures relate to, among others: utilization and protection of wetlands; the regulating of the flow pattern of run-off water; the utilization and protection of vegetation; the control of weeds and invader plants; and the restoration or reclamation of eroded land or land which is disturbed or denuded.

CARA defines different categories of alien plants. Category 1 weeds are prohibited and must be controlled; Category 2 declared invader plants are allowed in demarcated areas under controlled conditions and under a permit; and Category 3 alien plants are mostly ornamental plants having escaped from gardens, but are proven invaders, and may no longer be planted except under a permit from DAFF. Several listed invasive species were observed on site and these species should be controlled as part of the EMPR.

National Water Act (Act No. 36 of 1998);

The purpose of the National Water Act (Act No. 36 of 1998) (NWA) is to ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors: protecting aquatic ecosystems and their biodiversity; and reducing and preventing pollution and degradation. A Water Use License (WUL) would be required from the Department of Water and Sanitation to carry out any activity involving modifications to watercourses or wetlands as well as the bed or banks of the wetland. Hence, any infrastructure located within a wetland, or 500 m from its edge will require a WUL from the Department of Water and Sanitation and letters of approval from the City of uMhlathuze and uThungulu District Municipality.

National Environmental Management Act (Act No. 107 of 1998);

The National Environmental Management Act (Act No. 107 of 1998) (NEMA) requires impacts on biodiversity to be avoided or, when they cannot be altogether avoided, to be minimized and remedied. Biodiversity offsets should be considered for any and all land use changes that could have a significant adverse impact on biodiversity.

Integrated Coastal Management Act (Act No. 24 of 2008);

The Integrated Coastal Management Act (Act No. 24 of 2008) (ICMA) emanates from the White Paper for Sustainable Coastal Development in South Africa and proposes inter alia establishing a system of integrated coastal and estuarine management. This legislation firmly establishes integrated coastal management as the preferred vehicle for the promotion of sustainable coastal development in South Africa. This is promoted through directives in terms of the conservation and maintenance of the natural attributes of the coastal environment concomitant with development that is both sustainable, and socially and economically justifiable. It defines the rights and responsibilities of all coastal stakeholders including those of organs of state and gives effect to South Africa’s international responsibilities in respect of coastal pollution. The Act aims to facilitate the implementation of the principles and guidelines presented by the White Paper and have a number of objectives including:

- The provision of a legal and administrative framework to promote cooperative, coordinated and integrated coastal management;
- The protection of the natural coastal environment as a national heritage;
- The management of coastal resources in the interests of the whole community;

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- The promotion of equitable access to the resources and benefits provided by the coast; and
- The fulfilment of South Africa’s obligations under international law.

uMhlathuze Municipality Spatial Development Framework (2007)

The Spatial Development Framework (SDF) for the City of uMhlathuze recognizes that development should integrate social, economic, institutional and environmental aspects. Sensitive, vulnerable, highly dynamic or stressed ecosystems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

The detrimental environmental impacts of economic growth and development should be mitigated as far as possible. This does not mean that economic growth and development should not take place or that environmental management and conservation not be implemented, but rather that there should be a balance between the two. This would also mean that there will be areas of trade-off between the two.

uMhlathuze Environmental Services Management Plan.

The uMhlathuze Environmental Services Management Plan (ESMP) focuses on planning and management of natural assets at a municipal level. Ecosystem services are critical to the functioning of the Earth’s life-support system. These natural environmental services make an important contribution to the economy of the uMhlathuze Municipality. The ESMP aims, among others, to assist in meeting biodiversity conservation targets as set by EKZNW. Four levels of environmental service supply and management zones are recognised:

- Nature reserves (Level 1): includes areas of biodiversity or environmental significance such as estuaries, lakes, major wetlands, natural forests, coastal buffers and critically endangered habitats that are protected in terms of legislation and should be declared as nature reserves.
- Conservation zone (Level 2): includes areas of biodiversity or environmental significance. No development of land for purposes other than conservation should be permitted in this zone.
- Open Space Linkage Zone (Level 3): provides a natural buffer for Level 1 and 2 zones. Transformation of natural assets and the development of land in these zones should only be permitted under controlled conditions.
- Development Zone (Level 4): areas are either already developed or transformed and are not critical for environmental service supply. This zone should be developed in a manner that supports, or at least does not adversely impact on, the sustainability of environmental service supply in Level 1, 2 and 3 zones.

Figure 1: Regional location of study area.

3.0 APPROACH

The terrestrial ecology assessment included an ecological characterisation phase, followed by an impact assessment phase. The ecological characterisation phase comprised a desktop literature review component, as well as a field programme that included fauna and flora sampling. The impact assessment was informed by the findings of the ecological characterisation, and assessed the significance of potential impacts. Thereafter, appropriate mitigatgion measures for identified for inclusion into the project's EMP.

4.0 ASSUMPTIONS AND LIMITATIONS

Limitations of this study are as follows:

- The results of this study are based on a literature study and two field surveys. The first field surveywas conducted from 10 - 14th March 2014 by Golder. The second was conducted from 9 - 11th September 2014 by ACER;
- Due to the complexities of ecological systems and the sensitive dependence on initial conditions, predictions of the effects of perturbation are made with very low confidence;
- The fact that a species is not recorded during a survey (or surveys) cannot support the assumption that the species in question does not occur in the area. It can only indicate a decreased probability of the species being present. This is particularly pertinent if the species has been recently recorded in the area;
- The maps and drawings produced for the purposes of this report are to be used for the purposes of this report only and cannot be used for design purposes;
- GPS co-ordinates are accurate to within 15 m and lines drawn on maps can only be assumed to be accurate to within a distance of 200 m;
- Data obtained from published articles, reference books, field guides, official databases or any other official published or electronic sources are assumed to be correct and no review of such data was undertaken by Golder; and
- Ecological studies are usually undertaken over a period of a number of seasons or years in order to obtain long term significant ecological data. Studies are usually conducted in this way in order to eliminate the effects of unusual climatic conditions or other unusual conditions prevailing at the study area during the time of study. Due to time and budget constraints in the case of the kind of study undertaken for the purposes of this report, such long term studies are impossible and conclusions are drawn from data collected over a much shorter time period and may be subject to data skewed by the abovementioned unusual conditions if such conditions were to occur in the area.

5.0 METHODOLOGY

The tasks and methods associated with the desktop literature review and the field programme components are detailed in Sections 5.1 and 5.2.

5.1 Literature Review

5.1.1 Vegetation

Mucina and Rutherford (2006) and ACER (2013), as well as other relevant literatures sources were consulted to develop an understanding of the broader vegetation characteristics of the Richards Bay area and the habour peninsula on which the sudy area is located. Vegetation data for the 2832CC quarter degree grid square as presented on SANBI's SIBIS (Version 2) database and the EKZNW database (2011b) were obtained to develop plant species lists for the site.

5.1.2 Arthropoda

A list of expected arthropod species list was compiled by consultation of a number of literature sources relevant to the study area including the EKZNW database data for the 2832CC quarter degree grid square (EKZNW, 2011b). Field guides such as Picker *et al* (2002) were also consulted during the compilation of the expected species list.

5.1.3 Reptiles

An expected reptile species list was compiled by consultation of a number of literature sources relevant to the study area, including the EKZNW database data (EKZNW, 2011b) and ACER (2013). Field guides such as Branch (1996), as well as the MSc. thesis by Maritz (2007), were consulted during the compilation of the expected species list.

5.1.4 Amphibians

An expected amphibian species list was compiled by consulting the EKZNW database data (EKZNW, 2011b), ACER (2013), Du Preez and Carruthers (2009), and the MSc Thesis by Maritz (2007).

5.1.5 Birds

A list of expected bird species was compiled by consulting the EKZNW database (EKZNW, 2011b), Harrison, et al. (1997a), Sinclair et al. (2002) and ACER (2013).

5.1.6 Mammals

A list of expected mammal species was compiled by consulting the EKZNW database (EKZNW, 2011b) and literature sources such as Smithers (1983), ACER (2013), and the field guide by Stuart and Stuart (2007)

5.2 Field Methodology

5.2.1 Vegetation Surveys

Satellite imagery of the area was consulted as a first approximation of the plant communities within the study area. Plant communities were roughly delineated based on the satellite imagery and previous studies were consulted in order to determine the vegetation type. In order to study the vegetation in greater detail relevés (sample plots) were selected according to vegetation types identified. Relevé data was collected in the field by means of point transects (for species occurring in the herbaceous layer) and belt transects (for tree and shrub species and lianas).

Species that were not identified in the field were sampled or photographed for identification at a later stage by consulting literature sources. Vegetation data was collected by Golder from 10 - 14th March 2014 and by ACER from 9 - 11th September 2014, and refereced as ACER pers. comm. (2014).

5.2.2 Fauna surveys

Fauna sampling sites were selected on completion of the initial vegetation assessment in order to encompass all of the possible habitats found on site, as well as concentrate on sites which will either be directly affected by the proposed project, or be likely to host increased diversity or protected / Red Data species. Field work was conducted on site by Golder for 5 days from the 10th - 14th March 2014 and by ACER from 9 - 11th September 2014.

Arthropoda

Surveying techniques for anthrpods included the following:

- Pitfall traps were set out in a 10 m x 10 m grid within each of the selected sites;
- Sweep netting was conducted where vegetation was appropriate for this technique. Transects of 50 m were swept for arthropods at each site.

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- Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching in suitable habitats (rocks, logs, artificial cover, leaf litter, artificial litter, bark, leaf axils, etc), and scanning sites where specimens were likely to be found.

Reptiles

The following survey techniques were used to sample for reptiles:

- Roads and paths on the site were traversed during the day. Emphasis was placed on attempting to find *Bradypodion setaroi* (Setaro's Dwarf Chameleon), which may occur in the area; and

- Active searching was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching all suitable habitats (rocks, logs, artificial cover, leaf litter, artificial litter, bark, leaf axils, etc), and scanning basking sites and places where specimens were likely to be found.

Amphibes

Amphibian sampling included active searchers, which was conducted at each of the fauna survey sites. Active searching was conducted on foot and included searching suitable habitat types (leaf litter, artificial litter, pools, streams, etc.), and scanning basking sites and places where specimens were likely to be found.

Birds

The avian surveys were conducted by means of point counts of 15 minutes each (Bibby et al, 1993). During the survey, bird species were identified, and where necessary, identifications were verified using Sasol Birds of Southern Africa, 3rd ed. (Sinclair *et al*. 2002). Particular attention was paid to suitable roosting, foraging and nesting habitats for Red Data species.

Mammals

Small mammals were trapped by means of ten Sherman traps placed in a single grid, at each of the fauna survey sites. The data collected during Sherman trapping was augmented by surveys of tracks, signs and other evidence of small or large mammal activity.

The mammal sensitivity assessment was based on the suitability of available habitat for species of particular conservation concern. The sensitivity of the mapped habitats was then assessed in terms of how the potential impacts of the proposed project would alter the state of the habitat and therefore the continued presence of the particular species.

5.3 Red Data/Protected Species Analysis

To assess the Red List and / or protected status of species recoded or potentially occurring in the study area, the following sources were consulted:

- National Environmental Management: Biodiversity Act (NEM:BA) (Act No. 10 of 2004) - Threatened or Protected Species List (Notice 389 of 2013) (NEM:BA TOPS List 2013);

- International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (2014.2) – Regional Statuses (i.e. South African Red Data Lists);

- National Forests Act (Act No. 84 of 1998) – List of Protected Tree Species; and

- KwaZulu-Natal Nature Conservation Management Amendment Act (Act No. 5 of 1999).

The following parameters were then used to assess the probability of occurrence of each of the Red Data species:

- Habitat requirements (HR): Most Red Data animals have very specific habitat requirements and the presence of these habitat characteristics in the study area was evaluated;

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- Habitat status (HS): The status or ecological condition of available habitat in the area was assessed. Often a high level of habitat degradation prevalent in a specific habitat will negate the presence of Red Data species (this is especially evident in wetland habitats); and
- Habitat linkage (HL): Movement between areas for breeding and feeding forms an essential part of the existence of many species. Connectivity of the study area to surrounding habitat and the adequacy of these linkages are evaluated for the ecological functioning of Red Data species within the study area.

Probability of occurrence is presented in four categories, namely:

- Low;
- Medium;
- High; and
- Recorded.

5.4 Floristic Sensitivity Analysis

Floristic sensitivity analysis was determined by assessing the ecological function and conservation importance of the vegetation, as defined in Table 1.

Table 1: Floristic sensitivity assessment criteria

	Ecological integrity	**Conservation importance**
High	Sensitive ecosystems with either low inherent resistance or resilience towards disturbance factors or highly dynamic systems considered to be stable and important for the maintenance of ecosystems integrity (e.g. pristine grasslands, pristine wetlands and pristine ridges).	Ecosystems with high species richness and which provide suitable habitat for a number of threatened species. Usually termed ‘no-go’ areas and unsuitable for development, and should be protected.
Moderate	Relatively important ecosystems at gradients of intermediate disturbances. An area may be considered of medium ecological function if it is directly adjacent to sensitive/pristine ecosystem.	Ecosystems with intermediate levels of species diversity without any threatened species. Low-density development may be allowed, provided the current species diversity is conserved.
Low	Degraded and highly disturbed systems with little or no ecological function.	Areas with little or no conservation potential and usually species poor (most species are usually exotic).

The study area was delineated according to plant communities and these communities were assessed according to the criteria described in Table 1. Each communities was then given a Ecological Integrity rating of High, Moderate or Low and an Conservation importance rating of High, Moderate or Low.

5.5 Impact Assessment Methodology

The significance of the identified impacts will be determined using the approach outlined in Table 2. This incorporates two aspects for assessing the potential significance i.e. occurrence and severity, which are further sub-divided as indicated. The impact ranking will be described for both pre and post implementation of mitigation/management measures conditions.

Table 2: Impact Classification for Impact Assessment

Occurrence			Severity				Environmental Consequence
Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency	

Occurrence:

- Direction of an impact may be **positive, neutral or negative** with respect to the particular impact (e.g., a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative).
- Probability of occurrence is a description of the probability of the impact actually occurring as **improbable** (less than 5% chance), **low probability** (5% to 40% chance), **medium probability** (40 % to 60 % chance), **highly probable** (most likely, 60% to 90% chance) or **definite** (impact will definitely occur).
- Duration refers to the length of time over which an environmental impact may occur: i.e. **transient** (less than 1 year), **short-term** (0 to 5 years [construction]), **medium term** (5 to 15 years [operational]), **long-term** (greater than 15 years with impact ceasing after closure of the project) or **permanent**.

Severity:

- Magnitude is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as: **negligible**: no measurable effect (<1%) from current conditions; **low**: <10% change from current conditions; **moderate**: 10 to 20% change from current conditions; and **high**: >20% change from current conditions. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. Each specialist study will attempt to quantify the magnitude and outline the rationale used.
- Scale/Geographic extent refers to the area that could be affected by the impact and is classified as **site**; **local**: effect restricted to the LSA; **regional**: effect extends beyond the LSA into the RSA; and **beyond regional**: effect extends beyond the RSA site.
- Reversibility allows for the impact to be described as **reversible** or **irreversible**.
- Frequency may be **low**: occurs once; **medium**: occurs intermittently; or **high**: occurs continuously.

Environmental Consequence:

Environmental Consequence: The overall residual consequence for each effect will be classified as one of: negligible**,** low**,** moderate **or** high **by evaluation of the rankings for magnitude, geographic extent and duration**

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Table 3: Categories describing Environmental Consequence

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur. There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
No Impact	Zero Impact.

5.5.1 Prediction Confidence

Although not explicitly included in the criteria tables, there is uncertainty associated with the information and methods used in an EIA because of its predictive nature. The certainty with which an impact analysis can be completed depends on a number of factors including:

- Understanding of natural/ecological and socio-economic processes at work now and in the future; and
- Understanding of present and future properties of the affected resource.

The level of prediction confidence for an impact analysis will be discussed when there are questions about the factors reviewed above. Where the level of prediction confidence makes a prediction of the impact problematic, a subjective assessment is made based on the available information, the applicability of information on surrogates and on professional opinion.

The level of prediction confidence is sufficiently low in some cases that an estimate of environmental consequence cannot be made with a sufficient degree of confidence. Undetermined ratings are accompanied by recommendations for research or monitoring to provide more data in the future.

5.5.2 Development of Mitigation Measures

A common approach to describing mitigation measures for critical impacts is to specify a range of targets with a predetermined acceptable range and an associated monitoring and evaluation plan. To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute. The following summarize the different approaches that may be used in prescribing and designing mitigation measures:

- Avoidance: e.g. mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site;
- Minimization: mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact;
- Rectification: mitigation through the restoration of environments affected by the action;
- Reduction: mitigation by taking maintenance steps during the course of the action; and
- Compensation: mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

6.0 RESULTS OF THE DESKTOP LITERATURE REVIEW

6.1 Description of the Regional Environment

The study area falls within the ecoregion described as the KwaZulu-Cape Coastal Forest Mosaic (AT0116) (WWF, 2014). This ecoregion extends along the eastern coast of South Africa, and represents the southernmost African distribution of tropical fauna and flora. It is characterised by a mix of forest interspersed with thornveld.

The topography of the KwaZulu-Cape Coastal Forest Mosaic ecoregion varies from steeply rolling hills and ridges in the north to coastal platforms and gorges in the south (WWF, 2014). The climate of the ecoregion is generally tropical, with summer temperatures ranging from 15°C to 24°C and winter temperature from 10°C to 15°C. Rainfall is between 900 to 1,500 mm per year, with the north receiving rain in the summer and the south in winter (WWF, 2014).

Soils are typically poorly developed and are characterised by deep, medium to coarse-grained calcareous sands that are alkaline in nature (WWF, 2014). The geology of the region is defined mostly by sediments of the Karoo sequence with elements of the Natal Group sandstones and basement rocks (WWF, 2014).

From a biodiversity perspective, the study area falls within the Maputaland-Pondoland-Albany hotspot of biodiversity. The region is defined by high biological endemism and diversity, and extends below the Great Escarpment from the Eastern Cape, through KwaZulu-Natal into Mpumalanga Province (Conservation International, 2008).

The floristic richness of the region is second only to the Cape Floristic Region in Africa. Approximately 8 100 plant species are present, of which, 1,900 are strict endemics (Conservation International, 2008). The region also has remarkable fauna diversity, with 540 birds, 200 mammals, over 200 reptiles and 72 amphibians recorded (Conservation International, 2008).

According to Conservation International (2008) an estimated 20% of the original extent of the Maputaland-Pondoland-Albany hotspot has been transformed. Both commercial and subsistence agriculture are a major agents of transformation, as are commercial forestry, urbanisation and mining. As a large proportion of the hotspot is also under communal ownership, and as a result large areas that aren't transformed *per se*, are nonetheless severely overgrazed (Conservation International, 2008).

Anthropogenic activity throughout the ecoregion has resulted in the fragmentation and transformation of much the KwaZulu-Cape Coastal Forest Mosaic, with little over half the historic extent remaining (WWF, 2014). Although large forest patches do occur, most forest areas are confined to small, isolated pockets set in a modified landscape matrix. Forest patches occur on private and tribal land, and in conservancies and protected areas. Those not in formal conservation areas are often subject to intense utilisation, with the WWF (2014) indicating that forests are harvested for buidling material, traditional medicine, food and water. Forest patches are cleared to make way for agriculture and grazing, with sugar cane and forestry being major landuse drivers. Other common threats to forests in KwaZulu-Natal include mining, urban and recreational developments, alein plant species encroachment and unrestricted vbehicle access (WWF, 2014).

6.2 Regional Vegetation Types

According to Mucina & Rutherford (2006) the sub-regional environment encompasses two vegetation types namely Northern Coastal Forest (FOz 7) and Maputaland Coastal Belt (CB1). At a provincial level, Scott-Shaw & Escott (2011) have refined and updated Mucina & Rutherford's (2006) work in an attempt to represent the pre-transformation extent of KwaZulu-Natal's vegetation types. These authors refer to Mucina & Rutherford's (2006) Northern Coastal Forest vegetation type as KwaZulu-Natal Dune Forest: Maputaland Dune Forest.

The characteristics of the relevant vegetaion types are based on Mucina & Rutherford (2006) descriptions, however the delineations as shown in Figure 2 reflect the pre-transformation vegetation types as determined by Scott-Shaw & Escott (2011):

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6.2.1 The Northern Coastal Forest (FOz 7)

This vegetation type, also refered to as KwaZulu-Natal Dune Forest: Maputaland Dune Forest by Scott-Shaw & Escott (2011), occurs in KwaZulu-Natal, particularly along the Indian Ocean seaboard and in Maputaland. It occurs to a very small extent in the Eastern Cape Province. It occurs at low altitudes between 10 - 150 m above mean sea level (Mucina & Rutherford, 2006).

Climate

The climate is subtropical; data from Richards Bay indicate relative humidity ranging from 72% in November to 59% in August. Mean maximum and minimum temperatures range between 32.6°C and 5.8°C respectively. Richards Bay and St Lucia both have 41.6% of their rainfall in winter, with mean annual rainfall varying between 839 mm and 1272 mm. The region is under constant severe pressure from winds with occasional cyclones developing and impacting on the region (Mucina & Rutherford, 2006).

Vegetation

The vegetation is characterized by species rich, tall/medium height subtropical coastal forests on rolling coastal plains and stabilized coastal dunes. Forests of the coastal plains are dominated by *Drypetes natalensis, Englerophytum natalense, Albizia adianthifolia, Diospyros inhacaensis* etc. The low tree and shrubby understoreys are species rich and comprise many taxa of subtropical origin. On dunes, these forests have well-developed tree, shrub and herb layers. *Mimusops caffra, Sideroxylon inerme, Dovyalis longispina, Acacia kosiensis* and *Psydrax obovata* are the most common constituents of the tree layer. *Brachylaena discolor, Chrysanthemoides monilifera, Carissa bispinosa, Euclea natalensis, Euclea racemosa, Eugenia capensis, Gymnosporia nemorosa, Kraussia floribunda, Peddiea africana, Strelitzia nicolai* and *Dracaena aletriformis* are frequent in the understorey. The herb layer usually contains *Asystasia gangetica, Isoglossa woodii, Microsorium scolopendrium, Zamioculcas zamiifolia* and *Oplismenus hirtellus.* Herbaceous vines and woody climbers are important structural determinants in these forests, including *Acacia kraussiana, Artabotrys monteiroae, Dalbergia armata, Landolphia kirkii, Monanthotaxis caffra, Rhoicissus tomentosa, Rhus nebulosa, Scutia myrtina, Uvaria caffra, Gloriosa superba* (Mucina & Rutherford, 2006).

Conservation

About 68% is statutorily conserved in a range of reserves mostly under EKZNW management. The original extent of these forests has been diminished by agriculture (mainly sugarcane and fruit orchards), timber plantations, urban sprawl and tourist-related development of the KwaZulu-Natal coast. Illegal clearing for small-scale agriculture is also a threat. In addition, these subtropical forests are sensitive to alien plant invasion, particularly *Chromolaena odorata* (Mucina & Rutherford, 2006).

6.2.2 Maputaland Coastal Belt (CB1)

This vegetation type is found in KwaZulu-Natal Province (and continuing also in southern Mozambique), with a 35 km broad strip along the coast of the Indian Ocean stretching from the Mozambique border in the north to Mtunzini in the south. Altitude varies from about 20–120 m (Mucina & Rutherford, 2006).

Vegetation

Dryland vegetation types are dominated by grassland or *Syzigium* savanna where fire has been frequent, but tend toward shrubland where the fire regime has been disrupted. Lack of fire and disturbance has promoted the invasion of alien trees and shrubs to the extent that distinct patches of these invaded grasslands can be recognized. In some instances self-sustaining stands of pines, eucalypts or gums have established, with usually an understory of grassland. Areas of hard geology may support grassland but also commonly support *Acacia karroo* savanna or woodland. As with vegetation of marine sands, a decrease in fire frequency or increased disturbance has promoted the establishment of alien shrubs and trees. In addition, preclusion of fire may promote thickening of woody vegetation such that *A. karroo* thickets may develop (Mucina & Rutherford, 2006).

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Conservation

This vegetation type is classified as Vulnerable, with a conservation target of 25%, whereas only 15% is currently statutorily conserved in the Greater St Lucia Wetland Park as well as in Sileza, Enseleni and Amathikulu Nature Reserves. More than 30% has been transformed for plantations and cultivation and by urban sprawl. Alien invasive species include scattered populations of *Chromolaena odorata* and *Lantana camara*. Erosion levels are mostly very low. This vegetation type has a relatively high number of plant taxa at the southernmost and northernmost limits of their distribution range—the occurrence of widely disjunct or outlier populations increases the conservation value of this vegetation type (Mucina & Rutherford, 2006).

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Figure 2: Map of study area showing the Scott-Shaw & Escott (2011) vegetation types.

6.3 Study area in relation to the uMhlathuze ESMP

The uMhlathuze Environmental Services Management Plan (ESMP) is of particularly relevance to the study area, with three management zone levels identified on-site, *viz*. levels 2, 3 and 4. Figure 3 shows the spatial extent of these in the study area. For an explanation of the management zones refer to Section 2.1.

6.4 National and provincial conservation considerations

The Richard's Bay Nature Reserve is an important protected area in the greater Richard's Bay area. The reserve is 1192 ha in extent and is located less than three kilometres west of the study area. This site is formally recognised as a 'nature reserve' (Category IV, Site Code 13307) by the IUCN and was created by the construction of a four-kilometre long causeway across the Richard's Bay estuary (BirdLife International, 2013), creating what is now termed the Mhlathuze Estuary. Three rivers drain into the estuary at this point creating a shallow tidal lagoon fringed by mangroves (*Rhizophoraceae*), papyrus and other reeds and sedges (BirdLife International, 2013). Remnant climax coastal dune forests grow on the eastern side of the sanctuary, with savanna making up the remaining terrestrial habitat (BirdLife International, 2013).
The estuary and surrounding marginal vegetation are critical estuarine habitat for a complex community of waterbirds and water-associated birds and the site is recognised as an Important Bird Area (IBA) (ZA079) by Birdlife International (2013).

The main Richard's Bay harbour is situated beyond the peninsula on which the study area is located. Despite its active use, the harbour continues to function as an estuary and like the adjacent Mhlathuze Estuary, contains important and diverse marine habitats, including intertidal and shallow sub-tidal mudflats and sandbanks, deep-water basins and channels (CRUZ 2012).

The South African National Biodiversity Institute's (SANBI) list of threatened ecosystems identifies much of the land around the Richard's Bay harbour as critically endangered and small pockets as Endangered (Figure 4). A closer examination of the spatial data however, indicates that SANBI adopted a course-grain delineation of this ecosystem as large areas designated as critically endangered are in fact completely transformed or already highly disturbed.

Habitat modelling by Ezemvelo KZN Widllife highlights that the greater harbour area of Richards Bay may comprise potential habitat for two species of conservation importance, namely the millipede *Centrobolus richardi* and the frog *Hyperolius pickersgilli* (Figure 5).

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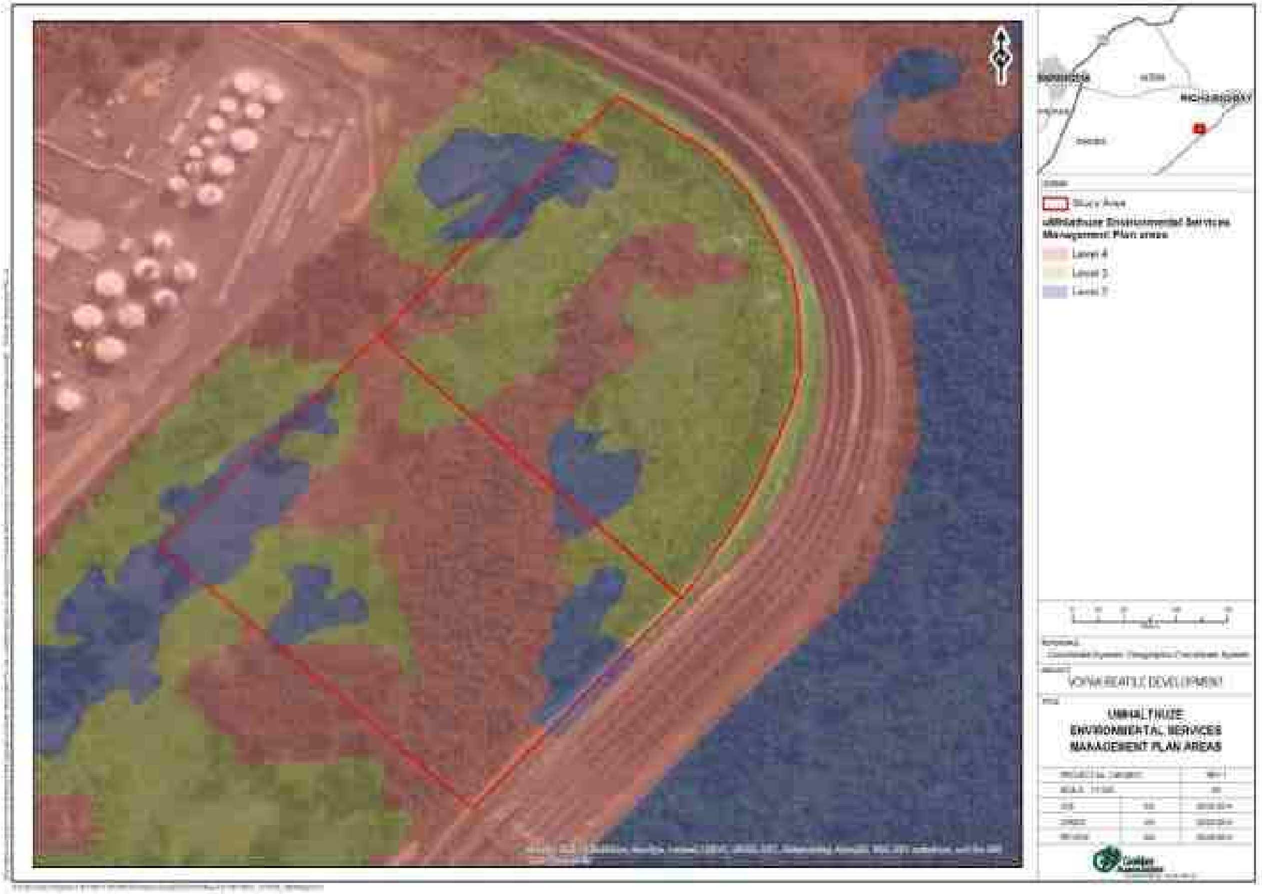

Figure 3: uMhlathuze ESMP zones in relation to the study area

Figure 4: Delineation of threatened ecosystems (SANBI 2009).

Figure 5: Ecological irreplaceability map.

6.5 Flora of Conservation Importance

In 2013 ACER conducted a terresteial ecology study of land immediately adjacent to the study area. They recorded five plant species of conservation importance on a site immediately adjacent to the study area, namely *Adenia gummifera* var. *gummifera, Dioscorea sylvatica, Ficus trichopoda, Sideroxylon inerme* and *Mimusops caffra* (ACER, 2013). Several additional species of conservation importance may occur in the project area, as listed in Table 4.

Table 4: Plant species of special concern occurring and potentially occuring in the project area (adapted from ACER 2013)

Species	**IUCN (2014.2) – Regional Status**	**Protected Tree Species (National Forest Act No. 84 of 1998)**	**KwaZulu-Natal - Protected Species (1999)**
Adenia gummifera var. *gummifera* - Recorded (ACER, 2013)	Declining	-	-
Bonatea lamprophylla	Vulnerable	-	-
Didymoplexus verrucosa	VU	-	-
Dioscorea sylvatica – Recorded (ACER, 2013)	Vulnerable	-	-
Disperis johnstonii	Near Threatened	-	-
Elaeodendron croceum	Declining	-	-
Eulophia speciosa	Declining	-	-
Ficus trichopoda – Recorded (ACER, 2013)		Protected	Protected
Kniphofia leucocephala	Critically Endangered	-	Protected
Kniphofia littoralis	Near Threatened	-	Protected
Sideroxylon inerme – Recorded (ACER, 2013)	-	Protected	Protected
Mimusops caffra – Recorded (ACER, 2013)	-	Protected	Protected

6.6 Exotic Invasive Plant Species

Weeds and exotic plant species are regulated according to the Conservation of Agricultural Resources Act (Act No. 43 of 1983) (CARA) and the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEMBA). Both sets of regulations have been development to control the spread of exotic invasive species.

6.6.1 National Environmental Management: Biodiversity Act (Act No. 10 of 2004)

According to the NEM:BA Regulations, exotic species can be listed into one of four categories; 1a, 1b, 2 and 3. In respect of Government Notice 1, the following restrictions are relevant to listed plant species:

NEM:BA Category 1a and 1b

The propagation, release, conveying or allowing the spread of any species listed as Category 1a and 1b is prohibited.

NEM:BA Category 2

A permit is required to be in possession of, propagate, release, spread or allow the spread of any species listed as Category 2.

NEM:BA Category 3

The propagation and release of Category 3 species is prohibited, however an exemption is made to be in possession of, or allow the spread of these species.

6.6.2 Conservation of Agricultural Resources Act (Act No. 43 of 1983)

The 2001 revision of the CARA recognises three categories of invasive plant, namely: Category 1 - declared weeds, Category 2 - declared invader plants with a commercial or utility value, and Category 3 - ornamental plants. These are listed in Regulations 15 and 16 of CARA. The regulations pertaining to each category are summarised below:

CARA Category 1: Declared weeds

Category 1 listed plants have no economic value and possess characteristics harmful to humans, animals or the environment. These species tend to produce high volumes of seed, are wind or bird dispersed, or have efficient vegetative reproduction, and are thus highly invasive causing substantial environmental degradation. As such, Category 1 listed plants may not be planted or propagated in rural and urban areas, and the trade in their seeds, cuttings and other propagatory material is prohibited. Moreover, it is recommended that active measures be taken to control and eradicate populations of these species (ARC, 2010, internet).

CARA Category 2: Declared invader plants with commercial or utility value

Although Category 2 listed plants are invasive species, they do have beneficial properties and general utility. They are permitted in demarcated areas (as granted by the Executive Officer) under controlled conditions, and in bio control reserves. Seed and propagative material may only be sold to, and acquired by land users of areas demarcated for that particular species, as determined by the Executive Officer. These species may not occur within 30 m of the 1:50 year flood line of a water course or wetland, except under authorisation in terms of the National Water Act (No. 36 of 1998) (ARC, 2010, internet).

CARA Category 3: Mostly ornamental plants

These are exotic plants that are generally popular ornamental and garden species but show high invasive potential and frequently encroach into natural areas. Existing plants may remain provided they do not occur within 30 m from the 1:50 year flood line of a water course or wetland, and provided all reasonable steps are taken to limit the further spread of that species. No further planting or trade in propagative material is permitted (ARC, 2010, internet).

Table 5 lists the alien and invasive plants found in the general area in which the study area is located, as documented in ACER (2013).

Table 5: Exotic species recorded on site (adapted from ACER 2013)

Species Name	Common Name	CARA Category	NEMBA Category
Arundo donax	Spanish reed	1	1b
Asclepias physocarpa	Milkweed		-
Casuarina equisetifolia	Horsetail tree	2	2
Chromolaena odorata	Triffid weed	1	1b
Conyza bonariensis	Flax-leaf fleabane	-	-
Euphorbia heterophylla	Wild poinsettia	-	-
Lantana camara	Common lantana	1	1b

Species Name	Common Name	CARA Category	NEMBA Category
Melia azedarach	Syringa	3	1b 3 in urban areas
Pinus elliottii	Slash pine	2	2 – stertile speciemans 1b - nonstertile speciemans
Ricinus communis	Castor-oil plant	2	2
Rivina humilis	Bloodberry	1	1b
Schefflera actinophylla	Umbrella tree		1b
Schinus terebinthifolius	Brazillian pepper tree	1	1b
Solanum nigrum	Nightshade	-	-
Solanum mauritianum	Bugweed	1	1b
Solanum sisymbriifolium	Dense-thorned bitter apple	1	1b

6.7 Fauna of Conservation Importance

The important animal taxa of the study site include reptiles, amphibians, birds and mammals. The potential for species to occur within the site was ranked in terms of conservation importance and characterised in terms of status (e.g.: Rare, Threatened and Endemic etc.). The species status was determined from Red Data books and any other relevant literature/ previous studies of the area, e.g. Biodiversity status assessment EKZNW C-Plan.

6.7.1 Reptiles

Ten reptile species of conservation importance have been recorded within the Richards Bay region and may potentially occur in the study area. These are listed in Table 6.

Table 6: Reptile species of conservation importance potentially occurring in the study area

Scientific Name	Common Name	IUCN (2014.2)	NEMBA TOPS List (2013)	KwaZulu-Natal - Protected Species (1999)
Bitis gabonica	Gaboon Adder	-	Protected	Specially Protected
Bradypodion setaroi	Setaro's Dwarf Chameleon	Least Concern	-	Specially Protected
Crocodylus niloticus	Nile Crocodile	Least Concern	Vulnerable	Protected
Dendroaspis angusticeps	Green Mamba	-	-	-
Kinixys natalensis	Natal Hinge-backed Tortoise	Near threatened	-	Protected
Leptotyphlops sylvicolus	Forest Thread Snake	-	-	Protected
Lycophidion pygmaeum	Pygmy wolf snake	-	-	Protected
Python natalensis	Southern African Python	-	Protected	Specially Protected
Tetradactylus africanus	Eastern Long-tailed Seps	Least Concern		-

6.7.2 Amphibians

According to ACER (2013), six amphibians listed as species of conservation importance may occur in the study area. These are listed in Table 7.

Table 7: Amphibians of conservation importance potentially occurring in the study area (adapted from ACER 2013)

Scientific Name	Common Name	IUCN (2014.2)	SA Red Data Book	KwaZulu-Natal - Protected Species (1999)
Afrixalus spinifrons	Natal leaf-folding frog	Near Threatened	Vulnerable	Protected
Breviceps sopranus	Whistling rain frog	-	Data Deficient	-
Cacosternum sp. B	KwaZulu caco	-	-	-
Cacosternum striatum	Striped caco	-	Data Deficient	-
Hemisus guttatus	Spotted shovel-nosed frog	Vulnerable	Vulnerable	Protected
Hyperolius pickersgilli	Pickersgill's reed frog	Critically Endangered	Endangered	Specially Protected

6.7.3 Birds

This region has long been known as an avifaunal “hotspot” with high avifaunal diversity. This is especially true for the Richard’s Bay Nature Reserve, which lies approximately 1.5 km to the south. Richards Bay Nature Reserve hosts a huge community of water birds and wildlife. Rare species such as the Pink-backed pelican have been observed here and the reserve hosts approximately 300 other species of birds, along with some migrant birds, including waders, cormorants and flamingos as popular locals. Furthermore, the lagoon area provides a wetland environment, creating a protected habitat for, *inter alia*, hippos and crocodiles.

Based on the South African Bird Atlas Project, 329 bird species have been recorded in the quarter degree grid cell (QDGC) 2832CC in which the project area is situated. This equates to 51.5 % of the 691 species listed for KwaZulu-Natal (Barnes, 2004). Of the 329 expected bird species, 104 may potentially breed in the area and the remainder may occur as visitors in the area. Of the expected bird assemblage 10 species are listed in the National Red Data book on birds (Barnes, 2004).

Table 8 provides an account of Red Data bird species that could potentially occur in the project area, as per (ACER, 2013).

Table 8: Bird species of conservation importance potentially occurring in the study site and immediate surroundings (adapted from ACER 2013).

Species Name	Common Name	IUCN (2014.2)	SA Red Data Book	KwaZulu-Natal - Protected Species (1999)
Batis fratrum	Zululand Batis	Least Concern	Near Threatened	Protected
Ephippiorhynchus senegalensis	Saddle-billed Stork	Least Concern	Endangered	Specially protected
Glareola pratincola	Collared Pratincole	Least Concern	Near Threatened	Protected
Mycteria ibis	Yellow-billed Stork	Near Threatened	Near Threatened	Specially protected

Species Name	**Common Name**	**IUCN (2014.2)**	**SA Red Data Book**	**KwaZulu-Natal - Protected Species (1999)**
Neotis denhami	Denham's Bustard	Near Threatened	Vulnerable	Protected
Pelecanus onocrotalus	Great White Pelican	Least Concern	Near Threatened	Specially protected
Pelecanus rufescens	Pink-backed Pelican	Least Concern	Vulnerable	Specially protected
Phoenicopterus minor	Lesser Flamingo	Near Threatened	Near Threatened	Protected
Scotopelia peli	Pel's fishing-owl	Least Concern	Vulnerable	Specially protected
Sterna caspia	Caspian Tern	Least Concern	Near Threatened	Protected
Zoothera guttata	Spotted ground-thrush	Endangered	Endagered	Specially protected

6.7.4 Mammals

The high level of disturbance in the area means that many of the larger species, which would have occurred in the area have become locally extinct. The dominant mammal species are therefore likely to be those with one or more of the following traits:

- Small range requirements;
- Broad habitat requirements;
- High reproductive rates; and
- Ability to move easily between vegetation patches.

A list of mammal species of conservation importance that may occur in the project area is provided in Table 9.

Table 9: Mammal species of conservation importance possibly occurring in the area

Scientific Name	**Colloquial Name**	**IUCN (2014.2)**	**NEMBA TOPS List (2013)**	**KwaZulu-Natal - Protected Species (1999)**
Chrysospalax villosus	Rough-haired golden mole	Vulnerable	-	Specially protected
Myosorex sclateri	Sclater’s tiny mouse shrew	Near Threatened	-	-
Mystromys albicaudatus	White-tailed mouse	Endangered	-	Protected

7.0 RESULTS OF THE FIELD SURVEY

7.1 Vegetation Assessment

The study area is situated on an island that is surrounded by water and connected to the main land through a narrow land bridge. The vegetation assessment recognised two vegetation communities in the study area (ACER pers. comm. 2014):

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- Brachylaena discolor – Apodytes dimidiata short thicket community; and
- Phragmites australis – Typha capensis wetlands.

The general characteristics and flora composition of these communities, as per (ACER pers. comm. 2014) are discussed below:

7.1.1 *Brachylaena discolor – Apodytes dimidiata* short thicket community

The *Brachylaena discolor – Apodytes dimidiata* short thicket community is a degraded representation of the Maputaland Coastal Belt vegetation type. This community is a mosaic of coastal thickets, secondary coastal thickets and *Imperata cylindrica* as well as *Typha* wetlands. In places, the topography is sharply undulating (ACER pers. comm. 2014).

Where fast drainage of water occurs, *Imperata* wetlands are found, and where the water drains away slowly, *Typha* wetlands are found. This plant community can be found on Site 4 and 5. This community was severely disturbed in the past by the invasive alien species, Horsetail tree (*Casuarina equisetifolia*), however, recently, the Horsetail trees were cut down in an effort to control alien invasives (ACER pers. comm. 2014). This has allowed indigenous vegetation to return to site, and at present this plant community is in various stages of succession. The community to the south-western corner of Site 5 is still in good ecological condition, albeit slightly disturbed by common Lantana (*Lantana camara*) (ACER pers. comm. 2014).

The species listed in Table 10 were identified in this plant community during the survey (alien weeds and invasive plants are indicated with an asterisk).

Adenia gummifera var. *gummifera* is listed as Declining (IUCN(2014.2) – Regional Status, while *Ficus trichopoda, Sideroxylon inerme* and *Mimusops caffra* are listed as protected according to both the National Forest Act (No. 84 of 1998) and Schedule 7 of the KwaZulu-Natal Nature Conservation Management Amendment Act (No. 5 of 1999).

Table 10: Plant species recorded in the *Brachylaena discolor – Apodytes dimidiata* short thicket community (ACER pers. comm. 2014).

Growth Form	Scietific name
Woody species	*Acacia karroo* Hayne
	Adenia gummifera (Harv.) Harms *var. gummifera*
	*Allophylus natalensis (*Sond.) De Winter
	Apodytes dimidiata E.Mey. ex Arn.
	Brachylaena discolor DC.
	Brachylaena huillensis O.Hoffm.
	Bridelia cathartica Bertol.f.
	Bridelia micrantha (Hochst.) Baill.
	**Casuarina equisetifolia* L.
	Celtis africana Burm.f.
	Chrysanthemoides monilifera (L.) Norl.
	Clerodendrum glabrum E.Mey.
	Cordia caffra Sond.
	Deinbollia oblongifolia (E.Mey. ex Arn.) Radlk.
	Dovyalis longispina (Harv.) Warb.
	Dracaena aletriformis (Haw.) Bos

Growth Form	Scietific name
	Ekebergia capensis Sparrm.
	Euclea natalensis A.DC.
	Erythrina lysistemon Hutch.
	Ficus lutea Vahl
	Ficus sur Forssk.
	Ficus trichopoda Baker
	Grewia occidentalis L.
	Gymnosporia nemorosa (Eckl. & Zeyh.) Szyszyl.
	Harpephyllum caffrum Bernh. ex C.Krauss
	**Lantana camara* L.
	**Litsea glutinosa* (Lour.) C.B.Rob.
	**Melia azedarach* L.
	Mimusops caffra E.Mey. ex A.DC.
	Passerina rigida Wikstr.
	**Passiflora subpeltata* Ortega
	Phoenix reclinata Jacq.
	Rauvolfia caffra Sond.
	Rhoicissus digitata (L.f.) Gilg & M.Brandt
	Rhoicissus tomentosa (Lam.) Wild & R.B.Drumm.
	**Schefflera actinophylla* (Endl.) Harms
	Scolopia zeyheri (Nees) Harv.
	Scutia myrtina (Burm.f.) Kurz
	Searsia nebulosa (Schönland) Moffett *forma nebulosa*
	Searsia rigida (Mill.) F.A.Barkley
	Senecio tamoides DC.
	Sideroxylon inerme L.
	Strelitzia nicolai Regel & Körn.
	Tacazzea apiculata Oliv.
	Trema orientalis (L.) Blume
	Trichilia emetica Vahl
	Vepris lanceolata (Lam.) G.Don
	**Washingtonia robusta* H.Wendl.
Herbaceous species	*Aneilema aequinoctiale* (P.Beauv.) Loudon
	Asystasia gangetica (L.) T.Anderson
	Bidens pilosa L.
	Boerhavia erecta L.
	Carpobrotus dimidiatus (Haw.) L.Bolus

Growth Form	Scietific name
	Cheilanthes viridis (Forssk.) Sw.
	**Chromolaena odorata* (L.) R.M.King & H.Rob.
	Cissampelos torulosa E.Mey. ex Harv.
	**Conyza bonariensis* (L.) Cronquist
	Commelina erecta L.
	**Cuscuta campestris* Yunck.
	Desmodium incanum DC.
	Gomphocarpus physocarpus E.Mey.
	Helichrysum kraussii Sch.Bip.
	Helichrysum ruderale Hilliard & B.L.Burtt
	Microsorum scolopendria (Burm.f.) Copel.
	Mikania natalensis DC.
	Pollichia campestris Aiton
	Pteridium aquilinum (L.) Kuhn
	Rhoicissus tomentosa (Lam.) Wild & R.B.Drumm.
	**Ricinus communis* L.
	**Rivina humilis* L.
	Sarcostemma viminale (L.) R.Br.
	Scadoxus puniceus (L.) Friis & Nordal
	Secamone filiformis (L.f.) J.H.Ross
	Senecio deltoideus Less.
Grass species	**Arundo donax* L.
	Cenchrus incertus M.A.Curtis
	Cynodon dactylon (L.) Pers.
	Dactyloctenium aegyptium (L.) Willd.
	Digitaria eriantha Steud.
	Imperata cylindrica (L.) Raeusch.
	Leersia hexandra Sw.
	Melinis repens (Willd.) Zizka
	Oplismenus hirtellus (L.) P.Beauv.
	Panicum maximum Jacq.
	Setaria megaphylla (Steud.) T.Durand & Schinz
	Sporobolus africanus (Poir.) Robyns & Tournay
	Stenotaphrum secundatum (H.Walter) Kuntze
	Stiburus alopecuroides (Hack.) Stapf

7.1.2 *Phragmites australis – Typha capensis* wetlands

The *Phragmites australis* – *Typha capensis* wetlands are permanently inundated with water and occur in depressions that allow for the accumulation of surface water. The high water table which is encountered at a depth of between 0.9 and 1.5 m across the project site, and at surface in the dune slack wetland areas (SRK, 2013) provides a significant groundwater contribution to the wetlands (ACER pers. comm. 2014).

The deep water zone is dominated by *Typha capensis* and *Phragmites australis*. The seasonal zone is dominated by *Cyclosorus interruptus* and *Leersia hexandra*. Several *Cyperus* species are abundant and *Juncus kraussii* can also be found. *Ficus sur* and *Ficus trichopoda* are found outside the deep water zone (ACER pers. comm. 2014). The alien plant *Casuarina equisetifolia* invades this wetland from the edge of the temporary zone (ACER pers. comm. 2014).

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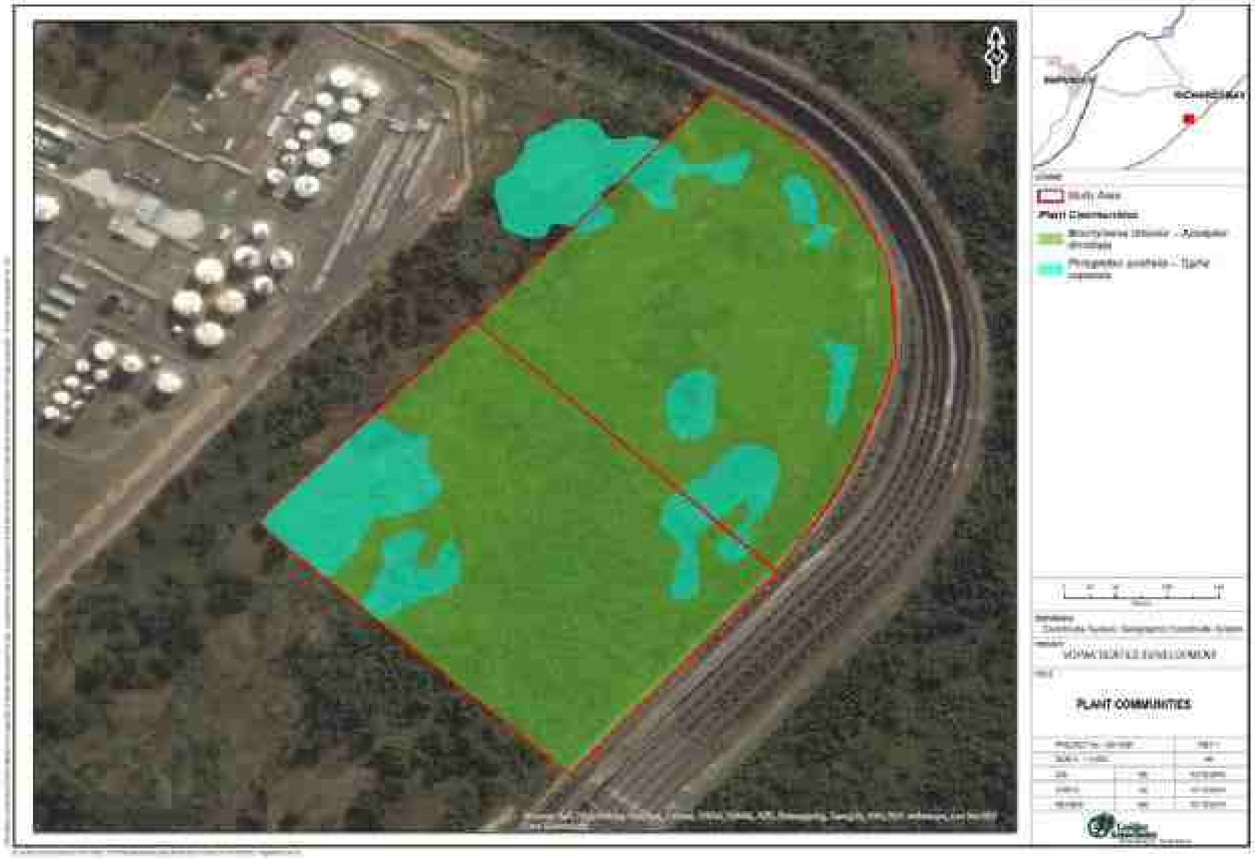

Figure 6: Plant communities identified in the study area.

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7.2 Fauna Asessment

7.2.1 Arthropoda

A total of 56 arthropod species, comprising 45 families and 15 orders, were recorded during the site survey (see APPENDIX C). The low floral diversity in the majority of the area, as well as the timing of the survey may have contributed to the reduced arthropod diversity recorded during the survey. All of the species recorded during the survey are common savanna species and none are listed as species of conservation importance. Apart from the possible presence of millipedes of conservation importance, such as *Centrobolus richardi,* there is little literature regarding other Red Data arthropod species occurring in the area.

7.2.2 Reptiles

Six reptile species were recorded during the March 2014 survey (Table 11). None of the recorded species are restricted in terms of habitat and distribution, or classified as Red Data species. The reptile diversity recorded during the field survey was moderate for the area, and could even be considered high when the degraded and isolated nature of the study area is taken into account.

Sixty nine reptile species potentially occur in the region in which the study area is located. These are listed in APPENDIX D.

Table 11: Reptile species recorded in the study area during the survey

Scientific name	Common name
Bitis arietans	Puff Adder
Chamaeleo dilepsis	Flap-neck Chameleon
Crotaphopeltis hotamboeia	Red-Lipped Snake
Dasypeltis scabra	Common Egg Eater
Nucras ornata	Ornate Sandveld Lizard
Philothamnus semivariegatus	Spotted Bush Snake

7.2.3 Amphibians

Five amphibian species were recorded in or adjacent to the study area. These are the Common river frog (*Amieta angolensis*), Guttural toad (*Amietophrynus gutturalis*), Mozambique rain frog (*Breviceps mossambicus*), Tinker reed frog (*Hypercolius tuberilinguis*) and Argus reed frog (*Hyperolius argus*) (ACER, 2013). None of the recorded species are restricted in terms of habitat and distribution, or classified as Red Data species. The number of species recorded during this study is high, when considering the status of the systems in the study area.

Based on available literature, 51 frog species as listed in APPENDIX E, are expected to occur within the project region

7.2.4 Birds

Twenty eight bird species were recorded in the study area during the March 2014 field survey (Table 12). The lack of perennial waterbodies and rivers excludes waterfowl and other water related avian species from the project area and contributed to the reduced species diversity.

Based on the South African Bird Atlas Project, 329 bird species have been recorded in the quarter degree grid cell (QDGC) 2832CC in which the project area is situated. Refer to APPENDIX F for a list of bird species potentially occurring in the study area.

Table 12: Bird species recorded during the survey

Scientific Name	**Common Name**
Acridotheres tristis	Common Myna
Acrocephalus baeticatus	African Reed-Warbler
Actitis hypoleucos	Common Sandpiper
Burhinus capensis	Spotted Thick-knee
Campethera abingoni	Golden-tailed Woodpecker
Chalcomitra amethystina	Amethyst Sunbird
Charadrius pecuarius	Kittlitz's Plover
Cisticola juncidis	Zitting Cisticola
Colius striatus	Speckled Mousebird
Columba guinea	Speckled Pigeon
Columba livia	Rock Dove
Crithagra mozambica	Yellow-fronted Canary
Estrilda astrild	Common Waxbill
Falco amurensis	Amur Falcon
Gallinula chloropus	Common Moorhen
Hedydipna collaris	Collared Sunbird
Lanius collaris	Fiscal Shrike
Lonchura cucullata	Bronze Mannikin
Motacilla aguimp	African Pied Wagtail
Motacilla capensis	Cape Wagtail
Numida meleagris	Helmeted Guineafowl
Ploceus ocularis	Spectacled Weaver
Streptopelia semitorquata	Red-eyed Dove
Tringa glareola	Wood Sandpiper
Upupa africana	African Hoopoe
Vanellus armatus	Blacksmith Lapwing
Vanellus coronatus	Crowned Lapwing
Vanellus senegallus	African Wattled Lapwing

7.2.5 Mammals

Seven mammal species were recorded during the March 2014 field survey (Table 13). Recorded mammals are common species that occur in a wide range of habitats. None are listed as Red Data/protected species.

Ninety two mammals historically occur in the region as per Stuart and Stuart (2006). These are listed in APPENDIX G.

Table 13: Mammal species recorded during the survey

Scientific Name	Colloquial Name
Aethomys chrysophilus	Red veld rat
Rhabdomys pumilio	Striped mouse
Lemniscomys rosalia	Single-striped mouse
Mus minutoides	Pygmy mouse
Mastomys natalensis	Natal multimammate mouse
Otomys angoniensis	Angoni vlei rat
Otomys irroratus	Vlei rat

7.3 Habitat Sensitivity Analysis

7.3.1 Ecological Integrity

Connectivity between the natural plant communities inside the study area and those outside is very limited. The railway and road system in place effectively isolate the study area from surrounding habitats.

The *Brachylaena discolor – Apodytes dimidiata* short thicket community is degraded, having been disturbed in the past by the invasive alien species. In the south-western corner of Site 5, vegetation is generally in good ecological condition. The ecological integrity of *Brachylaena discolor – Apodytes dimidiata* short thicket community is therefore considered low-moderate. The ecological integirty of the *Phragmites australis – Typha capensis* wetlands is considered moderate (Figure 7).

7.3.2 Conservation Importance

Despite the habour peninsula being largely disturbed and disconnected from the mainland, the study area and its surrounds does provide habitat for flora and fauna, some of which, are species of conservation importance. Indeed, four plant species of conservation importance have been recorded in the study area, namely *Adenia gummifera var. gummifera, Ficus trichopoda, Sideroxylon inerme, Mimusops caffra* (ACER pers. comm. 2014). An additional species of conservation importance (*Dioscorea sylvatica)* has also previously been recorded adjacent to the study area (ACER, 2013).

The *Brachylaena discolor – Apodytes dimidiata* short thicket community is thus considered to have a moderate conservation importance, while the *Phragmites australis – Typha capensis* wetlands are of high conservation importance (Figure 8).

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Figure 7: Ecological integrity of vegetation communities in the study area.

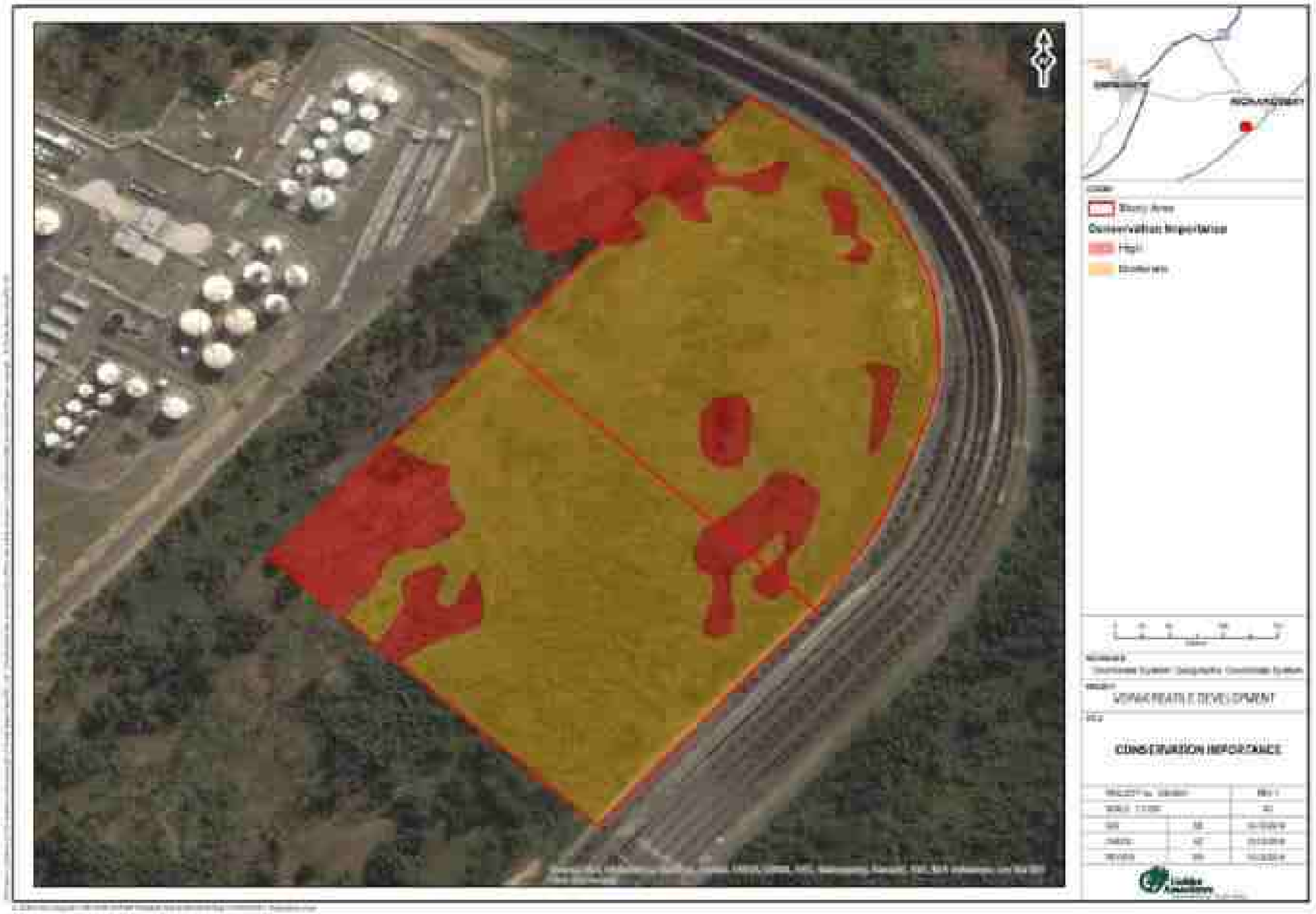

Figure 8: Conservation importance of vegetation communities in the study area.

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8.0 IMPACT ASSESSMENT

8.1 Impact Characterisation

Impacts on terrestrial ecology resulting from the proposed project include:

- Habitat loss as a result of vegetation clearing;
- Loss of plant species of conservation importance;
- Spread of alien invasive species;
- Killing or injuring of fauna; and
- Habitat degradation due to dust.

These are characterised in Section 8.1.1 to 8.1.5.

8.1.1 Habitat loss as a result of vegetation clearing

Nature of impact

Habitat loss refers to the removal of natural habitat. In terrestrial ecosystems habitat loss occurs primarily through the clearing of indigenous vegetation or through the homogenisation of available habitat. This results not only in the immediate destruction of individual plants and some fauna species, but may also lead to a loss of biodiversity and a contingent breakdown in ecosystem functioning.

Habitat degradation refers to an extreme form of ecosystem disturbance. In such instances much of the original ecosystem processes have been disrupted and many of the original species have been excluded (Begon *et al*. 2002).

Although habitat loss and degradation are normally associated with the immediate vegetation clearing and earth works that precede construction activities, the impacts can be long term, persisting throughout the operational and closure phases. In certain instances, these impacts can be ameliorated by successful rehabilitation of the site.

Impact in relation to proposed project

Vegetation clearing is likely to be the greatest direct impact on the ecology in the study area. Vegetation clearing will commence during the construction phase and will lead to the permanent removal of natural / semi-natural habitat in the proposed development footprint. This will negatively affect on-site flora and fauna communities.

8.1.2 Loss of plant species of conservation importance

Nature of impact

During initial vegetation clearing and earth works, flora and fauna of conservation importance such as Red Data and protected species may be killed, injured or damaged. Moreover, habitat loss and degradation may result in sensitive species being disturbed.

Impact in relation to proposed project

Vegetation clearing may also result in the removal of plant species of conservation importance. These are *Adenia gummifera* var. *gummifera, Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra*.

8.1.3 Spread of alien invasive species

Nature of impact

Clearing of natural vegetation may create conditions conducive to the establishment and colonisation of exotic and/or declared NEM:BA and CARA listed invader plants. Most exotic, invasive species if left

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uncontrolled will suppress or replace indigenous plants leading to a concomitant reduction in fauna species diversity and abundance (Bromilow, 2010). Moreover, certain common invasive plants are highly flammable and can increase the frequency and intensity of fires which may further alter ecosystem structure and functioning.

Facilitated by indigenous vegetation clearing, encroachment by exotic invasive species may initially occur during construction. However, if not controlled, the scale and magnitude of infestation will rapidly increase and may persist for the entire lifecycle of the project.

Impact in relation to proposed project

Several CARA and NEMBA listed alien invasive plant species were recorded in the study area. Alien invasive plants can out-compete indigenous vegetation, creating large almost monospecific exotic vegetation stands. Construction activities are likely to facilitate the further establishment and spread of alien invasive species into adjacent areas. If not adequately controlled, alien invasive vegetation will continue to spread during the operational and decommissioning phases.

8.1.4 Killing or injuring of fauna

Nature of impact

Forest areas in South Africa provide habitat for a number of fauna species. It is likely that upon commencement of construction activates many larger and more agile species will move-off to avoid disturbance. A number of smaller and less mobile species however, may be trapped and killed /injured during all phases of the project.

Impact in relation to proposed project

During the construction phase fauna may be killed or injured as a result of earth works, vehicle activity and poaching. This impact is unlikely to be of concern during the operational and decommissioning phases.

8.1.5 Habitat degradation due to dust

The clearing of vegetation for construction coupled with increased vehicular traffic and the establishment of top soil and waste stockpiles, will result in the increased potential for dust entrainment. Dust settling on plant material can affect photosynthesis, respiration, transpiration rates, and allow for the penetration of phototoxic gaseous pollutants into plant tissue (Farmer, 1993). These impacts can result in decreased plant productivity which may lead to alterations in plant community structure and composition, and consequent changes in herbivore diversity and abundance (Farmer, 1993).

Moreover, dust may directly affect fauna. In arthropods for example, exposure to dust may lead to the smothering of adults and larvae and the disrupting of chemical cues used for mating (Talley et al. 2006), while mammals exposed to dust may show respiratory afflictions (Borm & Tran, 2002).

Impact in relation to proposed project

Dust will be generated during vegetation clearing, earthworks, from top-soil stockpiles, and as a result of vehicle activity. These activities mainly occur during the construction phase, but dust generation may persist during the operational and decommissioning phases if undeveloped areas that have been cleared of vegetation are not rehabilitated.

8.2 Impact Rating

Based on the study areas ecological characteristics and the nature of potential impacts, the environmental significance of each impact were assessed for the construction, operational and decommissioning phases. The results of the assessment are detailed in Table 14.

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Table 14: Environmental Impact Assessment MatrixTable

Impacts	Occurrence			Severity				Environmental Consequence Before Mitigation	Environmental Consequence After Mitigation
	Direction	Probability	Duration	Magnitude	Geographic Extent	Reversibility	Frequency		
Loss of habitat as a result of vegetation clearing	Negative	Definite	Permanent	High	Local	Irreversible	Low	High	High
Loss of plant species of conservation importance	Negative	Highly probable	Short-term	High	Local	Irreversible	Low	High	Moderate
Spread of alien invasive species	Negative	Highly probable	Long term	Moderate	Local	Reversible	High	Moderate	Low
Killing or injuring of fauna	Negative	Medium probability	Short-term	High	Local	Irreversible	Low	Moderate	Low
Habitat degradation due to dust	Negative	Highly probable	Short-term	Moderate	Local	Reversible	Medium	Low	Low

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8.3 Mitigation Measures

8.3.1 Construction Phase Mitigation Measures

Construction Phase: Environmental impacts and mitigation measures
Terrestrial ecology
Project activity: Construction activities ***Impact*:** Clearing of vegetation in the development footprint will lead to a loss of habitat for flora and fauna and a likely reduction in on-site biodiversity. ***Management objective***: To minimise the vegetation clearing and impacts on vegetation associated with the development. The impact of vegetation clearing is likely to be a long term impact. ***Mitigation measures*:** The following measures will be implemented: ■ The total footprint area to be disturbed / developed will be kept to a minimum by demarcating the construction areas and restricting construction to these areas only; ■ Develop and implement a rehabilitation programme, encompassing active revegetating using indigenous plant species, of all areas exposed during construction. The ECO should be responsible for overseeing the rehabilitation programme.
Project activity: Construction activities ***Impact*:** Loss of plant species of conservation importance. ***Management objective***: To limit the number of plant species of conservation importance that are cleared during construction, and obtain clearing permits for those where clearing is unavoidable. ***Mitigation measures*:** The following measures will be implemented: ■ Where possible, infrastructure should be sited so as to avoid clearing protected plant species; ■ Where clearing is unavoidable, clearane permits must be obtained from the relevant authorities to clear Red List and protected plants - *Adenia gummifera* var. *gummifera, Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra.*
Project activity: Construction activities ***Impact*:** Establishment and spread of alien invasive species. ***Management objective***: To control and prevent the spread of alien invasive species into adjacent undeveloped natural/semi-natural areas. ***Mitigation measures*:** The following measures will be implemented: ■ An alien invasive species control programme that includes regular monitoring and follow-up treatments, must be developed and implemented to reduce the establishment and spread of exotic invasive species in and to the study area; and ■ It is recommended that the ECO be responsible for monitoring the nature and extent of on-site exotic, invasive plants.
Project activity: Construction activities ***Impact*:** Killing and injurying of fauna. ***Management objective***: To reduce the likelihood that fauna occurring in the will be killed or injured during construction activities.

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Construction Phase: Environmental impacts and mitigation measures

Mitigation measures: The following measures will be implemented:

- A suitably trained ECO needs to be appointed to manage fauna, such as reptiles and amphibians, that are found in the project footprint and that do not readily disperse during construction activities. These fauna should be handled correctly and relocated to adjacent undisturbed natural areas; and
- Educate all construction personell about the presence of fauna on-site and the need to protect them.

Project activity: Construction activities

Impact: Habitat degradation due to dust

Management objective: To minimise the effects of dust on terrestrial fauna and flora.

Mitigation measures: The following measures will be implemented:

- Dust suppression on roads must be applied using water bowsers; and
- Exposed excavations, disturbed ground surfaces, stockpiles and unpaved traffic areas must be maintained in a moist condition.

8.3.2 Operation Phase Mitigation Measures

Operational Phase: Environmental impacts and mitigation measures

Terrestrial ecology

Project activity: Operational phase activities

Impact: Establishment and spread of alien invasive species.

Management objective: Continue controlling alien invasive species in the study area

Mitigation measures: The following measures will be implemented:

- Conduct regular monitoring and follow-up treatments, as per the alien invasive species control programme.

Project activity: Operational activities

Impact: Habitat degradation due to dust

Management objective: To minimise the effects of dust on terrestrial fauna and flora.

Mitigation measures: The following measures will be implemented:

- Revegetate exposed surfaces, as per the rehabilitation programme.

8.3.3 Decommissioning Phase Mitigation Measures

Decommissioning Phase: Environmental impacts and mitigation measures

Terrestrial ecology

Project activity: Decommisioning phase activities

Impact: Establishment and spread of alien invasive species.

Management objective: To control and prevent the spread of alien invasive species into adjacent

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Decommissioning Phase: Environmental impacts and mitigation measures
undeveloped natural/semi-natural areas. ***Mitigation measures*:** The following measure will be implemented: ■ Conduct regular monitoring and follow-up treatments as per the alien invasive species control programme for a one-year period following decommisioning.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The study area is located on a peninsula-like island at the mouth of the Richards Bay habour. The site is connected to the mainland by a road- and rail-access bridge, and is bounded to the south-east and north-east by railway tracks and to the north-west by an existing industrial facility.

The vegetation of the study area comprises two vegetation communities, namely *Brachylaena discolor – Apodytes dimidiata* short thicket community and *Phragmites australis – Typha capensis* wetlands. Both communities have localised sites of disturbance, mostly from the establishment of alien invasive plant species, such as Lantana (*Lantana camara*) (ACER pers. comm. 2014).

Four plant species of conservation importance were recorded in the study area. These are *Ficus trichopoda*, *Sideroxylon inerme* and *Mimusops caffra* (ACER pers. comm. 2014), both of which are listed as protected according to the National Forest Act (No. 84 of 1998) and the KwaZulu-Natal Nature Conservation Management Amendment Act (No. 5 of 1999), and *Adenia gummifera* var. *gummifera* which is listed as Declining (IUCN 2014.2, Regional Status). Moreover, *Dioscorea sylvatica* which is listed as Vulnerable (IUCN 2014.2, Regional Status) was previously recorded by ACER (2013) on a site immediately adjacent to the study area and therefore has a high probability of occuring on-site.

Despite its disturbed nature the site does comprise habitat for a variety of fauna, with several taxa recorded during the field survey. None of the recorded taxa are Red List or protected species; however a number of species of conservation importance may potentially occur in the study area.

There is the possibility that during the clearing of vegetation for the proposed project that there is a likelihood that there will be impact upon the flora and fauna in the vicinity of the construction site, and to this end the management measures that are proposed for the relocation of flora and the vigilance in capturing and relocating of fauna should be closely monitored.

Vegetation clearing and associated construction activities will also increase the potential for the establishment and spread of invasive plant species. It is thus important that the management measures, as outlined in this report, are incoporated into the environmental management programme of the proposed project.

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APPENDIX A

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APPENDIX B

Plant species previously recorded in the area as represented by 2832CC QDS and presented in SANBI's SIBIS (Version 2) database

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Family	Scientific Name
ACANTHACEAE	*Asystasia gangetica subsp. micrantha*
ACANTHACEAE	*Chaetacanthus burchellii*
ACANTHACEAE	*Hypoestes aristata var. aristata*
ACANTHACEAE	*Hypoestes forskaolii*
ACANTHACEAE	*Justicia campylostemon*
ACANTHACEAE	*Justicia protracta subsp. protracta*
ACANTHACEAE	*Phaulopsis imbricata subsp. imbricata*
ACHARIACEAE	*Xylotheca kraussiana*
AMARANTHACEAE	*Alternanthera sessilis*
AMARANTHACEAE	*Pupalia lappacea var. lappacea*
ANACARDIACEAE	*Searsia natalensis*
ANOMODONTACEAE	*Anomodon pseudotristis*
ANTHERICACEAE	*Chlorophytum comosum*
ANTHERICACEAE	*Chlorophytum krookianum*
ANTHERICACEAE	*Chlorophytum saundersiae*
APIACEAE	*Centella glabrata var. natalensis*
APOCYNACEAE	*Ancylobotrys petersiana*
APOCYNACEAE	*Carissa bispinosa*
APOCYNACEAE	*Catharanthus roseus*
APOCYNACEAE	*Cynanchum obtusifolium*
APOCYNACEAE	*Gomphocarpus physocarpus*
APOCYNACEAE	*Raphionacme hirsuta*
APOCYNACEAE	*Raphionacme palustris*
APOCYNACEAE	*Secamone filiformis*
APOCYNACEAE	*Sisyranthus compactus*
APOCYNACEAE	*Sisyranthus imberbis*
APOCYNACEAE	*Tacazzea apiculata*
ARALIACEAE	*Hydrocotyle bonariensis*
ASPARAGACEAE	*Asparagus falcatus*
ASPHODELACEAE	*Aloe myriacantha*
ASPHODELACEAE	*Kniphofia leucocephala*
ASPHODELACEAE	*Kniphofia littoralis*
ASPHODELACEAE	*Trachyandra saltii var. saltii*
ASPLENIACEAE	*Asplenium prionitis*
ASTERACEAE	*Ageratum houstonianum*
ASTERACEAE	*Aspilia natalensis*
ASTERACEAE	*Bidens pilosa*
ASTERACEAE	*Brachylaena discolor*

Family	Scientific Name
ASTERACEAE	*Chrysanthemoides monilifera subsp. rotundata*
ASTERACEAE	*Conyza attenuata*
ASTERACEAE	*Conyza canadensis*
ASTERACEAE	*Conyza sumatrensis var. sumatrensis*
ASTERACEAE	*Conyza ulmifolia*
ASTERACEAE	*Crassocephalum rubens var. rubens*
ASTERACEAE	*Distephanus angulifolius*
ASTERACEAE	*Doellia cafra*
ASTERACEAE	*Ethulia conyzoides subsp. conyzoides*
ASTERACEAE	*Ethulia conyzoides subsp. kraussii*
ASTERACEAE	*Felicia erigeroides*
ASTERACEAE	*Gazania rigens var. uniflora*
ASTERACEAE	*Gazania rigens var. uniflora*
ASTERACEAE	*Helichrysum adenocarpum subsp. ammophilum*
ASTERACEAE	*Helichrysum asperum var. comosum*
ASTERACEAE	*Helichrysum aureum var. monocephalum*
ASTERACEAE	*Helichrysum candolleanum*
ASTERACEAE	*Helichrysum cymosum subsp. cymosum*
ASTERACEAE	*Helichrysum longifolium*
ASTERACEAE	*Helichrysum tongense*
ASTERACEAE	*Hypochaeris brasiliensis*
ASTERACEAE	*Nidorella auriculata*
ASTERACEAE	*Nidorella linifolia*
ASTERACEAE	*Osteospermum grandidentatum*
ASTERACEAE	*Othonna carnosa var. discoidea*
ASTERACEAE	*Pulicaria scabra*
ASTERACEAE	*Senecio erubescens var. erubescens*
ASTERACEAE	*Senecio macrocephalus*
ASTERACEAE	*Senecio madagascariensis*
ASTERACEAE	*Senecio speciosus*
AVICENNIACEAE	*Avicennia marina*
BLECHNACEAE	*Blechnum punctulatum var. punctulatum*
BRACHYTHECIACEAE	*Rhynchostegium brachypterum*
BRASSICACEAE	*Coronopus didymus*
BRASSICACEAE	*Heliophila subulata*
BRASSICACEAE	*Lepidium africanum subsp. africanum*
BRASSICACEAE	*Lepidium virginicum*
BRYACEAE	*Bryum argenteum*

Family	Scientific Name
BRYACEAE	*Bryum canariense*
BRYACEAE	*Bryum dichotomum*
BRYACEAE	*Rhodobryum commersonii*
CACTACEAE	*Opuntia vulgaris*
CAMPANULACEAE	*Wahlenbergia abyssinica subsp. abyssinica*
CAMPANULACEAE	*Wahlenbergia undulata*
CANNACEAE	*Canna indica*
CAPPARACEAE	*Capparis fascicularis var. zeyheri*
CAPPARACEAE	*Maerua racemulosa*
CARYOPHYLLACEAE	*Krauseola mosambicina*
CARYOPHYLLACEAE	*Silene burchellii var. angustifolia*
CELASTRACEAE	*Elaeodendron croceum*
CELASTRACEAE	*Gymnosporia markwardii*
CELASTRACEAE	*Gymnosporia senegalensis*
CELASTRACEAE	*Hippocratea schlechteri var. peglerae*
CELASTRACEAE	*Maytenus peduncularis*
CELASTRACEAE	*Maytenus procumbens*
CELASTRACEAE	*Salacia kraussii*
CHENOPODIACEAE	*Salicornia perrieri*
CHENOPODIACEAE	*Sarcocornia natalensis var. natalensis*
CHRYSOBALANACEAE	*Parinari capensis subsp. incohata*
COMMELINACEAE	*Aneilema aequinoctiale*
COMMELINACEAE	*Aneilema dregeanum*
COMMELINACEAE	*Coleotrype natalensis*
COMMELINACEAE	*Commelina africana var. africana*
COMMELINACEAE	*Commelina diffusa subsp. diffusa*
CONVOLVULACEAE	*Convolvulus natalensis*
CONVOLVULACEAE	*Hewittia malabarica*
CONVOLVULACEAE	*Ipomoea cairica var. cairica*
CONVOLVULACEAE	*Ipomoea mauritiana*
CONVOLVULACEAE	*Xenostegia tridentata subsp. angustifolia*
CUCURBITACEAE	*Citrullus lanatus*
CUCURBITACEAE	*Kedrostis foetidissima*
CUCURBITACEAE	*Lagenaria sphaerica*
CUCURBITACEAE	*Momordica balsamina*
CUCURBITACEAE	*Mukia maderaspatana*
CUCURBITACEAE	*Zehneria parvifolia*
CYPERACEAE	*Bulbostylis contexta*

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Family	Scientific Name
CYPERACEAE	*Bulbostylis hispidula subsp. pyriformis*
CYPERACEAE	*Carex cognata*
CYPERACEAE	*Cladium mariscus subsp. jamaicense*
CYPERACEAE	*Cyperus albostriatus*
CYPERACEAE	*Cyperus articulatus*
CYPERACEAE	*Cyperus brevis*
CYPERACEAE	*Cyperus digitatus subsp. auricomus*
CYPERACEAE	*Cyperus dubius var. dubius*
CYPERACEAE	*Cyperus esculentus var. esculentus*
CYPERACEAE	*Cyperus fastigiatus*
CYPERACEAE	*Cyperus involucratus*
CYPERACEAE	*Cyperus laevigatus*
CYPERACEAE	*Cyperus macrocarpus*
CYPERACEAE	*Cyperus natalensis*
CYPERACEAE	*Cyperus papyrus*
CYPERACEAE	*Cyperus pectinatus*
CYPERACEAE	*Cyperus prolifer*
CYPERACEAE	*Cyperus rotundus subsp. tuberosus*
CYPERACEAE	*Cyperus rubicundus*
CYPERACEAE	*Cyperus solidus*
CYPERACEAE	*Cyperus sphaerospermus*
CYPERACEAE	*Cyperus tenax*
CYPERACEAE	*Eleocharis caduca*
CYPERACEAE	*Eleocharis limosa*
CYPERACEAE	*Fimbristylis bivalvis*
CYPERACEAE	*Fimbristylis complanata*
CYPERACEAE	*Fimbristylis cymosa*
CYPERACEAE	*Fimbristylis ferruginea*
CYPERACEAE	*Fimbristylis squarrosa*
CYPERACEAE	*Fuirena hirsuta*
CYPERACEAE	*Isolepis prolifera*
CYPERACEAE	*Pycreus mundii*
CYPERACEAE	*Pycreus nitidus*
CYPERACEAE	*Pycreus polystachyos var. polystachyos*
CYPERACEAE	*Pycreus unioloides*
CYPERACEAE	*Rhynchospora brownii*
CYPERACEAE	*Rhynchospora gracillima subsp. subquadrata*
CYPERACEAE	*Rhynchospora perrieri*

Family	Scientific Name
CYPERACEAE	*Rhynchospora rubra subsp. africana*
CYPERACEAE	*Schoenoplectus scirpoides*
CYPERACEAE	*Scleria achtenii*
CYPERACEAE	*Scleria angusta*
CYPERACEAE	*Scleria sobolifer*
DIOSCOREACEAE	*Dioscorea rupicola*
DIOSCOREACEAE	*Dioscorea sylvatica var. sylvatica*
DRACAENACEAE	*Sansevieria hyacinthoides*
EQUISETACEAE	*Equisetum ramosissimum subsp. ramosissimum*
ERYTHROXYLACEAE	*Erythroxylum emarginatum*
EUPHORBIACEAE	*Clutia cordata*
EUPHORBIACEAE	*Dalechampia scandens var. natalensis*
EUPHORBIACEAE	*Euphorbia hirta*
EUPHORBIACEAE	*Euphorbia inaequilatera var. inaequilatera*
EUPHORBIACEAE	*Euphorbia kraussiana var. kraussiana*
EUPHORBIACEAE	*Jatropha hirsuta var. glabrescens*
FABACEAE	*Acacia nilotica subsp. kraussiana*
FABACEAE	*Argyrolobium rotundifolium*
FABACEAE	*Aspalathus gerrardii*
FABACEAE	*Caesalpinia bonduc*
FABACEAE	*Chamaecrista mimosoides*
FABACEAE	*Crotalaria capensis*
FABACEAE	*Crotalaria globifera*
FABACEAE	*Crotalaria pallida var. pallida*
FABACEAE	*Desmodium dregeanum*
FABACEAE	*Dichilus reflexus*
FABACEAE	*Eriosema parviflorum subsp. parviflorum*
FABACEAE	*Eriosema salignum*
FABACEAE	*Indigofera charlieriana var. charlieriana*
FABACEAE	*Indigofera inhambanensis*
FABACEAE	*Indigofera melanadenia*
FABACEAE	*Indigofera neglecta*
FABACEAE	*Indigofera spicata var. spicata*
FABACEAE	*Indigofera tristoides*
FABACEAE	*Indigofera williamsonii*
FABACEAE	*Leobordea carinata*
FABACEAE	*Macrotyloma axillare var. axillare*
FABACEAE	*Melilotus albus*

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Family	Scientific Name
FABACEAE	*Melilotus indicus*
FABACEAE	*Ormocarpum trichocarpum*
FABACEAE	*Sesbania bispinosa var. bispinosa*
FABACEAE	*Tephrosia burchellii*
FABACEAE	*Tephrosia glomeruliflora subsp. glomeruliflora*
FABACEAE	*Tephrosia linearis*
FABACEAE	*Tephrosia macropoda var. macropoda*
FABACEAE	*Tephrosia polystachya var. hirta*
FABACEAE	*Tephrosia polystachya var. polystachya*
FABACEAE	*Vigna luteola var. luteola*
FABACEAE	*Vigna unguiculata subsp. dekindtiana var. huillensis*
FABACEAE	*Vigna unguiculata subsp. stenophylla*
FABACEAE	*Zornia capensis subsp. capensis*
FISSIDENTACEAE	*Fissidens aciphyllus*
GERANIACEAE	*Monsonia praemorsa*
GOODENIACEAE	*Scaevola plumieri*
HYACINTHACEAE	*Ornithogalum tenuifolium subsp. tenuifolium*
HYDROCHARITACEAE	*Lagarosiphon muscoides*
HYPERICACEAE	*Hypericum lalandii*
HYPOXIDACEAE	*Hypoxis filiformis*
HYPOXIDACEAE	*Hypoxis longifolia*
HYPOXIDACEAE	*Hypoxis rigidula var. pilosissima*
ICACINACEAE	*Apodytes dimidiata subsp. dimidiata*
ICACINACEAE	*Pyrenacantha scandens*
IRIDACEAE	*Aristea abyssinica*
IRIDACEAE	*Aristea gerrardii*
IRIDACEAE	*Dierama sp.*
IRIDACEAE	*Freesia laxa subsp. azurea*
IRIDACEAE	*Gladiolus dalenii subsp. dalenii*
IRIDACEAE	*Gladiolus densiflorus*
JUNCACEAE	*Juncus kraussii subsp. kraussii*
JUNCAGINACEAE	*Triglochin bulbosa*
JUNCAGINACEAE	*Triglochin striata*
LAMIACEAE	*Acrotome hispida*
LAMIACEAE	*Ocimum americanum var. americanum*
LAMIACEAE	*Plectranthus verticillatus*
LAMIACEAE	*Stachys natalensis var. galpinii*
LAURACEAE	*Cassytha filiformis*

Family	Scientific Name
LEMNACEAE	*Spirodela punctata*
LENTIBULARIACEAE	*Utricularia australis*
LENTIBULARIACEAE	*Utricularia sp.*
LENTIBULARIACEAE	*Utricularia stellaris*
LINDSAEACEAE	*Lindsaea ensifolia*
LOBELIACEAE	*Lobelia anceps*
LOBELIACEAE	*Lobelia erinus*
LOBELIACEAE	*Lobelia tomentosa*
LOMARIOPSIDACEAE	*Acrostichum aureum*
LYTHRACEAE	*Galpinia transvaalica*
LYTHRACEAE	*Nesaea tolypobotrys*
MALPIGHIACEAE	*Acridocarpus natalitius var. natalitius*
MALPIGHIACEAE	*Sphedamnocarpus pruriens subsp. galphimiifolius*
MALVACEAE	*Abutilon grandifolium*
MALVACEAE	*Abutilon grantii*
MALVACEAE	*Corchorus trilocularis*
MALVACEAE	*Grewia caffra*
MALVACEAE	*Grewia occidentalis var. occidentalis*
MALVACEAE	*Hibiscus surattensis*
MALVACEAE	*Hibiscus trionum*
MALVACEAE	*Malvastrum coromandelianum*
MALVACEAE	*Sida cordifolia subsp. cordifolia*
MALVACEAE	*Sida dregei*
MALVACEAE	*Triumfetta pilosa var. tomentosa*
MALVACEAE	*Triumfetta rhomboidea var. rhomboidea*
MALVACEAE	*Waltheria indica*
MARSILEACEAE	*Marsilea sp.*
MELASTOMATACEAE	*Antherotoma phaeotricha*
MELASTOMATACEAE	*Dissotis canescens*
MELIACEAE	*Ekebergia capensis*
MELIACEAE	*Trichilia dregeana*
MELIACEAE	*Trichilia emetica subsp. emetica*
MELIACEAE	*Turraea floribunda*
MELIANTHACEAE	*Bersama lucens*
MELIANTHACEAE	*Bersama tysoniana*
MESEMBRYANTHEMACEAE	*Carpobrotus dimidiatus*
MORACEAE	*Ficus capreifolia*
MORACEAE	*Ficus natalensis subsp. natalensis*

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Family	Scientific Name
MORACEAE	*Ficus sycomorus subsp. sycomorus*
MORACEAE	*Ficus trichopoda*
MYRICACEAE	*Morella serrata*
MYRTACEAE	*Eugenia albanensis*
MYRTACEAE	*Eugenia capensis subsp. capensis*
MYRTACEAE	*Syzygium cordatum*
MYRTACEAE	*Syzygium cordatum subsp. cordatum*
NAJADACEAE	*Najas marina subsp. armata*
NYCTAGINACEAE	*Boerhavia coccinea var. coccinea*
NYCTAGINACEAE	*Commicarpus chinensis subsp. natalensis*
NYMPHAEACEAE	*Nymphaea nouchali var. zanzibariensis*
OLEACEAE	*Chionanthus peglerae*
ONAGRACEAE	*Oenothera affinis*
ONAGRACEAE	*Oenothera parodiana subsp. parodiana*
OPHIOGLOSSACEAE	*Ophioglossum reticulatum*
ORCHIDACEAE	*Bonatea lamprophylla*
ORCHIDACEAE	*Cheirostylis gymnochiloides*
ORCHIDACEAE	*Disa woodii*
ORCHIDACEAE	*Disperis johnstonii*
ORCHIDACEAE	*Eulophia cucullata*
ORCHIDACEAE	*Eulophia sp.*
ORCHIDACEAE	*Eulophia speciosa*
ORCHIDACEAE	*Oeceoclades lonchophylla*
ORCHIDACEAE	*Satyrium sp.*
ORCHIDACEAE	*Satyrium sphaerocarpum*
OROBANCHACEAE	*Buchnera dura*
OROBANCHACEAE	*Cycnium tubulosum subsp. tubulosum*
OROBANCHACEAE	*Sopubia simplex*
OROBANCHACEAE	*Striga gesnerioides*
ORTHOTRICHACEAE	*Macromitrium lebomboense*
PASSIFLORACEAE	*Adenia gummifera var. gummifera*
PASSIFLORACEAE	*Basananthe polygaloides*
PHYLLANTHACEAE	*Phyllanthus glaucophyllus*
PHYLLANTHACEAE	*Phyllanthus parvulus var. garipensis*
PHYTOLACCACEAE	*Rivina humilis*
PILOTRICHACEAE	*Callicostella tristis*
POACEAE	*Acroceras macrum*
POACEAE	*Alloteropsis semialata subsp. semialata*

Family	Scientific Name
POACEAE	*Andropogon eucomus*
POACEAE	*Aristida junciformis subsp. junciformis*
POACEAE	*Bambusa sp.*
POACEAE	*Brachiaria arrecta*
POACEAE	*Brachiaria humidicola*
POACEAE	*Chloris gayana*
POACEAE	*Cymbopogon nardus*
POACEAE	*Cynodon dactylon*
POACEAE	*Dactyloctenium geminatum*
POACEAE	*Digitaria diversinervis*
POACEAE	*Digitaria eriantha*
POACEAE	*Digitaria natalensis*
POACEAE	*Digitaria scalarum*
POACEAE	*Echinochloa colona*
POACEAE	*Echinochloa jubata*
POACEAE	*Echinochloa pyramidalis*
POACEAE	*Ehrharta calycina*
POACEAE	*Ehrharta erecta var. erecta*
POACEAE	*Eleusine coracana subsp. africana*
POACEAE	*Eragrostis ciliaris*
POACEAE	*Eragrostis curvula*
POACEAE	*Eragrostis tenuifolia*
POACEAE	*Hyparrhenia cymbaria*
POACEAE	*Hyparrhenia filipendula var. filipendula*
POACEAE	*Hyparrhenia hirta*
POACEAE	*Leptochloa fusca*
POACEAE	*Lolium temulentum*
POACEAE	*Megastachya mucronata*
POACEAE	*Panicum dregeanum*
POACEAE	*Panicum genuflexum*
POACEAE	*Panicum hymeniochilum*
POACEAE	*Panicum maximum*
POACEAE	*Panicum natalense*
POACEAE	*Panicum subflabellatum*
POACEAE	*Paspalidium obtusifolium*
POACEAE	*Paspalum scrobiculatum*
POACEAE	*Polypogon monspeliensis*
POACEAE	*Setaria italica*

Family	Scientific Name
POACEAE	*Sporobolus natalensis*
POACEAE	*Sporobolus subtilis*
POACEAE	*Sporobolus subtilis*
POACEAE	*Sporobolus virginicus*
POACEAE	*Stenotaphrum secundatum*
POACEAE	*Stipagrostis zeyheri subsp. barbata*
POACEAE	*Tricholaena monachne*
PODOCARPACEAE	*Podocarpus falcatus*
POLYGALACEAE	*Polygala capillaris subsp. capillaris*
POLYGALACEAE	*Polygala hottentotta*
POLYGONACEAE	*Oxygonum robustum*
POLYGONACEAE	*Persicaria attenuata subsp. africana*
POLYGONACEAE	*Persicaria decipiens*
POLYPODIACEAE	*Microsorum punctatum*
POLYPODIACEAE	*Microsorum scolopendria*
PONTEDERIACEAE	*Eichhornia crassipes*
POTAMOGETONACEAE	*Potamogeton nodosus*
POTAMOGETONACEAE	*Potamogeton pectinatus*
POTAMOGETONACEAE	*Potamogeton schweinfurthii*
POTTIACEAE	*Tortella xanthocarpa*
POTTIACEAE	*Trichostomum brachydontium*
PTERIDACEAE	*Pteris vittata*
RAMALINACEAE	*Ramalina farinacea*
RAMALINACEAE	*Ramalina sp.*
RAMALINACEAE	*Ramalina thraustoides*
RHAMNACEAE	*Scutia myrtina*
RHIZOPHORACEAE	*Bruguiera gymnorrhiza*
ROCCELLACEAE	*Opegrapha sorediifera*
RUBIACEAE	*Agathisanthemum bojeri subsp. bojeri*
RUBIACEAE	*Kohautia virgata*
RUBIACEAE	*Mitriostigma axillare*
RUBIACEAE	*Pavetta revoluta*
RUBIACEAE	*Pavetta sp.*
RUBIACEAE	*Pentanisia prunelloides subsp. latifolia*
RUBIACEAE	*Tricalysia sonderiana var. sonderiana*
RUPPIACEAE	*Ruppia cirrhosa*
RUPPIACEAE	*Ruppia maritima*
RUTACEAE	*Teclea natalensis*

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Family	Scientific Name
SALICACEAE	*Scolopia mundii*
SALICACEAE	*Scolopia zeyheri*
SANTALACEAE	*Osyris compressa*
SANTALACEAE	*Thesium resedoides*
SAPINDACEAE	*Allophylus natalensis*
SAPINDACEAE	*Cardiospermum grandiflorum*
SAPINDACEAE	*Deinbollia oblongifolia*
SAPINDACEAE	*Pancovia golungensis*
SAPOTACEAE	*Manilkara concolor*
SAPOTACEAE	*Mimusops caffra*
SAPOTACEAE	*Sideroxylon inerme subsp. inerme*
SCROPHULARIACEAE	*Hebenstretia comosa*
SCROPHULARIACEAE	*Manulea parviflora var. parviflora*
SCROPHULARIACEAE	*Scoparia dulcis*
SCROPHULARIACEAE	*Selago cucullata*
SCROPHULARIACEAE	*Zaluzianskya pachyrrhiza*
SOLANACEAE	*Physalis peruviana*
SOLANACEAE	*Solanum acanthoideum*
SOLANACEAE	*Solanum goetzei*
SOLANACEAE	*Solanum torvum*
STRYCHNACEAE	*Strychnos madagascariensis*
THELYPTERIDACEAE	*Ampelopteris prolifera*
THELYPTERIDACEAE	*Cyclosorus interruptus*
THYMELAEACEAE	*Gnidia microcephala*
THYMELAEACEAE	*Gnidia splendens*
THYMELAEACEAE	*Passerina rigida*
THYMELAEACEAE	*Peddiea africana*
TYPHACEAE	*Typha capensis*
URTICACEAE	*Laportea peduncularis subsp. peduncularis*
VERBENACEAE	*Phyla nodiflora var. nodiflora*
VERBENACEAE	*Verbena brasiliensis*
VITACEAE	*Cissus fragilis*
VITACEAE	*Cyphostemma cirrhosum subsp. transvaalense*
VITACEAE	*Rhoicissus digitata*
VITACEAE	*Rhoicissus revoilii*
VITACEAE	*Rhoicissus sp.*
VITTARIACEAE	*Vittaria isoetifolia*
XYRIDACEAE	*Xyris natalensis*

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Family	Scientific Name
ZOSTERACEAE	*Zostera capensis*

Source: (SANBI, SIBIS Version 2).

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APPENDIX C

Arthropod species recorded in the study area

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Superclass	Class	Order	Family	Genus	Species	Common Name
	Insecta	Collembola	Sminthuridae	-	-	Globular springtail
		Odonata	Lestidae	-	-	Spreadwing
			Protoneuridae	-	-	Threadtail
		Anisoptera	Libellulidae	*Trithemis*	*arteriosa*	Red-veined Dropwing
		Blattodea	Blattidae	*Deropeltis*	*erythrocephela*	-
			Blaberidae	*Bantua*	sp.	-
			Pseudophyllodromiidae	*Supella*	*dimidiata*	-
		Mantodea	Hymenopodidae	*Harpagomantis*	*tricolor*	Flower Mantid
			Mantidae	*Sphodromantis*	*gastrica*	Common green Mantid
		Dermaptera	Libiduridae	*Labidura*	*riparia*	Long-horned EaRWDig
		Orthoptera	Gryllacrididae	-	-	Leaf-rolling Cricket
			Tettigonidae	*Phaneroptera*	sp.	Leaf Katydid
			Gryllidae	*Gryllus*	*bimaculatus*	Common Cricket
				Oecanthus	sp.	Tree Cricket
			Gryllotalpidae	-	-	Mole Cricket
			Acrididae	*Cyrtacanthacris*	*aeruginosa*	Green Tree Locust
		Phasmatodea	Heteronemiidae	*Bactrododema*	*tiaratum*	Stick insect
		Hemiptera	Reduviidae	*Acanthaspis*	*obscura*	-
				Ectrichodia	*crux*	Millipede Assasin
			Coreidae	*Homoeocerus*	*auriculatus*	-
			Alydidae	*Mirperus*	*jaculus*	-
		Thysanoptera	Thripidae	-	-	Common Thrip

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Superclass	Class	Order	Family	Genus	Species	Common Name
		Megaloptera	Coydalidae	*Taeniochauloides*	*ochraceopennis*	Dobsonfly
		Neuroptera	Chrysopidae	*Chrysoperla*	sp.	Green Lacewing
			Myrmeleontidae	*Hagenomyia*	*tristis*	Gregarious Antlion
			Notonectidae	*Anisops*	-	Common Backswimmers
		Coleoptera	Carabidae	*Thermophilum*	*homoplatum*	Two-spot Ground Beetle
			Scarabidae	*Pachnoda*	*sinuata*	Fruit Chafer
			Tennebrionidae	*Psammodes*	*bertolonii*	-
			Meloidae	*Decapotoma*	*lunata*	Blister Beetle
		Diptera	Culicidae	*Aedes*	sp.	Bush Mosquito
				Culex	sp.	House Mosquito
			Tabanidae	*Tabanus*	*taeniatus*	-
			Bombyliidae	*Exoprosopa*	sp.	-
			Calliphoridae	*Chrysomya*	*chloropyga*	-
			Yponomeutidae	-	-	Ermine Moth
			Ctenuchinae	*Amata*	*atricornis*	-
			Limacodidae	*Coenabasis*	*amoena*	-
			Pyralidae	*Zitha*	*laminalis*	-
			Sphingidae	*Hippotion*	*celerio*	-
			Arctiidae	*Utetheisa*	*pulchella*	-
			Lamantriidae	*Naroma*	*varipes*	-
			Hesperiidae	*Spialia*		-
			Nymphalidae	*Danaus*	*chrysippus*	-

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Superclass	Class	Order	Family	Genus	Species	Common Name
				Hyalites	*esebria*	-
				Cassionympha	*cassius*	-
			Papilionidae	*Papilio*	*demodocus*	-
				Papilio	*nireus*	-
			Pieridae	*Colotis*	*euippe*	-
				Eurema	*brigitta*	-
				Cynthia	*cardui*	-
		Hymenoptera	Apidae	*Apis*	*mellifera*	-
			Formicidae	*Dorylus*	*helvolus*	-
				Tetraponera		Slender ants
Myriapodia	-	-	-	-	-	Centipede
						Millipede

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APPENDIX D

Reptile species potentially occurring in the study area

Scientific name	**Common name**	**Status**
Acanthocercus atricollis	Southern Tree Agama	-
Acontias plumbeus	Giant Legless Skink	Endemic (Branch 1998)
Agama aculeate		
Amblyodipsas concolor	Natal Purple-Glossed Snake	Endemic (Branch 1998)
Amblyodipsas polylepis	Common Purple-Glossed Snake	-
Aparallactus capensis	Cape Centipede Eater	-
Atractaspis bibronii	Southern or Bibron's Burrowing Asp	-
Bitis arietans	Puff Adder	-
Bitis gabonica	Gaboon Adder	Peripheral (Branch 1988a)
Bradypodion setaroi	Setaro's Dwarf Chameleon	Endangered (Hilton-Taylor 2000)
Causus defilippii	Snouted Night Adder	-
Causus rhombeatus	Common / Rhombic Night Adder	-
Chamaeleo dilepsis	Flap-neck Chameleon	-
Chamaesaura anguina	Cape Grass Lizard	-
Chamaesaura macrolepis	Large Scaled Grass Lizard	-
Crocodylus niloticus	Nile Crocodile	Vulnerable (Branch 1998)
Crotaphopeltis hotamboeia	Red-Lipped Snake	-
Dasypeltis inornata	Southern Brown Egg Eater	Endemic (Branch 1998)
Dasypeltis scabra	Common Egg Eater	-
Dendroaspis angusticeps	Green Mamba	-
Dendroaspis polylepis	Black Mamba	-
Dispholidus typus	Boomslang	-
Duberria lutrix	Common Slug Eater	-
Gerrhosaurus flavigularis	Yellow-Throated Plated Lizard	-
Hemidactylus mabouia	Mareau's Tropical House Gecko	-
Kinixys belliana	Bell's Hinged Tortoise	-
Lamprophis aurora	Aurora House Snake	Rare & Endemic (Branch 1998)
Lamprophis inornatus	Olive House Snake	Endemic (Branch 1998)
Leptotyphlops conjunctus	Cape & Eastern Thread Snake	-
Leptotyphlops scutifrons	Peter's Thread Snake	-
Leptotyphlops sylvicolus	Forest Thread Snake	Endemic (Branch 1998)
Lycodonomorphus capensis		
Lycodonomorphus rufulus	Common Brown Water Snake	Endemic (Branch 1998)
Lycophidion capense	Cape Wolf Snake	-

Scientific name	Common name	Status
Lygodactylus capensis	Cape Dwarf Gecko	-
Mabuya homalocephala		
Macrelaps microlepidotus	Natal Black Snake	Endemic (Branch 1998)
Mehelya capensis	Cape File Snake	-
Mehelya nyassae	Black File Snake	-
Naja annulifera	Snouted Cobra	-
Naja melanoleuca	Forest Cobra	Peripheral (Branch 1988a)
Naja mossambica	Mozambique Spitting Cobra	-
Nucras ornata	Ornate Sandveld Lizard	-
Panaspis wahlbergii	Wahlberg's Snake-Eyed Skink	-
Pelomedusa subrafa	Marsh or helmeted Terrapin	-
Pelomedusa subrafa	Marsh or helmeted Terrapin	-
Pelusios castanoides	Yellow-bellied Hinged Terrapin	Peripheral (Branch 1988a)
Pelusios castanoides	Yellow-bellied Hinged Terrapin	Peripheral (Branch 1988a)
Pelusios rhodesianus	Mashona Hinged Terrapin	Peripheral (Branch 1988a)
Pelusios sinuatus	Serrated Hinged Terrapin	
Philothamnus natalensis	Eastern Green Snake	Endemic (Branch 1998)
Philothamnus semivariegatus	Spotted Bush Snake	-
Philothamnushoplogaster	Green Water Snake	-
Prosymna stuhlmannii	East African Shovel-snout	-
Psammophis brevirostris	Leopard & Short-snouted Grass Snake	-
Psammophis mossambicus	Olive Grass Snake	-
Pseudapsis cana	Mole Snake	-
Pseudocordylus melanotus melanotus	Drakensberg Crag Lizard	Endemic (Branch 1998)
Python natalensis	Southern African Python	Vulnerable (Branch 1988a)
Rhinotyphlops schlegelii	Schlegel's Beaked Blind Snakes	-
Scelotes mossambicus	Mozambique Dwarf Burrowing Skink	Endemic (Branch 1998)
Stigmochelys paradalis / Geochelone pardalis	Leopard Tortoise	-
Telescopes semiannulatus	Eastern Tiger Snake	-
Tetradactylus africanus	African Long-tailed Sep	Endemic (Branch 1998)
Thelotornis capensis	Twig or Vine Snake	-
Trachylepis homalocephala /	Red-Sided Skink	Endemic (Branch 1998)
Trachylepis striata / Mabuya striata	Striped Skink	-
Trachylepis varia / Mabuya varia	Variable Skink	-
Typhlops bibronii	Bibron's Blind Snake	Endemic (Branch 1998)

Scientific name	Common name	Status
Varanus albigularis	Rock or White-throated Monitor	-
Varanus niloticus	Nile or water Monitor	

Source: (Branch W. , Snakes and other reptiles of Southern Africa, 1996)

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APPENDIX E

Amphibian species potentially occurring in the study area

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Species Name	Status
Afrixalus aureus	Rare (Delisted Branch & Harrison 2004)
Afrixalus delicatus	Least Concern
Afrixalus fornasinii	Least Concern
Afrixalus spinifrons	Vulnerable (Branch & Harrison 2004)
Amieta angolensis	Least Concern
Amietophrynus garmani	Least Concern
Amietophrynus gutturalis	Least Concern
Amietophrynus rangeri	Least Concern
Anthroleptella hewitti	KZN Endemic
Arthroleptis stenodactylus	Least Concern
Arthroleptis wahlbergi	KZN Endemic
Breviceps adspersus	Least Concern
Breviceps mossambicus	Least Concern
Breviceps soptranos	Data deficient (Branch & Harrison 2004)
Breviceps verrucosus	Least Concern
Cacosternum boettgeri	Least Concern
Cacosternum nanum	Least Concern
Chiromantis xerampelina	Least Concern
Heleophryne natalensis	Least Concern
Hemisus guttatus	Vulnerable (Branch & Harrison 2004)
Hemisus marmoratus	Least Concern
Hyperolius acuticeps	
Hyperolius argus	Least Concern
Hyperolius marmoratus	Least Concern
Hyperolius nasutus	Least Concern
Hyperolius pickersgilli	Rare
Hyperolius pusillus	Least Concern
Hyperolius semidiscus	Least Concern
Hyperolius tuberilinguis	Least Concern
Kassina maculata	Least Concern
Kassina senegalensis	Least Concern
Leptopelis mossambicus	Least Concern
Leptopelis natalensis	KZN Endemic
Natalobatrachus bonebergi	Endangered (Branch & Harrison 2004)

Species Name	**Status**
Phrynobatrachus mababiensis	Least Concern
Phrynobatrachus natalensis	Least Concern
Phrynomantis bifasciatus	Least Concern
Ptychadena anchietae	Least Concern
Ptychadena mascareniensis	Least Concern
Ptychadena mossambica	Least Concern
Ptychadena oxyrhynchus	Least Concern
Ptychadena porosissima	Least Concern
Ptychadena taenioscelis	Least Concern
Pyxicephalus adspersus	Near-threatenend; regional (Branch & Harrison 2004)
Pyxicephalus edulis	Least Concern
Schisaderma carens	Least Concern
Strongylopus fasciatus	Least Concern
Strongylopus grayii	Least Concern
Tomopterna cryptotis	Least Concern
Tomopterna natalensis	Least Concern
Xenopus laevis	Least Concern

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APPENDIX F

Birds species potentiallyy occurring in the study area

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Scientific Name	Common Name	IUCN Status
Accipiter badius	Shikra	
Accipiter melanoleucus	Black Sparrowhawk	
Accipiter minulls	Little Sparrowhawk	
Accipiter tachiro	African Goshawk	
Acridotheres tristis	Common Myna	
Acrocephalus baeticatus	African Reed-Warbler	
Acrocephalus gracilirostris	Lesser Swamp Warbler	
Actitis hypoleucos	Common Sandpiper	
Actophilornis africanus	African Jacana	
Alcedo cristata	Malachite Kingfisher	
Alcedo semitorquata	Half-collared Kingfisher	Near-threatened
Alopochen aegytiacus	Egyptian Goose	
Amandava subflava	Orange-breasted Waxbill	
Amaurornis flavirostris	Black Crake	
Amblyospiza albifrons	Thick-billed Weaver	
Anas capensis	Cape Teal	
Anas erythrorhyncha	Red-billed Teal	
Anas hottentota	Hottentot Teal	
Anas Sparsa	African Black Duck	
Anas undulata	Yellow-billed Duck	
Anastomus lamelligerus	African Openbill	Near-threatened
Andropadus importunus	Sombre Greenbul	
Anhinga rufa	African Darter	
Anthus cinnamomeus	African Pipit	
Anthus leucophrys	Plain-backed Pipit	
Apalis flavida	Yellow-breasted Apalis	
Apalis thoracica	Bar-throated Apalis	
Apaloderma narina	Narina Trogon	
Aplopelia larvata	Lemon Dove	
Apus affinis	Little Swift	
Apus apus	Common Swift	
Apus barbatus	African Black Swift	
Apus caffer	White-rumped Swift	
Aquila wahlbergi	Wahlberg's Eagle	
Ardea cinerea	Grey Heron	
Ardea goliath	Goliath Heron	
Ardea melanocephala	Black-headed Heron	
Ardea purpurea	Purple Heron	
Ardeola ralloides	Squacco Heron	
Arenaria interpres	Ruddy Turnstone	
Aviceda cuculoides	African Cuckoo Hawk	
Balearica regulorum	Grey Crowned Crane	Vulnerable

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Scientific Name	Common Name	IUCN Status
Batis capensis	Cape Batis	
Batis molitor	Chinspot Batis	
Bostrychia hagedash	Hadeda Ibis	
Botaurus stellaris	Eurasian Bittern	Critically Endangered
Bubo africanus	Spotted Eagle Owl	
Bubulcus ibis	Cattle egret	
Burhinus capensis	Spotted Thick-knee	
Burhinus vermiculatus	Water Thick-knee	
Buteo b. vulpinus	Steppe Buzzard	
Buteo rufofuscus	Jackal Buzzard	
Butorides striatus	Green-backed Heron	
Bycanistes bucinator	Trumpeter Hornbill	
Calidris ferruginea	Curlew Sandpiper	
Calidris minuta	Little Stint	
Camaroptera brachyura	Green-backed Camaroptera	
Campephaga flava	Black Cuckooshrike	
Campethera abingoni	Golden-tailed Woodpecker	
Caprimulgus europaeus	European Nightjar	
Caprimulgus fossii	Square-tailed Nightjar	
Caprimulgus natalensis	Swamp Nightjar	Vulnerable
Caprimulgus pectoralis	Fiery-necked Nightjar	
Centropus burchelli	Burchell's Coucal	
Cercomela familiaris	Familiar Chat	
Ceryle rudis	Pied Kingfisher	
Ceuthmochares aereus	Green Malkoha	
Chalcomitra amethystina	Amethyst Sunbird	
Chalcomitra senegalensis	Scarlet-chested Sunbird	
Charadrius hiaticula	Common Ringed Plover	
Charadrius pecuarius	Kittlitz's Plover	
Charadrius tricollaris	Three-banded Plover	
Chlidonias hybridus	Whiskered Tern	
Chlidonias leucopterus	White-winged Tern	
Chlorocichla flaviventris	Yellow-bellied Greenbul	
Chrysococcyx caprius	Diderick Cuckoo	
Chrysococcyx cupreus	African Emerald Cuckoo	
Chrysococcyx klaas	Klaas's Cuckoo	
Ciconia ciconia	White Stork	
Ciconia episcopus	Wooly-necked Stork	Near-threatened
Ciconia nigra	Black Stork	Near-threatened
Cinnyricinclus leucogaster	Violet-backed Starling	
Cinnyris afra	Greater Double-collared Sunbird	
Cinnyris bifasciata	Purple-banded Sunbird	

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Scientific Name	**Common Name**	**IUCN Status**
Cinnyris talatala	White-bellied Sunbird	
Circaetus cinereus	Brown Snake Eagle	
Circaetus gallicus	Black-chested Snake-Eagle	
Circeatus fasciolatus	Southern-banded Snake-Eagle	Vulnerable
Circus ranivorus	African Marsh-Harrier	Vulnerable
Cisticola chinianus	Rattling Cisticola	
Cisticola erythrops	Red-faced Cisticola	
Cisticola fulvicapilla	Neddicky	
Cisticola galactotes	Rufous-winged Cisticola	
Cisticola juncidis	Zitting Cisticola	
Cisticola natalensis	Croaking Cisticola	
Colius striatus	Speckled Mousebird	
Columba arquatrix	African Olive Pigeon	
Columba delagorguei	Eastern Bronze-naped Pigeon	Vulnerable
Columba guinea	Speckled Pigeon	
Columba livia	Rock Dove	
Coracias garrulus	European Roller	
Coracias spatulata	Lilac-breasted Roller	
Coracina caesia	Grey Cuckooshrike	
Corvus albus	Pied Crow	
Corvus capensis	Cape Crow	
Cossypha caffra	Cape Robin-Chat	
Cossypha dichroa	Chorister Robin-Chat	
Cossypha heuglini	White-browed Robin-Chat	
Cossypha humeralis	White-throated Robin-Chat	
Cossypha natalensis	Red-capped Robin-Chat	
Coturnix coturnix	Common Quail	
Coturnix delegorguei	Harlequin Quail	
Creatophora cinerea	Wattled Starling	
Crecopsis egregia	African Crake	
Crex crex	Corn Crake	Vulnerable
Crithagra mozambica	Yellow-fronted Canary	
Crithagra suphuratus	Brimestone Canary	
Cuculus canorus	Common Cuckoo	
Cuculus clamosus	Black Cuckoo	
Cuculus solitarius	Red-chested Cuckoo	
Cyanomitra olivacea	Eastern Olive Sunbird	
Cyanomitra veroxii	Grey Sunbird	
Cypsiurus parvus	African Palm Swift	
Delichon urbica	House Martin	
Dendrocygna bicolor	Fulvous Duck	
Dendrocygna viduata	White-faced Duck	

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Scientific Name	Common Name	IUCN Status
Dendropicos fuscescens	Cardinal Woodpecker	
Dendropicos griseocephalus	Olive Woodpecker	
Dicrurus adsimilis	Fork-tailed Drongo	
Dicrurus ludwigii	Square-tailed Drongo	
Dryoscopus cubla	Black-backed Puffback	
Egretta alba	Great Egret	
Egretta ardeiaca	Black Heron	
Egretta garzetta	Little Egret	
Egretta intermedia	Yellow-billed Egret	
Elanus caeruleus	Black-shouldered Kite	
Emberiza flaviventris	Golden-breasted Bunting	
Ephippiorhynchus senegalensis	Saddle-billed Stork	Endangered
Erythropygia leucophrys	White-browed Scrub-Robin	
Erythropygia signata	Brown Scrub-Robin	
Estrilda astrild	Common Waxbill	
Estrilda melanotis	Swee Waxbill	
Estrilda perreini	Grey Waxbill	
Euplectes albonotatus	White-winged Widowbird	
Euplectes ardens	Red-collared Widowbird	
Euplectes axillaris	Fan-tailed Widowbird	
Euplectes orix	Southern Red Bishop	
Eupodotis melanogaster	Black-bellied Bustard	Near-threatened
Eurystomus glaucurus	Broad-billed Roller	
Falco amurensis	Amur Falcon	
Falco biarmicus	Lanner Falcon	Near-threatened
Falco concolor	Sooty Falcon	
Falco subbuteo	Eurasian Hobby	
Fulica cristata	Red-knobbed Coot	
Gallinago nigripennis	African Snipe	
Gallinula angulata	Lesser Moorhen	
Gallinula chloropus	Common Moorhen	
Geronticus calvus	Southern Bald Ibis	Vulnerable
Glareola pratincola	Collared Pratincole	Near-threatened
Gorsachius leuconotus	White-backed Night-Heron	Vulnerable
Gypohierax angolensis	Palm-nut Vulture	
Halcyon albiventris	Brown-hooded Kingfisher	
Halcyon chelicuti	Striped Kingfisher	
Halcyon leucocephala	Grey-headed Kingfisher	
Halcyon senegaloides	Mangrove Kingfisher	Vulnerable
Haliaeetus vocifer	African Fish Eagle	
Hedydipna collaris	Collared Sunbird	
Hieraaetus ayresii	Ayres's Hawk Eagle	Near-threatened

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Scientific Name	Common Name	IUCN Status
Hieraaetus fasciatus	African Hawk Eagle	
Hirundo abyssinica	Lesser Striped Swallow	
Hirundo albigularis	White-throated Swallow	
Hirundo cucullata	Greater Striped Swallow	
Hirundo fuligula	Rock Martin	
Hirundo rustica	Barn Swallow	
Hirundo semirufa	Red-breasted Swallow	
Hirundo smithii	Wire-tailed Swallow	
Indicator indicator	Greater Honeyguide	
Indicator minor	Lesser Honeyguide	
Indicator variegatus	Scaly-throated Honeyguide	
Ispidina picta	African Pygmy Kingfisher	
Ixobrychus minutus	Little Bittern	
Kaupifalco monogrammicus	Lizard Buzzard	
Lamprotornis corruscus	Black-bellied Starling	
Lamprotornis nitens	Cape Glossy Starling	
Laniarius ferrugineus	Southern Boubou	
Lanius collaris	Fiscal Shrike	
Lanius collurio	Red-backed Shrike	
Larus cirrocephalus	Grey-headed Gull	
Larus fuscus	Lesser Black-backed Gull	
Larus vetula/ dominicanus	Cape/ Kelp Gull	
Leptoptilos crumeniferus	Marabou Stork	Near-threatened
Logonosticta rubricata	African Firefinch	
Logonosticta senegala	Red-billed Firefinch	
Lonchura cucullata	Bronze Mannikin	
Lonchura fringilloides	Magpie Mannikin	Near-threatened
Lonchura nigriceps	Red-backed Mannikin	
Lopheatus occipitalis	Long-crested Eagle	
Lybius torquatus	Black-collared Barbet	
Macheiramphus alcinus	Bat Hawk	Near-threatened
Macronyx capensis	Cape Longclaw	
Macronyx croceus	Yellow-throated Longclaw	
Malaconotus blanchoti	Grey-headed Bush-Shrike	
Mandigoa nitidula	Green Twinspot	
Megaceryle maxima	Giant Kingfisher	
Melaenornis pammelaina	Southern Black Flycatcher	
Merops apiaster	European Bee-eater	
Merops bullockoides	White-fronted Bee-eater	
Merops hirundineus	Swallow-tailed Bee-eater	
Merops persicus	Blue-cheeked Bee-eater	
Merops pusillus	Little Bee-eater	

Scientific Name	Common Name	IUCN Status
Microparra capensis	Lesser Jacana	Near-threatened
Milvus migrans	Black Kite	
Mirafra africana	Rufous-naped Lark	
Motacilla aguimp	African Pied Wagtail	
Motacilla capensis	Cape Wagtail	
Motacilla flava	Yellow Wagtail	
Muscicapa adusta	Dusky Flycatcher	
Muscicapa caerulescens	Ashy Flycatcher	
Muscicapa striata	Spotted Flycatcher	
Musophaga porphyreolopha	Purple-crested Turaco	
Mycteria ibis	Yellow-billed Stork	Near-threatened
Nettapus auritus	African Pygmy Goose	Near-threatened
Numida meleagris	Helmeted Guineafowl	
Nycticorax nycticorax	Black-crowned Night-Heron	
Oena capensis	Namaqua Dove	
Onychognathus morio	Red-winged Starling	
Oriolus larvatus	Black-headed Oriole	
Oriolus oriolus	Eurasian Golden Oriole	
Otygospiza atricollis	African Quail Finch	
Oxylophus jacobinus	Jacobin Cuckoo	
Pandion haliaetus	Osprey	
Parus niger	Southern Black Tit	
Passer domesticus	House Sparrow	
Pelecanus onocrotalus	Great White Pelican	Near-threatened
Pelecanus rufescens	Pink-backed Pelican	Vulnerable
Pernis apivorus	European Honey-Buzzard	
Phalacrocorax africanus	Reed Cormorant	
Phalacrocorax lucidus	White-breasted Cormorant	
Philomachus pugnax	Ruff	
Phoeniculus purpureus	Green Wood-Hoopoe	
Phyllastrephus terrestris	Terrestrial Brownbul	
Phylloscopus trochilus	Willow Warbler	
Platalea alba	African Spoonbill	
Platysteira peltata	Black-throated Wattle-eye	Near-threatened
Plectropterus gambensis	Spur-winged Goose	
Plegadis falcinellus	Glossy Ibis	
Ploceus bicolor	Dark-backed Weaver	
Ploceus capensis	Cape Weaver	
Ploceus cucullatus	Village Weaver	
Ploceus ocularis	Spectacled Weaver	
Ploceus suaureus	Yellow Weaver	
Podica senegalensis	African Finfoot	Vulnerable

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Scientific Name	**Common Name**	**IUCN Status**
Podiceps nigricollis	Black-necked Grebe	
Pogoniulus bilineatus	Yellow-rumped Tinkerbird	
Pogoniulus pusillus	Red-fronted Tinkerbird	
Pogonocichla stellata	White-starred Robin	
Polyboroides typus	African Harrier-Hawk	
Porphyrio alleni	Allen's Gallinule	
Porphyrio madagascariensis	African Purple Swamphen	
Prinia subflava	Tawny-flanked Prinia	
Prionops plumatus	White-crested Helmet-Shrike	
Prodotiscus regulus	Brown-backed Honeybird	
Psalidoprocne holomelaena	Black Saw-Wing	
Pseudhirundo griseopyga	Grey-rumped Swallow	
Pternistes afer	Red-necked Spurfowl	
Pternistes natalensis	Natal Francolin	
Pycnonotus tricolor	Dark-capped Bulbul	
Quelea erythrops	Red-headed Quelea	
Quelea quelea	Red-billed Quelea	
Rallus caerulescens	African Rail	
Recurvirostra avosetta	Pied Avocet	
Rhinoptilus chalcopterus	Bronze-winged Courser	
Riparia bicincta	Banded Martin	
Riparia paludicola	Brown-throated Martin	
Rostratula beghalensis	Greater Painted-Snipe	Near-threatened
Sagittarius serpentarius	Secretarybird	Near-threatened
Sarkidiornis melanotos	Comb Duck	
Sarothrura elegans	Buff-spotted Flufftail	
Sarothrura rufa	Red-chested Flufftail	
Saxicola torquata	African Stonechat	
Scleroptila shalleyi	Shelley's Francolin	
Scopus umbretta	Hamerkop	
Scotopelia peli	Pel's Fishing Owl	Vulnerable
Serinus canicollis	Cape Canary	
Serinus gularis	Streaky-headed Canary	
Sigelus silens	Fiscal Flycatcher	
Smithornis capensis	African Broadbill	Near-threatened
Stactolaema leucotis	White-eared Barbet	
Stephanoaetus coronatus	Crowned Eagle	Near-threatened
Streptopelia capicola	Cape Turtle-Dove	
Streptopelia semitorquata	Red-eyed Dove	
Streptopelia senegalensis	Laughing Dove	
Strix woodfordii	Wood Owl	
Sylvia borin	Garden Warbler	

Scientific Name	**Common Name**	**IUCN Status**
Sylvietta rufescens	Long-billed Crombec	
Tachybaptus ruficollis	Little Grebe	
Tachymarptis melba	Alpine Swift	
Tchagra australis	Brown-crowed Tchagra	
Tchagra senegala	Black-crowned Tchagra	
Telophorus olivaceus	Olive Bush-Shrike	
Telophorus quadricolor	Gorgeous Bush-Shrike	
Telophorus sulfureopectus	Orange-breasted Bush-Shrike	
Terpsiphone viridis	African Paradise Flycatcher	
Thalassornis leuconotus	White-backed Duck	
Threskiornis aethiopicus	African Sacred Ibis	
Tockus alboterminatus	Crowned Hornbill	
Trachyphonus vaillantii	Crested Barbet	
Treron calva	African Green Pigeon	
Tringa glareola	Wood Sandpiper	
Tringa nebularia	Common Greenshank	
Tringa stagnatilis	Marsh Sandpiper	
Trochocercus cyanomelas	Blue-mantled Crested Flycatcher	
Turdus libonyana	Kurrichane Thrush	
Turdus olivaceus	Olive Thrush	
Turnix sylvatica	Small Buttonquail	
Turtur chalcospilos	Emerald-spotted Wood-Dove	
Turtur tympanistra	Tambourine Dove	
Tyto alba	Barn Owl	
Upupa africana	African Hoopoe	
Uraeginthus angolensis	Blue Waxbill	
Urocolius indicus	Red-faced Mousebird	
Vanellus armatus	Blacksmith Lapwing	
Vanellus coronatus	Crowned Lapwing	
Vanellus melanopterus	Black-winged Lapwing	Near-threatened
Vanellus senegallus	African Wattled Lapwing	
Vidua funerea	Dusky Indigobird	
Vidua macroura	Pin-tailed Whydah	
Zoothera guttata	Spotted Ground-Thrush	Endangered
Zosterops virens	Cape White-eye	

APPENDIX G

Mammals potentially occurring in the study area

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Scientific Name	Colloquial Name	IUCN Red List
Aethomys chrysophilus	Red veld rat	
Amblysomus hottentotus	Hottentot golden mole	Least concern
Amblysomus iris	Zulu golden mole	
Aonyx capensis	Cape clawless otter	Least concern
Atilax paludinosus	Water mongoose	Lower risk / least concern
Cephalophus natalensis	Red duiker	Lower risk / least concern
Cercopithecus aethiops	Vervet monkey	Lower risk / least concern
Cercopithecus mitis	Samango monkey	Lower risk / least concern
Chrysospalax villosus	Rough-haired golden mole	Vulnerable
Crocidura cyanea	Reddish-grey musk shrew	Least concern
Crocidura flavescens	Greater musk shrew	Least concern
Crocidura hirta	Lesser red musk shrew	Least concern
Crocidura mariquensis	Swamp musk shrew	Least concern
Cryptomys hottentotus	Common molerat	Least concern
Dasymys incomtus	Water rat	
Epomophorus wahlbergi	Wahlberg’s epauletted fruit bat	
Eptesicus somalicus	Somali serotine bat	
Galerella sanguinea	Slender mongoose	Lower risk / least concern
Genetta tigrina	Large-spotted genet	Lower risk / least concern
Grammomys dolichurus	Woodland mouse	
Graphiurus murinus	Woodland dormouse	Least concern
Graphiurus parvus	Lesser savanna dormouse	
Herpestes ichneumon	Large grey mongoose	
Ictonyx striatus	Striped polecat	Lower risk / least concern
Lemniscomys rosalia	Single-striped mouse	Least concern
Lepus saxatilis	Scrub Hare	Lower risk / least concern
Mastomys coucha	Multimammate mouse	Least concern
Mastomys natalensis	Natal multimammate mouse	Least concern
Mungos mungo	Banded mongoose	Lower risk / least concern
Mus minutoides	Pygmy mouse	Least concern
Myosorex sclateri	Sclater’s tiny mouse shrew	Vulnerable
Myosorex varius	Forest shrew	Least concern
Mystromys albicaudatus	White-tailed mouse	Endangered
Neoromicia capensis	Cape serotine bat	Least concern
Nycteris thebaica	Egyptian slit-faced bat	
Otolemur crassicaudatus	Thick-tailed bushbaby	Lower risk / least concern
Otomys angoniensis	Angoni vlei rat	Least concern
Otomys irroratus	Vlei rat	Least concern

Scientific Name	Colloquial Name	IUCN Red List
Paraxerus palliatus	Red Squirrel	Least concern
Philantomba monticola	Blue duiker	Lower risk / least concern
Pipistrellus kuhlii	Kuhl’s Pipstrelle	
Pipistrellus nanus	Banana bat	
Poecilogale albinucha	Striped weasel	
Potamochoerus porcus koiropotamus	Bushpig	Lower risk / least concern
Rhabdomys pumilio	Striped mouse	Least concern
Rhynchogale melleri	Meller's Mongoose	
Saccostomus campestris	Pouched mouse	Least concern
Scotophilus dinganii	Yellow house bat	Least concern
Steatomys pratensis	Fat mouse	Least concern
Sylvicapra grimmia	Common duiker	
Tadarida aegyptiaca	Egyptian free-tailed bat	Least concern
Tadarida pumila	Little free-tailed bat	Least concern
Taphozous mauritianus	Mauritian tomb bat	
Thallomys paedulcus	Tree mouse	Least concern
Thryonomys swinderianus	Greater cane rat	
Tragelaphus scriptus	Bushbuck	

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APPENDIX G

Hydrology Impact Assessment Specialist Study

January 2015
Report No. 13614921-13289-4

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October 2014

VOPAK-REATILE TERMINAL RICHARDS BAY

Surface Water Assessment for the Vopak-Reatile Terminal Richards Bay

Submitted to:
Vopak South African Developments
105 Taiwan Road
Island View
Bluff

REPORT

Report Number: 13614921-13118-2

Distribution:

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was appointed by Vopak South Africa Developments (VSAD), a joint venture between Royal Vopak and Reatile Resources, to conduct an Environmental Impact Assessment (EIA) for the proposed bulk storage terminal known as the Vopak-Reatile Terminal Richards Bay.

Golder's understanding of the project is that the Vopak-Reatile Richards Bay Terminal will be a green field's development, will be situated on land awarded to Vopak Reatile by the National Ports Authority in 2012. The area under investigation for this study consists of two parcels of land, namely, Lot 4 (covering approximately 7.7ha) and Lot 5 (covering approximately 7.8ha), on the southern bank of the Richards Bay harbour mouth. This terminal will be developed in phases and will store a combination of Liquid Petroleum Gas (LPG), Clean Petroleum Products (CPP) and chemicals.

This report details the approach, methodology and findings of the surface water study required for the EIA.

2.0 OBJECTIVES

The objectives of the surface water study are:

- To collect hydrology data to describe the baseline hydrological situation in the area;
- To assess the site wide water management plan. The water management plan includes the management of stormwater from clean and dirty water catchments;
- To assess the sizes of the water management infrastructure including diversion berms, dirty water collection drains and pollution control dams;
- Surface water impact assessment; and
- To develop a monitoring programme.

3.0 METHODOLOGY

The following activities were undertaken as part of this task:

- Available daily rainfall data was collected, updated, reviewed and analysed. The available data was used to patch a daily rainfall record for use in determining rainfall statistics. The rainfall data analysis included trends, monthly averages and 24 hour rainfall depths for the 2, 5, 10, 20, 50 and 100 year recurrence interval storms;
- The available climate data was collected and reviewed to produce monthly potential evaporation;
- A regional hydrology assessment of the catchment area was undertaken;
- The stormwater management plan for the site as provided by the client was asses to determine clean and dirty water separation and the capacity of the drainage system. The PCSWMM model was used to do this assessment;
- An assessment of the impacts of the proposed development on the surface water hydrology was undertaken using the impact ranking system; and
- A surface water monitoring programme was developed for the proposed development. The monitoring programme was based on the results of the hydrology impact assessment. The plan indicates the location of sampling points and lists the water quality variables to be measured and the sampling frequency.

4.0 CATCHMENT DESCRIPTION

Vopak-Reatile Terminal will be located on lot 4 and 5 to the south of the Richards Bay Harbour. The proposed site (see Figure 2) is approximately 15.5 ha, and is currently undeveloped. The site is located

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adjacent to the Richards Bay Coal Terminal and the existing Island View Storage Gas and Fuel facility. The proposed development is located immediately to the north of the railway line feeding the coal terminal. The Indian Ocean is about 1 km to the south of the site and the Mhlatuze River estuary is about 3.2 km to the southwest.

Regionally the area is located in the Mhlatuze River catchment or Drainage Region W. Locally the area falls entirely within quaternary catchment W12F. The study area is situated to the east of the quaternary catchment. Quaternary catchment W12F covers an area of 39 900 ha. There are no water courses crossing the site and the area is covered in dense bush. Therefore runoff from the site will flow to the northeast towards the mouth of the harbour.

5.0 ASSESSMENT OF CLIMATE DATA

Rainfall data was downloaded from the DWS website (Department of Water Affairs, 2008) in the area around the Vopak Terminal. The detail of the rainfall station is presented in Table 1 and shown in Figure 2.

Table 1: Rainfall station in the Richard's Bay area

Station	Name	Distance (km)	Altitude (masl)	From	To	No. of Years	MAP (mm)
W1E009	Arboretum @ Msingasi Lake	6.22	10	1976	2014	38	1310

Figure 1 shows the monthly rainfall distribution for the Arboretum @ Msingasi Lake Station.

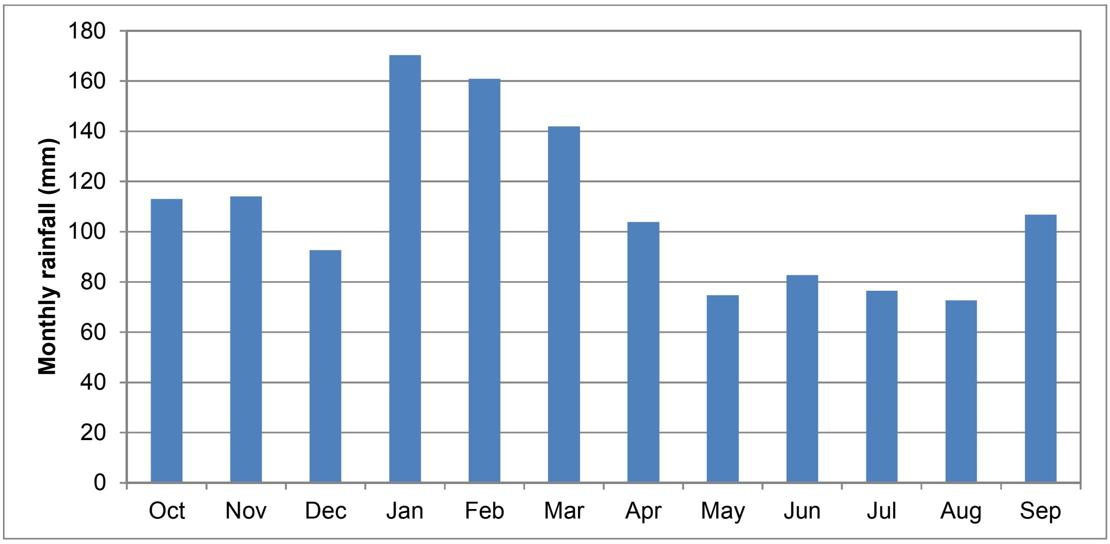

Figure 1: Monthly rainfall distribution for Arboretum @Msingasi Lake rainfall station

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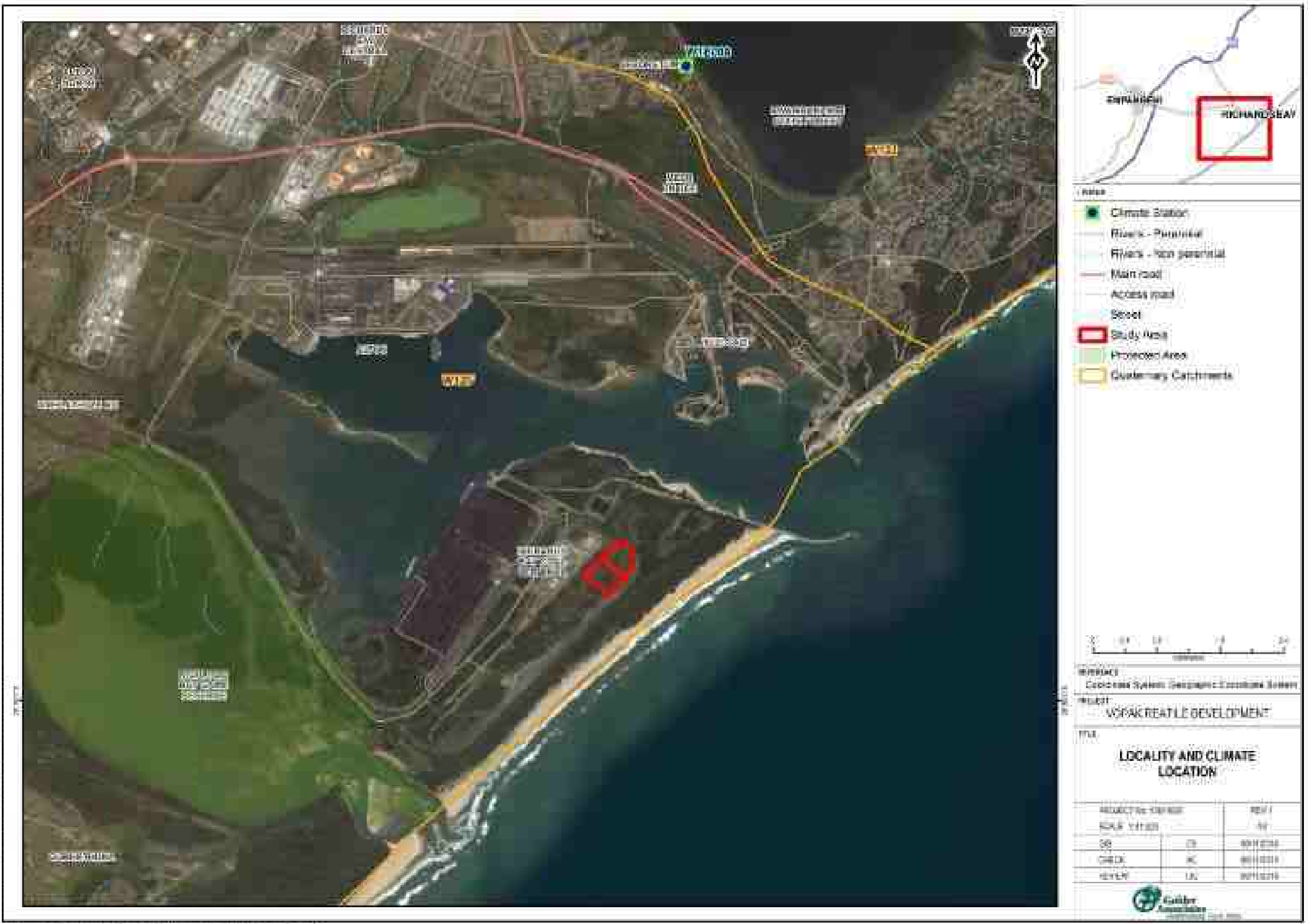

Figure 2: Locality and climate of Vopak-Reatile Terminal

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Figure 3 shows the cumulative plot for the rainfall station. The straightness of this line indicates that there are no anomalies in the data and the data can be relied upon.

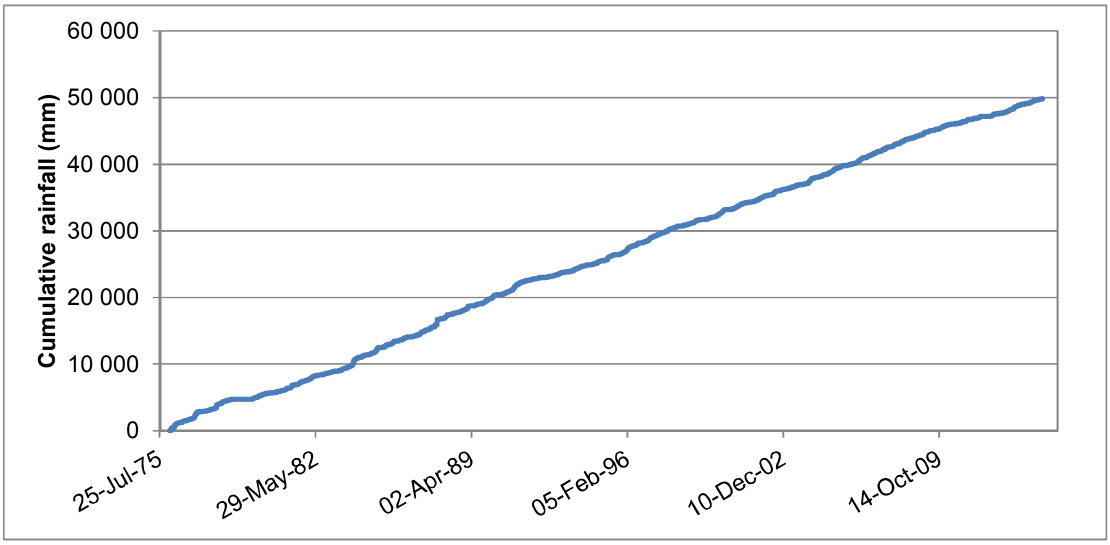

Figure 3: Cumulative rainfall for Arboretum @Msingasi Lake rainfall station rainfall station

Figure 4 and Figure 5 shows the daily rainfall and the annual rainfall for the Arboretum @ Msingasi Lake Rainfall Station respectively.

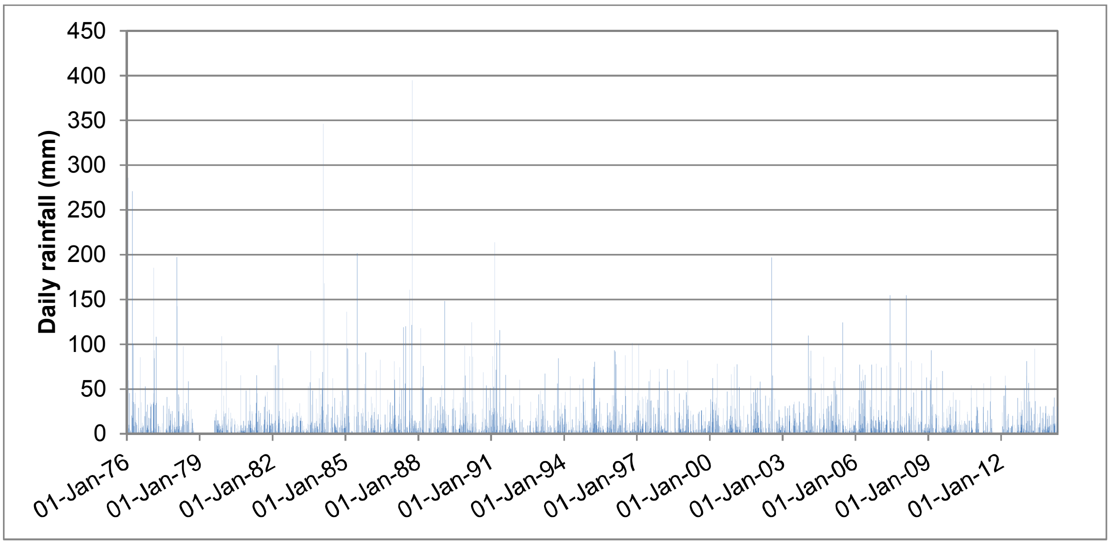

Figure 4: Daily rainfall for Arboretum @Msingasi Lake Rainfall Station (W1E009)

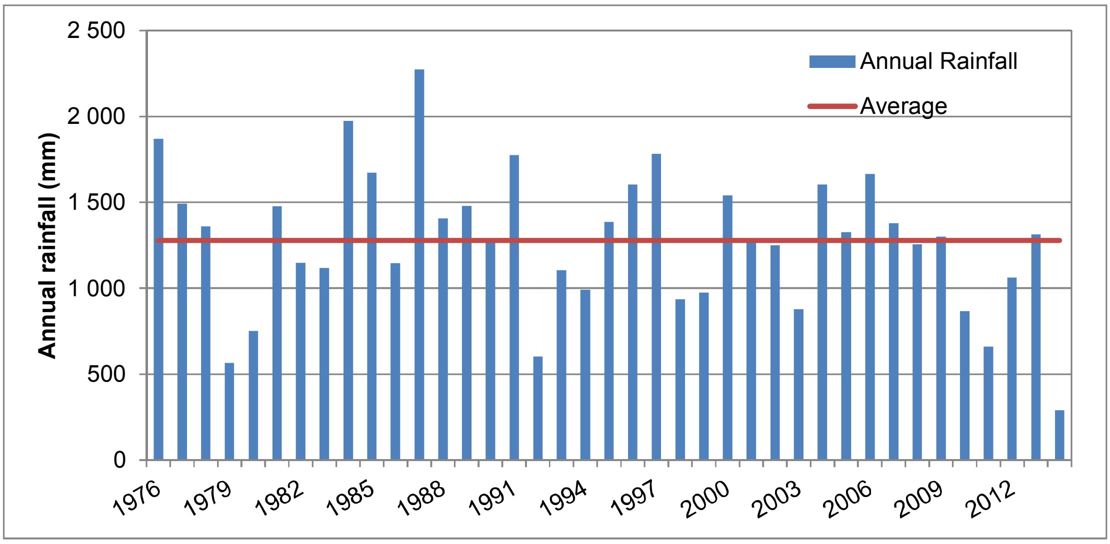

Figure 5: Annual rainfall for Arboretum @Msingasi Lake Rainfall Station (W1E009)

The mean annual rainfall for Arboretum @ Msingasi Lake is 1310 mm. The lowest rainfall year was 1979 with 565.3 mm and the highest rainfall year was 1987 with 2 273.9 mm.

The 5, 50 and 95 percentile of the annual rainfall totals for the rainfall station is presented in Table 2. Figure 6 shows the annual probability curve for the Arboretum @ Msingasi Lake station.

Table 2: 5, 50 and 95 percentile of the annual rainfall totals

Station number	Station name	5%	50%	95%
W1E009	Arboretum @ Msingasi Lake	600.49	1 301.20	1 881.57

Table 2 shows for Arboretum @ Msingasi Lake there was:

- Less than 600 mm/annum rainfall for 5 % of the time;
- Less than 1 301 mm/annum rainfall for 50 % of the time; and
- Less than 1 882 mm rainfall for 95 % of the time.

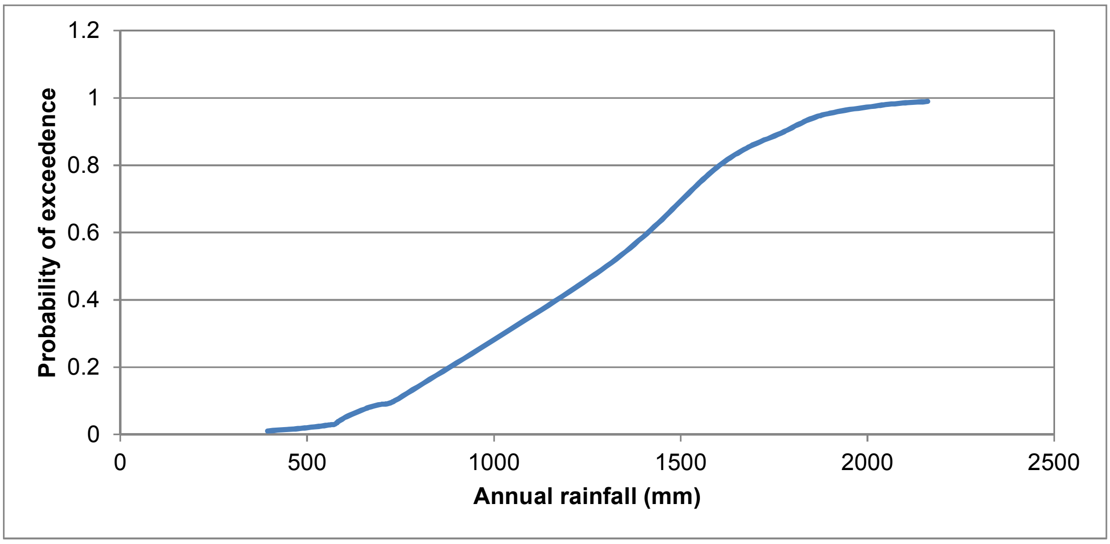

Figure 6: Annual probability curve for the Arboretum @Msingasi Lake Rainfall Station

At the Arboretum @ Msingasi Lake station 33 events measured more than 100 mm/day and rainfall events with more than 200 mm/day was recorded 6 times during the data period.

Table 3: High rainfall events

Maximum recorded daily rainfall (mm)	**Date of maximum rainfall**
286	26 January 1976
271	20 March 1976
346	31 January 1984
202	23 June 1985
395	28 September 1987
214	18 February 1991

From Table 3 it is evident that this site will experience high rainfall events (frequently over 100 mm/d and occasionally 200 mm/d) and thus should be designed accordingly.

The 24-hour rainfall depths for the 1 in 2, 1 in 5, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence intervals at the station were calculated from the data available. In order to determine the likely magnitude of storm events, a statistical approach, using the Reg Flood program (Alexander, et al., 2003) was applied, to the available recorded daily rainfall depths. The maximum 24 hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit is the Log Pearson distribution which resulted in the 24 h storm rainfall depths summarised in Table 4. The data used and the Log Pearson curve appears in APPENDIX B.

Table 4: Computed 24 hour rainfall depths for different recurrence intervals in mm/day

Recurrence interval (years)	**1 in 2**	**1 in 5**	**1 in 10**	**1 in 20**	**1 in 50**	**1 in 100**	**1 in 200**
24 hour rainfall depth (mm)	103	168.47	218	280	378	466	570

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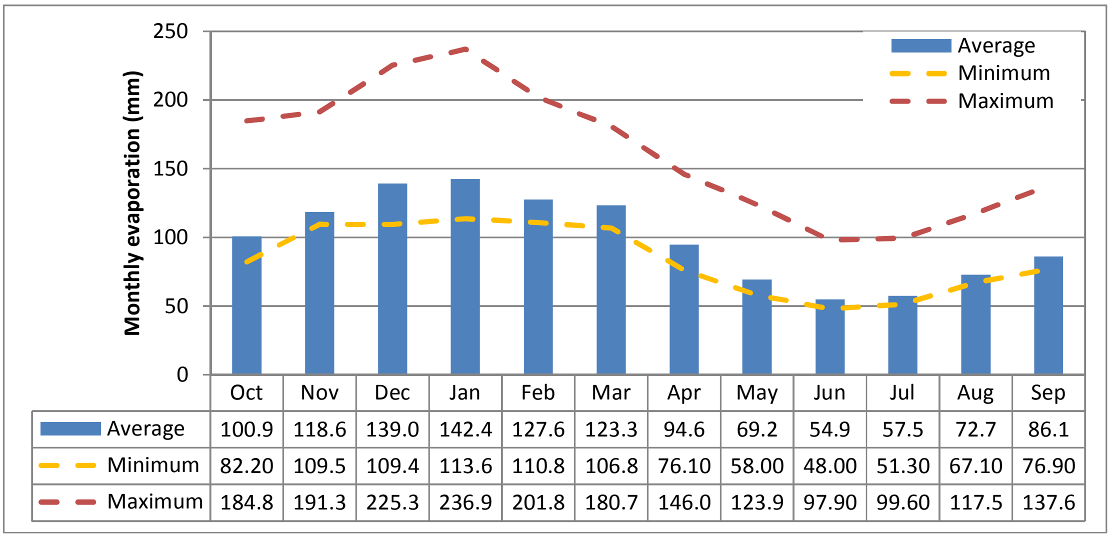
6.0 POTENTIAL EVAPORATION

The study area falls in evaporation zone 22A (Midgley, et al., 1994). The mean annual S-pan evaporation depth in the area is between 1 300 and 1 400 mm/a. Table 5 summarises the average monthly evaporation values using Arboretum @ Msingasi Lake Station. The monthly average evaporation depths for the station are shown in Figure 7.

Table 5: Average monthly evaporation (mm)

Month	**W1E009 Arboretum @ Msingasi Lake**
Oct	100.9
Nov	118.6
Dec	139.0
Jan	142.4
Feb	127.6
Mar	123.3
Apr	94.6
May	69.2
Jun	54.9
Jul	57.5
Aug	72.7
Sep	86.1
Annual Evaporation (mm)	**1 186.9**



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average	100.9	118.6	139.0	142.4	127.6	123.3	94.6	69.2	54.9	57.5	72.7	86.1
Minimum	82.20	109.5	109.4	113.6	110.8	106.8	76.10	58.00	48.00	51.30	67.10	76.90
Maximum	184.8	191.3	225.3	236.9	201.8	180.7	146.0	123.9	97.90	99.60	117.5	137.6

Figure 7: Average monthly evaporation values for station W1E009 (S-pan)

7.0 STORMWATER MANAGEMENT PLAN

The Vopak-Reatile Terminal infrastructure is shown in Figure 8. The information in the figure is based on information provided in drawing SM000304/C.01a/001 Issue H1. The site is serviced by both road and rail system. There is currently no formal stormwater system on site. Transnet are planning to construct

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stormwater drains to the north of the site which are planned to discharge into the Richards Bay Harbour to the east.

7.1 Clean and dirty water sub-catchments

The Vopak-Reatile Terminal was discretised based on the topography of the site. These sub-catchments were then classified as either clean or dirty water catchments based on the land usage. The sub-catchments are shown in Figure 9. The sub-catchments are all classified as clean; the only catchment where the runoff could be potentially polluted is the truck loading area that could be potentially contaminated with oil and grease.

7.2 Proposed stormwater management plan

The Vopak-Reatile Terminal will be constructed in two phases. Phase 1 will be constructed in the northeast of the site (see Figure 10) and Phase 2 to the southwest. The stormwater drainage system will be constructed in phase 1 and is designed to accommodate the runoff from Phase 2.

The proposed stormwater management strategy is as follows:

- The site is sloping towards the northeast and the stormwater runoff will be collected into two sumps SU1 and SU2 (see Figure 10);
- The Bullet laydown and staging area (sub-catchments S3 – S8) is to be surrounded by trenches that drain to the southeast and will discharge to the main drain (C1 – C4) that runs along the southern boundary of the terminal. The main drain reports to SU1;
- The runoff from the southeast area of the Terminal (S11 and S9) will report to the main drain. The water will then be pumped into newly constructed Transnet stormwater channels which will then drain east to the harbour;
- The northern part of the site (S12 and S10) will be serviced by a pipe and rainwater culvert that will drain into sump SU1; and
- The remaining catchments (S13 – S17) will be serviced by pipes running east along the northwest boundary of the site and draining into sump SU2. This sump will then also be pumped into the newly constructed Transnet stormwater channels which will then drain to the harbour; and
- Measures will be taken by the security wall or berms to prevent stormwater runoff from entering the site.

8.0 MODELLING THE STORMWATER MANAGEMENT CONDUIT SYSTEM

The PCSWMM model was used as the flood analysis model. PCSWMM is a dynamic rainfall-runoff simulation model used for single event or long-term simulation of runoff quantity. This model was set up for the site and used to size the conveyance structures for separation of clean and dirty stormwater runoff.

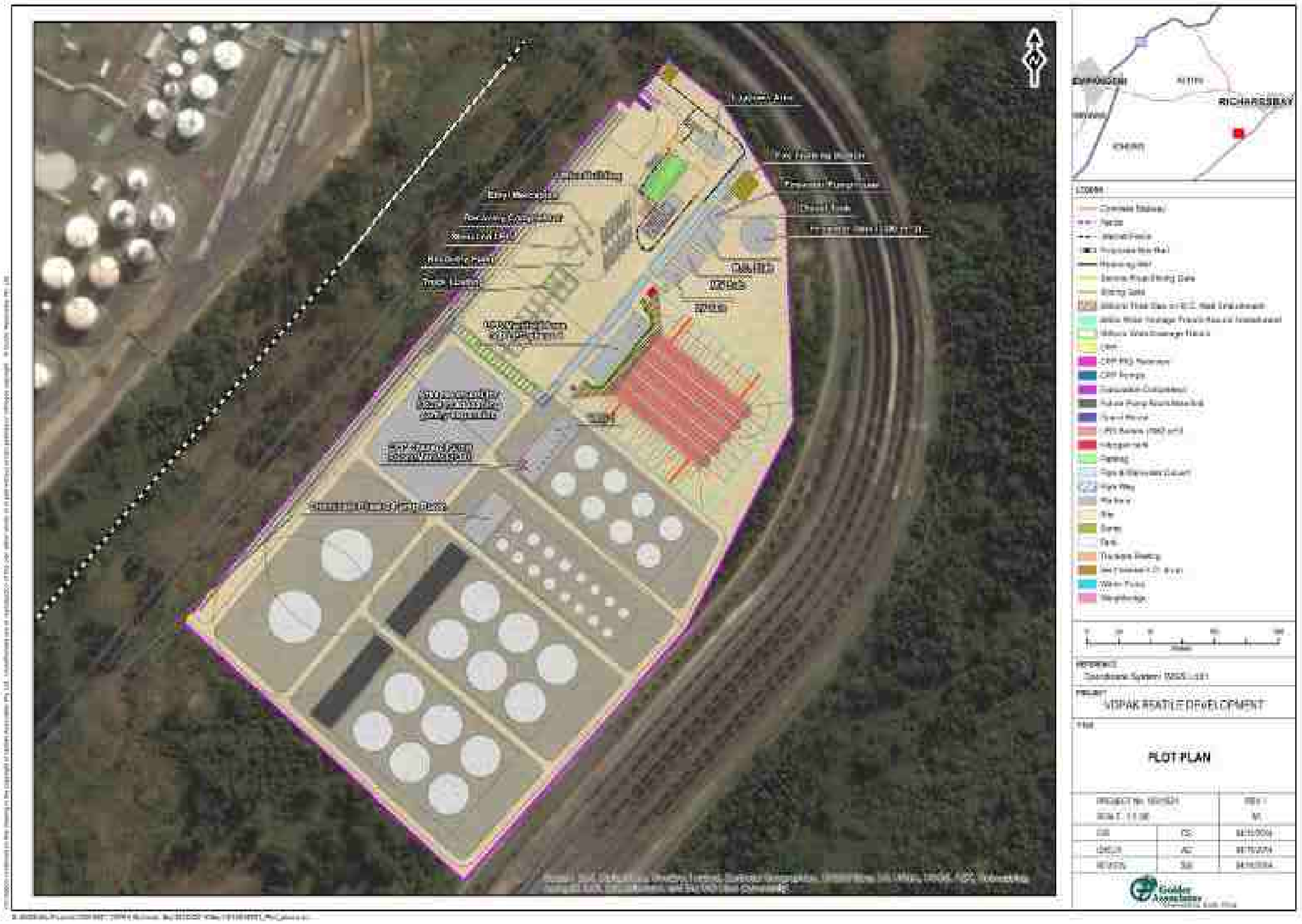

Figure 8: Proposed Terminal layout

Figure 9: Sub-catchments of the Vopak-Reatile Terminal

Figure 10: Stormwater management plan layout for Vopak-Reatile Terminal

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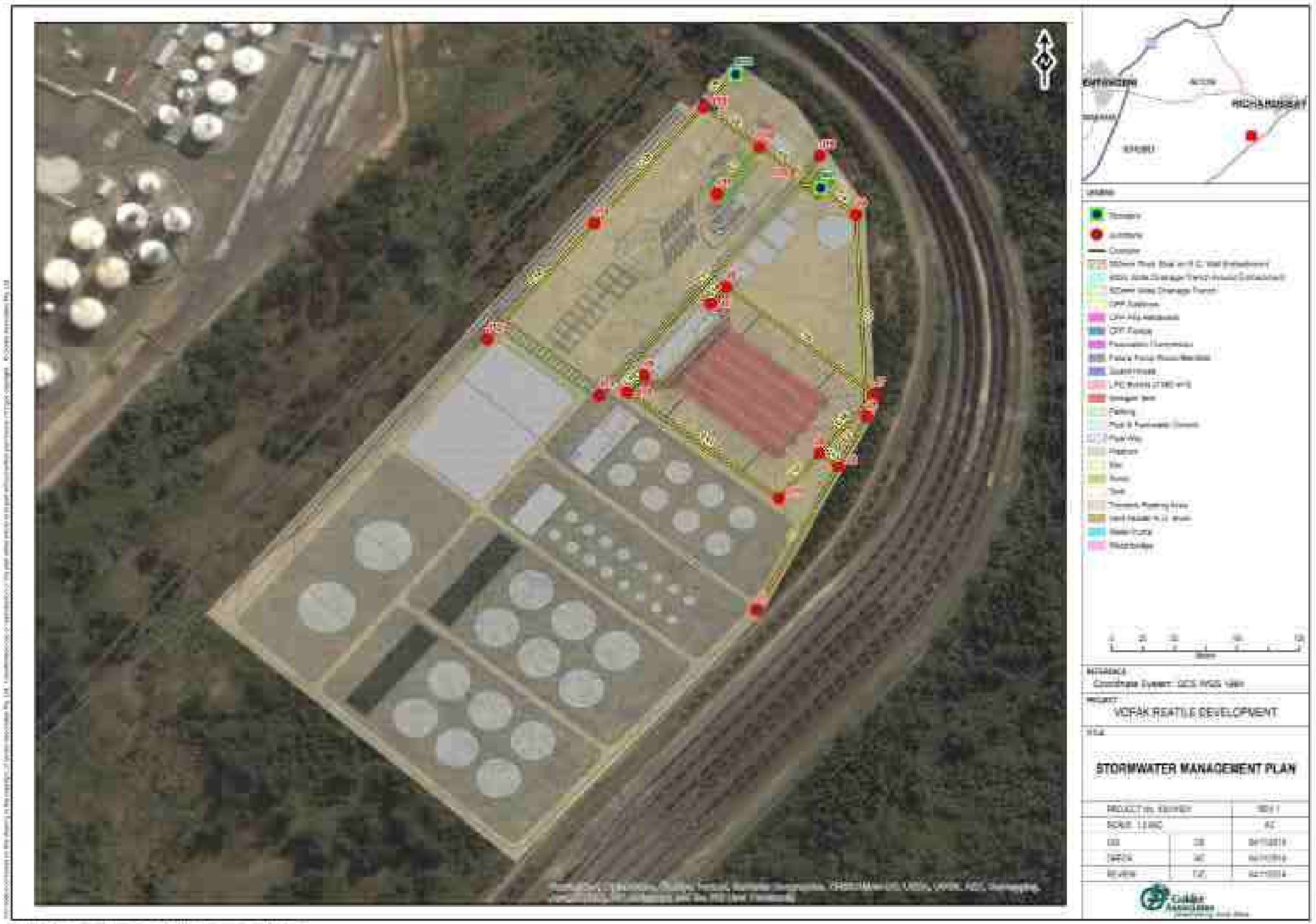

Figure 11: Stormwater management plan layout for Vopak-Reatile Terminal

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8.1 Sub-catchment characteristics

The parameters used to model the overland and channel flow are given in Table 6. The Manning's 'n' coefficient used in the model for the impervious areas and pervious areas was 0.015 and 0.15 respectively.

The soils were identified as being in the sand group. The model uses these criteria to incorporate infiltration into the analysis using the Green-Ampt infiltration method. The infiltration parameters for the sand soil group are a suction head of 49.5 mm, a hydraulic conductivity of 235.6 mm/hr and an initial soil moisture deficit of 0.346. Most of the site will be covered with either concrete paving or engineered gravel road with only a small area being left for landscaping thus the runoff generated onsite will be high. The catchment areas, slopes and percent of impervious area together with the total runoff volume and the flood peaks for the 20 and 50 year storm events are presented in Table 6. The stormwater has been analysed for both the 20 and 50 year storm events since the stormwater layout has been designed by an external party.

8.2 Channel characteristics

The diversion channel layout is shown in Figure 10 and Figure 11. The Manning's roughness assumed for the concrete drains was 0.012 and for the concrete trenches was 0.015 (Webber, 1971). The dimensions, slope and maximum velocity of the channels are listed in Table 7.

8.3 Stormwater management discussion

The client provided the following drawings which can be found in APPENDIX C:

- SM000304/C.01a/0001 Issue H1
- SM000304/C.01a/0032 Rev A
- SM000304/C.01a/0050 Issue A
- SM000304/C.01a/0053 Issue B
- SM000304/C.01a/0054 Issue B
- SM000304/C.01a/00160 Issue A
- SM000304/C.01a/00161 Issue A

These drawings listed above included amongst others the plot plan and the stormwater layout of the site. PCSWMM was then used to determine the recurrence interval storm that the system can accommodate.

The stormwater management system has not been designed to convey the 1:50 year flood. Channels C1, C2, C6, C18, C13 and trenches C11 and C12 will be flooded in the 1 in 50 year storm event occurs. If the 1 in 20 year storm event occurs, channels C1, C2 and C13 and trench C12 will be flooded. These areas are deemed clean and thus if the flood risk for Vopak is acceptable then there is no need to resize the drains. The stormwater management system cannot convey the 1 in 2 year storm event due to one channel C2 being undersized, however if the channel C2 is changed to a 900mm*Φ* ROCLA pipe instead of a 600mm*Φ* ROCLA pipe the 1 in 2 year storm can be accommodated.

It is recommended that an oil trap be placed at the truck loading area to filter out any oil and grease that may spill from the loading trucks and contaminate the stormwater. If an oil trap is installed then this will filter through any oil or grease and then the water can be considered clean and then be drained through the site and disposed of as explained in Section 7.2.

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Table 6: Catchment areas, slopes, computed runoff volumes and flood peaks for the 20 and 50 year storm

Name	Area (ha)	Slope (%)	Impervious area (%)	24h storm depth (mm)	Total runoff volume per 24h (Megalitres) 2y	2y Peak Runoff (L/s)	Total runoff volume per 24h (Megalitres) 20y	20y Peak Runoff (L/s)	Total runoff volume per 24h (Megalitres) 50y	50y Peak Runoff (L/s)
S1	4.29	0.01	50	279.88	2.13	201.24	5.87	700.65	7.95	1030.87
S2	2.35	0.01	50	279.88	1.17	116.24	3.22	403.59	4.37	597.07
S3	0.12	0.19	100	279.88	0.12	26.37	0.33	82.47	0.45	114.69
S4	0.38	0.26	100	279.88	0.39	91.35	1.06	275.55	1.43	379.43
S5	0.11	0.19	100	279.88	0.11	24.62	0.31	76.9	0.42	106.9
S6	0.40	0.29	100	279.88	0.41	100.39	1.13	298.6	1.52	409.72
S7	0.15	0.22	100	279.88	0.15	34.03	0.42	105.41	0.57	146.19
S8	0.20	0.24	100	279.88	0.21	47.64	0.57	145.73	0.77	201.41
S9	1.15	0.005	10	279.88	0.12	27.7	0.32	84.06	0.44	117.49
S10	0.23	0.01	90	279.88	0.22	42.03	0.59	136.77	0.8	195.04
S11	0.20	0.005	25	279.88	0.05	10.53	0.14	33.57	0.19	48.03
S12	1.84	0.01	50	279.88	0.91	78.78	2.5	279.54	3.39	404.49
S13	1.92	0.01	50	279.88	0.95	91.06	2.62	316.1	3.55	466.73
S14	0.39	0.005	50	279.88	0.2	40.73	0.54	130.53	0.73	186.7
S15	0.62	0.005	100	279.88	0.63	87.72	1.72	307.59	2.33	443.8
S16	0.143	0.005	5	279.88	0.01	2.03	0.02	5.65	0.03	8.16
S17	0.22	0.005	20	279.88	0.04	10.64	0.12	31.89	0.16	44.51

Table 7: Dimensions of runoff diversion channels and the flows and velocities associated with the 20 and 50 year storms

Name	Inlet Node	Outlet Node	Length (m)	Roughness	Cross-Section	Height/Diameter (m)	Bottom width (m)	Slope (m/m)	Maximum flow (L/s) 2y	Maximum velocity (m/s) 2y	Maximum flow (L/s) 20y	Maximum velocity (m/s) 20y	Maximum flow (L/s) 50y	Maximum velocity (m/s) 50y
C1	J1	J2	129.15	0.012	Circular	0.585	0	0.0025	200.05	1.23	336.13	1.38	336.4	1.38
C2	J2	J4	44.56	0.012	Circular	0.585	0	0.0024	597.7*	1.59*	329.82	1.33	329.88	1.33
C3	J4	J3	161.78	0.012	Circular	0.853	0	0.00247	597.85	1.62	344.81	1.46	350.34	1.45
C4	J3	SU1	28.29	0.012	Circular	0.853	0	0.00159	617.5	1.35	416.35	1.25	461.48	1.28
C6	J15	SU2	30.3	0.012	Circular	0.853	0	0.00297	215.28	1.32	748.53	1.81	987.5	1.9
C7	J17	J18	48.1	0.012	Circular	0.585	0	0.00848	40.01	1.23	128.52	1.73	184.06	1.91
C8	J18	J15	51.06	0.012	Circular	0.853	0	0.00787	41.56	1.16	132.94	1.64	190.61	1.82
C9	J19	J18	34.46	0.012	Circular	0.585	0	0.00749	1.96	0.48	5.51	0.65	7.99	0.73
C10	J9	J10	17.53	0.015	Rectangular	1	0.4	0.01	26.17	0.93	81.93	1.32	113.93	1.44
C11	J10	J11	136.26	0.015	Rectangular	1	0.4	0.01	220.66	1.68	739.02	2.03	807.68	2.05
C12	J11	J8	46.52	0.015	Rectangular	1	0.4	0.01	251.61	1.71	807.68	2.03	807.68	2.03
C13	J8	J2	16.7	0.012	Circular	0.585	0	0.005	414.61	1.86	473.26	1.91	474.84	1.91
C14	J5	J6	17.04	0.015	Rectangular	1	0.4	0.01	24.43	0.91	76.4	1.29	106.19	1.41
C15	J6	J7	135.84	0.015	Rectangular	1	0.4	0.01	119.49	1.48	360.29	1.88	496.06	1.98
C16	J7	J8	61.19	0.015	Rectangular	1	0.4	0.01	163.24	1.57	493.58	1.93	680.04	2.01
C18	J12	J13	120	0.012	Circular	0.585	0	0.003	90.53	1.07	316.72	1.45	368.51	1.51
C19	J13	J15	120.49	0.012	Circular	0.853	0	0.00299	172.81	1.25	600.09	1.73	774.65	1.83
C5	J16	SU1	26.94	0.015	Rectangular	1	5	0.0052	0	0	0	0	0	0
C17	J14	SU1	220.39	0.015	Rectangular	1	5	0.00392	109.35	0.52	383.93	0.84	563	0.98

*This flow and velocity are based on pipe C2 being a 900mmΦ ROCLA pipe and not 600mmΦ ROCLA pipe

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9.0 WATER QUALITY MONITORING PROGRAMME

The objectives of the water quality monitoring programme are:

- To identify possible contaminated water on site; and
- To address the contamination of water exiting the site.

The three main areas that have been identified for water quality monitoring appear in Figure 12. These are mainly at the two sumps that collect the stormwater before pumping to the Transnet stormwater drains and the oil trap that has been recommended to filter out any oil and grease that may be spilt from the truck loading area.

The monitoring of these three site should take place monthly and additional monitoring should take place when pumping to the Transnet drains i.e. if pumping to the Transnet drains takes place over three days then a daily sample should be taken for those three day to ensure knowledge of what is exiting the site.

Since this site should be free of most contaminants the stormwater should be tested for oil and grease that could leak from the trucks at the loading bay. The general limit is 2.5 mg/l as set out by the Department of Water and Sanitation (Department of Water Affairs, 2013). The basic system variables of pH and EC should also be included in the monitoring programme.

10.0 IMPACT ASSESSMENT

10.1 Potential surface water impacts

The potential surface water impacts from the project, both direct and indirect, are summarised in Table 8. In summary, these potential impacts contribute to the overall surface water impacts and include:

- Changes in surface water quality; and
- Change in surface water runoff and erosion.

The surface water quality impacts will ultimately impact on the downstream water users, including the provision of irrigation water when the water make becomes feasible for such use. The detailed impact assessment is outlined in Section 10.2.

Table 8: Summary of potential surface water impacts with respect to Vopak-Reatile Terminal

Major aspect	Key Environmental Issues / Potential Impacts
Changes in surface water catchment areas	■ Catchment areas are reduced due to the erecting of pump rooms and bullet laydown areas.
Changes in surface water quality	■ The mobilisation of sediments in the borrow pit area during construction; ■ Spillage from equipment during construction; ■ Pollution from gas leakages during operations.
Change in surface water runoff	■ Runoff impacts due to Terminal footprint during operation and closure; ■ Potential flooding of neighbouring properties during construction, operation and decommission.

Figure 12: Water quality monitoring at the Vopak-Reatile Terminal

10.2 Surface Water Impact Assessment

10.2.1 Impact Assessment Methodology

The significance of the impacts during the impact assessment phase was determined using the approach described in Table 9 and provides the method for defining intensity, geographic extent and duration.

Table 9: Impact assessment criteria

CRITERIA	DESCRIPTION			
EXTENT	**National (4)** The whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of the construction site	**Site (1)** Within the construction site
DURATION	**Permanent (4)** Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient	**Long-term (3)** The impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter. The only class of impact which will be non-transitory	**Medium-term (2)** The impact will last for the period of the construction phase, where after it will be entirely negated	**Short-term (1)** The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase
INTENSITY	**Very High (4)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**High (3)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Moderate (2)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (1)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected
PROBABILITY OF OCCURRENCE	**Definite (4)** Impact will certainly occur	**Highly Probable (3)** Most likely that the impact will occur	**Possible (2)** The impact may occur	**Improbable (1)** Likelihood of the impact materialising is very low

Low impact **(4 - 6 points)**	**A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.**
Medium impact **(7 - 9 points)**	Mitigation is possible with additional design and construction inputs.
High impact **(10 - 12 points)**	The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment.
Very high impact **(13 - 16 points)**	Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a “very high impact” is likely to be a fatal flaw.

10.2.2 Surface Water Impacts

Table 10 sets out the detailed potential surface water impacts during construction, operation and at closure.

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Table 10: Impact assessment during construction, operation and at closure

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Mitigation
CONSTRUCTION PHASE							
Runoff water quality	■ Stripping of vegetation and topsoil to expose a barren site. High flood peaks lead high runoff from this area during construction; ■ Spillage of fuels, lubricants, oil and grease; ■ Construction equipment, vehicles and temporary workshop areas will be likely sources of pollution as a non-point source.	1	2	2	2	**7** **medium**	It is expected that without mitigation a **medium** negative impact can be expected. Mitigation will include: ■ Bunded areas to store chemicals and/or fuel; ■ Clean-up of spills as soon as they occur; Keep construction activities away from the Mhlatuze River mouth and Richards Bay harbour as much as possible. The significance of the impact after mitigation is likely to decrease to a **low** negative impact.
Runoff peak flows	■ Stripping of vegetation and topsoil to expose a barren site. High flood peaks lead high runoff from this area during construction;	2	2	2	3	**9** **medium**	A **medium** impact can be expected. ■ In order to minimise impacts, construction needs to take place during the dry season (winter months). ■ Consider also placing an outer berm around the site to divert any runoff away from any construction activities. Mitigation could reduce the impact to **low.**

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OPERATIONAL PHASE							
Pollution of stormwater	■ Potential pollution of stormwater from spillage of fuels, lubricants, oil and grease and gas leaks; ■ Vehicles will be a likely source of pollution as a non-point source.	1	3	2	1	**7** **medium**	It is expected that without mitigation a **medium** negative impact can be expected. Mitigation will include: ■ Use the oil trap in truck loading area; ■ Bunded areas to store chemicals and/or fuel; ■ Clean-up of spills as soon as they occur; ■ Stop pumping stormwater into Transnet drains until spill has been cleaned. The significance of the impact after mitigation is likely to decrease to a **low** negative impact.
CLOSURE PHASE							
Run-off	Demolition activities Decommissioning may leave large barren areas that may increase erosion, which might increase the amount of suspended solids flowing towards neighbouring properties.	1	1	3	2	**7** **medium**	The total disturbed area is less than 0.2 km² and it is not likely that the impact will be significant upon closure. However, the topography of the area should be, where possible, returned to pre-construction state. Disturbed areas will be re-vegetated and thus the surface water flow regime will be primarily limited to seepage.

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11.0 CONCLUSION

The following conclusions were drawn from this study:

- This site will be subjected to high rainfall events as shown by the rainfall analysis;
- The stormwater system as currently proposed cannot accommodate a 1:2 year storm event. The information will be provided to the site designers who will design the site to accommodate a 1:50 year storm event;
- A monitoring programme has been proposed to ensure the quality of the water exiting the site is to standard; and
- The impacts are largely related to surface water runoff and preventing the flooding of the neighbouring properties during construction and operation. They were ranked as medium risks but with appropriate mitigation these can be reduced to low risks.

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APPENDIX A

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APPENDIX B

24 hour Storm Rainfall Depths Statistical Analysis

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Table B1 shows the data used in the Reg Flood program (Alexander, et al., 2003) to produce the 24 hour rainfall depths for the 1 in 2, 1 in 10, 1 in 20, 1 in 50, 1 in 100 and 1 in 200 recurrence intervals at the Arboretum @ Msingasi Lake station

Table B1: Daily recorded maximum's for every year

Year	Maximum daily rainfall (mm)
1976	286
1977	185.2
1978	197.1
1979	109.1
1980	81
1981	65.4
1982	99
1983	92.8
1984	346.1
1985	201.6
1986	83
1987	394.6
1988	118
1989	148.4
1990	124.6
1991	214.2
1992	60.6
1993	84.2
1994	64.4
1995	80.4
1996	102
1997	101
1998	72.3
1999	82.4
2000	78.2
2001	77.6
2002	197
2003	36
2004	109.5
2005	124.4
2006	78.4
2007	155
2008	155
2009	93.5
2010	54.3

Year	Maximum daily rainfall (mm)
2011	64
2012	65
2013	95
2014	40.2

In order to determine the likely magnitude of storm events, a statistical approach, using the Reg Flood program (Alexander, et al., 2003), was applied to the available recorded daily rainfall depths. The maximum 24 hour rainfall depth for each year was analysed. This method statistically analyses the maximum daily rainfall depths for each year to determine the different recurrence interval daily rainfall depths. The best fit is the Log Pearson distribution which resulted in the 24 h storm rainfall depths. Figure B1 shows the Log Pearson graph.

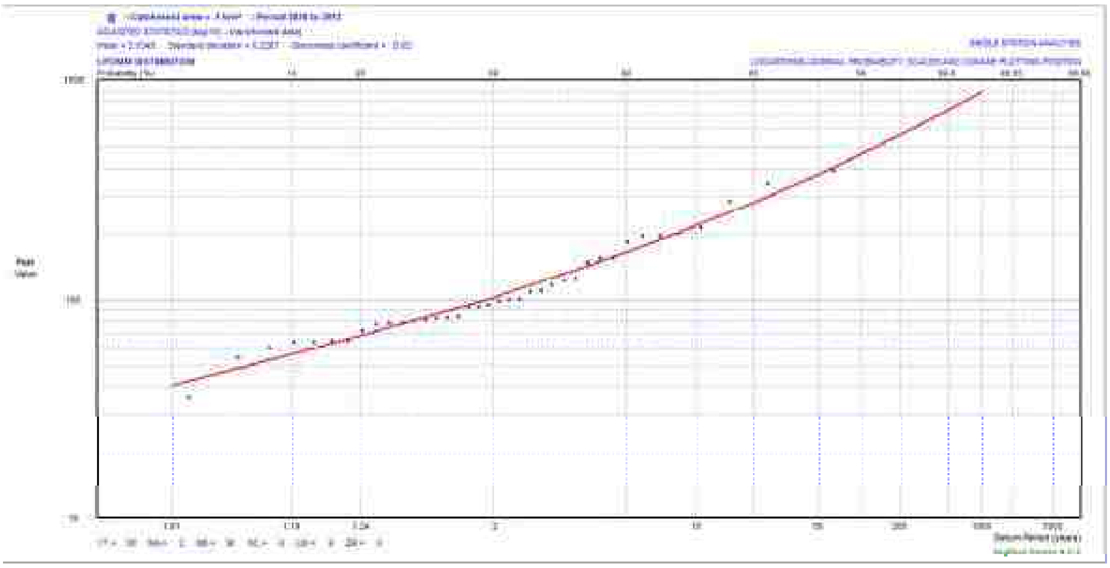
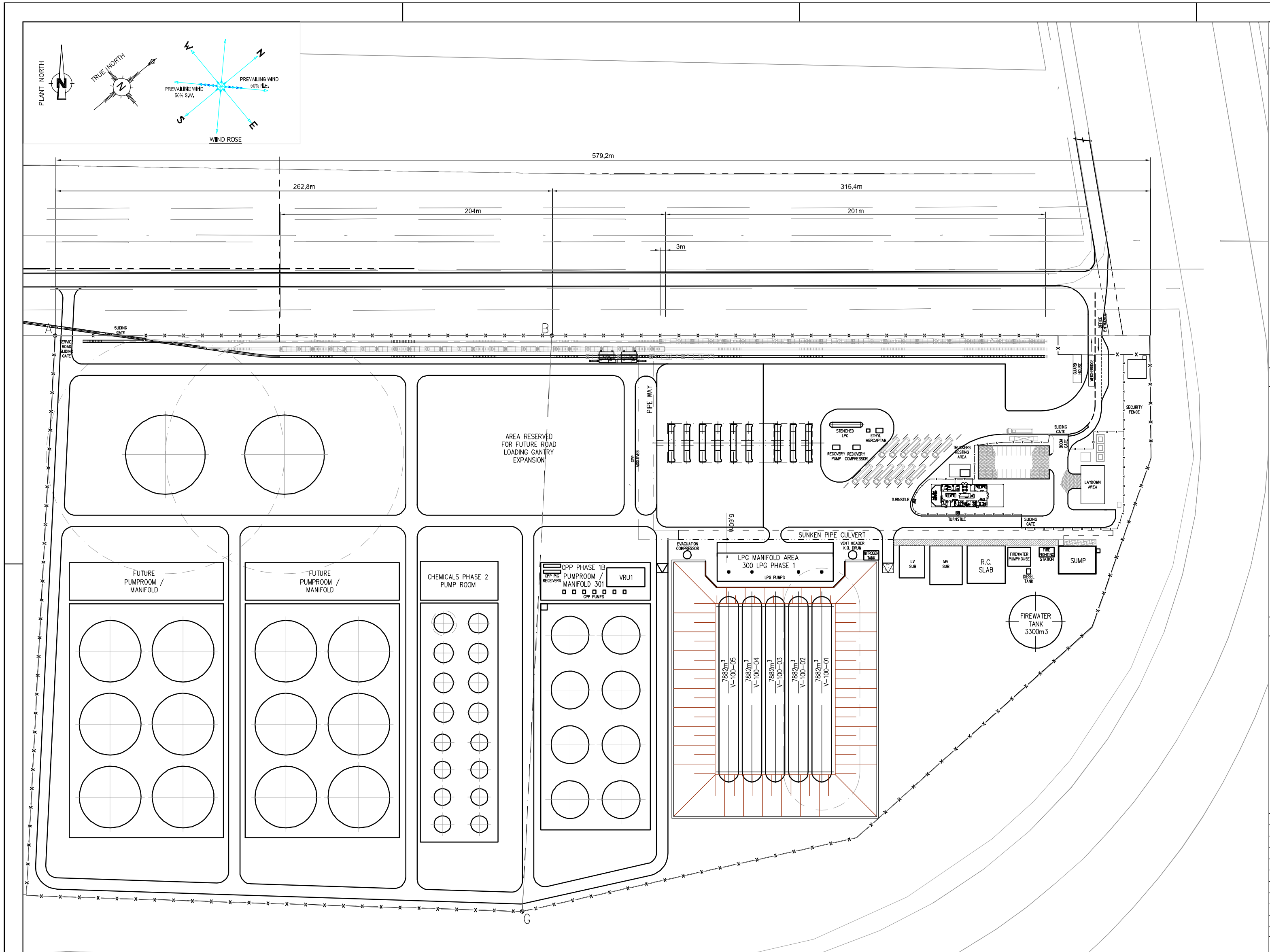


Figure B1: Log Pearson distribution curve

PDF created with pdfFactory Pro trial version www.pdffactory.com

APPENDIX C

Vopak-Reatile Terminal Drawings



GENERAL NOTES

1. ALL DIMENSIONS ARE IN mm, UNLESS SPECIFIED OTHERWISE.
2. SAFETY DISTANCE ACC. TO SANS 10089-1:2003 EDITION 4.1 AND SANS 10087-3:2008 EDITION 4
3. SAFETY DISTANCES FOR REFRIGERATED LPG STORAGE TO API 2510
4. RAILWAY TO CROSS STORM WATER CHANNEL BY MEANS OF A CULVERT.

LEGEND

CO-ORDINATE LIST
CLARKE 1880 SYSTEM Lo 31° EAST

	-Y	+X
A	-104 222,683	3189 419,539
B	-104 390,570	3189 217,352
C	-104 592,699	3188 973,925
D	-104 642,955	3189 014,756
E	-104 691,802	3189 095,781
F	-104 698,056	3189 262,968
G	-104 615,015	3189 424,083
H	-104 440,980	3189 620,606

REFERENCE DRAWINGS

- RBH 81A-626 (2011-12-14)

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
H1	07/04/2014	LW	.	.	LINE WEIGHTS ADJUSTED.
H	27/03/2014	LW	.	.	LAYOUT ADJUSTED TO
					ACCOMODATE BULLET MOUND.
G	05/03/2014	LW	.	.	03/03/14 COMMENTS INCORP.
F	27/02/2014	LW	.	.	BULLETS SIZE REVISED.87,7m LNG
E	21/02/2014	LW	.	.	REVIEW COMMENTS INCORPORATED
D	07/02/2014	LW	.	.	REVIEW COMMENTS INCORPORATED
C	03/01/2014	LW	.	.	EQUIPMENT ADDED
B	25/11/2013	LW	SvdM	WvW	ISLAND & SERVICE ROAD ADDED
A	22/11/2013	LW	SvdM	WvW	ISSUED FOR CLIENT COMMENT

JACOBS MATASIS

Vopak RICHARDS BAY

TITLE:

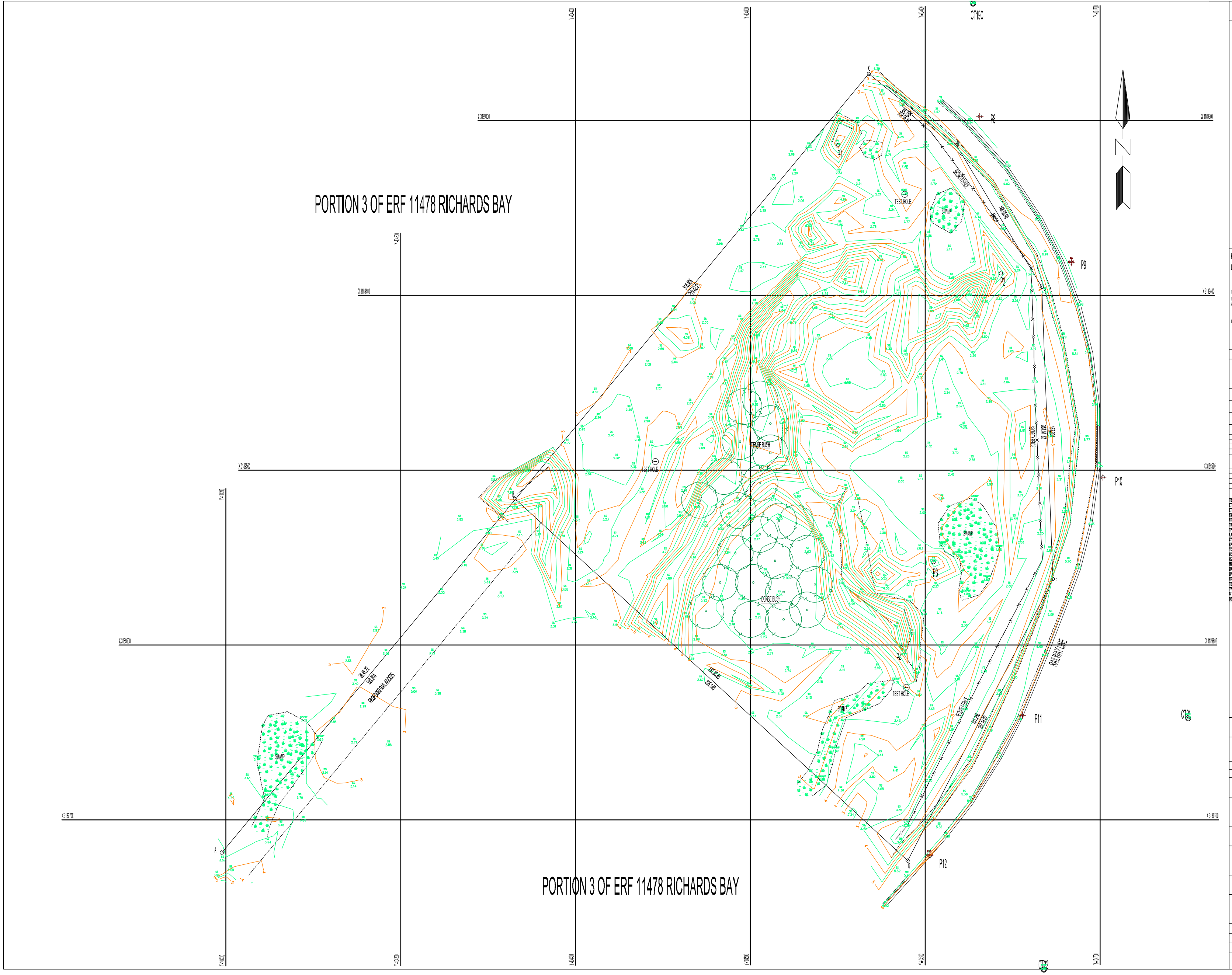
PLOT PLAN

SCALE: 1:1000	DATE:	FORMAT: A1	ARCH.NR.:	SHEET: 01
DRAWN: DEM	10/06/2012		DRAWINGNR.: SM000304/C.01a/0001	OF: 01
CHECKED: SvdM	.			ISSUE: H1

Contractor drawingnumber:

XRef: Accessorieslist: Partlist: ACAD version: 2013 Filename: .DWG

PDF created with pdfFactory Pro trial version www.pdffactory.com



NOTAS / NOTES

1: All heights and measurements given in metres.
2: Survey based on WG31
3: Heights based on mean sea level
4: Contours shown at 0,50m intervals
5: All data and measurements to be checked on site prior to commencement of work.
6. BENCH MARKS

PRIMARY BENCH MARKS (TOP OF CONCRETE PILLAR)

CT19C	-104627,333	3189233,098	7,880
CT21	-104750,416	3189641,977	7,350
CT22	-104667,856	3189785,732	6,993

SECONDARY BENCH MARKS (12mm IRON PEG)

P1	-104550,098	3189313,974	5,367
P2	-104643,262	3189337,415	5,898
P3	-104604,826	3189552,610	5,019
P4	-104586,354	3189601,387	8,742
P8	-104631,214	3189297,703	6,129
P9	-104683,627	3189331,330	6,207
P10	-104701,597	3189504,135	6,001
P11	-104656,581	3189640,361	6,059
P12	-104602,596	3189720,626	5,888

KMH & ASSOCIATES
LAND SURVEYORS / LANDMETERS

P.O. BOX 10321 POSBUS
MEERENSEE
3901

TEL.: (035) 7531043/7
FAX.: (035) 7531048
email.: eedup@iafrica.com

K M H P LAND SURVEYORS

SURVEYED	E.E. DU PREEZ	OPGEMEET
SIGNATURE		HANDTEKENING
DRAWN	A. VAN TONDER	GETEKEN
TRACED		NAGETREK
CHECKED		NAGESIEN

	LINE TYPE		LAYERS
		BANK	TOP AND BOTTOM BANK
	ROAD	DRAIN	TOP AND BOTTOM DRAIN
	FENCE	CADASTRAL	CADASTRAL BOUNDARY
	POWERLINE	CONCRETE	BUILDINGS, SLABS ETC
	CADASTRAL BOUNDARY	GATE	EMBANKMENTS
	SERVITUDE BOUNDARY	FENCE	GATES
	PIPE	GRID	GRID
	EDGE OF WATER	PIPELINE	ALL PIPES
	CONCRETE/WALL/DRAIN/BUILDING	GUARDRAIL	GUARDRAIL
		POWERLINE	ELEC POWER LINES
		LP	LIGHT POLE
	CODES	NORTH	NORTH POINT
		RES	RESERVOIR
TB, T, BB	TOP / BOTTOM BANK	ROAD	ALL ROADS
ET	EDGE OF TAR	SERVITUDE	CADASTRAL BOUNDARY OF SERV
ET'R,ET'TR	EDGE OF ROAD, TRACK	TELEPHONE	TELEPHONE LINES
E/WATER	EDGE OF WATER	WATER	EDGE OF WATER
EDAM	EDGE OF POND	LIGHTPOLE	LIGHTPOLES
TR	TRACK	TREES	ALL TREES
TP	TELEPHONE LINE	MANHOLES	ALL MANHOLES
F,FP,FL,FC	FENCE	CAD	FRAME
STAY	STAY WIRE	LEGEND	LEGEND
EP	POWERLINE	BUILDING	BUILDINGS
TC, BC	TOP / BOTTOM CULVERT	WALL	WALLS
BC	BUILDING CORNER	WATER	ALL WATER
RES	RESERVOIR		
MH	MANHOLE		
BK, TK	BOTTOM / TOP KERB		
LP	LIGHT POLE		
CPIT	CATCHPIT		
TD, BD	TOP / BOTTOM DRAIN		
TW, BW	TOP / BOTTOM WALL		
G, GR	GUARD RAIL		
DB	DISTRIBUTION BOX		

AMENDMENTS / WYSIGINGS

DESCRIPTION BESKRYWING	REV. HERS.	BY: DEUR:	DATE: DATUM:

CLIENT / KLIENT

S R K CONSULTING

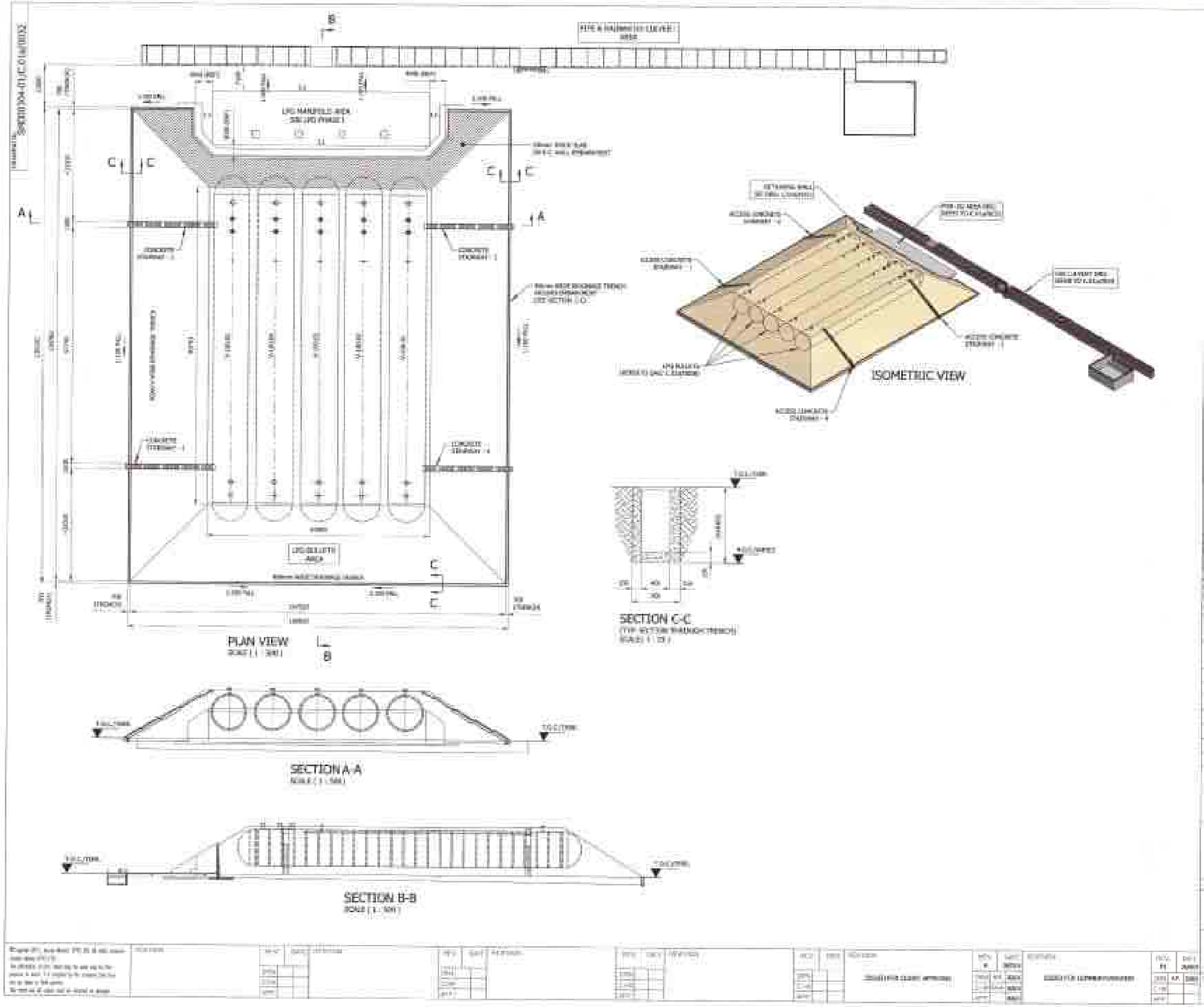
PROJECT / PROJEK

VOPAK SITE RICHARDS BAY HARBOUR

TITLE / TITEL

GENERAL SURVEY

SCALE	1 : 1000	SKAAL
DATE	DECEMBER 2013	DATUM
PLAN NO	10014 - 01	PLAN NR



JACOBS MATASIS

KEY PLAN

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DRAWING NUMBER	TITLE
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

JACOBS MATASIS

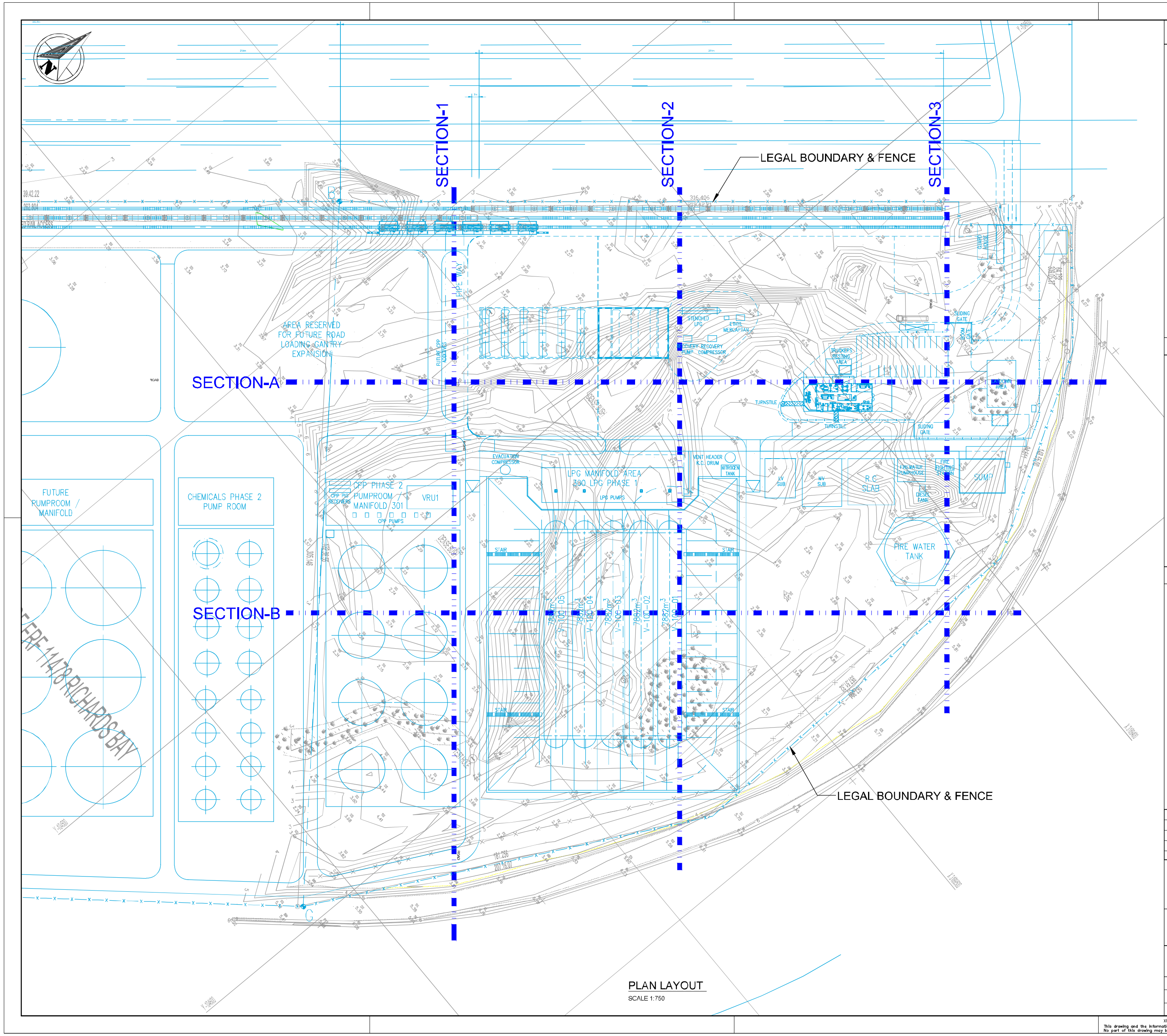
Vopak RICHARDS BAY

CLIENT:
PROJECT:
VOPAK REATILE
RICHARDS BAY
TERMINAL 10% FEED STUDY

TITLE:
CIVIL LAYOUT
BULLET LAYDOWN & STAGING AREA
GENERAL ARRANGEMENT

DRAWING No: SMX0034-01/C.01a/0032
SCALE: 1:500

PDF created with pdfFactory Pro trial version www.pdffactory.com



PLAN LAYOUT

SCALE 1:750

GENERAL NOTES

1. ALL DIMENSIONS ARE IN mm, UNLESS SPECIFIED OTHERWISE.
2. SAFETY DISTANCE ACC. TO SANS 10089-1:2003 EDITION 4.1 AND SANS 10087-3:2008 EDITION 4
3. SAFETY DISTANCES FOR REFRIGERATED LPG STORAGE TO API 2510
4. RAILWAY TO CROSS STORM WATER CHANNEL BY MEANS OF A CULVERT.

LEGEND

REFERENCE DRAWINGS

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
A	2014.04.23	JDP	SC		ISSUED FOR CLIENT APPROVAL
P1	2014.02.05	JDP	SC		ISSUED FOR CLIENT COMMENT

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Vopak

RICHARDS BAY

TITLE:
SITE PLAN
LAYOUT

SCALE: AS SHOWN	DATE:	FORMAT:	ARCH.NR.:	SHEET: 01
DRAWN: JDP	2014.02.05	A1	DRAWINGNR.: SM000304/C.01a/0050	OF: 01
CHECKED: SC	.			ISSUE: A

Contractor drawingnumber:

XRef: Accessorieslist: Partlist: ACAD version: 2013 Filename: .DWG

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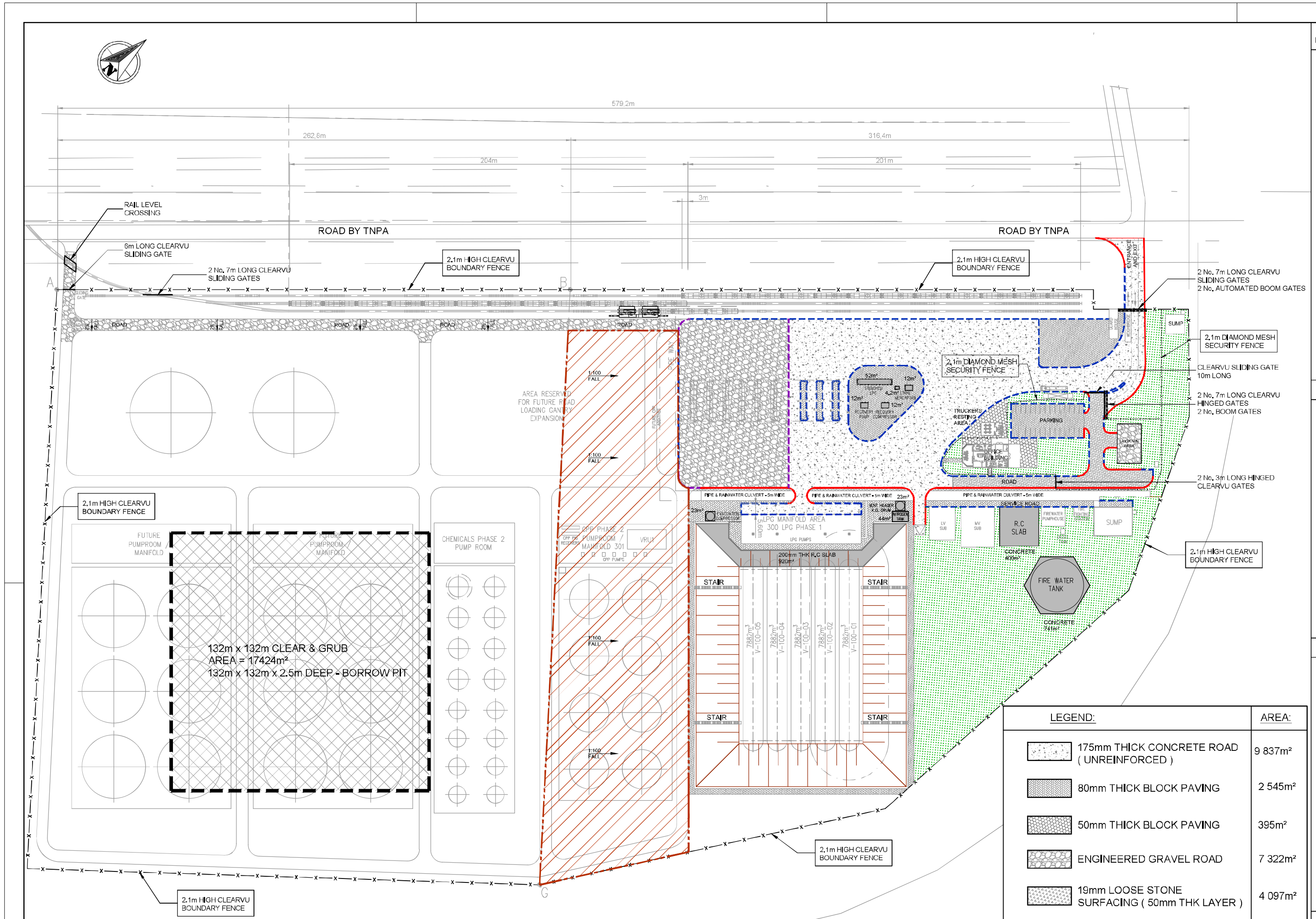
GENERAL NOTES

LEGEND

REFERENCE DRAWINGS



LEGEND:		AREA:
▨	175mm THICK CONCRETE ROAD (UNREINFORCED)	9 837m²
▨	80mm THICK BLOCK PAVING	2 545m²
▨	50mm THICK BLOCK PAVING	395m²
▨	ENGINEERED GRAVEL ROAD	7 322m²
▨	19mm LOOSE STONE SURFACING (50mm THK LAYER)	4 097m²
🟩	LANDSCAPED AREA	11 576m²
▨	BULK & SECONDARY EARTHWORKS SAND COMPACTED TO 100% MOD AASHTO	18 510m²
—x—x—	2.1m HIGH CLEARVU BOUNDARY FENCE	1 630m
-·-·-·-	2.1m DIAMOND MESH SECURITY FENCE	330m
- - - -	KERB FIG 3	1 216m
——	KERB FIG 8b	462m
- - - -	KERB FIG 10	123m

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
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A	2014.03.18	JDP	SC		ISSUED FOR CLIENT REVIEW AND
					20% COST ESTIMATE
P1	22/11/2013	YB	SC		ISSUED FOR INTERNAL REVIEW

RICHARDS BAY

TITLE:
INFRASTRUCTURE
LAYOUT

SCALE: 1:1000	DATE:	FORMAT:	ARCH.NR.:	SHEET: 01
DRAWN: YB/JDP	2014.02.06	A1	DRAWINGNR.: SM000304/C.01a/0053	OF: 01
CHECKED: SC	.			ISSUE: B

Contractor drawingnumber:

XRef: Accessorieslist: Partlist: ACAD version: 2013 Filename: .DWG

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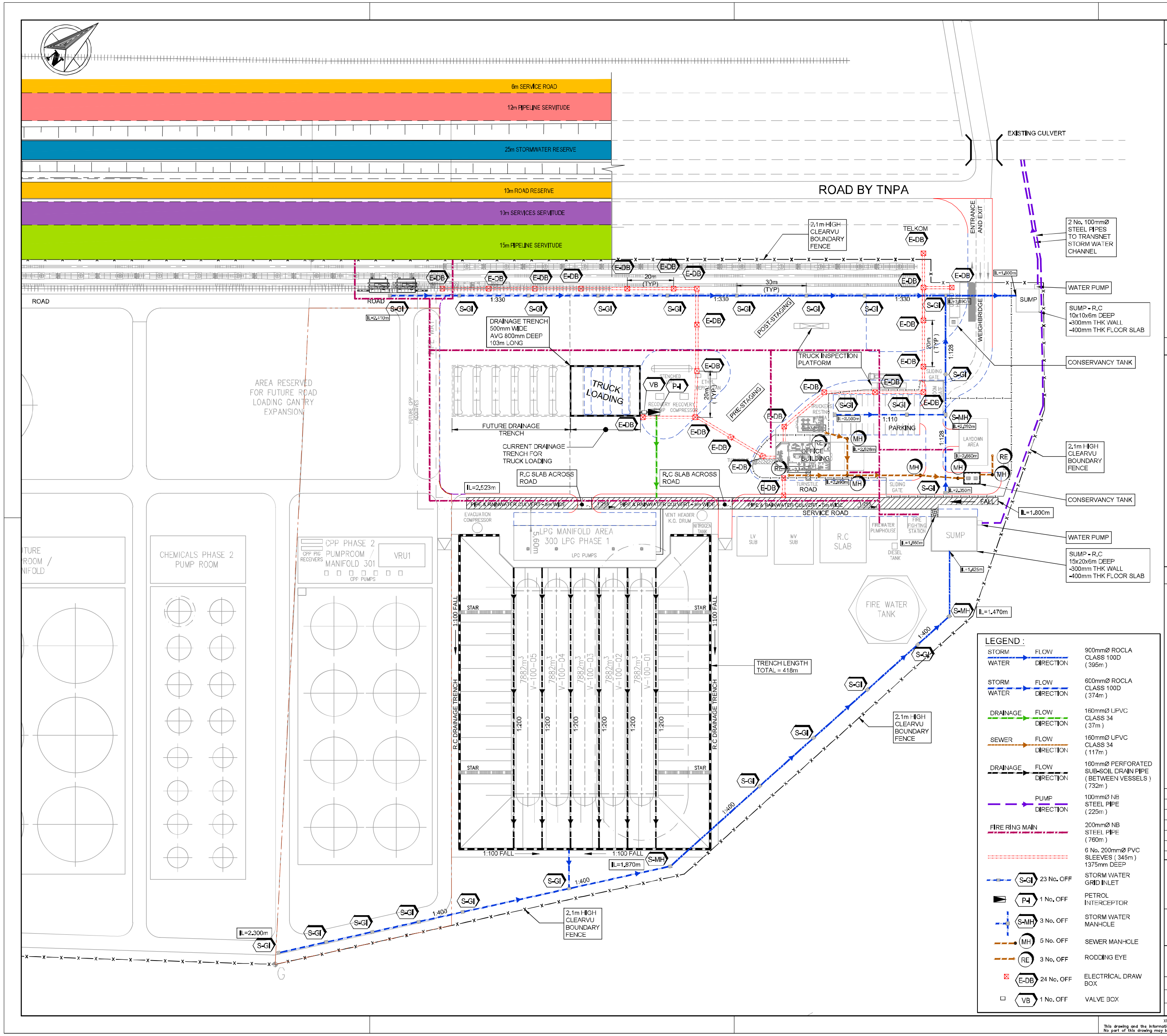

GENERAL NOTES

LEGEND

REFERENCE DRAWINGS

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
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A	2014.03.18	JDP	SC		ISSUED FOR CLIENT REVIEW AND 20% COST ESTIMATE
P3	2014.02.17	JDP	SC		OFFICE & WORKSHOP UPDATED
P2	2014.02.13	JDP	SC		COMMENTS ADDED
P1	2014.02.05	JDP	SC		ISSUED FOR CLIENT COMMENT

JACOBS MATASIS

Vopak

RICHARDS BAY

TITLE:
SERVICES
PROPOSED S/W AND SEWER LAYOUT

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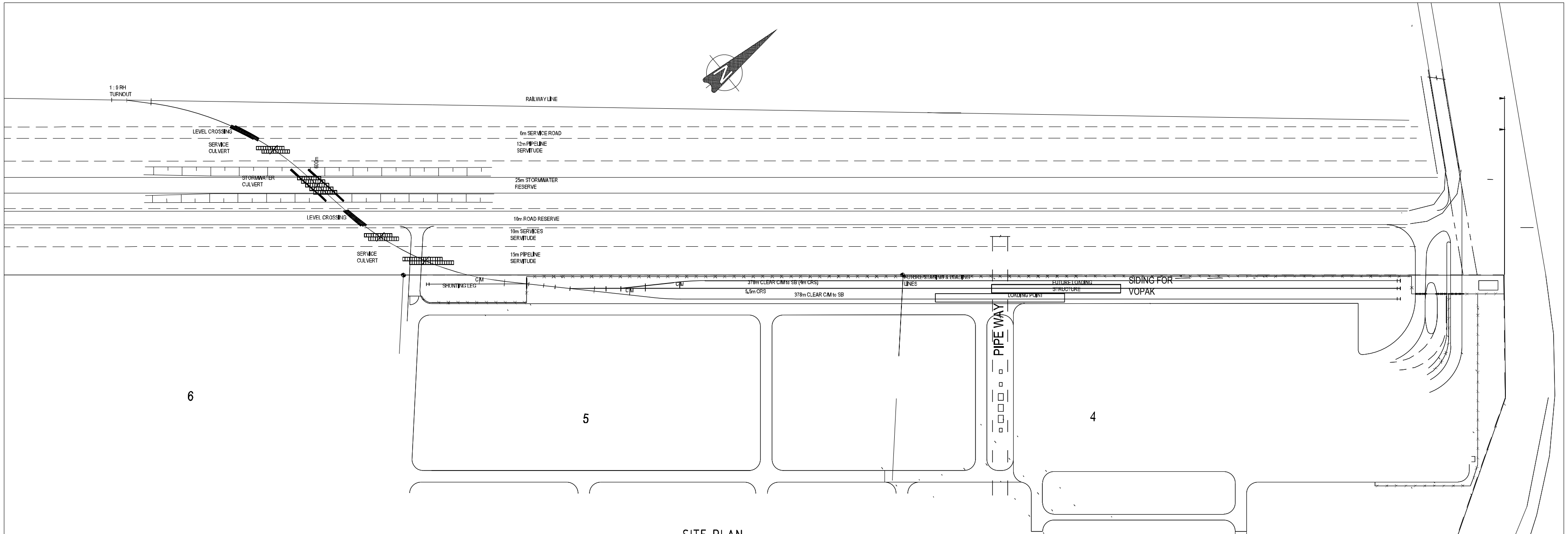
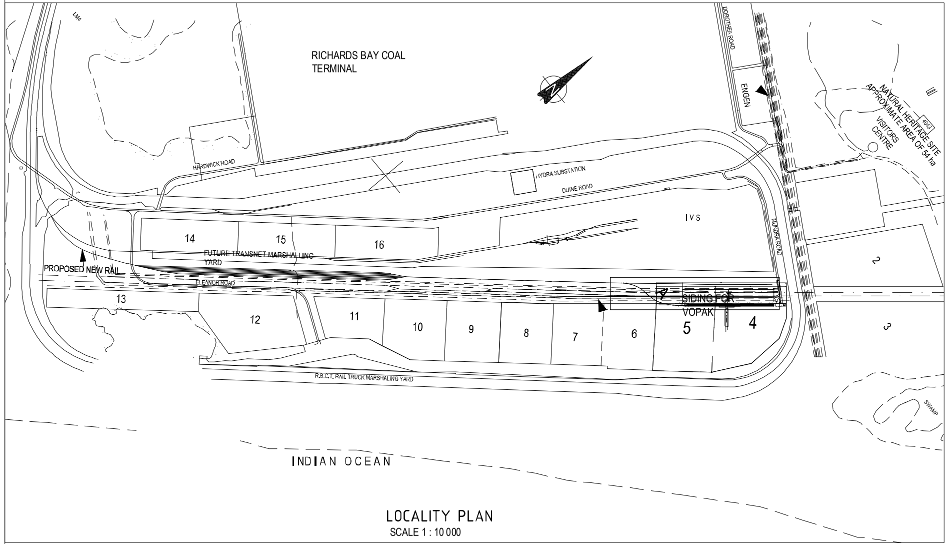


SITE PLAN
SCALE 1 : 1000



LOCALITY PLAN
SCALE 1 : 10 000

DIAGRAMMATIC LAYOUT
NOT TO SCALE

GENERAL NOTES

LEGEND

REFERENCE DRAWINGS

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2 DRAWING No 4122870-1-001-C-DE-0011-01-0C- TD - STORMWATER CHANNEL SECTIONS
3 DRAWING No 4122870-1-001-C-LA-0004-01-0C- TD - STORMWATER CHANNEL LAYOUT
4 DRAWING No SKETCH RBH 2012-03 - PROPOSED PRIVATE SIDING & PIPE SERVITUDE TO SITE FOR SITE 4 & 5 SOUTH DUNES

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
A	10-06-2014	R v/d H	SC		ISSUED FOR CLIENT APPROVAL
P1	04-04-2014	R v/d H	SC		ISSUED FOR INTERNAL REVIEW

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Vopak

RICHARDS BAY

TITLE:
CONCEPT TRACK LAYOUT
LINK LINE CROSSING STORMWATER CHANNEL

SCALE: AS SHOWN	DATE:	FORMAT:	ARCH.NR.:	SHEET:	01
DRAWN: R v/d H	2014.04.15	A1	DRAWINGNR.: SM000304/C.01a/00160	OF:	02
CHECKED:	.			ISSUE:	A

Contractor drawingnumber: RCE 436-RB- 001 SH01

XRef: Accessorieslist: Partlist: ACAD version: 2013 Filename: .DWG

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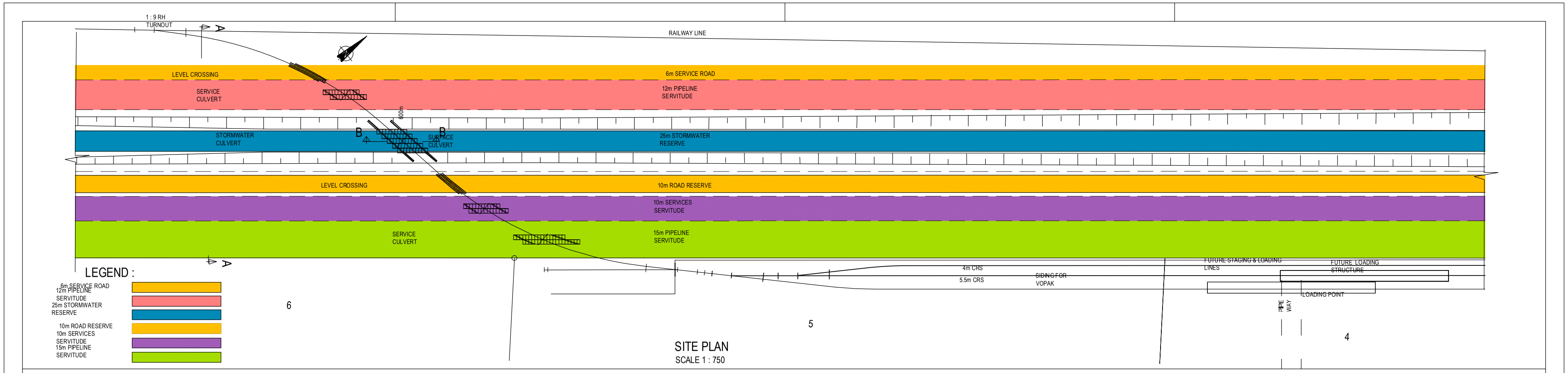
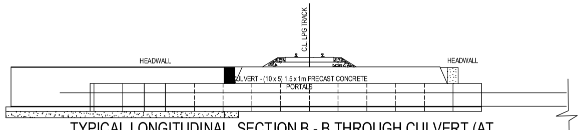


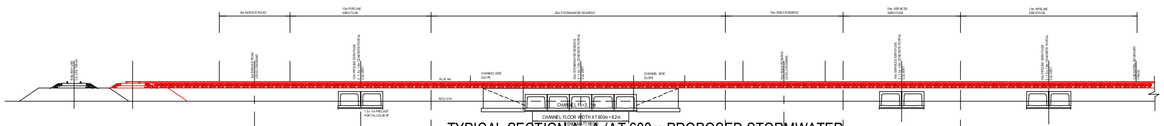
SITE PLAN

SCALE 1 : 750



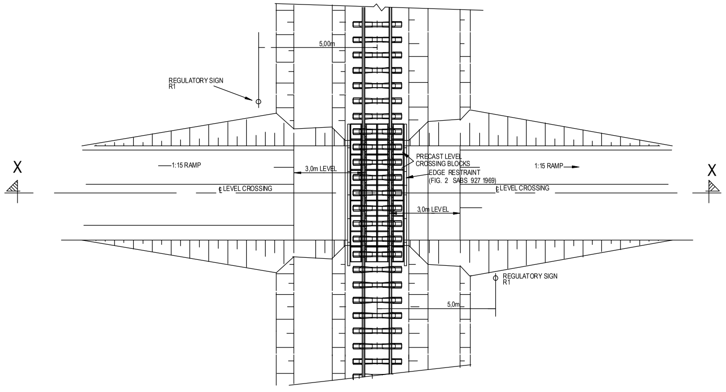
TYPICAL LONGITUDINAL SECTION B - B THROUGH CULVERT (AT 600m)

SCALE:- 1:100



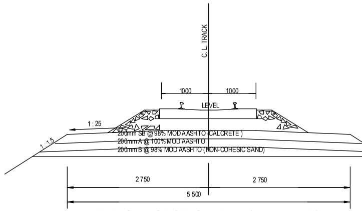
TYPICAL SECTION A - A (AT 600m PROPOSED STORMWATER CHANNEL)

SCALE:- 1:200



TYPICAL LEVEL CROSSING PLAN

SCALE = 1 : 50



TYPICAL SECTION FILL (LINK LINE)

SCALE :- 1 : 100

GENERAL NOTES

LEGEND

STANDARDS FOR SIDING

RAIL LEVEL TO FORMATION LEVEL = 580mm

SHARPEST RADIUS = 200m

MAXIMUM SPEED OVER TOTAL LENGTH OF LINES NOT TO EXCEED 15 km/h

CONTINUOUS WELDED RAILS

MAXIMUM TRUCK AXLE LOAD = 20 000kg

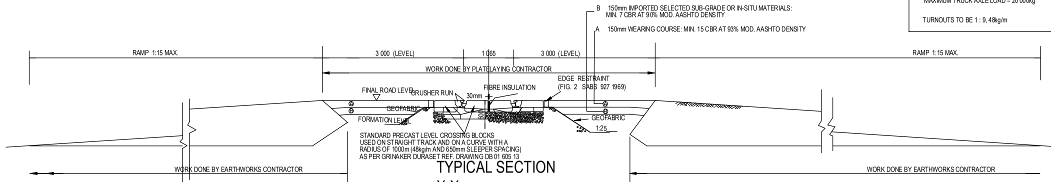
TURNOUTS TO BE 1 : 9, 48kg/m

PERMANENT WAY MATERIAL : CONVENTIONAL TRACK

48kg/m RAILS ON P2/F4 CONCRETE SLEEPERS

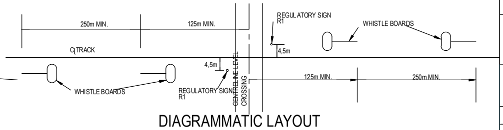
SLEEPER SPACING 700mm CRS.

BALLAST 1 250m³/km



TYPICAL SECTION X-X

SCALE = 1 : 50



DIAGRAMMATIC LAYOUT

REFERENCE DRAWINGS

1 DRAWING No SM000304/C.01a/00149 - LAYERWORKS DETAILS S
2 DRAWING No 4122870-1-001-C-DE-0011-01-0C- TD - STORMWATER CHANNEL SECTIONS
3 DRAWING No 4122870-1-001-C-LA-0004-01-0C- TD - STORMWATER CHANNEL LAYOUT
4 DRAWING No SKETCH RBH 2012-03 - PROPOSED PRIVATE SIDING & PIPE SERVITUDE TO SITE FOR SITE 4 & 5 SOUTH DUNES

ISSUE	DATE	DRAWN	CHECKED	APPROVED	DESCRIPTION
A	2014.06.10	R v/d H			ISSUED FOR CLIENT APPROVAL
P1	2014.04.15	R v/d H			ISSUED FOR INTERNAL REVIEW

JACOBS MATASIS

Vopak

RICHARDS BAY

TITLE: CONCEPT TRACK LAYOUT
LINK LINE CROSSING STORMWATER CHANNEL
DETAILS

SCALE: AS SHOWN	DATE:	FORMAT:	ARCH.NR.:	SHEET: 02
DRAWN: R v/d H	2014.04.15	A1	DRAWINGNR.: SM000304/C.01a/00161	OF: 02
CHECKED:	.			ISSUE: A

Contractor drawingnumber: RCE 436 - RB - 001 SH02

XRef: Accessorieslist: Partlist: ACAD version: 2013 Filename: .DWG

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APPENDIX H

Risk Impact Assessment Specialist Study

January 2015
Report No. 13614921-13289-4

PROJECT DONE ON BEHALF OF
GOLDER ASSOCIATES AFRICA (PTY) LTD

A QUANTITATIVE RISK ASSESSMENT FOR THE PROPOSED VOPAK-REATILE TERMINAL IN RICHARDS BAY, KWAZULU-NATAL

Report No.: R/14/GOL-01 Rev 0

OCTOBER 2014

Authored by M P Oberholzer
Reviewed by H M Smith

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Fax: +27 (0) 86 624 9423
E-mail: mike@riscom.co.za

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DOCUMENT CHANGE HISTORY			
PAGE/LINE	**CHANGE**	**DATE**	**REV**
Document	Initial release	20 Oct 2014	0

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RISCOM (PTY) LTD

RISCOM (PTY) LTD is a consulting company that specialises in process safety. Further to this, RISCOM* is an approved inspection authority (AIA) for conducting Major Hazard Installation (MHI) risk assessments in accordance with the OHS Act 85 of 1993 and its Major Hazard Installation regulations (July 2001). In order to maintain the status of approved inspection authority, RISCOM is accredited by the South African National Accreditation System (SANAS) in accordance with the IEC/ISO 17020:2012 standard. The accreditation consists of a number of elements, including technical competence and third party independence.

The independence of RISCOM is demonstrated by the following:

- RISCOM does not sell or repair equipment that can be used in the process industry;
- RISCOM does not have any shareholding in processing companies nor companies performing EIA risk assessment functions;
- RISCOM does not design equipment or processes.

Mike Oberholzer is a professional engineer, holds a Bachelor of Science in Chemical Engineering and is an approved signatory for MHI risk assessments, thereby meeting the competency requirements of SANAS for assessment of the risks of hazardous components, including fires, explosions and toxic releases.

M P Oberholzer Pr. Eng. BSc (Chem. Eng.) MIChemE MSAIChE

---

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LIST OF FIGURES

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LIST OF TABLES

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EXECUTIVE SUMMARY

1 A QUANTITATIVE RISK ASSESSMENT FOR THE PROPOSED VOPAK-REATILE TERMINAL IN RICHARDS BAY, KWAZULU-NATAL

1.1 Introduction

1.1.1 Scope

Vopak South African Development (Pty) Ltd, hereinafter referred to as VSAD, wishes to construct a fuel terminal for the storage and distribution of liquid fuels and liquefied petroleum gas (LPG).

The proposed VSAD terminal would be located within the Transnet Ports Authority (TNPA) area at the Richards Bay harbour and would import product from ships into the bulk storage tanks for redistribution.

Since off-site incidents may result due to the hazards of some of the material to be stored on or transported onto site, RISCOM (PTY) LTD was commissioned to conduct a risk assessment to quantify the extent of the impacts on and risks to the surrounding communities.

1.1.2 Study objectives

The risk assessment was completed for the purposes of an environmental impact assessment (EIA), conducted by Golder Associates Africa (Pty) Ltd. For the purposes of the EIA, this risk assessment has the main objective to determine any fatal flaws that would prevent the project from proceeding. This differs from a Major Hazard Installation (MHI) risk assessment, which will determine if the project could be constructed and operate with risks to employees and the public at an acceptable level.

The risk assessment should have a statement from a professional person covering the following questions:

1. Whether the proposed project would likely be considered an MHI;
2. If it is likely to be considered an MHI, whether it would meet the requirements of the MHI regulations and whether the risks could be engineered or managed to meet acceptable risks;
3. Whether there are any factors that will prevent the project from proceeding to the next phase of construction or whether the project could continue under certain conditions or mitigations;
4. Whether there are any special requirements that local authorities need to know when evaluating the proposal.

1.1.2.1 Purpose and main activities of the terminal

The main activity of the proposed VSAD terminal would be the storage and distribution of LPG, petrol, diesel and Avgas as bulk products.

1.1.2.2 Main hazards due to substance and process

The main hazards due to the flammability of the products are thermal radiation from fires and overpressure from explosions.

1.1.3 Approach to the study

As an approved inspection authority (AIA), RISCOM uses the methodologies and criteria described in Appendix D. The quantitative risk assessment (QRA) process is also summarised in that appendix.

It is important to know the difference between hazard and risk. A hazard is anything that has the potential to cause damage to life, the property and the environment. Furthermore, it is a constant parameter (such as that of petrol, chlorine, ammonia, etc.) that poses the same hazard whenever present. Risk, on the other hand, is the probability that a hazard will actually cause damage and how severe that damage will be. Risk is therefore the probability that a hazard will manifest itself. For instance, the risk presented by a chemical depends upon the amount present, the process it is used in, the design and safety features of its container, prevailing environmental and weather conditions, the exposures and so on.

1.2 Terms of reference

The main aim of the investigation was to quantify the risks to employees and neighbours with regard to the proposed VSAD terminal in Richards Bay.

This risk assessment was conducted with the following terms of reference:

1. The development of accidental spill and fire scenarios for the storage facility;
2. Using generic failure rate data (tanks, pumps, valves, flanges, pipework, gantry, couplings, etc.), the determination of the probability of each accident scenario;
3. For each incident developed in Step 2, the determination of the consequences (thermal radiation, domino effect, toxic cloud formation, etc.);
4. The calculation of maximum individual risk (MIR) values taking into account all accidents, meteorological conditions and lethality.

This risk assessment is for the use of the EIA and is not intended to replace a Major Hazard Installation risk assessment. Furthermore, the assessment covers only acute events and sudden ruptures and not chronic and on-going releases, such as fugitive emissions. It is not intended to be an environmental risk assessment and may not meet specific the requirements of environmental legislation.

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1.3 Baseline environment

1.3.1 General background

The proposed VSAD terminal is to be located within the TNPA area in the Richards Bay harbour on Lot 4 and Lot 5, having areas of 77 ha and 78 ha, respectively, as shown in Figure 1. The current rail infrastructure used by the coal terminal is routed around the plots. The sites are situated less than a kilometre from the current jetties at the port. Ships would dock at Berth 208 or Berth 209.

Figure 1: Location of the proposed VSAD terminal at Richards Bay

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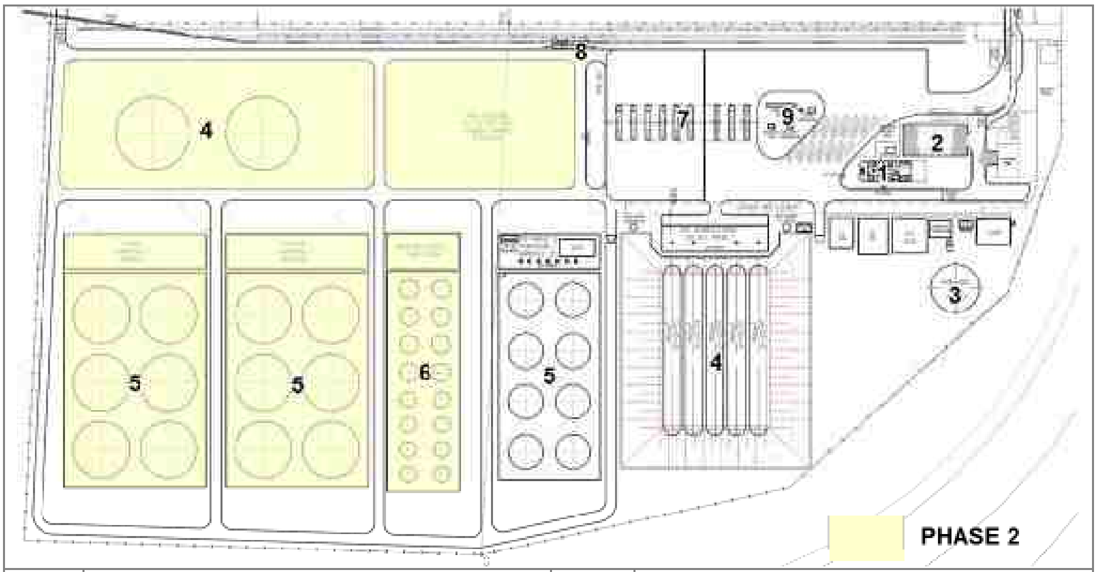
1.3.2 Project description

As described in the following subsections the key components of the project include the construction of a tank farm and transport pipelines as well as the installation of infrastructure at the terminal. The overall project includes importation of bulk liquid fuels and LPG from ships in the Richards Bay harbour. The material to be stored in the bulk storage vessels would be dispatched via road or rail to customers.

The proposed VSAD terminal in Richards Bay would consist of offices, bulk fuel, LPG and chemical storage, road and rail gantries, a laboratory and a fire water tank, as shown Figure 5.



No.	Description	No.	Description
1	Offices	2	Truck resting area
3	Fire water	4	LPG storage
5	Fuel storage	6	Chemical storage
7	Road gantry	8	Rail gantry
9	Stenching tank		

Figure 5: Conceptual layout of the VSAD terminal in Richards Bay

1.3.2.1 Transport pipelines from berthed ship to terminal

Ships would dock at Berth 208 or Berth 209 and product would be loaded or offloaded. Shipping operations would be carried out continuously over a 24 hour period seven days per week until the intended parcel is offloaded or loaded.

The expected batch size of the shipping operations is 40 000 m^3 for petrol and diesel and 15 000 m^3 for Avgas at a pumping rate of between 800-1200 m^3/hr.

The LPG ship would be expected to offload a parcel of 26 000 m^3 in 28 hours at a pumping rate of 930 m^3/h and a maximum flow rate of 7 m/s. The flanges on the pipelines would be rated at 300, which could experience a maximum pressure of 51 bar.

Pipelines would be installed for the initial transfer of bulk liquids and LPG from Berth 208 and Berth 209 to the tank farm and vice versa. Figure 6 illustrates the pipeline routing that has been proposed to run from the berths to the VSAD terminal.

The pipelines would run aboveground and would consist of the following dedicated lines for Phase 1 of the project:

- 1 x 16" carbon steel line for Avgas;
- 1 x 16" carbon steel line for diesel;
- 1 x 16" carbon steel line for petrol;
- 1 x 10" shipping line (LPG liquid);
- 1 x 10" shipping line (LPG vapour).

The number of additional pipelines for Phase 2 is still to be confirmed.

Figure 6: Proposed routing of the pipelines from the berths to the tank farm

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1.3.2.2 Bulk atmospheric storage

The bulk atmospheric fuel storage would provide storage for clean petroleum products (CPP), hydrocarbon products such as petrol, diesel and Avgas. General chemicals would also be stored in a separate bunded area. The terminal in Richards Bay would be developed in two phases. Phase 1 would consist of 8 x 5000 m^3 CPP atmospheric storage vessels. Phase 2 of the project has not been confirmed but could consist of an additional 12 x 10 000 m^{3}of CPP atmospheric storage vessels and 16 x 1500 m^3 of chemical storage vessels.

Phase 1 and Phase 2 would include new tanks, manifolds, a vapour recovery unit, road and rail loading gantries and pipelines. Phase 1 would include the initial tanks, all the utilities (designed for both Phase 1 and Phase 2), offices, storage, shipping pipelines, rail siding and other infrastructure. Phase 2 may include additional rail loading bays. Since this is a new plot, during the engineering segment it would be ensured that enough space is kept for additional pipe racks and extensions to structures as well as changes in operation, automation and maintenance philosophies.-

The bulk liquid tanks would be classified as vertical tanks and would be constructed according to SANS 10089, the American Petroleum Institute standard API 650 and the tank design manual (the Vopak standard); all which pertain to the construction of atmospheric steel tanks.

The storage tanks that would contain products that wouldn't be considered volatile, such as diesel, would be fitted with fixed roofs. However, the storage tanks that would contain volatile products, such as petrol and Avgas, would be fitted with f internal floating roofs to reduce vapour loss. An internal floating roof system consists of a roof that floats on the surface of the product stored within the tanks, together with a seal around the rim. The floating roof would reposition according to the level of the stored product to reduce the potential of a vapour zone occurring above the product.

A tank gauging system would be provided for managing tank inventory for each client as well as overfill protection. The level transmitters on the tanks would provide high and high-high level alarms on the distributed control system (DCS). Separate independent high level switches would trip the emergency shut-off valves in order to stop transfer to the product tanks (hardwired trips).

Walls around the tanks, called bunds (or tank pits), are intended to retain any accidental spillages. The bunding in the proposed tank farm has been designed to comply with or exceed the requirements of the most recent SANS specifications (particularly SANS 10089) to minimize any risk associated with product spills into the environment. It is anticipated that the bund walls would be composed of reinforced concrete. The bund wall capacity is expected to be able to retain 110% of the largest tank capacity within the main bund area but not to exceed 1.8 m in height.

The proposed safety features as engineering controls and protective measures are summarised as follows:

- Proposed engineering design features to reduce risks would be as follows:
  - All petrol and Avgas tanks would be fitted with internal floating roofs;
  - Tanks are to be designed according to API 650 and SANS 10089;
  - All tanks would be earthed;
  - All instrumentation would be specified in accordance with the hazardous area classification as per SANS 10108;
  - Overfill protection would consist of two independent level indicators, with alarm indication at high level and an independent high level switch that would close the incoming valve;
  - Secondary containment around the storage tanks would be provided with a volume of 110% of the largest tank as containment;
- Proposed protective measures to reduce the risks would be as follows:
  - The tank storage area would be protected by fire-fighting systems, consisting of tank pourers and bund foam pourers;
  - The loading bay would be fully protected with a water-deluge system;
  - The filling operation would prevent loading if the vehicle is not earthed.

1.3.2.3 Bulk LPG storage

The Richards Bay terminal is a Greenfield project and would be developed in two phases. Phase 1 would include 5 x 7882 m^3 mounded LPG pressurised storage vessels, and the future Phase 2 would include 2 x 34 000 m^3 refrigerated aboveground storage vessels (spheres). This would give a total storage capacity of up to 107 410 m³. In Phase 1 the tanks would be pressurised and mounded, thereby preventing the formation of a BLEVE.

In Phase 2 two new tanks would be built, with an additional storage volume of up to 67 000 m³. These tanks would have the relevant accessories and would be refrigerated below the boiling point of the stored gases to prevent excess pressure build up.

The refrigerant of the chiller unit is proposed to be nontoxic and nonflammable.

The liquid fill line from the ship into the tanks would be via a spray header to reduce the pressure of the LPG vapour in the tank, to optimize transfer rates throughout the discharge and to prevent accidental flow back from the storage tank to the berths.

A tank gauging system would be provided for managing the tank inventory of each tank as well as overfill protection. The level transmitters on the tanks would provide high and high-high level alarms on the distributed control system (DCS). Separate independent high level switches would trip the emergency shut-off valves in order to stop transfer to the product tanks. These would be hardwired trips. The weighbridges and tank gauging would be approved for stock control.

The proposed safety features as engineering controls and protective measures are summarised as follows:

- Proposed engineering design features to reduce risks would be as follows:
    - Tanks are to be designed to API 2510 and SANS 10087;
    - All tanks would be earthed;
    - All instrumentation would be specified in accordance with the hazardous area classification as per SANS 10108;
    - Overfill protection would consist of two independent level indicators, with alarm indication at high level and an independent high level switch that would close the incoming valve;
    - Secondary containment around the storage tanks would be provided with a volume of 110% of the largest tank as containment;
    - Loading of LPG would be done with a fully-automated system and a number of permissives to prevent overfilling and to ensure safe loading;
    - Loading of LPG would be done using loading arms with breakaway couplings;
    - Emergency shutdown (ESD) would be provided that would automatically shut systems down in the event of an emergency and would be independent of the control systems;
    - Overfill protection would be provided:
        - If all overfill protection systems fail, the pressure safety valve (PSV; as a last line of defence) would relieve to a safe area;
- Proposed protective measures to reduce the risks would be as follows:
    - Tanks would be pressurised and mounded, thereby preventing the formation of a BLEVE;
    - Fire-fighting systems would be provided.

1.3.2.4 Road gantries

The loading gantry for liquid fuel and chemical road tankers would initially contain up to three loading bays in Phase 1, which could be expanded to hold up to two additional loading bays at a later stage. The gantry would serve as a transfer area for bulk liquids (CPP fuels and chemicals) from the storage tanks to the road tankers.

There are would be various combinations and sizes of trucks for CPP products. Either a single truck would be loaded or one with a trailer or pup (an additional type of trailer compartment to increase load volume). All trucks would have bottom loading 'scully-type' connections. This type of connection would allow filling only if all permissives were in place, such as earthing, and would form part of the batching control and shut down.

The loading of the CPP road tankers would operate 24 hours per day and seven days per week. These road tankers are expected to have a maximum capacity of 40 m^3 and would be loaded at 125 m^3/h.

The road gantries would be fully automated for loading petrol and diesel. The petrol and diesel would be pumped from the manifold area to the road loading bays via dedicated product headers. Each loading bay would be equipped with a positive displacement flow metre; no weighbridges would be required at the loading bays. A vapour recovery unit would be installed to recover the vapours from the loading of petrol at the road loading bays.

The area of the loading gantry for road tankers may be fitted with spill control slabs as a contingency measure to ensure that any spillage is contained. Each loading bay would contain a central drain to collect the spills that would lead to a separator. Should any of the spilt material ignite; it would initially be contained at the oil separator.

The loading gantry would be covered with a fixed canopy to provide protection against the weather elements, thereby minimizing the volume of storm water entering the oily water drainage system. The gantry would also be equipped with mezzanine floors in order to store the gantry equipment and provide access to the top of the vehicles. Fall protection measures would be implemented to ensure the safety of all personnel during all phases of the project lifecycle.

Only one entrance would be allowed for LPG truck movement. For safety reasons a second gate would be present on the plot as an emergency exit only. Parking space for six LPG tankers would be provided on site with up to two tankers per loading bay.

The loading of the LPG road tankers would be fully automated and would operate 16 hours per day and seven days per week. The LPG road tankers are expected to have a maximum capacity of 50 m^3 and would be loaded at 80 m^3/h. The weighbridges and tank gauging would be approved for stock control.

1.3.2.5 Rail gantries

The rail gantry for loading liquid fuel and chemicals would consist of about 30 loading points that would be installed during Phase 1. Additional loading points could be installed during Phase 2.

The rail gantry would consist of fully automated batch filling for diesel and petrol, with a vapour recovery system. Petrol and diesel would be pumped from the manifold area to the rail loading bays via the dedicated product headers. Each loading bay would be equipped with a positive displacement flow metre; no weighbridges would be required at the loading bays.

The rail gantry for loading liquid fuel and chemicals would operate 24 hours per day and 7 days per week. The expected rail tanker capacity would be 74 m^3.

The loading of the LPG rail tankers would be fully automated and would operate 24 hours per day and 7 days per week. The LPG rail tankers would range in size from 19 t to 36 t (with an average capacity of 56 m^3) and would be loaded at 80 m^3/h. Weighbridges and tank gauging would be approved for stock control.

Phase 1 would include two LPG rail loading bays. In a later phase an additional two bays would be designed to handle peak demand and enable block train loading of up to 36 rail cars per day and about 1000 t per day.

1.3.2.6 Odourisation

Ethyl mercaptan would be used to stench the LPG. The odorant specification in the final batch product would be 15 µL/L (SANS 1774 2007). One 90 m^3 LPG tank would be provided for stenched gases.

1.3.2.7 Utility Systems

Nitrogen

Nitrogen would be required for instrument air. The nitrogen inventory has not been specified, and it is assumed that nitrogen would be generated on site with minimal inventory.

1.3.2.8 Summary of proposed inventories

The summary of bulk materials to be stored on site is given for each phase:

- Phase 1:
    - 8 x 5000 m^3 petrol, diesel and Avgas atmospheric storage vessels;
    - 5 x 7882 m^3 mounded LPG pressurised storage vessels;
- Phase 2:
    - 16 x 1500 m^3 chemical storage vessels;
    - 12 x 10 000 m^3 petrol, diesel and Avgas atmospheric storage vessels;
    - 2 x 34 000 m^3 refrigerated aboveground LPG storage vessels.

1.4 Methodology

The first step in any risk assessment is to identify all hazards. The merit of including a hazard for further investigation is then determined by how significant it is, normally by using a cut-off or threshold value.

Once a hazard has been identified, it is necessary to assess it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequence should be considered but there are occasions where, if either the probability or the consequence can be shown to be sufficiently low or sufficiently high, decisions can be made based on just one factor.

During the hazard identification component of the report, the following considerations are taken into account:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- The type and design of containers, vessels or pipelines;
- The quantity of material that could be involved in an airborne release;
- The nature of the hazard most likely to accompany hazardous materials spills or releases, e.g. airborne toxic vapours or mists, fires or explosions, large quantities in storage and certain handling conditions of processed components.

The evaluation methodology assumes that the facility will perform as designed in the absence of unintended events such as component and material failures of equipment, human errors, external events and process unknowns.

Due to the absence of South African legislation regarding determination methodology for quantitative risk assessment (QRA), the methodology of this assessment is based on the legal requirements of the Netherlands, outlined in CPR 18E (Purple Book) and RIVM (2009). The evaluation of the acceptability of the risks is done in accordance with the Health and Safety Executive (HSE; UK) ALARP criteria, which clearly covers land use, based on the determined risks.

The QRA process is summarised in the steps listed in Appendix D.

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1.5 Conclusions

Risk calculations are not precise. The accuracy of predictions is determined by the quality of the base data and expert judgements. A number of well-known sources of incident data were consulted and applied to obtain the likelihood of an incident to occur. The risk assessment included the consequences of fires and explosions at the VSAD facility in Richards Bay.

The risk assessment was done on the assumption that the site is maintained to an acceptable level and that all statuary regulations are applied. It was also assumed that the detailed engineering designs would be done by competent people and are correctly specified for the intended duty. For example, it is assumed that the tank wall thicknesses would have been correctly calculated, that the vents have been sized for emergency conditions, that the instrumentation and electrical components comply with the specified electrical area classification, that the material of construction is compatible with the products, etc. It is the responsibility of VSAD and their contractors to ensure that all engineering designs have been completed by competent persons and that all equipment has been installed correctly. All designs should be in full compliance with (but not limited to) the Occupational Health and Safety Act 85 of 1993 and its regulations, the National Buildings Regulations and the Buildings Standards Act 107 of 1977 as well as local bylaws.

A number of incident scenarios were simulated, taking into account the prevailing meteorological conditions, and described in the report.

1.5.1 Hazardous components

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic.

Nitrogen is an inert gas but can replace air and act as an asphyxiant. . The nitrogen inventory has not been specified, and it is assumed that nitrogen would be generated on site with minimal inventory.

1.5.2 Notifiable substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances requires any employer who has a substance equal to or exceeding the quantity as listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Petrol, diesel, Avgas and nitrogen are not listed as notifiable products.

As more than 25 t of LPG would be stored in a single vessel in both Phase 1 and Phase 2, LPG would then be classified as a notifiable substance and automatically the facility **would be classified as a Major Hazard Installation**.

1.5.3 Transport pipelines from berthed ship to terminal

Transport pipelines would be used to carry CPP products and LPG to and from the terminal to and from the berths. Petrol was used for all modelling for the CPP pipelines to reflect the worst case scenario.

Impacts from petrol pool fires as well as LPG jet fires, flash fires and VCEs, due to a release from a single point on the relevant pipeline with an ignition, could extend various distances from that pipeline.

The worst case of the failure of the LPG pipeline could extend 230 m to the 1% fatality but would not constitute a NEMA Section 30 incident as it wouldn't reach an area used by the general public or cause pollution to the environment.

The worst case of the failure of the CPP pipeline could extend 95 m to the 1% fatality and would constitute a NEMA Section 30 incident as it could cause pollution to the environment.

The risks are dominated by the flash fire and VCE risks. However, the risk of $1x10^{-6}$ fatalities per person per year isopleth follows the pipeline and always remains within TNPA area; therefore, there is no risk to the public.

1.5.4 LPG bulk storage and gantries

LPG would be transported from ships to the LPG storage vessels from there the LPG would be loaded into road or rail tankers.

The 1% fatality for jet fires, due to the release from a single mounded vessel in Phase 1 followed by ignition, could extend beyond the site boundary but not beyond the TNPA area.

In worst conditions, a flash fire or VCE from a similar loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas. This would constitute a NEMA Section 30 incident as it could reach the public.

A BLEVE would not be expected at the bulk storage tanks of Phase 1 as the tanks would be mounded to prevent LPG pooling below the tank. However, a BLEVE could be formed at the LPG stenched vessel or at the LPG road and rail tankers. While the impacts could extend beyond the VSAD facility, no fatalities would be expected outside of the TNPA area.

VSAD has indicated that Phase 2 may include two LPG spherical vessels. A VCE would produce the greatest distance to the 1% fatality isopleth, which could extend beyond the site boundary but not beyond the TNPA area.

The risk of $3x10^{-7}$ fatalities per person per year isopleth, representing trivial risk, could extend about 2.9 km downwind from the release into the harbour area but not into the residential areas. The risk of $1x10^{-6}$ fatalities per person per year isopleth could extend beyond Port Authority into unoccupied ocean. Thus, the risk due to the proposed facility would be considered acceptable provided that the PADHI land use restrictions are applied.

1.5.5 Bulk atmospheric storage and gantries

The terminal would receive CPP liquid fuels and other components that would be stored in bulk tanks and dispatched by ship, road or rail. Petrol was used for all modelling to reflect the worst case scenario.

The 1% fatality due to pool fires at Phase 1 bulk storage could extend beyond the site boundary but not beyond the TNPA area. Releases from the road and railway gantries would be collected in the sump. Impacts from pool fires at the sump would not extend beyond the site boundary.

Impacts at Phase 1 bulk storage from tank-top fires, flash fires, fixed-roof tank explosions and VCEs would not extend beyond the site boundaries. The process description provided indicated that spillages at the road and rail gantry would be directed to the sump, making BLEVEs of road and rail tankers an implausible scenario.

The risk was calculated to include Phase 2 bulk storage. The risk of $1x10^{-4}$fatalities per person per year isopleth, representing the upper limit of tolerable, extends beyond the site boundary on the southern and eastern site boundaries but would not extend beyond the TNPA area. Thus, the risks to the public would be considered acceptable.

1.5.6 Consolidated risks

The consolidated risk was combined from the contributions of each hazardous area on site for Phase 1of the project.

The risk of $1x10^{-4}$ fatalities per person per year isopleth (generally considered the upper limit of tolerable) remains within the TNPA area and does not enter areas used by the general public.

Similarly, the risk of $1x10^{-6}$ fatalities per person per year isopleth, representing the lower limit of tolerable, does not extend into areas used by the general public. Risks less than $3x10^{-7}$ fatalities per person per year would be considered trivial and acceptable for land use by vulnerable populations, such as hospitals, nursery schools, retirement homes, etc.

The addition of Phase 2 would increase the extent of the risk of $1x10^{-6}$ fatalities per person per year isopleth but would have little effect otherwise. As the components to be stored in the tanks of Phase 2 have not been full described, this study assumed the worst case as petrol. In the event that the tanks would contain higher flashpoint materials, the risk isopleths may diminish in size.

1.5.7 Land planning

Currently, the surrounding land use is agricultural, and as such the terminal does not pose risks to the public at large. It would be preferable for the surrounding land use to remain agricultural. If the land use changed, acceptable usage can be confirmed using the HSE land planning guidelines (HSE 2011). The PADHI land-planning tables can be found attached in Appendix H.

1.5.8 Major Hazard Installation

This investigation concluded that the proposed VSAD terminal in Richards Bay, including the transportation pipelines and the terminal, **would be considered a Major Hazard Installation as more than 25 t of LPG in both Phase 1 and Phase 2 would be stored in a single vessel and LPG would thereby be classified as notifiable substance**.

This study is not intended to replace the Major Hazard Installation risk assessment. Once detail designs have been finalised incorporating the mitigation of the EIA, the MHI risk assessment should be completed prior to construction of the terminal to determine the acceptability of the risks posed to the public.

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1.6 Recommendations

As a result of the risk assessment study conducted for the proposed VSAD terminal in Richards Bay a number of events were found to have risks beyond the site boundary. These risks could be mitigated to acceptable levels, as shown in the report.

RISCOM did not find any fatal flaws that would prevent the project proceeding to the detailed engineering phase of the project.

RISCOM would support the project with the following conditions:

1. Compliance with all statutory requirements, i.e. pressure vessel designs;
2. Compliance with applicable SANS codes, i.e. SANS 10087, SANS 10089, SANS 10108, etc.;
3. Incorporation of applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
4. Completion of a recognised process hazard analysis (such as a HAZOP study, FMEA, etc.) on the proposed facility prior to construction to ensure design and operational hazards have been identified and adequate mitigation put in place;
5. Full compliance with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent to ensure that adequate protective instrumentation is included in the design and would remain valid for the full life cycle of the tank farm:
    a. Including demonstration from the designer that sufficient and reliable instrumentation would be specified and installed at the facility;
6. Preparation and issue of a safety document detailing safety and design features reducing the impacts from fires, explosions and flammable atmospheres to the MHI assessment body at the time of the MHI assessment:
    a. Including compliance to statutory laws, applicable codes and standards and world’s best practice;
    b. Including the listing of statutory and non-statutory inspections, giving frequency of inspections;
    c. Including the auditing of the built facility against the safety document;
    d. Noting that codes such as IEC 61511 can be used to achieve these requirements;
7. Demonstration by VSAD or their contractor that the final designs would reduce the risks posed by the installation to internationally acceptable guidelines;
8. Signature of all terminal designs by a professional engineer registered in South Africa in accordance with the Professional Engineers Act, who takes responsibility for suitable designs;
9. Completion of an emergency preparedness and response document for on-site and off-site scenarios prior to initiating the MHI risk assessment (with input from local authorities);
10. Permission not being granted for increases to the product list or product inventories without redoing part of or the full EIA;
11. Final acceptance of the facility risks with an MHI risk assessment that must be completed in accordance to the MHI regulations:

1. Basing such a risk assessment on the final design and including engineering mitigation.

ABBREVIATIONS AND ACRONYMS

AEGL	**Acute exposure guideline levels** are values published by the US Environmental Protection Agency (EPA). AEGL values represent threshold exposure limits for the general public applicable to five emergency exposure periods (10 minutes, 30 minutes, 1 hour, 4 hours and 8 hours) and are distinguished by varying degrees of severity of toxic effects. **AEGL-1** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. **AEGL-2** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long lasting adverse health effects or an impaired ability to escape. **AEGL-3** is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death. Although the AEGL values represent threshold levels for the general public, including susceptible subpopulations, such as infants, children, the elderly, persons with asthma and those with other illnesses, it is recognized that individuals, subject to unique or idiosyncratic responses, could experience the effects described at concentrations below the corresponding AEGL value.
AIA	See **Approved Inspection Authority**
ALARP	The UK Health and Safety Executive (HSE) developed the risk **ALARP** triangle, in an attempt to account for risks in a manner similar to those used in everyday life. This involved deciding: • Whether a risk is so high that something must be done about it; • Whether the risk is or has been made so small that no further precautions are necessary; • Whether a risk falls between these two states and has been reduced to levels '**as low as reasonably practicable'** (ALARP). Reasonable practicability involves weighing a risk against the trouble, time and money needed to control it.
Approved Inspection Authority	An **approved inspection authority** (AIA) is defined in the Major Hazard Installation regulations (July 2001)
Asphyxiant	An **asphyxiant** is a gas that is nontoxic but may be fatal if it accumulates in a confined space and is breathed at high concentrations since it replaces oxygen containing air.
Blast Pressure	**Blast pressure** is a measure used in the multi-energy method to indicate the strength of the blast, indicated by a number ranging from 1 (for very low strengths) up to 10 (for detonative strength).
BLEVE	**Boiling liquid expanding vapour explosions** result from the sudden failure of a vessel containing liquid at a temperature above its boiling point. A **BLEVE** of flammables results in a large fireball.
Detonation	**Detonation** is a release of energy caused by the extremely rapid chemical reaction of a substance, in which the reaction front of a substance is determined by compression beyond the auto-ignition temperature.
Emergency Plan	An **emergency plan** is a plan in writing that describes how potential incidents identified at the installation together with their consequences should be dealt with, both on site and off site.

ERPG	**Emergency response planning guidelines** were developed by the American Industrial Hygiene Association. **ERPG-1** is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing anything other than mild transient adverse health effects or perceiving a clearly defined objectionable odour. **ERPG-2** is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. **ERPG-3** is the maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
Explosion	An **explosion** is a release of energy that causes a pressure discontinuity or blast wave.
Flammable Limits	**Flammable limits** are a range of gas or vapour concentrations in the air that will burn or explode if a flame or other ignition source is present. The lower point of the range is called the lower flammable limit (LFL). Likewise, the upper point of the range is called the upper flammable limit (UFL).
Flammable Liquid	The Occupational Health and Safety Act 85 of 1993 defines a **flammable liquid** as any liquid which produces a vapour that forms an explosive mixture with air and includes any liquid with a closed cup flashpoint of less than 55°C. Flammable products have been classified according to their flashpoints and boiling points, which ultimately determine the propensity to ignite. Separation distances described in the various codes are dependent on the flammability classification. **Class** **Description** 0 Liquefied petroleum gas (LPG) IA Liquids that have a closed cup flashpoint of below 23°C and a boiling point below 35°C IB Liquids that have a closed cup flashpoint of below 23°C and a boiling point of 35°C or above IC Liquids that have a closed cup flashpoint of 23°C and above but below 38°C II Liquids that have a closed cup flashpoint of 38°C and above but below 60.5°C IIA Liquids that have a closed cup flashpoint of 60.5°C and above but below 93°C
Flash Fire	A **flash fire** is defined as the combustion of a flammable vapour and air mixture in which the flame passes through the mixture at a rate less than sonic velocity so that negligible damaging overpressure is generated.
Frequency	The **frequency** is the number of times an outcome is expected to occur in a given period of time.
Ignition Source	An **ignition source** is a source of temperature and energy sufficient to initiate combustion.
Individual Risk	**Individual risk** is the probability that in one year a person will become a victim of an accident if the person remains permanently and unprotected in a certain location. Often the probability of occurrence in one year is replaced by the frequency of occurrence per year.
Isopleth	See **Risk Isopleth**
Jet	The **jet** is the outflow of material emerging from an orifice with significant momentum.
Jet Fire or Flame	The **jet fire/flame** is the combustion of material emerging from an orifice with a significant momentum.
LFL	**Lower Flammable Limit** see Flammable Limits

LOC	See **Loss of Containment**
Local Government	**Local government** is defined in Section 1 of the Local Government Transition Act, 1993 (Act No. 209 of 1993).
Loss of Containment	**Loss of containment** (LOC) is the event resulting in a release of material into the atmosphere.
Major Hazard Installation	**Major Hazard Installation** (MHI) means an installation: • Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; • Where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident (the potential of which will be determined by the risk assessment).
Major Incident	A **major incident** is an occurrence of catastrophic proportions, resulting from the use of plant or machinery or from activities at a workplace. When the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident is catastrophic.
Material Safety Data Sheet	According to ISO-11014, a **material safety data sheet** (MSDS) is a document that contains information on the potential health effects of exposure to chemicals or other potentially dangerous substances and on safe working procedures when handling chemical products. It is an essential starting point for the development of a complete health and safety program. It contains hazard evaluations on the use, storage, handling and emergency procedures related to that material. The MSDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure and what to do if such incidents occur.
MHI	See **Major Hazard Installation**
MIR	**Maximum Individual Risk** (see Individual Risk)
MSDS	See **Material Safety Data Sheet**
OHS Act	**Occupational Health and Safety Act**, 1993 (Act No. 85 of 1993)
PADHI	**PADHI** (**planning advice for developments near hazardous installations**) is the name given to a methodology and software decision support tool developed and used in the HSE. It is used to give land-use planning (LUP) advice on proposed developments near hazardous installations. PADHI uses two inputs into a decision matrix to generate either an 'advise against' or 'don't advise against' response: • The zone in which the development is located of the three zones that HSE sets around the major hazard: ○ The inner zone (> $1x10^{-5}$ fatalities per person per year); ○ The middle zone ($1x10^{-5}$ fatalities per person per year to $1x10^{-6}$ fatalities per person per year); ○ The outer zone ($1x10^{-6}$ fatalities per person per year to $3x10^{-7}$ fatalities per person per year); • The 'sensitivity level' of the proposed development which is derived from an HSE categorisation system of 'development types' (see the 'development type tables' in Appendix E).
QRA	See **Quantitative Risk Assessment**
Quantitative Risk Assessment	The **quantitative risk assessment** is the process of hazard identification, followed by a numerical evaluation of effects of incidents, both consequences and probabilities and their combination into the overall measure of risk.
Risk	**Risk** is the measure of the consequence of a hazard and the frequency at which it is likely to occur. Risk is expressed mathematically as: **Risk = Consequence x Frequency of Occurrence**

Risk Assessment	**Risk assessment** is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a major hazard installation and the measures required to remove, reduce or control the potential causes of such an incident.
Risk Contour	See **Risk Isopleth**
Societal Risk	**Societal risk** is risk posed on a societal group who are exposed to a hazardous activity.
Temporary Installation	A **temporary installation** is an installation that can travel independently between planned points of departure and arrival for the purpose of transporting any substance and which is only deemed to be an installation at the points of departure and arrival, respectively.
UFL	**Upper Flammable Limit** (see Flammable Limits)
Vapour Cloud Explosion	A **vapour cloud explosion** (VCE) results from the ignition of a premixed cloud of a flammable vapour, gas or spray with air, in which flames accelerate to sufficiently high velocities to produce significant overpressure.
VCE	See **Vapour Cloud Explosion**

1 A QUANTITATIVE RISK ASSESSMENT FOR THE PROPOSED VOPAK-REATILE TERMINAL IN RICHARDS BAY, KWAZULU-NATAL

1.1 Introduction

1.1.1 Scope

Vopak South African Development (Pty) Ltd, hereinafter referred to as VSAD, wishes to construct a fuel terminal for the storage and distribution of liquid fuels and liquefied petroleum gas (LPG).

The proposed VSAD terminal would be located within the Transnet Ports Authority (TNPA) area at the Richards Bay harbour and would import product from ships into the bulk storage tanks for redistribution.

Since off-site incidents may result due to the hazards of some of the material to be stored on or transported onto site, RISCOM (PTY) LTD was commissioned to conduct a risk assessment to quantify the extent of the impacts on and risks to the surrounding communities.

1.1.2 Legislation

Risk assessments are conducted when required by law or by companies wishing to determine the risks of the facility for other reasons, such as insurance. In South Africa, risk assessments are carried out under the legislation of two separate acts, each with different requirements. These are discussed in the subsections that follow.

1.1.2.1 National Environmental Management Act (No. 107 of 1998; NEMA) and its regulations

The National Environmental Management Act (No. 107 of 1998; NEMA) contains the principal South African environmental legislation. Its primary objective is to make provision for cooperative governance by establishing principles for decision making on matters related to the environment, on the formation of institutions that will promote cooperative governance and on establishing procedures for coordinating environmental functions exercised by organs of state as well as to provide for matters connected therewith.

Section 30 of the NEMA deals with the control of emergency incidents where an "*incident*" is defined as an "*unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed*".

The act defines "*pollution*" as *"any change in the environment caused by:*

> *(i) Substances;*
> *(ii) Radioactive or other waves; or*
> *(iii) Noise, odours, dust or heat…*
>
> *Emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or wellbeing or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future..."*

"*Serious*" is not fully defined but would be accepted as having long lasting effects that could pose a risk to the environment or to the health of the public that is not immediately reversible.

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This is similar to the definition of a Major Hazard Installation (MHI) as defined in the Occupational Health and Safety Act (OHS Act) 85 of 1993 and its MHI regulations.

Section 28 of the NEMA makes provision for anyone who causes pollution or degradation of the environment to be made responsible for the prevention of the occurrence, continuation or reoccurrence of related impacts and for the costs of repair to the environment. In terms of the provisions under Section 28 that are stated as:

> " *Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped…* "

1.1.2.2 The Occupational Health and Safety Act (No. 85 of 1993; OHS Act)

The Occupational Health and Safety Act (No. 85 of 1993; OHS Act) is primarily intended for the health and safety of the workers, whereas its MHI regulations are intended for the health and safety of the public.

The OHS Act shall not apply in respect of:

> " *a) A mine, a mining area or any works as defined in the Minerals Act, 1991 (Act No. 50 of 1991), except in so far as that Act provides otherwise;*
>
> *b) Any load line ship (including a ship holding a load line exemption certificate), fishing boat, sealing boat and whaling boat as defined in Section 2 (1) of the Merchant Shipping Act, 1951 (Act No. 57 of 1951), or any floating crane, whether or not such ship, boat or crane is in or out of the water within any harbour in the Republic or within the territorial waters thereof, (date of commencement of paragraph (b) to be proclaimed.), or in respect of any person present on or in any such mine, mining area, works, ship, boat or crane.* "

While the OHS Act has made provision for excluding the application of the act on shipping activities, in Clause 78 of the Government Notice 255 Ports Rules of 2009 requires compliance of the OHS Act and its regulations.

> " *78. Occupational health and safety legislation*
>
> *All persons, including service providers, terminal operators, drivers of transport vehicles, employers, lessees and visitors within port limits, must comply with the provisions of any legislation relating to occupational health and safety matters, including the Merchant Shipping Act No. 57 of 1951, the Occupational Health and Safety Act No. 85 of 1993 and its regulations, the Maritime Safety Regulations of 1994, the IMDG Code and the National Road Traffic Act No. 93 of 1996.* "

Major Hazard Installation (MHI) regulations

The Major Hazard Installation (MHI) regulations (2001) published under Section 43 of the Occupational Health and Safety Act (OHS Act) require employers, self-employed persons and users who have on their premises, either permanently or temporarily, a major hazard installation or a quantity of a substance which may pose a **risk** (our emphasis) that could affect the health and safety of workers and the public to conduct a risk assessment in accordance with the legislation. In accordance with legislation, the risk assessment must be done by an approved inspection authority (AIA), which is registered with the Department of Labour and accredited by the South African Accreditation System (SANAS), **prior to construction of the facility**.

Similar to Section 30 of NEMA as it relates to the health and safety of the public, the MHI regulations are applicable to the health and safety of workers and the public in relation to the operation of a facility and specifically in relation to sudden or accidental major incidents involving substances that could pose a risk to the health and safety of workers and the public.

It is important to note that the MHI regulations are applicable to the risks posed and not merely the consequences. This implies that both the consequence and likelihood of an event need to be evaluated, with the classification of an installation being determined on the risk posed to workers and the public.

Notification of the MHI classification is described in the regulations as an advertisement placement and specifies the timing of responses from the advertisement. It should be noted that the regulation does not require public participation.

The regulations, summarised in Appendix C, essentially consists of six parts, namely:

1. The duties for notification of a Major Hazard Installation (existing or proposed), including:
    a. Fixed;
    b. Temporary installations;
2. The minimum requirements for a quantitative risk assessment (QRA);
3. The requirements for an on-site emergency plan;
4. The reporting steps for risk and emergency occurrences;
5. The general duties required of suppliers;
6. The general duties required of local government.

1.1.2.3 Pressure equipment regulations

These regulations apply to the design, manufacture, operation, repair, modification, maintenance, inspection and testing of pressure equipment, with a design pressure equal to or greater than 50 kPa, with a view to health and safety.

1.1.2.4 National Ports Act (No. 12 of 2005)

The National Ports Act (No. 12 of 2005) gives instruction to operations within the TNPA jurisdiction and includes the development of the port, provision of services and the control of operations within the port.

This proposed project clearly falls under the National Ports Act as per the definition of the act where:

> " …'**port terminal**' *means terminal infrastructure, cargo-handling equipment, sheds and other land-based structures used for the loading, storage, transhipment and discharging of cargo or the embarkation and disembarkation of passengers*… "

The National Ports Act states that Transnet is responsible for the land development as well as the health and safety of people within the ports area (see Subsection 1.1.2.2 regarding the applicability of the OHS Act and its MHI regulations).

1.1.2.5 National Building Regulations and Building Standards Act (No. 103 of 1977)

National Building Regulations and Building Standards Act (No. 103 of 1977) governs how buildings should be constructed. The legislation became enforceable as law in September 1985 and two years later was published by the South African Bureau of Standards (SABS) as part of the original Code of Practice for the Application of the National Building Regulations (SABS 0400-1987).

The following referenced documents[1] are indispensable for the application of this document:

- SANS 10087-2 (SABS 087-2), the handling, storage, and distribution of liquefied petroleum gas in domestic, commercial and industrial installations; Part 2, installations in mobile units and small non-permanent buildings;
- SANS 10087-3, the handling, storage, and distribution of liquefied petroleum gas in domestic, commercial and industrial installations; Part 3, liquefied petroleum gas installations involving storage vessels of individual water capacity exceeding 500 ℓ;
- SANS 10087-7, the handling, storage, and distribution of liquefied petroleum gas in domestic, commercial and industrial installations; Part 7, storage and filling premises for refillable liquefied petroleum gas (LPG) containers of gas capacity not exceeding 9 kg and the storage of individual gas containers not exceeding 48 kg;
- SANS 10087-10, the handling, storage, and distribution of liquefied petroleum gas in domestic, commercial and industrial installations; Part 10, mobile filling stations for refillable liquefied petroleum gas (LPG) containers of capacity not exceeding 9 kg;
- SANS 10089-3, the petroleum industry; Part 3, the installation, modification and decommissioning of underground storage tanks, pumps or dispensers and pipework at service stations and consumer installations;
- SANS 10131[2], aboveground storage tanks for petroleum products.

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[1] For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[2] SANS 10131 is a standard for tanks below the volume of 85 m^3. Aboveground storage of petroleum products in bulk is covered in SANS 10089-1.

1.1.3 Study objectives

The risk assessment was completed for the purposes of an environmental impact assessment (EIA), conducted by Golder Associates Africa (Pty) Ltd. For the purposes of the EIA, this risk assessment has the main objective to determine any fatal flaws that would prevent the project from proceeding. This differs from a Major Hazard Installation (MHI) risk assessment, which will determine if the project could be constructed and operate with risks to employees and the public at an acceptable level.

The risk assessment should have a statement from a professional person covering the following questions:

1. Whether the proposed project would likely be considered an MHI;
2. If it is likely to be considered an MHI, whether it would meet the requirements of the MHI regulations and whether the risks could be engineered or managed to meet acceptable risks;
3. Whether there are any factors that will prevent the project from proceeding to the next phase of construction or whether the project could continue under certain conditions or mitigations;
4. Whether there are any special requirements that local authorities need to know when evaluating the proposal.

1.1.3.1 Purpose and main activities of the terminal

The main activity of the proposed VSAD terminal would be the storage and distribution of LPG, petrol, diesel and Avgas as bulk products.

1.1.3.2 Main hazards due to substance and process

The main hazards due to the flammability of the products are thermal radiation from fires and overpressure from explosions.

1.1.4 Approach to the study

As an approved inspection authority (AIA), RISCOM uses the methodologies and criteria described in Appendix D. The quantitative risk assessment (QRA) process is also summarised in that appendix.

It is important to know the difference between hazard and risk. A hazard is anything that has the potential to cause damage to life, the property and the environment. Furthermore, it is a constant parameter (such as that of petrol, chlorine, ammonia, etc.) that poses the same hazard whenever present. Risk, on the other hand, is the probability that a hazard will actually cause damage and how severe that damage will be. Risk is therefore the probability that a hazard will manifest itself. For instance, the risk presented by a chemical depends upon the amount present, the process it is used in, the design and safety features of its container, prevailing environmental and weather conditions, the exposures and so on.

1.2 Terms of reference

The main aim of the investigation was to quantify the risks to employees and neighbours with regard to the proposed VSAD terminal in Richards Bay.

This risk assessment was conducted with the following terms of reference:

1. The development of accidental spill and fire scenarios for the storage facility;
2. Using generic failure rate data (tanks, pumps, valves, flanges, pipework, gantry, couplings, etc.), the determination of the probability of each accident scenario;
3. For each incident developed in Step 2, the determination of the consequences (thermal radiation, domino effect, toxic cloud formation, etc.);
4. The calculation of maximum individual risk (MIR) values taking into account all accidents, meteorological conditions and lethality.

This risk assessment is for the use of the EIA and is not intended to replace a Major Hazard Installation risk assessment. Furthermore, the assessment covers only acute events and sudden ruptures and not chronic and on-going releases, such as fugitive emissions. It is not intended to be an environmental risk assessment and may not meet specific the requirements of environmental legislation.

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1.3 Baseline environment

1.3.1 General background

The proposed VSAD terminal is to be located within the TNPA area in the Richards Bay harbour on Lot 4 and Lot 5, having areas of 77 ha and 78 ha, respectively, as shown in Figure 1. The current rail infrastructure used by the coal terminal is routed around the plots. The sites are situated less than a kilometre from the current jetties at the port. Ships would dock at Berth 208 or Berth 209.

Figure 1: Location of the proposed VSAD terminal at Richards Bay

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1.3.2 Meteorology

Meteorological mechanisms govern the dispersion, transformation and eventual removal of hazardous vapours from the atmosphere. The extent to which hazardous vapours will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises of vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface, i.e. the mixing layer, define the vertical component. The horizontal dispersion of hazardous vapours in the boundary layer is primarily a function of wind field. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume stretching. Similarly, the generation of mechanical turbulence is a function of the wind speed in combination with surface roughness. Wind direction and variability in wind direction both determine the general path hazardous vapours will follow and the extent of crosswind spreading. Concentration levels of hazardous vapours therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth and to shifts in the wind field.

Meteorological data was analysed to characterise the atmospheric dispersion potential for the Richards Bay area. Meteorological parameters that were taken into account included hourly wind speed as well as direction and were supplied by the South African Weather Service as measured at the Richards Bay airport for the period from the 1st of January 2009 to the 31st of December 2013.

The long-term rainfall, humidity and temperature used a 30 year average for Richards Bay, as measured by the South African Weather Service.

1.3.2.1 Surface winds

The predominant winds blow from the north and southwest quadrants, with calm conditions occurring up to 6% of the time. Low wind speeds are predominant, with wind speeds of more than 8.7 m/s occurring about 1.4% of the time.

Although wind shifts between the northeasterly and southwesterly sectors occur all the months of the year, the frequency with which such wind shifts occur varies seasonally as a function of synoptic climatology. During the summer months, wind from the northeasterly sector becomes more frequent, as shown in Figure 2.

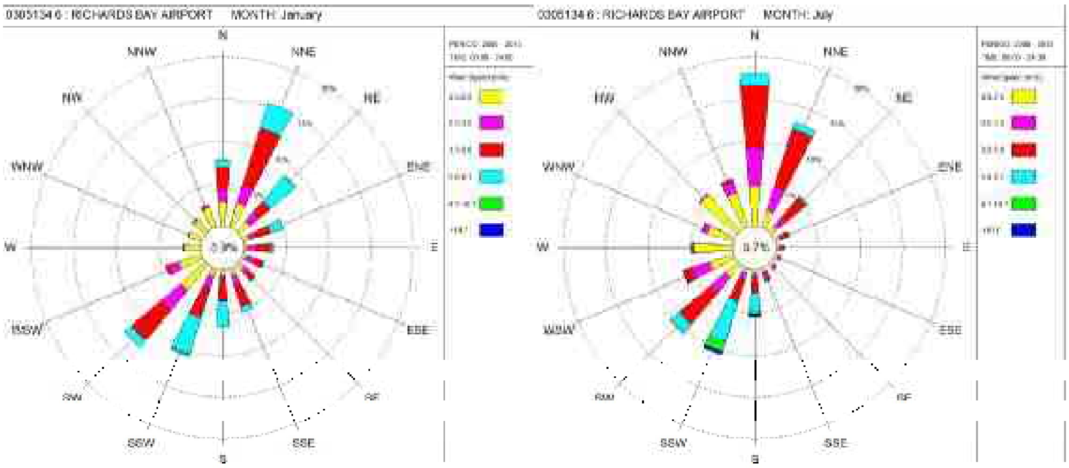

Figure 2: Wind analysis for winter and summer variations

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1.3.2.2 Precipitation and relative humidity

Relative humidity, the amount of water that is contained in the atmosphere, influences the extent of fires and toxic clouds. The warmer the air, the more moisture it can hold. Should the relative humidity reach 100%, precipitation occurs. The long-term average precipitation and humidity supplied by the South African Weather Service is given in Table 1, indicating an average annual relative humidity in excess of 50%.

Table 1: Long-term average precipitation and relative humidity for Richards Bay

Month	Average Precipitation (mm)	Relative Humidity at 14H00 (%)	Relative Humidity at 20H00 (%)
January	172	70	79
February	167	71	79
March	107	71	78
April	109	71	81
May	109	63	79
June	57	61	72
July	60	59	74
August	65	59	74
Sept	77	66	73
October	105	67	79
November	114	70	80
December	86	69	79
Year	**1228**	**67**	**79**

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1.3.2.3 Temperature

Air temperature is important for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), for estimating evaporation rates and for determining the development of the mixing and inversion layers.

The long-term average temperatures supplied by the South African Weather Service are given in Table 2. Extreme temperatures frequently occur due to *berg wind* conditions, during which temperatures over 40°C are reported for all months of the year.

Table 2: Long-term temperature averages for Richards Bay

Month	**Average Maximum (°C)**	**Average Minimum (°C)**	**Mean Average (°C)**
January	29.2	21.2	25.2
February	28.9	21.2	25
March	28.9	20.4	24.6
April	27	18.1	22.5
May	24.8	15.2	20
June	23.1	12.3	17.7
July	23	12.3	17.6
August	24	14.1	19
September	24.9	16	20.3
October	25.4	17.3	21.3
November	26.7	18.6	22.7
December	28.7	20.4	24.5
Year	**26.2**	**17.3**	**21.7**

1.3.2.4 Atmospheric stability

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 3. The atmospheric stability, in combination with the wind speed, is important in determining the extent of a particular hazardous vapour from a release. A very stable atmospheric condition, typically at night, would have low wind speeds and produce the greatest endpoint for a dense gas. Conversely, a buoyant gas would have the greatest endpoint distance due to high wind speeds.

Table 3: Classification scheme for atmospheric stability

Stability Class	**Stability Classification**	**Description**
A	Very unstable	Calm wind, clear skies, hot daytime conditions
B	Moderately unstable	Clear skies and daytime conditions
C	Unstable	Moderate wind, slightly overcast daytime conditions
D	Neutral	Strong winds or cloudy days and nights
E	Stable	Moderate wind, slightly overcast night-time conditions
F	Very stable	Low winds, clear skies, cold night-time conditions

Figure 3 depicts the atmospheric stability distribution for each wind direction as calculated from the hourly weather measurements recorded at the Richards Bay airport for the period from the 1st of January 2009 to the 31st of December 2013.

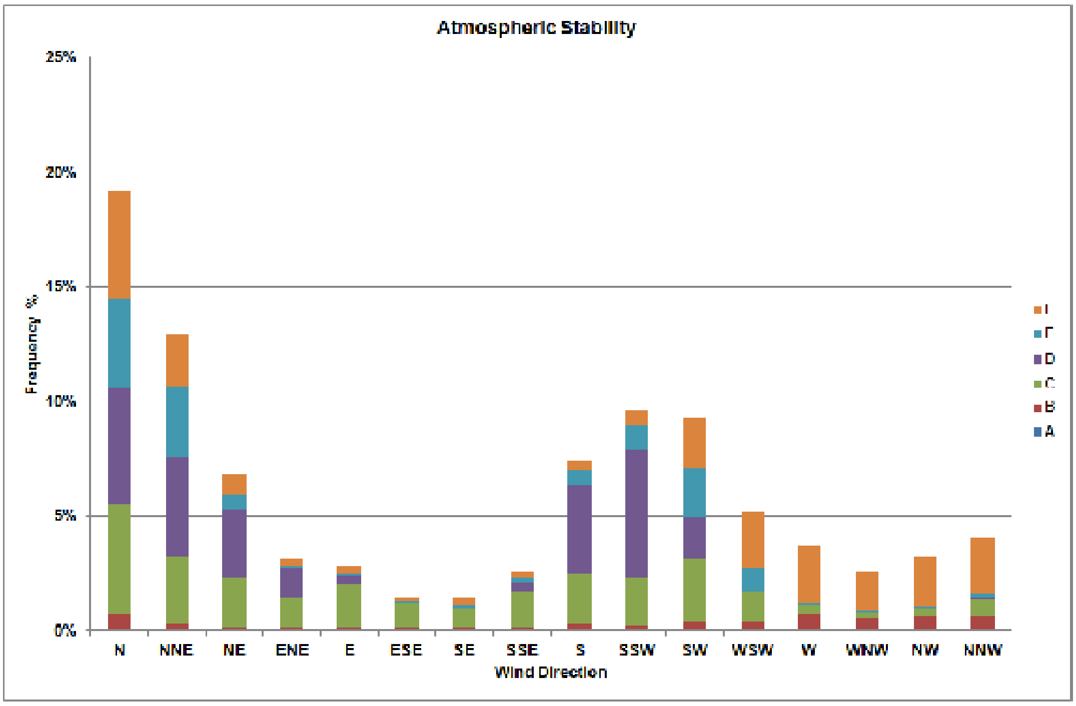

Figure 3: Atmospheric stability as a function of wind direction in Richards Bay

This risk assessment's calculations are based on six representative weather classes covering the stability conditions of stable, neutral and unstable as well as low and high wind speeds. In terms of Pasquill classes, the representative conditions are given in Table 4.

Table 4: Representative weather classes

Stability Class	Wind (m/s)
B	3
D	1.5
D	5
D	9
E	5
F	1.5

The allocation of observations into the six weather classes is summarised in Table 5, with the representative weather classes for Richards Bay given in Figure 4.

Table 5: Allocation of observations into six weather classes

<table>
<tr><th>Wind Speed</th><th>A</th><th>B</th><th>B/C</th><th>C</th><th>C/D</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>< 2.5 m/s</td><td colspan="3" rowspan="3">B 3 m/s</td><td colspan="3">D 1.5 m/s</td><td colspan="2">F 1.5 m/s</td></tr>
<tr><td>2.5 - 6 m/s</td><td colspan="3">D 5 m/s</td><td colspan="2" rowspan="2">E 5 m/s</td></tr>
<tr><td>> 6 m/s</td><td colspan="3">D 9 m/s</td></tr>
</table>

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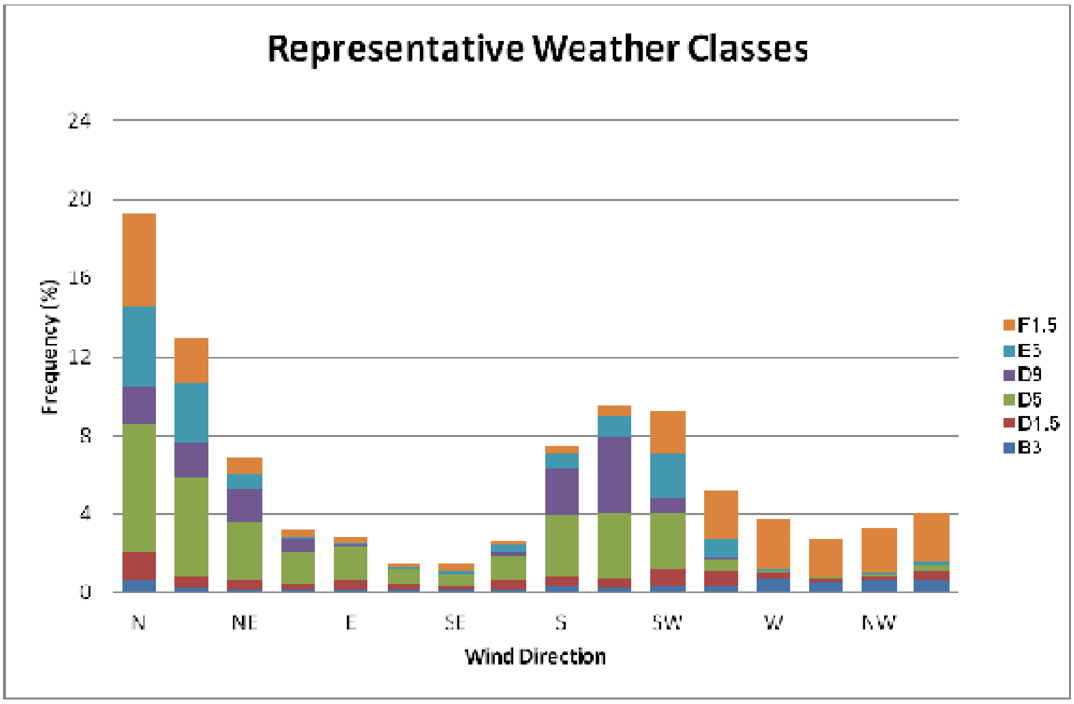


Figure 4: **Representative weather classes for Richards Bay (2007-2011)**

1.3.2.5 Meteorological simulation values

The default meteorological values used in the simulations, based on local conditions, are given in Table 6.

Table 6: **The meteorological values used in the simulation, based on local conditions**

Parameter	Default Value Daytime	Default Value Night-time
Ambient temperature (°C)	26	17
Substrate/bund temperature (°C)	22	22
Water temperature (°C)	22	22
Air pressure (bar)	1.013	1.013
Humidity (%)	67	78
Fraction of a 24-hour period	0.5	0.5
Mixing height	[1]	[1]

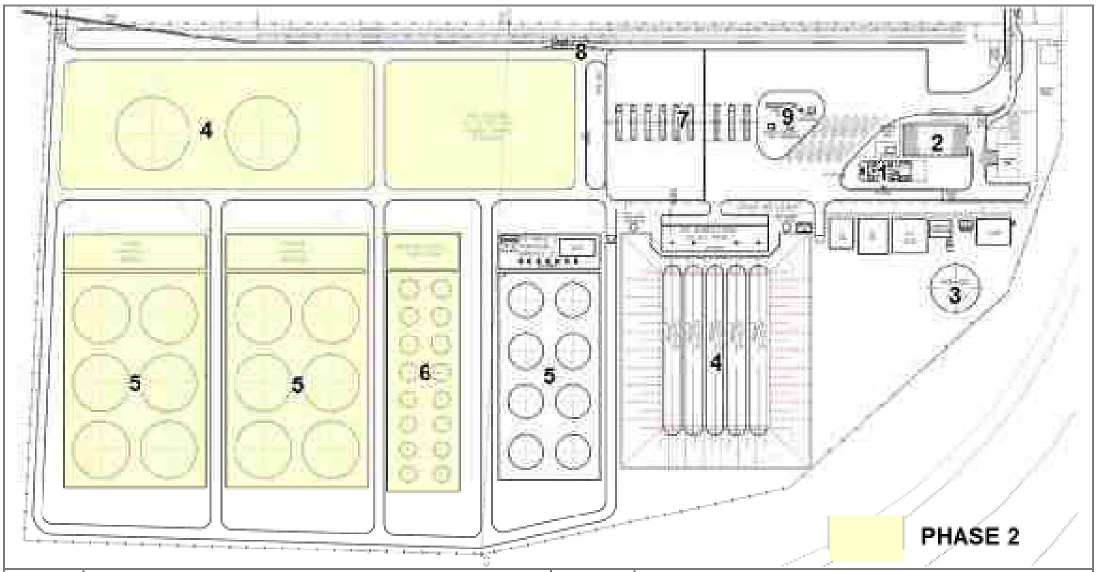
---

[1] The default values for the mixing height, which are included in the model, are 1500 m for weather category B3, 300 m for weather category D1.5, 500 m for weather category D5 and D9, 230 m for weather category E5 and 50 m for weather category F1.5.

1.3.3 Project description

As described in the following subsections the key components of the project include the construction of a tank farm and transport pipelines as well as the installation of infrastructure at the terminal. The overall project includes importation of bulk liquid fuels and LPG from ships in the Richards Bay harbour. The material to be stored in the bulk storage vessels would be dispatched via road or rail to customers.

The proposed VSAD terminal in Richards Bay would consist of offices, bulk fuel, LPG and chemical storage, road and rail gantries, a laboratory and a fire water tank, as shown Figure 5.



No.	Description	No.	Description
1	Offices	**2**	Truck resting area
3	Fire water	**4**	LPG storage
5	Fuel storage	**6**	Chemical storage
7	Road gantry	**8**	Rail gantry
9	Stenching tank		

Figure 5: Conceptual layout of the VSAD terminal in Richards Bay

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1.3.3.1 Transport pipelines from berthed ship to terminal

Ships would dock at Berth 208 or Berth 209 and product would be loaded or offloaded. Shipping operations would be carried out continuously over a 24 hour period seven days per week until the intended parcel is offloaded or loaded.

The expected batch size of the shipping operations is 40 000 m^3 for petrol and diesel and 15 000 m^3 for Avgas at a pumping rate of between 800-1200 m^3/hr.

The LPG ship would be expected to offload a parcel of 26 000 m^3 in 28 hours at a pumping rate of 930 m^3/h and a maximum flow rate of 7 m/s. The flanges on the pipelines would be rated at 300, which could experience a maximum pressure of 51 bar.

Pipelines would be installed for the initial transfer of bulk liquids and LPG from Berth 208 and Berth 209 to the tank farm and vice versa. Figure 6 illustrates the pipeline routing that has been proposed to run from the berths to the VSAD terminal.

The pipelines would run aboveground and would consist of the following dedicated lines for Phase 1 of the project:

- 1 x 16" carbon steel line for Avgas;
- 1 x 16" carbon steel line for diesel;
- 1 x 16" carbon steel line for petrol;
- 1 x 10" shipping line (LPG liquid);
- 1 x 10" shipping line (LPG vapour).

The number of additional pipelines for Phase 2 is still to be confirmed.

Figure 6: Proposed routing of the pipelines from the berths to the tank farm

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1.3.3.2 Bulk atmospheric fuel storage

The bulk atmospheric fuel storage would provide storage for clean petroleum products (CPP), hydrocarbon products such as petrol, diesel and Avgas. General chemicals would also be stored in a separate bunded area. The terminal in Richards Bay would be developed in two phases. Phase 1 would consist of 8 x 5000 m^3 CPP atmospheric storage vessels. Phase 2 of the project has not been confirmed but could consist of an additional 12 x 10 000 $m^3$of CPP atmospheric storage vessels and 16 x 1500 m^3 of chemical storage vessels.

Phase 1 and Phase 2 would include new tanks, manifolds, a vapour recovery unit, road and rail loading gantries and pipelines. Phase 1 would include the initial tanks, all the utilities (designed for both Phase 1 and Phase 2), offices, storage, shipping pipelines, rail siding and other infrastructure. Phase 2 may include additional rail loading bays. Since this is a new plot, during the engineering segment it would be ensured that enough space is kept for additional pipe racks and extensions to structures as well as changes in operation, automation and maintenance philosophies.-

The bulk liquid tanks would be classified as vertical tanks and would be constructed according to SANS 10089, the American Petroleum Institute standard API 650 and the tank design manual (the Vopak standard); all which pertain to the construction of atmospheric steel tanks.

The storage tanks that would contain products that wouldn't be considered volatile, such as diesel, would be fitted with fixed roofs. However, the storage tanks that would contain volatile products, such as petrol and Avgas, would be fitted with f internal floating roofs to reduce vapour loss. An internal floating roof system consists of a roof that floats on the surface of the product stored within the tanks, together with a seal around the rim. The floating roof would reposition according to the level of the stored product to reduce the potential of a vapour zone occurring above the product.

A tank gauging system would be provided for managing tank inventory for each client as well as overfill protection. The level transmitters on the tanks would provide high and high-high level alarms on the distributed control system (DCS). Separate independent high level switches would trip the emergency shut-off valves in order to stop transfer to the product tanks (hardwired trips).

Walls around the tanks, called bunds (or tank pits), are intended to retain any accidental spillages. The bunding in the proposed tank farm has been designed to comply with or exceed the requirements of the most recent SANS specifications (particularly SANS 10089) to minimize any risk associated with product spills into the environment. It is anticipated that the bund walls would be composed of reinforced concrete. The bund wall capacity is expected to be able to retain 110% of the largest tank capacity within the main bund area but not to exceed 1.8 m in height.

The proposed safety features as engineering controls and protective measures are summarised as follows:

- Proposed engineering design features to reduce risks would be as follows:
  - All petrol and Avgas tanks would be fitted with internal floating roofs;
  - Tanks are to be designed according to API 650 and SANS 10089;
  - All tanks would be earthed;
  - All instrumentation would be specified in accordance with the hazardous area classification as per SANS 10108;
  - Overfill protection would consist of two independent level indicators, with alarm indication at high level and an independent high level switch that would close the incoming valve;
  - Secondary containment around the storage tanks would be provided with a volume of 110% of the largest tank as containment;
- Proposed protective measures to reduce the risks would be as follows:
  - The tank storage area would be protected by fire-fighting systems, consisting of tank pourers and bund foam pourers;
  - The loading bay would be fully protected with a water-deluge system;
  - The filling operation would prevent loading if the vehicle is not earthed.

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1.3.3.3 Bulk LPG storage

The Richards Bay terminal is a Greenfield project and would be developed in two phases. Phase 1 would include 5 x 7882 m^3 mounded LPG pressurised storage vessels, and the future Phase 2 would include 2 x 34 000 m^3 refrigerated aboveground storage vessels (spheres). This would give a total storage capacity of up to 107 410 m³. In Phase 1 the tanks would be pressurised and mounded, thereby preventing the formation of a BLEVE.

In Phase 2 two new tanks would be built, with an additional storage volume of up to 67 000 m³. These tanks would have the relevant accessories and would be refrigerated below the boiling point of the stored gases to prevent excess pressure build up.

The refrigerant of the chiller unit is proposed to be nontoxic and nonflammable.

The liquid fill line from the ship into the tanks would be via a spray header to reduce the pressure of the LPG vapour in the tank, to optimize transfer rates throughout the discharge and to prevent accidental flow back from the storage tank to the berths.

A tank gauging system would be provided for managing the tank inventory of each tank as well as overfill protection. The level transmitters on the tanks would provide high and high-high level alarms on the distributed control system (DCS). Separate independent high level switches would trip the emergency shut-off valves in order to stop transfer to the product tanks. These would be hardwired trips. The weighbridges and tank gauging would be approved for stock control.

The proposed safety features as engineering controls and protective measures are summarised as follows:

- Proposed engineering design features to reduce risks would be as follows:
  - Tanks are to be designed to API 2510 and SANS 10087;
  - All tanks would be earthed;
  - All instrumentation would be specified in accordance with the hazardous area classification as per SANS 10108;
  - Overfill protection would consist of two independent level indicators, with alarm indication at high level and an independent high level switch that would close the incoming valve;
  - Secondary containment around the storage tanks would be provided with a volume of 110% of the largest tank as containment;
  - Loading of LPG would be done with a fully-automated system and a number of permissives to prevent overfilling and to ensure safe loading;
  - Loading of LPG would be done using loading arms with breakaway couplings;
  - Emergency shutdown (ESD) would be provided that would automatically shut systems down in the event of an emergency and would be independent of the control systems;
  - Overfill protection would be provided:
    - If all overfill protection systems fail, the pressure safety valve (PSV; as a last line of defence) would relieve to a safe area;
- Proposed protective measures to reduce the risks would be as follows:
  - Tanks would be pressurised and mounded, thereby preventing the formation of a BLEVE;
  - Fire-fighting systems would be provided.

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1.3.3.4 Road gantries

The loading gantry for liquid fuel and chemical road tankers would initially contain up to three loading bays in Phase 1, which could be expanded to hold up to two additional loading bays at a later stage. The gantry would serve as a transfer area for bulk liquids (CPP fuels and chemicals) from the storage tanks to the road tankers.

There are would be various combinations and sizes of trucks for CPP products. Either a single truck would be loaded or one with a trailer or pup (an additional type of trailer compartment to increase load volume). All trucks would have bottom loading ‘scully-type’ connections. This type of connection would allow filling only if all permissives were in place, such as earthing, and would form part of the batching control and shut down.

The loading of the CPP road tankers would operate 24 hours per day and seven days per week. These road tankers are expected to have a maximum capacity of 40 m^3 and would be loaded at 125 m^3/h.

The road gantries would be fully automated for loading petrol and diesel. The petrol and diesel would be pumped from the manifold area to the road loading bays via dedicated product headers. Each loading bay would be equipped with a positive displacement flow metre; no weighbridges would be required at the loading bays. A vapour recovery unit would be installed to recover the vapours from the loading of petrol at the road loading bays.

The area of the loading gantry for road tankers may be fitted with spill control slabs as a contingency measure to ensure that any spillage is contained. Each loading bay would contain a central drain to collect the spills that would lead to a separator. Should any of the spilt material ignite; it would initially be contained at the oil separator.

The loading gantry would be covered with a fixed canopy to provide protection against the weather elements, thereby minimizing the volume of storm water entering the oily water drainage system. The gantry would also be equipped with mezzanine floors in order to store the gantry equipment and provide access to the top of the vehicles. Fall protection measures would be implemented to ensure the safety of all personnel during all phases of the project lifecycle.

Only one entrance would be allowed for LPG truck movement. For safety reasons a second gate would be present on the plot as an emergency exit only. Parking space for six LPG tankers would be provided on site with up to two tankers per loading bay.

The loading of the LPG road tankers would be fully automated and would operate 16 hours per day and seven days per week. The LPG road tankers are expected to have a maximum capacity of 50 m^3 and would be loaded at 80 m^3/h. The weighbridges and tank gauging would be approved for stock control.

1.3.3.5 Rail gantries

The rail gantry for loading liquid fuel and chemicals would consist of about 30 loading points that would be installed during Phase 1. Additional loading points could be installed during Phase 2.

The rail gantry would consist of fully automated batch filling for diesel and petrol, with a vapour recovery system. Petrol and diesel would be pumped from the manifold area to the rail loading bays via the dedicated product headers. Each loading bay would be equipped with a positive displacement flow metre; no weighbridges would be required at the loading bays.

The rail gantry for loading liquid fuel and chemicals would operate 24 hours per day and 7 days per week. The expected rail tanker capacity would be 74 m^3.

The loading of the LPG rail tankers would be fully automated and would operate 24 hours per day and 7 days per week. The LPG rail tankers would range in size from 19 t to 36 t (with an average capacity of 56 m^3) and would be loaded at 80 m^3/h. Weighbridges and tank gauging would be approved for stock control.

Phase 1 would include two LPG rail loading bays. In a later phase an additional two bays would be designed to handle peak demand and enable block train loading of up to 36 rail cars per day and about 1000 t per day.

1.3.3.6 Odourisation

Ethyl mercaptan would be used to stench the LPG. The odorant specification in the final batch product would be 15 µL/L (SANS 1774 2007). One 90 m^3 LPG tank would be provided for stenched gases.

1.3.3.7 Utility systems

Nitrogen

Nitrogen would be required for instrument air. The nitrogen inventory has not been specified, and it is assumed that nitrogen would be generated on site with minimal inventory.

Plant water (potable and fire)

Potable water would be supplied by the TNPA, but the actual location of the battery limit or tie-in will be determined later. As there is no separate source of industry water supplied by the TNPA, potable water will be used as process water.

Potable water would be used as process water, as sanitary water and in the offices. Process water would be used for:

- Fire water tank filling;
- Cleaning and rinsing of pipes and tanks;
- Use at the tank pits, pump rooms, manifolds and loading areas (utility stations);
- Tank hydrostatic tests;
- Eye wash and safety showers;
- Use in the laboratory.

A water buffer tank would be installed for potable water supply before distribution to utility hose stations or the laboratory and after distribution to the offices and sanitary facilities. A distribution system for process water is foreseen. Water pipes would be shaded or insulated to prevent solar heating of water in the pipe.

Electricity supply

The electricity network would be connected to the local electricity supply network. The requirements for a stand-by generator are subject to an electricity supply and equipment failure risk assessment.

All rail unloading pumps would have a backup using a programmable logic controller (PLC) system where at least one pump per product can be selected for operation.

1.3.3.8 Summary of proposed inventories

The summary of bulk materials to be stored on site is given for each phase:

- Phase 1:
    - 8 x 5000 m^3 petrol, diesel and Avgas atmospheric storage vessels;
    - 5 x 7882 m^3 mounded LPG pressurised storage vessels;
- Phase 2:
    - 16 x 1500 m^3 chemical storage vessels;
    - 12 x 10 000 m^3 petrol, diesel and Avgas atmospheric storage vessels;
    - 2 x 34 000 m^3 refrigerated aboveground LPG storage vessels.

1.3.4 Hazard identification

1.3.4.1 Notifiable substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances requires any employer who has a substance equal to or exceeding the quantity as listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Petrol, diesel, Avgas and nitrogen are not listed as notifiable products.

As more than 25 t of LPG would be stored in a single vessel in both Phase 1 and Phase 2, LPG would then be classified as a notifiable substance and automatically the facility **would be classified as a Major Hazard Installation**.

1.3.4.2 Substances hazards

All components on site were assessed for potential hazards according to the criteria discussed in this subsection.

Chemical properties

A short description of bulk hazardous components to be stored on or transported onto site is given in the following subsections. The material safety data sheets (MSDSs) of the respective materials are attached in Appendix J.

Liquid petroleum gas (LPG)

LPG primarily consists of propane with minor impurities such as butane. It is a colourless gas at room temperature with an odour of commercial natural gas. It has a low boiling point of -41.9°C and is often compressed and transported and sold as a liquid, primarily as a fuel.

Propane is a severe fire and explosion hazard with an invisible vapour that spreads easily and can be set on fire by many sources such as pilot lights, welding equipment, electrical motors, switches, etc. It is heavier than air and can travel along ground for some distance to an ignition source.

It is not compatible with strong oxidants and can react with these, resulting in fires and explosions.

It is not considered a carcinogenic material. The toxicology and the physical and chemical properties suggest that overexposure is unlikely to aggravate existing medical conditions.

Overexposure to propane may cause dizziness and drowsiness. Effects of a single (acute) overexposure may result in asphyxiation, due to lack of oxygen, which could be fatal. Self-contained breathing apparatus may be required by rescue workers. Moderate concentrations may cause headaches, drowsiness, dizziness, excitation, excess salivation, vomiting and unconsciousness. Vapour contact with the skin will not cause any harm. However, contact with the liquid may cause frostbite due to the low temperature of liquid propane.

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Petrol (gasoline)

Petrol is a hydrocarbon mixture with variable composition with a boiling point range of between 20°C and 215°C. It is a pale yellow liquid with strong petroleum odour. Due to the flash point at minus 40°C, this material is considered highly flammable and will readily ignite under suitable conditions. The vapours are heavier than air and may travel some distance to an ignition source.

Petrol may contain up to 5% volume of benzene, a known animal carcinogen. It may also contain ethers and alcohols, as oxygenates, to a maximum concentration of 2%. It may also contain small quantities of multifunctional additives to enhance performance.

It is stable under normal conditions. It will react with strong oxidising agents and nitrate compounds, which may cause fires and explosions.

Although it is of a low to moderate oral toxicity to adults, ingestion of small quantities may prove dangerous or fatal to small children. Contact with the vapours may result in slight irritation to nose, eyes and skin. Vapours may cause headache, dizziness, loss of consciousness or suffocation as well as lung irritation, with coughing, gagging, dyspnoea, substernal distress and rapidly developing pulmonary oedema. If swallowed, it may cause nausea or vomiting, swelling of the abdomen, headache, CNS depression, coma and death.

The long-term effects of Avgas exposure have not been determined. However, it may affect lungs and may cause the skin to dry out and become cracked.

It floats on water and can result in environmental hazards with large spills into waterways. It is harmful to aquatic life in high concentrations.

Avgas

Avgas is aviation fuel that consists mostly of gasoline (petrol). It is a hydrocarbon mixture with variable composition and with a boiling point range of between 35°C and 170°C. It is a pale yellow liquid with a strong petroleum odour. Due to the flashpoint of -40°C, this material is considered highly flammable and will readily ignite under suitable conditions. The vapours of petrol are heavier than air and may travel some distance to an ignition source.

Avgas may contain benzene up to 5% of its volume, a known animal carcinogen. It may also contain ethers and alcohols as oxygenates to a maximum concentration of 2% and small quantities of lead to enhance performance.

It is stable under normal conditions. It will react with strong oxidising agents and nitrate compounds, which reaction may cause fires and explosions.

Although it is of a low to moderate oral toxicity to adults, ingestion of small quantities may prove dangerous or fatal to small children. Contact with the vapours may result in slight irritation to nose, eyes and skin. Vapours may cause headache, dizziness, loss of consciousness or suffocation as well as lung irritation, with coughing, gagging, dyspnoea, substernal distress and rapidly developing pulmonary oedema. If swallowed, it may cause nausea or vomiting, swelling of the abdomen, headache, CNS depression, coma and death.

The long-term effects of Avgas exposure have not been determined. However, it may affect lungs and may cause the skin to dry out and become cracked.

It floats on water and can result in environmental hazards with large spills into waterways. It is harmful to aquatic life in high concentrations.

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Diesel

Diesel is a hydrocarbon mixture with variable composition with a boiling-point range of between 252°C and 371°C. It is a pale yellow liquid with a petroleum odour. Due to a flashpoint between 38°C and 65°C, this material is not considered highly flammable but will readily ignite under suitable conditions.

It is stable under normal conditions. It will react with strong oxidising agents and nitrate compounds. This reaction may cause fires and explosions.

Diesel is not considered a toxic material. Contact with vapours may result in slight irritation to nose, eyes and skin. Vapours may cause headache, dizziness, loss of consciousness or suffocation as well as lung irritation with coughing, gagging, dyspnoea, substernal distress and rapidly developing pulmonary oedema.

If swallowed, it may cause nausea or vomiting, swelling of the abdomen, headache, CNS depression, coma and death.

The long-term effects of exposure have not been determined. However, this may affect the lungs and may cause the skin to dry out and become cracked.

Diesel floats on water and can result in environmental hazards with large spills into waterways. It is harmful to aquatic life in high concentrations.

Nitrogen

Nitrogen is a colourless, odourless gas that is non-flammable and can be considered inert since it does not readily react with other components.

It has a molecular weight of 28 and has a similar density to air. It could accumulate in confined areas and low points displacing oxygen, which may result in asphyxiation. Typical oxygen deficiencies effects are given in Table 7.

Table 7: Exposure to oxygen-deficient atmosphere

Oxygen Content of Air	Signs and Symptoms of Persons at Rest
15%–19.5%	Decreased ability to work strenuously May impair coordination and may induce symptoms in persons with coronary, pulmonary or circulatory problems
12%–15%	Respiration deepens, increased pulse rate and impaired coordination, perception and judgment
10%–12%	Further increase in rate and depth of respiration, further increase in pulse rate, performance failure, giddiness, poor judgment and blue lips
8%–10%	Mental failure, nausea, vomiting, fainting, unconsciousness, ashen face and blue lips
6%–8%	Eight minutes may be fatal in 50-100% of exposures; six minutes may be fatal in 25-50% of exposures; and, after four to five minutes there may be recovery with treatment
4%–6%	Coma in 40 seconds; convulsions, respiration ceases and death

Nitrogen is normally stored as a liquid at low temperatures and elevated pressures. Exposure to liquid nitrogen can cause frostbite.

It can only be absorbed into the body by inhalation with resultant asphyxiation risks.

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Corrosive liquids

Corrosive liquids considered under this subsection are those components that have a low or high pH and that may cause burns if they come into contact with people or may attack and cause failure of equipment.

No materials to be stored on or transported onto site are considered highly corrosive.

Reactive components

Reactive components are components that when mixed or exposed to one another react in a way that may cause a fire, explosion or release a toxic component.

All components to be stored on or transported onto site are considered thermally stable in atmospheric conditions. The reaction with air is covered under the subsection dealing with ignition probabilities.

Flammable and combustible components

Flammable and combustible components are those that can ignite and give a number of possible hazardous effects, depending on the nature of the component and conditions. These effects may include pool fires, jet fires and flash fires as well as explosions and fireballs.

The flammable and combustible components to be stored on or transported onto site are listed in Table 8. These components have been analysed for fire and explosion risks.

Table 8: Flammable and combustible components to be stored on or transported onto site

Compound	Flashpoint (°C)	Boiling Point (°C)
LPG	-103.7	-42
Petrol	-40	87
Avgas	-40	35–170
Diesel	> 55	290

Toxic and asphyxiant components

Toxic or asphyxiant components of interest to this study are those that could produce dispersing vapour clouds upon release into the atmosphere. These could subsequently cause harm through inhalation or absorption through the skin. Typically, the hazard posed by toxic or asphyxiant components will depend on both concentration of the material in the air and the exposure duration.

Nitrogen is not considered toxic but will act as an asphyxiant by replacing oxygen. However the inventory is unknown and possibly would be generated on site without storage.

1.3.4.3 Physical properties

For this study the petroleum substances to be stored on site were modelled as the pure components given in Table 9. The physical properties used in the simulations were based on the DIPPR[1] data base and are summarised in Appendix E.

Table 9: Representative components

Substance	**Modelled as**
Petrol	Heptane
Avgas	Heptane
Diesel	Dodecane

1.3.4.4 Components excluded from the study

Components excluded from the study are listed in Table 10.

Table 10: Components excluded from the study

Component	**Inventory**	**Reasons for Exclusion**
Nitrogen	Unknown	Unknown inventory

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[1] Design Institute for Physical PRoperties

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1.3.4.5 Historical major incidents at refineries and storage facilities

Some historical incidents at refineries should be reviewed in an attempt to identify the root cause of such incidents to prevent occurrences at the proposed VSAD terminal in Richards Bay.

Durban (2007)

On the evening of the 19th of November 2007, lightning struck gasoline storage tanks at the Engen refinery in Durban, South Africa. The fire did not result in fatalities but resulted in extensive damage to the storage tanks and part of the refinery.

The tank-top fire, as shown in Figure 7, did not cause the complete failure of the tank, which would have resulted in the fire spreading into the bunded area with possible knock-on effects.

Figure 7: Tank-top fire at the Engen refinery caused by lightning

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Buncefield (2005)

In the early hours of Sunday, on the 11th of December 2005, a number of explosions occurred at Buncefield storage depot in Hemel Hempstead, the United Kingdom. At least one of the initial explosions was of massive proportions and there was a large fire that engulfed most of the site. Over 40 people were injured; fortunately there were no fatalities. Significant damage occurred to both commercial and residential properties in the vicinity and a large area around the site was evacuated on emergency service advice. The fire burned for several days, destroying most of the site and emitted large clouds of black smoke into the atmosphere.

The damage caused by the Buncefield incident extended further than expected and has put into question the distance and safety of petroleum storage terminals (see Figure 8).

The cause of the explosions and fires was attributed to an overfilling of a petrol tank followed by an ignition. The full mechanism of the incident including the source of ignition is not fully understood although the HSE (UK) has published an investigation.

Lessons learnt and proposed mitigation to prevent a recurrence of a similar tank farm fire have been prepared and published by the HSE (UK), as shown in Appendix F.

Buncefield fire

Explosion damage

Figure 8: The Buncefield incident

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1.4 Impact assessment

Assessment was done of each processing unit by firstly selecting the scenario and completing outflow and consequence modelling. Consequences with possible impacts beyond the site boundary were retained for the risk analysis of the unit. Finally, the risk of the entire facility is determined as a combination of the risk calculated for each unit.

The Major Hazard Installation regulations describe what must be included in a risk assessment but do not provide methodology to determine risks nor criteria of analysis of the risks posed. In the absence of South African legislation, this study used the approach legislated in the Netherlands that would be compliant with Section 24, Section 36 and Section 39 of the South African constitution.

Selection of release scenarios for the study was based on the aforementioned Dutch legislation. The consequences or impacts were evaluated using six representative weather classes each with certain wind speed and stability conditions; two weather classes represented conditions during the day, two both during the day and the night and two only during the night. The furthest distance to the 1% fatality for each impact scenario would be retained for risk analysis.

If the distance to the 1% fatality extended beyond the site boundary so that both workers and the public could be involved in a major incident, then there would be a possibility of the facility being classified as a Major Hazard Installation and a risk assessment would be required to determine this.

The methodology used in this study is fully described in Appendix D.

1.4.1 Transport pipelines from berthed ship to terminal

1.4.1.1 Purpose of the processing unit

Transport pipelines would be used to carry CPP products and LPG to and from the terminal to and from the berths.

1.4.1.2 Hazard identification

Flammable or combustible components to be stored, transported or processed

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic.

The pipelines, other than those for LPG, would transport a variety of products. LPG would have a dedicated pipeline. Of all the CPP products, petrol has the lowest flashpoint, and therefore it was used for the modelling as the worst case. The modelling assumed a pipeline operating pressure of 10 barg with a maximum flow of 1000 m^3/h for LPG and 1200 m^3/h for CPP products. No correction was made for pressure losses along the pipeline or potential increase in flow due to rupture along the line. It is also assumed that design would prevent any backflow from the storage vessels. The maximum outflow from the pipeline was assumed to be determined by the ships pumps.

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1.4.1.3 Consequence modelling

Pool fires

A failure of a transport pipeline would form a pool that would spread until it could spread no more, or until it was contained by natural barriers. The maximum area of a spill is assumed to be 3000 m^2 (RIVM 2009). A full-bore rupture as well as a leak from a hole of 50 mm would both produce a flammable pool limited to 3000 m^2.

Figure 9 shows the extent of a pool fire, at a single point, from a loss of containment of petrol from the pipeline. The solid lines represent the extent of the impacts during a westerly wind, while the dashed lines indicate the extent of the impact from all wind directions.

The 1% fatality is represented by the 10 kW/m^2 thermal radiation isopleth. Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m^2 isopleth, was reached.

LEGEND	**THERMAL RADIATION (kW/m^2)**
🟦	4
🟨	10
🟥	35

Figure 9: Thermal-radiation isopleths from petrol pool fires resulting from a pipeline failure

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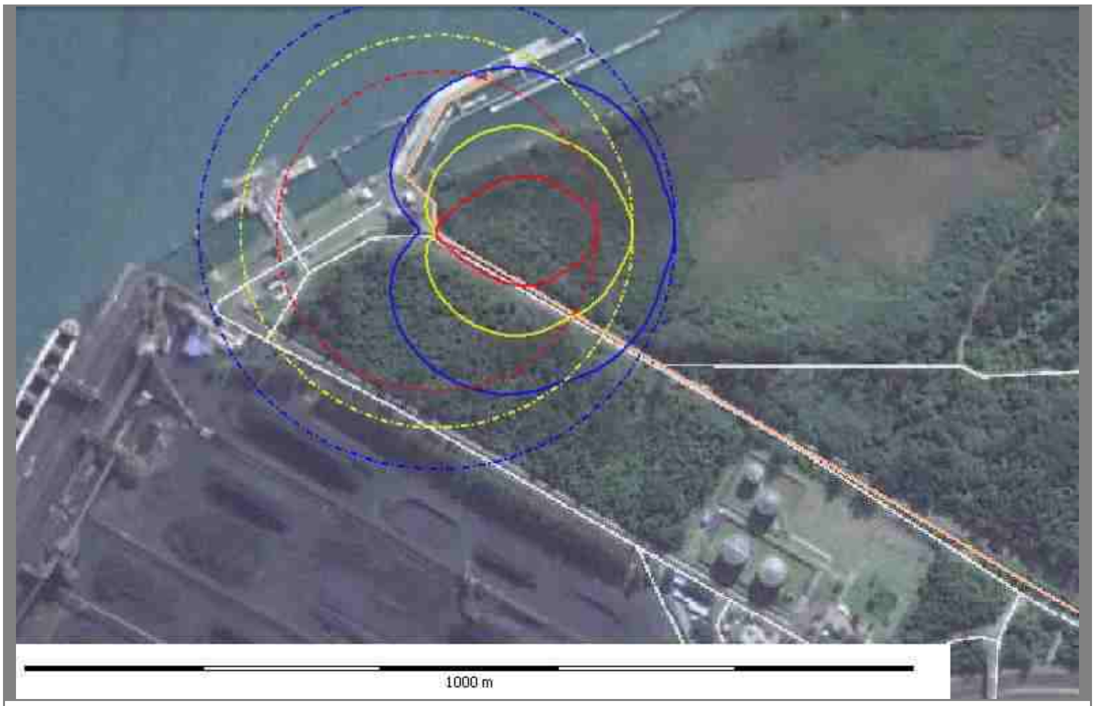
Jet fires

A release of LPG under pressure could result in a jet fire. The simulations assume the jet fire to be in the worst orientation i.e. horizontal for aboveground pipelines. The jet fire scenarios are given in Appendix G. The most significant scenarios are described in the following subsections.

Full-bore rupture

The worst-case release orientation would be in the horizontal plane producing a flame length of 135 m. The edge of the flame would have over 209 kW/m^2 of thermal radiation and could cause severe damage to equipment as well as result in fatalities, within a short time and a short distance from the flame.

Figure 10 gives the thermal radiation for a full-bore rupture of pipeline at a single point, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations. While the effect zone appears large, the actual damage at high thermal radiation would be limited to a relatively small area.



LEGEND	**THERMAL RADIATION (kW/m^2)**
🟦	4
🟨	10
🟥	35

Figure 10: Thermal radiation for a jet fire from a full-bore rupture of the LPG pipeline

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A 25 mm hole

A 25 mm hole represents approximately 10% of the possible pipeline diameter. The worst-case release orientation would be in the horizontal plane producing a flame length of 34 m in still air. The edge of the flame would have over 207 kW/m^2 of thermal radiation and could cause severe damage to equipment as well as result in fatalities, within a short time and a short distance from the flame.

Figure 11 gives the thermal radiation at a single point, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations.

LEGEND	**THERMAL RADIATION (kW/m^2)**
🟦	4
🟨	10
🟥	35

Figure 11: Thermal radiation for a jet fire from a release from a 25 mm hole in the LPG pipeline

In either scenario, an accidental jet fire from the LPG gas pipeline could have considerable reach and, depending on the orientation and point of release, could damage surrounding pipelines and equipment.

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Flash fires

A flash fire would extend to the lower flammable limit (LFL) but could extend beyond this limit, due to the formation of pockets. It is assumed that people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed. The incident scenarios for flash fires are given in Appendix G.

Flash fires from an LPG pipeline failure are the dominant scenarios and could extend 291 m from a single point of release as shown in Figure 12. The solid lines represent the extent of the impacts as indicated by the LFL during a westerly wind, while the dashed lines indicate the extent of the impact from all wind directions.

Figure 12: The extent of a flash fire from a LPG pipeline failure as indicated by the LFL

Vapour cloud explosions (VCEs)

A vapour cloud explosion (VCE) from a LPG release would have endpoint distances for overpressures of 0.1 bar (representing the 1% fatality and partial damage to buildings) extending up to 326 m from the point of release, shown in Figure 13. In the scenario modelled, the vapours drifted to an ignition point before detonating. This is referred to as a 'late explosion'. The solid lines indicate the overpressures from vapours drifting during a southwesterly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions. While the effect zone appears large, the actual explosion damage at high overpressures would be limited to a relatively small area.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. The effects of the blast could damage nearby pipelines, the LPG installation at the terminal or ships in the harbour, with cascading consequences.

VCEs from petrol or Avgas spills would be more localised.

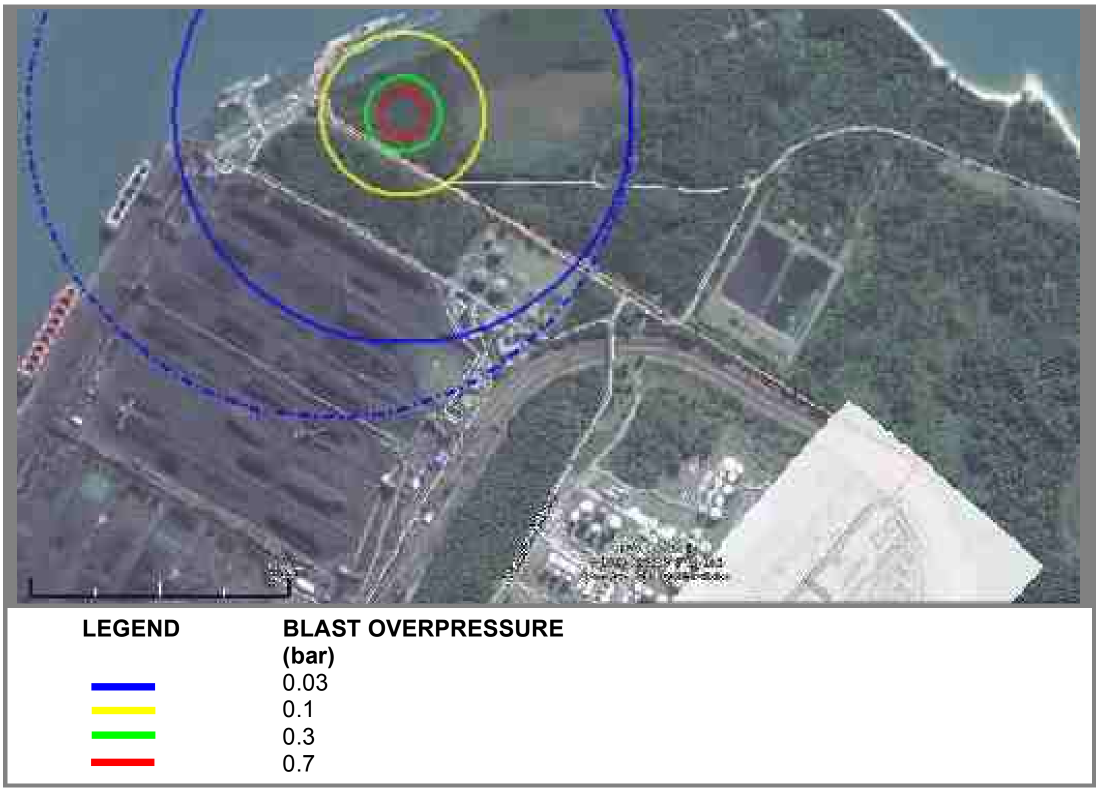

Figure 13: Blast overpressures from a large LPG pipeline release resulting in a VCE

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Summary of impacts

Releases from pipelines can result in more than one undesirable consequence, with certain consequences having a larger endpoint to the 1% fatality. The maximum distances to the 1% fatality isopleth for releases from the transport pipelines, including all the types of scenarios, are given in Table 11.

Table 11: Summary of impacts from LPG releases

Scenario	Max. Distance to the 1% Fatality Isopleth (m)	NEMA Section 30 Incident[1]
LPG failure	230	No
Petrol rupture	95	Yes Pollution detrimental to the environment
Diesel rupture	85	Yes Pollution detrimental to the environment
LPG leak	50	No
Petrol leak	30	Yes Pollution detrimental to the environment
Diesel leak	28	Yes Pollution detrimental to the environment

---

[1] Section 30 of the NEMA deals with the control of emergency incidents where an “incident” is defined as an “unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed”.

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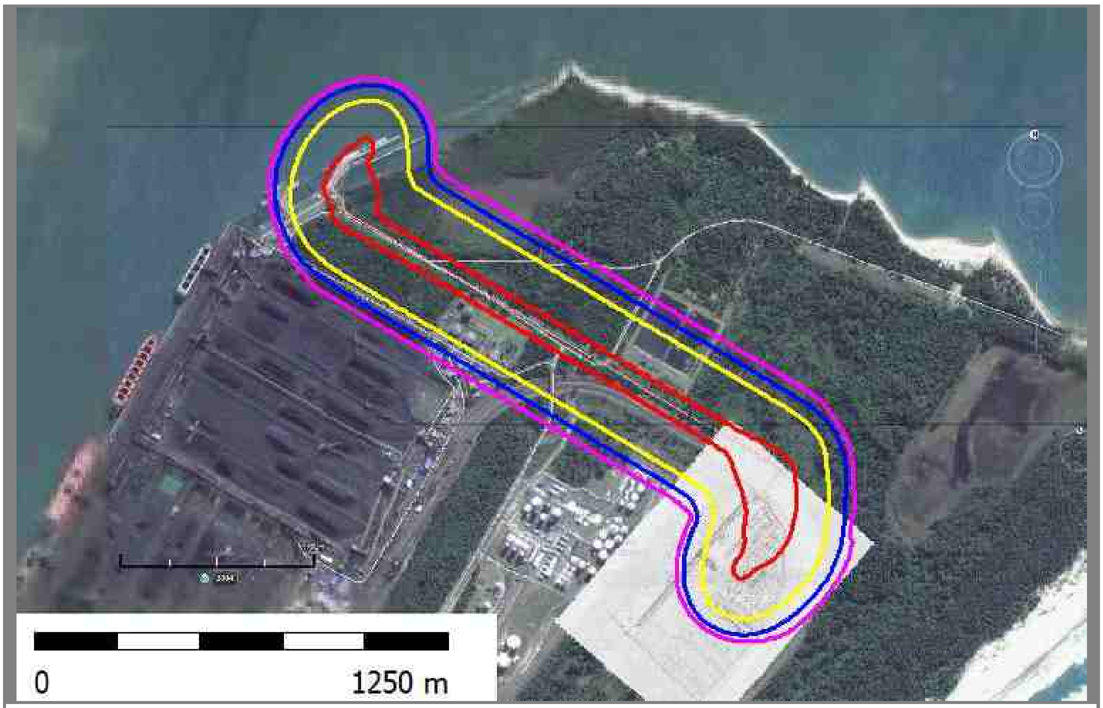
1.4.1.4 Maximum individual risk (MIR)

The MIR for the transport pipelines is shown in Figure 14 for Routing Option 2. The risks are dominated by the flash fire and VCE risks. However, the risk of 1x10^{-6} fatalities per person per year isopleth follows the pipeline and always remains within the TNPA area; therefore, there is no risk to the public.



LEGEND	**RISK (fatalities per person per year)**
🟥	1x10^{-4}
🟨	1x10^{-5}
🟦	1x10^{-6}
🟪	3x10^{-7}

Figure 14: Combined risks for the transport pipelines

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1.4.1.5 Reduction of risk

From the simulations performed, a number of events have risks that extend beyond the point of release with potential to impact on future developments.

Mitigation that can be considered to reduce the risks to acceptable levels is listed in following subsections. It should be emphasised that suggested mitigation is for consideration only. RISCOM does not imply that the suggested mitigation must be implemented or that any suggested mitigation is the only measure to reduce risks. Implementation of mitigation should always be done in accordance with recognised engineering practices, using applicable codes and standards. Implementation of some or all of the mitigation would not guarantee full compliance with the Major Hazard Installation regulations.

Mitigation for consideration is included in the following subsections.

Risk ranking

This risk assessment considered numerous scenarios assigning both a consequence and a probability of release. Some scenarios have more serious consequences than others. However, the scenarios of particular interest are those with high risk frequencies extending beyond the boundary of the site.

The most significant risk is the failure of the LPG pipeline. Thus, the overall risk would improve with mitigation to the LPG pipeline.

Codes and standards

A number of international codes are available for the design, manufacture and maintenance of cross-country pipelines, such as the ASME B31 range covering both gas and liquid pipelines. It is recommended that the transport pipelines be fully compliant with ASME B31 or an equivalent.

Buried pipeline

The major contribution to the pipeline risks is gas transmission. The risk assessment assumes a horizontal release of gas as the worst orientation for aboveground pipelines. Burying the pipeline to a depth required by the standards would reduce the risks by ensuring that the release is in the vertical plane as well as fire and explosion distances.

Pressure surges

A sudden closure of a valve along a pipeline produces a pressure surge that could break supporting pipeline structures or exceed the pressure rating of the pipeline, resulting in a possible loss of containment of the transported material. It is recommended that the designers of the pipeline demonstrate that pressure surges would not occur during the operation of the pipeline or that maximum pressure surges have been incorporated into the design such that the pipeline or associated equipment would not be damaged and there would not be loss of containment.

Reverse flow

The risk assessment assumed that a loss of containment along the pipeline would be from the pumping operation and that there would be no reverse flow of material from storage containment to the point of release. It is thus recommended that the pipeline designs ensure that reverse flow from the storage containment is not a plausible scenario.

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1.4.2 LPG bulk storage and gantries

1.4.2.1 Purpose of the processing unit

LPG would be transported from ships to the LPG storage vessels from there the LPG would be loaded into road or rail tankers.

1.4.2.2 Hazard identification

Notifiable substances

As more than 25 t of LPG would be stored in a single vessel in both Phase 1 and Phase 2, LPG would then be classified as a notifiable substance and automatically the facility **would be classified as a Major Hazard Installation**.

Flammable or combustible components to be stored, transported or processed

LPG is considered to be an extremely flammable component but is not considered acutely toxic.

1.4.2.3 Consequence modelling

Pool fires

No pool fires would be expected as the released LPG would flash into the vapour state with liquid LPG droplets evaporating rapidly. Further to this, the LPG tanks would be mounded preventing the formation of flammable LPG pools below the storage vessels.

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Jet fires

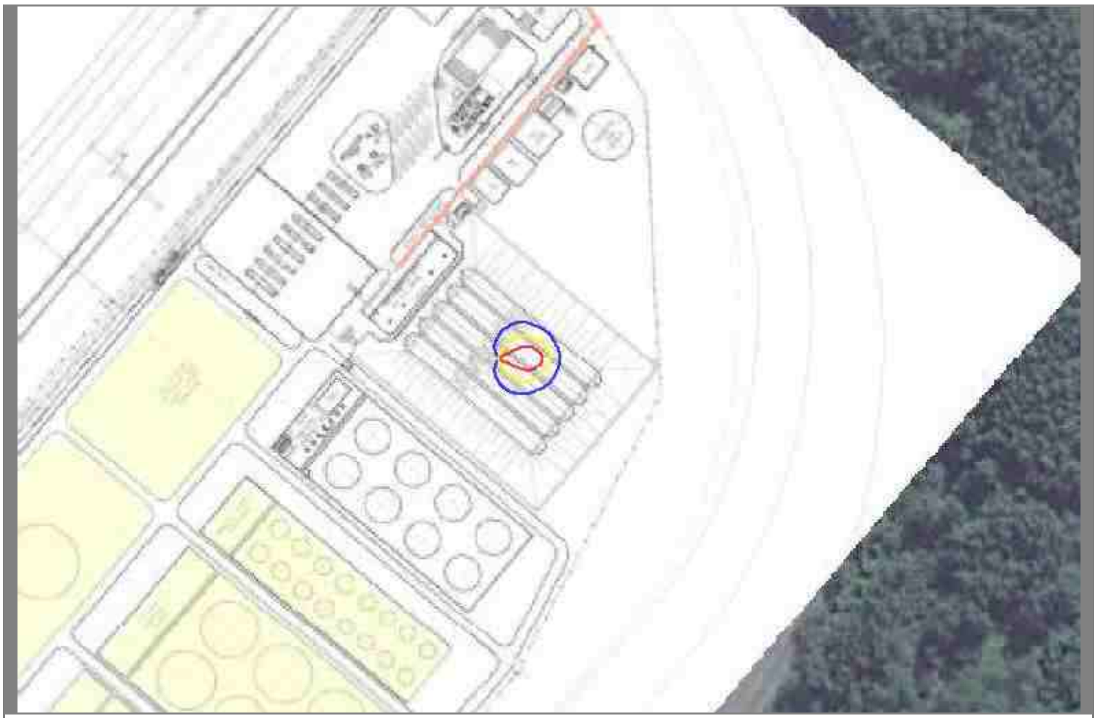
A release of LPG under pressure could result in a jet fire. The simulations assume the jet fire to be in the worst orientation i.e. horizontal for all releases except a PSV release which would be in the vertical orientation. The jet fire scenarios are given in Appendix G. The most significant scenarios are described in the following subsections.

10 mm hole

A 10 mm hole would be typical of a small hole or flange gasket failure. The worst-case release orientation would be in the horizontal plane producing a flame length of 20 m in still air. The edge of the flame would have over 51 kW/m^2 of thermal radiation and could cause severe damage to equipment as well as result in fatalities, within a short time and a short distance from the flame.

Figure 15 gives the thermal radiation for a single vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The contours indicate the flame from a single release orientation.

The 1% fatality, represented by the 10 kW/m^2 thermal radiation isopleth, remains within the site boundary. As no external consequences from this scenario are expected, no further analysis would be required.



LEGEND	THERMAL RADIATION (kW/m^2)
🟦	4
🟨	10
🟥	35

Figure 15: Thermal radiation of a LPG jet fire from a 10 mm hole at Phase 1 storage

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Pressure safety valve (PSV) failure

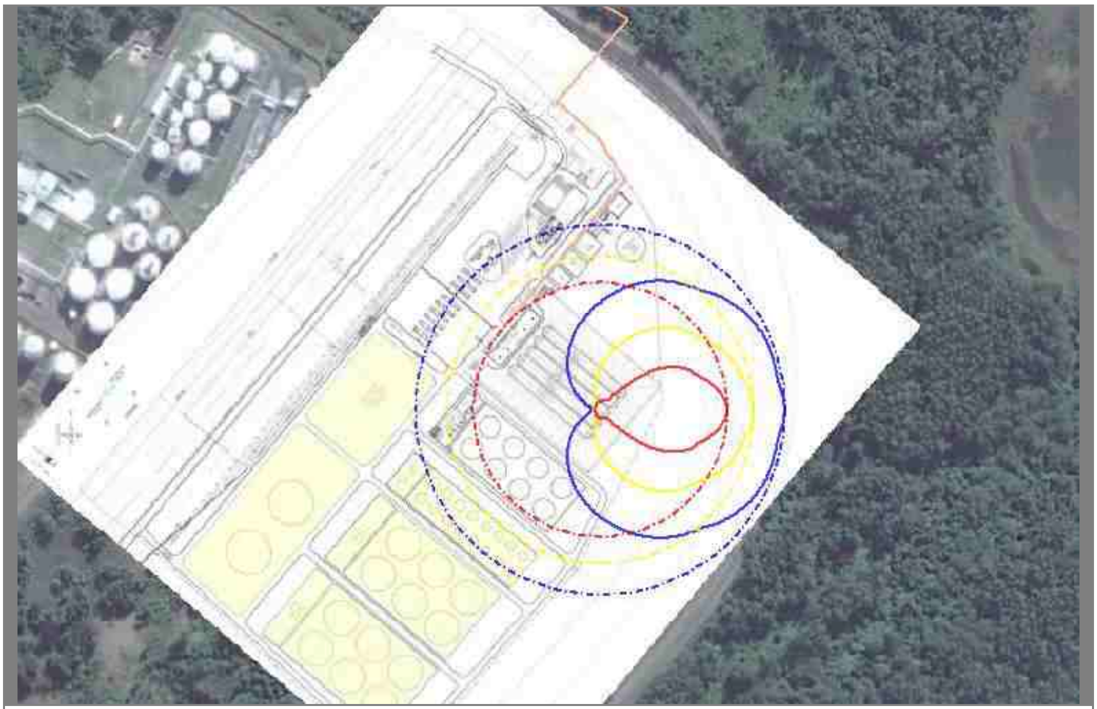
A pressure safety valve (PSV) would be located on the LPG tanks and is a statutory requirement to protect the vessel in the event of overpressure. A failure of the PSV would result in a vertical release. A strong wind could tilt the flame giving the largest distance for ground thermal radiation.

A PSV release from an 8"opening would be in the vertical plane producing a flame length of 95 m in still air. The edge of the flame would have over 208 kW/m^2 of thermal radiation and could cause damage to an adjacent unprotected LPG vessel.

Figure 16 gives the thermal radiation for a single vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations. While the effect zone appears large, the actual damage at high thermal radiation would be limited to a relatively small area.

The 1% fatality, represented by the 10 kW/m^2 thermal radiation isopleth, extends beyond the site boundary but not beyond the TNPA area.

Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m^2 isopleth, could extend a distance with potential to damage surrounding LPG and liquid fuel tanks with cascading effects.



LEGEND	THERMAL RADIATION (kW/m^2)
🟦	4
🟨	10
🟥	35

Figure 16: Thermal radiation of a LPG jet fire from a PSV failure at Phase 1 storage

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Vessel empties in 10 minutes

The design of the mounded LPG tanks would determine if a jet fire from a vessel failure could be a plausible scenario. Assuming the mound covers the lower portion of the vessel only, a 7882 m^3 LPG vessel that empties in 10 minutes would have a mass flow of 5890 kg/s producing a flame length of 656 m for a short duration. The edge of the flame would have over 346 kW/m^2 of thermal radiation that could cause damage to an adjacent unprotected LPG vessel.

Figure 17 gives the thermal radiation for a single vessel, illustrating the distance of the jet fires and the rapid drop in thermal radiation with distance. The solid lines indicate the flame, while the dashed lines indicate the effect zone with flames in all orientations.

The 1% fatality, represented by the 10 kW/m^2 thermal radiation isopleth, extends beyond the site boundary but not beyond the TNPA area.

Thermal radiation that would result in 100% fatality and damage to steel, represented by the 35 kW/m^2 isopleth, could extend a *considerable* distance with potential to damage surrounding LPG and liquid fuel tanks with cascading effects.

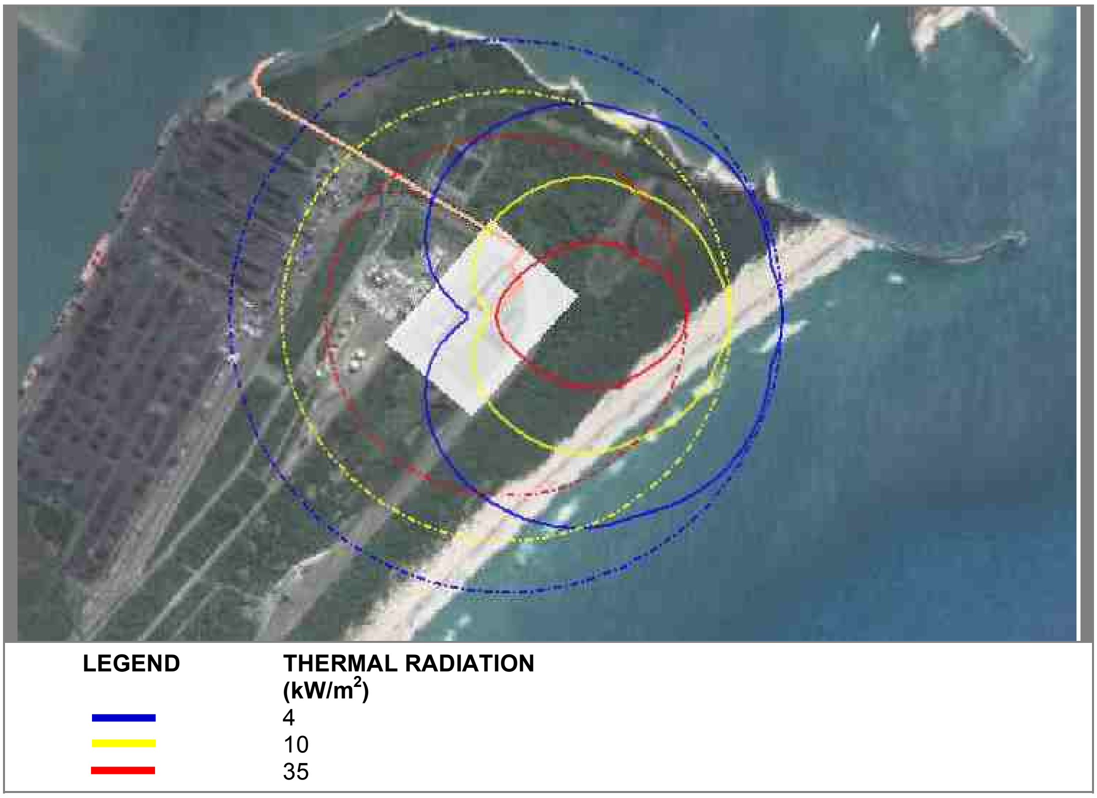

Figure 17: Thermal radiation of a LPG jet fire from a fixed duration release at Phase 1 storage

Flash fires

A flash fire would extend to the lower flammable limit (LFL) but could extend beyond this limit, due to the formation of pockets. It is assumed that unprotected people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed. The incident scenarios for flash fires are given in Appendix G.

The dominant flash fire scenario is the failure of a single 7882 m^3 storage vessel, as shown in Figure 18. Off-site impacts are indicated by the LFL, which in the worst-case scenario can extend 3.3 km downwind of the release. The extent of a flash fire from the 90 m^3 stenched vessel is shown for comparison.

In the worst conditions, a flash fire from a loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas.

LEGEND	FLASH-FIRE SCENARIO	
🟨	LPG storage vessel (7882 m^3):	Empties in 10 min
🟦	LPG storage vessel (7882 m^3):	Catastrophic failure
🟥	LPG stenched vessel (90 m^3):	Catastrophic failure
🟪	LPG stenched vessel (90 m^3):	Empties in 10 min

Figure 18: Maximum extent of the impact from LPG flash fires at Phase 1 storage

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Vapour cloud explosions (VCEs)

Figure 19 indicates the off-site blast overpressures of 0.1 bar (representing the 1% fatality and partial damage to buildings) due to loss of containment of LPG vapours from a single 7882 m^3 storage vessel in the worst meteorological conditions. The VCE from a loss of containment of the 90 m^3 stenched vessel is shown for comparison.

In the scenario modelled, the vapours drifted to an ignition point before detonating. This is referred to as a 'late explosion'. The solid lines indicate the overpressures from vapours drifting during a westerly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions. While the effect zone appears large, the actual explosion damage at high overpressures would be limited to a relatively small area.

LEGEND	FLASH-FIRE SCENARIO	
🟨	LPG storage vessel (7882 m^3):	Empties in 10 min
🟦	LPG storage vessel (7882 m^3):	Catastrophic failure
🟥	LPG stenched vessel (90 m^3):	Catastrophic failure
🟪	LPG stenched vessel (90 m^3):	Empties in 10 min

Figure 19: Maximum distances to the 0.1 bar overpressure for LPG VCEs at Phase 1 storage

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The worst-case blast overpressures would be the fixed duration release of a single LPG storage vessel, as shown in Figure 20. The solid lines indicate the overpressures from vapours drifting during a westerly wind, while the dashed lines show the effect zone from drifting clouds from all wind directions.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. A large release of LPG could result in extensive damage and fatalities up to 1.4 km downwind of the release.

No lethal effects are expected below 0.1 bar overpressure for people in the open. The VCE scenarios are given in Appendix G. In the worst conditions, a VCE from a loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas.

LEGEND	**BLAST OVERPRESSURE (bar)**
🟦	0.1
🟨	0.3
🟥	0.7

Figure 20: Blast overpressures for the worst-case vapour cloud explosion from a release from a single 7882 m^3 LPG storage vessel

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Boiling liquid expanding vapour explosions (BLEVEs)

A boiling liquid expanding vapour explosion (BLEVE) could occur if a flame impinges on a LPG pressure vessel, particularly in the vapour space region where cooling by evaporation of the contained LPG does not occur.

The major consequences of a BLEVE are intense thermal radiation from the fireball, a blast wave and fragments from the shattered vessel. These fragments may be projected to considerable distances. Analyses of the travel range of fragment missiles from a number of BLEVEs suggest that the majority land within 700 m from the incident. A blast wave from a BLEVE is fairly localised but can cause significant damage to immediate equipment.

A BLEVE would not be expected at the bulk storage tanks as the tanks would be mounded to prevent LPG pooling below the tank. However, a BLEVE could be formed at the LPG stenched vessel or at the LPG road and rail tankers. The characteristics of these BLEVEs are indicated in Table 12.

Table 12: Characteristics of LPG BLEVEs at the stenched vessel or at the road and rail tankers

Parameter	Stenched Vessel (90 m^3)	Rail Tanker (56 m^3)	Road Tanker (50 m^3)
Initial mass in vessel (kg)	44623	27766	24791
Duration of the fire ball (s)	13.1	11.6	11.3
Maximum diameter of the fire ball (m)	205.7	175.6	169.1
Maximum height of the fire ball (m)	308.6	263.4	253.7
Distance to 1% fatality (m)	293.5	241.2	230.3
Distance to10% fatality (m)	248.2	203.4	194.0
Distance to 50% fatality (m)	199.4	162.8	155.2
Distance to 90% fatality (m)	156.9	127.4	121.2

The 1% fatality from LPG BLEVEs at the stenched vessel or road and rail tankers is shown in Figure 21. While the impacts from LPG BLEVEs could extend beyond the VSAD facility, no fatalities would be expected outside of the TNPA area.

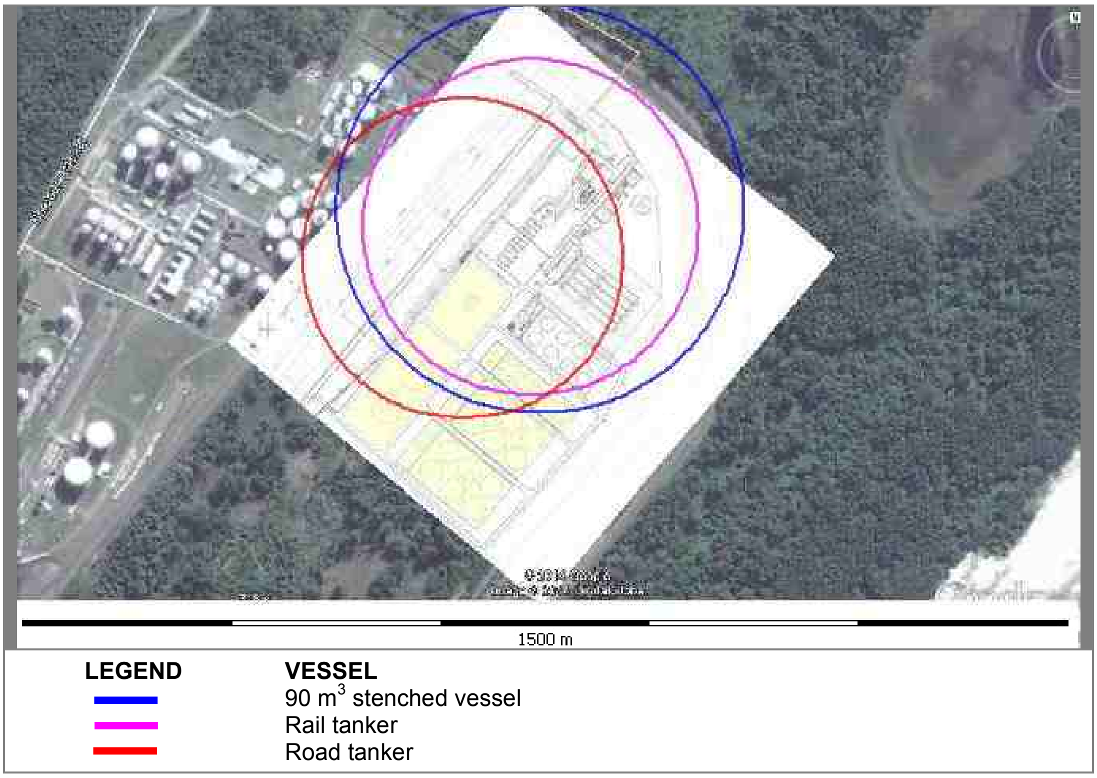

Figure 21: The 1% fatality from LPG BLEVEs at the stenched vessel or at the road and rail tankers

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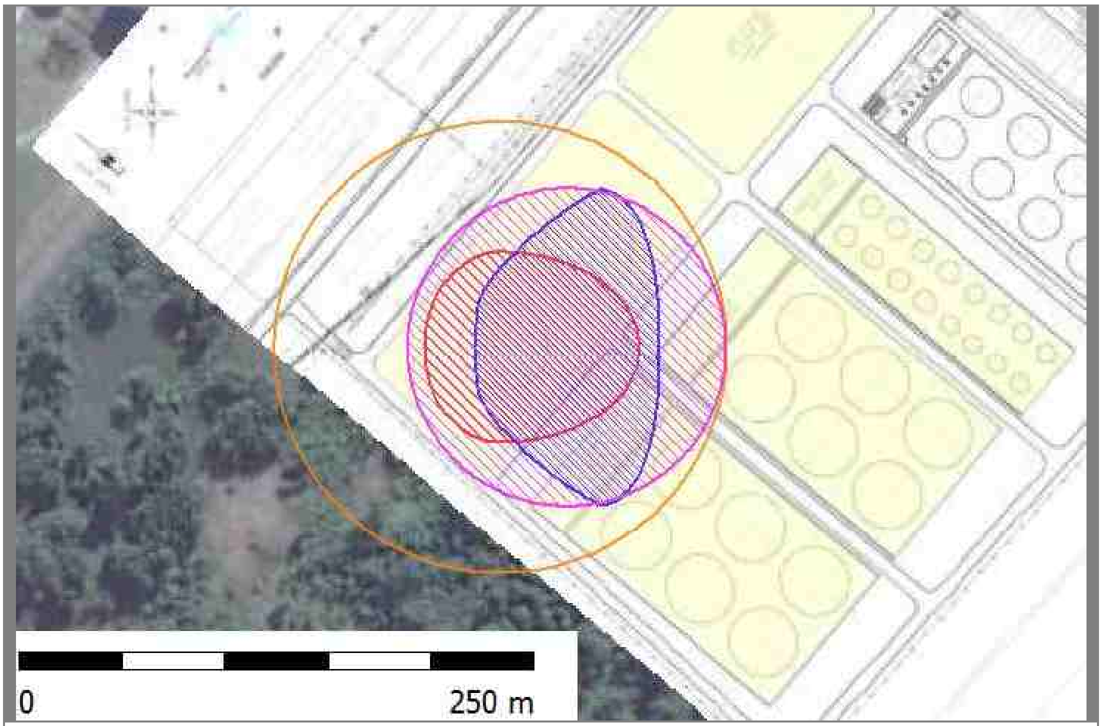
Future projects

VSAD has indicated that future projects may include two spherical vessels of 34 000 m^3, each containing refrigerated LPG.

The extent of the 1% fatality from a loss of containment from a single refrigerated LPG sphere is shown in Figure 22. The shaded areas indicate the extent of impacts from particular scenarios during a westerly wind, while the single line shows maximum distance to the 1% fatality isopleth from all wind directions.

A VCE would produce the greatest distance to the 1% fatality isopleth that could extend beyond the site boundary but not beyond the TNPA area.



LEGEND RISK

▬ Vapour cloud explosion (0.1 bar overpressure)
▬ Pool fire (10 kW/m^2)
▬ Flash fire (LFL)
▬ Maximum distance to the 1% fatality isopleth

Figure 22: The extent of the 1% fatality from a loss of containment of the proposed LPG sphere

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Summary of impacts

Loss of containment of LPG can result in more than one undesirable consequence, with certain consequences having a larger endpoint to the 1% fatality. The maximum distances to the 1% fatality isopleth from all LPG release scenarios are given in Table 13.

Table 13: Summary of impacts from LPG releases at bulk storage or the gantries

Scenario	**Max. Distance to the 1% Fatality Isopleth (m)**	**NEMA Section 30 Incident**[1]
Future LPG Storage (34 000 m^3)		No
Catastrophic failure	110	
Fixed duration release	109	
LPG Rail Gantry		No
Rail tanker (56 m^3) failure	344	
Rail tanker loading arm failure	188	
Rail tanker loading arm leak	25	
LPG Road Gantry		No
Road tanker (50 m^3) failure	332	
Road tanker loading arm failure	188	
Road tanker loading arm leak	25	
LPG Storage (7882 m^3)		Yes Reaches the public
Fixed duration release	3385	
Pump failure	3160	
Vessel failure	2201	
Overfill	383	
PSV failure	150	
10 mm hole	37	
LPG Stenched Vessel (90 m^3)		No
Pump failure	557	
Vessel failure	406	
Fixed duration release	272	
PSV failure	149	
Overfill	88	
10 mm hole	37	

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[1] Section 30 of the NEMA deals with the control of emergency incidents where an "incident" is defined as an "unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed".

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1.4.2.4 Maximum individual risk (MIR)

The risks for LPG bulk storage and gantries for Phase 1 and subsequent phases are shown in Figure 23. The risk of 3x10^{-7} fatalities per person per year isopleth, representing trivial risk, extends about 2.9 km downwind from the release into the harbour area but not into the residential areas. The risk of 1x10^{-6} fatalities per person per year isopleth would extend beyond Port Authority into unoccupied ocean. Thus, the risk due to the proposed facility would be considered acceptable provided that the PADHI land use restrictions are applied.

Figure 23: Risk contours for LPG releases at the bulk storage and gantries

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1.4.2.5 Reduction of risks

From the simulations performed, a number of events have risks that extend beyond the point of release with potential to impact on future developments.

Mitigation that can be considered to reduce the risks to acceptable levels is listed in following subsections. It should be emphasised that suggested mitigation is for consideration only. RISCOM does not imply that the suggested mitigation must be implemented or that any suggested mitigation is the only measure to reduce risks. Implementation of mitigation should always be done in accordance with recognised engineering practices, using applicable codes and standards. Implementation of some or all of the mitigation would not guarantee full compliance with the Major Hazard Installation regulations.

Mitigation for consideration is included in the following subsections.

Risk ranking

Comparison of the risk of 1x10^{-6} fatalities per person per year isopleths for the combined risk and the scenarios of overfilling of storage vessels and pump failure is shown in Figure 24. The pump failure, represented by pump casing failure, would release the storage vessel contents via the connecting pipeline. The rate of release is determined by the vessel pressure and the size of the pump suction inlet .Thus, improving the risk of overfilling and of loss of containment from a pump casing failure would be the most significant mitigation in risk reduction.

LEGEND	**RISK COMPARISON** **(1x10^{-6} fatalities per person per year)**
🟩	Phase 1 and Phase 2 total
🟪	Pump failure
🟦	Overfill

Figure 24: Comparison of the risk of 1x10^{-6} fatalities per person per year isopleths

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Codes and standards

It has been indicated that the applicable standard for the design would be SANS 10087. This is an acceptable standard and *full compliance* with this standard would be expected. Full compliance with SANS 10108, covering the types of electrical instrumentation required for a process in order to reduce ignition sources, would also be mandatory.

Safety instrumented systems

IEC 61508/11 (Safety Instrumented Systems) are codes specifically related to the instrumentation requirements to ensure adequate protection from the hazards in chemical plants and is applicable to the *life cycle* of the plant. These codes are aimed at reducing to acceptable levels risks to surrounding populations.

The significance of the code is that designs would be evaluated against the criteria of the code and instrumentation with specific failure rates would be specified as well as minimum periods of checking. Thus, the selection of instrumentation is not based on price alone. Further to this, instrumentation cannot be reduced or changed without reviewing the code. The specification of this code implies that designs presented at EIA and MHI evaluations cannot be altered at construction for the sole function of reducing costs. Moreover, the code ensures that the plant would continue to maintain the safety functions for the *life cycle* of the plant, retaining a safe working environment for both workers and the public.

The European standards body (CENELEC) has adopted this standard as EN 61511. This means that in each of the member states of the European Union, the standard is published as a national standard. For example, in Great Britain, it is published by the national standards body as BS EN 61511. The content of these national publications is identical to that of IEC 61511. However, kindly note that the code is not harmonized under any directive of the European Commission.

In the United States ANSI/ISA 84.00.01-2004 was issued in September 2004. It mirrors IEC 61511 in content with the exception that it contains a grandfathering clause:

> “ *Compliance with IEC 61508 and IEC 61511 (or ANSI/ISA 84.00.01-2004) would be a requirement in many countries around the world to achieve an acceptable risk to workers and public.* ”

Demonstrating compliance with the IEC 61508/11 can be achieved only once full-detail designs have been completed, and it is thus premature at this stage in the project.

Assessment of potential impacts for the operation phase

The impacts, identified from loss of containment and ignition at the bulk LPG storage, are shown in Table 14.

Mitigation to prevent undesirable impacts involves applying suitable engineering designs that maintain the integrity of equipment and system control, such as overfill protection and removal of ignition sources from vulnerable areas. In addition to this, the integrity of the system also relies on preventative maintenance where the system is checked and faults are corrected, such as corrosion detection and remedy.

Table 14: Impacts identified from loss of containment and ignition at bulk LPG storage

Direct Impacts								
Impact	**Mitigation**	**Spatial Extent**	**Intensity**	**Duration**	**Probability**	**Significance and Status**		**Confidence**
						Without Mitigation	**With Mitigation**	
1	Formation of on-site fires and explosions							
	Engineering designs	Site specific	High	Temporary	Improbable	Medium	Low	High
	Preventative maintenance in line with API 510/70 and AP 653							
2	Formation of off-site fires and explosions							
	Engineering designs	Local	High	Temporary	Improbable	Medium	Low	High
	Preventative maintenance in line with API 510/70 and AP 653							

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1.4.3 Bulk atmospheric storage and gantries

1.4.3.1 Purpose of the processing unit

The terminal would receive CPP liquid fuels and other components that would be stored in bulk tanks and dispatched by ship, road or rail.

1.4.3.2 Hazard identification

Notifiable substances

Liquid fuels are not considered notifiable substances.

Flammable or combustible components to be stored, transported or processed

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic.

A number of chemicals could be stored on and transported onto site during subsequent project phases. At the full chemical inventory could change, calculations were done on a conservative basis using petrol in all scenarios.

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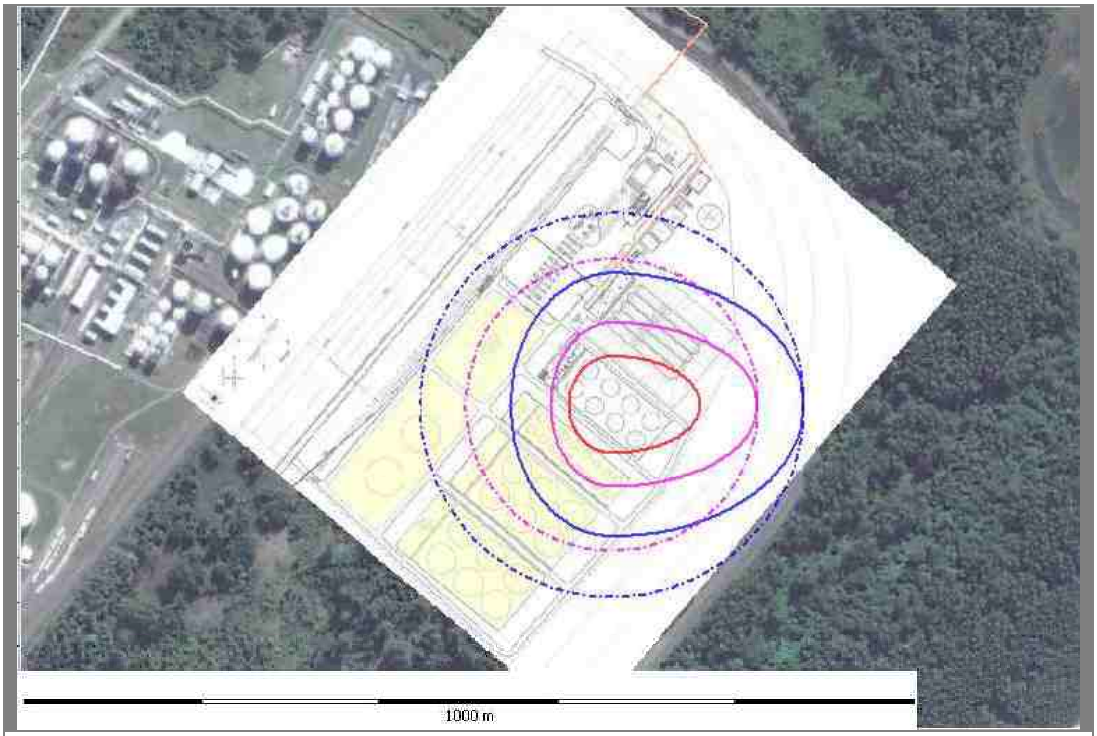
1.4.3.3 Consequence modelling

Bund and pool fires

Pool fires would occur with a loss of containment of flammable or combustible material followed by an ignition. The scenarios used in the simulations are given in Appendix G.

In the event of a pool fire the flames would tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of the impacts of thermal radiation. In the event of a large release from a tank or associated piping, the spilt material would be contained within the bunded area. The extent of pool fires, under strong wind conditions, is shown in Figure 25. The solid lines indicate a westerly wind, while the dashed lines indicate a wind from all directions.

The 1% fatality, represented by the 10 kW/m^2 thermal radiation isopleth, extends beyond the site boundary but not beyond the TNPA area.



LEGEND	THERMAL RADIATION (kW/m^2)
🟦	4
🟪	10
🟥	35

Figure 25: The extent of thermal radiation from a large bund fire for the first phase of CPP storage

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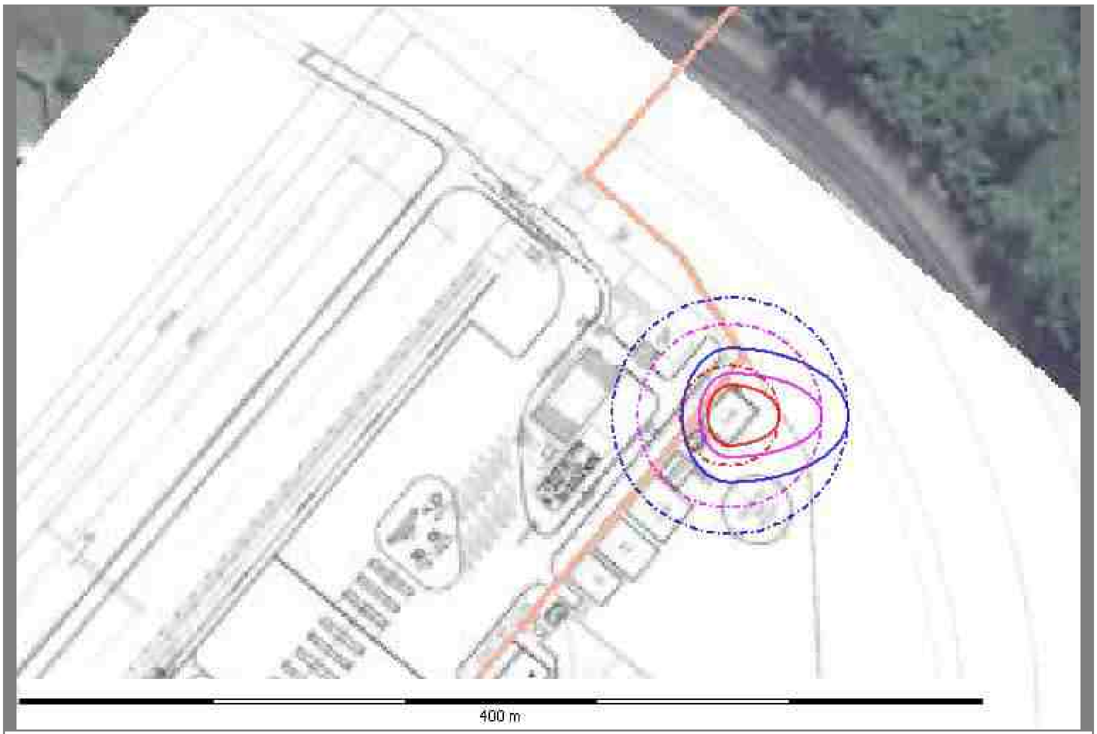
Releases from the road and railway gantries would be collected in the sump. Thus, all major fires would occur at the sump, producing the thermal radiation shown in Figure 26.

Impacts from pool fires at the sump would not extend beyond the site boundary, and thus no further analysis would be required.



LEGEND	**THERMAL RADIATION (kW/m^2)**
—	4
—	10
—	35

Figure 26: The extent of thermal radiation a large pool fire at the sump of the gantries

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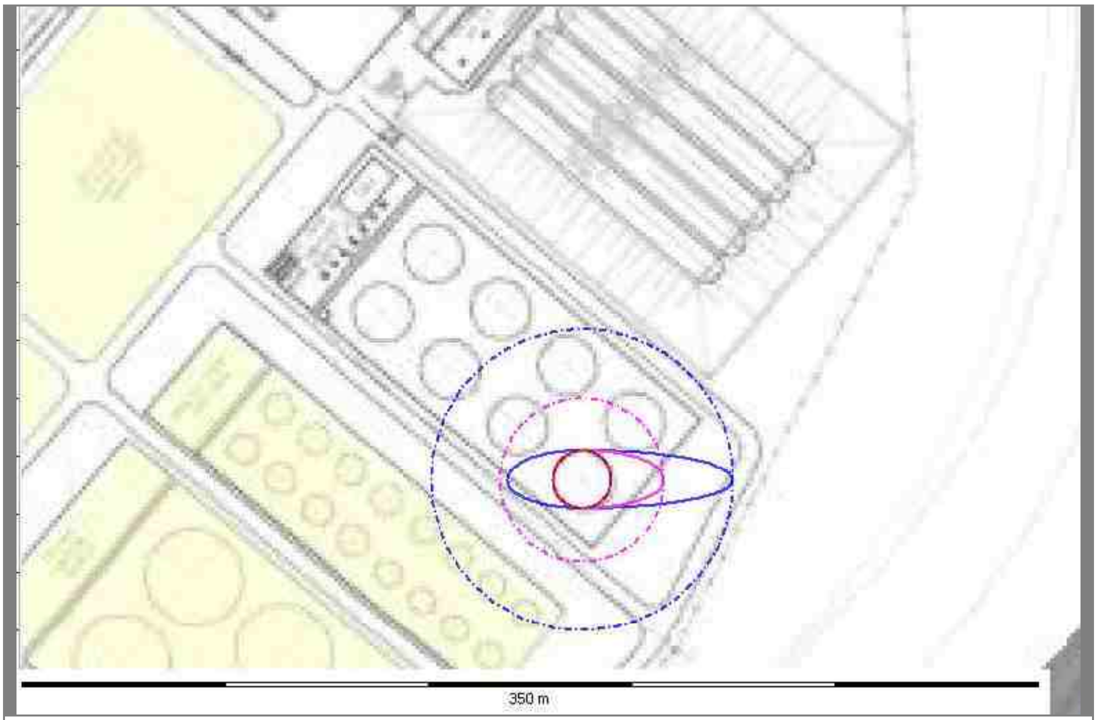
Tank-top fires

A tank-top fire would occur if the flammable vapours above the stored liquid ignite. The resulting fire would be contained within the tank but could cascade into a bund fire with the collapsing of the tank. Incident scenarios for tank-top fires are summarised in Appendix G.

The thermal-radiation isopleths from a single tank-top fire, representing the largest tank, are shown in Figure 27.

The 1% fatality, represented by the 10 kW/m^2 thermal radiation isopleth, remains within the site boundary. As no external consequences from this scenario are expected, no further analysis would be required.



LEGEND	**THERMAL RADIATION (kW/m^2)**
🟦	4
🟪	10
🟥	35

Figure 27: Thermal radiation from tank-top fires for the first phase of CPP storage

Flash fires

A flash fire would extend to the lower flammable limit (LFL) but could extend beyond this limit, due to the formation of pockets. It is assumed that unprotected people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed. The incident scenarios for flash fires are given in Appendix G.

Flash fires from large bund spillages of petrol are illustrated in Figure 28. The thin line shows the flammable cloud shape during a northerly wind, while the dashed line shows the effect zone from all wind directions.

Flash fires would remain on site and would only pose a threat to workers in the immediate vicinity. As flash fires would not extend beyond the site boundary, no further action would be required. It is recommended that under emergency conditions, people should be evacuated well beyond the LFL

It should be noted that the flashpoint of diesel is sufficiently high to preclude flash fires.

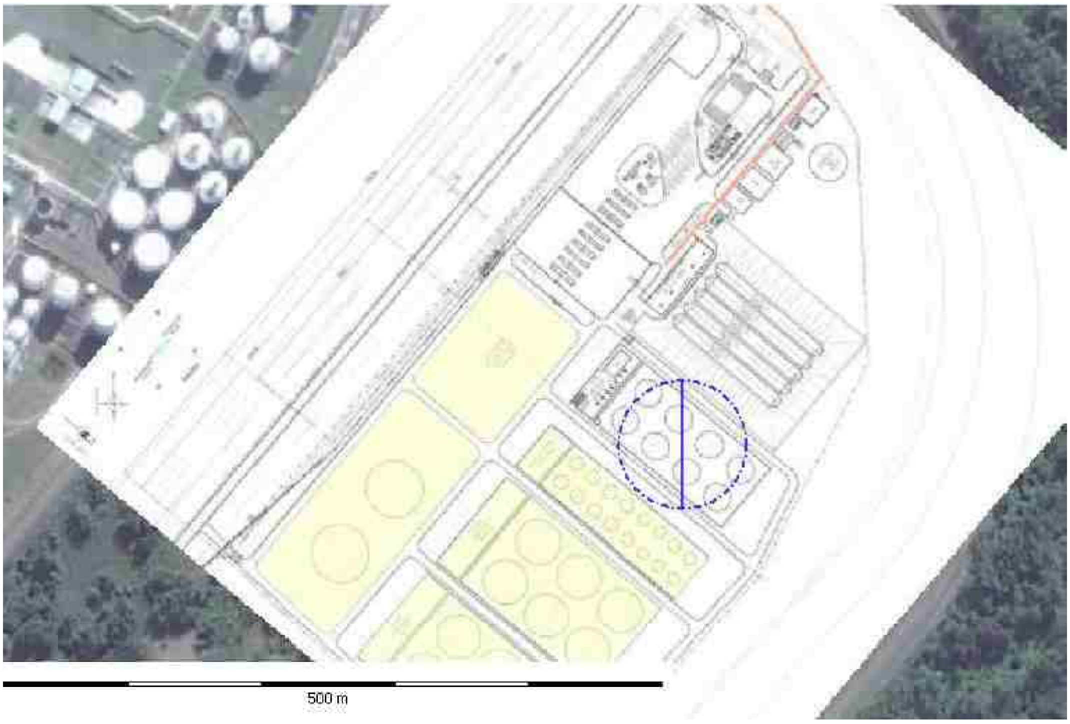


Figure 28: Flash fires from loss of containment within the first phase of CPP storage

Fixed-roof tank explosions

Petrol tanks would have internal floating roofs eliminating the formation of a flammable cloud above the liquid level. However, the floating roof rests on legs approximately 1.8 m above the base of the tank. Thus, under certain conditions when the tank is almost empty flammable vapours can occupy the space below the floating roof. The mass used in the explosion calculations is the volume of flammable material at its lower flammability limit.

The blast overpressures from a fixed-roof explosion at a single petrol storage tank for Phase 1 is shown in Figure 29.

As the 0.1 bar overpressure isopleth, representing the 1% fatality and partial damage to buildings, does not extend beyond the site boundary, there would be no off-site consequences from fixed-tank explosions.

The 0.7 bar overpressure isopleth indicates total destruction of equipment, and the 0.3 bar overpressure isopleth indicates severe damage to brick buildings. A large explosion may damage the storage tank as well as surrounding tanks with cascading effects.

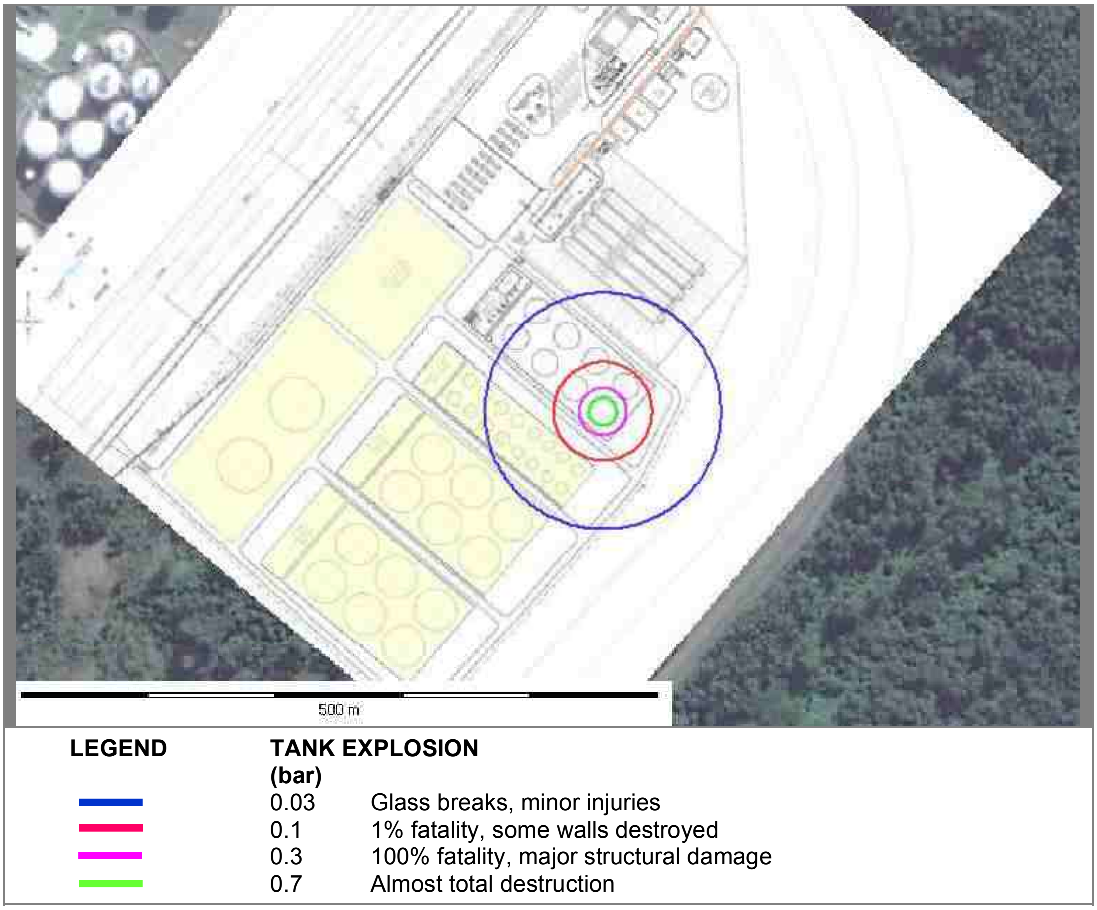


Figure 29: Blast overpressures for a single fixed-roof tank explosion at the first phase of CPP storage

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Vapour cloud explosions (VCEs)

Figure 30 indicates the expected blast overpressures from a large release of petrol into the bund. Bund blast impacts would remain on site without potential injuries to the public.

LEGEND	VCE (bar)	
🟦	0.03	Glass breaks, minor injuries
🟥	0.1	1% fatality, some walls destroyed
🟪	0.3	100% fatality, major structural damage
🟩	0.7	Almost total destruction

Figure 30: Vapour cloud explosions from bund spillages at the first phase of CPP storage

Boiling liquid expanding vapour explosions (BLEVEs)

A boiling liquid expanding vapour explosion (BLEVE) could occur if a flame impinges on a petrol road or rail tanker, particularly in the vapour space region where cooling by evaporation of the contained petrol does not occur.

However, the process description provided indicated that spillages at the road and rail gantry would be directed to the sump, making BLEVEs of road and rail tankers an implausible scenario.

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1.4.3.4 Maximum individual risk (Phase 1 and Phase 2)

Each vessel would have two level transmitters that would signal the level to the control system. At high level an alarm would be activated in the control room for remedial action. The level transmitters would be independent and would not suffer common mode failure. The failure rate of the level controllers has not been given, and thus the lowest SIL value of 1 (0.1 failure per annum) was assigned.

A level switch would signal to the emergency shutdown (ESD) system to close the valve on the incoming line. The failure rate of the level switch has not been given, and thus the lowest SIL value of 1 was assigned. The level controls and level switch would be independent.

The risk isopleths for the tank farm after completion of Phase 2 are indicated in Figure 31. The risk of 1x10^{-4}fatalities per person per year is close in value to the risk of 3x10^{-7} fatalities per person per year, as the risk drops rapidly from the point of release. The risk of 1x10^{-4}fatalities per person per year extends beyond the site boundary on the southern and eastern site boundaries but would not extend beyond the TNPA area. Thus, the risks to the public would be considered acceptable.

As the components to be stored in the tanks of Phase 2 have not been full described, this study assumed the worst case being petrol. In the event that the tanks would contain higher flashpoint materials, the risk isopleths may diminish in size.

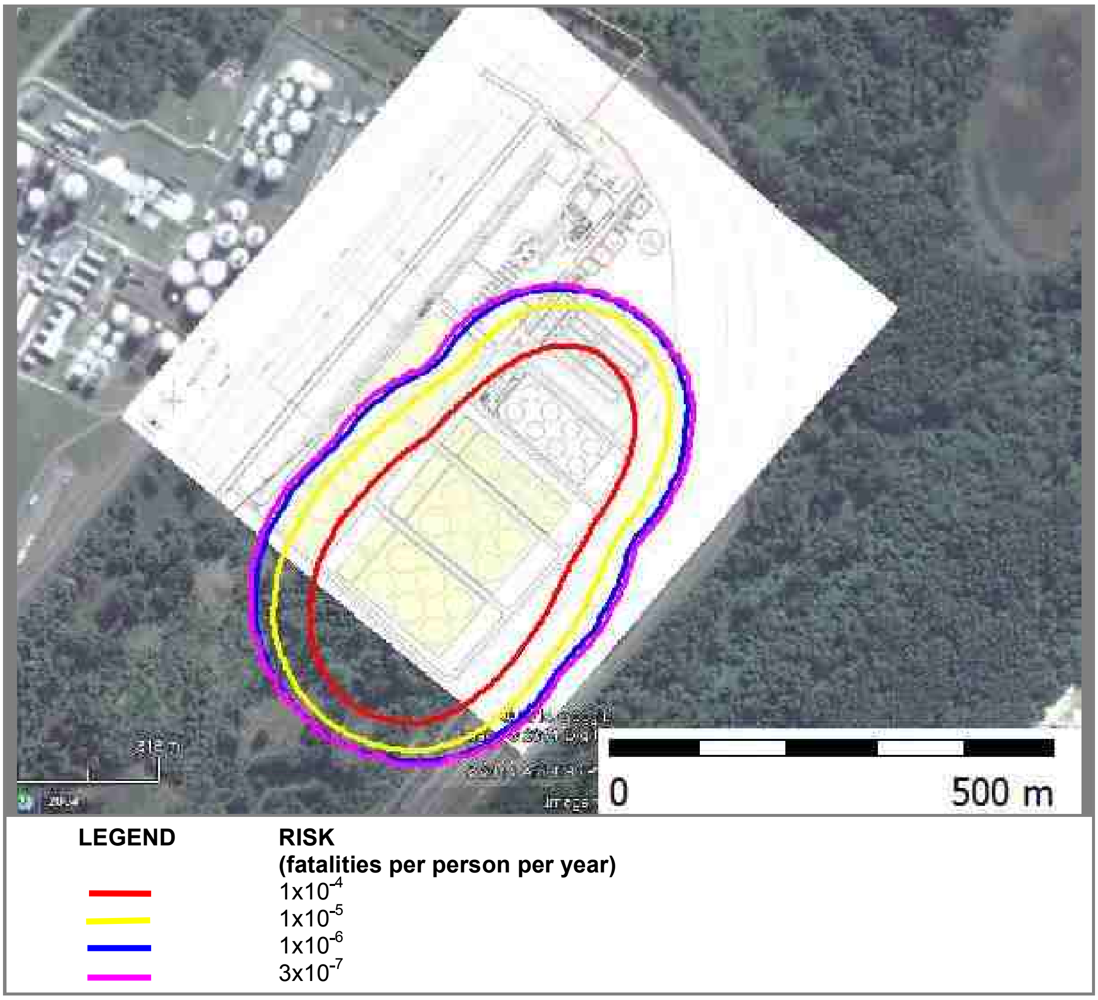

Figure 31: Risk isopleths for Phase 1 and Phase 2 of the bulk atmospheric storage

1.4.3.5 Reduction of risks

From the simulations performed, a number of events have risks that extend beyond the point of release with potential to impact on future developments.

Mitigation that can be considered to reduce the risks to acceptable levels is listed in following subsections. It should be emphasised that suggested mitigation is for consideration only. RISCOM does not imply that the suggested mitigation must be implemented or that any suggested mitigation is the only measure to reduce risks. Implementation of mitigation should always be done in accordance with recognised engineering practices, using applicable codes and standards. Implementation of some or all of the mitigation would not guarantee full compliance with the Major Hazard Installation regulations.

Mitigation for consideration is included in the following subsections.

Risk ranking

This risk assessment considered numerous scenarios for the bulk atmospheric storage that could result in fires and explosions on the site. Some of these scenarios have more serious consequences than other scenarios. The scenarios of particular interest are those with high risk frequencies extending beyond the boundaries of the site.

Risk reduction starts with the identification of the scenarios with the highest contribution to the overall risk, after which VSAD can determine appropriate mitigation.

The overriding contribution to the risk profile is the overfilling scenario followed by an ignition.

Codes and standards

It has been indicated that the applicable standard for the design would be SANS 10089. This is an acceptable standard and *full compliance* with this standard would be expected. Full compliance with SANS 10108, covering the types of electrical instrumentation required for a process in order to reduce ignition sources, would also be mandatory.

Safety instrumented systems

IEC 61508/11 (Safety Instrumented Systems) are codes specifically related to the instrumentation requirements to ensure adequate protection from the hazards in chemical plants and is applicable to the *life cycle* of the plant. These codes are aimed at reducing to acceptable levels risks to surrounding populations.

The significance of the code is that designs would be evaluated against the criteria of the code and instrumentation with specific failure rates would be specified as well as minimum periods of checking. Thus, the selection of instrumentation is not based on price alone. Further to this, instrumentation cannot be reduced or changed without reviewing the code. The specification of this code implies that designs presented at EIA and MHI evaluations cannot be altered at construction for the sole function of reducing costs. Moreover, the code ensures that the plant would continue to maintain the safety functions for the *life cycle* of the plant, retaining a safe working environment for both workers and the public.

The European standards body (CENELEC) has adopted this standard as EN 61511. This means that in each of the member states of the European Union, the standard is published as a national standard. For example, in Great Britain, it is published by the national standards body as BS EN 61511. The content of these national publications is identical to that of IEC 61511. However, kindly note that the code is not harmonized under any directive of the European Commission.

In the United States ANSI/ISA 84.00.01-2004 was issued in September 2004. It mirrors IEC 61511 in content with the exception that it contains a grandfathering clause:

> “ *Compliance with IEC 61508 and IEC 61511 (or ANSI/ISA 84.00.01-2004) would be a requirement in many countries around the world to achieve an acceptable risk to workers and public.* ”

Demonstrating compliance with the IEC 61508/11 can be achieved only once full-detail designs have been completed, and it is thus premature at this stage in the project.

In the United States ANSI/ISA 84.00.01-2004 was issued in September 2004. It mirrors IEC 61511 in content with the exception that it contains a grandfathering clause:

Compliance with IEC 61508 and IEC 61511 (or ANSI/ISA 84.00.01-2004) would be a requirement in many countries around the world to achieve an acceptable risk to workers and public.

Demonstrating compliance with the IEC 61508/11 can be achieved only once full-detail designs have been completed, and it is thus premature at this stage in the project.

It should be noted that Riscom would recommend compliance with the IEC 61508/11.

Buncefield recommendations

Due to the similarity of the VSAD terminal in Richards Bay to the terminal involved in the Buncefield incident, the recommendations from the Buncefield report are listed in Appendix F and should be applied to the VSAD terminal in Richards Bay where applicable.

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1.4.4 Consolidated risks

The consolidated risk is combined from the MIRs described in the previous subsections and is shown in Figure 32 for Phase 1of the project, with the contributions from each hazardous area on site.

The risk of $1x10^{-4}$ fatalities per person per year isopleth (generally considered the upper limit of tolerable) remains within the TNPA area and does not enter areas used by the general public.

Similarly, the risk of $1x10^{-6}$ fatalities per person per year isopleth, representing the lower limit of tolerable, does not extend into areas used by the general public. Risks less than $3x10^{-7}$ fatalities per person per year would be considered trivial and acceptable for land use by vulnerable populations, such as hospitals, nursery schools, retirement homes, etc.

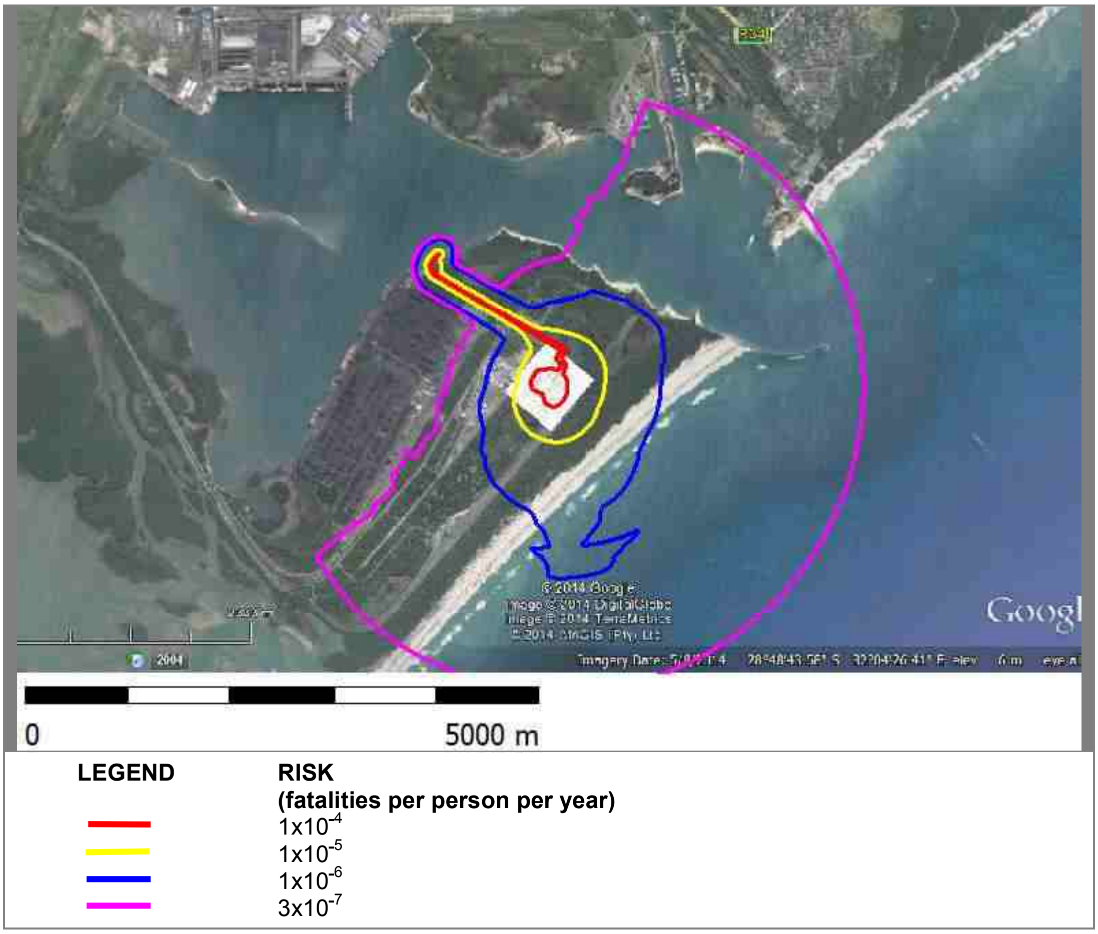

Figure 32: Combined risks for Phase 1 of the VSAD project

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The combined risks for Phase 1 and Phase 2 are shown in Figure 33. The addition of Phase 2 would increase the extent of the risk of 1x10^{-6} fatalities per person per year isopleth but would have little effect otherwise.

LEGEND	**RISK (fatalities per person per year)**
🟥	1x10^{-4}
🟨	1x10^{-5}
🟦	1x10^{-6}
🟪	3x10^{-7}

Figure 33: Combined risks for Phase 1 and Phase 2 of the VSAD project

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1.4.5 Assessment rating of potential impacts

The assessment rating of potential impacts, shown in Table 15, was done according to the methodology given in Appendix D. The methodology for assessing the potential impacts is qualitative and subjective with time frames of less than 20 years and without benchmarking to acceptable criteria. In comparison, this report is quantitative where probabilities are calculated to 1 in 10 000 years and lower; the risk isopleths have been calculated and presented. **Therefore, the assessment of the potential impacts using qualitative analysis is not compatible with quantitative risk assessment and the assessment rating was completed for EIA compliance only**.

The accuracy of the study is dependent on the accuracy of the information presented. Furthermore, this is not the final design, and changes could be made with the application of mitigation. However, major changes are not expected, giving a good confidence of accuracy. The methodology used to determine the impacts is based on international standards and could be reproduced by other parties using similar inputs.

Table 15: Classification of impacts for assessment of the VSAD terminal in Richards Bay

Impacts	**Occurrence**			**Severity**				**Environmental Consequence Before Mitigation**
	Direction	**Probability**	**Duration**	**Magnitude**	**Geographic Extent**	**Reversibility**	**Frequency**	
Transport pipelines								
Fires and explosions due to loss of containment with an ignition	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Low
Fires and explosions due to a loss of containment of LPG pipeline from the berths to the terminal	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Low
Fires and explosions due to a loss of containment of CPP pipeline from the berths to the terminal	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Low
Soil and water contamination due to a loss of containment of CPP pipeline from the berths to the terminal	Negative	Improbable	Short term	High	Local	Reversible	Low	Low
LPG bulk storage and gantries								
Fires and explosions due to loss of containment with an ignition	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Low
Fires and explosions due to a loss of containment at the gantries	Negative	Improbable	Permanent	High	Local	Irreversible	Low	Low
Atmospheric bulk storage and gantries								
Fires and explosions due to loss of containment with an ignition	Negative	Improbable	Short term	High	Local	Irreversible	Low	Low
Fires and explosions due to a loss of containment at the gantries	Negative	Improbable	Short term	High	Local	Irreversible	Low	Low

1.5 Conclusions

Risk calculations are not precise. The accuracy of predictions is determined by the quality of the base data and expert judgements. A number of well-known sources of incident data were consulted and applied to obtain the likelihood of an incident to occur. The risk assessment included the consequences of fires and explosions at the VSAD facility in Richards Bay.

The risk assessment was done on the assumption that the site is maintained to an acceptable level and that all statuary regulations are applied. It was also assumed that the detailed engineering designs would be done by competent people and are correctly specified for the intended duty. For example, it is assumed that the tank wall thicknesses would have been correctly calculated, that the vents have been sized for emergency conditions, that the instrumentation and electrical components comply with the specified electrical area classification, that the material of construction is compatible with the products, etc. It is the responsibility of VSAD and their contractors to ensure that all engineering designs have been completed by competent persons and that all equipment has been installed correctly. All designs should be in full compliance with (but not limited to) the Occupational Health and Safety Act 85 of 1993 and its regulations, the National Buildings Regulations and the Buildings Standards Act 107 of 1977 as well as local bylaws.

A number of incident scenarios were simulated, taking into account the prevailing meteorological conditions, and described in the report.

1.5.1 Hazardous components

LPG, Avgas and petrol are highly flammable substances, while diesel is not considered flammable but may sustain combustion after ignition. None of these components are considered to be acutely toxic.

Nitrogen is an inert gas but can replace air and act as an asphyxiant. . The nitrogen inventory has not been specified, and it is assumed that nitrogen would be generated on site with minimal inventory.

1.5.2 Notifiable substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances requires any employer who has a substance equal to or exceeding the quantity as listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Petrol, diesel, Avgas and nitrogen are not listed as notifiable products.

As more than 25 t of LPG would be stored in a single vessel in both Phase 1 and Phase 2, LPG would then be classified as a notifiable substance and automatically the facility would be classified as a Major Hazard Installation.

1.5.3 Transport pipelines from berthed ship to terminal

Transport pipelines would be used to carry CPP products and LPG to and from the terminal to and from the berths. Petrol was used for all modelling for the CPP pipelines to reflect the worst case scenario.

Impacts from petrol pool fires as well as LPG jet fires, flash fires and VCEs, due to a release from a single point on the relevant pipeline with an ignition, could extend various distances from that pipeline.

The worst case of the failure of the LPG pipeline could extend 230 m to the 1% fatality but would not constitute a NEMA Section 30 incident as it wouldn't reach an area used by the general public or cause pollution to the environment.

The worst case of the failure of the CPP pipeline could extend 95 m to the 1% fatality and would constitute a NEMA Section 30 incident as it could cause pollution to the environment.

The risks are dominated by the flash fire and VCE risks. However, the risk of $1x10^{-6}$ fatalities per person per year isopleth follows the pipeline and always remains within TNPA area; therefore, there is no risk to the public.

1.5.4 LPG bulk storage and gantries

LPG would be transported from ships to the LPG storage vessels from there the LPG would be loaded into road or rail tankers.

The 1% fatality for jet fires, due to the release from a single mounded vessel in Phase 1 followed by ignition, could extend beyond the site boundary but not beyond the TNPA area.

In worst conditions, a flash fire or VCE from a similar loss of containment of LPG could extend across the bay into the harbour area but would not extend into the residential areas. This would constitute a NEMA Section 30 incident as it could reach the public.

A BLEVE would not be expected at the bulk storage tanks of Phase 1 as the tanks would be mounded to prevent LPG pooling below the tank. However, a BLEVE could be formed at the LPG stenched vessel or at the LPG road and rail tankers. While the impacts could extend beyond the VSAD facility, no fatalities would be expected outside of the TNPA area.

VSAD has indicated that Phase 2 may include two LPG spherical vessels. A VCE would produce the greatest distance to the 1% fatality isopleth, which could extend beyond the site boundary but not beyond the TNPA area.

The risk of $3x10^{-7}$ fatalities per person per year isopleth, representing trivial risk, could extend about 2.9 km downwind from the release into the harbour area but not into the residential areas. The risk of $1x10^{-6}$ fatalities per person per year isopleth could extend beyond Port Authority into unoccupied ocean. Thus, the risk due to the proposed facility would be considered acceptable provided that the PADHI land use restrictions are applied.

1.5.5 Bulk atmospheric storage and gantries

The terminal would receive CPP liquid fuels and other components that would be stored in bulk tanks and dispatched by ship, road or rail. Petrol was used for all modelling to reflect the worst case scenario.

The 1% fatality due to pool fires at Phase 1 bulk storage could extend beyond the site boundary but not beyond the TNPA area. Releases from the road and railway gantries would be collected in the sump. Impacts from pool fires at the sump would not extend beyond the site boundary.

Impacts at Phase 1 bulk storage from tank-top fires, flash fires, fixed-roof tank explosions and VCEs would not extend beyond the site boundaries. The process description provided indicated that spillages at the road and rail gantry would be directed to the sump, making BLEVEs of road and rail tankers an implausible scenario.

The risk was calculated to include Phase 2 bulk storage. The risk of $1x10^{-4}$fatalities per person per year isopleth, representing the upper limit of tolerable, extends beyond the site boundary on the southern and eastern site boundaries but would not extend beyond the TNPA area. Thus, the risks to the public would be considered acceptable.

1.5.6 Consolidated risks

The consolidated risk was combined from the contributions of each hazardous area on site for Phase 1of the project.

The risk of $1x10^{-4}$ fatalities per person per year isopleth (generally considered the upper limit of tolerable) remains within the TNPA area and does not enter areas used by the general public.

Similarly, the risk of $1x10^{-6}$ fatalities per person per year isopleth, representing the lower limit of tolerable, does not extend into areas used by the general public. Risks less than $3x10^{-7}$ fatalities per person per year would be considered trivial and acceptable for land use by vulnerable populations, such as hospitals, nursery schools, retirement homes, etc.

The addition of Phase 2 would increase the extent of the risk of $1x10^{-6}$ fatalities per person per year isopleth but would have little effect otherwise. As the components to be stored in the tanks of Phase 2 have not been full described, this study assumed the worst case as petrol. In the event that the tanks would contain higher flashpoint materials, the risk isopleths may diminish in size.

1.5.7 Land planning

Currently, the surrounding land use is agricultural, and as such the terminal does not pose risks to the public at large. It would be preferable for the surrounding land use to remain agricultural. If the land use changed, acceptable usage can be confirmed using the HSE land planning guidelines (HSE 2011). The PADHI land-planning tables can be found attached in Appendix H.

1.5.8 Major Hazard Installation

This investigation concluded that the proposed VSAD terminal in Richards Bay, including the transportation pipelines and the terminal, **would be considered a Major Hazard Installation as more than 25 t of LPG in both Phase 1 and Phase 2 would be stored in a single vessel and LPG would thereby be classified as notifiable substance**.

This study is not intended to replace the Major Hazard Installation risk assessment. Once detail designs have been finalised incorporating the mitigation of the EIA, the MHI risk assessment should be completed prior to construction of the terminal to determine the acceptability of the risks posed to the public.

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1.6 Recommendations

As a result of the risk assessment study conducted for the proposed VSAD terminal in Richards Bay a number of events were found to have risks beyond the site boundary. These risks could be mitigated to acceptable levels, as shown in the report.

RISCOM did not find any fatal flaws that would prevent the project proceeding to the detailed engineering phase of the project.

RISCOM would support the project with the following conditions:

1. Compliance with all statutory requirements, i.e. pressure vessel designs;
2. Compliance with applicable SANS codes, i.e. SANS 10087, SANS 10089, SANS 10108, etc.;
3. Incorporation of applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
4. Completion of a recognised process hazard analysis (such as a HAZOP study, FMEA, etc.) on the proposed facility prior to construction to ensure design and operational hazards have been identified and adequate mitigation put in place;
5. Full compliance with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent to ensure that adequate protective instrumentation is included in the design and would remain valid for the full life cycle of the tank farm:
   a. Including demonstration from the designer that sufficient and reliable instrumentation would be specified and installed at the facility;
6. Preparation and issue of a safety document detailing safety and design features reducing the impacts from fires, explosions and flammable atmospheres to the MHI assessment body at the time of the MHI assessment:
   a. Including compliance to statutory laws, applicable codes and standards and world's best practice;
   b. Including the listing of statutory and non-statutory inspections, giving frequency of inspections;
   c. Including the auditing of the built facility against the safety document;
   d. Noting that codes such as IEC 61511 can be used to achieve these requirements;
7. Demonstration by VSAD or their contractor that the final designs would reduce the risks posed by the installation to internationally acceptable guidelines;
8. Signature of all terminal designs by a professional engineer registered in South Africa in accordance with the Professional Engineers Act, who takes responsibility for suitable designs;
9. Completion of an emergency preparedness and response document for on-site and off-site scenarios prior to initiating the MHI risk assessment (with input from local authorities);
10. Permission not being granted for increases to the product list or product inventories without redoing part of or the full EIA;
11. Final acceptance of the facility risks with an MHI risk assessment that must be completed in accordance to the MHI regulations:
    a. Basing such a risk assessment on the final design and including engineering mitigation.

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1.7 Limitations (data gaps and assessment shortcomings)

The risk assessment was based on the designs of the pipeline routing and tank farm layout at the time of preparing this study. Furthermore, EIAs are intended to suggest mitigation which may alter the design and layout of the project. It is thus understood that post EIA and the Record of Decision detailed designs would be required to complete the project for construction.

RISCOM used the information provided and made engineering assumptions as described in the document. The accuracy of the document would be limited to the available documents presented at the EIA.

The risk assessment excludes the following:

- Road and rail transportation outside of the facility;
- Natural events such as earthquakes and floods;
- Ecological risk assessment;
- An emergency plan.

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1.8 References

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1.9 Appendix A: Department of Labour certificate

Republic of South Africa

Department of Labour

Certificate

This is to certify that

RISCOM (PTY) LTD

Has been approved as an

APPROVED INSPECTION AUTHORITY

Type A; Explosive Chemicals, Gases, Flammable Gases, Non-Flammable, Non toxic gases (asphyxiants), Toxic gases and Flammable liquids, Flammable solids, Substances liable to spontaneous combustion, Substances that on contact with water release flammable gasses, Oxidizing substances and organic peroxides, Toxic liquids and Solids.

In terms of the Occupational Health and Safety Act, 1993, read with the Major Hazard Installation Regulations 5(5) (a) regarding risk assessments

....

Chief Inspector

Valid From: 27 May 2013

Expires: 26 May 2017

MHI 0005

....

Certificate Number

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1.10 Appendix B: SANAS certificates

sanas
South African National
Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2)(b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

RISCOM (PTY) LTD
Co. Reg. No.: 2002/019697/07
JOHANNESBURG

Facility Accreditation Number: **MHI0013**

Is a South African National Accreditation System accredited Inspection Body to undertake **TYPE A** inspection provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation, Annexure "A", bearing the above accreditation number for

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:2012

The accreditation demonstrates technical competency for a defined scope and the operation of a quality management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates

Mr R Josias
Chief Executive Officer

Effective Date: 27 May 2013
Certificate Expires: 26 May 2017

This certificate does not, on its own confer authority to act as an Approved Inspection Authority as contemplated in the Major Hazard Installation Regulations. Approval to inspect within the regulatory domain is granted by the Department of Labour.

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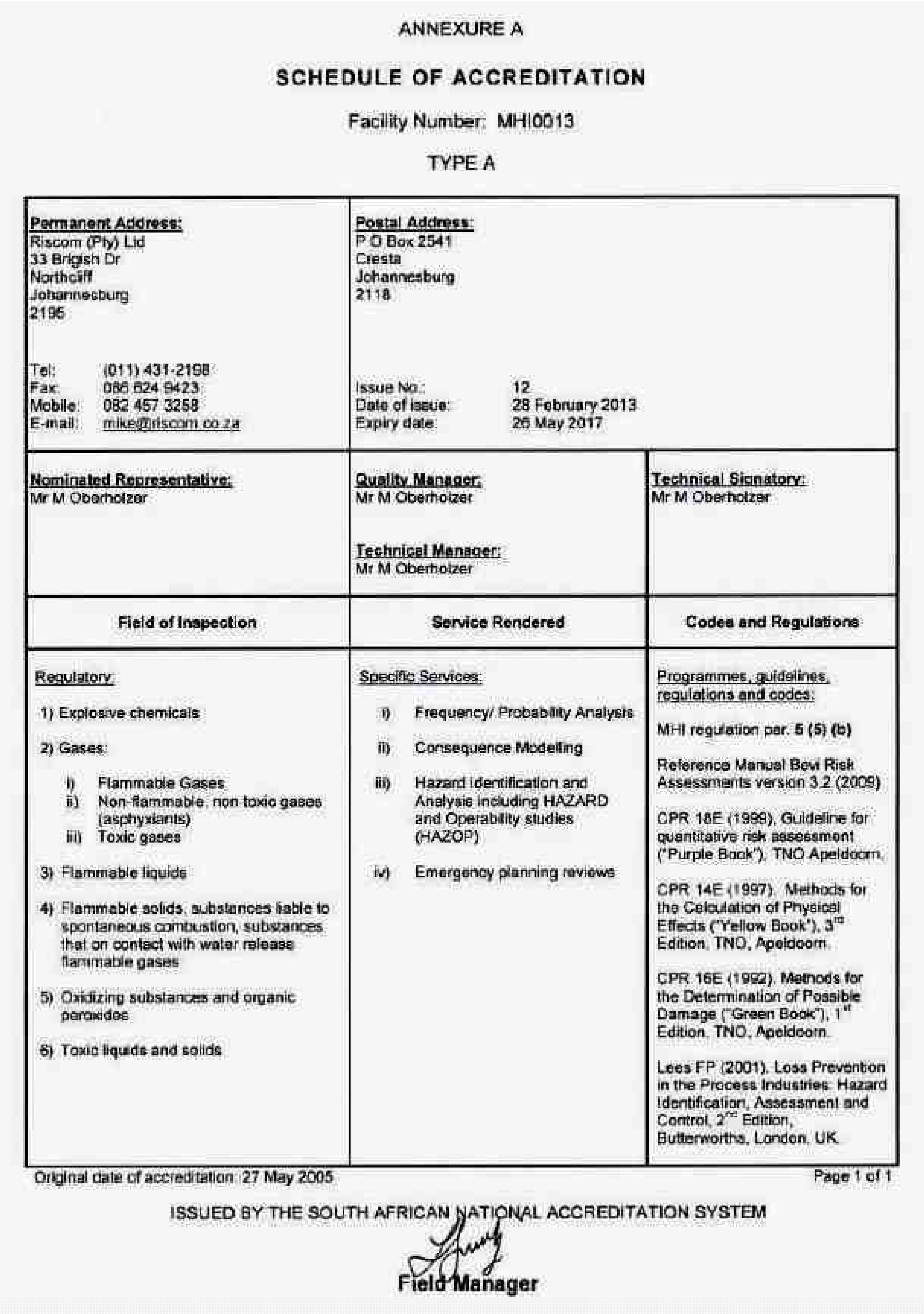

ANNEXURE A

SCHEDULE OF ACCREDITATION

Facility Number: MHI0013

TYPE A

Permanent Address:
Riscom (Pty) Ltd
33 Brigish Dr
Northcliff
Johannesburg
2195

Tel: (011) 431-2198
Fax: 086 624 9423
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Postal Address:
P O Box 2541
Cresta
Johannesburg
2118

Issue No.: 12
Date of issue: 28 February 2013
Expiry date: 26 May 2017

Nominated Representative:
Mr M Oberholzer

Quality Manager:
Mr M Oberholzer

Technical Manager:
Mr M Oberholzer

Technical Signatory:
Mr M Oberholzer

Field of Inspection	Service Rendered	Codes and Regulations
Regulatory: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	Specific Services: i) Frequency/ Probability Analysis ii) Consequence Modelling iii) Hazard identification and Analysis including HAZARD and Operability studies (HAZOP) iv) Emergency planning reviews	Programmes, guidelines, regulations and codes: MHI regulation par. 5 (5) (b) Reference Manual Bevi Risk Assessments version 3.2 (2009) CPR 18E (1999), Guideline for quantitative risk assessment ("Purple Book"), TNO Apeldoorn. CPR 14E (1997). Methods for the Calculation of Physical Effects ("Yellow Book"), 3rd Edition, TNO, Apeldoorn. CPR 16E (1992), Methods for the Determination of Possible Damage ("Green Book"), 1st Edition, TNO, Apeldoorn. Lees FP (2001). Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control, 2nd Edition, Butterworths, London, UK

Original date of accreditation: 27 May 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Field Manager

1.11 Appendix C: Notification of Major Hazard Installation classification

Prior to the assessment of the potential impact of the various accidental spills, reference needs to be made to the legislation, regulations and guidelines governing the operation of the development.

Section 1 of the Occupational Health and Safety Act (OHS Act; Act No. 85 of 1993) defines a "*major hazard installation*" to mean an installation:

> *“ (a) Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily;*
>
> *(b) Where any substance is produced, processed, used, handled or stored in such a form and quantity that it has the potential to cause a major incident (our emphasis). ”*

It should be noted that if either (a) or (b) is satisfied, the Major Hazard Installation (MHI) regulations will apply. The prescribed quantity of a chemical can be found in Section 8(1) of the General Machinery Regulation 8.

A major incident is defined as: "*an occurrence of catastrophic proportions, resulting from the use of plant and machinery or from activities at a workplace*”. Catastrophic in this context means loss of life and limbs or severe injury to employees or members of the public, particularly those who are in the immediate vicinity.

It is important to note that the definition refers to an occurrence, whereas Section 1b) refers to the potential to cause a major incident. If the potential to cause a major incident exists, then the OHS Act and the Major Hazard Installation regulations will apply (our emphasis).

On the 16th of January 1998, the MHI regulations were promulgated under the OHS Act (Act No. 85 of 1993), with a further amendment on the 30th of July 2001. The provisions of the regulations apply to installations that have on their premises a certain quantity of a substance that can pose a significant risk to the health and safety of employees and the public.

The scope of application given in Section 2 of the MHI regulations is as follows:

> *“ (1) Subject to the provisions of Subregulation (3) these regulations shall apply to employers, self-employed persons and users, who have on their premises, either permanently or temporarily, a major hazard installation or a quantity of a substance which may pose a risk that could affect the health and safety of employees and the public (our emphasis);*
>
> *(2) These regulations shall apply to local governments, with specific reference to Regulation 9. “*

It is important to note that the regulations refer to a substance, and furthermore the regulations are applicable to risks posed by the substance and **NOT** merely the potential consequences (our emphasis).

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The regulations essentially consist of six parts, namely:

1. Duties for notification of a Major Hazard Installation (existing or proposed), including:
   a. Fixed (see List 1);
   b. Temporary installations;
2. The minimum requirements for a quantitative risk assessment (see List 2);
3. The requirements of an on-site emergency plan (see List 3);
4. The reporting steps of risk and emergency occurrences (see List 4);
5. The general duties required of suppliers;
6. The general duties required of local government.

Notification of installation (List 1) indicates that:

- Applications need to be made in writing to the relevant local authority and the provincial director for permission:
  - To erect any Major Hazard Installation;
  - Prior to the modification of any existing installation that may significantly increase the risk related to it (e.g. an increase in the storage or production capacity or alteration of the process);
- Applications need to include the following information:
  - Physical address of installation;
  - Complete material safety data sheets of all hazardous substances;
  - Maximum quantity of each substance envisaged to be on the premises at any one time;
  - The risk assessment of the installation (see List 2);
  - Any further information that may be deemed necessary by an inspector in the interests of health and safety to the public;
- Applications need to be advertised in at least one newspaper serving the surrounding communities and by way of notices posted within these communities.

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The risk assessment (List 2):

- Is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a Major Hazard Installation and the measures required to remove, reduce or control the potential causes of such an incident;
- Needs to be undertaken at intervals not exceeding 5 years and needs to be submitted to the relevant local emergency services;
- Must be made available in copies to the relevant health and safety committee and 60 days must be given to comment thereon and ensure that the results of the assessment be made available to any relevant representative or committee to comment thereon;
- Should be undertaken by competent person(s) and include the following:
  - A general process description;
  - A description of major incidents associated with this type of installation and the consequences of such incidents (including potential incidents);
  - An estimation of the probability of a major incident;
  - The on-site emergency plan;
  - An estimation of the total result in the case of an explosion;
  - An estimation of the effects of thermal radiation in the case of fire;
  - An estimation of concentration effects in the case of a toxic release;
  - Potential effects of a major incident on an adjacent major hazard installation or part thereof;
  - Potential effects of a major incident on any other installation, members of the public (including all persons outside the premises) and on residential areas;
  - Meteorological tendencies;
  - Suitability of existing emergency procedures for the risks identified;
  - Any requirements laid down in terms of the Environmental Conservation Act of 1989 (Act No. 73 of 1989);
  - Any organisational measures that may be required;
  - The employer shall ensure that the risk assessment is of an acceptable standard and shall be reviewed should:
    - It be suspected that the preceding assessment is no longer valid;
    - Changes in the process that affect hazardous substances;
    - Changes in the process that involve a substance that resulted in the installation being classified a Major Hazard Installation or in the methods, equipment or procedures for the use, handling or processing of that substance;
    - Incidents that have brought the emergency plan into operation and may affect the existing risk assessment;
- Must be made available at a time and place and in a manner agreed upon between parties for scrutiny by any interested person that may be affected by the activities.

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Requirements related to the on-site emergency plan (List 3) are:

- After submission of the notification, the following shall be established:
    - An on-site emergency plan must be made available and must be followed inside the premises of the installation or the part of the installation classified as a Major Hazard Installation, in consultation with the relevant health and safety representative or the relevant health and safety committee;
    - The on-site emergency plan must be discussed with the relevant local government, taking into consideration any comment on the risk related to the health and safety of the public;
    - The on-site emergency plan must be reviewed and where necessary updated, in consultation with the relevant local government, at least once every three years;
    - A copy of the on-site emergency plan must be signed in the presence of two witnesses, who shall attest the signature;
    - The on-site emergency plan must be readily available at all times for implementation and use;
    - All employees must be conversant with the on-site emergency plan;
    - The on-site emergency plan must be tested in practice at least once a year, and a record must be kept of such testing;
- Any employer, self-employed person and user owning or in control of a pipeline that could pose a threat to the general public shall inform the relevant local government and shall be jointly responsible with the relevant local government for the establishment and implementation of an on-site emergency plan.

In reporting of risk and emergency occurrences (List 4):

- Following an emergency occurrence, the user of the installation shall:
    - Subject to the provisions of Regulation 6 of the General Administrative Regulations, within 48 hours by means of telephone, facsimile or similar means of communication inform the chief inspector, the provincial director and relevant local government of the occurrence of a major incident or an incident that brought the emergency plan into operation or any near miss;
    - Submit a report in writing to the chief inspector, provincial director and local government within seven days;
    - Investigate and record all near misses in a register kept on the premises, which shall at all times be available for inspection by an inspector and local government representatives.

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The duties of the supplier refer specifically to:

- The supplying of material safety data sheets for the hazardous substances employed or contemplated in the installation;
- Assessment of the circumstances and substance involved in an incident or potential incident and the informing all persons being supplied with that substance of the potential dangers surrounding it;
- Provision of a service that shall be readily available on a 24-hour basis to all employers, self-employed persons, users, relevant local government and any other body concerned to provide information and advice in the case of a major incident with regard to the substance supplied.

The duties of local government are summarised as follows:

" 9. (1) Without derogating from the provisions of the National Building Regulations and Building Standards Act of 1977 (Act No. 103 of 1977), no local government shall permit the erection of a new major hazard installation at a separation distance less than that which poses a risk to:

(a) Airports;
(b) Neighbouring independent major hazard installations;
(c) Housing and other centres of population; or,
(d) Any other similar facility…

Provided that the local government shall permit new property development only where there is a separation distance which will not pose a risk (our emphasis) in terms of the risk assessment: Provided further that the local government shall prevent any development adjacent to an installation that will result in that installation being declared a major hazard installation.

(2) Where a local government does not have facilities available to control a major incident or to comply with the requirements of this regulation that local government shall make prior arrangements with a neighbouring local government, relevant provincial government or the employer, self-employed person and user for assistance…

(3) All off-site emergency plans to be followed outside the premises of the installation or part of the installation classified as a major hazard installation shall be the responsibility of the local government… "

1.12 Appendix D: Methodology

As mentioned in the introduction of the report, the Major Hazard Installation (MHI) regulations give instructions to the applicant regarding the requirements of the risk assessment but stop short on providing methodologies and criteria that must be used for such studies.

As an approved inspection authority (AIA), RISCOM (PTY) LTD uses the methodologies and criteria described in the internationally recognised CPR 18E (Purple Book) and RIVM (2009) that constitute documentation to which conformance can be measured. This is a requirement of accreditation and implies that similar results should be obtained by independent risk assessors compliant to the aforementioned documents. Furthermore, CPR 18E (Purple Book) and RIVM (2009) are legal requirements for conducting quantitative risk assessments (QRAs) in the Netherlands and form the basis of commercially available software.

The evaluation of the acceptability of risks is extended to the ALARP criteria of the Health and Safety Executive (HSE) of the United Kingdom, which clearly explains and covers land use based on determined risks (see the subsection dealing with ‘Acceptable risks’).

The QRA process is summarised with the following steps:

1. The identification of components that are flammable, toxic, reactive or corrosive and that have the potential to result in a major incident from fires, explosions or toxic releases;
2. The development of accidental loss-of-containment scenarios for equipment containing hazardous components (including the release rate, location and orientation of release);
3. For each incident developed in Step 2, the determination of the consequences (thermal radiation, domino effects, toxic-cloud formation, etc.);
4. For scenarios with off-site consequences (i.e. greater than 1% fatality off-site), the calculation of the maximum individual risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

1.12.1 Hazard identification

The first step in any risk assessment is to identify all hazards. The merit of including a hazard for further investigation is then determined by how significant it is, normally by using a cut-off or threshold value.

Once a hazard has been identified, it is necessary to assess it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequence should be considered but there are occasions where, if either the probability or the consequence can be shown to be sufficiently low or sufficiently high, decisions can be made based on just one factor.

During the hazard identification component of the report, the following considerations are taken into account:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- The type and design of containers, vessels or pipelines;
- The quantity of material that could be involved in an airborne release;
- The nature of the hazard most likely to accompany hazardous materials spills or releases, e.g. airborne toxic vapours or mists, fires or explosions, large quantities in storage and certain handling conditions of processed components.

The evaluation methodology assumes that the facility will perform as designed in the absence of unintended events such as component and material failures of equipment, human errors, external events and process unknowns.

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1.12.2 Scenario selection

This risk assessment is based upon the analysis of a series of scenarios that characterise the release mechanisms that determine the nature and extent of consequences or impacts. Furthermore, impacts that do not extend beyond the site boundary, determined by the 1% fatality, can be excluded from the risk assessment.

The selection of the release scenarios ultimately determines the accuracy of the risk assessment and must cover both low and high frequency events.

The guidelines for the selection of scenarios is given in RIVM (2009) and CPR 18E (Purple Book). A particular scenario may produce more than one major consequence. In such cases, the consequences are evaluated separately and assigned failure frequencies in the risk analysis. Some of these phenomena are described in the subsections that follow.

Scenarios for release of a pressurised liquefied gas

The nature of the release of a liquefied gas from a pressurised vessel is dependent on the position of the hole.

A hole above the liquid level will result in a vapour release only, and the release rate would be related to the size of the hole and internal pressure of the tank. Over a period of time, the bulk temperature reduces, with an associated decrease in the vapour release rate.

A hole below the liquid level will result in a release of a liquid stream. With the reduced pressure of the atmosphere, a portion of the liquid will vaporise at the normal boiling point. This phenomenon is called flashing, as shown in Figure 34. The pool, formed after flashing, then evaporates at a rate proportional to the pool area, surrounding temperature and wind velocity.

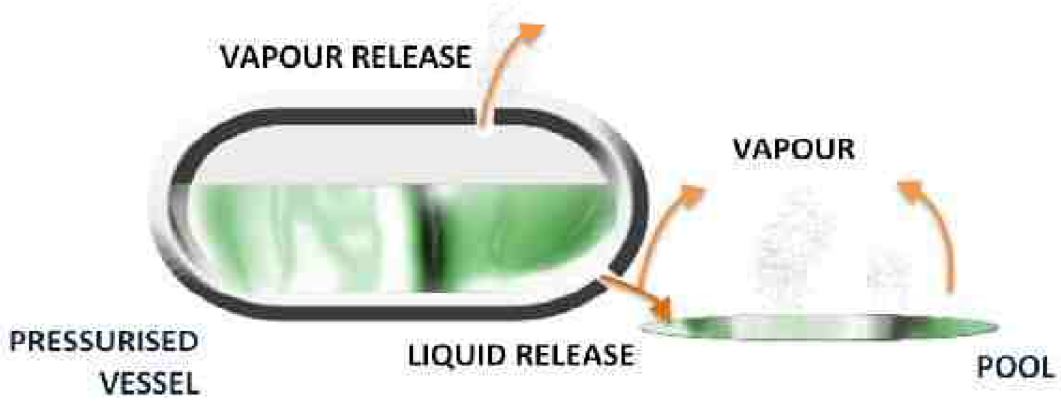

Figure 34: Airborne vapours from a loss of containment of liquefied gas stored in a pressurised vessel

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Instantaneous release of a liquefied flammable gas

An instantaneous loss of containment of a liquefied flammable gas could result in the consequences given in the event tree of Figure 35. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios of shown in the figure are determined separately and reported in the relevant subsections of the report.

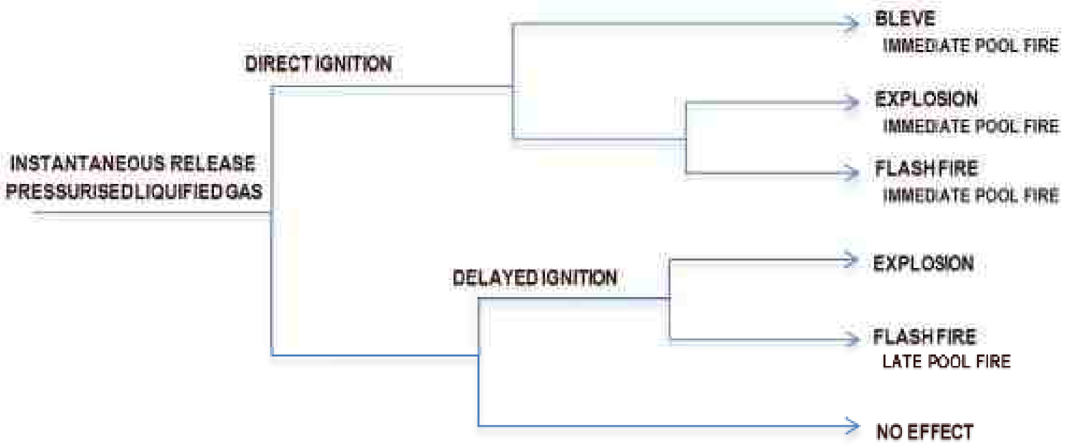

Figure 35: Event tree for an instantaneous release of a pressurised flammable gas

Continuous release of a pressurised liquefied flammable gas

A continuous loss of containment of a liquefied flammable gas could result in the consequences given in the event tree of Figure 36. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios shown in the figure are determined separately and reported in the relevant subsections of the report.

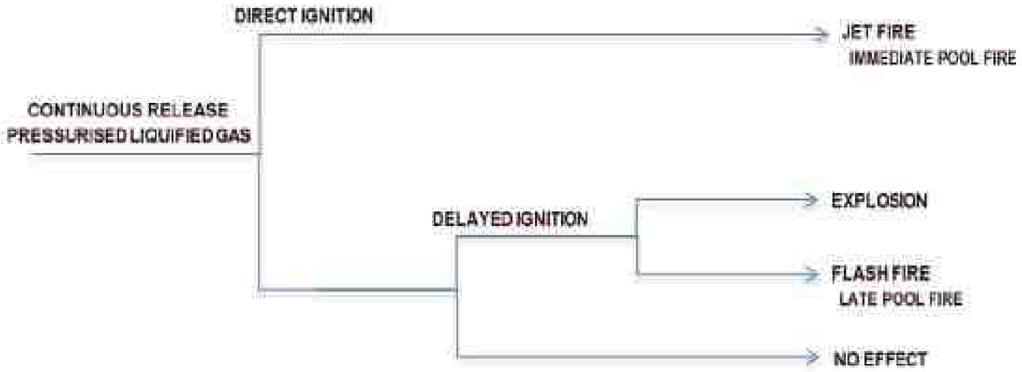

Figure 36: Event tree for a continuous release of a pressurised flammable gas

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Continuous release of a flammable liquid

A continuous loss of containment of flammable liquids could result in the consequences given in the event tree of Figure 37. The probabilities of the events occurring are dependent on a number of factors and are determined accordingly. All the scenarios shown in the figure are determined separately and reported in the relevant subsections of the report.

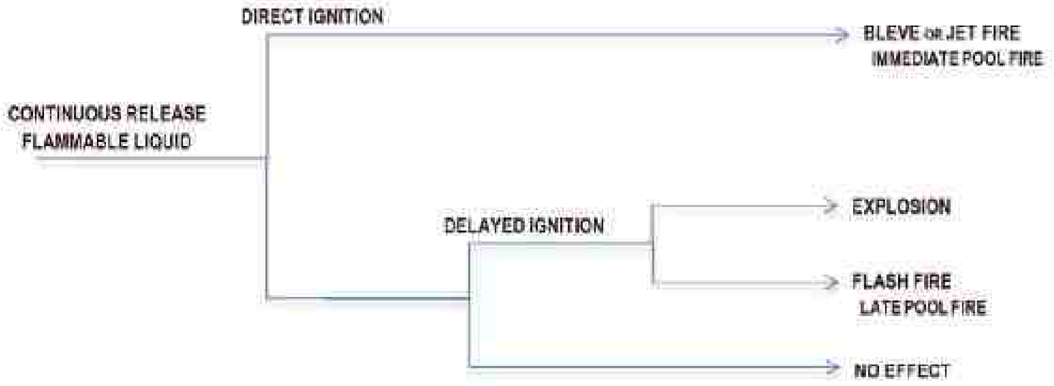

Figure 37: Event tree for a continuous release of a flammable liquid

1.12.3 Modelling software

The physical consequences were calculated with TNO's EFFECTS v. 9.0.20 and the data derived was entered into TNO's RISKCURVES v. 9.0.23. All calculations were performed by Mr M P Oberholzer.

1.12.4 Physical and consequence modelling

In order to establish the impacts following an accident, it is necessary first to estimate: the physical process of the spill (i.e. rate and size); the spreading of the spill; the evaporation from the spill; the subsequent atmospheric dispersion of the airborne cloud; and, in the case of ignition, the burning rate and resulting thermal radiation from a fire and the overpressures from an explosion.

The second step is then to estimate the consequences of a release on humans, fauna, flora and structures. This merely illustrates the significance and the extent of the impact in the event of a release. The consequences would be due to toxic and asphyxiant vapours, thermal radiation or explosion overpressures. The consequences may be described in various formats. The simplest methodology follows a comparison of predicted concentrations (or thermal radiation or overpressures) to short-term guideline values. In a different, but more realistic fashion, the consequences may be determined by using a dose-response analysis. Dose-response analysis aims to relate the intensity of the phenomenon that constitutes the hazard to the degree of injury or damage that it can cause. Probit analysis is possibly the method mostly used to estimate probability of death, hospitalisation or structural damage. The probit is a lognormal distribution and represents a measure of the percentage of the vulnerable resource that sustains injury or damage. The probability of injury or death (i.e. risk level) is in turn estimated from this probit (risk characterisation).

The consequence modelling gives an indication of the extent of the impact for selected events and is used primarily for emergency planning. A consequence that would not cause irreversible injuries would be considered insignificant, and no further analysis would be required.

This subsection addresses the impact of releases without taking into account the probability of occurrence. This merely illustrates the significance and the extent of the impact in the event of a release.

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1.12.4.1 Fires

Combustible materials within their flammable limits may ignite and burn if exposed to an ignition source of sufficient energy. On process plants this normally occurs as a result of a leakage or spillage. Depending on the physical properties of the material and the operating parameters, the combustion of material may take on a number of forms i.e. pool fires, jet fires and flash fires.

Thermal radiation

The effect of thermal radiation is very dependent on the type of fire and duration exposed to the thermal radiation. Certain codes, such as API 520 and API 2000, suggest the maximum heat absorbed by vessels for adequate relief designs to prevent the vessel from failure due to overpressure. Other codes, such as API 510 and BS 5980, give guidelines for the maximum thermal-radiation intensity that act as a guide to equipment layout, as given in Table 16.

The effect of thermal radiation on human health has been widely studied, relating injuries to the time and intensity of the radiation exposure.

Table 16: Thermal radiation guidelines (BS 5980 1990)

Thermal Radiation Intensity (kW/m^2)	Limit
1.5	Will cause no discomfort for long exposure
2.1	Sufficient to cause pain if unable to reach cover within 40 seconds
4.5	Sufficient to cause pain if unable to reach cover within 20 seconds
12.5	Minimum energy required for piloted ignition of wood and melting of plastic tubing
25	Minimum energy required to ignite wood at indefinitely long exposures
37.5	Sufficient to cause serious damage to process equipment

For pool fires, jet fires and flash fires CPR 18E suggests the following thermal radiation levels be reported:

- 4 kW/m^2, the level that glass can withstand, preventing the fire entering a building, and that should be used for emergency planning;
- 10 kW/m^2, the level that represents the 1% fatality for 20 seconds of unprotected exposure and at which plastic and wood may start to burn, transferring the fire to other areas;
- 35 kW/m^2, the level at which spontaneous ignition of hair and clothing occurs, with an assumed 100% fatality, and at which initial damage to steel may occur.

Bund and pool fires

Pool fires, either tank or bund fires, consist of large volumes of liquid flammable material at atmospheric pressure burning in an open space. The flammable material will be consumed at the burning rate, depending on factors including the prevailing winds. During combustion heat will be released in the form of thermal radiation. Temperatures close to the flame centre will be high but will reduce rapidly to tolerable temperatures over a relatively short distance. Any building or persons close to the fire or within the intolerable zone will experience burn damage with the severity depending on the distance from the fire and the time exposed to the heat of the fire.

In the event of a pool fire, the flames will tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of thermal radiation generated.

Tank-top fires

A tank-top fire occurs within the tank, and thus the pool fire is limited to the area of the tank. A tank-top fire could escalate to a bund fire should the tank fail, releasing flammable or combustible material into the bund.

Jet fires

Jet fires occur when flammable material of a high exit velocity ignites. In process industries this may be due to design (such as flares) or due to accidental releases. Ejection of flammable material from a vessel, pipe or pipe flange may give rise to a jet fire and in some instances the jet flame could have substantial ‘reach’.

Depending on wind speed, the flame may tilt and impinge on other pipelines, equipment or structures. The thermal radiation from these fires may cause injury to people or damage equipment some distance from the source of the flame.

For risk assessment studies the release would be assumed to be in the worst orientation. For belowground releases the orientation would be assumed to be vertical and for aboveground releases the orientation would be assumed to be horizontal.

Flash fires

A loss of containment of flammable material could form a cloud that could drift to a point of ignition. On ignition, the flammable cloud could form either a flash fire or a vapour cloud explosion. The extent of the flammable cloud would depend on the released quantity, physical properties of the released gas, wind speed and weather stability.

A flash fire would extend to the lower flammable limit (LFL), but due to the formation of pockets, it could extend beyond this limit to the point defined as the ½ LFL. It is assumed that people within the flash fire would experience lethal injuries, while people outside of the flash fire would remain unharmed. The ½ LFL is used for emergency planning to evacuate people to a safe distance in the event of a release.

It is assumed that the lethality rate for people within the flash fire would be 100% and 0% for people outside of the flash. A loss of containment of flammable materials would mix with air and form a flammable mixture. The cloud of flammable material would be defined by the lower flammable limit (LFL) and the upper flammable limit (UFL). The extent of the flammable cloud would depend on the quantity of released material, physical properties of the released gas, wind speed and weather stability. An ignition within a flammable cloud can result in an explosion if the front is propagated by pressure. If the front is propagated by heat, then the fire moves across the flammable cloud at the flame velocity and is called a flash fire. Flash fires are characterised by low overpressure, with injuries caused by thermal radiation. The effects of overpressure due to an exploding cloud are covered in the subsection dealing with vapour cloud explosions (VCEs).

A flash fire would extend to the lower flammable limit; however, due to the formation of pockets, it could extend beyond this limit to the point defined as the ½ LFL. It is assumed that people within the flash fire would experience lethal injuries while people outside of the flash fire would remain unharmed. The ½ LFL is used for emergency planning to evacuate people to a safe distance in the event of a release.

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1.12.4.2 Explosions

An explosion may give rise to any of the following effects:

- Blast damage;
- Thermal damage;
- Missile damage;
- Ground tremors;
- Crater formation;
- Personal injury.

Obviously, the nature of these effects depends on the pressure waves and the proximity to the actual explosion. Of concern in this investigation are the ‘far distance’ effects, such as limited structural damage and the breakage of windows, rather than crater formations. Table 17 and Table 18 give a more detailed summary of the damage produced by an explosion due to various overpressures.

CPR 18E (1999) suggests the following overpressures be determined:

- 0.03 bar overpressure, corresponding to the critical overpressure causing windows to break;
- 0.1 bar overpressure, corresponding to 10% of the houses being severely damaged and a probability of death indoors equal to 0.025 (no lethal effects are expected below 0.1 bar overpressure on unprotected people in the open);
- 0.3 bar overpressure, corresponding to structures being severely damaged and a probability of death equal to 1.0 for unprotected people in the open;
- 0.7 bar overpressure, corresponding to an almost entire destruction of buildings and 100% fatality for people in the open.

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Table 17: Summary of consequences of blast overpressure (Clancey 1972)

Pressure (Gauge)		Damage
Psi	kPa	
0.02	0.138	Annoying noise (137 dB), if of low frequency (10 – 15 Hz)
0.03	0.207	Occasional breaking of large glass windows already under strain
0.04	0.276	Loud noise (143 dB); sonic boom glass failure
0.1	0.69	Breakage of small under strain windows
0.15	1.035	Typical pressure for glass failure
0.3	2.07	‘Safe distance’ (probability 0.95; no serious damage beyond this value); missile limit; some damage to house ceilings; 10% window glass broken
0.4	2.76	Limited minor structural damage
0.5–1.0	3.45–6.9	Large and small windows usually shattered; occasional damage to window frames
0.7	4.83	Minor damage to house structures
1.0	6.9	Partial demolition of houses, made uninhabitable
1.0–2.0	6.9–13.8	Corrugated asbestos shattered; corrugated steel or aluminium panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blown in
1.3	8.97	Steel frame of clad building slightly distorted
2.0	13.8	Partial collapse of walls and roofs of houses
2.0–3.0	13.8–20.7	Concrete or cinderblock walls (not reinforced) shattered
2.3	15.87	Lower limit of serious structural damage
2.5	17.25	50% destruction of brickwork of house
3.0	20.7	Heavy machines (1.4 t) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations
3.0–4.0	20.7–27.6	Frameless, self-framing steel panel building demolished
4.0	27.6	Cladding of light industrial buildings demolished
5.0	34.5	Wooden utilities poles (telegraph, etc.) snapped; tall hydraulic press (18 t) in building slightly damaged
5.0–7.0	34.5–48.3	Nearly complete destruction of houses
7.0	48.3	Loaded train wagons overturned
7.0–8.0	48.3–55.2	Brick panels (20 – 30 cm) not reinforced fail by shearing or flexure
9.0	62.1	Loaded train boxcars completely demolished
10.0	69.0	Probable total destruction buildings; heavy (3 t) machine tools moved and badly damaged; very heavy (12 000 lb. / 5443 kg) machine tools survived
300	2070	Limit of crater lip

Table 18: Damage caused by overpressure effects of an explosion (Stephens 1970)

Equipment	Overpressure (psi)																								
	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	12	14	16	18	20
Control house steel roof	A	C	V				N																		
Control house concrete roof	A	E	P	D			N																		
Cooling tower	B			F			O																		
Tank: cone roof		D				K							U												
Instrument cubicle			A			LM						T													
Fire heater				G	I					T															
Reactor: chemical				A				I				P						T							
Filter				H					F									V			T				
Regenerator						I				IP					T										
Tank: floating roof						K							U												D
Reactor: cracking							I							I							T				
Pine supports							P					SO													
Utilities: gas meter									Q																
Utilities: electric transformer									H					I						T					
Electric motor										H								I							V
Blower										Q										T					
Fractionation column											R			T											
Pressure vessel horizontal												PI						T							
Utilities: gas regulator												I								MQ					
Extraction column													I							V	T				
Steam turbine															I						M	S			V
Heat exchanger															I			T							
Tank sphere																I						I	T		
Pressure vessel vertical																					I	T			
Pump																					I		Y		

A	Windows and gauges break
B	Louvers fall at 0.3–0.5 psi
C	Switchgear is damaged from roof collapse
D	Roof collapses
E	Instruments are damaged
F	Inner parts are damaged
G	Bracket cracks
H	Debris-missile damage occurs
I	Unit moves and pipes break
J	Bracing fails
K	Unit uplifts (half filled)
L	Power lines are severed
M	Controls are damaged
N	Block wall fails
O	Frame collapses
P	Frame deforms
Q	Case is damaged
R	Frame cracks
S	Piping breaks
T	Unit overturns or is destroyed
U	Unit uplifts (0.9 filled)
V	Unit moves on foundations

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Vapour loud Explosions (VCEs)

A release of flammable material into the atmosphere could result in the formation of a flash fire, as described in the subsection on flash fires, or a vapour cloud explosion (VCE).

The concentration of the combustible component would decrease from the point of release to below the lower explosive limits (LEL), at which concentration the component can no longer ignite. The material contained in the vapour cloud between the higher explosive limits (HEL) and the lower explosive limit (LEL), if it ignites, could form a flash fire or a fireball. The sudden detonation of the explosive mass of material would cause overpressures that can result in injury or damage to property.

Fixed-roof tank explosions

A confined gas explosion is where the exploding gas is restricted from expanding by physical barriers, such as walls or equipment and obstacles. A fixed-roof tank explosion is concerned with such an explosion within a tank. The explosive mass is calculated as the volume of the tank at its lower flammable limit (LFL). A fixed-roof explosion can only occur if a flammable atmosphere can be formed. For this study, only flammable components with flashpoints lower than 38°C were considered.

Boiling liquid expanding vapour explosions (BLEVEs)

A boiling liquid expanding vapour explosion (BLEVE) can occur when a flame impinges on a pressure cylinder, particularly in the vapour space region where cooling by evaporation of the contained material does not occur. The cylinder shell would weaken and rupture with a total loss of the contents, and the issuing mass of material would burn as a massive fireball.

The major consequences of a BLEVE are the intense thermal radiation from the fireball, a blast wave and fragments from the shattered vessel. These fragments may be projected to considerable distances. Analyses of the travel range of fragment missiles from a number of BLEVEs suggest that the majority land within 700 m from the incident. A blast wave from a BLEVE is fairly localised but can cause significant damage to immediate equipment.

A BLEVE occurs sometime after the vessel has been engulfed in flames. Should an incident occur that could result in a BLEVE, people should be evacuated to beyond the 1% fatality isopleth.

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1.12.5 Risk analysis

1.12.5.1 Background

It is important to understand the difference between hazard and risk.

A hazard is anything that has the potential to cause damage to life, property and the environment. Furthermore, it has constant parameters (of petrol, chlorine, ammonia, etc.) that pose the same hazard wherever present.

Risk, on the other hand, is the probability that a hazard will actually cause damage along with how severe that damage will be (consequence). Risk is therefore the probability that a hazard will manifest itself. For instance, the risks of a chemical accident or spill depends upon the amount present, the process the chemical is used in, the design and safety features of its container, the exposure, the prevailing environmental and weather conditions and so on.

Risk analysis consists of a judgement of probability based on local atmospheric conditions, generic failure rates and the severity of consequences, based on the best available technological information.

Risks form an inherent part of modern life. Some risks are readily accepted on a day-to-day basis, while certain hazards attract headlines even when the risk is much smaller, particularly in the field of environmental protection and health. For instance, the risk of one-in-ten-thousand chance of death per year associated with driving a car is acceptable to most people, whereas the much lower risks associated with nuclear facilities (one-in-ten-million chance of death per year) are deemed unacceptable.

A report by the British Parliamentary Office of Science and Technology (POST), titled ‘Safety in Numbers? Risk Assessment and Environmental Protection’, explains how public perception of risk is influenced by a number of factors in addition to the actual size of the risk. These factors were summarised as follows in Table 19.

Table 19: The influence of public perception of risk on the acceptance of that risk, based on the POST report

Control	People are more willing to accept risks they impose upon themselves or they consider to be ‘natural’ than to have risks imposed upon them
Dread and Scale of Impact	Fear is greatest where the consequences of a risk are likely to be catastrophic rather than spread over time
Familiarity	People appear more willing to accept risks that are familiar rather than new risks
Timing	Risks seem to be more acceptable if the consequences are immediate or short term, rather than if they are delayed (especially if they might affect future generations)
Social Amplification and Attenuation	Concern can be increased because of media coverage, graphic depiction of events or reduced by economic hardship
Trust	A key factor is how far the public trusts regulators, policy makers or industry; if these bodies are open and accountable (being honest as well as admitting mistakes and limitations and taking account of differing views without disregarding them as emotive or irrational), then the public is more likely consider them credible

A risk assessment should be seen as an important component of ongoing preventative actions, aimed at minimising or hopefully avoiding accidents. Reassessments of risk should therefore follow at regular intervals and after any changes that could alter the nature of the hazard, so contributing to the overall prevention programme and emergency response plan of the plant. Risks should be ranked in decreasing severity and the top risks reduced to acceptable levels.

Procedures for predictive hazard evaluation have been developed for the analysis of processes when evaluating very low probability accidents with very high consequences (for which there is little or no experience) as well as more likely releases with fewer consequences (for which there may be more information available). These address both the probability of an accident as well as the magnitude and nature of undesirable consequences of that accident. Risk is usually defined as some simple function of both the probability and consequence.

1.12.5.2 Predicted risk

The physical and consequence modelling addresses the impacts of a release of hazardous materials without taking into account the probability of occurrence. This merely illustrates the significance and the extent of the impact in the event of a release. The modelling also contains an analysis of the possibility of cascading or knock-on effects due to incidents in the facility and the surrounding industries and suburbs. In risk analysis the likelihood of various incidents is assessed, the consequences calculated and finally the risk for the facility is determined.

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Generic equipment failure scenarios

In order to characterise the various failure events and assign a failure frequency, fault trees were constructed starting with a final event and working from the top down to define all initiating events and frequencies. The analysis was completed using published failure rate data. Equipment failures can occur in tanks, pipelines and other items handling hazardous materials. These failures may result in:

- Release of combustible, flammable and explosive components with fires or explosions upon ignition;
- Release of toxic or asphyxiant components.

Storage tanks

Incidents involving storage tanks include catastrophic failure leading to product leakage into the bund and a possible bund fire. A tank-roof failure could result in a possible tank fire. A fracture of the tank nozzle or the transfer pipeline could also result in product leakage into the bund and a possible bund fire.

Typical failure frequencies for atmospheric tanks and pressure vessels are listed, respectively, in Table 20 and Table 21.

Table 20: Failure frequencies for atmospheric tanks

Event	Leak Frequency (per item per year)
Small leaks	$1x10^{-4}$
Severe leaks	$3x10^{-5}$
Catastrophic failure	$5x10^{-6}$

Table 21: Failure frequencies for pressure vessels

Event	Failure Frequency (per item per year)
Small leaks	$1x10^{-5}$
Severe leaks	$5x10^{-7}$
Catastrophic failure	$5x10^{-7}$

Transport and process piping

Piping may fail as a result of corrosion, erosion, mechanical impact damage, pressure surge (water hammer) or operation outside the design limitations for pressure and temperature. Failures caused by corrosion and erosion usually result in small leaks, which are detected and corrected early. For significant failures, the leak duration may be from 10–30 minutes before detection.

The generic data for leak frequency for process piping is generally expressed in terms of the cumulative total failure rate per year for a 10 m section of pipe and each pipe diameter. Furthermore, the failure frequency normally decreases with increasing pipe diameter. The scenarios and failure frequencies for a pipeline apply to pipelines with connections, such as flanges, welds and valves.

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The failure data given in Table 22 represents the total failure rate, incorporating all failures of whatever size and due to all probable causes. These frequencies are based on an environment where no excessive vibration, corrosion, erosion or thermal cyclic stresses are expected. For potential risk causing significant leaks (e.g. corrosion) the failure rate will be increased by a factor of 10.

Table 22: Failure frequencies for process pipes

Description	Frequencies of Loss of Containment for Process Pipes (per meter per year)	
	Full Bore Rupture	Leak
Nominal diameter < 75 mm	$1x10^{-6}$	$5x10^{-6}$
75 mm < nominal diameter < 150 mm	$3x10^{-7}$	$2x10^{-6}$
Nominal diameter > 150 mm	$1x10^{-7}$	$5x10^{-7}$

For scenarios and failure frequencies no distinction is made between process pipes and transport pipes, the materials from which a pipeline is made, the presence of cladding, the design pressure of a pipeline or its location on a pipe bridge. However, a distinction is made between aboveground pipes and underground pipes. The scenarios for aboveground pipes are given in Table 23, and those for underground pipes are given in Table 24.

Transport pipelines aboveground can be compared, under certain conditions, with underground pipes in a pipe bay. The necessary conditions for this are external damage being excluded, few to no flanges and accessories present and the pipe is clearly marked. In very specific situations the use of a lower failure frequency for transport pipes aboveground can be justified.

Table 23: Failure frequencies for aboveground transport pipelines

Description	Frequency (per meter per annum)		
	Nominal Diameter < 75 mm	75 mm > Nominal Diameter > 150 mm	Nominal Diameter > 150 mm
Full bore rupture	$1x10^{-6}$	$3x10^{-7}$	$1x10^{-7}$
Leak with an effective diameter of 10% of the nominal diameter, up to a maximum of 50 mm	$5x10^{-6}$	$2x10^{-6}$	$5x10^{-7}$

Table 24: Failure frequencies for underground transport pipelines

Description	Frequency (per meter per annum)		
	Pipeline in Pipe Lane[1]	Pipeline Complies with NEN 3650	Other Pipelines
Full bore rupture	$7x10^{-9}$	$1.525x10^{-7}$	$5x10^{-7}$
Leak with an effective diameter of 20 mm	$6.3x10^{-8}$	$4.575x10^{-7}$	$1.5x10^{-6}$

---

[1] A pipeline located in a 'lane' is a pipeline located in a group of pipelines on a dedicated route. Losses of containment frequencies for this situation are lower because of extra preventive measures.

Pumps and compressors

Pumps can be subdivided roughly into two different types: reciprocating pumps and centrifugal pumps. This last category can be further subdivided into canned pumps (sealless pumps) and pumps with seals (a gasket). A canned pump can be defined as an encapsulated pump where the process liquid is located in the space around the rotor (impeller) and in which case gaskets are not used.

Compressors can also be subdivided roughly into reciprocating compressors and centrifugal compressors.

Failure rates for pumps and compressors are given in Table 25 and Table 26.

Table 25: Failure frequency for centrifugal pumps and compressors

Event	Canned (No Gasket) Frequency (per annum)	Gasket Frequency (per annum)
Catastrophic failure	1.0×10^{-5}	1.0×10^{-4}
Leak (10% diameter)	5.0×10^{-5}	4.4×10^{-3}

Table 26: Failure frequency for reciprocating pumps and compressors

Event	Frequency (per annum)
Catastrophic failure	1.0×10^{-4}
Leak (10% diameter)	4.4×10^{-3}

Loading and unloading

Loading can take place from a storage vessel to a transport unit (road tanker, tanker wagon or ship) or from a transport unit to a storage vessel. The failure frequencies for loading and unloading arms are given in Table 27.

Table 27: Failure frequencies for loading and unloading arms and hoses

Event	Frequency (per hour)	
	Loading and Unloading Arms	Loading and Unloading Hoses
Rupture	3×10^{-8}	4×10^{-6}
Leak with effective diameter at 10% of nominal diameter to max. 50 mm	3×10^{-7}	4×10^{-5}

Road or rail tankers within the establishment

Road or rail tankers are transport vehicles with fixed and removable tanks. In addition, they include battery wagons and, insofar as these are fitted on a transport vehicle, tank containers, swap-body tanks and MEGCs (multiple element gas containers).

The failure rate of tankers at an establishment is dependent on the pressure rating of the tank and is given in Table 28 and Table 29.

Table 28: Failure frequencies for road tankers with an atmospheric tank

Event	Frequency (per annum)
Instantaneous release of the entire contents	$1x10^{-5}$
Release of contents from the largest connection	$5x10^{-7}$

Table 29: Failure frequencies for road tankers with a pressurised tank

Event	Frequency (per annum)
Instantaneous release of the entire contents	$1x10^{-7}$
Release of contents from the largest connection	$5x10^{-7}$

It should be noted that no scenarios are included for loss of containment as a result of external damage to tanker or fire in the surrounding areas. It is assumed that sufficient measures are taken to prevent external damage to the tanker.

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Human failure

Human error and failure can occur during any life cycle or mode of operation of a facility. In this respect, human failures can be divided into the following categories:

- Human failures during design, construction and modification of the facility;
- Human failure during operation and maintenance;
- Human failure due to errors of management and administration.

Human failures during design, construction and modification are part of the generic failures given in this subsection. Human failures concerning organisation and management are influencing factors. Some of the types of tasks that have been evaluated for their rates of human failure are given in Table 30.

Table 30: Human failure rates of specific types of tasks

Tasks	Human Failure (events per year)
Totally unfamiliar, performed at speed with no real idea of likely consequences	0.55
Failure to carry out rapid and complex actions to avoid serious incident such as an explosion	0.5
Complex task requiring high level of comprehension and skill	0.16
Failure to respond to audible alarm in control room within 10 minutes	1.0×10^{-1}
Failure to respond to audible alarm in quiet control room by some more complex action such as going outside and selecting one correct value among many	1.0×10^{-2}
Failure to respond to audible alarm in quiet control room by pressing a single button	1.0×10^{-3}
Omission or incorrect execution of step in a familiar start-up routine	1.0×10^{-3}
Completing a familiar, well-designed, highly-practiced, routine task occurring several times per hour, performed to highest possible standards by a highly-motivated, highly-trained and experienced person totally aware of implications of failures, with time to correct potential error but without the benefit of significant job aids	4.0×10^{-4}

Ignition probability of flammable gases and liquids

The estimation of the probability of an ignition is a key step in the assessment of risk for installations where flammable liquids or gases are stored. There is a reasonable amount of data available relating to characteristics of ignition sources and the effects of release type and location.

The probability of ignition for stationary installations is given in Table 31 (along with the classification of flammable substances in Table 32). These can be replaced with ignition probabilities related to the surrounding activities. For example, the probability of a fire from a flammable release at an open flame would increase to a value of 1.

Table 31: The probability of direct ignition for stationary installations (RIVM 2009)

Substance Category	Source-Term Continuous	Source-Term Instantaneous	Probability of Direct Ignition
Category 0 Average to high reactivity	< 10 kg/s 10 – 100 kg/s > 100 kg/s	< 1000 kg 1000 – 10 000 kg > 10 000 kg	0.2 0.5 0.7
Category 0 Low reactivity	< 10 kg/s 10 – 100 kg/s > 100 kg/s	< 1000 kg 1000 – 10 000 kg > 10 000 kg	0.02 0.04 0.09
Category 1	All flow rates	All quantities	0.065
Category 2	All flow rates	All quantities	0.0043[1]
Category 3 Category 4	All flow rates	All quantities	0

Table 32: Classification of flammable substances

Substance Category	Description	Limits
Category 0	Extremely flammable	Liquids, substances and preparations that have a flashpoint lower than 0°C and a boiling point (or the start of the boiling range) less than or equal to 35°C Gaseous substances and preparations that may ignite at normal temperature and pressure when exposed to air
Category 1	Highly flammable	Liquids, substances and preparations that have a flashpoint of below 21°C
Category 2	Flammable	Liquids, substances and preparations that have a flashpoint equal to 21°C and less than 55°C
Category 3		Liquids, substances and preparations that have a flashpoint greater than 55°C and less than or equal to 100°C
Category 4		Liquids, substances and preparations that have a flashpoint greater than 100°C

---

[1] This value is taken from the CPR 18E (1999). RIVM (2009) gives the value of delayed ignition as zero. RISCOM (PTY) LTD believes the CPR 18E is more appropriate for warmer climates and is a conservative value.

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1.12.5.3 Risk calculations

Maximum individual risk parameter

Standard individual risk parameters include: average individual risk; weighted individual risk; maximum individual risk; and, the fatal accident rate. The latter parameter is more applicable to occupational exposures. Only the maximum individual risk (MIR) parameter will be used in this assessment. For this parameter the frequency of fatality is calculated for an individual who is presumed to be present at a specified location. This parameter (defined as the consequence of the event multiplied by the likelihood of the event) is not dependent on knowledge of the population at risk. So, it is an easier parameter to use in the predictive mode than the average individual risk and weighted individual risk. The unit of measure is risk of fatality per person per year.

Acceptable risks

The next step, after having characterised a risk and obtained a risk level, is to recommend whether the outcome is acceptable. In contrast to the employees in a plant, who may be assumed to be healthy, the adopted exposure assessment applies to an average population group that also includes sensitive subpopulations. Sensitive subpopulation groups are those people that for reasons of age or medical condition have a greater than normal response to contaminants. Health guidelines and standards used to establish risk normally incorporate safety factors that address this group.

Among the most difficult tasks of risk characterisation is the definition of acceptable risk. In an attempt to account for risks in a manner similar to those used in everyday life, the UK Health and Safety Executive (HSE) developed the risk ALARP triangle. Applying the triangle involves deciding:

- Whether a risk is so high that something must be done about it;
- Whether the risk is or has been made so small that no further precautions are necessary;
- If a risk falls between these two states that it has been reduced to levels as low as reasonably practicable (ALARP).

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This is illustrated in Figure 38.

ALARP stands for ‘as low as reasonably practicable’. As used in the UK, it is the region between that which is intolerable, at 1x10^{-4} per year, and that which is broadly acceptable, at 1x10^{-6} per year/ A further lower level of risk of 3x10^{-7} per year is applied to either vulnerable or very large populations for land-use planning.

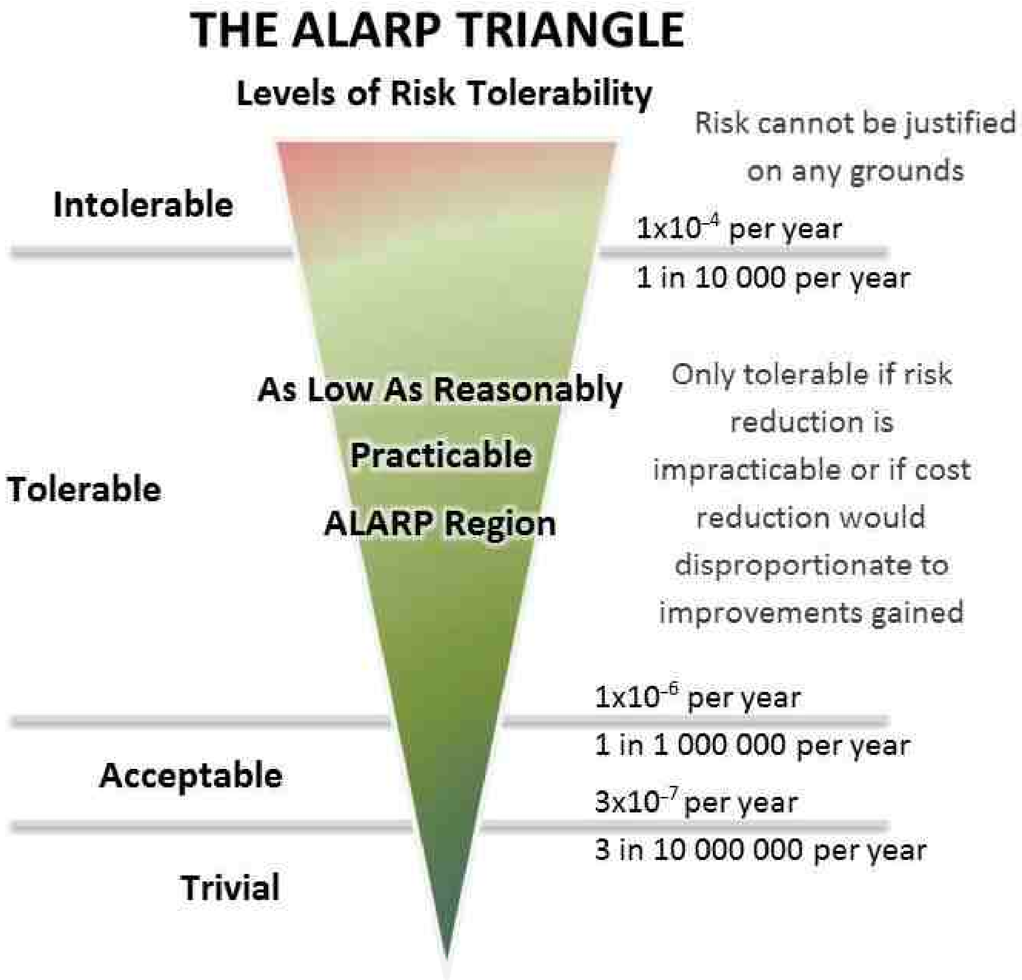

Figure 38: UK HSE decision-making framework

It should be noted that acceptable risks posed to workers are different to those posed to the public. This is due to the fact that workers have personal protection equipment (PPE), are aware of the hazards, are sufficiently mobile to evade or escape the hazards and receive training in preventing injuries.

The HSE (UK) gives more detail on the word practicable in the following statement:

> “ *In essence, making sure a risk has been reduced to ALARP is about weighing the risk against the sacrifice needed to further reduce it. The decision is weighted in favour of health and safety because the presumption is that the duty-holder should implement the risk reduction measure. To avoid having to make this sacrifice, the duty-holder must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. Extreme examples might be:*
>
> - *To spend £1m to prevent five staff members suffering bruised knees is obviously grossly disproportionate; but,*
> - *To spend £1m to prevent a major explosion capable of killing 150 people is obviously proportionate.*
>
> *Proving ALARP means that if the risks are lower than 1x10^{-4} fatalities per person per year it can be demonstrated that there would be no more benefit from further mitigation, sometimes using cost benefit analysis.* “

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Land planning

There are no legislative land-planning guidelines in South Africa and in many parts of the world. Further to this, land-planning guidelines vary from one country to another, and thus it is not easy to benchmark the results of this study to international criteria. In this instance, RISCOM would only advise on applicable land planning and would require governmental authorities to make final decisions.

The land zoning applied in this study follows the HSE (UK) approach of defining the area into three zones, consistent to the ALARP approach (HSE 2011).

The three zones are defined as follows: the inner zone (greater than $1x10^{-5}$ fatalities per person per year); the middle zone ($1x10^{-5}$ fatalities per person per year to $1x10^{-6}$ fatalities per person per year); and, the outer zone ($1x10^{-6}$ fatalities per person per year to $3x10^{-7}$ fatalities per person per year). The risks decrease from the inner zone to the outer zone as shown in Figure 39 and Figure 40.

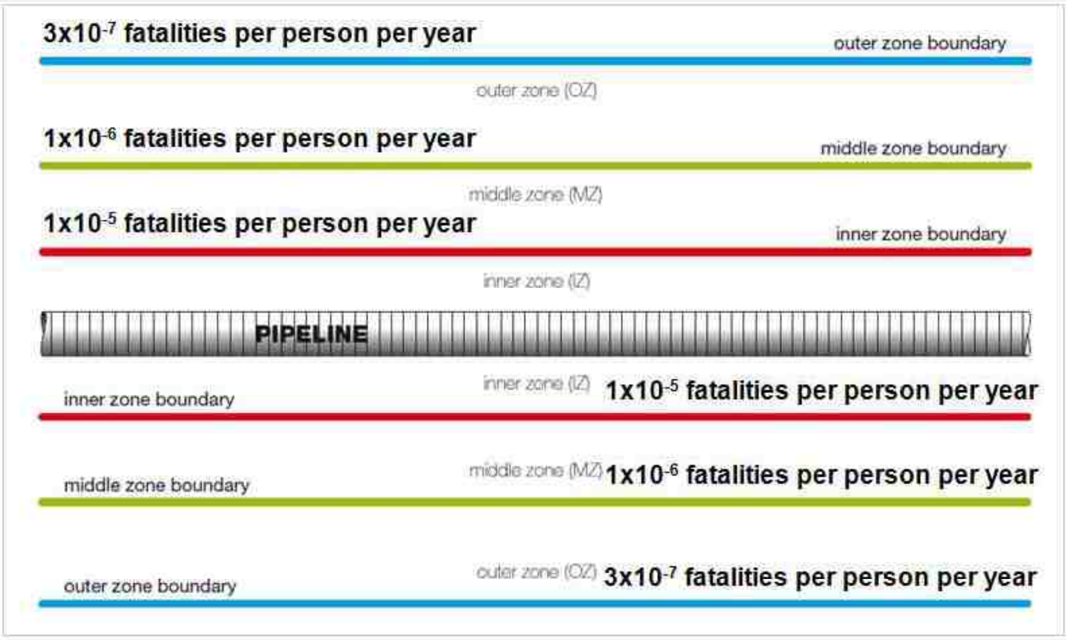

Figure 39: Town-planning zones for pipelines

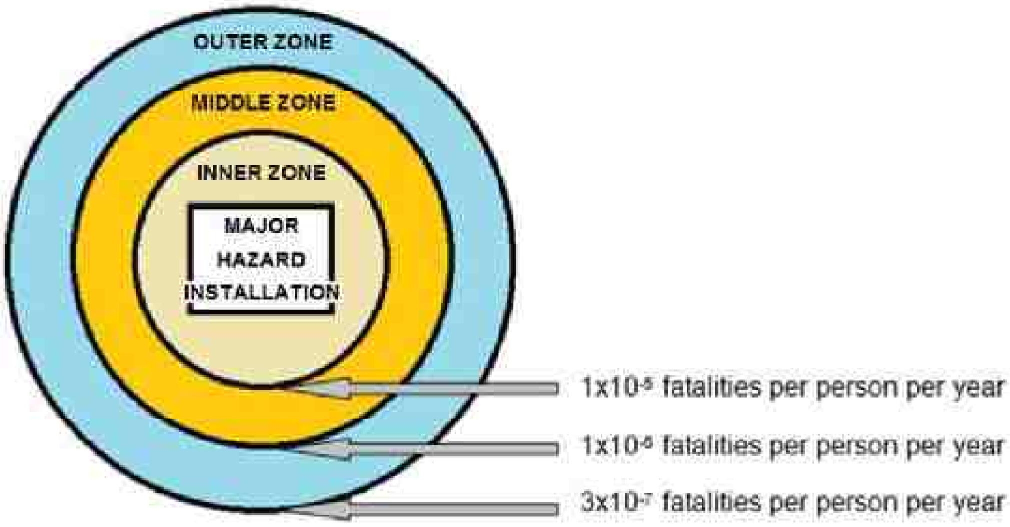

Figure 40: Town-planning zones

Once the zones are calculated, the HSE (UK) methodology then determines whether a development in a zone should be categorised as 'advised against' (AA) or as 'don't advise against' (DAA), depending on the sensitivity of the development, as indicated in Table 33. There are no land-planning restrictions beyond the outer zone.

Table 33: Land-use decision matrix

Level of Sensitivity	Development in Inner Zone	Development in Middle Zone	Development in Outer Zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA

The sensitivity levels are based on a clear rationale, progressively more severe restrictions are to be imposed as the sensitivity of the proposed development increases.

There are four sensitivity levels, with the sensitivity for housing defined as follows:

- Level 1: based on workers who have been advised of the hazards and trained accordingly;
- Level 2: based on the general public at home and involved in normal activities;
- Level 3: based on the vulnerability of members of the public (e.g. children, those with mobility difficulties or those unable to recognise physical danger);
- Level 4: large examples of Level 2 and of Level 3.

Refer to Appendix H for detailed planning advice for developments near hazardous installations (PADHI) tables. These tables illustrate how the HSE land-use decision matrix, generated using the three zones and the four sensitivity levels, is applied to a variety of development types.

1.12.5.4 Assessment rating of potential impacts

Impacts will be assessed using information gathered during the baseline assessment in combination with previously collected data and the detailed project plan. The impact assessment described in this subsection was supplied by Golder Associates (Pty) Ltd.

The significance of the identified impacts will be determined using the approach outlined in Table 34. This incorporates two aspects for assessment of potential significance (i.e. occurrence and severity), which are further subdivided as indicated in the table. The impact ranking will be described for both before and after implementation of mitigation or management measures.

Table 34: Classification of impacts for assessment

Occurrence			**Severity**				**Environmental Consequence**
Direction	**Probability**	**Duration**	**Magnitude**	**Geographic Extent**	**Reversibility**	**Frequency**	

Direction of an impact may be **positive**, **neutral** or **negative** with respect to the particular impact (e.g. habitat gain for a key species would be classed as positive, whereas habitat loss would be considered negative).

Probability of occurrence is a description of the probability of the impact actually occurring, rated as **improbable** (less than 5% chance), **low probability** (5% to 40% chance), **medium probability** (40% to 60% chance), **highly probable** (most likely; 60% to 90% chance) or **definite** (impact will definitely occur).

Duration refers to the length of time over which an environmental impact may occur, rated as **transient** (less than 1 year), **short term** (0-5 years; during construction), **medium term** (5-15 years; during operation), **long term** (greater than 15 years, with impact only ceasing after closure of the project) or **permanent**.

Magnitude is a measure of the degree of change in a measurement or analysis (e.g. the area of pasture or the concentration of a metal in water compared to the water quality guideline value for the metal). Magnitude is classified as **negligible** (no measurable effect on current conditions; < 1%), **low** (< 10% change from current conditions), **moderate** (10% to 20% change from current conditions) or **high** (> 20% change from current conditions). The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts or professional judgment) pertinent to the appropriate discipline area and key questions analysed. Each specialist study will attempt to quantify the magnitude and outline the rationale used.

Scale or **geographic extent** refers to the area that could be affected by the impact and is classified as **local** (effects restricted to the LSA), **regional** (effect extends beyond the LSA into the RSA) and **beyond regional** (effects extend beyond the RSA site).

Reversibility allows for the impact to be described as **reversible** or **irreversible**.

Frequency may be **low** (occurs once), **medium** (occurs intermittently) or **high** (occurs continuously).

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For **environmental consequence**, the overall residual consequence for each effect will be classified as **negligible**, **low**, **moderate** or **high** by evaluation of the rankings for magnitude, geographic extent and duration in Table 35.

Table 35: Categories describing environmental consequences

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur There is no possible mitigation that could offset the impact or mitigation is difficult
Moderate	Impact is real but not substantial in relation to other impacts that might take effect within the bounds of those that could occur Mitigation is both feasible and possible
Low	Impact is of a low order and therefore likely to have little real effect Mitigation is either easily achieved or little mitigation is required, or both
No impact	Zero impact.

Prediction confidence

Although not explicitly included in the criteria tables, there is uncertainty associated with the information and methods used in an EIA because of its predictive nature. The certainty with which an impact analysis can be completed depends on a number of factors including: understanding of natural or ecological and socioeconomic processes at work, now and in the future, and understanding of present and future properties of the affected resource.

The level of prediction confidence for an impact analysis will be discussed when there are questions about the factors reviewed previously. Where the level of prediction confidence makes a prediction of the impact problematic, a subjective assessment is made based on the available information, the applicability of information on surrogates and on professional opinion.

The level of prediction confidence is sufficiently low in some cases that an estimate of environmental consequence cannot be made with a sufficient degree of confidence. Undetermined ratings are accompanied by recommendations for research or monitoring to provide more data in the future.

Development of mitigation measures

A common approach to describing mitigation measures for critical impacts is to specify a range of targets with a predetermined acceptable range and an associated monitoring and evaluation plan. To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute. The following summarize the different approaches that may be used in prescribing and designing mitigation measures:

- Avoidance i.e. mitigation by not carrying out the proposed action on the specific site but rather on a more suitable site;
- Minimization i.e. mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact;
- Rectification i.e. mitigation through the restoration of environments affected by the action;
- Reduction i.e. mitigation by taking maintenance steps during the course of the action;
- Compensation i.e. mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

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1.13 Appendix E: Physical properties

1.13.1 Petrol and Avgas (modelled as heptane)

1.13.1.1 Heptane constants

Constant	Unit	Value
Acentric Factor		0.3495
Acid Association Flag		Not modelled
Aerosol Class Number		8
Combustion At		0.9468
Combustion Ct		0.01874
Critical Pressure	bar	27.4
Critical Temperature	°C	267.1
Emissive Power Length Scale	m	8.33
Flammable/Toxic Flag		Flammable
Flash Point	°C	-4.15
Heat of Combustion	kJ/kmol	4.47E+06
Immediate Ignition Category		Unknown
Laminar Burning Velocity	m/s	0.52
Lower Flammability Limit	ppm	1.00E+04
Luminous/Smoky Flame Flag		Smoky
Maximum Surface Emissive Power	kW/m^2	140
Melting Point	°C	-90.58
Molecular Weight		100.2
Normal Boiling Point	°C	98.43
Pool Fire Burn Rate Length	m	0.7
Reaction with Water Model		None
Reactivity with Atmosphere		Not strongly reactive
Solubility in Water		0
SRK Alpha Calculation Flag		Soave
Triple Point Pressure	bar	1.83E-06
Triple Point Temperature	°C	-90.58
Upper Flammability Limit	ppm	7.00E+04
Water Heat Transfer Coefficient	$W/m^2 \cdot K$	500

1.13.1.2 Heptane coefficients

Parameter	Equation Number	Lower Temp. Limit (°C)	Upper Temp. Limit (°C)	Coefficient A	Coefficient B	Coefficient C	Coefficient D	Coefficient E
Vapour Viscosity	102	-90.58	726.9	6.67E-08	0.8284	85.75	0	
Vapour Thermal Conductivity	102	66	726.9	-0.07003	0.3807	-7050	-2.40E+06	
Vapour Pressure	101	-90.58	267.1	87.83	-6996	-9.88	7.21E-06	2
Trimer Coefficients	101			0	0	0	0	0
Surface Tension	106	-90.58	267.1	0.05414	1.251	0	0	0
Second Virial Equation Coefficient	104	-3.05	1227	0.2746	-291	-4.42E+07	-8.80E+19	1.29E+22
Saturated Liquid Density	105	-90.58	267.1	0.6126	0.2621	540.2	0.2814	
Octamer Coefficients	101			0	0	0	0	0
Liquid Viscosity	101	-90.58	100	-24.45	1533	2.009	0	0
Liquid Thermal Conductivity	100	-90.58	98.43	0.215	-0.0003	0	0	0
Liquid Heat Capacity	114	-90.58	246.9	61.26	3.14E+05	1825	-2548	0
Ideal Gas Heat Capacity	107	-73.15	1227	1.20E+05	4.00E+05	1677	2.74E+05	756.4
Hexamer Coefficients	101			0	0	0	0	0
Dimer Coefficients	101			0	0	0	0	0

1.13.2 Diesel (modelled as dodecane)

1.13.2.1 Dodecane constants

Constant	Unit	Value
Acentric Factor		0.5764
Acid Association Flag		Not modelled
Combustion At		0.9418
Combustion Ct		0.01123
Critical Pressure	bar	18.2
Critical Temperature	°C	384.9
Emissive Power Length Scale	m	8.33
Flash Point	°C	73.85
Heat of Combustion	kJ/kmol	7.51E+06
Heat of Solution	kJ/kg	0
Laminar Burning Velocity	m/s	0.52
Liquid Water Surface Tension	dyne/cm	0
Lower Flammability Limit	ppm	6000
Luminous/Smoky Flame Flag		Smoky
Maximum Burn Rate	$kg/m^2 \cdot s$	0
Melting Point	°C	-9.582
Molecular Weight		170.3
Normal Boiling Point	°C	216.3
Pool Fire Burn Rate Length	m	0.1
Solubility in Water		0
TNT Explosion Efficiency	%	0
Triple Point Pressure	bar	6.15E-06
Triple Point Temperature	°C	-9.582
Upper Flammability Limit	ppm	4.90E+04
Water Heat Transfer Coefficient	$W/m^2 \cdot K$	0

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1.13.2.2 Dodecane coefficients

Parameter	Equation Number	Lower Temp. Limit (°C)	Upper Temp. Limit (°C)	Coefficient A	Coefficient B	Coefficient C	Coefficient D	Coefficient E
Vapour Viscosity	102	-9.58	726.9	6.34E-08	0.8287	219.5	0	
Vapour Thermal Conductivity	102	216.3	726.9	5.72E-06	1.47	579.4	0	
Vapour Pressure	101	-9.58	384.9	137.5	-1.20E+04	-16.7	8.09E-06	2
Trimer Coefficients	0			0				
Surface Tension	106	-9.58	384.9	0.05549	1.326	0	0	0
Second Virial Equation Coefficient	104	55.85	1227	0.88	-1091	-5.03E+07	-5.49E+21	1.50E+24
Saturated Liquid Density	105	-9.58	384.9	0.3554	0.2551	658	0.2937	
Octamer Coefficients	0			0				
Liquid Viscosity	101	-9.58	216.3	-18.8	1839	1.062	0	0
Liquid Thermal Conductivity	100	-9.58	216.3	0.2047	-0.000233	0	0	0
Liquid Heat Capacity	100	-9.58	56.85	5.08E+05	-1369	3.102	0	0
Ideal Gas Heat Capacity	107	-73.15	1227	2.13E+05	6.63E+05	1716	4.52E+05	777.5
Hexamer Coefficients	0			0				
Dimer Coefficients	0			0				

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1.14 Appendix F: Buncefield recommendations

1.14.1 Buncefield report Recommendation 1

The Competent Authority and operators of Buncefield-type sites should develop and agree a common methodology to determine safety integrity level (SIL) (Link to SIL Info) requirements for overfill prevention systems in line with the principals set out in Part 3 of BS EN 61511 resource centre link. This methodology should take into account of:

1. The existence of nearby sensitive resources or populations;
2. The nature and intensity of depot operations;
3. Realistic reliability expectations for tank gauging systems;
4. The extent/rigour of operator monitoring.

Application of the methodology should be clearly demonstrated in the COMAH safety report submitted to the Competent Authority for each applicable site. Existing safety reports will need to be reviewed to ensure this methodology is adopted.

1.14.2 Buncefield report Recommendation 2

Operators of Buncefield-type sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. This should include, but not be limited to reviews of the following:

1. The arrangements and procedures for periodic proof testing of storage tank overfill prevention systems to minimise the likelihood of any failure that could result in loss of containment; any revisions identified pursuant to this review should be put into immediate effect;
2. The procedures for implementing changes to equipment and systems to ensure any such changes do not impair the effectiveness of equipment and systems in preventing loss of containment or in providing emergency response.

1.14.3 Buncefield report Recommendation 3

Operators of Buncefield-type sites should protect against loss of containment of petrol and other highly flammable liquids by fitting a high integrity, automatic operating overfill prevention system (or a number of such systems, as appropriate) that is physically and electrically separate and independent from the tank gauging system.

Such systems should meet the requirements of Part 1 of BS EN 61511 resource centre link for the required safety integrity level main website link, as determined by the agreed methodology (see Recommendation 1). Where independent automatic overfill prevention systems are already provided, their efficacy and reliability should be reappraised in line with the principles of Part 1 of BS EN 61511 resource centre link and for the required safety integrity level, as determined by the agreed methodology (see Recommendation 1).

1.14.4 Buncefield report Recommendation 4

The overfill prevention system (comprising means of level detection, logic/control equipment and independent means of flow control) should be engineered, operated and maintained to achieve and maintain an appropriate level of safety integrity in accordance with the requirements of the recognised industry standard for 'safety instrumented systems', Part 1 of BS EN 61511 resource centre link.

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1.14.5 Buncefield report Recommendation 5

All elements of an overfill prevention system should be proof tested in accordance with the validated arrangements and procedures sufficiently frequently to ensure the specified safety integrity level is maintained in practice in accordance with the requirements of Part 1 of BS EN 61511 resource centre link.

1.14.6 Buncefield report Recommendation 6

The sector should put in place arrangements to ensure the receiving site (as opposed to the transmitting location) has ultimate control of tank filling. The receiving site should be able to safely terminate or divert a transfer (to prevent loss of containment or other dangerous conditions) without depending on the actions of a remote third party, or on the availability of communications to a remote location. These arrangements will need to consider upstream implications for the pipeline network, other facilities on the system, and refineries.

1.14.7 Buncefield report Recommendation 7

In conjunction with Recommendation 6, the sector and the Competent Authority should undertake a review of the adequacy of existing safety arrangements, including communications, employed by those responsible for pipeline transfers of fuel. This work should be aligned with implementing. Recommendations 19 and 20 on high reliability organisations to ensure major hazard risk controls address the management of critical organisational interfaces.

1.14.8 Buncefield report Recommendation 8

The sector, including its supply chain of equipment manufacturers and suppliers, should review and report without delay on the scope to develop improved components and systems, including but not limited to the following:

1. Alternative means of ultimate high level detection for overfill prevention that do not rely on components internal to the storage tank, with the emphasis on ease of inspection, testing, reliability and maintenance;
2. Increased dependability of tank level gauging systems through improved; AND,
3. Validation of measurements and trends, allowing warning of faults and through using modern sensors with increased diagnostic capability and systems to control and log override actions.

1.14.9 Buncefield report Recommendation 9

Operators of Buncefield-type sites should introduce arrangements for the systematic maintenance of records to allow a review of all product movements together with the operation of the overfill prevention systems and any associated facilities. The arrangements should be fit for their design purpose and include, but not be limited to, the following factors:

1. The records should be in a form that is readily accessible by third parties without the need for specialist assistance;
2. The records should be available both on site and at a different location;
3. The records should be available to allow periodic review of the effectiveness of control measures by the operator and the Competent Authority, as well as for root cause analysis should there be an incident; AND,
4. A minimum period of retention of one year.

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1.14.10 Buncefield report Recommendation 10

The sector should agree with the Competent Authority on a system of leading and lagging performance indicators for process safety performance. This system should be in line with HSE's recently published guidance on developing process safety indicators HSG254.

1.14.11 Buncefield report Recommendation 11

Operators of Buncefield-type sites should review the classification of places within COMAH sites where explosive atmospheres may occur and their selection of equipment and protective systems (as required by the Dangerous Substances and Explosive Atmospheres Regulations 2002. This review should take into account the likelihood of undetected loss of containment and the possible extent of an explosive atmosphere following such an undetected loss of containment. Operators in the wider fuel and chemicals industries should also consider such a review, to take account of events at Buncefield.

1.14.12 Buncefield report Recommendation 12

Following on from Recommendation 11, operators of Buncefield-type sites should evaluate the siting and/or suitable protection of emergency response facilities such as fire-fighting pumps, lagoons or manual emergency switches.

1.14.13 Buncefield report Recommendation 13

Operators of Buncefield-type sites should employ measures to detect hazardous conditions arising from loss of primary containment, including the presence of high levels of flammable vapours in secondary containment. Operators should without delay undertake an evaluation to identify suitable and appropriate measures. This evaluation should include, but not be limited to, consideration of the following:

1. Installing flammable gas detection in bunds containing vessels or tanks into which large quantities of highly flammable liquids or vapour may be released;
2. The relationship between the gas detection system and the overfill prevention system. Detecting high levels of vapour in secondary containment is an early indication of loss of containment and so should initiate action, for example through the overfill prevention system, to limit the extent of any further loss;
3. Installing CCTV equipment to assist operators with early detection of abnormal conditions. Operators cannot routinely monitor large numbers of passive screens, but equipment is available that detects and responds to changes in conditions and alerts operators to these changes.

1.14.14 Buncefield report Recommendation 14

Operators of new Buncefield-type sites or those making major modifications to existing sites (such as installing a new storage tank) should introduce further measures including, but not limited to, preventing the formation of flammable vapour in the event of tank overflow. Consideration should be given to modifications of tank top design and to the safe rerouting of overflowing liquids.

1.14.15 Buncefield report Recommendation 15

The sector should begin to develop guidance without delay to incorporate the latest knowledge on preventing loss of primary containment and on inhibiting escalation if loss occurs. This is likely to require the sector to collaborate with the professional institutions and trade associations.

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1.14.16 Buncefield report Recommendation 16

Operators of existing sites, if their risk assessments show it is not practicable to introduce measures to the same extent as for new ones, should introduce measures as close to those recommended by Recommendation 14 as is reasonably practicable. The outcomes of the assessment should be incorporated into the safety report submitted to the Competent Authority.

1.14.17 Buncefield report Recommendation 17

The Competent Authority and the sector should jointly review existing standards for secondary and tertiary containment with a view to the Competent Authority producing revised guidance by the end of 2007.

The review should include, but not be limited to the following:

1. Developing a minimum level of performance specification of secondary containment (typically this will be bunding);
2. Developing suitable means for assessing risk so as to prioritise the programme of engineering work in response to the new specification;
3. Formally specifying standards to be achieved so that they may be insisted upon in the event of lack of progress with improvements;
4. Improving firewater management and the installed capability to transfer contaminated liquids to a place where they present no environmental risk in the event of loss of secondary containment and fires;
5. Providing greater assurance of tertiary containment measures to prevent escape of liquids from site and threatening a major accident to the environment.

1.14.18 Buncefield report Recommendation 18

Revised standards should be applied in full to new build sites and to new partial installations. On existing sites, it may not be practicable to fully upgrade bunding and site drainage. Where this is so operators should develop and agree with the Competent Authority risk-based plans for phased upgrading as close to new plant standards as is reasonably practicable.

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1.14.19 Buncefield report Recommendation 19

The sector should work with the Competent Authority to prepare guidance and/or standards on how to achieve a high reliability industry through placing emphasis on the assurance of human and organisational factors in design, operation, maintenance and testing. Of particular importance are:

1. Understanding and defining the role and responsibilities of the control room operators (including in automated systems) in ensuring safe transfer processes;
2. Providing suitable information and system interfaces for front line staff to enable them to reliably detect, diagnose and respond to potential incidents;
3. Training, experience and competence assurance of staff for safety critical and environmental protection activities
4. Defining appropriate workload, staffing levels and working conditions for front line personnel;
5. Ensuring robust communications management within and between sites and contractors and with operators of distribution systems and transmitting sites (such as refineries);
6. Prequalification auditing and operational monitoring of contractors' capabilities to supply, support and maintain high integrity equipment;
7. Providing effective standardised procedures for key activities in maintenance, testing and operations;
8. Clarifying arrangements for monitoring and supervision of control room staff;
9. Effectively managing changes that impact on people, processes and equipment.

1.14.20 Buncefield report Recommendation 20

The sector should ensure that the resulting guidance and/or standards is/are implemented fully throughout the sector, including where necessary with the refining and distribution sectors. The Competent Authority should check that this is done.

1.14.21 Buncefield report Recommendation 21

The sector should put in place arrangements to ensure that good practice in these areas, incorporating experience from other high hazard sectors, is shared openly between organisations.

1.14.22 Buncefield report Recommendation 22

The Competent Authority should ensure that safety reports submitted under the COMAH Regulations contain information to demonstrate that good practice in human and organisational design, operation, maintenance and testing is implemented as rigorously as for control and environmental protection engineering systems.

1.14.23 Buncefield report Recommendation 23

The sector should set up arrangements to collate incident data on high potential incidents including overfilling, equipment failure, spills, and alarm system defects, evaluate trends, and communicate information on risks, their related solutions and control measures to the industry.

1.14.24 Buncefield report Recommendation 24

The arrangements set up to meet Recommendation 23 should include, but not be limited to, the following:

1. Thorough investigation of root causes of failures and malfunctions of safety and environmental protection critical elements during testing or maintenance, or in service;
2. Developing incident databases that can be shared across the entire sector, subject to data protection and other legal requirements;
3. Collaboration between the workforce and its representatives, duty holders and regulators to ensure lessons are learned from incidents, and best practices are shared.

1.14.25 Buncefield report Recommendation 25

In particular, the sector should draw together current knowledge of major hazard events, failure histories of safety and environmental protection critical elements and developments in new knowledge and innovation to continuously improve the control of risks. This should take advantage of the experience of other high hazard sectors such as chemical processing, offshore oil and gas operations, nuclear processing and railways.

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1.15 Appendix G: Incident development scenarios

1.15.1 Transport pipelines from berthed ship to terminal

Scenario No.	Equip.	Medium	Scenario	Incident	Press. (barg)	Temp. (°C)	Event Frequency (per meter per annum)	System Reaction 1	System Reaction 1 Prob.	System Reaction 2	System Reaction 2 Probability	Prob. of Ignition	Total System Event Frequency (per annum)
PIPE-01	Pipeline	LPG	Rupture	Jet fire	20	22	1.00E-07	Pipelines	1	None	1	0.7	7.00E-08
PIPE-02				Flash fire	20	22	1.00E-07	Pipelines	1	None	1	0.18	1.80E-08
PIPE-03				VCE	20	22	1.00E-07	Pipelines	1	None	1	0.12	1.20E-08
PIPE-04			Leak	Jet fire	20	22	5.00E-07	Pipelines	1	None	1	0.5	2.50E-07
PIPE-05				Flash fire	20	22	5.00E-07	Pipelines	1	None	1	0.3	1.50E-07
PIPE-06				VCE	20	22	5.00E-07	Pipelines	1	None	1	0.2	1.00E-07
PIPE-07		Petrol	Rupture	Pool fire	20	22	1.00E-07	Pipelines	2	None	1	0.065	1.30E-08
PIPE-08				Flash fire	20	22	1.00E-07	Pipelines	2	None	1	0.039	7.80E-09
PIPE-09				VCE	20	22	1.00E-07	Pipelines	2	None	1	0.026	5.20E-09
PIPE-10			Leak	Pool fire	20	22	5.00E-07	Pipelines	2	None	1	0.065	6.50E-08
PIPE-11				Flash fire	20	22	5.00E-07	Pipelines	2	None	1	0.039	3.90E-08
PIPE-12				VCE	20	22	5.00E-07	Pipelines	2	None	1	0.026	2.60E-08
PIPE-13		Diesel	Rupture	Pool fire	20	22	1.00E-07	Pipelines	1	None	1	0.065	6.50E-09
PIPE-14			Leak		20	22	5.00E-07	Pipelines	4	None	1	0.065	3.25E-08

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1.15.2 LPG bulk storage and gantries

Scenario No.	Equip.	Scenario	Incident	Duration (min)	Event Frequency (per annum)	System Reaction 1	System Reaction 1 Prob.	System Reaction 2	System Reaction 2 Probability	Prob. of Ignition	Total System Event Frequency (per annum)
LPG-1	V100-01 to 05	Catastrophic failure	BLEVE	Instant	5.00E-07	Mounded	0	None	1	0.49	0.00E+00
LPG-2			Flash fire	Instant	5.00E-07	Bullets	3	None	1	0.306	4.59E-07
LPG-3			VCE	Instant	5.00E-07	Bullets	3	None	1	0.204	3.06E-07
LPG-4		Fixed duration release	Pool fire	10	5.00E-07	Mounded	0	None	1	0	0.00E+00
LPG-5			Jet fire	10	5.00E-07	Bullets	3	None	1	0.7	1.05E-06
LPG-6			Flash fire	`10	5.00E-07	Bullets	3	None	1	0.18	2.70E-07
LPG-7			VCE	10	5.00E-07	Bullets	3	None	1	0.12	1.80E-07
LPG-8		10 mm hole	Jet fire	30	1.00E-05	Bullets	3	None	1	0.2	6.00E-06
LPG-9			Flash fire	30	1.00E-05	Bullets	3	None	1	0.48	1.44E-05
LPG-10			VCE	30	1.00E-05	Bullets	3	None	1	0.32	9.60E-06
LPG-11		PSV fails open	Jet fire	30	1.00E-05	Bullets	3	None	1	0.5	1.50E-05
LPG-12			Flash fire	30	1.00E-05	Bullets	3	None	1	0.3	9.00E-06
LPG-13			VCE	30	1.00E-05	Bullets	3	None	1	0.2	6.00E-06
LPG-14		Overfill	Jet fire	30	1.00E-03	Frac. hrs. offloading	0.16	None	1	0.2	3.20E-05
LPG-15			Flash fire	30	1.00E-03	Frac. hrs. offloading	0.16	None	1	0.2	3.20E-05
LPG-16			VCE	30	1.00E-03	Frac. hrs. offloading	0.16	None	1	0.2	3.20E-05

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Scenario No.	Equip.	Scenario	Incident	Duration (min)	Event Frequency (per annum)	System Reaction 1	System Reaction 1 Prob.	System Reaction 2	System Reaction 2 Probability	Prob. of Ignition	Total System Event Frequency (per annum)
LPG-17	P100-01 to 05	Pump failure	Jet fire	30	1.00E-04	Bullets	3	None	1	0.5	1.50E-04
LPG-18			Flash fire	30	1.00E-04	Bullets	3	None	1	0.3	9.00E-05
LPG-19			VCE	30	1.00E-04	Bullets	3	None	1	0.2	6.00E-05
LPG-20		Pump leak	Jet fire	30	4.40E-03	Bullets	3	None	1	0.2	2.64E-03
LPG-21			Flash fire	30	4.40E-03	Bullets	3	None	1	0.48	6.34E-03
LPG-22			VCE	30	4.40E-03	Bullets	3	None	1	0.32	4.22E-03
LPG-23	V100-03to06	Catastrophic failure	BLEVE	Instant	5.00E-07	Mounded	0	None	1	0.49	0.00E+00
LPG-24			Flash fire	Instant	5.00E-07	Bullets	3	None	1	0.306	4.59E-07
LPG-25			VCE	Instant	5.00E-07	Bullets	3	None	1	0.204	3.06E-07
LPG-26		Fixed duration release	Pool fire	10	5.00E-07	Mounded	0	None	1	0	0.00E+00
LPG-27			Jet fire	10	5.00E-07	Bullets	3	None	1	0.7	1.05E-06
LPG-28			Flash fire	`10	5.00E-07	Bullets	3	None	1	0.18	2.70E-07
LPG-29			VCE	10	5.00E-07	Bullets	3	None	1	0.12	1.80E-07
LPG-30		10 mm hole	Jet fire	30	1.00E-05	Bullets	3	None	1	0.2	6.00E-06
LPG-31			Flash fire	30	1.00E-05	Bullets	3	None	1	0.48	1.44E-05
LPG-32			VCE	30	1.00E-05	Bullets	3	None	1	0.32	9.60E-06
LPG-33		PSV fails open	Jet fire	30	1.00E-05	Bullets	3	None	1	0.5	1.50E-05
LPG-34			Flash fire	30	1.00E-05	Bullets	3	None	1	0.3	9.00E-06
LPG-35			VCE	30	1.00E-05	Bullets	3	None	1	0.2	6.00E-06

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Scenario No.	Equip.	Scenario	Incident	Duration (min)	Event Frequency (per annum)	System Reaction 1	System Reaction 1 Prob.	System Reaction 2	System Reaction 2 Probability	Prob. of Ignition	Total System Event Frequency (per annum)
LPG-36	V100-03to06: pump	Pump failure	Jet fire	30	1.00E-04	Bullets	3	Emergency stop	0.1	0.5	1.50E-05
LPG-37			Flash fire	30	1.00E-04	Bullets	3	Emergency stop	0.1	0.3	9.00E-06
LPG-38			VCE	30	1.00E-04	Bullets	3	Emergency stop	0.1	0.2	6.00E-06
LPG-39		Pump leak	Jet fire	30	4.40E-03	Bullets	3	Emergency stop	0.1	0.2	2.64E-04
LPG-40			Flash fire	30	4.40E-03	Bullets	3	Emergency stop	0.1	0.48	6.34E-04
LPG-41			VCE	30	4.40E-03	Bullets	3	Emergency stop	0.1	0.32	4.22E-04
LPG-42	Road tanker	Catastrophic failure	BLEVE	Instant	1.00E-07	No. of tankers	3.00	None	1	0.49	1.47E-07
LPG-43			Flash fire	Instant	1.00E-07	No. of tankers	3.00	None	1	0.306	9.18E-08
LPG-44			VCE	Instant	1.00E-07	No. of tankers	3.00	None	1	0.204	6.12E-08
LPG-45		Rupture of loading arm	Jet fire	30	2.63E-04	No. of tankers	3.00	Operator with ES	0.1	0.5	3.94E-05
LPG-46			Flash fire	30	2.63E-04	No. of tankers	3.00	Operator with ES	0.1	0.3	2.37E-05
LPG-47			VCE	30	2.63E-04	No. of tankers	3.00	Operator with ES	0.1	0.2	1.58E-05
LPG-48		Leak of offloading arm	Jet fire	30	2.63E-03	No. of tankers	3.00	Operator with ES	0.1	0.2	1.58E-04
LPG-49			Flash fire	30	2.63E-03	No. of tankers	3.00	Operator with ES	0.1	0.48	3.78E-04
LPG-50			VCE	30	2.63E-03	No. of tankers	3.00	Operator with ES	0.1	0.32	2.52E-04

Scenario No.	Equip.	Scenario	Incident	Duration (min)	Event Frequency (per annum)	System Reaction 1	System Reaction 1 Prob.	System Reaction 2	System Reaction 2 Probability	Prob. of Ignition	Total System Event Frequency (per annum)
LPG-51	Rail tanker	Catastrophic failure	BLEVE	Instant	1.00E-07	No. of tankers	2.00	None	1	0.49	9.80E-08
LPG-52			Flash fire	Instant	1.00E-07	No. of tankers	2.00	None	1	0.306	6.12E-08
LPG-53			VCE	Instant	1.00E-07	No. of tankers	2.00	None	1	0.204	4.08E-08
LPG-54		Rupture of loading arm	Jet fire	30	2.63E-04	No. of tankers	2.00	Operator with ES	0.1	0.5	2.63E-05
LPG-55			Flash fire	30	2.63E-04	No. of tankers	2.00	Operator with ES	0.1	0.3	1.58E-05
LPG-56			VCE	30	2.63E-04	No. of tankers	2.00	Operator with ES	0.1	0.2	1.05E-05
LPG-57		Leak of offloading arm	Jet fire	30	2.63E-03	No. of tankers	2.00	Operator with ES	0.1	0.2	1.05E-04
LPG-58			Flash fire	30	2.63E-03	No. of tankers	2.00	Operator with ES	0.1	0.48	2.52E-04
LPG-59			VCE	30	2.63E-03	No. of tankers	2.00	Operator with ES	0.1	0.32	1.68E-04

1.15.3 Atmospheric bulk storage

For the tank farm all tanks were assumed to contain petrol. The following values were used:

- Tank failure: $5X10^{-6}$ events per annum;
- Tank overfill: $1x10^{-3}$ events per annum (two independent level transmitters and one independent level switch all at SIL-1 failure);
- Probability of fire: 6.5% of direct ignition and 6.5% of delayed ignition per spillage;
- Probability of flash fire: 60%;
- Probability of explosions: 40%;
- Mass of petrol used in tank explosion = mass of vessel to blanket (assumed 1.8 m above grade) at the LFL.

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1.16 Appendix H: PADHI land-planning tables (HSE 2011)

1.16.1 Development type Table 1: People at work, parking

Development Type	Examples	Development Detail and Size	Justification
DT1.1 Workplaces	Offices, factories, warehouses, haulage depots, farm buildings, nonretail markets, builder's yards	Workplaces (predominantly nonretail), providing for less than 100 occupants in each building and less than 3 occupied storeys (Level 1)	Places where the occupants will be fit and healthy and could be organised easily for emergency action Members of the public will not be present or will be present in very small numbers and for a short time
		Exclusions	
		DT1.1 x1 Workplaces (predominantly nonretail) providing for 100 or more occupants in any building or 3 or more occupied storeys in height (Level 2 except where the development is at the major hazard site itself, where it remains Level 1)	Substantial increase in numbers at risk with no direct benefit from exposure to the risk
	Sheltered workshops, Remploy	DT1.1 x2 Workplaces (predominantly nonretail) specifically for people with disabilities (Level 3)	Those at risk may be especially vulnerable to injury from hazardous events or they may not be able to be organised easily for emergency action
DT1.2 Parking Areas	Car parks, truck parks, lockup garages	Parking areas with no other associated facilities (other than toilets; Level 1)	
		Exclusions	
	Car parks with picnic areas or at a retail or leisure development or serving a park and ride interchange	DT1.2 x1 Where parking areas are associated with other facilities and developments the sensitivity level and the decision will be based on the facility or development	

1.16.2 Development type Table 2: Developments for use by the general public

Development Type	**Examples**	**Development Detail and Size**	**Justification**
DT2.1 **Housing**	Houses, flats, retirement flats or bungalows, residential caravans, mobile homes	Developments up to and including 30 dwelling units and at a density of no more than 40 per hectare (Level 2)	Development where people live or are temporarily resident It may be difficult to organise people in the event of an emergency
	Exclusions		
	Infill, back-land development	DT2.1 x1 Developments of 1 or 2 dwelling units (Level 1)	Minimal increase in numbers at risk
	Larger housing developments	DT2.1 x2 Larger developments for more than 30 dwelling units (Level 3)	Substantial increase in numbers at risk
		DT2.1 x3 Any developments (for more than 2 dwelling units) at a density of more than 40 dwelling units per hectare (Level 3)	High-density developments
DT2.2 **Hotel or Hostel or Holiday Accommodation**	Hotels, motels, guest houses, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, accommodation centres, holiday caravan sites, camping sites	Accommodation up to 100 beds or 33 caravan or tent pitches (Level 2)	Development where people are temporarily resident It may be difficult to organise people in the event of an emergency
	Exclusions		
	Smaller: guest houses, hostels, youth hostels, holiday homes, halls of residence, dormitories, holiday caravan sites, camping sites	DT2.2 x1 Accommodation of less than 10 beds or 3 caravan or tent pitches (Level 1)	Minimal increase in numbers at risk
	Larger: hotels, motels, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, holiday caravan sites, camping sites	DT2.2 x2 Accommodation of more than 100 beds or 33 caravan or tent pitches (Level 3)	Substantial increase in numbers at risk

Development Type	Examples	Development Detail and Size	Justification
DT2.3 Transport Links	Motorway, dual carriageway	Major transport links in their own right i.e. not as an integral part of other developments (Level 2)	Prime purpose is as a transport link Potentially large numbers exposed to risk but exposure of an individual is only for a short period
	Exclusions		
	Estate roads, access roads	DT2.3 x1 Single carriageway roads (Level 1)	Minimal numbers present and mostly a small period of time exposed to risk Associated with other development
	Any railway or tram track	DT2.3 x2 Railways (Level 1)	Transient population, small period of time exposed to risk Periods of time with no population present

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Development Type	**Examples**	**Development Detail and Size**	**Justification**
DT2.4 Indoor Use by Public	*Food and drink:* restaurants, cafes, drive-through fast food, pubs *Retail:* shops, petrol filling station (total floor space based on shop area not forecourt), vehicle dealers (total floor space based on showroom or sales building not outside display areas), retail warehouses, super-stores, small shopping centres, markets, financial and professional services to the public *Community and adult education*: libraries, art galleries, museums, exhibition halls, day surgeries, health centres, religious buildings, community centres. adult education, 6th form college, college of FE *Assembly and leisure*: Coach or bus or railway stations, ferry terminals, airports, cinemas, concert or bingo or dance halls, conference centres, sports or leisure centres, sports halls, facilities associated with golf courses, flying clubs (e.g. changing rooms, club house), indoor go kart tracks	Developments for use by the general public where total floor space is from 250 m^2 up to 5000 m^2 (Level 2)	Developments where members of the public will be present (but not resident) Emergency action may be difficult to coordinate
	Exclusions		
		DT2.4 x1 Development with less than 250 m^2 total floor space (Level 1)	Minimal increase in numbers at risk
		DT2.4 x2 Development with more than 5000 m^2 total floor space (Level 3)	Substantial increase in numbers at risk

Development Type	**Examples**	**Development Detail and Size**	**Justification**
DT2.5 Outdoor Use by Public	*Food and drink*: food festivals, picnic areas *Retail*: outdoor markets, car boot sales, funfairs *Community and adult education*: open-air theatres and exhibitions *Assembly and leisure*: coach or bus or railway stations, park and ride interchange, ferry terminals, sports stadia, sports fields or pitches, funfairs, theme parks, viewing stands, marinas, playing fields, children's play areas, BMX or go kart tracks, country parks, nature reserves, picnic sites, marquees	Principally an outdoor development for use by the general public i.e. developments where people will predominantly be outdoors and not more than 100 people will gather at the facility at any one time (Level 2)	Developments where members of the public will be present (but not resident) either indoors or outdoors Emergency action may be difficult to coordinate
	Exclusions		
	Outdoor markets, car boot sales, funfairs picnic area, park and ride interchange, viewing stands, marquees	DT2.5 x1 Predominantly open-air developments likely to attract the general public in numbers greater than 100 people but up to 1000 at any one time (Level 3)	Substantial increase in numbers at risk and more vulnerable due to being outside
	Theme parks, funfairs, large sports stadia and events, open air markets, outdoor concerts, pop festivals	DT2.5 x2 Predominantly open-air developments likely to attract the general public in numbers greater than 1000 people at any one time (Level 4)	Very substantial increase in numbers at risk, more vulnerable due to being outside Emergency action may be difficult to coordinate

1.16.3 Development type Table 3: Developments for use by vulnerable people

Development Type	Examples	Development Detail and Size	Justification
DT3.1 Institutional Accommodation and Education	Hospitals, convalescent homes, nursing homes, old people’s homes with warden on site or ‘on call’, sheltered housing, nurseries, crèches, schools and academies for children up to school leaving age	Institutional, educational and special accommodation for vulnerable people or that provides a protective environment (Level 3)	Places providing an element of care or protection Because of age, infirmity or state of health the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult
		Exclusions	
	Hospitals, convalescent homes, nursing homes, old people’s homes, sheltered housing	DT3.1 x1 24-hour care where the site on the planning application being developed is larger than 0.25 hectare (Level 4)	Substantial increase in numbers of vulnerable people at risk
	Schools, nurseries, crèches	DT3.1 x2 Day care where the site on the planning application being developed is larger than 1.4 hectare (Level 4)	Substantial increase in numbers of vulnerable people at risk
DT3.2 Prisons	Prisons, remand centres	Secure accommodation for those sentenced by court, or awaiting trial, etc. (Level 3)	Places providing detention Emergency action and evacuation may be very difficult

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1.16.4 Development type Table 4: Very large and sensitive developments

Development Type	Examples	Development Detail and Size	Justification
Note: all Level 4 developments are by exception from Level 2 or 3 and are reproduced in this table for convenient reference			
DT4.1 **Institutional Accommodation**	Hospitals, convalescent homes, nursing homes, old people's homes, sheltered housing	Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where 24-hour care is provided and where the site on the planning application being developed is larger than 0.25 hectare (Level 4)	Places providing an element of care or protection Because of age or state of health the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult The risk to an individual may be small but there is a larger societal concern
	Nurseries, crèches, schools for children up to school leaving age	Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where day care (not 24-hour care) is provided and where the site on the planning application being developed is larger than 1.4 hectare (Level 4)	Places providing an element of care or protection Because of a the occupants may be especially vulnerable to injury from hazardous events Emergency action and evacuation may be very difficult The risk to an individual may be small but there is a larger societal concern
DT4.2 **Very Large Outdoor Use by Public**	Theme parks, large sports stadia and events, open air markets, outdoor concerts, pop festivals	Predominantly open air developments where there could be more than 1000 people present (Level 4)	People in the open air may be more exposed to toxic fumes and thermal radiation than if they were in buildings Large numbers make emergency action and evacuation difficult The risk to an individual may be small but there is a larger societal concern

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1.17 Appendix I: Reference drawings

Reference drawings used in the study are shown in Table 36.

Table 36: Reference drawings

Drawing No.	Description	Rev
SM000304/C.01a/0001	Vopak RICHARDS BAY PLOT PLAN	H1

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1.18 Appendix J: Material safety data sheets

1.18.1 Petrol modelled as heptane

n-HEPTANE	**ICSC:** 0657 Peer-Review Status: 04.11.1997 Validated
CAS #: 142-82-5 RTECS #: MI7700000 UN #: 1206 EC #: 601-008-00-2 EINECS #: 205-563-8	Formula: C_7H_{16} / $CH_3(CH_2)_5CH_3$ Molecular mass: 100.2

TYPES OF HAZARD / EXPOSURE	**ACUTE HAZARDS / SYMPTOMS**	**PREVENTION**	**FIRST AID / FIRE FIGHTING**
FIRE	Highly flammable.	NO open flames, NO sparks and NO smoking.	Use powder, foam, carbon dioxide. NO water.
EXPLOSION	Vapour/air mixtures are explosive.	Closed system, ventilation, explosion-proof electrical equipment and lighting. Prevent build-up of electrostatic charges (e.g., by grounding). Do NOT use compressed air for filling, discharging, or handling.	In case of fire: keep drums, etc., cool by spraying with water.
EXPOSURE			
Inhalation	Lethargy. Headache.	Use ventilation.	Fresh air, rest. Artificial respiration may be needed. Refer for medical attention.
Skin	Dry skin.	Protective gloves.	Remove contaminated clothes. Rinse and then wash skin with water and soap. Refer for medical attention. Wear protective gloves when administering first aid.
Eyes	Redness. Pain.	Wear safety goggles or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.
Ingestion	Abdominal cramps. Burning sensation. Nausea. Vomiting.	Do not eat, drink, or smoke during work.	Rinse mouth. Do NOT induce vomiting. Rest. Refer for medical attention.

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SPILLAGE DISPOSAL	PACKAGING & LABELLING
Collect leaking and spilled liquid in sealable containers as far as possible. Absorb remaining liquid in sand or inert absorbent. Then store and dispose of according to local regulations. Do NOT wash away into sewer. Personal protection: filter respirator for organic gases and vapours adapted to the airborne concentration of the substance.	**EC Classification** Symbol: F, Xn, N; R: 11-38-50/53-65-67; S: (2)-9-16-29-33-60-61-62; Note: C **UN Classification** UN Hazard Class: 3; UN Pack Group: II **GHS Classification**

EMERGENCY RESPONSE	SAFE STORAGE
Transport Emergency Card: TEC (R)-30GF1-I+II. NFPA Code: H1; F3; R0.	Fireproof. Separated from strong oxidants. Store in an area without drain or sewer access.

IMPORTANT DATA	
Physical State; Appearance VOLATILE COLOURLESS LIQUID WITH CHARACTERISTIC ODOUR. **Physical dangers** The vapour is heavier than air and may travel along the ground; distant ignition possible. As a result of flow, agitation, etc., electrostatic charges can be generated. **Chemical dangers** Reacts violently with strong oxidants. Attacks many plastics. **Occupational exposure limits** TLV: 400 ppm as TWA; 500 ppm as STEL; (ACGIH 2004).	**Routes of exposure** The substance can be absorbed into the body by inhalation of its vapour and by ingestion. **Inhalation risk** A harmful contamination of the air will be reached rather slowly on evaporation of this substance at 20°C. **Effects of short-term exposure** The substance is irritating to the eyes and skin. The vapour is irritating to the eyes, skin and respiratory tract. If this liquid is swallowed, aspiration into the lungs may result in chemical pneumonitis. The substance may cause effects on the central nervous system. **Effects of long-term or repeated exposure** The liquid defats the skin. The substance may have effects on the liver. This may result in impaired functions.

PHYSICAL PROPERTIES	ENVIRONMENTAL DATA
Boiling point: 98°C Melting point: -91°C Relative density (water = 1): 0.68 Solubility in water: none Vapour pressure, kPa at 20°C: 4.6 Relative vapour density (air = 1): 3.46 Flash point: -4°C Auto-ignition temperature: 285°C Explosive limits, vol.% in air: 1.1-6.7 Octanol/water partition coefficient as log Pow: 4.66	The substance is toxic to aquatic organisms. Bioaccumulation of this chemical may occur in fish. It is strongly advised not to let the chemical enter into the environment.

NOTES
The odour warning when the exposure limit value is exceeded is insufficient. Skellysolve-C is a trade name. Card has been partly updated in October 2005. See sections Occupational Exposure Limits, EU classification, Emergency Response. Card has been partially updated in August 2007: see Fire fighting, Storage, Occupational Exposure Limits, and Environmental Data. Card has been partially updated in January 2008: see Occupational Exposure Limits.

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IPCS International Programme on Chemical Safety	Prepared in the context of cooperation between the International Programme on Chemical Safety and the European Commission **© IPCS 2004**
LEGAL NOTICE	Neither the EC nor the IPCS nor any person acting on behalf of the EC or the IPCS is responsible for the use which might be made of this information.

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1.18.2 Diesel modelled as dodecane

SAFETY DATA SHEET
DODECANE

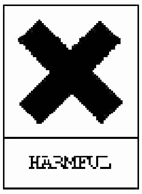
1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product name	DODECANE
In-house No.	0220
Supplier	Fisher Scientific AB gtf.info@thermofisher.com Södra Langebergsgatan 30 SE 421 32 Västra Frölunda Tel: 031-689400 Fax: 031-680717
EC No.	297-629-8
CAS No.	93685-81-5

2. HAZARDS IDENTIFICATION

EYE CONTACT: can irritate the eyes. SKIN CONTACT: irritating to the skin harmful if absorbed through the skin. May cause dermatitis. INGESTION: can give nausea, vomiting and diarrea. If the substance has reached the lungs it can give pneumonia and oedemas. INHALATION: can cause CNS-disturbances with nausea, vomiting, dizziness and unconsciousness. Irritating to the respiratory tract and can cause pneumonia and oedemas. Flammable.

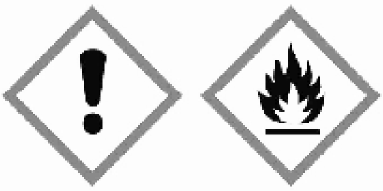
Symbol(s)



Risk phrases	R-65 Harmful: may cause lung damage if swallowed. R-66 Repeated exposure may cause skin dryness or cracking.
Safety phrases	S-16 Keep away from sources of ignition - No Smoking. S-24 Avoid contact with skin.

CLP

Hazard pictograms



Precautionary statements	P210 Keep away from heat/sparks/open flames/hot surfaces. – No smoking. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes Remove contact lenses, if present and easy to do. Continue rinsing

3. COMPOSITION/INFORMATION ON INGREDIENTS

Ingredients

Name	EC No.	CAS No.	Content	Symbol	Classification
DODECANE	297-629-8	93685-81-5	90 %	Xn	R-65, R-66

CLP

Name	CAS No.	REACH No.	Content	Symbol	Classification
DODECANE	93685-81-5		90 %	GHS07, GHS02	

Section 16 contains detailed classification phrases.

4. FIRST AID MEASURES

Inhalation	Move the exposed person to fresh air at once. Perform artificial respiration if breathing has stopped. Keep the affected person warm and at rest. Get prompt medical attention.
Ingestion	NEVER MAKE AN UNCONSCIOUS PERSON VOMIT OR DRINK FLUIDS! Promptly get affected personnel to drink large volumes of water to dilute the swallowed chemical. DO NOT induce vomiting. Get medical attention immediately.
Skin	Wash off promptly and flush contaminated skin with water. Promptly remove clothing if soaked through and flush skin with water.
Eyes	Promptly wash eyes with plenty of water while lifting the eye lids. Get medical attention if any discomfort continues.

5. FIRE-FIGHTING MEASURES

Extinguishing media	Powder, foam or CO2.
Special fire fighting procedures	Move container from fire area if it can be done without risk. Use water to keep fire-exposed containers cool and disperse vapours. Avoid breathing fire vapours
Specific hazards	Vapours may ignite. Forms explosive mixtures with air.

6. ACCIDENTAL RELEASE MEASURES

Spill cleanup methods	Extinguish all ignition sources. Avoid sparks, flames, heat and smoking. Ventilate. Clean-up personnel should use respiratory and/or liquid contact protection. Collect with absorbent, non-combustible material into suitable containers. Flush area with water.

7. HANDLING AND STORAGE

Usage precautions	Avoid spilling, skin and eye contact. Avoid inhalation of vapours.
Storage precautions	Flammable/combustible - Keep away from oxidisers, heat and flames. Keep in cool, dry, ventilated storage and closed containers. Store isolated from oxidising materials.
Storage criteria	Flammable liquid storage.

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Ingredient comments	AFS = Swedish Exposure Limits. 2000.
Protective equipment	
Ventilation	All handling to take place in well-ventilated area. Explosion proof general and local exhaust ventilation.
Respirators	If ventilation is insufficient, suitable respiratory protection must be provided. CCROV, CCR with organic vapour cartridge.
Protective gloves	Use protective gloves made of: Nitrile.
Eye protection	Wear approved chemical safety goggles where eye exposure is reasonably probable.
Hygienic work practices	Wash at the end of each work shift and before eating, smoking and using the toilet. Promptly remove any clothing that becomes contaminated. Wash promptly if skin becomes wet. Use appropriate hand lotion to prevent defatting and cracking of skin. DO NOT SMOKE IN WORK AREA!

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Liquid. Clear.		
Colour	Colourless		
Odour	Mild (or faint).		
Solubility description	Insoluble in water. Soluble in: Alcohol. Ether.		
Molecular weight	170,34		
Boiling point (°C, interval)	175 - 192	**Pressure**	
Density (g/cm3)	0.751	**Temperature (°C)**	20
Flash point (°C)	44	**Method**	
Auto ignition temp. (°C)	430		
Flammability limit (%)	0.5 - 4		

10. STABILITY AND REACTIVITY

Stability	Avoid: Heat, sparks, flames. Air and oxidisers.
Materials to avoid	Strong oxidising agents.
Hazardous decomp. products	High temperatures generate: Very toxic gases/vapours/fumes of: Carbon monoxide (CO). Carbon dioxide (CO2).

11. TOXICOLOGICAL INFORMATION

Health warnings	CNS depressant. Narcotic effect. Skin drying with risk of formation of eczema. Unconsciousness/cessation of breathing. Prolonged or repeated contact: Liver and/or kidney damage.
Route of entry	Inhalation. Skin absorption. Ingestion.
Target organs	Central nervous system. Eyes. Kidneys. Liver. Respiratory system, lungs. Skin. Mucous membranes
Medical symptoms	Prolonged or repeated exposure may cause: Irritation of eyes and mucous membranes. Upper respiratory irritation.

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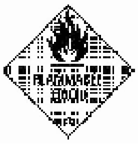
12. ECOLOGICAL INFORMATION

13. DISPOSAL CONSIDERATIONS

Disposal methods	Confirm disposal procedures with environmental engineer and local regulations.

14. TRANSPORT INFORMATION

Label for conveyance



ROAD TRANSPORT (ADR):	
UN no. road	3295
ADR class no.	3
ADR class	Class 3: Flammable liquids.
Classification code	F1
ADR packing group	III, LQ7
Hazard no. (ADR)	30
RAIL TRANSPORT (RID):	
RID class no.	3
RID packing group	III

15. REGULATORY INFORMATION

EC no.	297-629-8

16. OTHER INFORMATION

Explanations to R-phrases in section 3	R-65 Harmful: may cause lung damage if swallowed. R-66 Repeated exposure may cause skin dryness or cracking

*** Information revised since the previous version of the SDS**

Information sources	Registry of Toxic Effects of Chemical Substances (RTECS). Sigma-Aldrich Library of Chemical Safety Data. Edition 2, 1988
Revision date	2010-10-11

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APPENDIX I

Traffic Impact Assessment Specialist Study

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VOPAK - REATILE TERMINAL
TRAFFIC IMPACT ASSESSMENT

DRAFT REPORT

December 2014

Prepared by

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1. INTRODUCTION

1.1 BACKGROUND

Royal Vopak is the world's largest independent tank operator specialising in the handling and storage of liquefied gases, chemicals and oil products.

Vopak-Reatile have entered into a lease agreement with Transnet National Ports Authority (TNPA) for Lots 4 an 5 of Portion 3 of Erf 11478 in the Port of Richards Bay, which occupy a combined land area of approximately 15.8 Ha (158 525 m^2), to develop a storage facility for clean petroleum products as well as liquefied petroleum gasses. The site will be developed in a phased manner with the initial phase providing approximately 36 000 m^3 of storage capacity, and further phases providing up to 264 000 m^3 additional storage capacity.

In terms of the National Environmental Management Act, NEMA, (Act 107 of 1998), Vopak is required to obtain environmental authorisation from the Department of Agriculture and Environmental Affairs (DAEA), for which a full Environmental Impact Assessment is required. Vopak has appointed Golder Associates as the independent Environmental Practitioner to undertake the EIA, who have in-turn appointed ILISO Consulting (Pty) Ltd to undertake the Specialist Traffic and Transportation Study, viz the Traffic Impact Assessment (TIA), which is the focus of this report.

1.2 PURPOSE AND OBJECTIVE

The primary focus of the Traffic Impact Assessment is to:

a) Quantify the transportation demands as a result of the proposed project, with particular emphasis on road based transport
b) Assess the impact of the additional road based transportation demand on the surrounding road network and infrastructure.
c) Propose mitigation measures, if required, to the road network and infrastructure to support the proposed development

1.3 SITE LOCATION

The proposed Vopak-Reatile Terminal Richards bay is located in the south Dunes Precinct of the Port of Richards bay (KwaZulu-Natal). The South Dunes Precinct constitutes an island surrounded by areas of fresh and salt water. It is connected to the mainland via a narrow strip of land. The South Dunes Precinct is bordered by the Port of Richards Bay to the west, the harbour mouth to the north, the Indian Ocean to the east, and the Indian Ocean and Richards Bay Game reserve to the south. The South Dunes precinct is used primarily for liquid chemical and petroleum storage facilities. Figure 1 shows the proposed site location of the Vopak-Reatile Terminal.

Figure 1: Site LocationFigure 2: Detailed layout of development

2. EXISTING CONDITIONS

The primary movement of traffic to and from the site is expected to be to/from Durban and Johannesburg via the N2, and thus the logical route that will be followed to gain access to the proposed site from the N2 is via John Ross Highway, along Ferro Close and finally Harbour Arterial.

As a result of the above routing, traffic counts were undertaken for the three primary intersections leading to the proposed site for Vopak-Reatile Terminal as shown in Figure 2:

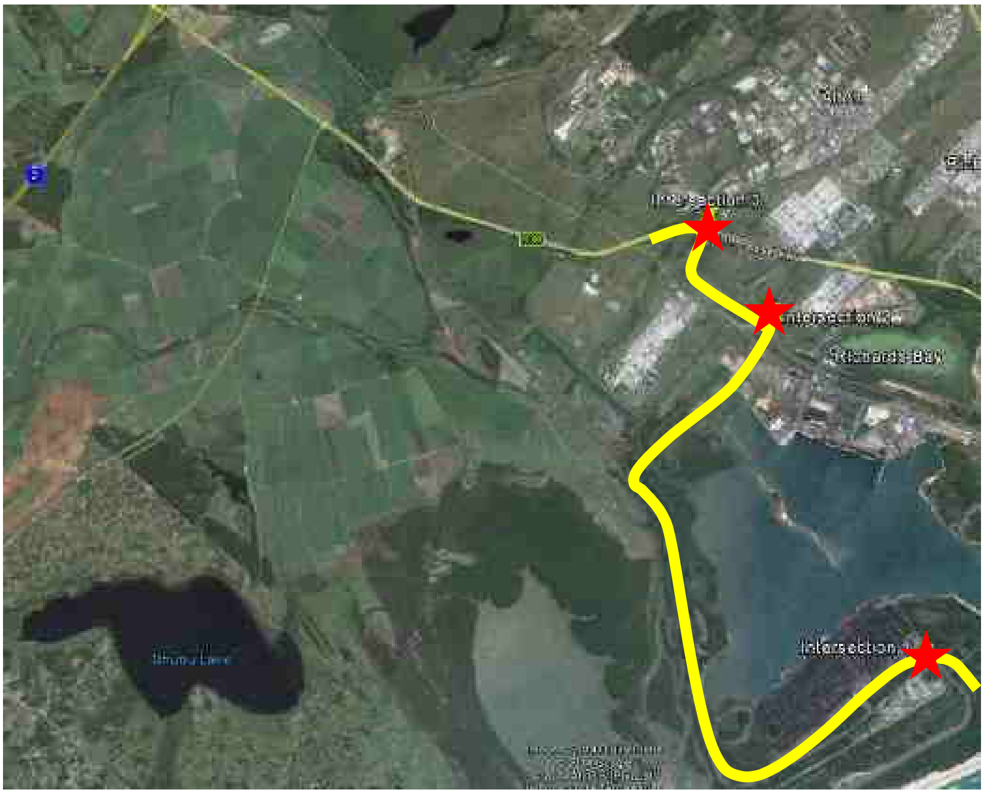

Figure 3: Intersections 1, 2 and 3

A 12 hour count was conducted from 6:00 to 18:00 at the three identified intersections. It was found that 06:45 to 07:45 is the typically the morning (AM) peak hour and 15:45 to 16:45 is typically the afternoon (PM) peak hour for all three intersections. The following figure shows the existing conditions in the AM as well as the PM peak hours for the three intersections leading to the proposed Vopak-Reatile Terminal site.

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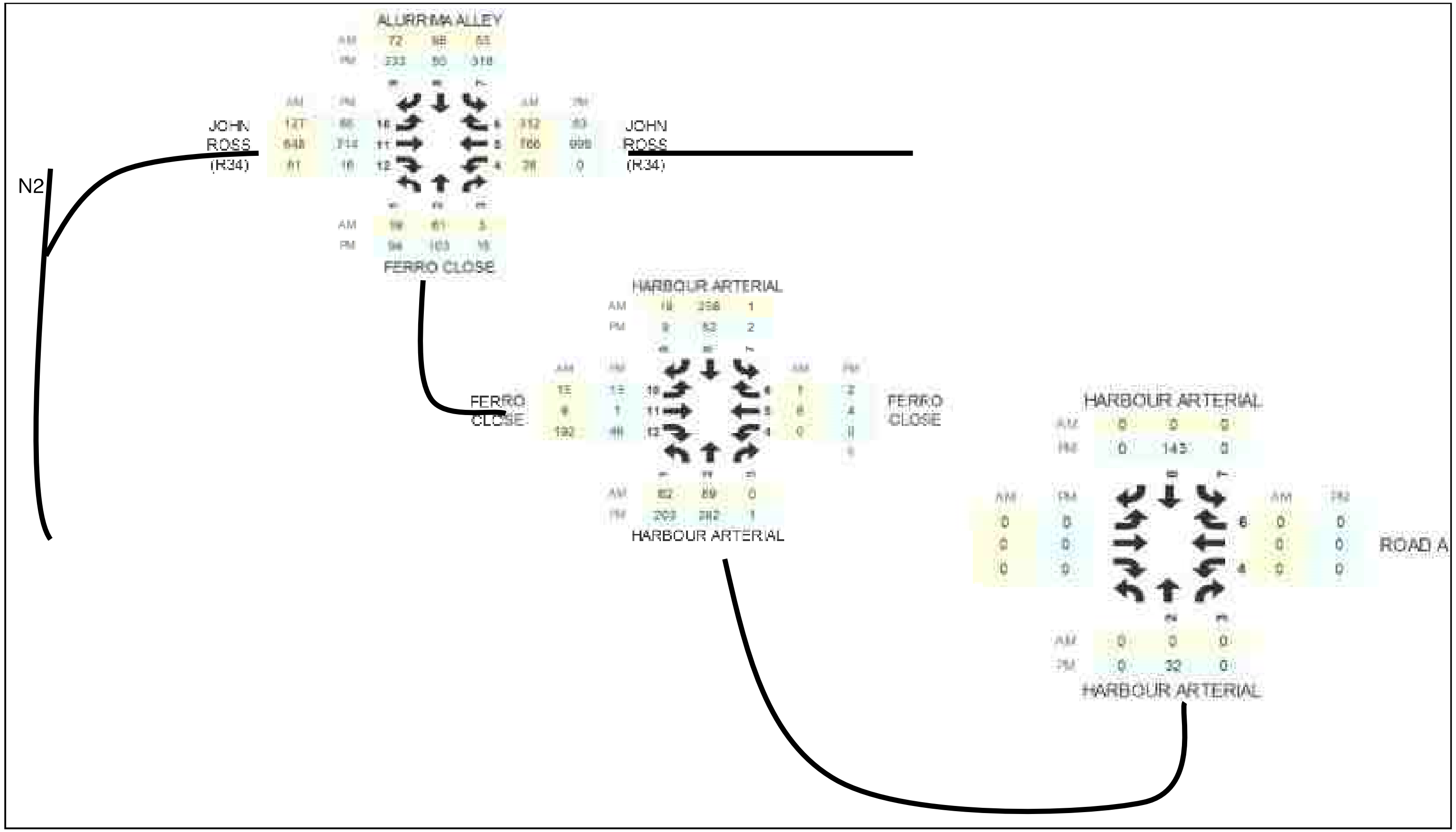

Figure 4: Weekday AM/PM Peak Hour Volumes

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Intersection two and three are existing signalised intersections. Intersection one is a priority controlled Intersection. The following table shows the results of a SIDRA analysis of the existing conditions (2014).

Table 1: Intersection analysis, background traffic - 2014

BACKGROUND TRAFFIC - 2014							
Approach	Road Name	John Ross Highway/Ferro Close		Ferro Close / Harbour Arterial		Harbour Arterial / Road A	
		AM	PM	AM	PM	AM	PM
East	LOS	B	B	B	B	B	B
	Delay (s)	18.4	17.4	13.4	16.1	10.6	11.6
	V/C	0.874	0.501	0.025	0.016	0.001	0.002
	Queue Length (m)	114.2	59.3	2	1.2	0.1	0.1
West	LOS	A	B	C	C	x	x
	Delay (s)	9.8	16.1	21.8	22.7	x	x
	V/C	0.288	0.532	0.403	0.154	x	x
	Queue Length (m)	50	63.6	34.3	11	x	x
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	24.9	11.7	10.1	10.5	4.2	0.9
	V/C	0.163	0.165	0.116	0.396	0.001	0.02
	Queue Length (m)	21.3	19.3	9.8	38.1	0	1
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	28	15.9	12.3	11.1	4.1	0.1
	V/C	0.298	0.537	0.384	0.138	0.001	0.083
	Queue Length (m)	32.3	42.3	36.3	12.3	0	0
Overall intersection performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	16.3	16.2	15.1	11.8	6.3	0.3
	V/C	0.874	0.537	0.403	0.396	0.001	0.083
	Queue Length (m)	114.2	63.6	36.3	38.1	0.1	1

The results summarised in Table 1 reveal that all the intersections are currently operating at an acceptable LOS (deemed to be LOS D or better) during the AM as well as the PM peak hour.

The full traffic counts are included in Appendix A.

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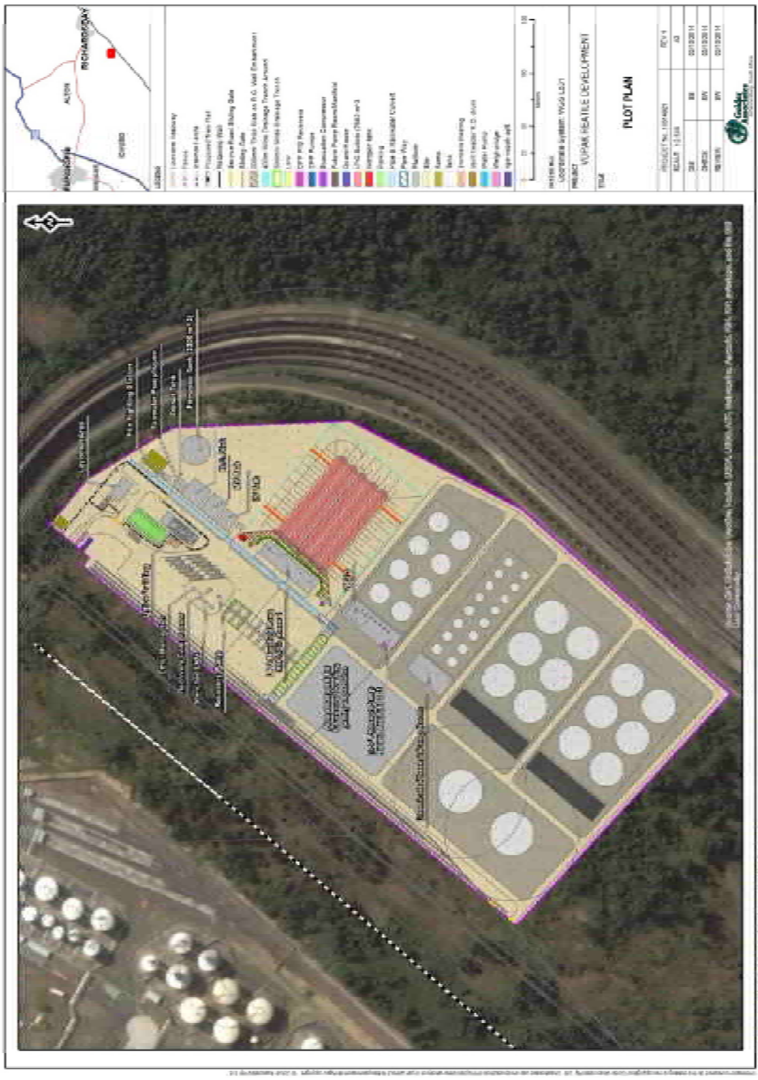
3. DEVELOPMENT PROPOSAL

The Vopak-Reatile Terminal Richards Bay constitutes a greenfield site, and will be developed in phases. Once completed, the total combined storage capacity would be approximately 300,000 m³. The project will comprise the following phases:

- An Initial Phase with a total storage capacity of approximately 36,000 m³; and
- Further Phases with a total storage capacity of up to 264,000 m³.



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The infrastructure proposed for each of the phases is indicated in the table below.

Table 2: Development Proposal and Phasing

SITE	PHASE 1	PHASE 2
Pipeline	• 1 x 16' carbon steel line for Avdag • 1 x 16' carbon steel line for diesel • 1 x 16' carbon steel line for petrol • 1 x 10' shipping line (liquid) • 1 x 10' shipping line (vapour)	• Number of additional pipelines sill to be comfirmed
Atmospheric storage	• 8 x 5 000 m^3 CPP storage vessels • New tanks, manifolds, vapour recovery unit, road and rail loading gantries and pipelines, utilities, offices, storage, shipping pipelines, rail siding and other infrastructure	• 12 x 10 000 m^3 of CPP atmospheric storage vessels • 16 x 1 500 m^3 of chemical storage vessels • Additional rail loading bays
LPG storage	• 5 x 7 882 m^3 mounded LPG pressurised storage vessels	• 2 x 34 000 m^3 refrigerated aboveground storage vessels
Road Gantries	• Three loading bays • Vapour recovery unit • Spill control slabs • Fixed canopy	• Two additional loading bays • Spill control slabs • Fixed canopy
Rail Gantries	• 30 Loading points • Vapour recovery system • Positive displacement flow metres • Two LPG rail loading bays	• Additional loading points • Additional two LPG rail loading bays • Positive displacement flow metres

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4. DEVELOPMENT IMPACT

4.1 TRIP GENERATION

4.1.1 HGV Trip Generation

Whilst the proposed project is anticipated to have impacts on shipping, rail and pipeline operations, the focus of this report are the impacts on the road network and supporting road infrastructure. The road gantry loading capacity of the proposed terminal was utilised to determine the trip generation of the development, and hence the impacts on the road network. The following tables show anticipated HGV volumes for Phase 1 and 2 of the project:

Table 3: Phase 1

PHASE 1	
Loading Bays (#)	9
Average Truck Load (m^3)	25
Maximum Pump Rate (m^3/h)	102,5
Clearance Time Coeficient	50%
HGV Volumes	18

Table 4: Phase 2

PHASE 2	
Loading Bays (#)	9
Average Truck Load (m^3)	25
Maximum Pump Rate (m^3/h)	102,5
Clearance Time Coeficient	50%
HGV Volumes	18

The HGV volumes calculation has been based on the following criteria:

- Number of loading bays of 9 bays for Phase 1 and a further 9 bays for Phase 2
- The average pump rate of 102.5m^3/h, being the average pump rate of 125m^3/h for CPP and 80m^3/h for LPG
- The average truck load of 25m^3, based on trucks being between 17m^3 and 40m^3

4.1.2 LV Trip Generation

The staff trips were estimated based on the following criteria:

- 120 general workers would be employed at the facility, who would utilise public transport in the form of mini-bus taxis
- 12 supervisory/management staff who would utilise private vehicles.

Public transport trips were estimated at 10 trips in the peak hour based on a vehicle (taxi) capacity of 12 passengers, whilst private vehicle trips were estimated at 12 trips in the peak hour based on a vehicle occupancy of 1 person.

Table 5: PT and PV trips

TRIP TYPE	PEOPLE	VEH CAPACITY	TRIPS	IN/OUT
PT Trips	120	12	10	100/100
PV Trips	12	1	12	80/20

4.1.3 Total Trips Generated

The total volumes for all trips for Phase 1 and Phase 2 are shown in the tables below:

Table 6: Total vehicle Volumes – Phase 1

TOTAL VEHICLE VOLUMES			
TOTAL IN			
HGV			18
PT			10
PV			10
TOTAL OUT			
HGV			17
PT			10
PV			2

Table 7: Total vehicle Volumes – Phase 2

TOTAL VEHICLE VOLUMES			
TOTAL IN			
HGV			37
PT			10
PV			10
TOTAL OUT			
HGV			33
PT			10
PV			2

* A reverse haul (loaded on entry and exit) percentage of 10% was assumed

4.2 TRIP DISTRIBUTION AND ASSIGNMENT

The total forecasted traffic for Phase 1, which includes background traffic, 2.5% p.a. growth rate from 2014 and development traffic, for the 2015 analysis years is shown in Figure 4.

Figure 5 shows the total forecasted traffic for Phase 2, which includes background traffic, 2.5% p.a. growth rate from 2014 and development traffic, for the 2020 analysis year.

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4.2.1 2015 (phase 1)

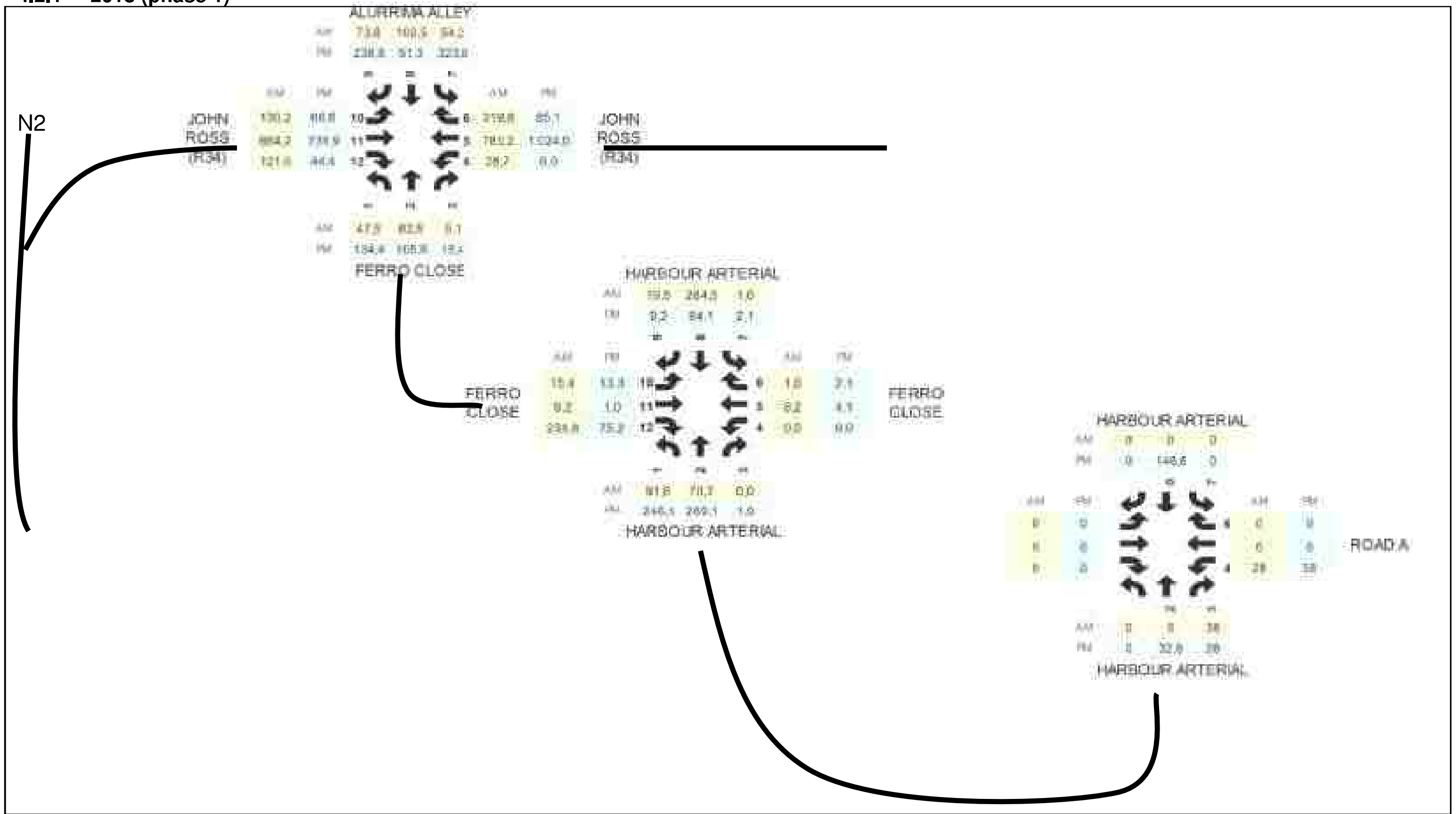

Figure 5: 2015 Total Forecasted traffic

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4.2.2 2020 (phase 2)

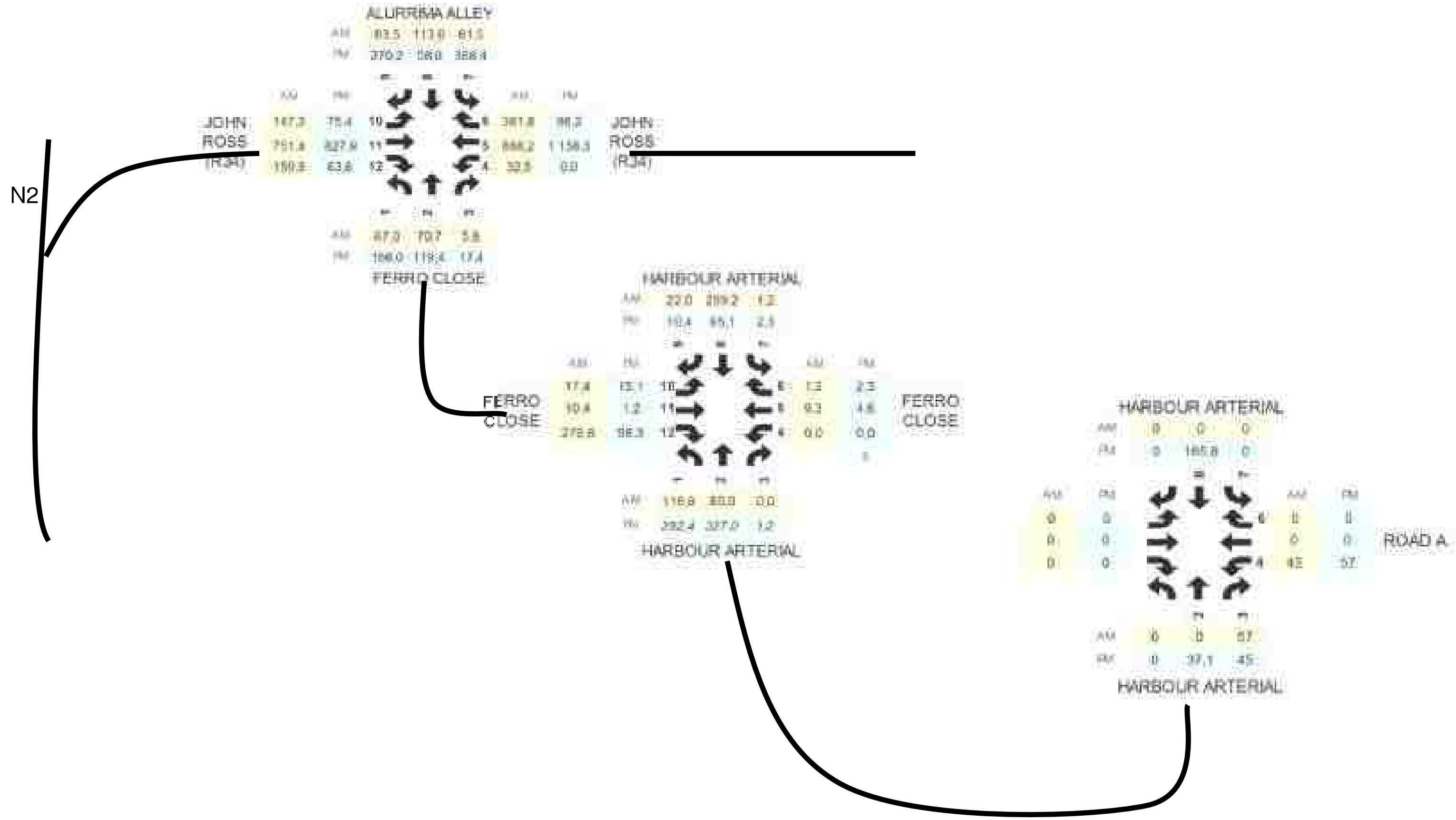

Figure 6: 2020 Total Forecasted traffic

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5. TRAFFIC ANALYSIS

5.1 INTERSECTION ANALYSIS

The intersections within the study area were analysed utilising the SIDRA Intersection Analysis software, to determine their operational characteristics for the 2015 and 2020 analysis years. The results from the traffic analysis are summarized in Tables 8 and 9 for the expected morning and afternoon peak hour traffic loadings on all the intersections for 2015 and 2020 analysis years respectively, whilst the full SIDRA output is given in Appendix B.

5.1.1 Phase 1 Intersection Analysis

Table 8: 2015 Phase 1 Intersection Analysis

PHASE 1 - 2015							
Approach	Road Name	John Ross Highway/Ferro Close		Ferro Close / Harbour Arterial		Harbour Arterial / Road A	
		AM	PM	AM	PM	AM	PM
East	LOS	B	B	B	B	B	C
	Delay (s)	17.4	17.5	12	16	14	15.3
	V/C	0.870	0.513	0.023	0.017	0.028	0.047
	Queue Length (m)	114.2	61.1	1.9	1.2	1.8	2.7
West	LOS	B	B	C	C	x	x
	Delay (s)	10.5	16.9	20.9	23.4	x	x
	V/C	0.429	0.545	0.459	0.234	x	x
	Queue Length (m)	51.5	65.6	41.8	17.3	x	x
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	21.4	17.5	10.7	10.5	10.1	6.8
	V/C	0.167	0.513	0.132	0.406	0.035	0.056
	Queue Length (m)	21.8	61.1	10.7	39.3	1.9	3.7
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	28.1	16	14.1	11.2	4.1	0.1
	V/C	0.306	0.552	0.437	0.141	0.001	0.085
	Queue Length (m)	33.2	43.7	40	12.7	0	0
Overall intersection performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	16	16.5	15.8	12.2	11.5	4.1
	V/C	0.870	0.552	0.459	0.406	0.035	0.085
	Queue Length (m)	114.2	65.6	41.8	39.3	1.9	3.7

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The analysis has revealed that all the intersections within the study area would operate at an acceptable LOS for the 2015 analysis year.

Table 9: 2020 Phase 2 Intersection Analysis

PHASE 2 - 2020							
Approach	Road Name	John Ross Highway/Ferro Close		Ferro Close / Harbour Arterial		Harbour Arterial / Road A	
		AM	PM	AM	PM	AM	PM
East	LOS	B	B	B	B	B	C
	Delay (s)	14.2	15.5	11.3	16.1	15	17.4
	V/C	1	0.515	0.025	0.019	0.05	0.086
	Queue Length (m)	127.9	65.4	2.1	1.3	3.5	5.4
West	LOS	B	B	C	C	X	X
	Delay (s)	11.8	15.8	21.0	24.2	X	X
	V/C	0.714	0.715	0.542	0.315	X	X
	Queue Length (m)	59.8	70.4	52.4	24	X	X
South	LOS	C	B	B	B	N/A	N/A
	Delay (s)	23.8	13.8	11.2	10.7	10.9	9
	V/C	0.252	0.372	0.158	0.459	0.059	0.091
	Queue Length (m)	28.6	24.8	12.6	45.8	3.6	6.5
North	LOS	C	B	B	B	N/A	N/A
	Delay (s)	33.0	18.7	15.3	11.3	4.1	0
	V/C	0.367	0.641	0.524	0.16	0.001	0.096
	Queue Length (m)	43.6	58.3	48.1	14.4	0	0
Overall intersection performance	LOS	B	B	B	B	N/A	N/A
	Delay (s)	15.5	16.1	16.4	12.6	12.5	5.7
	V/C	1	0.715	0.542	0.459	0.059	0.096
	Queue Length (m)	127.9	70.4	52.4	45.8	3.6	6.5

The analysis has revealed that all the intersections within the study area would operate at an acceptable LOS for the 2020 analysis year.

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6. SUMMARY OF FINDINGS AND RECOMMENDATIONS

6.1 SUMMARY OF FINDINGS

The Traffic Impact Assessment for the proposed Vopak-Reatile Terminal Richards Bay has revealed the following outcomes and findings:

a) For Phase 1, the proposed Vopak-Reatile Terminal Richards Bay would generate approximately 38 vehicle trip inbound (18 HGVs and 20 light motor vehicles) and 29 vehicle trips outbound (17 HGVs and 12 light motor vehicles) in the AM Peak hour, with the reverse flows in the PM peak hour.

b) For Phase 2, the proposed Vopak-Reatile Terminal Richards Bay would generate approximately 57 vehicle trip inbound (37 HGVs and 20 light motor vehicles) and 45 vehicle trips outbound (33 HGVs and 12 light motor vehicles) in the AM Peak hour, with the reverse flows in the PM peak hour.

c) The intersection analysis for the 2015 (Phase 1) and 2020 (Phase 2) analysis years has revealed that all the intersections within the study area would operate at an acceptable LOS with the development in place.

d) In light of the road network performing at an acceptable LOS, no mitigation measures are required.

6.2 RECOMMENDATION

The Vopak-Reatile Terminal Richards Bay does not have a significant impact on the operational performance or safety of the surrounding road network and thus it is recommended that this project be approved from a transportation perspective.

Appendix A

Traffic Counts

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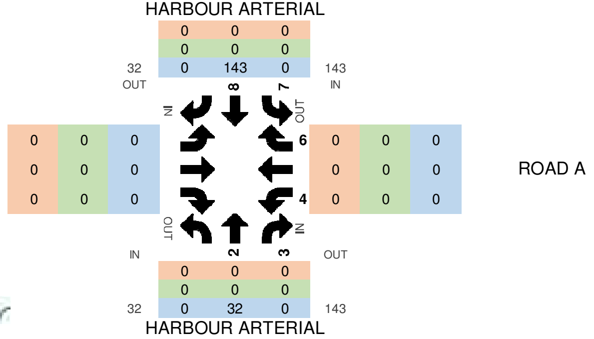
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 1	INTERSECTION OF HARBOUR ARTERIAL AND ROAD A	27/11/2014
12 HOUR COUNT	TOTAL VEHICLES	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
		2	3	4		6	7	8						
06:00														
06:15														
06:30														
06:45														06:00
07:00														06:15
07:15														06:30
07:30														06:45
07:45														07:00
08:00														07:15
08:15														07:30
08:30		2						1					3	07:45
08:45		12						5					20	08:00
09:00		10						10					40	08:15
09:15		8						5					53	08:30
09:30		6						4					60	08:45
09:45		9						3					55	09:00
10:00		3						4					42	09:15
10:15		5						5					39	09:30
10:30		7						6					42	09:45
10:45		5						6					41	10:00
11:00		9						9					52	10:15
11:15		10						9					61	10:30
11:30		10		2				2					62	10:45
11:45		8						13					72	11:00
12:00		7	1					11					73	11:15
12:15		7		3				1					65	11:30
12:30		7						4					62	11:45
12:45		5						7					53	12:00
13:00		11						7					52	12:15
13:15		5						4					50	12:30
13:30		6						5					50	12:45
13:45		8						12					58	13:00
14:00		5						7					52	12:15
14:15		6						4					53	12:30
14:30		5						14					61	12:45
14:45		8						5					54	14:00
15:00		6						6					54	14:15
15:15		2						4					50	14:30
15:30		2						13					46	14:45
15:45		8						17					58	15:00
16:00		4						12					62	15:15
16:15		17						41					114	15:30
16:30		3						73					175	15:45
16:45		8						22					180	16:00
17:00		6						11					181	16:15
17:15		11						9					143	16:30
17:30		14						3					84	16:45
17:45		11						13					78	17:00
18:00													61	17:15
18:15													41	17:30
18:30													24	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total		**276**	**1**	**5**				**387**					**669**	
AM PEAK														
PM PEAK		**32**						**143**					**175**	

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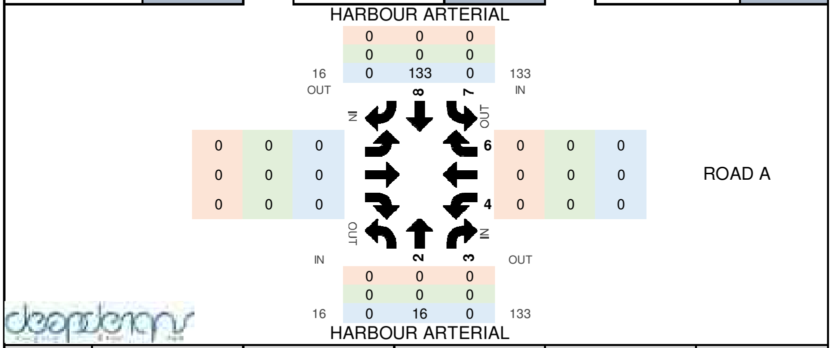
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 1	INTERSECTION OF HARBOUR ARTERIAL AND ROAD A			27/11/2014
12 HOUR COUNT	CARS			THURSDAY
AM PEAK	06:45 07:45		PM PEAK	15:45 16:45



Time	South			East			North			West			Hourly	
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06:00														
06:15														
06:30														
06:45														06:00
07:00														06:15
07:15														06:30
07:30														06:45
07:45														07:00
08:00														07:15
08:15														07:30
08:30		2						1					3	07:45
08:45		12						4					19	08:00
09:00		10						9					38	08:15
09:15		8						5					51	08:30
09:30		6						4					58	08:45
09:45		9						3					54	09:00
10:00		3						3					41	09:15
10:15		4						5					37	09:30
10:30		7						6					40	09:45
10:45		5						6					39	10:00
11:00		8						7					48	10:15
11:15		10						8					57	10:30
11:30		10		2				2					58	10:45
11:45		7						12					66	11:00
12:00		6	1					11					69	11:15
12:15		5		3				1					60	11:30
12:30		4						2					52	11:45
12:45		3						6					42	12:00
13:00		10						7					41	12:15
13:15		5						3					40	12:30
13:30		4						5					43	12:45
13:45		7						10					51	13:00
14:00		5						5					44	13:15
14:15		5						4					45	13:30
14:30		4						13					53	13:45
14:45		6						4					46	14:00
15:00		5						6					47	14:15
15:15		2						3					43	14:30
15:30		2						7					35	14:45
15:45		2						16					43	15:00
16:00		4						9					45	15:15
16:15		9						36					85	15:30
16:30		1						72					149	15:45
16:45		6						15					152	16:00
17:00		5						8					152	16:15
17:15		8						9					124	16:30
17:30		11						3					65	16:45
17:45		10						12					66	17:00
18:00													53	17:15
18:15													36	17:30
18:30													22	17:45
18:45														18:00
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19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total		**230**	**1**	**5**				**342**					**578**	
AM PEAK	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**0**	**16**	**0**	**0**	**0**	**0**	**0**	**133**	**0**	**0**	**0**	**0**	**149**	

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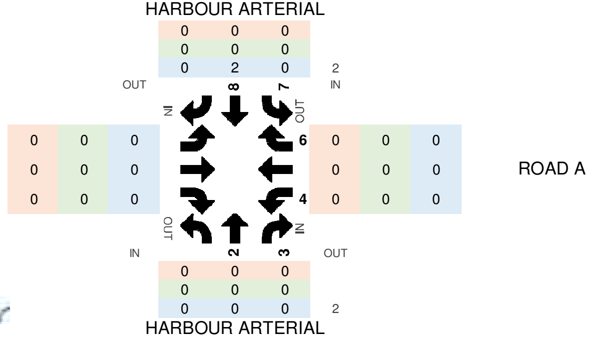
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 1	INTERSECTION OF HARBOUR ARTERIAL AND ROAD A	27/11/2014
12 HOUR COUNT	MINIBUSES	THURSDAY

AM PEAK	06:45 07:45			PM PEAK	15:45 16:45



Time	South			East			North			West			Hourly	
		2	3	4		6	7	8						
06:00														
06:15														
06:30														
06:45														06:00
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08:00														07:15
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19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total		11						6					17	
AM PEAK	0	0	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0	0	0		
PM PEAK	0	0	0	0	0	0	0	2	0	0	0	0	2	

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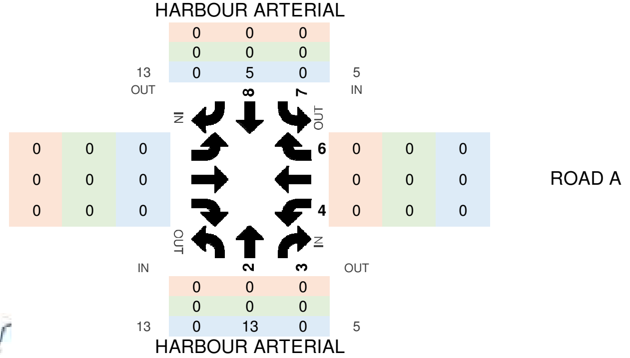
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 1	INTERSECTION OF HARBOUR ARTERIAL AND ROAD A	27/11/2014
12 HOUR COUNT	BUSES	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
		2	3	4		6	7	8						
06:00														
06:15														
06:30														
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15:45		6											7	15:00
16:00								2					9	15:15
16:15		7						2					18	15:30
16:30								1					18	15:45
16:45		1						6					19	16:00
17:00		1						1					19	16:15
17:15		1											11	16:30
17:30		3											13	16:45
17:45								1					7	17:00
18:00													5	17:15
18:15													4	17:30
18:30													1	17:45
18:45														18:00
19:00														18:15
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19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total		20						14					34	
AM PEAK	0	0	0	0	0	0	0	0	0	0	0	0		
	0	0	0	0	0	0	0	0	0	0	0	0		
PM PEAK	0	13	0	0	0	0	0	5	0	0	0	0	18	

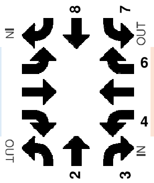
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 1	**INTERSECTION OF HARBOUR ARTERIAL AND ROAD A**	**27/11/2014**
12 HOUR COUNT	**TRUCKS**	**THURSDAY**
AM PEAK 06:45 07:45		**PM PEAK** 15:45 16:45

HARBOUR ARTERIAL

	0	0	0	
	0	0	0	
3	0	3	0	3
OUT				IN

0	0	0
0	0	0
0	0	0



0	0	0
0	0	0
0	0	0

ROAD A

IN				OUT
	0	0	0	
	0	0	0	
3	0	3	0	3

HARBOUR ARTERIAL

Time	South			East			North			West			Hourly	
		2	3	4		6	7	8						
06:00														
06:15														
06:30														
06:45														06:00
07:00														06:15
07:15														06:30
07:30														06:45
07:45														07:00
08:00														07:15
08:15														07:30
08:30														07:45
08:45														08:00
09:00								1					1	08:15
09:15													1	08:30
09:30													1	08:45
09:45													1	09:00
10:00														09:15
10:15		1											1	09:30
10:30													1	09:45
10:45													1	10:00
11:00		1						2					4	10:15
11:15													3	10:30
11:30													3	10:45
11:45		1						1					5	11:00
12:00													2	11:15
12:15		1											3	11:30
12:30		3						2					8	11:45
12:45								1					7	12:00
13:00		1											8	12:15
13:15								1					8	12:30
13:30		1											4	12:45
13:45		1						2					6	13:00
14:00								2					7	13:15
14:15		1											7	13:30
14:30								1					7	13:45
14:45													4	14:00
15:00		1											3	14:15
15:15								1					3	14:30
15:30								5					7	14:45
15:45													7	15:00
16:00								1					7	15:15
16:15		1						2					9	15:30
16:30		2											6	15:45
16:45								1					7	16:00
17:00								2					8	16:15
17:15													5	16:30
17:30													3	16:45
17:45													2	17:00
18:00														17:15
18:15														17:30
18:30														17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total		**15**						**25**					**40**	
AM PEAK	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**6**	

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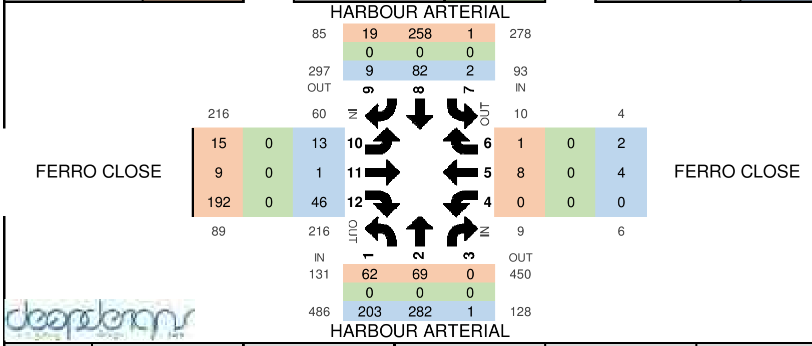
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 2 | **INTERSECTION OF HARBOUR ARTERIAL AND FERRO CLOSE** | **27/11/2014**

12 HOUR COUNT | **TOTAL VEHICLES** | **THURSDAY**

AM PEAK 06:45 07:45 | **PM PEAK** 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	25	19			1				9	11	1	8		
06:15	33	17				1		27	1	2		23		
06:30	30	24					1	67	4	1		37		
06:45	24	23			2	1	1	93	6	3	4	71	570	06:00
07:00	9	11			1			47	5	3	1	39	612	06:15
07:15	16	18			3			62	5	2	3	41	658	06:30
07:30	13	17			2			56	3	7	1	41	634	06:45
07:45	20	15			1			65	4	1		40	552	07:00
08:00	20	27			2			44	8	2	2	45	586	07:15
08:15	20	22		1	1		1	33	4	4	2	17	541	07:30
08:30	24	41					1	39	3	7	4	29	549	07:45
08:45	18	28			2	2		32	3	6	2	20	516	08:00
09:00	12	20		1	1	1	1	30	1	8	2	31	474	08:15
09:15	24	36		1	2	2		35	1	7	1	37	515	08:30
09:30	25	19				2	1	33		3	1	27	478	08:45
09:45	24	24			3		2	34	1	5		17	475	09:00
10:00	32	19		1	1	1	1	40	7	3		25	497	09:15
10:15	24	29						18		3	1	43	469	09:30
10:30	12	15			1		1	27	4	6	3	27	454	09:45
10:45	25	35			2		1	27	6	2	3	19	464	10:00
11:00	27	47		1	1	1		26	4	4	2	17	464	10:15
11:15	34	62			1			33	3	2	1	15	497	10:30
11:30	20	42	1	1	1		1	24		3	3	16	513	10:45
11:45	27	43	1		3	1		35	2	3	1	23	532	11:00
12:00	15	35			1	1		30	2	3	2	25	516	11:15
12:15	27	39			1	1	2	23	1	3		17	479	11:30
12:30	39	49			1			28	3	2	3	15	507	11:45
12:45	26	23					2	35	2	4	1	16	477	12:00
13:00	43	48	2		1			23	3	3		31	517	12:15
13:15	12	24			2			29	2	4	1	38	515	12:30
13:30	12	23		1	2			36	2	1	1	22	475	12:45
13:45	29	25			1	2	1	28	2	3	1	20	478	13:00
14:00	23	36				2		27	3	1	1	23	440	12:15
14:15	37	34		1				11	2	3	1	27	444	12:30
14:30	39	35			3	1	2	22	4	5	1	21	477	12:45
14:45	19	37			1			16	1	3	2	13	457	14:00
15:00	21	30			2	1		17	6	4	1	13	436	14:15
15:15	22	28			1			18	1	2		16	408	14:30
15:30	42	59			1			14	1	3		14	409	14:45
15:45	40	55			1	1		24	1	1	1	13	454	15:00
16:00	49	67	1		1	1		29		6		19	532	15:15
16:15	67	94			2		1	13	4	4		7	636	15:30
16:30	47	66					1	16	4	2		7	645	15:45
16:45	43	78						22		1		10	662	16:00
17:00	24	35				1		15	2	2	1	22	591	16:15
17:15	15	30						22		7		26	499	16:30
17:30	14	27						27		2		18	444	16:45
17:45	21	23					1	15	2	1		21	374	17:00
18:00													272	17:15
18:15													172	17:30
18:30													84	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**1264**	**1653**	**5**	**8**	**52**	**23**	**22**	**1467**	**132**	**168**	**55**	**1162**	**6011**	
AM PEAK	**62**	**69**			**8**	**1**	**1**	**258**	**19**	**15**	**9**	**192**	**634**	
PM PEAK	**203**	**282**	**1**		**4**	**2**	**2**	**82**	**9**	**13**	**1**	**46**	**645**	

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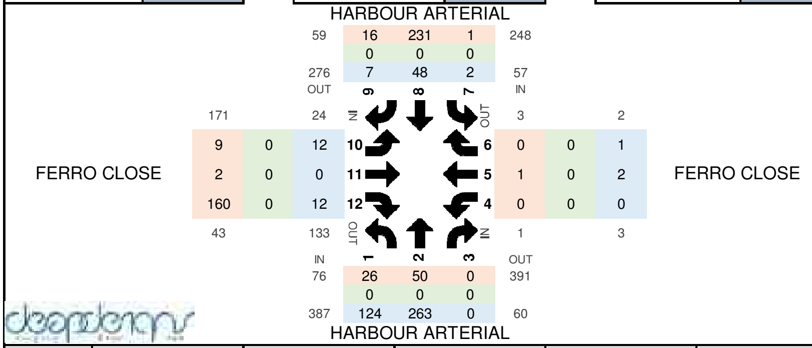
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

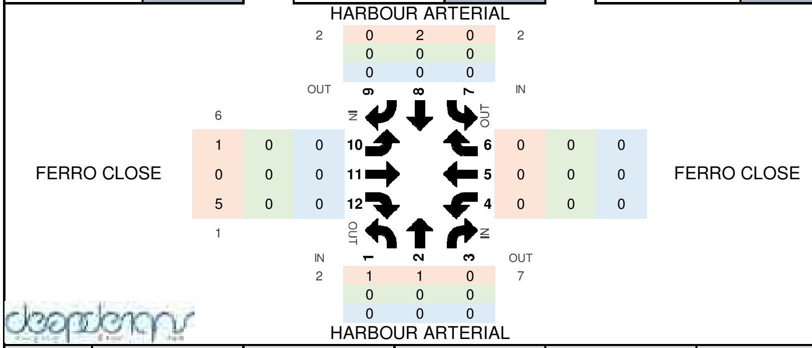
LOCATION 2	INTERSECTION OF HARBOUR ARTERIAL AND FERRO CLOSE	27/11/2014
12 HOUR COUNT	CARS	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	17	12			1				5	11		4		
06:15	24	14						18	1	1		21		
06:30	16	14						57	4	1		32		
06:45	10	18					1	84	5			52	423	06:00
07:00	5	6						45	5	3	1	37	475	06:15
07:15	5	13			1			53	4	2	1	39	514	06:30
07:30	6	13						49	2	4		32	496	06:45
07:45	13	11						56	3			26	435	07:00
08:00	7	22						42	2	2	1	31	440	07:15
08:15	11	21		1	1		1	30	3	3	1	12	406	07:30
08:30	9	32						28	3	2	1	18	393	07:45
08:45	8	24				2		24	2	3	2	15	364	08:00
09:00	7	15		1			1	27	1	3	1	15	328	08:15
09:15	14	29		1	2	2		29	1	4		18	344	08:30
09:30	11	18				1	1	29		3		14	328	08:45
09:45	10	18			1			29	1	5		14	326	09:00
10:00	21	16		1	1			25	6	2		11	338	09:15
10:15	13	27						14		3		17	312	09:30
10:30	9	14					1	19	4	6	2	17	307	09:45
10:45	13	29			1		1	21	5	2	2	15	318	10:00
11:00	8	38		1		1		17	3	2		6	311	10:15
11:15	19	55						25	3	2	1	7	349	10:30
11:30	10	40	1	1			1	21		3	1	10	365	10:45
11:45	13	33	1		1	1		29	1	2		11	368	11:00
12:00	11	33						22	2	2	1	17	380	11:15
12:15	14	34				1	2	15	1	3		5	343	11:30
12:30	16	42			1			19	2	1	1	9	346	11:45
12:45	12	15						26	2	3	1	7	320	12:00
13:00	23	42	2		1			19	3	1		18	341	12:15
13:15	6	21						25	2	4		22	346	12:30
13:30	8	12						32	2	1		14	324	12:45
13:45	14	21						18	1	2		15	329	13:00
14:00	10	28				2		16	3	1		10	290	13:15
14:15	26	27						7	2	3		9	284	13:30
14:30	30	33					2	19	4	3		13	319	13:45
14:45	14	32			1			15	1	3	1	8	323	14:00
15:00	10	26				1		17	1	4		7	319	14:15
15:15	6	21						14	1	1		9	297	14:30
15:30	19	49						12	1	3		6	283	14:45
15:45	17	52			1	1		15	1	1		3	299	15:00
16:00	34	63			1			15		6		6	358	15:15
16:15	50	85					1	11	3	4			460	15:30
16:30	23	63					1	7	3	1		3	471	15:45
16:45	27	69						14		1		5	496	16:00
17:00	11	30				1		9	1	1	1	15	440	16:15
17:15	9	22						20				17	354	16:30
17:30	10	23						22		2		12	322	16:45
17:45	18	20					1	10	1	1		17	274	17:00
18:00													205	17:15
18:15													137	17:30
18:30													68	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**697**	**1395**	**4**	**6**	**14**	**13**	**14**	**1170**	**101**	**121**	**19**	**721**	**4275**	
AM PEAK	**26**	**50**	**0**	**0**	**1**	**0**	**1**	**231**	**16**	**9**	**2**	**160**	**496**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**124**	**263**	**0**	**0**	**2**	**1**	**2**	**48**	**7**	**12**	**0**	**12**	**471**	

RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 2	**INTERSECTION OF HARBOUR ARTERIAL AND FERRO CLOSE**	**27/11/2014**
12 HOUR COUNT	**MINIBUSES**	**THURSDAY**
AM PEAK 06:45 07:45		**PM PEAK** 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	3	2												
06:15		1						1						
06:30		1						2				1		
06:45								2				2	15	06:00
07:00												1	11	06:15
07:15	1											1	11	06:30
07:30		1								1		1	10	06:45
07:45									1				7	07:00
08:00													6	07:15
08:15													4	07:30
08:30								1					2	07:45
08:45													1	08:00
09:00													1	08:15
09:15													1	08:30
09:30														08:45
09:45														09:00
10:00														09:15
10:15														09:30
10:30														09:45
10:45														10:00
11:00														10:15
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11:30														10:45
11:45														11:00
12:00														11:15
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16:00														15:15
16:15														15:30
16:30														15:45
16:45														16:00
17:00														16:15
17:15										1		2	3	16:30
17:30								1					4	16:45
17:45		1											5	17:00
18:00													5	17:15
18:15													2	17:30
18:30													1	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**4**	**6**						**7**	**1**	**2**		**8**	**28**	
AM PEAK	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**5**	**10**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		

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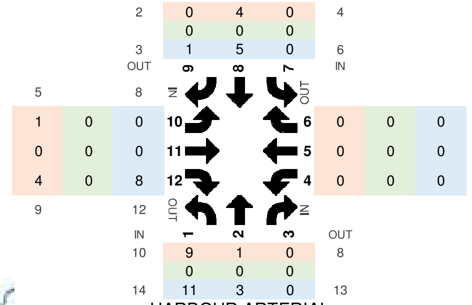
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 2	INTERSECTION OF HARBOUR ARTERIAL AND FERRO CLOSE		27/11/2014
12 HOUR COUNT	BUSES		THURSDAY
AM PEAK	06:45 07:45	PM PEAK	15:45 16:45

HARBOUR ARTERIAL

FERRO CLOSE



FERRO CLOSE

HARBOUR ARTERIAL

Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	4	4										3		
06:15	2	1						2		1		2		
06:30	8	2						3						
06:45	2	1						3		1		4	43	06:00
07:00								1					33	06:15
07:15	2												27	06:30
07:30	5												19	06:45
07:45								1					9	07:00
08:00													8	07:15
08:15	2												8	07:30
08:30													3	07:45
08:45													2	08:00
09:00													2	08:15
09:15														08:30
09:30														08:45
09:45														09:00
10:00														09:15
10:15														09:30
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10:45														10:00
11:00														10:15
11:15														10:30
11:30														10:45
11:45														11:00
12:00	1												1	11:15
12:15												1	2	11:30
12:30	1												3	11:45
12:45	1							1					5	12:00
13:00								1				6	11	12:15
13:15								1				4	15	12:30
13:30													14	12:45
13:45												1	13	13:00
14:00	3	2											11	13:15
14:15	4	2										1	13	13:30
14:30	5	1											19	13:45
14:45													18	14:00
15:00													13	14:15
15:15		1										3	10	14:30
15:30	1	2										1	8	14:45
15:45	4							1				1	14	15:00
16:00	1							3				5	23	15:15
16:15	3	2										2	26	15:30
16:30	3	1						1	1				28	15:45
16:45	2	4						1					29	16:00
17:00		1							1	1		4	27	16:15
17:15		1						1		2			24	16:30
17:30													18	16:45
17:45	1								1				13	17:00
18:00													6	17:15
18:15													2	17:30
18:30													2	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	55	25						20	3	5		38	146	
AM PEAK	9	1	0	0	0	0	0	4	0	1	0	4	19	
	0	0	0	0	0	0	0	0	0	0	0	0		
PM PEAK	11	3	0	0	0	0	0	5	1	0	0	8	28	

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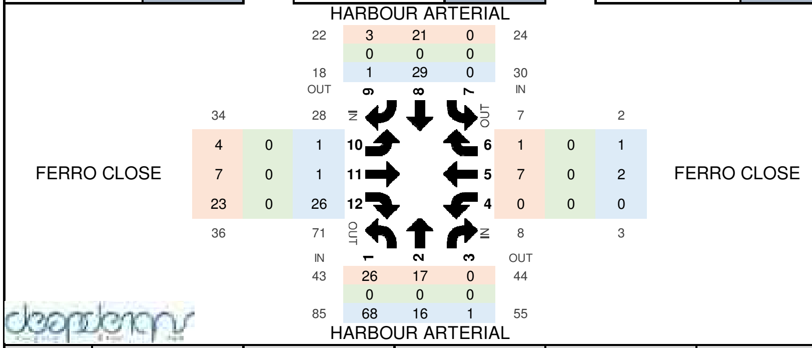
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 2	INTERSECTION OF HARBOUR ARTERIAL AND FERRO CLOSE	27/11/2014
12 HOUR COUNT	TRUCKS	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	1	1							4		1	1		
06:15	7	1				1		6						
06:30	6	7					1	5				4		
06:45	12	4			2	1		4	1	2	4	13	89	06:00
07:00	4	5			1			1				1	93	06:15
07:15	8	5			2			9	1		2	1	106	06:30
07:30	2	3			2			7	1	2	1	8	109	06:45
07:45	7	4			1			8		1		14	101	07:00
08:00	13	5			2			2	6		1	14	132	07:15
08:15	7	1						3	1	1	1	5	123	07:30
08:30	15	9					1	10		5	3	11	151	07:45
08:45	10	4			2			8	1	3		5	149	08:00
09:00	5	5			1	1		3		5	1	16	143	08:15
09:15	10	7						6		3	1	19	170	08:30
09:30	14	1				1		4			1	13	150	08:45
09:45	14	6			2		2	5				3	149	09:00
10:00	11	3				1	1	15	1	1		14	159	09:15
10:15	11	2						4			1	26	157	09:30
10:30	3	1			1			8			1	10	147	09:45
10:45	12	6			1			6	1		1	4	146	10:00
11:00	19	9			1			9	1	2	2	11	153	10:15
11:15	15	7			1			8				8	148	10:30
11:30	10	2			1			3			2	6	148	10:45
11:45	14	10			2			6	1	1	1	12	164	11:00
12:00	3	2			1	1		8		1	1	8	135	11:15
12:15	13	5			1			8				11	134	11:30
12:30	22	7						9	1	1	2	6	158	11:45
12:45	13	8					2	8		1		9	152	12:00
13:00	20	6						3		2		7	165	12:15
13:15	6	3			2			3			1	12	154	12:30
13:30	4	11		1	2			4			1	8	137	12:45
13:45	15	4			1	2	1	10	1	1	1	4	136	13:00
14:00	10	6						11			1	13	139	13:15
14:15	7	5		1				4			1	17	147	13:30
14:30	4	1			3	1		3		2	1	8	139	13:45
14:45	5	5						1			1	5	116	14:00
15:00	11	4			2				5		1	6	104	14:15
15:15	16	6			1			4		1		4	101	14:30
15:30	22	8			1			2				7	118	14:45
15:45	19	3						8			1	9	141	15:00
16:00	14	4	1			1		11				8	151	15:15
16:15	14	7			2			2	1			5	150	15:30
16:30	21	2						8		1		4	146	15:45
16:45	14	5						7				5	137	16:00
17:00	13	4						6				3	124	16:15
17:15	6	7						1		4		7	118	16:30
17:30	4	4						4				6	100	16:45
17:45	2	2						5				4	82	17:00
18:00													56	17:15
18:15													31	17:30
18:30													13	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	508	227	1	2	38	10	8	270	27	40	36	395	1562	
AM PEAK	26	17	0	0	7	1	0	21	3	4	7	23	109	
	0	0	0	0	0	0	0	0	0	0	0	0		
PM PEAK	68	16	1	0	2	1	0	29	1	1	1	26	146	

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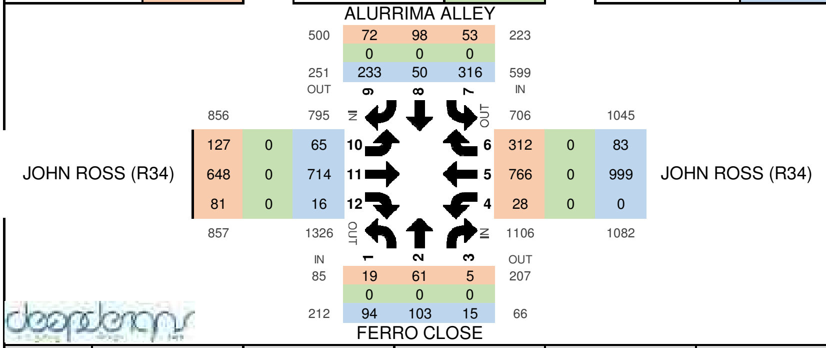
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 3	INTERSECTION OF JOHN ROSS AND FERRO CLOSE	27/11/2014
12 HOUR COUNT	TOTAL VEHICLES	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	13	19		2	69	42	6	7	3	7	85	18		
06:15	14	23		4	79	51	6	9	4	9	104	18		
06:30	2	6		3	72	57	9	13	8	21	88	4		
06:45	6	14	1	9	184	83	11	22	17	34	139	23	1418	06:00
07:00	2	21		7	179	78	10	24	20	31	176	28	1723	06:15
07:15	4	13	2	7	219	81	13	24	14	19	154	17	1969	06:30
07:30	7	13	2	5	184	70	19	28	21	43	179	13	2270	06:45
07:45	6	11		4	124	40	11	25	24	31	157	8	2168	07:00
08:00	6	16	3		137	26	16	23	25	22	108	17	1991	07:15
08:15	6	23	1	1	117	17	8	24	20	24	113	12	1790	07:30
08:30	8	6	1	1	136	11	7	19	35	17	140	5	1592	07:45
08:45	5	19	1	1	114	11	3	12	27	8	96	3	1451	08:00
09:00	3	16	2		122	29	6	19	31	15	95	19	1409	08:15
09:15	4	12	1		114	11	10	15	34	18	108	17	1387	08:30
09:30	4	13	1	1	93	16	14	20	39	12	93	8	1315	08:45
09:45	4	14	1	2	156	31	11	13	32	8	103	5	1395	09:00
10:00	10	18	1		83	9	7	17	29	6	77	6	1301	09:15
10:15	3	17			114	9	7	28	28	14	128	6	1311	09:30
10:30	6	18	3		123	12	14	14	28	4	101		1320	09:45
10:45	5	20	1	2	161	12	23	29	28	9	108		1338	10:00
11:00	8	21			122	12	12	14	24		98	4	1390	10:15
11:15	9	24			113	14	7	9	15	7	80	2	1316	10:30
11:30	8	20			131	9	13	19	22	7	106	6	1334	10:45
11:45	6	18	1	2	152	26	13	21	23	8	140	3	1349	11:00
12:00	8	10		4	132	9	9	16	34	3	90		1349	11:15
12:15	15	24		3	185	19	9	14	31	16	116	5	1506	11:30
12:30	7	22	1		122	14	10	12	42	19	99	5	1518	11:45
12:45	12	25	1		163	17	20	16	34	15	103	1	1512	12:00
13:00	13	25			182	15	8	15	28	10	84	14	1591	12:15
13:15	6	16			154	11	5	20	22	15	112	10	1525	12:30
13:30	5	14	1		159	12	10	11	36	40	97	11	1568	12:45
13:45	6	17			160	15	12	11	31	22	103	6	1544	13:00
14:00	10	15	1		163	13	19	16	51	18	119	4	1579	12:15
14:15	10	16		2	222	16	18	24	55	23	168	3	1765	12:30
14:30	23	17			188	17	16	18	39	8	131	8	1834	12:45
14:45	11	14			187	15	16	15	38	17	131	4	1899	14:00
15:00	5	18	2		201	9	12	10	24	10	145	3	1909	14:15
15:15	4	19	1	1	185	8	14	15	35	10	133	5	1782	14:30
15:30	4	35	2		191	9	24	10	35	11	74	1	1713	14:45
15:45	10	30			195	16	39	14	57	31	219	4	1880	15:00
16:00	21	27	4		248	21	109	14	60	11	115	4	2075	15:15
16:15	47	33	5		317	31	90	12	54	11	191	4	2440	15:30
16:30	16	13	6		239	15	78	10	62	12	189	4	2688	15:45
16:45	7	13			264	8	55	7	47	9	169	2	2654	16:00
17:00	5	8			255	8	23	10	50	1	123	7	2510	16:15
17:15	8	8		1	238	15	7	8	31	12	118	7	2168	16:30
17:30	12	2		1	167	2	17	14	23	4	128	3	1897	16:45
17:45	10	13			196	10	15	5	30	7	112	14	1728	17:00
18:00													1238	17:15
18:15													785	17:30
18:30													412	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**424**	**829**	**46**	**63**	**7811**	**1082**	**891**	**765**	**1500**	**709**	**5845**	**371**	**20336**	
AM PEAK	**19**	**61**	**5**	**28**	**766**	**312**	**53**	**98**	**72**	**127**	**648**	**81**	**2270**	
PM PEAK	**94**	**103**	**15**		**999**	**83**	**316**	**50**	**233**	**65**	**714**	**16**	**2688**	

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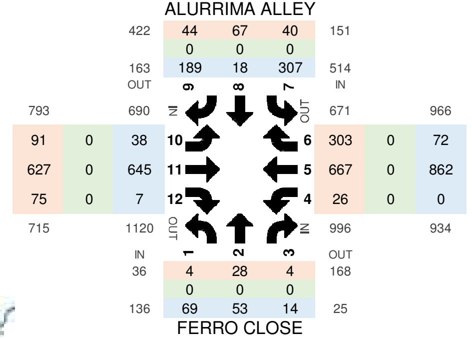
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 3	INTERSECTION OF JOHN ROSS AND FERRO CLOSE	27/11/2014
12 HOUR COUNT	CARS	THURSDAY

AM PEAK 06:45 07:45

PM PEAK 15:45 16:45



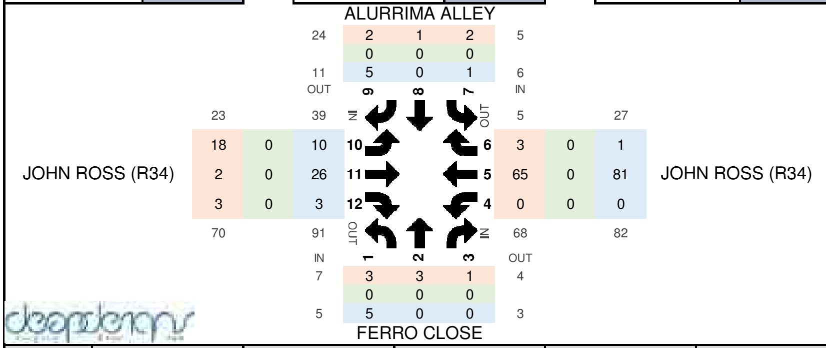
Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	7	14		2	57	41	5	5	2	7	83	17		
06:15	9	17		4	67	49	5	7	3	9	101	16		
06:30	1	2		3	64	55	7	9	5	19	77	4		
06:45	1	6	1	9	159	83	9	9	11	28	137	20	1246	06:00
07:00	2	11		6	163	77	7	21	15	24	168	26	1526	06:15
07:15	1	5	2	6	186	77	8	21	10	13	150	16	1734	06:30
07:30		6	1	5	159	66	16	16	8	26	172	13	1976	06:45
07:45	3	5		3	102	37	8	13	18	18	152	7	1869	07:00
08:00	2	5	2		110	23	12	12	18	14	98	14	1659	07:15
08:15	4	8	1		103	14	6	14	15	13	99	10	1451	07:30
08:30	1	4	1	1	112	10	7	8	29	11	133	5	1285	07:45
08:45	3	7		1	94	9	3	7	20	5	91	1	1160	08:00
09:00	2	5	2		100	24	6	7	21	8	91	13	1129	08:15
09:15	4	4	1		92	7	10	5	27	11	99	15	1117	08:30
09:30	2	3		1	81	13	13	8	25	7	88	8	1044	08:45
09:45	2	7		1	124	26	9	5	24	5	101	4	1111	09:00
10:00	7	8			68	8	5	5	21	3	76	4	1037	09:15
10:15	2	10			90	7	6	10	23	5	120	2	1037	09:30
10:30	4	10	2		101	10	12	7	18	3	93		1048	09:45
10:45	3	7	1	2	137	11	20	21	16	7	108		1073	10:00
11:00	6	6			102	12	11	6	15		90	3	1119	10:15
11:15	7	9			92	14	4	5	10	6	72	1	1064	10:30
11:30	5	10			109	8	10	13	16	4	92	5	1076	10:45
11:45	6	6	1	2	135	15	11	9	16	4	123	3	1074	11:00
12:00	7	4		3	114	9	8	7	23	1	85		1084	11:15
12:15	13	10		2	161	17	9	5	22	9	100	3	1215	11:30
12:30	3	6	1		99	10	9	5	30	13	93	3	1215	11:45
12:45	7	6	1		135	13	16	7	24	11	97	1	1202	12:00
13:00	11	9			153	14	6	8	19	4	80	8	1253	12:15
13:15	5	7			123	10	4	8	19	9	109	6	1202	12:30
13:30	4	7	1		136	11	9	3	23	33	87	11	1255	12:45
13:45	2	10			129	11	9	6	22	14	93	2	1235	13:00
14:00	8	4	1		139	12	16	7	42	12	106	3	1273	13:15
14:15	7	4		2	190	12	15	9	46	17	148		1423	13:30
14:30	17	7			154	15	14	10	33	7	113	3	1471	13:45
14:45	9	9			157	9	9	10	30	10	115	2	1533	14:00
15:00	5	8	1		177	7	9	5	19	4	132	1	1551	14:15
15:15	1	7	1		155	7	13	8	26	5	118	1	1443	14:30
15:30	1	12	2		161	6	22	5	26	5	68	1	1379	14:45
15:45	5	15			167	14	38	3	49	17	191	2	1520	15:00
16:00	14	10	4		215	17	107	4	48	5	101	1	1678	15:15
16:15	40	23	5		268	27	89	4	46	8	175	2	2023	15:30
16:30	10	5	5		212	14	73	7	46	8	178	2	2274	15:45
16:45	6	7			216	8	54	2	39	3	161		2269	16:00
17:00	5	2			211	8	21	6	41	1	117	5	2160	16:15
17:15	8	4		1	198	13	6	3	20	10	110	4	1850	16:30
17:30	7	2		1	138	2	14	7	17	4	121		1603	16:45
17:45	7	9			168	5	15	1	25	4	102	13	1456	17:00
18:00													1039	17:15
18:15													662	17:30
18:30													349	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**286**	**362**	**37**	**55**	**6583**	**967**	**795**	**383**	**1121**	**464**	**5414**	**281**	**16748**	
AM PEAK	**4**	**28**	**4**	**26**	**667**	**303**	**40**	**67**	**44**	**91**	**627**	**75**	**1976**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**69**	**53**	**14**	**0**	**862**	**72**	**307**	**18**	**189**	**38**	**645**	**7**	**2274**	

RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 3 | INTERSECTION OF JOHN ROSS AND FERRO CLOSE | 27/11/2014

12 HOUR COUNT | MINIBUSES | THURSDAY

AM PEAK 06:45 07:45 | PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	2	1			8	1					2			
06:15	1				7	2					2			
06:30					5	1	1				1			
06:45	1	2			16		1		2	3		1	60	06:00
07:00					12		1	1		4		1	65	06:15
07:15		1			15	1				4		1	75	06:30
07:30	2		1		22	2				7	2		103	06:45
07:45					15	1				4	2		99	07:00
08:00	2		1		20	1	1		2	4	4	2	117	07:15
08:15	1	1			10	1				7	4	1	120	07:30
08:30	1				16					4	3		108	07:45
08:45		2	1		8				2	1	4		104	08:00
09:00					10				2	4	1		84	08:15
09:15		1			13					1	1		75	08:30
09:30					3			1	3	1	2		61	08:45
09:45			1	1	24	1			2	1		1	74	09:00
10:00	1	1	1		7				1	1			69	09:15
10:15					12				1	2	4		72	09:30
10:30			1		17	1			1		2		84	09:45
10:45	1				19				1	1			75	10:00
11:00					10				2		1		76	10:15
11:15					15				1		3		76	10:30
11:30					14				1		4		73	10:45
11:45					14						7		72	11:00
12:00					12					2	1		74	11:15
12:15				1	15					2	5		78	11:30
12:30					12	1				2	2		76	11:45
12:45	2				15	2	1			1	5		81	12:00
13:00					17				1	1	1		86	12:15
13:15		1			22					4	2	1	93	12:30
13:30		2			12				2	4	3		99	12:45
13:45					13					4	6	2	98	13:00
14:00		1			13				1	3	5		101	13:15
14:15	1	2			18					2	10	1	105	13:30
14:30	1	1			21		1				9	1	116	13:45
14:45					18		1			3	6	1	120	14:00
15:00			1		15	1				1	5	1	121	14:15
15:15					20						5	4	116	14:30
15:30					18				1	2	5		108	14:45
15:45					15				1	5	12	1	113	15:00
16:00	2				19	1	1		2	1	3		118	15:15
16:15	2				29				2	1	8	1	132	15:30
16:30	1				18					3	3	1	132	15:45
16:45					25					3	5		131	16:00
17:00					30				1		4		137	16:15
17:15					26					1	5	2	128	16:30
17:30					21		1	1	1		3	2	131	16:45
17:45	1	1			25	2				1	7	1	136	17:00
18:00													101	17:15
18:15													67	17:30
18:30													38	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**22**	**17**	**7**	**2**	**761**	**19**	**9**	**3**	**33**	**95**	**169**	**26**	**1163**	
AM PEAK	**3**	**3**	**1**	**0**	**65**	**3**	**2**	**1**	**2**	**18**	**2**	**3**	**103**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**5**	**0**	**0**	**0**	**81**	**1**	**1**	**0**	**5**	**10**	**26**	**3**	**132**	

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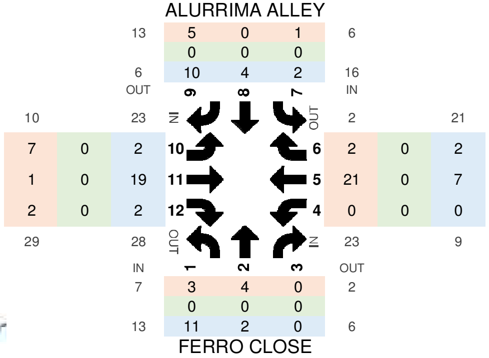
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 3 | **INTERSECTION OF JOHN ROSS AND FERRO CLOSE** | **27/11/2014**

12 HOUR COUNT | **BUSES** | **THURSDAY**

AM PEAK 06:45 07:45 | **PM PEAK** 15:45 16:45

ALURRIMA ALLEY



JOHN ROSS (R34)

JOHN ROSS (R34)

FERRO CLOSE

Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	1				1							1		
06:15	2				2									
06:30	1				2	1					5			
06:45	2				9				3			1	31	06:00
07:00					4					3	1	1	37	06:15
07:15	1				8	1	1		1	1			46	06:30
07:30		4				1			1	3			46	06:45
07:45		1			4	1			2	1	1		41	07:00
08:00					2	2				2			38	07:15
08:15		2			2					2			31	07:30
08:30					1				1	2	1		27	07:45
08:45		1			6								24	08:00
09:00					3					1			22	08:15
09:15										3	2		21	08:30
09:30					2				2	2			22	08:45
09:45					1	1			1				18	09:00
10:00									1				15	09:15
10:15					1		1				1		13	09:30
10:30													7	09:45
10:45							1		1				6	10:00
11:00									1		1		7	10:15
11:15					1								5	10:30
11:30									2		3		10	10:45
11:45									2		2		12	11:00
12:00		1			2			1	5				19	11:15
12:15											4		22	11:30
12:30									2	1			20	11:45
12:45		1							1				18	12:00
13:00		1			1		2		1	2	1	5	22	12:15
13:15					2		1		2			2	25	12:30
13:30					2				4				28	12:45
13:45		1					2		4			1	34	13:00
14:00	1	1							6	2	4		35	13:15
14:15		4			6		2	1	4		2		47	13:30
14:30	4	1			4		1		3		4		58	13:45
14:45					2		6		3	1	3		65	14:00
15:00									2	2	3		58	14:15
15:15							1	2	2		5		49	14:30
15:30	1				1			2	1	1			38	14:45
15:45	3								3	2	4		35	15:00
16:00	2				4	1		3	2		8	2	50	15:15
16:15	4	1			2	1		1			5		54	15:30
16:30	2	1			1		2		5		2		61	15:45
16:45	1				8				4	1	1	1	65	16:00
17:00		1			6			2	2		1	2	57	16:15
17:15					4		1		3	1	1		53	16:30
17:30					3				2				45	16:45
17:45	2	2						1	1	2	1		38	17:00
18:00													24	17:15
18:15													14	17:30
18:30													9	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**27**	**23**			**97**	**9**	**21**	**13**	**80**	**35**	**66**	**16**	**387**	
AM PEAK	**3**	**4**	**0**	**0**	**21**	**2**	**1**	**0**	**5**	**7**	**1**	**2**	**46**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**11**	**2**	**0**	**0**	**7**	**2**	**2**	**4**	**10**	**2**	**19**	**2**	**61**	

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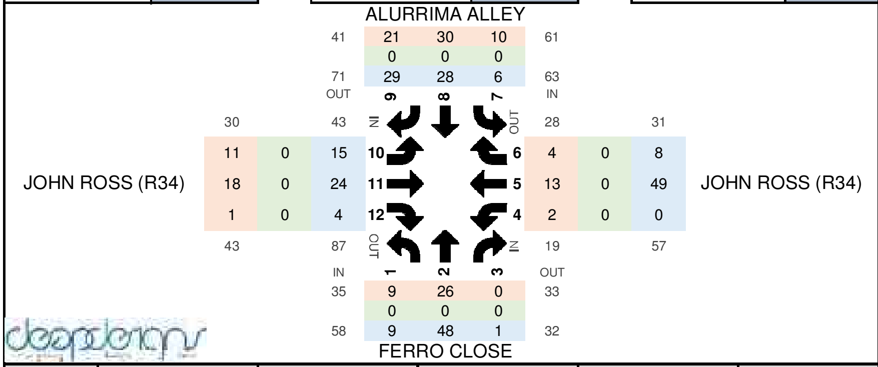
RICHARDS BAY TRAFFIC SURVEYS (ILISO)

LOCATION 3	INTERSECTION OF JOHN ROSS AND FERRO CLOSE	27/11/2014
12 HOUR COUNT	TRUCKS	THURSDAY
AM PEAK 06:45 07:45		PM PEAK 15:45 16:45



Time	South			East			North			West			Hourly	
	1	2	3	4	5	6	7	8	9	10	11	12		
06:00	3	4			3		1	2	1					
06:15	2	6			3		1	2	1		1	2		
06:30		4			1		1	4	3	2	5			
06:45	2	6					1	13	1	3	2	1	81	06:00
07:00		10		1		1	2	2	5		7		95	06:15
07:15	2	7		1	10	2	4	3	3	1	4		114	06:30
07:30	5	3			3	1	3	12	12	7	5		145	06:45
07:45	3	5		1	3	1	3	12	4	8	2	1	159	07:00
08:00	2	11			5		3	11	5	2	6	1	177	07:15
08:15	1	12		1	2	2	2	10	5	2	10	1	188	07:30
08:30	6	2			7	1		11	5		3		172	07:45
08:45	2	9			6	2		5	5	2	1	2	163	08:00
09:00	1	11			9	5		12	8	2	3	6	174	08:15
09:15		7			9	4		10	7	3	6	2	174	08:30
09:30	2	10	1		7	3	1	11	9	2	3		188	08:45
09:45	2	7			7	3	2	8	5	2	2		192	09:00
10:00	2	9			8	1	2	12	6	2	1	2	180	09:15
10:15	1	7			11	2		18	4	7	3	4	189	09:30
10:30	2	8			5	1	2	7	9	1	6		181	09:45
10:45	1	13			5	1	2	8	10	1			184	10:00
11:00	2	15			10		1	8	6		6	1	188	10:15
11:15	2	15			5		3	4	4	1	5	1	171	10:30
11:30	3	10			8	1	3	6	3	3	7	1	175	10:45
11:45		12			3	11	2	12	5	4	8		191	11:00
12:00	1	5		1	4		1	8	6		4		172	11:15
12:15	2	14			9	2		9	9	5	7	2	191	11:30
12:30	4	16			11	3	1	7	10	3	4	2	207	11:45
12:45	3	18			13	2	3	9	9	3	1		211	12:00
13:00	2	15			11	1		7	7	3	2	1	230	12:15
13:15	1	8			7	1		12	1	2	1	1	205	12:30
13:30	1	5			9	1	1	8	7	3	7		186	12:45
13:45	4	6			18	4	1	5	5	4	4	1	177	13:00
14:00	1	9			11	1	3	9	2	1	4	1	170	13:15
14:15	2	6			8	4	1	14	5	4	8	2	190	13:30
14:30	1	8			9	2		8	3	1	5	4	189	13:45
14:45	2	5			10	6		5	5	3	7	1	181	14:00
15:00		10			9	1	3	5	3	3	5	1	179	14:15
15:15	3	12		1	10	1		5	7	5	5		174	14:30
15:30	2	23			11	3	2	3	7	3	1		188	14:45
15:45	2	15			13	2	1	11	4	7	12	1	212	15:00
16:00	3	17			10	2	1	7	8	5	3	1	229	15:15
16:15	1	9			18	3	1	7	6	2	3	1	231	15:30
16:30	3	7	1		8	1	3	3	11	1	6	1	221	15:45
16:45		6			15		1	5	4	2	2	1	189	16:00
17:00		5			8		2	2	6		1		156	16:15
17:15		4			10	2		5	8		2	1	137	16:30
17:30	5				5		2	6	3		4	1	118	16:45
17:45		1			3	3		3	4		2		98	17:00
18:00													74	17:15
18:15													42	17:30
18:30													16	17:45
18:45														18:00
19:00														18:15
19:15														18:30
19:30														18:45
19:45														19:00
20:00														19:15
20:15														19:30
20:30														19:45
20:45														20:00
Total	**89**	**427**	**2**	**6**	**370**	**87**	**66**	**366**	**266**	**115**	**196**	**48**	**2038**	
AM PEAK	**9**	**26**	**0**	**2**	**13**	**4**	**10**	**30**	**21**	**11**	**18**	**1**	**145**	
	0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		
PM PEAK	**9**	**48**	**1**	**0**	**49**	**8**	**6**	**28**	**29**	**15**	**24**	**4**	**221**	

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Appendix B

SIDRA Analysis

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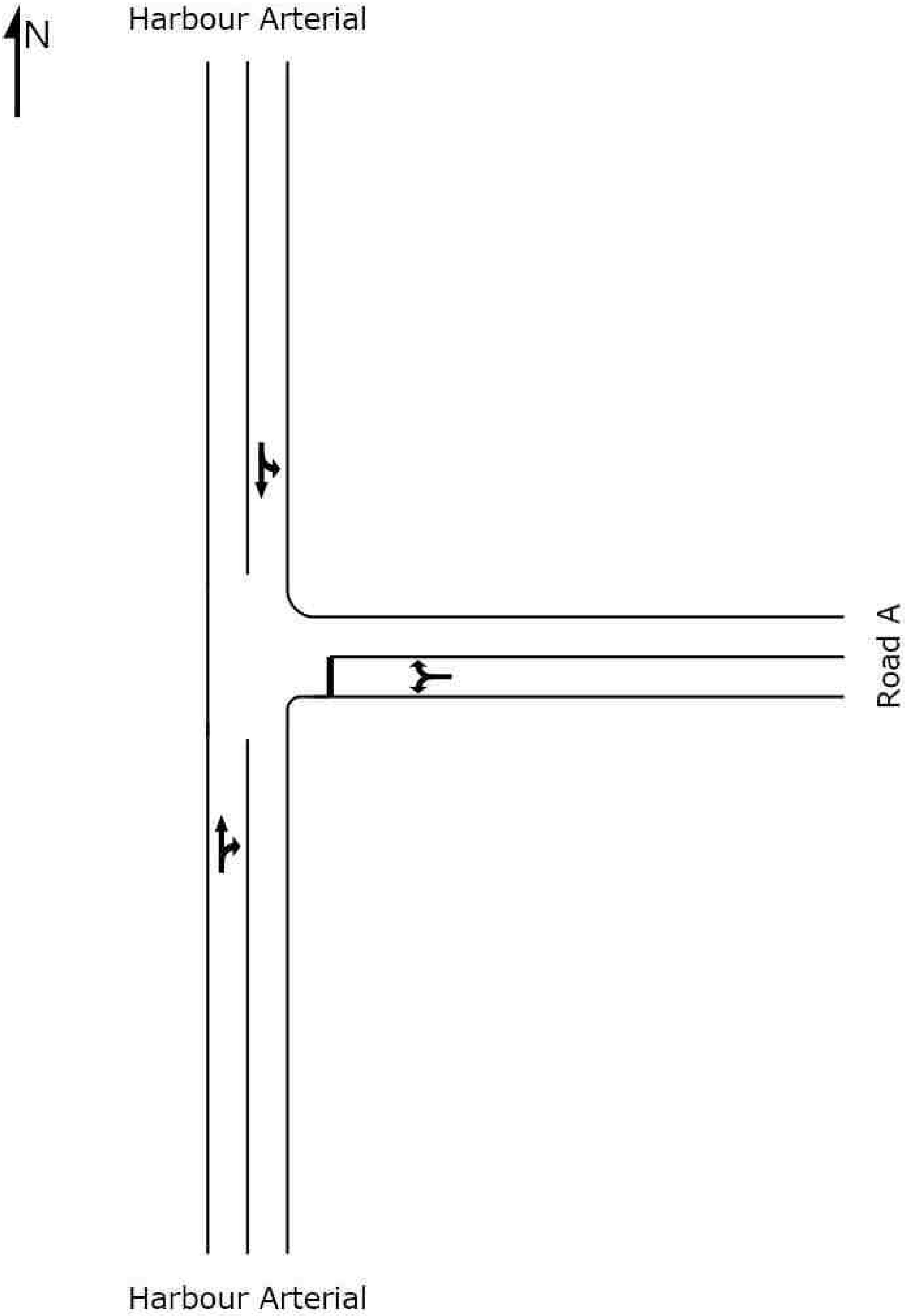

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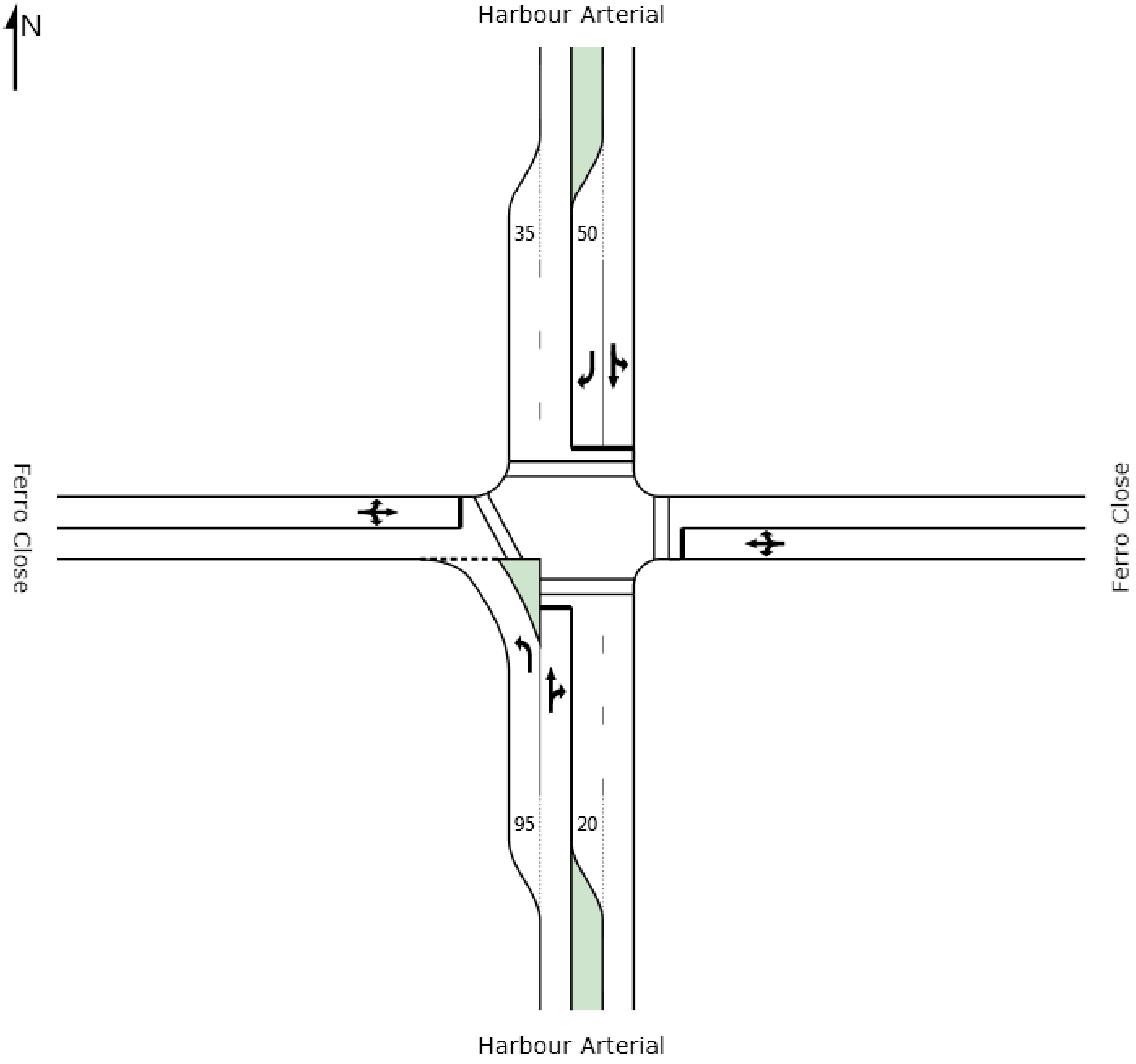

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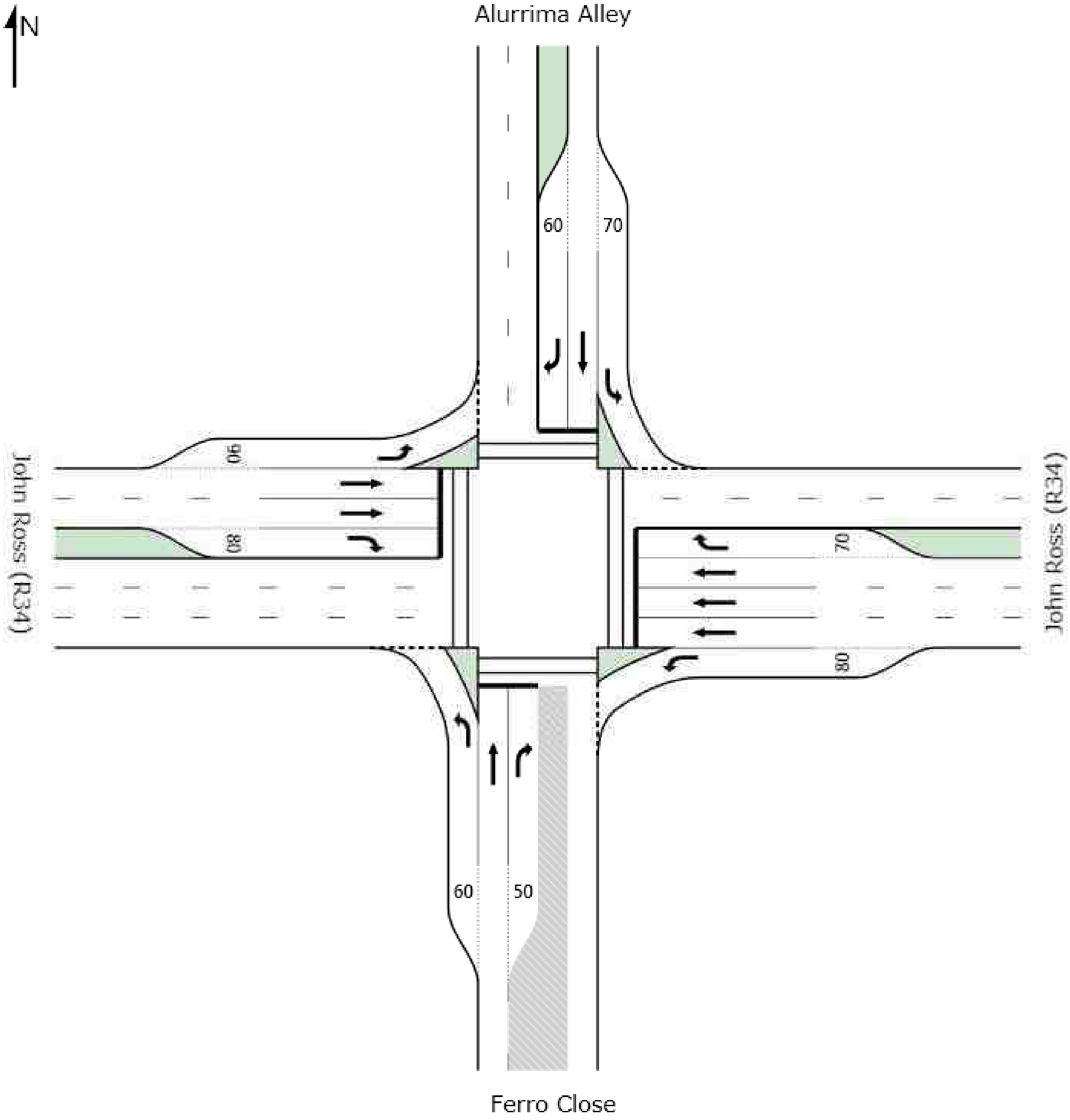
N
Alurrima Alley
60
70
90
80
John Ross (R34)
70
80
John Ross (R34)
60
50
Ferro Close

MOVEMENT SUMMARY

Site: Location 1 existing AM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
2	T	1	0.0	0.001	0.0	LOS A	0.0	0.0	0.02	0.00	59.4
3	R	1	0.0	0.001	8.4	LOS A	0.0	0.0	0.02	0.85	48.6
Approach		2	0.0	0.001	4.2	NA	0.0	0.0	0.02	0.42	53.5
East: Road A											
4	L	1	0.0	0.001	10.7	LOS B	0.0	0.1	0.03	0.95	46.4
6	R	1	0.0	0.001	10.5	LOS B	0.0	0.1	0.03	1.00	46.5
Approach		2	0.0	0.001	10.6	LOS B	0.0	0.1	0.03	0.97	46.4
North: Harbour Arterial											
7	L	1	0.0	0.001	8.2	LOS A	0.0	0.0	0.00	0.82	49.0
8	T	1	0.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		2	0.0	0.001	4.1	NA	0.0	0.0	0.00	0.41	53.9
All Vehicles		6	0.0	0.001	6.3	NA	0.0	0.1	0.02	0.60	51.0

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

Processed: 02 December 2014 01:14:29 PM
SIDRA INTERSECTION 5.1.12.2089

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MOVEMENT SUMMARY

Site: Location 1 existing PM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
2	T	34	9.4	0.020	0.7	LOS A	0.1	1.0	0.32	0.00	54.1
3	R	1	0.0	0.020	9.1	LOS A	0.1	1.0	0.32	0.93	49.1
Approach		35	9.1	0.020	0.9	NA	0.1	1.0	0.32	0.03	54.0
East: Road A											
4	L	1	0.0	0.002	11.7	LOS B	0.0	0.1	0.38	0.73	46.0
6	R	1	0.0	0.002	11.6	LOS B	0.0	0.1	0.38	0.78	46.2
Approach		2	0.0	0.002	11.6	LOS B	0.0	0.1	0.38	0.75	46.1
North: Harbour Arterial											
7	L	1	0.0	0.083	8.2	LOS A	0.0	0.0	0.00	1.09	49.0
8	T	151	2.1	0.083	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		152	2.1	0.083	0.1	NA	0.0	0.0	0.00	0.01	59.9
All Vehicles		188	3.4	0.083	0.3	NA	0.1	1.0	0.06	0.02	58.5

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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SIDRA INTERSECTION 5.1.12.2089
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MOVEMENT SUMMARY

Site: Location 2 existing AM

New Site
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
1	L	65	41.9	0.069	9.6	LOS A	0.2	2.0	0.27	0.64	48.3
2	T	73	24.6	0.116	10.4	LOS B	1.2	9.8	0.66	0.51	44.4
3	R	1	0.0	0.116	18.6	LOS B	1.2	9.8	0.66	0.89	41.9
Approach		139	32.6	0.116	10.1	LOS B	1.2	9.8	0.47	0.58	46.2
East: Ferro Close											
4	L	1	0.0	0.025	19.6	LOS B	0.2	2.0	0.67	0.79	40.6
5	T	8	87.5	0.025	11.4	LOS B	0.2	2.0	0.67	0.47	43.0
6	R	1	100.0	0.025	23.5	LOS C	0.2	2.0	0.67	0.84	41.1
Approach		11	80.0	0.025	13.4	LOS B	0.2	2.0	0.67	0.54	42.5
North: Harbour Arterial											
7	L	1	0.0	0.384	19.9	LOS B	4.8	36.3	0.75	0.90	41.1
8	T	272	8.1	0.384	11.8	LOS B	4.8	36.3	0.75	0.63	43.0
9	R	20	15.8	0.044	19.5	LOS B	0.3	2.5	0.65	0.71	39.4
Approach		293	8.6	0.384	12.3	LOS B	4.8	36.3	0.74	0.64	42.7
West: Ferro Close											
10	L	16	26.7	0.403	22.6	LOS C	4.3	34.3	0.79	0.80	37.6
11	T	9	77.8	0.403	13.4	LOS B	4.3	34.3	0.79	0.66	39.0
12	R	202	12.0	0.403	22.1	LOS C	4.3	34.3	0.79	0.81	37.6
Approach		227	15.7	0.403	21.8	LOS C	4.3	34.3	0.79	0.80	37.7
All Vehicles		669	17.1	0.403	15.1	LOS B	4.8	36.3	0.70	0.68	41.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	16.0	LOS B	0.1	0.1	0.80	0.80
P3	Across E approach	53	12.3	LOS B	0.1	0.1	0.70	0.70
P5	Across N approach	53	18.5	LOS B	0.1	0.1	0.86	0.86
P7	Across W approach	53	12.3	LOS B	0.1	0.1	0.70	0.70
All Pedestrians		212	14.7	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

Processed: 02 December 2014 01:09:30 PM
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MOVEMENT SUMMARY

Site: Location 2 existing PM

New Site
Signals - Fixed Time Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
1	L	214	33.5	0.206	9.5	LOS A	0.8	7.0	0.30	0.67	48.2
2	T	297	5.7	0.396	11.1	LOS B	5.2	38.1	0.74	0.63	43.5
3	R	1	100.0	0.396	23.2	LOS C	5.2	38.1	0.74	0.98	42.7
Approach		512	17.5	0.396	10.5	LOS B	5.2	38.1	0.56	0.64	45.4
East: Ferro Close											
4	L	1	0.0	0.016	20.2	LOS C	0.1	1.2	0.68	0.74	39.7
5	T	4	50.0	0.016	12.0	LOS B	0.1	1.2	0.68	0.47	41.8
6	R	2	50.0	0.016	22.2	LOS C	0.1	1.2	0.68	0.76	39.7
Approach		7	42.9	0.016	16.1	LOS B	0.1	1.2	0.68	0.59	40.9
North: Harbour Arterial											
7	L	2	0.0	0.138	18.0	LOS B	1.4	12.3	0.65	0.89	42.2
8	T	86	35.4	0.138	9.8	LOS A	1.4	12.3	0.65	0.51	44.9
9	R	9	11.1	0.025	21.6	LOS C	0.2	1.2	0.71	0.69	37.9
Approach		98	32.3	0.138	11.1	LOS B	1.4	12.3	0.65	0.54	44.1
West: Ferro Close											
10	L	14	7.7	0.154	21.4	LOS C	1.1	11.0	0.73	0.75	37.9
11	T	1	100.0	0.154	12.9	LOS B	1.1	11.0	0.73	0.57	38.1
12	R	48	56.5	0.154	23.3	LOS C	1.1	11.0	0.73	0.76	37.9
Approach		63	46.7	0.154	22.7	LOS C	1.1	11.0	0.73	0.75	37.9
All Vehicles		680	22.6	0.396	11.8	LOS B	5.2	38.1	0.59	0.64	44.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	16.8	LOS B	0.1	0.1	0.82	0.82
P3	Across E approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
All Pedestrians		212	14.8	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 existing AM

New Site
Signals - Fixed Time   Cycle Time = 90 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ferro Close											
1	L	20	47.4	0.056	10.1	LOS B	0.1	1.2	0.23	0.63	48.4
2	T	64	42.6	0.163	28.4	LOS C	2.2	21.3	0.81	0.63	32.2
3	R	5	0.0	0.019	38.2	LOS D	0.2	1.3	0.81	0.66	29.4
Approach		89	41.2	0.163	24.9	LOS C	2.2	21.3	0.68	0.63	34.7
East: John Ross (R34)											
4	L	29	7.1	0.027	8.7	LOS A	0.1	1.1	0.20	0.63	48.6
5	T	806	1.7	0.226	8.4	LOS A	5.2	37.2	0.48	0.41	47.0
6	R	328	1.3	0.874	43.8	LOS D	16.1	114.2	0.90	0.99	27.3
Approach		1164	1.7	0.874	18.4	LOS B	16.1	114.2	0.59	0.58	39.1
North: Alurrima Alley											
7	L	56	18.9	0.110	9.5	LOS A	0.4	3.3	0.24	0.65	48.1
8	T	103	30.6	0.246	29.1	LOS C	3.7	32.3	0.83	0.67	31.9
9	R	76	29.2	0.298	40.3	LOS D	2.8	24.6	0.86	0.77	28.9
Approach		235	27.4	0.298	28.0	LOS C	3.7	32.3	0.70	0.69	33.5
West: John Ross (R34)											
10	L	134	8.7	0.151	9.1	LOS A	0.8	6.1	0.25	0.66	48.3
11	T	682	2.8	0.288	8.8	LOS A	7.0	50.0	0.50	0.44	46.5
12	R	85	1.2	0.230	19.2	LOS B	2.0	13.9	0.54	0.74	39.3
Approach		901	3.5	0.288	9.8	LOS A	7.0	50.0	0.47	0.50	46.0
All Vehicles		2389	6.4	0.874	16.3	LOS B	16.1	114.2	0.56	0.56	40.5

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	10.3	LOS B	0.1	0.1	0.48	0.48
P3	Across E approach	53	39.2	LOS D	0.1	0.1	0.93	0.93
P5	Across N approach	53	11.8	LOS B	0.1	0.1	0.51	0.51
P7	Across W approach	53	39.2	LOS D	0.1	0.1	0.93	0.93
All Pedestrians		212	25.1	LOS C			0.71	0.71

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 existing PM

New Site
Signals - Fixed Time   Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ferro Close											
1	L	99	9.6	0.156	10.9	LOS B	0.9	6.5	0.45	0.70	46.5
2	T	108	46.6	0.165	11.3	LOS B	2.0	19.3	0.64	0.52	43.7
3	R	16	6.7	0.035	19.1	LOS B	0.3	2.0	0.61	0.68	39.6
Approach		223	27.4	0.165	11.7	LOS B	2.0	19.3	0.56	0.61	44.6
East: John Ross (R34)											
4	L	1	0.0	0.001	8.3	LOS A	0.0	0.0	0.22	0.60	48.6
5	T	1052	4.9	0.501	16.2	LOS B	8.1	59.3	0.83	0.70	39.3
6	R	87	9.6	0.438	32.2	LOS C	2.4	18.3	0.91	0.79	32.0
Approach		1140	5.3	0.501	17.4	LOS B	8.1	59.3	0.83	0.71	38.7
North: Alurrima Alley											
7	L	333	1.9	0.393	11.4	LOS B	4.1	28.9	0.53	0.74	45.6
8	T	53	56.0	0.084	10.9	LOS B	0.9	9.5	0.61	0.48	44.1
9	R	245	12.4	0.537	23.0	LOS C	5.5	42.3	0.78	0.80	37.1
Approach		631	10.5	0.537	15.9	LOS B	5.5	42.3	0.64	0.74	41.8
West: John Ross (R34)											
10	L	68	23.1	0.069	9.3	LOS A	0.3	2.4	0.28	0.65	48.3
11	T	752	3.4	0.532	16.4	LOS B	8.8	63.6	0.84	0.72	39.1
12	R	17	25.0	0.119	30.2	LOS C	0.4	3.6	0.82	0.72	33.3
Approach		837	5.4	0.532	16.1	LOS B	8.8	63.6	0.79	0.71	39.6
All Vehicles		2831	8.2	0.537	16.2	LOS B	8.8	63.6	0.75	0.71	40.0

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	17.6	LOS B	0.1	0.1	0.77	0.77
P3	Across E approach	53	21.7	LOS C	0.1	0.1	0.85	0.85
P5	Across N approach	53	20.0	LOS C	0.1	0.1	0.82	0.82
P7	Across W approach	53	21.7	LOS C	0.1	0.1	0.85	0.85
All Pedestrians		212	20.2	LOS C			0.82	0.82

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 1 2015 AM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
2	T	1	0.0	0.035	0.0	LOS A	0.2	1.9	0.03	0.00	59.1
3	R	40	47.4	0.035	10.3	LOS B	0.2	1.9	0.03	0.69	48.5
Approach		41	46.2	0.035	10.1	NA	0.2	1.9	0.03	0.68	48.8
East: Road A											
4	L	29	57.1	0.028	14.1	LOS B	0.2	1.8	0.02	0.98	46.4
6	R	1	0.0	0.028	10.5	LOS B	0.2	1.8	0.02	1.03	46.5
Approach		31	55.2	0.028	14.0	LOS B	0.2	1.8	0.02	0.98	46.4
North: Harbour Arterial											
7	L	1	0.0	0.001	8.2	LOS A	0.0	0.0	0.00	0.82	49.0
8	T	1	0.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		2	0.0	0.001	4.1	NA	0.0	0.0	0.00	0.41	53.9
All Vehicles		74	48.6	0.035	11.5	NA	0.2	1.9	0.03	0.79	47.9

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Location 1 2015 PM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		Vehicles veh	Distance m		per veh	km/h
South: Harbour Arterial											
2	T	35	9.5	0.056	1.8	LOS A	0.4	3.7	0.42	0.00	51.4
3	R	29	57.1	0.056	12.6	LOS B	0.4	3.7	0.42	0.79	47.8
Approach		64	31.4	0.056	6.8	NA	0.4	3.7	0.42	0.36	49.7
East: Road A											
4	L	40	47.4	0.047	15.4	LOS C	0.3	2.7	0.43	0.80	45.4
6	R	1	0.0	0.047	12.4	LOS B	0.3	2.7	0.43	0.84	45.6
Approach		41	46.2	0.047	15.3	LOS C	0.3	2.7	0.43	0.80	45.4
North: Harbour Arterial											
7	L	1	0.0	0.085	8.2	LOS A	0.0	0.0	0.00	1.09	49.0
8	T	154	2.1	0.085	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		155	2.1	0.085	0.1	NA	0.0	0.0	0.00	0.01	59.9
All Vehicles		260	16.2	0.085	4.1	NA	0.4	3.7	0.17	0.22	54.4

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Location 2 2015 AM

New Site
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
							Vehicles veh	Distance m			
South: Harbour Arterial											
1	L	96	46.6	0.106	9.7	LOS A	0.3	3.2	0.27	0.65	48.3
2	T	74	24.6	0.132	11.9	LOS B	1.3	10.7	0.70	0.55	43.0
3	R	1	0.0	0.132	20.1	LOS C	1.3	10.7	0.70	0.88	40.8
Approach		172	36.8	0.132	10.7	LOS B	1.3	10.7	0.46	0.61	45.8
East: Ferro Close											
4	L	1	0.0	0.023	18.2	LOS B	0.2	1.9	0.63	0.80	41.6
5	T	9	87.8	0.023	10.0	LOS A	0.2	1.9	0.63	0.44	44.4
6	R	1	100.0	0.023	22.0	LOS C	0.2	1.9	0.63	0.86	42.0
Approach		11	80.4	0.023	12.0	LOS B	0.2	1.9	0.63	0.52	43.8
North: Harbour Arterial											
7	L	1	0.0	0.437	21.7	LOS C	5.3	40.0	0.81	0.89	40.0
8	T	278	8.1	0.437	13.5	LOS B	5.3	40.0	0.81	0.68	41.4
9	R	21	15.9	0.047	21.0	LOS C	0.3	2.7	0.69	0.71	38.3
Approach		300	8.6	0.437	14.1	LOS B	5.3	40.0	0.80	0.68	41.1
West: Ferro Close											
10	L	16	26.6	0.459	21.5	LOS C	5.1	41.8	0.78	0.81	38.3
11	T	10	77.4	0.459	12.3	LOS B	5.1	41.8	0.78	0.66	39.8
12	R	247	17.7	0.459	21.3	LOS C	5.1	41.8	0.78	0.81	38.3
Approach		273	20.4	0.459	20.9	LOS C	5.1	41.8	0.78	0.81	38.4
All Vehicles		756	20.3	0.459	15.8	LOS B	5.3	41.8	0.71	0.71	41.1

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue		Prop. Queued	Effective Stop Rate per ped
					Pedestrian ped	Distance m		
P1	Across S approach	53	14.4	LOS B	0.1	0.1	0.76	0.76
P3	Across E approach	53	13.7	LOS B	0.1	0.1	0.74	0.74
P5	Across N approach	53	16.8	LOS B	0.1	0.1	0.82	0.82
P7	Across W approach	53	13.7	LOS B	0.1	0.1	0.74	0.74
All Pedestrians		212	14.7	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 2 2015 PM

New Site
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
1	L	259	35.6	0.254	9.6	LOS A	1.0	9.1	0.32	0.67	48.1
2	T	304	5.7	0.406	11.2	LOS B	5.3	39.3	0.74	0.63	43.5
3	R	1	100.0	0.406	23.3	LOS C	5.3	39.3	0.74	0.98	42.6
Approach		564	19.6	0.406	10.5	LOS B	5.3	39.3	0.55	0.65	45.5
East: Ferro Close											
4	L	1	0.0	0.017	20.2	LOS C	0.1	1.2	0.68	0.74	39.7
5	T	4	50.0	0.017	12.0	LOS B	0.1	1.2	0.68	0.47	41.8
6	R	2	50.0	0.017	22.2	LOS C	0.1	1.2	0.68	0.76	39.7
Approach		8	43.1	0.017	16.0	LOS B	0.1	1.2	0.68	0.59	40.9
North: Harbour Arterial											
7	L	2	0.0	0.141	18.0	LOS B	1.4	12.7	0.65	0.89	42.2
8	T	88	35.4	0.141	9.8	LOS A	1.4	12.7	0.65	0.51	44.9
9	R	10	10.9	0.026	21.6	LOS C	0.2	1.3	0.71	0.69	37.9
Approach		100	32.2	0.141	11.2	LOS B	1.4	12.7	0.65	0.54	44.1
West: Ferro Close											
10	L	14	7.5	0.234	21.8	LOS C	1.7	17.3	0.75	0.77	37.6
11	T	1	100.0	0.234	13.4	LOS B	1.7	17.3	0.75	0.60	37.6
12	R	79	56.8	0.234	23.8	LOS C	1.7	17.3	0.75	0.77	37.6
Approach		94	49.9	0.234	23.4	LOS C	1.7	17.3	0.75	0.77	37.6
All Vehicles		767	25.2	0.406	12.2	LOS B	5.3	39.3	0.59	0.65	44.1

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	16.8	LOS B	0.1	0.1	0.82	0.82
P3	Across E approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
All Pedestrians		212	14.8	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 2015 AM

New Site
Signals - Fixed Time   Cycle Time = 90 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ferro Close											
1	L	50	53.2	0.144	10.4	LOS B	0.4	3.6	0.25	0.65	48.2
2	T	66	42.7	0.167	28.5	LOS C	2.3	21.8	0.81	0.63	32.2
3	R	5	0.0	0.020	38.2	LOS D	0.2	1.3	0.81	0.66	29.4
Approach		121	45.1	0.167	21.4	LOS C	2.3	21.8	0.58	0.64	37.2
East: John Ross (R34)											
4	L	30	7.3	0.029	8.7	LOS A	0.2	1.1	0.20	0.63	48.6
5	T	826	1.7	0.231	8.4	LOS A	5.4	38.3	0.48	0.41	46.9
6	R	337	1.3	0.870	40.3	LOS D	16.1	114.2	0.94	0.97	28.5
Approach		1193	1.7	0.870	17.4	LOS B	16.1	114.2	0.60	0.58	39.7
North: Alurrima Alley											
7	L	57	18.9	0.113	9.5	LOS A	0.4	3.4	0.24	0.65	48.1
8	T	106	30.6	0.252	29.2	LOS C	3.8	33.2	0.84	0.67	31.9
9	R	78	29.1	0.306	40.4	LOS D	2.9	25.3	0.86	0.77	28.9
Approach		241	27.4	0.306	28.1	LOS C	3.8	33.2	0.70	0.70	33.5
West: John Ross (R34)											
10	L	137	8.7	0.156	9.1	LOS A	0.8	6.3	0.25	0.66	48.3
11	T	699	2.8	0.296	8.8	LOS A	7.2	51.5	0.51	0.44	46.4
12	R	127	15.7	0.429	21.6	LOS C	3.4	27.1	0.62	0.78	38.0
Approach		964	5.3	0.429	10.5	LOS B	7.2	51.5	0.49	0.52	45.4
All Vehicles		2519	7.6	0.870	16.0	LOS B	16.1	114.2	0.57	0.57	40.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	10.3	LOS B	0.1	0.1	0.48	0.48
P3	Across E approach	53	39.2	LOS D	0.1	0.1	0.93	0.93
P5	Across N approach	53	11.8	LOS B	0.1	0.1	0.51	0.51
P7	Across W approach	53	39.2	LOS D	0.1	0.1	0.93	0.93
All Pedestrians		212	25.1	LOS C			0.71	0.71

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 2015 PM

New Site
Signals - Fixed Time   Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ferro Close											
1	L	141	20.3	0.245	11.6	LOS B	1.4	11.6	0.50	0.72	46.2
2	T	111	46.6	0.170	11.4	LOS B	2.0	19.8	0.64	0.52	43.6
3	R	16	6.5	0.036	19.1	LOS B	0.3	2.1	0.61	0.68	39.5
Approach		269	30.3	0.245	11.9	LOS B	2.0	19.8	0.57	0.63	44.7
East: John Ross (R34)											
4	L	1	0.0	0.001	8.3	LOS A	0.0	0.0	0.22	0.60	48.6
5	T	1078	4.9	0.513	16.3	LOS B	8.4	61.1	0.83	0.71	39.2
6	R	90	9.6	0.461	32.4	LOS C	2.5	18.9	0.91	0.79	31.9
Approach		1169	5.3	0.513	17.5	LOS B	8.4	61.1	0.84	0.72	38.6
North: Alurrima Alley											
7	L	341	1.9	0.406	11.5	LOS B	4.3	30.6	0.55	0.74	45.5
8	T	54	55.9	0.086	10.9	LOS B	0.9	9.8	0.62	0.48	44.1
9	R	251	12.4	0.552	23.2	LOS C	5.6	43.7	0.79	0.80	37.0
Approach		646	10.5	0.552	16.0	LOS B	5.6	43.7	0.65	0.74	41.7
West: John Ross (R34)											
10	L	70	23.1	0.072	9.3	LOS A	0.3	2.5	0.28	0.65	48.3
11	T	770	3.4	0.545	16.5	LOS B	9.1	65.6	0.84	0.72	39.0
12	R	47	45.3	0.428	33.6	LOS C	1.3	13.0	0.89	0.78	31.9
Approach		887	7.1	0.545	16.9	LOS B	9.1	65.6	0.80	0.72	39.2
All Vehicles		2971	9.2	0.552	16.5	LOS B	9.1	65.6	0.76	0.72	39.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	17.6	LOS B	0.1	0.1	0.77	0.77
P3	Across E approach	53	21.7	LOS C	0.1	0.1	0.85	0.85
P5	Across N approach	53	20.0	LOS C	0.1	0.1	0.82	0.82
P7	Across W approach	53	21.7	LOS C	0.1	0.1	0.85	0.85
All Pedestrians		212	20.2	LOS C			0.82	0.82

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 1 2020 AM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
2	T	1	0.0	0.059	0.0	LOS A	0.3	3.6	0.03	0.00	59.1
3	R	60	64.9	0.059	11.0	LOS B	0.3	3.6	0.03	0.69	48.5
Approach		61	63.8	0.059	10.9	NA	0.3	3.6	0.03	0.68	48.7
East: Road A											
4	L	47	73.3	0.050	15.1	LOS C	0.3	3.5	0.03	0.98	46.4
6	R	1	0.0	0.050	10.5	LOS B	0.3	3.5	0.03	1.03	46.5
Approach		48	71.7	0.050	15.0	LOS B	0.3	3.5	0.03	0.98	46.4
North: Harbour Arterial											
7	L	1	0.0	0.001	8.2	LOS A	0.0	0.0	0.00	0.82	49.0
8	T	1	0.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		2	0.0	0.001	4.1	NA	0.0	0.0	0.00	0.41	53.9
All Vehicles		112	66.0	0.059	12.5	NA	0.3	3.6	0.03	0.80	47.7

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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MOVEMENT SUMMARY

Site: Location 1 2020 PM

New Site
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
							Vehicles veh	Distance m			
South: Harbour Arterial											
2	T	39	9.4	0.091	2.8	LOS A	0.7	6.5	0.48	0.00	50.2
3	R	47	73.3	0.091	14.1	LOS B	0.7	6.5	0.48	0.78	46.7
Approach		86	44.5	0.091	9.0	NA	0.7	6.5	0.48	0.43	48.2
East: Road A											
4	L	60	64.9	0.086	17.4	LOS C	0.5	5.4	0.50	0.82	44.6
6	R	1	0.0	0.086	13.4	LOS B	0.5	5.4	0.50	0.86	44.8
Approach		61	63.8	0.086	17.4	LOS C	0.5	5.4	0.50	0.82	44.6
North: Harbour Arterial											
7	L	1	0.0	0.096	8.2	LOS A	0.0	0.0	0.00	1.09	49.0
8	T	175	2.1	0.096	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		176	2.1	0.096	0.0	NA	0.0	0.0	0.00	0.01	59.9
All Vehicles		323	25.1	0.096	5.7	NA	0.7	6.5	0.22	0.27	53.1

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Minor Road Approach LOS values are based on average delay for all vehicle movements.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.
SIDRA Standard Delay Model used.

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SIDRA INTERSECTION 5.1.12.2089

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MOVEMENT SUMMARY

Site: Location 2 2020 AM

New Site
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
							Vehicles veh	Distance m			
South: Harbour Arterial											
1	L	123	54.1	0.144	10.0	LOS A	0.4	4.4	0.28	0.65	48.2
2	T	84	24.6	0.158	12.8	LOS B	1.5	12.6	0.73	0.57	42.2
3	R	1	0.0	0.158	21.0	LOS C	1.5	12.6	0.73	0.87	40.3
Approach		208	41.9	0.158	11.2	LOS B	1.5	12.6	0.47	0.62	45.6
East: Ferro Close											
4	L	1	0.0	0.025	17.5	LOS B	0.2	2.1	0.61	0.81	42.1
5	T	10	87.1	0.025	9.3	LOS A	0.2	2.1	0.61	0.43	45.1
6	R	1	100.0	0.025	21.4	LOS C	0.2	2.1	0.61	0.88	42.3
Approach		12	80.9	0.025	11.3	LOS B	0.2	2.1	0.61	0.51	44.5
North: Harbour Arterial											
7	L	1	0.0	0.524	23.0	LOS C	6.4	48.1	0.85	0.88	39.2
8	T	315	8.2	0.524	14.8	LOS B	6.4	48.1	0.85	0.72	40.3
9	R	23	15.8	0.052	21.9	LOS C	0.4	3.2	0.72	0.72	37.8
Approach		339	8.7	0.524	15.3	LOS B	6.4	48.1	0.84	0.72	40.1
West: Ferro Close											
10	L	18	26.4	0.542	21.3	LOS C	6.2	52.4	0.80	0.82	38.4
11	T	11	77.9	0.542	12.2	LOS B	6.2	52.4	0.80	0.69	39.7
12	R	294	22.8	0.542	21.3	LOS C	6.2	52.4	0.80	0.82	38.4
Approach		324	24.8	0.542	21.0	LOS C	6.2	52.4	0.80	0.82	38.5
All Vehicles		884	23.4	0.542	16.4	LOS B	6.4	52.4	0.73	0.73	40.7

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue		Prop. Queued	Effective Stop Rate per ped
					Pedestrian ped	Distance m		
P1	Across S approach	53	13.7	LOS B	0.1	0.1	0.74	0.74
P3	Across E approach	53	14.4	LOS B	0.1	0.1	0.76	0.76
P5	Across N approach	53	16.0	LOS B	0.1	0.1	0.80	0.80
P7	Across W approach	53	14.4	LOS B	0.1	0.1	0.76	0.76
All Pedestrians		212	14.6	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 2 2020 PM

New Site
Signals - Fixed Time   Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Harbour Arterial											
1	L	308	39.6	0.310	9.7	LOS A	1.3	11.7	0.33	0.68	48.0
2	T	344	5.7	0.459	11.5	LOS B	6.2	45.8	0.76	0.65	43.1
3	R	1	100.0	0.459	23.6	LOS C	6.2	45.8	0.76	0.97	42.5
Approach		653	21.9	0.459	10.7	LOS B	6.2	45.8	0.56	0.67	45.3
East: Ferro Close											
4	L	1	0.0	0.019	20.2	LOS C	0.1	1.3	0.68	0.74	39.7
5	T	5	50.0	0.019	12.0	LOS B	0.1	1.3	0.68	0.47	41.8
6	R	3	50.0	0.019	22.2	LOS C	0.1	1.3	0.68	0.76	39.6
Approach		8	43.8	0.019	16.1	LOS B	0.1	1.3	0.68	0.59	40.8
North: Harbour Arterial											
7	L	2	0.0	0.160	18.1	LOS B	1.6	14.4	0.65	0.89	42.2
8	T	100	35.3	0.160	9.9	LOS A	1.6	14.4	0.65	0.52	44.8
9	R	11	11.4	0.032	22.5	LOS C	0.2	1.5	0.73	0.70	37.3
Approach		114	32.3	0.160	11.3	LOS B	1.6	14.4	0.66	0.55	43.9
West: Ferro Close											
10	L	16	7.9	0.315	22.4	LOS C	2.3	24.0	0.78	0.78	37.3
11	T	1	100.0	0.315	13.9	LOS B	2.3	24.0	0.78	0.63	37.1
12	R	104	64.2	0.315	24.6	LOS C	2.3	24.0	0.78	0.79	37.3
Approach		121	57.2	0.315	24.2	LOS C	2.3	24.0	0.78	0.78	37.3
All Vehicles		896	28.1	0.459	12.6	LOS B	6.2	45.8	0.60	0.67	43.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	16.8	LOS B	0.1	0.1	0.82	0.82
P3	Across E approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
P5	Across N approach	53	19.4	LOS B	0.1	0.1	0.88	0.88
P7	Across W approach	53	11.6	LOS B	0.1	0.1	0.68	0.68
All Pedestrians		212	14.8	LOS B			0.77	0.77

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 2020 AM

New Site
Signals - Fixed Time   Cycle Time = 100 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Ferro Close											
1	L	71	64.8	0.252	11.0	LOS B	0.7	7.3	0.28	0.66	47.9
2	T	75	42.7	0.210	34.1	LOS C	3.0	28.6	0.85	0.67	29.7
3	R	6	0.0	0.025	45.4	LOS D	0.3	1.8	0.86	0.66	26.8
Approach		151	51.3	0.252	23.8	LOS C	3.0	28.6	0.58	0.66	36.0
East: John Ross (R34)											
4	L	34	7.1	0.035	8.9	LOS A	0.2	1.6	0.21	0.63	48.4
5	T	960	1.7	0.253	7.7	LOS A	6.4	45.6	0.45	0.39	47.7
6	R	356	1.3	1.000[3]	32.2	LOS C	18.1	127.9	1.00	0.91	31.9
Approach		1350	1.7	1.000	14.2	LOS B	18.1	127.9	0.59	0.53	42.2
North: Alurrima Alley											
7	L	65	18.9	0.148	9.6	LOS A	0.5	4.3	0.24	0.65	48.1
8	T	120	30.6	0.316	35.0	LOS D	4.9	43.6	0.87	0.70	29.3
9	R	88	29.2	0.367	47.5	LOS D	3.9	33.7	0.91	0.78	26.4
Approach		272	27.4	0.367	33.0	LOS C	4.9	43.6	0.73	0.72	31.1
West: John Ross (R34)											
10	L	155	8.7	0.182	9.1	LOS A	1.0	7.3	0.24	0.66	48.4
11	T	791	2.8	0.314	8.1	LOS A	8.3	59.8	0.47	0.41	47.3
12	R	159	25.3	0.714	32.4	LOS C	6.8	57.7	0.76	0.90	32.2
Approach		1105	6.8	0.714	11.8	LOS B	8.3	59.8	0.48	0.52	44.4
All Vehicles		2878	8.7	1.000	15.5	LOS B	18.1	127.9	0.56	0.55	41.2

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue Pedestrian ped	Average Back of Queue Distance m	Prop. Queued	Effective Stop Rate per ped
P1	Across S approach	53	9.2	LOS A	0.1	0.1	0.43	0.43
P3	Across E approach	53	44.2	LOS E	0.1	0.1	0.94	0.94
P5	Across N approach	53	10.6	LOS B	0.1	0.1	0.46	0.46
P7	Across W approach	53	44.2	LOS E	0.1	0.1	0.94	0.94
All Pedestrians		212	27.0	LOS C			0.69	0.69

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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MOVEMENT SUMMARY

Site: Location 3 2020 PM

New Site
Signals - Fixed Time   Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
							Vehicles veh	Distance m			
South: Ferro Close											
1	L	175	28.5	0.372	13.1	LOS B	2.3	19.8	0.62	0.75	45.0
2	T	126	46.6	0.217	13.7	LOS B	2.5	24.8	0.71	0.57	41.5
3	R	18	6.9	0.043	21.3	LOS C	0.3	2.6	0.66	0.69	38.1
Approach		319	34.4	0.372	13.8	LOS B	2.5	24.8	0.66	0.68	43.1
East: John Ross (R34)											
4	L	1	0.0	0.001	8.4	LOS A	0.0	0.0	0.24	0.60	48.5
5	T	1219	4.9	0.511	14.2	LOS B	9.0	65.4	0.79	0.68	40.9
6	R	101	9.7	0.515	31.3	LOS C	2.8	21.3	0.91	0.80	32.4
Approach		1322	5.3	0.515	15.5	LOS B	9.0	65.4	0.80	0.69	40.1
North: Alurrima Alley											
7	L	386	1.9	0.484	12.8	LOS B	6.2	43.8	0.66	0.78	44.4
8	T	61	56.0	0.110	13.1	LOS B	1.2	12.1	0.67	0.52	42.1
9	R	284	12.4	0.641	27.9	LOS C	7.5	58.3	0.90	0.85	34.2
Approach		731	10.5	0.641	18.7	LOS B	7.5	58.3	0.76	0.79	39.7
West: John Ross (R34)											
10	L	79	23.1	0.082	9.5	LOS A	0.4	3.3	0.30	0.66	48.2
11	T	871	3.4	0.542	14.4	LOS B	9.8	70.4	0.80	0.70	40.7
12	R	67	59.2	0.715	40.6	LOS D	2.3	24.7	0.95	0.96	29.2
Approach		1018	8.6	0.715	15.8	LOS B	9.8	70.4	0.77	0.71	40.1
All Vehicles		3389	10.1	0.715	16.1	LOS B	9.8	70.4	0.77	0.72	40.3

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Movement Performance - Pedestrians

Mov ID	Description	Demand Flow ped/h	Average Delay sec	Level of Service	Average Back of Queue		Prop. Queued	Effective Stop Rate per ped
					Pedestrian ped	Distance m		
P1	Across S approach	53	15.4	LOS B	0.1	0.1	0.72	0.72
P3	Across E approach	53	24.3	LOS C	0.1	0.1	0.90	0.90
P5	Across N approach	53	17.6	LOS B	0.1	0.1	0.77	0.77
P7	Across W approach	53	24.3	LOS C	0.1	0.1	0.90	0.90
All Pedestrians		212	20.4	LOS C			0.82	0.82

Level of Service (LOS) Method: SIDRA Pedestrian LOS Method (Based on Average Delay)
Pedestrian movement LOS values are based on average delay per pedestrian movement.
Intersection LOS value for Pedestrians is based on average delay for all pedestrian movements.

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