On behalf of Doug Jeffrey Environmental Consultants: Koeberg Power Station

Screening Assessment v2.0

Ref: 0306103

December 2016

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On behalf of Doug Jeffrey Environmental: Koeberg Power Station

Screening Assessment

Report v2.0

December 2016

Prepared by Peter Instone

Reference: 0306103
www.erm.com

For and on behalf of Environmental Resources Management

Approved by: Gary McFadden

Signed:

Position: *Partner*

Date: 05/12/2016

EXECUTIVE SUMMARY

Doug Jeffery Environmental Consultants approached ERM to perform a screening assessment of the risks that may be imposed on the public by the proposed future Diesel tank installations in the Eskom Koeberg Power Station. This is a high level assessment based on the limited technical information available at this stage of the project and taking into account expected quantities of hazardous material stored on site and the likely equipment used. From this assessment the decision will be taken if the proposed developments could be classed as a Major Hazard Installation as out lined in current legislation. If the development does pose a threat to "the public" beyond the Eskom Koeberg site boundaries then a full MHI QRA will be required.

This is a screening assessment of the proposed two Diesel storage tanks at the Eskom Koeberg Power Station, Western Cape Province, with the objective to produce consequence contours which can be used to produce land use planning zones in line with the UK HSE's Land Use Planning criteria.

It is understood that the Eskom Koeberg Power Station intends to store 2 x 68.75 m^3 (maximum) of Diesel, in tanks designed with a secondary containment bund within the portable tank. These tanks will initially be stored at either the Ekhaya site (Alternative 1 – preferred alternative) or at a second location (Alternative 2), while development continues at the Portable Emergency Equipment (PEE) site. Once developments are complete one tank will be moved to the PEE site.

Based on the results presented below, the risk contours envelop surrounding land that is currently undeveloped and land within the Eskom Koeberg site boundary. Therefore based on the United Kingdom Health and Safety Executive's (HSE) PADHI guidelines this proposed site would be considered under the category "Do not Advise Against" for any proposed future industrial developments.

In this assessment it was found that the consequences could extend beyond the site boundaries where the Diesel is stored. However this still remains within the greater Koeberg site and therefore the general public is not exposed to this risk.

Based on the results presented above, the contours envelop surrounding land that is undeveloped and land intended to be used for industrial use, but within the Eskom Koeberg site. Therefore based on the PADHI guidelines this proposed site would be considered under the category 'Do not Advise Against' for future development.

As *"the public"* beyond the Eskom Koeberg site boundaries are not exposed to *"a risk, that could affect the health and safety of employees **and** the public"*, this would result in the proposed development **not** being considered as a Major hazard Installation as outlined in current legislation.

CONTENTS

1 INTRODUCTION

1.1 GENERAL INTRODUCTION

A series of major accidents at fuel and gas storage, handling and production facilities have focused worldwide attention on the need to control the design and management of facilities where potential for major accidents exists. In South Africa, the Major Hazard Installation (MHI) Regulations were promulgated on the 16 January 1998 under Section 43 of the Occupational Health and Safety Act No. 85 of 1993 (1) as amended, to control and manage such activities. The MHI Regulations were revised on 30th July 2001 and they 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.'

Doug Jeffery Environmental Consultants approached ERM to perform a screening assessment of the risks that may be imposed on the public by the proposed future Diesel tank installations in the Eskom Koeberg Power Station. This is a high level assessment based on the limited technical information available at this stage of the project and taking into account expected quantities of hazardous material stored on site and the likely equipment used.

From this assessment the decision will be taken if the proposed development could be classed as a Major Hazard Installation as out lined in current legislation. If the development does pose a threat to "the public" beyond the Eskom Koeberg site boundaries then a full MHI QRA will be required.

Environmental Resources Management Southern Africa (Pty) Ltd (hereafter referred to as "ERM") is accredited by SANAS (certificate no. MHI-0012) and is a Department of Labour Approved Inspection Authority (AIA), No. MHI 0008 for Major Hazard Installation Regulations risk assessments. However this is a screening assessment not an MHI QRA.

It is understood that the Eskom Koeberg Power Station intends to store 2 x 68.75 m3 (maximum) of Diesel, in tanks designed with a secondary bund within the portable tank. These tanks will initially be stored at either the Ekhaya site (Alternative 1 – preferred alternative) or at a second location (Alternative 2), while development continues at the Portable Emergency Equipment (PEE) site. Once developments are complete one tank will be moved to the PEE site.

(1) Regulation R.692 Occupational Health and Safety Act (85/1993): Major Hazard Installation Regulations.

The aim of the project was to undertake a screening assessment of the proposed Koerberg Power Station Diesel storage facilities based on using the UK's HSE Land-Use Planning (LUP) consequence zones.

ERM have assumed that all equipment at the proposed Eskom Koeberg sites will be designed, constructed, operated and maintained to world class standards and will comply with all relevant South African legislation.

Technical specifications for the proposed Koerberg Power Station Diesel storage facilities were obtained in communications with Jenna Theron and Adél Groenewald of Doug Jeffery Environmental Consultants.

2 ENVIRONMENTAL SITE SETTINGS

2.1 SITE LOCATION

The proposed Diesel locations are within the boundary of the Eskom Koeberg Power Station, Western Cape Province and are marked within *Figure 2.1* and the PGS coordinates are:

- PEE site: 33.678356° S, 18.451552° E
- Alternative 1 – Preferred Alternative (Ekhaya Site): 33.677055° S, 18.435648° E
- Alternative 2: 33.675483° S, 18.440400° E

To the north, east and south the land is currently vacant and unused. To the west, Eskom Koeberg Power Station main site buildings are located.

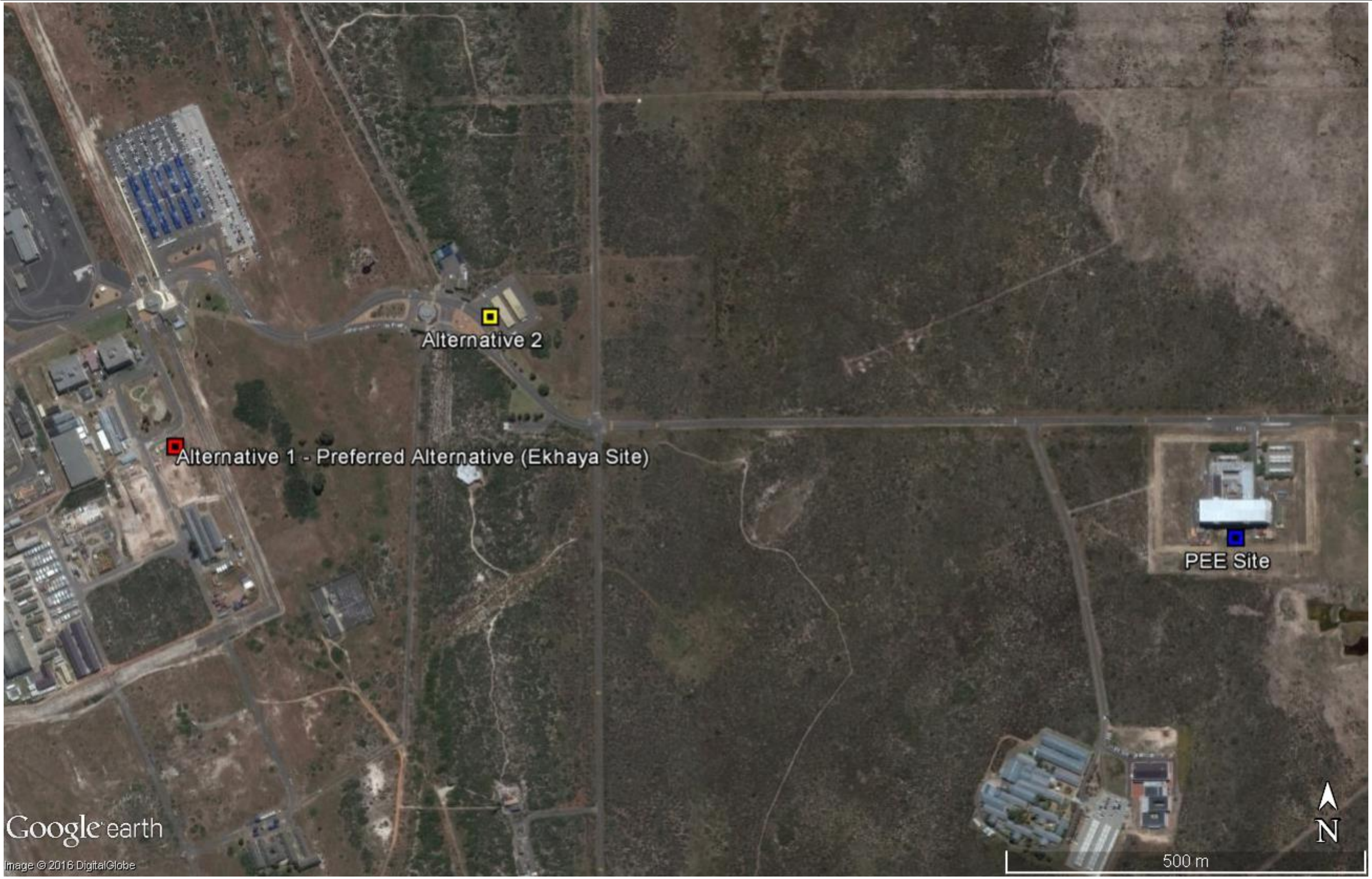
Major transport routes in close proximity to the site include:

- R27 is 1.5 km from the site to the east

The Eskom Koeberg Nuclear Power Station is specifically exempt from the Major Hazard Installation Regulations and there are no other MHIs in close proximity to the proposed Diesel sites.

The land-use surrounding the proposed Diesel sites is shown in *Figure 2.1*

Figure 2.1 Aerial Map of Site and Surroundings



2.2 METEOROLOGY

Typically, consequence assessments require information about the wind speed and stability class.

Atmospheric stability is difficult to measure and often varies dramatically over relatively short distances. Atmospheric stability classes need to be defined in the dispersion modelling to facilitate estimates of lateral and vertical dispersion parameters. The preferred stability classification scheme for use in air quality modelling applications is the scheme proposed by Pasquill (1961).

The Pasquill Stability Classes are defined by the letters A to F and are described as follows:

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

Neutral conditions correspond to a vertical temperature gradient of approximately 1 °C per 100 m. The meteorological conditions defining Pasquill stability classes are given in *Table 2.1*.

Table 2.1 Pasquill Stability Classes

Surface Wind Speed (m/s)	Day-time Insulation			Night-time Insulation	
	Strong	Moderate	Slight	>4/8 low cloud	≤4/8 cloud
<2	A	A - B	B		
2 – 3	A – B	B	C	E	F
3 – 5	B	B - C	C	D	E
5 – 6	C	C - D	D	D	D
>6	C	D	D	D	D

It is understood that to date no weather stations in South Africa measure both wind speed and stability categories. Since no site-specific weather data were available, meteorological data (ie wind and stability data) from the closest appropriate weather source, namely Cape Town was sourced from www.windfinder.com.

The average ambient temperature and humidity were obtained from www.weatherbase.com. A summary of the data is as follows:

- average day temperature = 21°C;
- average night temperature = 12°C; and
- Average relative humidity is 74.2%.

ERM selected three stability classes and wind speed scenarios for modelling purposes:

- **B3** – meaning a stability class of B (moderately unstable conditions) where the wind speed is greater than 3 m/s; and

- **C8** - meaning a stability class of C (Slightly unstable conditions) where the wind speed is greater than 8 m/s.

B3 and D5 give a conservative daytime weather condition.

- **F2** – meaning a stability class of F (moderately stable) where the wind speed is less than or equal to 2 m/s. This class is often used by the US Environmental Protection Agency for determining worse case scenarios for vapour cloud dispersion consequence analysis. F2 gives a conservative night time weather condition.

Selecting B3, C8 and F2 categories gives an average and a 'worst case' condition for the risk assessment study.

3 DESCRIPTION OF FACILITIES

3.1 DESCRIPTION OF SITE OPERATIONS

It is understood that the proposed Diesel storage tank design shown in *Figure 3.1* will be a self-contained unit with inbuilt secondary containment bund. The unit will also contain pumping and piping equipment.

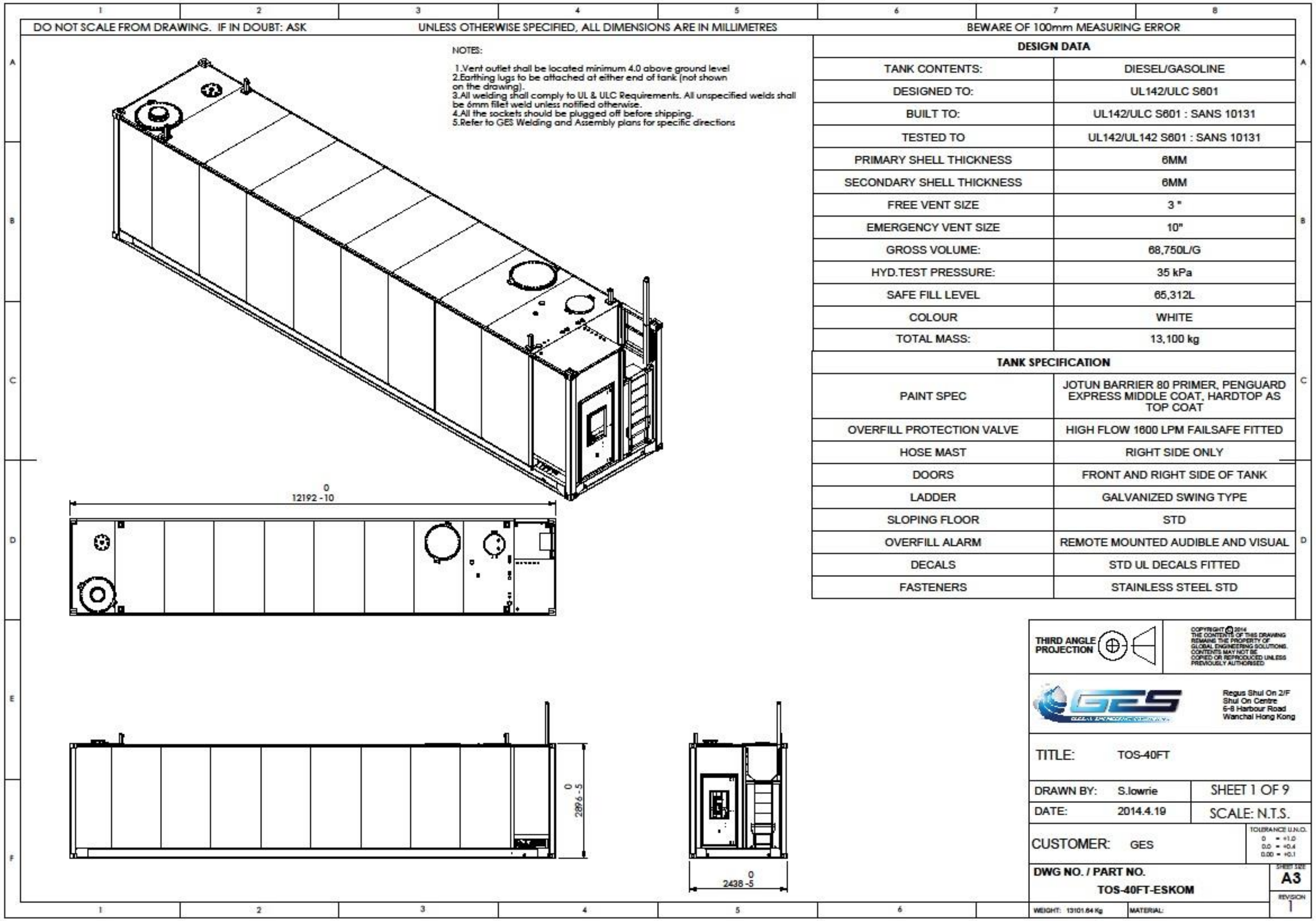
The site has proposed two of these tanks to be installed with a maximum volume of 68.75 m^3 each.

3.2 ROAD TANKERS

Once a year a road tanker will deliver replacement Diesel, it will be assumed that the maximum size of the road tanker will be 42m^3.

It is assumed that the Diesel is transported in the road tankers at the same ambient temperature and pressure as the bulk storage tanks.

Figure 3.1 Diesel tank design layout



4 LAND-USE PLANNING METHODOLOGY USED IN THIS ASSESSMENT

A number of countries have well developed approaches to land-use planning around Major Hazard Installations, being either primarily probabilistic (ie risk based) or deterministic (ie consequence based). The purpose of such systems is to prevent the growth of incompatible land-uses around major hazard sites, or the location of new major hazard sites in inappropriate locations. An overview of the approach used by the UK HSE is given below (1):

A three zone system is applied - inner zone, middle zone and outer zone with the outermost extent of the outer zone referred to as the Consultation Distance (CD). In combination with this, land-uses are classified according to sensitivity level, with Sensitivity Level 1 (typically places of work) being the least sensitive and Sensitivity Level 4 (typically large schools or hospitals) being the most sensitive. A set of rules (in the form of a 'decision matrix') is applied to determine which land-uses are appropriate for which zones.

In practice, the zones are related to the risk of an individual being exposed to a dangerous dose or load which would '*...cause severe distress to almost everyone, many [would] require medical treatment, some [would] be seriously injured and highly vulnerable people might be killed*'. This approach appreciates the general public's aversion not only to fatality but also to injury and other distress (ie the concept of harm) - and is distinct from approaches solely related to fatality.

Proposals for new developments in the vicinity of MHIs are assessed by the authorities. Different types of developments are assigned to different 'sensitivity levels', with schools and hospitals being amongst the most sensitive; and factories the least sensitive. The authorities recommend that a proposed development does not proceed if the level of risk is above the value that has been established for developments of that type. Similar approaches may be used for new hazardous installations in developed areas.

The extent of the three zones may be determined by either a probabilistic assessment (ie on a risk basis) or by performing a consequence assessment (ie on a 'protection' basis). For this study, the extent of each zone is based on consequence assessment. This takes into account distances at which a certain level of harm to an individual can be reached.

In the absence of 'official' South African guidance, the risk levels and consequence levels applied in this assessment are those employed by the UK Health and Safety Executive (HSE) when setting zones around MHIs. The zones for an individual being exposed to flame/heat, explosion overpressure, toxic gas or asphyxiant (ie a specified frequency of receiving a dangerous dose); have been set to correspond to those used by the HSE:

(1) Davies. P., Land-use Planning in the Vicinity of Major Hazard Installations www.hazardview.com, ERM Risk

- inner zone;
- middle; and
- outer zone (Consultation Distance).

In November 2001 the UK HSE modified its zoning criteria. This is summarised in *Table 4.1*, with proposed developments categorised as either 'advise against' (AA) or 'don't advise against' (DAA). This refers to the advice the HSE would give to the local authority in relation to a development proposal of a given type in the vicinity of a MHI.

For example, the HSE would advise the local authority against building of a new housing development in the inner zone.

Table 4.1 ***Land-use Sensitivity to Risk***

Level of Sensitivity	**Inner Zone**	**Middle Zone**	**Outer Zone**
1. The normal working public	DAA	DAA	DAA
2. The general public at home	AA	DAA	DAA
3. Vulnerable members of the public (schools, hospitals, etc.)	AA	AA	DAA
4. Large examples of No 3 & large outdoor examples of No 2 (ie recreational areas)	AA	AA	AA

Note that some types of development can change Sensitivity Level depending on their size. For example, large industrial / office land-uses (for more than 100 persons) would move up a Sensitivity Level from Sensitivity Level 1 to Sensitivity Level 2.

It should also be noted that HSE does not apply these criteria retrospectively to existing land-use around existing MHIs. This is because the cost of turning down proposals for a development that does not yet exist is much lower than the costs involved in relocating existing land-uses.

For example, the costs involved in relocating the occupants of houses in a residential area to new housing elsewhere would be very large compared to the cost of turning down a similar development before it is built. For this reason the land-use planning risk criteria are somewhat more stringent than the criteria applied to existing MHIs.

As stated above, the HSE uses these criteria to consider the suitability of proposed, new land-uses in the vicinity of an existing MHI. In this study, the criteria have been used as a screening step to judge whether further risk assessment studies would be appropriate.

Where land-uses are identified that would be advised against if they were submitted as new applications, this is used to indicate that further risk studies, potentially with application of risk reduction measures at the site, are required to show that the risks are as low as reasonably practicable (ALARP).

Land-uses that would be advised against if they were proposed as new applications are termed 'potentially incompatible'. The presence of potentially incompatible land-uses does not necessarily mean that the risks from the MHI are intolerable. It simply means that further studies would be worthwhile to determine whether or not more needs to be done to reduce the risk.

If no potential incompatibilities are identified, then further, more detailed risk analyses would not be considered necessary at this time.

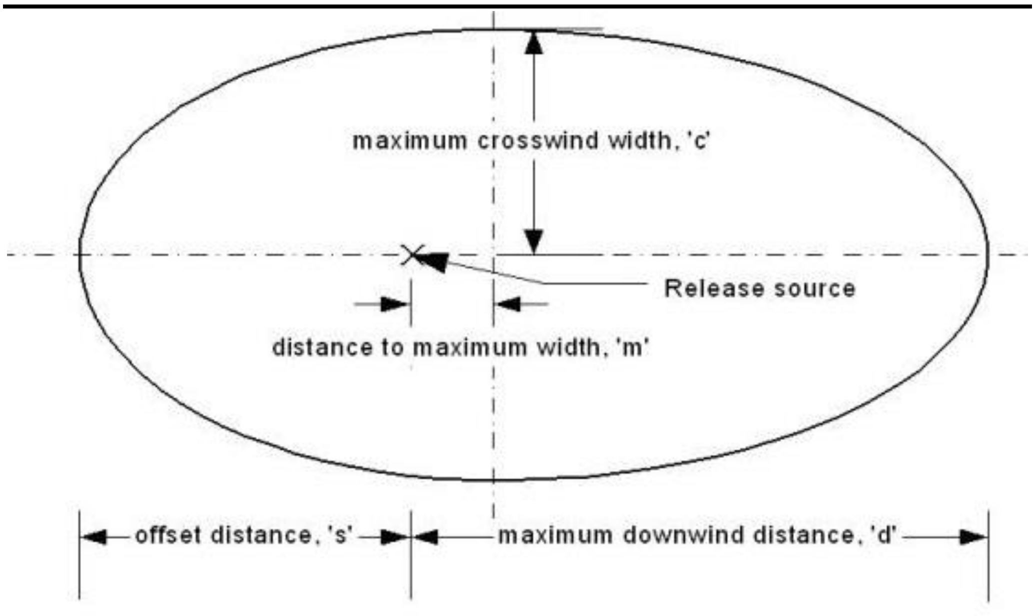
5 CONSEQUENCE ANALYSIS

In order to analyse the severity of a consequence, it is necessary to define harm criteria (or 'end points') for use with the consequence models. These are levels at which a consequence can reach which has a known effect on a population. In the case of this study, the harm criteria are levels of thermal radiation intensity. For more detail on the consequences, their affects and what factors can impact on their severity please refer to *Annex A.*

5.1 CONSEQUENCE DIMENSIONS

Consequence dimensions are expressed in terms of a number of parameters as illustrated in *Figure 5.1*.

Figure 5.1 Harm Envelope Dimension Parameters



5.2 HARM CRITERIA CHOSEN FOR LAND-USE PLANNING ZONING

To provide guidance on Land-use planning for proposed new developments, the HSE has provided both consequence and risk based land-use planning zones. For the purposes of this assessment, only the consequence based land-use planning zones will be considered are based on the following end point criteria.

The UK HSE has developed criteria based on a research report (1) that used the following relationship to calculate the thermal dose:

(1) Hymes I, The Physiological Effects of Thermal Radiation, SRD R 275, September, 1983.

$$tdu = tF^{4/3}$$

where

tdu thermal dose units ($[kW/m^2]^{4/3}$).s

T time (s)

F thermal flux (kW/m^2)

This report uses the HSE thermal radiation impact criteria for short duration fires that are chosen based on the effects described in *Table 5.1.*

Table 5.1 Thermal Dose Impact Criteria (HSE)

Thermal Dose (tdu)	Effect
1800	50% fatalities among a 'typical' population
1000	Dangerous dose to a 'typical' population – equates to approximately 1% fatalities
500	Dangerous dose to a vulnerable / sensitive population

This risk assessment uses 1000 tdu as the dangerous dose criterion for land use planning based on the HSE planning case assessment guide (1). Assuming that the maximum exposure time is 30 seconds (allowing for exposed persons to escape or find shelter), the thermal flux required to meet the above criteria of 1000 tdu is 13.9 kW/m^2. These values for land use planning are summarised in *Table 5.2.*

Table 5.2 Thermal Flux Impact Criteria for Land Use Planning Assessments (HSE)

Impact	Effect
1000 tdu	Dangerous dose to a 'typical' population – equates to approximately 1% fatalities
13.9 ($kW.m^{-2}$)	Intensity to reach a thermal dose of 1000 tdu in 30 seconds

Only the worst case consequences are considered for the Diesel installations. Therefore, for the screening assessment, the thermal flux impact criteria as detailed in *Table 5.2* were used.

(1) Planning Case Assessment Guide, 09/07/2002

6 CONSEQUENCE RESULTS

6.1 FLAMMABLE ESTIMATION OF WORST CASE CONSEQUENCES

Due to the chemical properties of Diesel, in the event of release from the tank or Road Tanker delivering the Diesel and ignition of the released material, a pool fire consequence could result. For this assessment we have the worst case consequences which result from a catastrophic failure of the storage tank or Road Tanker with ignition resulting in a pool fire.

6.1.1 *Pool Fires*

For pool fires, as outlined in *Section 2.2,* the end point criteria of interest is 13.9 kW/m^2. *Table 6.1* shows the maximum distances to the dangerous dose of interest associated with the worst-case failure scenarios at the site for the Ekhaya site and PEE site.

Table 6.1 Maximum Distances Associated with pool fires associated with Diesel releases

Location and Equipment	Scenario and Weather	Harm Criteria	Maximum Downwind Distance(m)
PEE site	Catastrophic road tanker failure (C8)	13.9 kW/m2	59
Alternative 1	Catastrophic road tanker failure (C8)	13.9 kW/m2	59
Alternative 2	Catastrophic road tanker failure (C8)	13.9 kW/m2	59

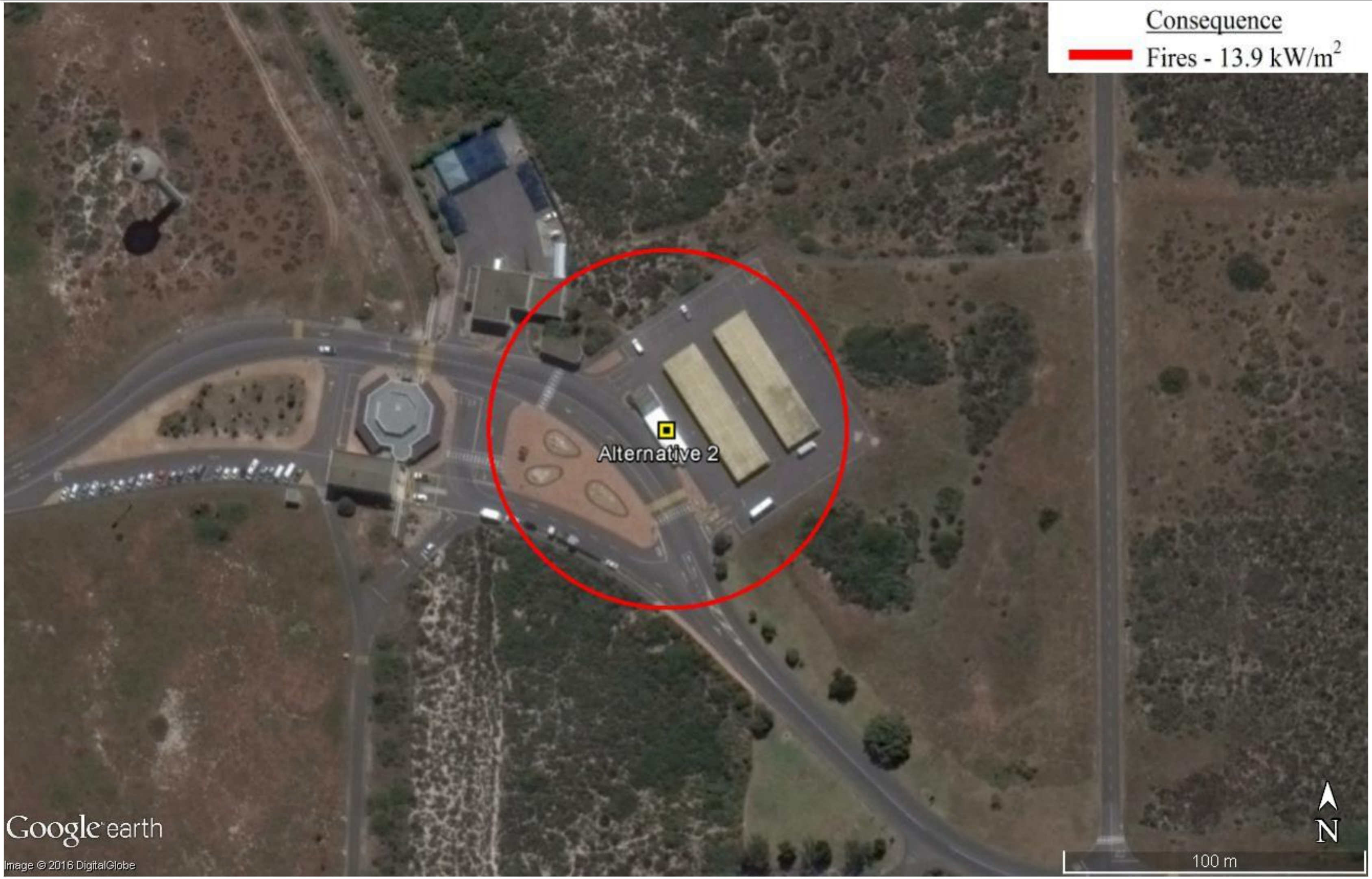
The distance to the maximum dangerous radiation level consequence envelope for the pool fires are illustrated in *Figure 6.1* overall and in *Figure 6.4, Figure 6.3* and *Figure 6.4* individually.

Figure 6.1 Areas Enveloped by Pool Fire – All Locations

Figure 6.2 Area Enveloped by Pool Fire for PEE

Figure 6.3 Area Enveloped by Pool Fire for Alternative 1

Figure 6.4 Area Enveloped by Pool Fire for Alternative 2



7 *LAND-USE PLANNING ZONING RESULTS*

Based on the consequence results in *Section* 6 and the zoning criteria explained in *Section 4, f*or the proposed sites the contours envelop surrounding land that is undeveloped and land intended to be used for industrial use. Therefore based on the PADHI guidelines this proposed site would be considered under the category 'Do not Advise Against' for the future development.

It should be noted that currently the proposed Diesel storage tank sites are surrounded by vacant land. This screening risk assessment has stated that the location is classed as "Do not Advise Against" but this applies to existing land use surrounding the proposed tank locations. The establishment of the tanks will place certain restrictions on potential developments which should be allowed adjacent to the Diesel storage tank sites in the future.

8 *CONCLUSIONS*

In this assessment it was found that the Diesel pool fire consequences could extend beyond the boundaries of the sites where the Diesel is stored. However theses still remain within the greater Koeberg site boundaries and therefore the general public is not exposed to this risk.

Based on the results presented above, the contours envelop surrounding land that is undeveloped and land intended to be used for future industrial use within the Eskom Koeberg site boundaries. Therefore based on the PADHI guidelines this proposed site would be considered under the category 'Do not Advise Against' for the potential future developments.

As *"the public"* beyond the Eskom Koeberg site boundaries are not exposed to *"a risk, that could affect the health and safety of employees **and** the public"*, this would result in the proposed development **not** being considered as a Major Hazard Installation (MHI) as outlined in current legislation.

Annex A

Potential Major Hazard Descriptions

A1 POTENTIAL MAJOR HAZARDS

A1.1 INTRODUCTION

The hazards that are present at the site that may result in injury to people or a fatality in more serious cases are considered to be a loss of containment of Diesel which is ignited and results in a fire. Some hazards may even give rise to multiple fatalities. This study is only concerned with 'major hazards', as described in the current MHI legislation which, for flammable releases could be as follows:

- pool fires;
- flash fires;
- jet fires;
- fireballs; and
- vapour cloud explosions.

Each of these hazards is described below.

This study is primarily concerned with 'major hazards' giving rise to off-site consequences and therefore for this assessment, on site risk has not been considered.

A1.2 MAJOR HAZARD EFFECTS

A1.2.1 Pool Fires

The principal type of hydrocarbon fire of interest in this study is a pool fire involving Diesel fuel. If a liquid release has time to form a pool and is then ignited before the pool evaporates or drains away, then a pool fire results.

Because they are less well aerated, pool fires tend to have lower flame temperatures and produce lower levels of thermal radiation than some other types of fire (such as jet fires); however, this means that they will produce more smoke.

Although a pool fire can still lead to structural failure of items within the flame, this will take several times longer than in a jet fire. An additional hazard of pool fires is their ability to move. A burning liquid pool can spread along a horizontal surface or run down a vertical surface to give a running fire.

Due to the presence of kerbs, slopes, drains and other obstacles; pool fire areas and directions can be unpredictable. To provide a good conservative model, the pool fires are modelled as perfect circles.

A1.2.2 Flash Fires

Vapour clouds can be formed from the release of flashing liquids from pressurised flammable material as well as from non-flashing liquid releases where vapour clouds can be formed from the evaporation of liquid pools or gas releases.

Where ignition of a release does not occur immediately, a vapour cloud is formed and moves away from the point of origin under the action of the wind. This drifting cloud may undergo delayed ignition if an ignition source is reached, resulting in a flash fire if the cloud ignites in an unconfined area or a vapour cloud explosion (VCE) if within confined area. (An unconfined vapour cloud explosion is also possible under certain conditions).

The flash fire is typically modelled through simulating the dispersion of the initial cloud to the lower flammability limit (LFL). The damage area then corresponds to the LFL cloud footprint. It is also possible that pockets of gas capable of igniting travel outside the LFL cloud footprint. Therefore concentrations are also modelled to the half LFL (0.5LFL) level.

Considered extremely unlikely for the Diesel fuel handled at this site.

A1.2.3 Jet Fires

Jet fires result from ignited continuous releases of pressurised flammable gas or liquid. The momentum release carries the material forwards in a long plume entraining air to give a flammable mixture. Jet fires have a high flame temperature and can produce very high intensity thermal radiation. The high temperatures pose a hazard not only from direct effects of heat on human beings, but also from the possibility of event escalation; if a jet flame impinges upon a target such as a vessel, pipe or structural member, it can cause the target to fail within a few minutes.

The materials which may cause jet fires at this site are all flammable gases under pressure (eg Hydrogen, acetylene or LPG). As a worst-case scenario, it is assumed that all failures occur in a horizontal position (ie the flame is orientated horizontally).

Considered extremely unlikely for the Diesel fuel handled at this site.

A1.2.4 Fireballs

A fireball can occur following an instantaneous release of light hydrocarbon fuel due to cold catastrophic failure of a vessel. A cold catastrophic failure of the storage vessel can occur from mechanical damage, for example. Such events have very high thermal radiation, similar to jet fires.

Considered extremely unlikely for the Diesel fuel handled at this site.

A1.2.5 *Gas / Vapour Cloud Explosions*

If the generation of heat in a fire involving a vapour-air mixture is accompanied by the generation of pressure then the resulting effect is a vapour cloud explosion (VCE). The amount of overpressure produced in a VCE is determined by the reactivity of the gas, the strength of the ignition source, the degree of confinement of the vapour cloud, the number of obstacles in and around the cloud and the location of the point of ignition with respect to the escape path of the expanding gases.

In most VCEs the expanding flame front travels more slowly than the pressure wave; this type of explosion is called a deflagration and the maximum overpressure is determined by the expansion ratio of the burning gases. If the flame front travels fast enough to coincide with the pressure wave then the explosion is called a detonation and very severe overpressures can be produced. Detonation is most likely to occur with more reactive gases such as hydrogen.

Considered extremely unlikely for Diesel fuel handled at this site.

A1.2.6 *Factors Affecting Consequences*

There are several factors which affect the consequences of materials released into the environment. These include (but are not limited to):

- Release quantity or release rate
- Duration of release
- Initial density of the release
- Source geometry
- Source elevation
- Prevailing atmospheric conditions
- Surrounding terrain
- Physical and chemical properties of the material released.

Such factors will affect the consequence zones for the specific hazardous materials, e.g. the distance at which the level of thermal radiation from a fire or overpressure from an explosion has reduced sufficiently so that it is no longer dangerous.

Factors Affecting Fire Hazards

When considering large open hydrocarbon fires, the principal hazard is from thermal radiation. The primary concerns are safety of people and potential damage to nearby facilities or equipment. Determination of thermal radiation hazard zones involves the following three steps:

- Geometric characterisation of the fire, that is, the determination of the burning rate and the physical dimensions of the fire;

- Characterisation of the radiative properties of the fire, that is, the determination of the average radiative heat flux from the flame surface; and

- Calculation of radiant intensity at a given location.

These, in turn, depend upon the nature of the flammable material, size and type of fire, prevailing atmospheric conditions and the location and orientation of the target/receptor.

Consequence Models

The hazards described above can be modelled analytically by standard models used for consequence analysis. Many of these models are performed by computer software and ERM has access to a range of such models.

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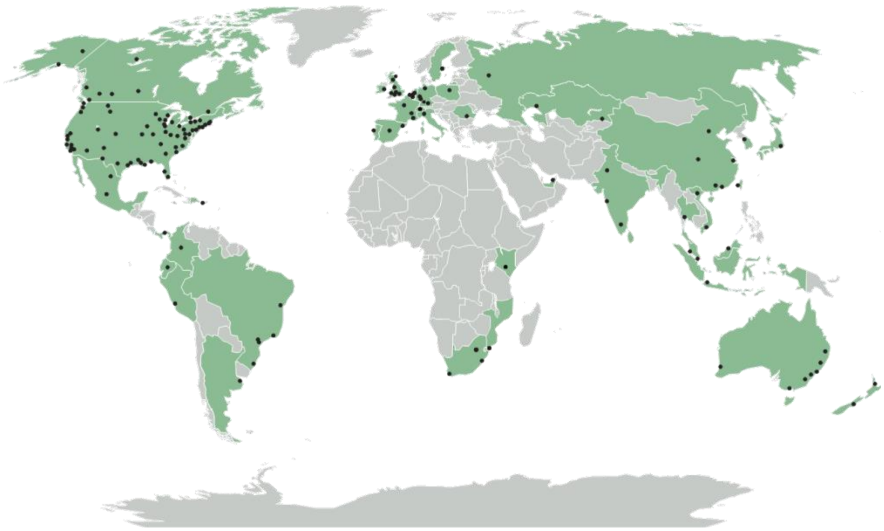

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