Hunter Power Project

Final Hazard Analysis (FHA)

Rev. C

Snowy Hydro Limited

Hunter Power Project

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Contents

List of figures

List of tables

Abbreviations

ADG	Australian Dangerous Goods
ALARP	As Low As Reasonably Practicable
AS	Australian Standard
CASA	Civil Aviation Safety Authority
CBD	Central Business District
CCTV	Closed-Circuit Television
CSG	Coal Seam Gas
DBB	Double Block and Bleed
DP&E	Department of Planning and Environment
EI	Energy Institute, London
EIS	Environmental Impact Statement
EMF	Electromagnetic Radiation Field
EMR	Electromagnetic Radiation
ERP	Emergency Response Plan
ETA	Event Tree Analysis
FHA	Final Hazard Analysis
FRED	Failure Rate and Event Data
FRL	Fire Resistance Level
HAZOP	HAZard and OPerability
HIPAP	Hazardous Industry Planning Advisory Paper
IR	Individual Risk
ISO	International Organization for Standardization
JGN	Jemena Gas Network
LFL	Lower Flammability Limit
LNG	Liquefied Natural Gas
LOPA	Layers of Protection Analysis
LPG	Liquefied Petroleum Gas
NEM	National Electricity Market
NGDE	Neutral Gas Dispersion Explosive
NSW	New South Wales
OCGT	Open Cycle Gas Turbine
OGP	The International Association of Oil & Gas Producers
P&ID	Piping and Instrumentation Diagram
PHA	Preliminary Hazard Analysis
RIVM	Dutch National Institute for Public Health and the Environment
SCADA	Supervisory Control And Data Acquisition

SEP	Surface Emissive Power
SNP	Sydney to Newcastle Pipeline
SOP	Standard Operating Procedure
UK HSE	United Kingdom Health and Safety Executive
VCE	Vapor Cloud Explosion

Executive Summary

Introduction

Snowy Hydro Limited's Hunter Power Project (the Project) (or referred to as the Hunter Power Station in this report) was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17th December 2021. The approved Project involves the development of a gas-fired power station comprising two open cycle gas turbine (OCGT) generators with a nominal capacity of up to 750 megawatts (MW), an electrical switchyard and associated supporting infrastructure. The gas turbines will primarily be fired on natural gas with the use of diesel fuel as a backup. The Project will operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market (NEM). The project is located at 73 Dickson Road, Loxford, New South Wales, on a portion of the former Hydro Aluminium Kurri Kurri aluminium smelter.

The purpose of this report is to satisfy Infrastructure Approval condition B12(c) which requires "*A Final Hazard Analysis based on the detailed design of the development prepared in accordance with the Department's Hazardous Industry Planning Advisor Paper No. 6 "Hazard Analysis". The scope of the study must include and not be limited to specifying all design variations between the final detailed design and the conceptual design described in the EIS*".

Since the Project's approval, a main equipment supplier has been engaged by Snowy Hydro and the detailed design for the Project has progressed. The main changes between the conceptual design and the detailed design relevant to this study is that 60 m high turbine exhaust stacks are required, the operational capacity of the power station will be 660 MW, and hydrogen cooling will be used for the generators.

In accordance with the New South Wales Department of Planning and Environment (DP&E) requirements set out in the *Hazardous Industry Planning Advisory Paper No. 6: Hazard Analysis* (January 2011), and for the risk to be evaluated and compared against the risk criteria in use in New South Wales as specified in the *Hazardous Industry Planning Advisory Paper No. 4: Risk Criteria for Land Use Planning* (January 2011), Jacobs has prepared this Final Hazard Analysis (FHA) on behalf of Snowy Hydro. The FHA has been carried out based on the Project's latest detailed design (done by others) information available at the time of preparing this report. It entails a full quantitative risk assessment for the following infrastructure:

- Gas turbine units that are able to run on both fuel gas (natural gas) and fuel oil (diesel).
- Fuel gas facilities (natural gas supply from the terminal point of the APA Delivery Station up to the gas turbine combustors including equipment such as the gas turbine fuel gas heater, filter coalescer, gas turbine fuel gas pressure and flow control units, all associated pipework, etc).
- Fuel oil facilities (including the diesel tanker, unloading hose, unloading pump, storage tank, forwarding pump, filters, gas turbine main fuel oil pump, combustors, all associated pipework, etc).
- Hydrogen facilities (including tube trailer, cylinder packs, pressure regulation and reduction units, generator cooling circuit, all associated pipework, etc).
- Other chemicals with smaller storage quantities onsite to support the plant operation and maintenance works.

Study Objective and Methodology

The purpose of the FHA is to systematically identify and assess the major hazards and risks associated with the Project and compare the risk results with relevant risk criteria for land use planning.

The FHA was carried out in accordance with industry practice and relevant international guidelines for quantitative risk assessment. The study considered loss of containment of hazardous substances in the event of failure of various equipment items, such as road tankers, unloading hose and coupling, atmospheric storage tank, pump, filter, heat exchanger/ heater, pressure vessel, gas tube trailer, gas cylinder package, flange, valve, instrument connection, and all associated pipework, leading to pool fire, jet fire, fireball, flash fire, and/ or vapor cloud explosion (VCE).

The FHA started with hazard identification, from which failure cases were derived to take forward for further assessment. The effects of potential hazardous outcomes were determined from consequence modelling performed using Gexcon's *Riskcurves Version 11.5* software. The likelihood of occurrence of potential hazardous outcomes was estimated using published generic failure rate data and relevant event trees and modifiers. The outcomes of the consequence analysis step and estimation of likelihood step were finally integrated using Gexcon's *Riskcurves Version 11.5* software to obtain profiles of risk posed by the plant to individual, property, and society.

Findings

The Project's individual fatality risks satisfy all the HIPAP No. 4 criteria as described below:

- The 0.5 x 10^{-6} per year contour extends outside the Project site boundary largely across the western boundary, with a maximum offsite distance of 57 metres. This contour encroaches lands zoned to heavy industrial and rural landscape, but does not reach any hospitals, schools, child-care facilities, or old age housing development.
- The 1 x 10^{-6} per year contour extends outside the Project site boundary largely across the western boundary, with a maximum offsite distance of 39 metres. This contour encroaches lands zoned to heavy industrial and rural landscape but does not reach any residential developments and places of continuous occupancy such as hotels and tourist resorts.
- The 5 x 10^{-6} per year contour extends slightly outside the Project site boundary in the Northwest direction, with a maximum offsite distance of 5 metres. This contour encroaches lands zoned to heavy industrial, but does not reach any commercial developments including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres.
- The 10 x 10^{-6} per year contour is confined within the Project site boundary, satisfying the criterion that this contour must not reach any sporting complexes and active open space areas.
- The 50 x 10^{-6} per year contour is entirely within the Project site, satisfying the criterion that this contour must be contained within the site boundary for industrial land uses.

The Project's individual injury risks satisfy all the HIPAP No. 4 criteria as described below:

- The 50 x 10^{-6} per year contour for 4.7 kW/m^2 thermal radiation threshold is confined within the Project site boundary and does not extend to any residential and sensitive use areas.
- Iso-risk level of 50 x 10^{-6} per year for 7 kPa explosion overpressure threshold is not reached.

The Project's property damage and accident propagation risks satisfy all the HIPAP No. 4 criteria as described below:

- The 50 x 10^{-6} per year contour for 23 kW/m^2 thermal radiation threshold is confined within the Project site boundary and does not extend to neighbouring potentially hazardous installations or land zoned to accommodate such installations.
- Iso-risk level of 50 x 10^{-6} per year for 14 kPa explosion overpressure threshold is not reached.

There are no material toxic hazards and risks from the Project; toxic exposure criteria as specified in HIPAP No. 4 was deemed to be not applicable to this Final Hazard Analysis.

Regarding societal risk, the F-N-curve, which is a plot of cumulative frequency of events that might kill (F) versus consequences measured as number of fatalities (N), was not activated or generated from the societal risk calculation as part of this analysis, primarily because the lands in the vicinity of the Project are largely zoned as 'Rural Landscape' (unoccupied), 'Heavy Industrial', and 'General Industrial', which have a very low population density. The Project boundary is at a minimum over one kilometre distant from the closest of land users (other than commercial/ industrial) considered to be a sensitive receptor or having continuous occupation; the risk from the Project does not reach the closest residence and is contained within industrial areas. The Project is not expected to give rise to societal concerns, over a potential to create multiple fatalities, due to being below the FN-curve limits.

Conclusion and recommendations

In conclusion, the Project satisfies all the HIPAP No. 4 criteria. No further risk reduction measures (preventive or mitigative) were identified in this FHA.

It is noted that the Preliminary Hazard Analysis (PHA) for the Project included some consideration of the on-site natural gas receiving station (GRS), being designed and built by APA under a separate planning approval, including compressors and delivery lines to the Project. In addition to this, the recently completed APA PHA demonstrated that the Hunter Power Station and adjacent APA gas supply infrastructure are relatively independent in terms of the cumulative risk and hence there is not a requirement to undertake a fully integrated FHA between the neighbouring facilities. It is anticipated that if the APA project receives planning approval, APA will progress to detailed design and conduct their own FHA which will include confirming the conclusion with respect to the cumulative impact of the facilities.

1. Introduction

1.1 Project Background

Snowy Hydro Limited's Hunter Power Project (the Project) (or referred to as the Hunter Power Station in this report) was approved as SSI-12590060 by the then Minister for Planning and Public Spaces on 17 December 2021. The approved Project involves the development of a gas-fired power station comprising two open cycle gas turbine (OCGT) generators with a nominal capacity of up to 750 megawatts (MW), an electrical switchyard and associated supporting infrastructure. The gas turbines will primarily be fired on natural gas with the use of diesel fuel as a backup. The Project will operate as a "peak load" generation facility supplying electricity at short notice when there is a requirement in the National Electricity Market (NEM). The project is located at 73 Dickson Road, Loxford, New South Wales, on a portion of the former Hydro Aluminium Kurri Kurri aluminium smelter.

The purpose of this report is to satisfy Infrastructure Approval condition B12(c) which requires "*A Final Hazard Analysis based on the detailed design of the development prepared in accordance with the Department's Hazardous Industry Planning Advisor Paper No. 6 "Hazard Analysis". The scope of the study must include and not be limited to specifying all design variations between the final detailed design and the conceptual design described in the EIS*".

Since the Project's approval, a main equipment supplier has been engaged by Snowy Hydro and the detailed design for the Project has progressed. The main changes between the conceptual design and the detailed design relevant to this study are the equipment supplier and their specialist stack designer have determined that 60 m high turbine exhaust stacks are required, the operational capacity of the power station will be 660 MW, and hydrogen cooling will be used for the generators.

The power station will now have a operational capacity of up to approximately 660 MW, which will be generated by two industrial-frame heavy-duty F-Class Open Cycle Gas Turbine (OCGT) units. The gas turbines will be capable of operating on both natural gas (primary fuel) and diesel (backup fuel). Natural gas will be supplied from Australia's existing gas fields that feed Sydney and Newcastle via the existing Sydney to Newcastle Pipeline (SNP); there will be no natural gas storage within the Project site. Diesel will be received from road tankers and stored onsite in bulk storage tanks.

The electrical switchyard will be built at the northern part of the Project site and will connect to the existing 132 kV electricity transmission infrastructure located adjacent to the Project site.

Other ancillary elements of the Project include:

- Service water infrastructure (storage tanks and pumps)
- Demineralised water infrastructure (storage tanks and pumps)
- Fire water infrastructure (storage tanks and pumps)
- Maintenance laydown areas
- Site access roads and car parking
- Admin building, workshop building, and chemical and equipment store

The Project is intended to be operational by the end of 2023.

The gas supply infrastructure required for the power station will be developed, constructed, and operated by a third party (APA Group). This Kurri Kurri Lateral Pipeline project is subject to separate planning approvals and associated FHA. The Kurri Kurri Lateral Pipeline project comprises the following primary components: a buried, steel Transmission Pipeline to provide gas from the existing SNP via the Jemena Gas Network (JGN) receipt and delivery facilities to the power station; a Compressor Station at the termination of Transmission Pipeline to boost gas pressure prior to transfer to the Storage Pipeline; a buried, steel Interconnect Pipeline to provide an interface between the Compressor Station, Storage Pipeline, and the Delivery Station; a buried, steel Storage Pipeline with approximately 70 TJ of useable gas storage capacity ready to supply to the power station; and a Delivery Station to receive gas from Storage Pipeline and regulate the gas temperature, pressure, and flow rate to meet specifications prior to delivery to the Hunter Power Station. The Storage Station (which incorporates the Compressor Station and Delivery Station) will be located adjacent to the Hunter Power Station and will connect to the power station gas facilities.

1.2 Hazard Analysis

The purpose of a hazard analysis is to systematically identify and assess the hazards and risks associated with a facility and based on agreed criteria, form judgements about the acceptability of those risks to the surrounding locality.

A Preliminary Hazard Analysis (PHA) based on the concept design was produced in April 2021, Ref. [1] to support the Environmental Impact Statement (EIS) for the Project.

As the Project progressed through the detailed design engineering stage, a Final Hazard Analysis (FHA) was carried out based on the latest available detailed design information for the Project at the time of preparing this report. While the entire detailed design for the Project has not yet been fully completed, it has advanced sufficiently enough to allow Jacobs to make what it believes are conservative enough assumptions on some design parameters for the risk assessment. With the objective being that some of the outcomes of the FHA may represent more of a "worst case" scenario where some aspects of the final design are yet to be finalised.

This document presents the methodology and findings of the FHA undertaken for the Project. The FHA approach is aligned with the New South Wales Department of Planning's Hazardous Industry Planning Advisory Paper No. 6: Hazard Analysis (January 2011) (hereinafter referred to as 'HIPAP No. 6'), Ref. [2], and the FHA adopts the risk criteria set out in New South Wales Department of Planning's Hazardous Industry Planning Advisory Paper No. 4: Risk Criteria for Land Use Safety Planning (January 2011) (hereinafter referred to as 'HIPAP No. 4'), Ref. [3].

1.3 Scope of Study

The scope of the FHA covers the Hunter Power Station which includes the following infrastructure:

- Gas turbine units that are able to run on both fuel gas (natural gas) and fuel oil (diesel);
- Fuel gas facilities (natural gas supply from the terminal point of APA Delivery Station up to the gas turbine combustors including equipment such as the gas turbine fuel gas heater, filter coalescer, gas turbine fuel gas pressure and flow control units, all associated pipework, etc);
- Fuel oil facilities (including diesel tanker, unloading hose, unloading pump, storage tank, forwarding pump, filters, gas turbine main fuel oil pump, combustors, all associated pipework, etc);
- Hydrogen facilities (including tube trailer, cylinder packs, pressure regulation and reduction units, generator cooling circuit, all associated pipework, etc);
- Other chemicals with smaller storage quantities onsite to support the plant operation and maintenance works; and
- An on-site natural GRS and delivery lines to the OCGTs. Note that while the GRS is not part of the approved power station, it is addressed in the FHA on the basis of documenting the cumulative risk impact due to proximity of the neighbouring facilities (refer Section 11.2).

The following gas supply infrastructure under the scope of the third party (APA) are excluded from this FHA study:

- JGN Receipt Facility;
- JGN Delivery Facility; and

- APA Buried Pipelines: Transmission Pipeline, Storage Pipeline.

This FHA covers the safety risks associated with the operation of the Hunter Power Station. It excludes construction, commissioning, testing, and inspection and maintenance activities.

2. Site Description

2.1 Site Location

The Project site is located in the small suburb of Loxford in the Hunter Valley region of New South Wales, approximately 3 km north of the town of Kurri Kurri, approximately 30 km north west of Newcastle Central Business District (CBD), and approximately 125 km north of Sydney (see Figure 2.1).

The Project site forms part of the now decommissioned Kurri Kurri aluminium smelter site which ceased operation in late 2012 and was permanently closed in 2014. The former Kurri Kurri aluminium smelter property is being sub-divided into allotment for a future industrial estate, and the Project site is largely rectangular in shape and flat. The Project site is shown in Figure 2.2.

2.2 Surrounding Land Use

The Project site is located within a future industrial estate that will incorporate both general and heavy industrial operations; the specific type of industrial operations at other neighbouring lots to the Project site are not defined at the time of writing of this report. Unoccupied rural landscape as bushland extends from north-east, across north and north-west of the Project site. West of the Project site is special purpose infrastructure area, i.e. a containment cell for waste from the former Kurri Kurri aluminium smelter. Figure 2.3 displays the proposed rezoning plan for the area incorporating the industrial estate development on the former Kurri Kurri aluminium smelter site.

Figure 2.1: Project Location (Regional)

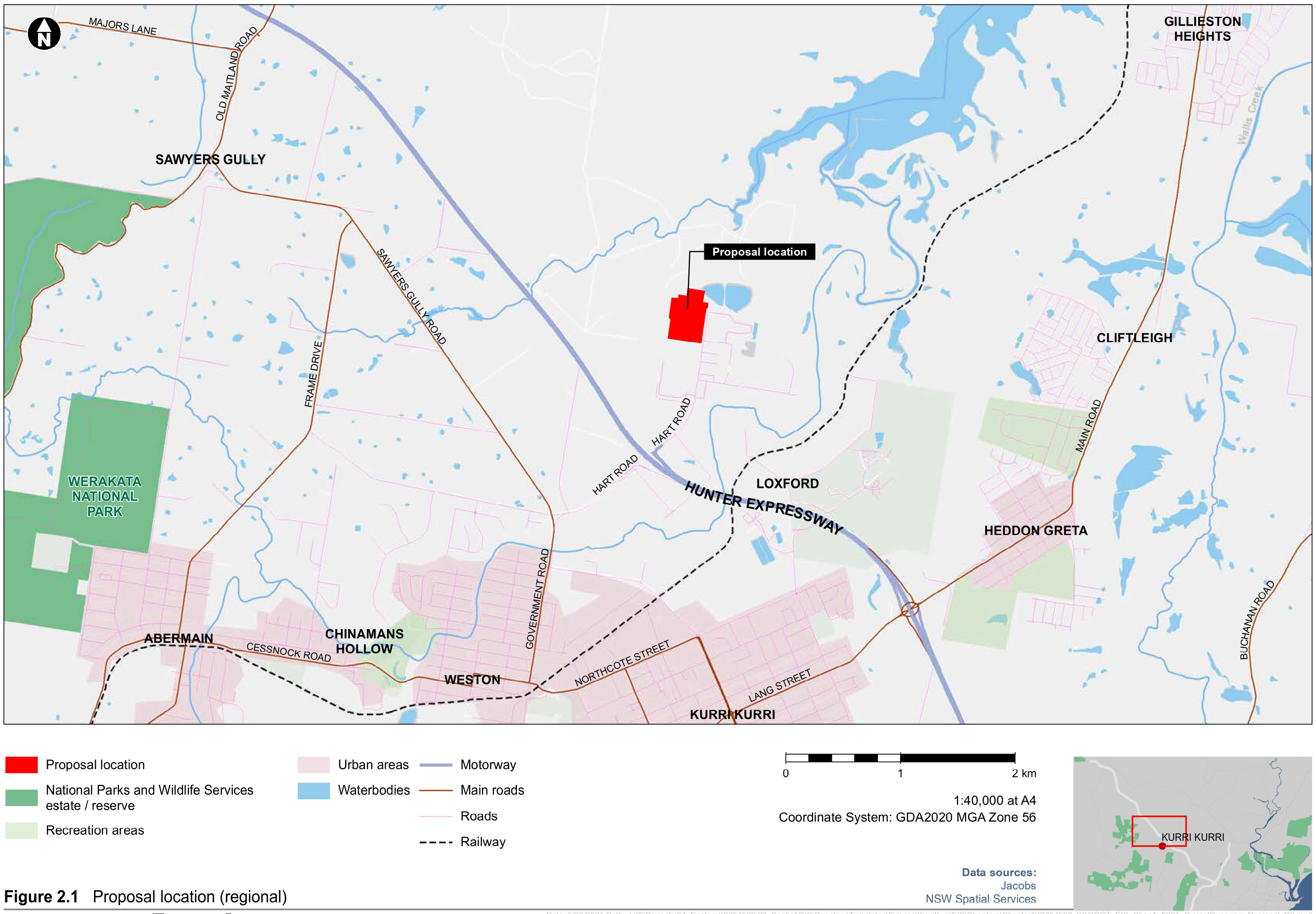
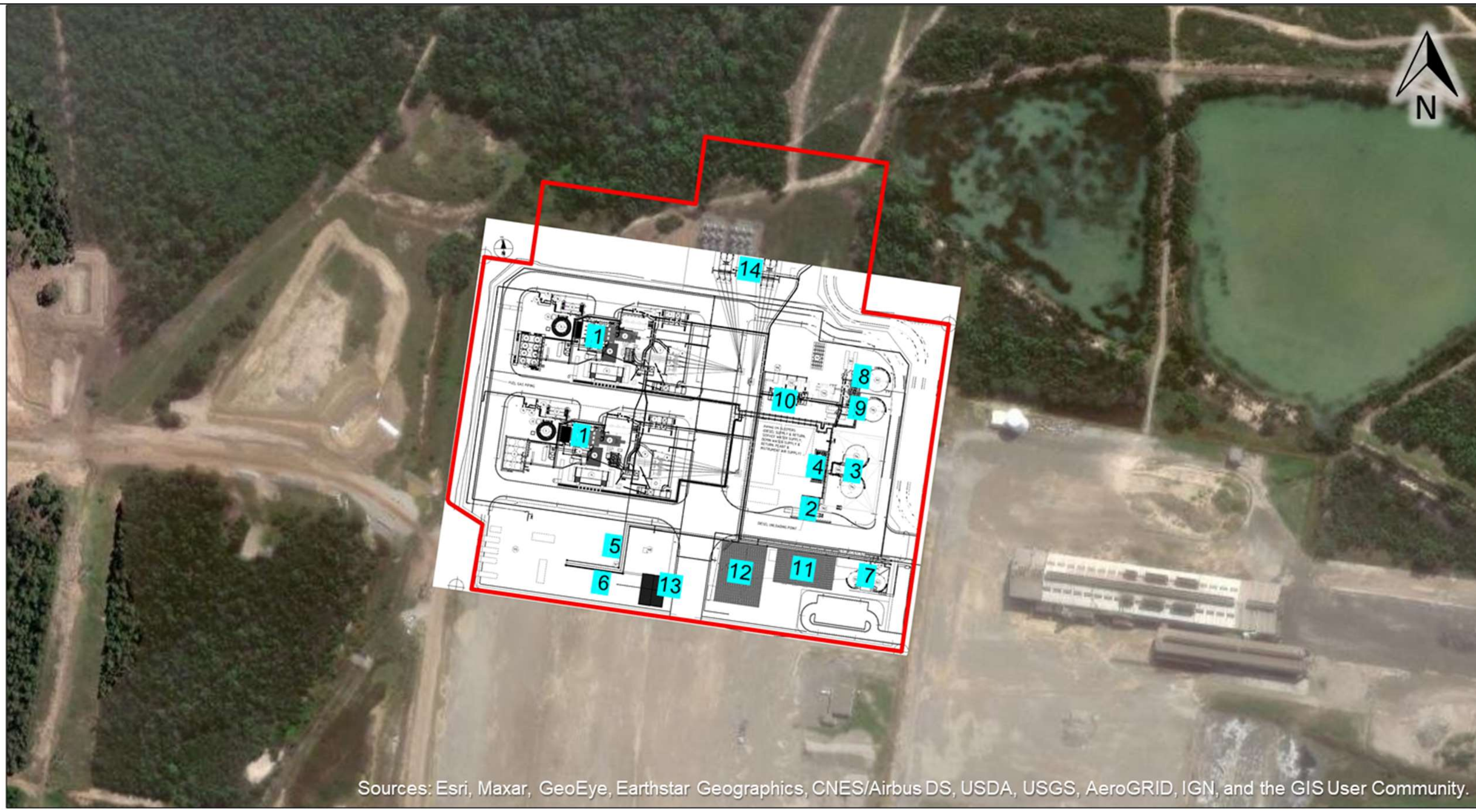


Figure 2.1 Proposal location (regional)

Figure 2.2: Project Site Layout



Proposal Site
[1] Power Island (GT1 and GT2)
[2] Diesel Tanker and Unloading Pumps
[3] Diesel Storage Tanks
[4] Diesel Forwarding Pumps and Filters
[5] Hydrogen Tube Trailer
[6] Hydrogen Gas Cylinder Packs
[7] Firewater Storage Tanks and Pumps
[8] Demineralised Water Storage Tank and Pumps
[9] Service Water Storage Tank and Pumps
[10] Switchroom
[11] Admin Building
[12] Workshop Building
[13] Chemical and Equipment Store
[14] Electrical Switchyard

Figure 2.2 Proposal Site Layout

Figure 2.3: Hydro Kurri Kurri Rezoning Concept Master Plan

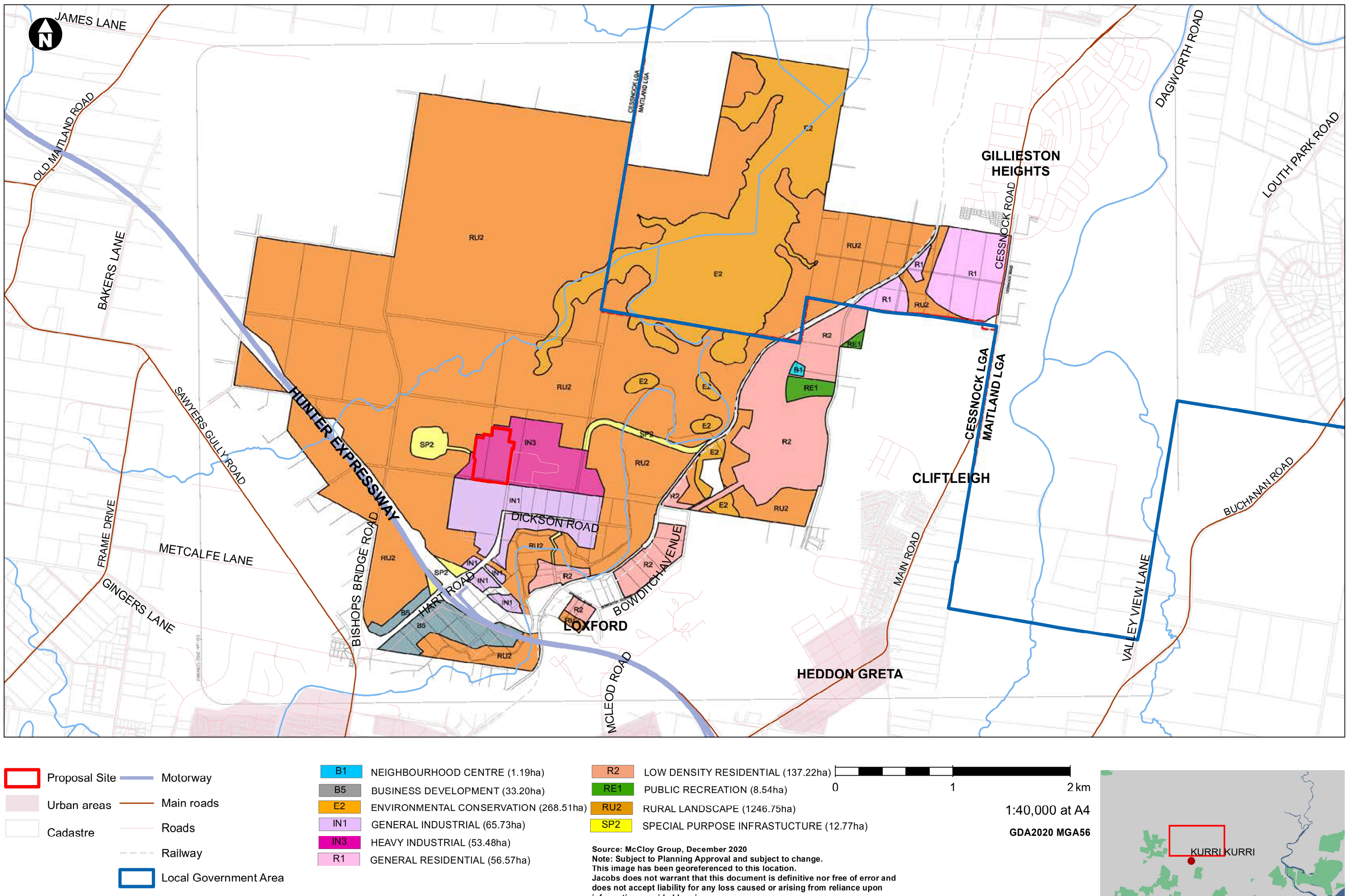


Figure 2.3 Hydro Kurri Kurri rezoning concept master plan

2.3 Residential and Sensitive Areas

There are no residential and/or sensitive areas in close proximity to the Project site. The closest residential-zoned lands are within Heddon Greta and Cliftleigh, located approximately 2.5 km east of the Project site. Further residential areas are within the suburban areas of Kurri Kurri, located approximately 3.0 km south and south-west of the Project site. There are some sparse, rural residential properties to the south and south-east of the Project site, the nearest being located on Dawes Avenue, Loxford, which is approximately 1.15 km south-east of the Project site.

2.4 External Population

The following populations external to the Project site were considered in the risk analysis, with the population densities described in Table 2.1, Ref. [1]:

- Industrial Estate occupants, at < 0.2 km distance
- Rural Residential occupants, at 1.15 km distance
- Urban Residential occupants, at > 2.5 km distance

Table 2.1: Population Densities Considered in Risk Analysis

Population	Population Density Estimate	Assumption/ Basis of Estimate
Industrial Estate	150.0 persons/km^2 [1.50/ha]	300 occupants$^{(1)}$ over 2 km^2
Rural Residential	4.8 persons/km^2 [0.05/ha]	Loxford area; 50 occupants$^{(2)}$ over 10.5 km^2
Urban Residential	1185.1 persons/km^2 [11.85/ha]	Kurri Kurri area; 6044 occupants$^{(3)}$ over 5.1 km^2

Notes:

1) Estimated occupants, assume mainly day-time occupation
2) Estimated occupants, assume 24-hour, 365-day occupation. Equates to 0.000005 persons/m^2
3) https://en.wikipedia.org/wiki/Kurri_Kurri,_New_South_Wales. Equates to 0.001185 persons/m^2

2.5 Site Operating and Control Philosophy

The eventual plant operating regime will be dependent upon the NEM conditions.

However, the power station is currently planned to operate at a capacity factor of up to 10% per year running on natural gas and up to 2% per year running on diesel. Thus, the gas turbines are planned to be in a non-generating state for the remaining 88% of time in a year. The power station is designed to be fully automated, with operations, control, and monitoring to be performed from Snowy Hydro's existing remote-control facility located in Cooma, New South Wales. Local control of the power station can also be taken as required.

2.6 Site Staffing and Onsite Occupied Building

The power station will be normally attended by up to 10 full time staff during normal business day-time hours (7:00 AM to 4:00 PM), mainly occupying the Control & Admin Building. There will be no staffing during normal night-time hours. The power station will continue to be operated remotely with a roster of staffs being placed on-call to address any immediate operational or maintenance requirements.

2.7 Site Security Arrangement

The power station will be secured by security fencing and lighting. Access to the power station will be controlled via the site entrance. The power station will implement 24/7 site surveillance and monitoring through Closed-Circuit Television (CCTV) video cameras at strategic locations across the site for crime prevention and security purposes. The power station will also include cyber security measures to protect critical electronic components located on the site from potential cyber-attacks.

2.8 Meteorological Data

The Project site weather conditions applied in the FHA are described in Table 2.2, which were based on the analysis/averages of the local Kurri Kurri and surrounds weather data (2018-2020), Ref. [4] to [6].

Table 2.2: Weather Conditions Applied in FHA

Weather Parameter	Value
Ambient Temperature (Day)	20.0°C
Ambient Temperature (Night)	15.8°C
Relative Humidity	72%
Solar Radiation Flux (Day)	447 W/m^2
Solar Radiation Flux (Night)	0 W/m^2

These three weather categories were modelled for each hazardous outcome in the FHA.

- B2 – Combination of Pasquill stability class B and wind speed 2 m/s to represent typical day time weather
- D5 – Combination of Pasquill stability class D and wind speed 5 m/s to represent typical day time weather
- F1 – Combination of Pasquill stability class F and wind speed 1 m/s to represent typical night time weather

The weather category splits and wind direction bias applied in the FHA are presented in Table 2.3, which were based on the analysis of the hourly meteorological data from Beresfield (2018-2020). Appendix A provides the meteorological data (raw data) and calculation steps involved in deriving the weather category splits and wind direction bias applied in the FHA.

Table 2.3: Weather Category Splits and Wind Direction Bias Applied in FHA

Direction	Probability of Occurrence (%) (1)			Total (%)
	B2 Day	D5 Day	F1 Night	
North (N)	1.07	0.28	0.88	2.23
North-northeast (NNE)	1.10	0.35	0.45	1.90
Northeast (NE)	1.04	0.39	0.43	1.86
East-northeast (ENE)	1.03	0.90	0.62	2.55
East (E)	1.26	1.98	0.95	4.19
East-southeast (ESE)	1.66	4.05	1.51	7.22
Southeast (SE)	3.09	1.76	2.00	6.86
South-southeast (SSE)	2.03	4.25	3.89	10.17

Direction	Probability of Occurrence (%) [1]			Total (%)
	B2 Day	D5 Day	F1 Night	
South (S)	2.70	1.45	4.64	8.80
South-southwest (SSW)	1.86	0.26	2.21	4.33
Southwest (SW)	0.70	0.59	1.39	2.68
West-southwest (WSW)	0.46	0.15	0.96	1.56
West (W)	0.67	2.16	1.45	4.28
West-northwest (WNW)	1.06	16.29	4.91	22.26
Northwest (NW)	1.78	8.51	5.05	15.34
North-northwest (NNW)	1.30	0.95	1.53	3.78
Total (%)	**22.80**	**44.31**	**32.89**	**100.00**

Note:

1) This is the percent of time the weather is in that category (B2/ D5/ F1) with the wind in that direction (N/ NNE/ NE/ ENE/ E/ etc.) which gives rise to hazard range.

3. Facility and Process Description

3.1 Facility Description

The Hunter Power Station is comprised of the main components as listed in Table 3.1, Ref. [7] and [8]. Further details of some of these main plant components are described in sections 3.2, 3.3, and 3.4.

Table 3.1: Hunter Power Station main component

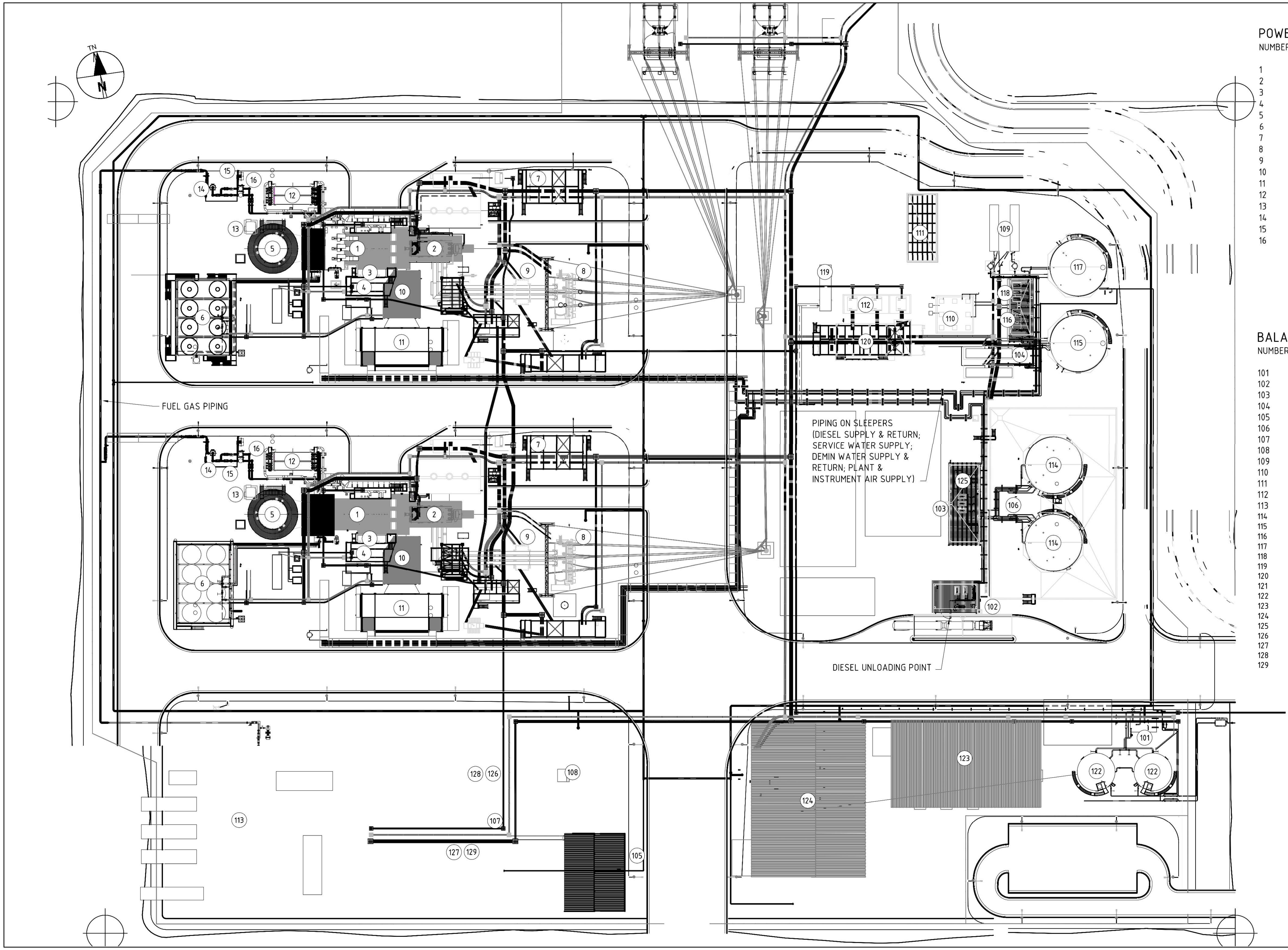
Component	Description
Power generation	Two industrial frame, heavy-duty, F-Class gas turbine units in Open Cycle Gas Turbine (OCGT) configuration supplied with either fuel gas (natural gas) or fuel oil (diesel). Each gas turbine power island includes an inlet air system with evaporative cooler, fuel gas and fuel oil supply systems with dual fuel combustors, lube oil and control oil systems, high pressure purge air system, demineralised water injection system, turbine exhaust and stack, generator and compressor closed loop cooling systems, continuous emissions monitoring instrumentation, service air and instrument air connections, and fire detection and protection systems.
Generator step-up transformer	Allows for voltage transfer between gas turbine generator and electrical switchyard.
Electrical switchyard	The electrical switchyard has a voltage level of 132 kV and connects into the existing Ausgrid overhead 132 kV transmission network.
Fuel gas (natural gas) supply	Natural gas is supplied from the third party supplier's (APA Group) gas supply infrastructure, with the compressor station and delivery station located on the land adjacent (south) to the power station and connected to the power station at the site boundary. The plant includes fuel gas knockout pots, drips tanks, fuel gas filter coalescers, fuel gas heaters and gas turbine fuel gas unit.
Fuel oil (diesel) storage and supply	Diesel is supplied to the plant via road tankers. The plant includes a diesel tanker unloading bay, unloading pumps, two storage tanks, forwarding pumps and filters and the gas turbine fuel oil unit.
Hydrogen (H_2) gas storage and supply	Hydrogen is used as a cooling medium for the gas turbine generator, including as top-up for minor leaks from the system. A sufficient supply of hydrogen will be stored onsite to meet the demands of the gas turbine units.
Carbon dioxide (CO_2) gas storage and supply	Carbon dioxide is used for fire fighting and purging purposes including for the gas turbine generator's hydrogen cooling circuit in order to displace air prior to admission of hydrogen when recharging the generator's cooling circuit. A sufficient supply of carbon dioxide will be stored onsite to meet the demands of the gas turbine units.

Component	Description
Nitrogen (N_2) gas storage and supply	Nitrogen is also used for purging various systems in order to remove natural gas and hydrogen and air mixture before maintenance or recommissioning. A sufficient supply of nitrogen will be stored onsite to meet the demands of the gas turbine units.
Service air skid	Service air is required for purging the gas turbine fuel gas and fuel oil supply system and for air tools. Equipment contained within the service air skid will include air filters, knock-out drums, dryers, and compressors.
Instrument air skid	Instrument air is required for operation of automated valves and various instruments on the gas turbines. Equipment contained within the instrument air skid will include air filters, knock-out drums, dryers, and compressors.
Service water storage and supply	Potable water will be supplied to the plant by Hunter Water via a new connection into their network on the eastern side of the plant. The main users include the demineralised water plant, firewater storages, domestic consumption and evaporative cooler makeup for the gas turbine inlet air system. One storage tank will be provided for buffer storage for service water demand in case of interruption to the potable water supply network. Pumps will be provided to supply service water to dedicated users.
Demineralised water plant, storage and supply	A demineralised water plant will be provided using reverse osmosis/ electro-deionisation technology. One storage tank will be provided to store demineralised water. Pumps will be provided to supply demineralised water for injection to the gas turbines for NOx suppression during plant operation.
Firewater storage and supply	Two storage tanks to store firewater will be provided. Pumps will be provided to supply firewater to dedicated users including fire hydrants across the site and various dedicated fire protection systems for the generator step-up transformers, admin and control building, workshop building, etc
Emergency power generation and supply	One diesel generator will be provided with internal fuel storage to generate and supply emergency power to support the essential systems in the event of main power failure. The diesel generator automatically starts in case of a main power failure.
Wastewater collection and treatment	Trade wastewater generated from various sources is collected and sent to a neutralisation pit on site. The neutralisation pit is used to treat the trade wastewater in order to meet the requirements provided in Hunter Water's *Trade Wastewater Standard* (July 2016), Ref. [9], prior to discharge.
Oily water collection and treatment	Drains from various plant areas including the transformer oil bund, various diesel containing bunds and gas turbine lubricating and control oil bunds are connected to an oily water system. The oily water system includes a centrifugal separator to separate oil and water.

Component	Description
Chemical and Equipment Store	This will store chemicals used to support plant operations and maintenance works.
Admin Building	Includes offices, meeting rooms, and amenities.
Workshop	Includes facilities used to perform repairs and maintenance of various plant equipment/ machineries/ assets.
Electrical Switchroom	Includes electrical equipment (e.g. disconnect switches, fuses, circuit breakers, relays, etc) used to control, protect, and isolate electrical circuits.

Figure 3.1 presents the plant layout labelled with the main equipment items, Ref. [10]. Processes involving major hazardous substances are further described in the subsequent sections.

Figure 3.1: Plant Layout



POWER ISLAND (GT1 AND GT2)

NUMBER	EQUIPMENT DESCRIPTION	QTY
1	GAS TURBINES	2-OFF
2	GT GENERATOR	2-OFF
3	GT FUEL GAS UNITS	2-OFF
4	GT FUEL OIL UNITS	2-OFF
5	EXHAUST STACKS	2-OFF
6	CLOSED CYCLE COOLING WATER COOLERS	2-OFF
7	ELECTRICAL CONTROL PACKAGES	2-OFF
8	GTG TRANSFORMERS	2-OFF
9	GT UNIT TRANSFORMERS	2-OFF
10	GT INLET AIR SILENCERS	2-OFF
11	GT INLET AIR FILTERS	2-OFF
12	FIN FAN COOLERS	2-OFF
13	POWER ISLAND OILY WATER PITS	2-OFF
14	NATURAL GAS KNOCK-OUT DRUM	2-OFF
15	NATURAL GAS DRIPS TANK	2-OFF
16	NATURAL GAS FILTER COALESCER	2-OFF

BALANCE OF PLANT

NUMBER	EQUIPMENT DESCRIPTION	QTY
101	FIRE WATER PUMPS	2-OFF
102	DIESEL UNLOADING PUMPS	2-OFF
103	DIESEL FORWARDING PUMPS	3-OFF
104	DEMIN PLANT	2-OFF
105	CHEMICAL AND EQUIPMENT STORE	1-OFF
106	DIESEL BUND AREA	1-OFF
107	H_2 STORAGE & PRESSURE REDUCTION PANELS	1-OFF
108	CO_2 & N_2 STORAGE & PRESSURE REDUCTION PANELS	2-OFF
109	PLANT & INSTRUMENT AIR	1-OFF
110	NEUTRALISATION PIT	1-OFF
111	PLANT OILY WATER PIT	1-OFF
112	PLANT TRANSFORMERS	3-OFF
113	APA GAS RECEIVING STATION	1-OFF
114	DIESEL STORAGE	2-OFF
115	DEMIN WATER STORAGE	1-OFF
116	DEMIN WATER PUMPS	3-OFF
117	SERVICE WATER STORAGE	1-OFF
118	SERVICE WATER PUMPS	3-OFF
119	EMERGENCY DIESEL GENERATOR	1-OFF
120	SWITCHROOM	1-OFF
121	TANKER UNLOADING BAY	1-OFF
122	FIRE WATER TANKS	2-OFF
123	ADMIN BUILDING	1-OFF
124	WORKSHOP BUILDING	1-OFF
125	DIESEL FORWARDING FILTER	2-OFF
126	HYDROGEN TUBE TRAILER PARKING SPOT	1-OFF
127	HYDROGEN CYLINDER PACK	2-OFF
128	HYDROGEN HIGH PRESSURE REGULATING PANEL	1-OFF
129	HYDROGEN PRESSURE REDUCTION UNIT	1-OFF

3.2 Process Description – Fuel Gas (Natural Gas)

3.2.1 Fuel Gas Supply Line

Fuel gas (natural gas) is delivered to the Hunter Power Station via the gas infrastructure supplier's Delivery Station, at a pressure between 38 to 47 bar.g (normally 44 bar.g), temperature between 5 to 60°C (normally 30°C), and flowrate between 3,600 to 73,800 kg/hr (depending on the requirements of the gas turbines). The fuel gas supply line is isolatable at the power station boundary by an automatic emergency shutdown valve and manual isolation valves, with downstream line venting to an elevated safe location and nitrogen purging facilities to displace fuel gas-air mixture to allow safe maintenance work to be carried out.

Downstream of the fuel gas supply line isolation facilities at the power station boundary are the pressure reduction unit and fuel gas calorie meter. The purpose of the pressure reduction unit is to provide pressure relief prior to the gas calorific value measurement.

The fuel gas supply line then runs along the western boundary of the plant before splitting to each of the two gas turbines. The fuel gas inlet line to each gas turbine is equipped with separate isolation valves, with downstream line venting to a cold vent and nitrogen purging facilities to displace fuel gas-air mixture to allow safe maintenance work to be carried out.

3.2.2 Fuel Gas Knockout Pot

Downstream of the fuel gas inlet line isolation valve at each gas turbine power island is the fuel gas knockout pot (1 off per gas turbine power island, duty-only). The purpose of the fuel gas knockout pot is to provide coarse removal of any condensed liquid in the fuel gas inlet to the gas turbine, in order to minimise the risk of downstream filter coalescer being overloaded with a large amount of liquid. The fall-out liquid from the gas stream is drained to a drips tank (see Section 3.2.7). Other equipment details key to the study are summarised in the following Table 3.2.

Table 3.2: Equipment Details – Fuel Gas Knockout Pot

Field	Description	Remark/ Reference
Quantity (per gas turbine power island)	1	Ref: Design P&ID
Nominal Diameter	1.5 m ID	Ref: Equipment Datasheet
Nominal Height	3.2 m T/T	Ref: Equipment Datasheet
Rated Capacity	75,000 kg/hr	Ref: Design P&ID
Operating Pressure	44 bar.g	Ref: Equipment Datasheet
Operating Temperature	Ambient (30°C)	Ref: Equipment Datasheet

3.2.3 Fuel Gas Filter Coalescer

Downstream of the fuel gas knockout pot are the fuel gas filter coalescers (2 off per gas turbine power island, duty/ standby). The purpose of the fuel gas filter coalescer is to remove fine particles and any remaining/ carry-over oil droplets in the fuel gas outlet from the fuel gas knockout pot. The fall-out liquid from the gas stream is drained to a drips tank (see Section 3.2.7). Other equipment details key to the study are summarised in the following Table 3.3.

Table 3.3: Equipment Details – Fuel Gas Filter Coalescer

Field	Description	Remark/ Reference
Quantity (per gas turbine power island)	2	Ref: Design P&ID
Nominal Diameter	1 m	Assumption taken for FHA purpose
Nominal Height	3.2 m	Assumption taken for FHA purpose
Rated Capacity	75,000 kg/hr	Ref: Design P&ID
Operating Pressure	44 bar.g	Ref: Equipment Datasheet
Operating Temperature	30°C	Ref: Equipment Datasheet

3.2.4 Gas Turbine Fuel Gas Heater

Downstream of the fuel gas filter coalescers is the gas turbine fuel gas heater (1 off per gas turbine power island, duty-only), via a gas turbine fuel gas flow meter and gas turbine fuel gas temperature control valve.

The fuel gas flow meter is intended to measure the fuel gas mass flow amount, and the output signal from which is transferred to the gas turbine control system for indication/ monitoring.

The fuel gas temperature control valve is a diaphragm, three-way type actuated by instrument air. Its purpose is to control the fuel gas temperature by adjusting the amount of fuel gas flow through the bypass of the fuel gas heater.

The fuel gas heater is radial type with finned tube bundles, which recovers heat from the forced draft air coming from the gas turbine cooling air system outlet. Its purpose is to pre-heat the fuel gas before it enters the combustors to increase the plant efficiency. Other equipment details key to the study are summarized in the following Table 3.4.

Table 3.4: Equipment Details – Gas Turbine Fuel Gas Heater

Field	Description	Remark/ Reference
Quantity (per gas turbine power island)	1	Ref: Design P&ID
Rated Capacity	19.65 kg/s	Ref: Input from gas turbine supplier
Operating Pressure	40.9 bar.g	Ref: Input from gas turbine supplier
Operating Outlet Temperature	200°C	Ref: Input from gas turbine supplier

3.2.5 Gas Turbine Fuel Gas Cartridge Filter

Downstream of the fuel gas heater is the gas turbine fuel gas cartridge filter (1 off per gas turbine power island, duty-only). The purpose of the fuel gas cartridge filter is to provide last-chance screening to remove any remaining particles from the fuel gas stream before it enters the combustors. Other equipment details key to the study are summarized in the following Table 3.5.

Table 3.5: Equipment Details – Gas Turbine Fuel Gas Cartridge Filter

Field	Description	Remark/ Reference
Quantity (per gas turbine power island)	1	Ref: P&ID
Rated Capacity	19.493 kg/s	Ref: Input from gas turbine supplier
Operating Pressure	38.1 bar.g	Ref: Input from gas turbine supplier
Operating Temperature	200°C	Ref: Input from gas turbine supplier

3.2.6 Gas Turbine Fuel Gas Manifolds up to Combustors

Downstream of the fuel gas cartridge filter are the gas turbine fuel gas manifolds and combustors, via a fuel gas supply unit, a fuel gas pressure control unit, and a fuel gas flow control unit (per gas turbine power island).

The fuel gas supply unit comprises of fuel gas shut off valves (x 2) and associated vent valve facilities to allow for the safe shutdown of the fuel gas flow. The fuel gas pressure control valves (x 2) functions to regulate the pressure of the fuel gas flow to the gas turbine, based on an output signal from the gas turbine control system. The fuel gas flow control valves (x 4) are located on each fuel gas supply line with the function being to control the volume of fuel gas flow to the gas turbine.

Each fuel gas manifold is equipped with pressure transmitters, and the output signal from which is transferred back to the gas turbine control system for indication/ monitoring. Each fuel gas manifold supplies the controlled amount of fuel gas to the gas turbine combustion chamber through combustors. Each gas turbine combustion chamber is equipped with ignitors which ignites the fuel.

3.2.7 Drips Tank

The purpose of the drips tank (1 off per gas turbine power island) is to collect condensate from the fuel gas knockout pot and fuel gas filter coalescer units. The contents of the drips tank will be collected by a third party for safe disposal. The drips tank is connected to a vertical vent stack to allow release of any entrained gas to a safe area. Other equipment details key to the study are summarized in the following Table 3.6.

Table 3.6: Equipment Details – Drips Tank

Field	Description	Remark/ Reference
Quantity (per gas turbine power island)	1	Ref: Design P&ID
Nominal Length	3 m T/T	Ref: Equipment Datasheet
Nominal Height	1.5 m ID	Ref: Equipment Datasheet
Capacity	5 m^3	Ref: Equipment Datasheet
Operating Pressure	1 bar.g	Ref: Equipment Datasheet
Operating Temperature	Ambient (25°C)	Ref: Equipment Datasheet

3.3 Process Description – Fuel Oil (Diesel)

The gas turbine supplier has referred to the back-up fuel as 'fuel oil' throughout the majority of their documentation, whereas throughout the rest of the design it is referred to as diesel. For the purposes of this report and the FHA, they are identical and can be used interchangeably.

3.3.1 Diesel Tanker

Fuel oil (diesel) at the power station will be replenished by a B-double tanker which will enter the site and refill the diesel storage tanks. The diesel tanker will be an atmospheric type tank, multi-compartmented. For the purpose of undertaking this analysis, we have assumed a total tank capacity of 50 m^3. The diesel tanker is likely to comprise of six independent compartments, resulting in each with unit capacity of 8.6 m^3.

The diesel tanker will be admitted to the site when there is a need to refill the diesel storage tanks either during or after each diesel run. Each diesel run could consume both diesel storage tanks' capacity, which would then be replenished by the diesel tanker. It has been estimated that each diesel tanker will take approximately 1 hour to unload. The diesel tanker visiting frequency will be dependent on the number of diesel runs per year. The scenario under consideration for the gas turbine operating on diesel fuel is up to 10 hours per day for 3 consecutive days, for a total of 175 hours per year.

Unloading of the diesel tanker will be via each tanker compartment (atmospheric pressure and ambient temperature (25°C)), through the unloading hose (⌀100 mm), to the downstream diesel unloading pump.

Facilities will also be provided to support a diesel tanker loading process in case the diesel needs to be removed from site. The facilities are designed to load diesel from one (selected) diesel storage tank to the diesel tanker. This diesel tanker loading process may occur if:

- There is a need to perform maintenance on the diesel storage tanks, which requires the storage tank to be emptied (a 10-yearly inspection is expected to be scheduled for the diesel storage tanks, based on Snowy Hydro's prior experience on other sites);
- There is an emergency that requires the diesel storage tanks to be emptied; and
- The diesel polishing system does not perform adequately resulting in off-specification diesel fuel, which requires the diesel storage tanks content to be replaced.

The diesel tanker loading process is performed as a non-routine maintenance item and/or as-needed basis (i.e. not under normal operations).

3.3.2 Diesel Unloading Pump

Downstream of the diesel tanker unloading facilities are the diesel unloading pumps (2 off, duty/ standby). The diesel unloading pumps are positive displacement, horizontal vane type with fixed speed. The primary function of the diesel unloading pump is to supply diesel from the diesel tanker to the selected diesel storage tank. Other equipment details key to the study are summarized in the following Table 3.7.

Table 3.7: Equipment Details – Diesel Unloading Pump

Field	Description	Remark/ Reference
Quantity	2	Ref: Design P&ID
Rated Capacity	100 m^3/hr	Ref: Equipment Datasheet
Operating Temperature	Ambient (25°C)	Ref: Design PFD, Equipment Datasheet
Operating Suction Pressure	1.009 bar.g	Ref: Equipment Datasheet

Field	Description	Remark/ Reference
Operating Discharge Pressure	2.5 bar.g	Ref: Design PFD, Equipment Datasheet

3.3.3 Diesel Storage Tank

Downstream of the diesel unloading pumps are the diesel storage tanks (2 off). The purpose of the diesel storage tanks is to store enough diesel to be supplied to both gas turbines when running on diesel for up to 10 hours per day for 3 consecutive days. Other equipment details key to the study are summarised in the following Table 3.8.

Table 3.8: Equipment Details – Diesel Storage Tank

Field	Description	Remark/ Reference
Quantity	2	Ref: Design P&ID
Nominal Diameter	15 m ID	Ref: Equipment Datasheet
Nominal Height	12 m	Ref: Equipment Datasheet
Working Capacity	1845 m^3	Ref: Design P&ID, Equipment Datasheet
Operating Pressure	Atmospheric	Ref: Design P&ID, PFD
Operating Temperature	Ambient (25°C)	Ref: Design PFD

Other facilities are provided to support the following processes:

- Diesel Polishing: The facilities are designed to recirculate contents of one (selected) diesel storage tank in order to remove sediment and water/ moisture/ condensation from diesel, or in the case of having off-specification diesel. This is an automated closed loop process performed as a routine preventive maintenance item (a 1-monthly diesel polishing routine is expected to be scheduled for the diesel storage tank, based on Snowy Hydro's prior experience on other sites).
- Diesel Transfer: The facilities are designed to transfer contents from one diesel storage tank to another in order to make room for new deliveries. This process is performed on an as-needed basis (not under normal operations).

3.3.4 Diesel Forwarding Pump

Downstream of the diesel storage tanks are the diesel forwarding pumps (3 off, duty/ duty/ standby). The diesel forwarding pump is a horizontal centrifugal type. The primary function of the diesel forwarding pumps is to supply diesel from the selected diesel storage tank through the diesel forwarding filter to the gas turbine fuel oil system. Other equipment details key to the study are summarised in the following Table 3.9.

Table 3.9: Equipment Details – Diesel Forwarding Pump

Field	Description	Remark/ Reference
Quantity	3	Ref: Design P&ID
Rated Capacity	90.3 m^3/hr	Ref: Equipment Datasheet
Operating Temperature	Ambient (25°C)	Ref: Design PFD, Equipment Datasheet
Operating Suction Pressure	Atmospheric	Ref: Design PFD, Equipment Datasheet
Operating Discharge Pressure	7.8 bar.g	Ref: Equipment Datasheet

3.3.5 Diesel Forwarding Filter

Downstream of the diesel forwarding pumps are the diesel forwarding filters (2 off, duty/ standby). The diesel forwarding filter is a cartridge/ basket type. The purpose of the diesel forwarding filter is to remove any suspended solids, dust, and rust (up to 10 μm) from the diesel stream prior to delivery to the gas turbine. Other equipment details key to the study are summarized in the following Table 3.10.

Table 3.10: Equipment Details – Diesel Forwarding Filter

Field	Description	Remark/ Reference
Quantity	2	Ref: Design P&ID
Rated Capacity	200 m^3/hr	Ref: Design P&ID
Operating Pressure	7.6 bar.g	Ref: Design PFD
Operating Temperature	Ambient (25°C)	Ref: Design PFD

From the diesel forwarding filter outlet, the diesel supply line runs along the pipe racks before splitting to each gas turbine power island. The diesel (fuel oil) inlet line to each gas turbine is equipped with separate isolation valves.

3.3.6 Gas Turbine Fuel Oil Inlet Filter

Downstream of the fuel oil inlet line isolation valve is the gas turbine fuel oil inlet filter (1 off, duty-only). The fuel oil inlet filter is a duplex, full-flow type. The purpose of the fuel oil inlet filter is to prevent any particles/ foreign materials from entering the downstream pump which otherwise could damage the pump. Other equipment details key to the study are summarized in the following Table 3.11.

Table 3.11: Equipment Details – Gas Turbine Fuel Oil Inlet Filter

Field	Description	Remark/ Reference
Quantity	1	Ref: Design P&ID
Rated Capacity	100 m^3/hr	Ref: Input from gas turbine supplier
Operating Pressure	7.0 bar.g	Ref: Input from gas turbine supplier
Operating Temperature	Ambient (25°C)	Ref: Input from gas turbine supplier

3.3.7 Gas Turbine Main Fuel Oil Pump

Downstream of the fuel oil inlet filter is the gas turbine main fuel oil pump (1-off, duty-only). The main fuel oil pump is a positive displacement, screw type. The purpose of the main fuel oil pump is to supply fuel oil at the required flow and pressure to the gas turbine. Other equipment details key to the study are summarised in the following Table 3.12.

Table 3.12: Equipment Details – Gas Turbine Main Fuel Oil Pump

Field	Description	Remark/ Reference
Quantity	1	Ref: Design P&ID
Rated Capacity	90.1 m^3/hr	Ref: Input from gas turbine supplier
Operating Temperature	Ambient (25°C)	Ref: Input from gas turbine supplier
Operating Suction Pressure	7.0 bar.g	Ref: Input from gas turbine supplier

Field	Description	Remark/ Reference
Operating Discharge Pressure	84.8 bar.g	Ref: Input from gas turbine supplier

3.3.8 Gas Turbine Fuel Oil Manifolds up to Combustors

Downstream of the gas turbine main fuel oil pump are the gas turbine fuel oil manifolds and combustors, via a gas turbine fuel oil unit and gas turbine flow divider unit.

The gas turbine fuel oil unit comprises the following:

- Gas turbine fuel oil flow meter (1 off), located downstream of the main fuel oil pump. Its function is to measure the fuel oil mass flow amount, and the output signal from which is transferred to the gas turbine control system for indication/ monitoring.
- Gas turbine fuel oil supply pressure control valve (1 off), located upstream of the fuel oil flow meter. Its function is to control and keep the fuel oil supply line pressure based on the pre-determined setting and return the surplus fuel oil to the diesel storage tank.
- Gas turbine fuel oil pressure control valves (3 off), located on each fuel oil supply line. The function is to regulate the pressure of the fuel oil flowing to gas turbine based on an output signal from the gas turbine control system.
- Gas turbine fuel oil flow control valves (3 off), located on each fuel oil supply line. The function is to control the volume of the fuel oil flow to the gas turbine based on output signal from the gas turbine control system.

The gas turbine flow divider unit comprises of flow dividers (2 off), located on each fuel oil supply line. The function is to provide equal fuel oil flow to each of the combustors. Each fuel oil supply line delivers the controlled amount of fuel oil to the gas turbine combustion chamber through the nozzles and combustors.

3.4 Process Description – Hydrogen (H_2) Gas

3.4.1 Hydrogen Tube Trailer

There will be one hydrogen tube trailer parked on site serving as the main supply source of hydrogen for the generator cooling circuit. The hydrogen tube trailer has a total capacity of approximately 320 kg at 165 bar.g. A typical hydrogen tube trailer is expected to have 10 tubes per trailer. All the hydrogen tubes will be manifolded together, and this tube trailer manifold will have only one valved connection point for delivery to the plant's hydrogen system. Each hydrogen tube will have a right-angle isolation valve at its outlet to the manifold, which allows selection of specific hydrogen tubes as the source of supply. The typical tube outlet valve is of Australian Standard, *AS 2473.2-2015 Valves for compressed gas cylinders Part 2: Outlet connections (threaded) and stem (inlet) threads*, Connection Type 20, with valve size of ⌀17 mm. The selection of hydrogen tubes will comply with the site operational plan, namely the number of hydrogen tubes allowed to be opened/available at any one time.

3.4.2 Hydrogen Gas Cylinder Pack

There will be hydrogen gas cylinder packs (2 off) on site serving as the secondary supply source in the event that the hydrogen tube trailer runs out of gas and requires replacement with a full tube trailer. Each hydrogen gas cylinder pack will comprise a total of 15 gas cylinders, size G2 and will have a capacity of 0.53 kg at 137 bar.g. All of the 15 gas cylinders will be within a single hydrogen gas cylinder pack which will be manifolded together, and this cylinder manifold will only have one valved connection point for delivery to the plant's fixed system.

3.4.3 Hydrogen Supply Line

Hydrogen will be supplied from one source, i.e. either from the hydrogen tube trailer or the hydrogen gas cylinder pack, at any one time. The selected hydrogen source will be connected to the hydrogen supply line (fixed steel pipework) by a flexible hose. The hydrogen supply line will be equipped with Double Block and Bleed (DBB) facilities to allow any entrained air/ moisture to be purged to the atmosphere prior to admission of the hydrogen gas. Downstream of the DBB facilities will be a check valve, a pressure instrument, and an emergency shutdown valve.

3.4.4 Hydrogen Pressure Regulating Panel

Downstream of the hydrogen supply line isolation valve will be the hydrogen pressure regulating panel. This panel comprises a particulate filter, a pressure regulating valve, and a pressure safety valve along with pressure instrumentation. The purpose of this panel is to reduce the inlet hydrogen delivery pressure from 230 bar.g to 50 bar.g. The pressure safety valve is set to protect the downstream facilities against potential over-pressurisation in case of pressure regulation failure.

3.4.5 Hydrogen Pressure Reduction Panel

Downstream of the hydrogen pressure regulating panel is the hydrogen pressure reduction panel. Similarly, this panel comprises a particulate filter, a pressure reduction valve, and a pressure safety valve along with pressure instrumentation. The purpose of this panel is to reduce the inlet/ hydrogen regulated pressure (50 bar.g) to 8 bar.g, and the pressure safety valve is set to protect the downstream facilities against potential over-pressurisation in case of pressure reduction failure.

3.4.6 Generator Gas Control Panel up to Generator Cooling Circuit

Downstream of the hydrogen pressure reduction panel will be an emergency shutdown valve, after which the hydrogen supply line runs along the pipe racks before splitting to each gas turbine power island.

At each gas turbine, hydrogen is supplied to the gas control panel located adjacent to the generator. The generator gas control panel is used to monitor the cooling circuit as well as providing continuous top-up hydrogen flow to the generator cooling circuit. The generator gas control panel is equipped with hydrogen venting facilities, which allow hydrogen gas to be vented to a safe area when required. The physical volume of the generator cooling circuit is approximately 110 m^3; and the hydrogen gas pressure within the generator cooling circuit is 5 bar.g.

4. Safe Control Measures

4.1 Fire and Gas Detection with Shutdown

Each gas turbine generator enclosure will be fitted with gas detectors. Each gas detector has two levels of setpoint to trigger a two-step safe action:

- Setpoint Level 1: When a low concentration of the gas is detected, this will initiate visible and audible alarms on the supervisory control panel located inside the Control Room. These alarms provide early warning of a minor gas release in order for the operator to intervene as appropriate.
- Setpoint Level 2: When a dangerous level of the gas concentration is detected, this will activate emergency shutdown of the applicable process section.

All buildings will be fitted with fire detectors. Upon a fire detection, this will activate an emergency shutdown of any applicable process and activate the dedicated local fire protection systems.

Further details on fire and gas detections for the Project site can be found in the plant designers fire safety study.

4.2 Spill Containment

The following facilities are provided with bunding or kerbing to contain accidental chemical leaks or spills to prevent the liquid from spreading to other areas of the plant:

- Diesel tanker and unloading facilities, will be located within the diesel tanker parking bay designed as a retention area (26 m L x 6.22 m W). The diesel tanker parking bay is a slabbed area where the slab is designed to fall to a washdown collection sump pit with heavy-duty grating, with the edge of the slab to join to a kerb upstand, and each end of the slab to join to the road pavement;
- Diesel unloading pumps, will be located within a bunded area (11.6 m L x 6.5 m W);
- Diesel storage tanks, will be located within a bund (33.6 m L x 50.6 m W) designed to hold 110% capacity of a single storage tank;
- Diesel forwarding pumps and diesel forwarding filters, will be located within a bunded area (8 m L x 20.4 m W);
- Gas turbine lubricating and control oil facilities, will be located within a bunded area; and
- Generator step-up transformer and other oil filled transformers, will be located within a bunded area.

From these bunded or kerbed areas, any spilled liquid will be drained to a centralised oily water pit. The centralised oily water pit is equipped with a centrifugal separator to separate oil and water. Separated oily water will be sent to a collection tank for safe disposal by a third party. Separated water will then be sent to the trade waste network for discharge from the site.

4.3 Fire Protection

Both passive and active fire protection are considered for this Project. For example, firewalls are built around three sides of all the oil-filled transformers including the generator step-up transformer, the gas turbine unit and auxiliary transformer, the static frequency convertor transformer, and the balance of plant transformer to prevent the passage of flames in the event of a fire. These firewalls are designed to Australian Standard, *AS 2067 Substations and high voltage installations exceeding 1 kV a.c.*, with a Fire Resistance Level (FRL) of 120/120/120.

The active fire protection systems incorporated into the design of the Hunter Power Station includes the water suppression system for the transformer area, fire hydrants, fire hose reels, portable fire extinguishers that will be installed at various locations across the sites. All buildings on the site will also have active fire protections systems installed including suppression systems, fire hose reels and portable fire extinguishers.

A fire safety study has been conducted for this Project to assess the fire hazard and risk on site and includes corresponding design mitigation actions required.

4.4 Overpressure Protection

Pressure relief valves will be installed downstream of the hydrogen storage area, at the connection of the fixed piping and pressure reduction panels to provide overpressure protection. When the hydrogen tube trailer or hydrogen cylinder rack is connected to the fixed piping, the pressure relief valves will also provide overpressure protection for the tube trailer and cylinder rack which are designed to discharge before the burst discs located on the tube trailer and cylinder rack.

There will be a hydrogen vent stack located near the hydrogen tube trailer and cylinder storage area which will discharge the hydrogen released from the pressure relief valves to a safe location, away from personnel and equipment. This will also protect the system from either accidental ignition or concentrated gas. Additionally, there will be small vent lines connected to the hydrogen vent stack which may be used for purging before or after maintenance.

As part of the safety in design process and plant layout design, the radiant heat due to venting from the hydrogen vent stack (should it ignite) was assessed by the plant designer and confirmed against compliance with the 4.7 kW/m^2 maximum thermal radiation exposure requirement at the APA Gas Receival Station boundary (treated as an offsite location).

4.5 Emergency Response

The Chemical and Equipment Store and Workshop buildings will be equipped with a safety shower and eye wash station, which will function to give quick drenching or flushing of the personnel's skin and eyes in case of exposure to hazardous chemicals. Similar safety shower and eye wash stations will be installed in close proximity to any battery rooms as well as in the targeted areas around the plant such as the diesel area, the demin plant area, hydrogen trailer, transformer areas and oily water and neutralisation pit areas.

All buildings will be equipped with exit signs (at exit points), exit signs (directional signs), and emergency lighting, which will function to facilitate personnel escape and evacuation during an emergency.

A site specific emergency response plan will be developed for the power plant. The emergency response plan will include procedures and information on, but not be limited to, the following as a minimum:

- Plant wide alarm/beeper systems throughout the plant
- Fire drills
- Facility and unit contingency plan
- Emergency and disaster response plan
- Emergency procedures for special incidents

4.6 Safety Studies

To improve the process safety in both design and operations of the Project and manage the safety risk to As Low As Reasonably Practicable (ALARP), a number of safety related studies have been conducted. They are as follows:

- Preliminary Hazard Analysis;
- Final Hazard Analysis (this study);
- HAZOP workshops (for both the AECOM balance of plant design and the Mitsubishi Power Island design);
- Safety in Design workshops (for both the AECOM balance of plant design and the Mitsubishi Power Island design);
- Layers of Protection Analysis (LOPA) workshops for the Mitsubishi Power Island design;
- Safety integrity level (SIL) assessment for the Project;
- Fire Safety Study for the Project; and
- Maintainability and Operational study (planned for).

5. Study Methodology

This FHA has been carried out based on the approach/methodology outlined in HIPAP No. 6, Ref. [2], which provides a general guidance on conducting a hazard analysis.

There are two key components of hazard analysis, Ref. [2]:

- Analysis, in which hazards are identified leading to an estimation of risks based on the consequences of credible accidents and their likelihood.
- Assessment, in which the risks are compared against relevant criteria, and risk mitigation and management options are evaluated.

The five stages of hazard analysis are described as follows, Ref. [2]:

- **Stage 1: Hazard Identification**

  Systematic identification of possible hazards of all natures and scales, both onsite and offsite. Selection of a representative set of discrete failure scenarios to be taken forward to next step for detailed assessment in the hazard analysis.

- **Stage 2: Estimate Consequence**

  Evaluation of the effects of various hazardous outcome events, e.g. fire, explosion, toxic gas dispersion, that may be expected from the failure scenarios. Mathematical models and computerised tools are often used to calculate the extent or magnitude of such outcome events and their impact on the surrounding people and property.

- **Stage 3: Estimate Likelihood**

  Evaluation of the likelihood of occurrence of initiating events. Evaluation of the likelihood of occurrence of potential hazardous outcome events resulting from the initiating events, with due consideration of all the safeguards (technical/ organisational/ operational) put in place.

- **Stage 4: Calculate Risk**

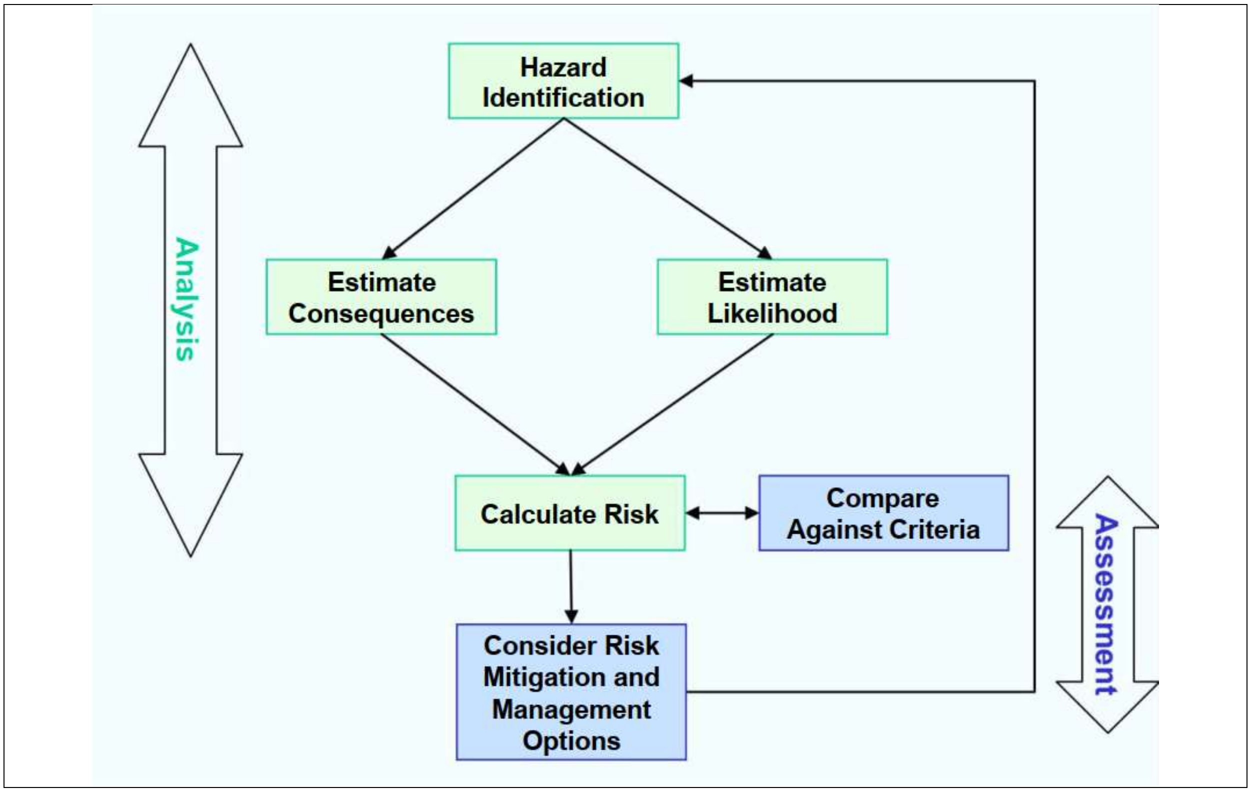
  Evaluation of the risks posed by the facility. For land use safety planning purpose, individual risk and societal risk are calculated. Individual risk is assessed to make sure that no individual located within the effect zone of a hazardous outcome event is exposed to unduly high levels of risk. Societal risk is assessed to make sure that the risk to the overall community is not excessive.

- **Stage 5: Compare Against Criteria**

  Comparison of the calculated risk levels against established risk criteria. Identification of opportunities for risk reduction (options that could reduce likelihood and consequence) where feasible/ practical.

Figure 5.1 provides a schematic of the hazard analysis process, Ref. [2].

Figure 5.1: Methodology for Hazard Analysis



6. Hazard Identification

6.1 Overview

Hazard identification involves the identification of all possible conditions that could lead to a hazardous incident. The primary objective of this exercise is to build up a picture of hazards intrinsic to the facility. Hazards associated with the facility itself (materials and processes) were identified based on a review of available relevant information, including design basis documents, site and equipment layouts, site chemical inventory, process flow diagrams, and piping and instrumentation diagrams. Materials were screened in the context of risk relevant to land use safety planning, and their hazardous aspects further examined. Each of the systems that store and/or handle these materials were further studied in terms of the possible causes of failure, potential consequences of failure, and safeguards in place.

The following documents were reviewed as part of this hazard identification exercise:

- Chemical inventory and chemical hazardous properties;
- The site layout plan;
- The piping and instrumentation diagrams (P&ID);
- Operating conditions, such as flow rate, temperature and pressure;
- Safety study reports including:
  - Preliminary Hazard Study conducted by Jacobs Group (Australia) Pty Limited/ Snowy Hydro Limited, Hunter Power Project, *Hazard and Risk Assessment*, Revision 0, 19 April 2021.
  - Draft version of the Hunter Power Project HAZOP Report, dated June 2022
  - HAZOP study report of the Hunter Power Station Gas Turbine Generator Process Design conducted by Pantac System Control, dated April 2022

As assessed and concluded in the PHA report and HAZOP studies, the process hazards with the potential to have severe hazardous effect well beyond the immediate area of a process incident were identified as:

- The high pressure natural gas system.
- The high pressure hydrogen system.
- The bulk diesel fuel system.

The subsequent sections provide details of the hazard identification process involving the facility (materials and processes) that were further reviewed in this FHA. The other hazards that were assessed in the PHA and HAZOP as being either not relevant, or not likely to impose severe offsite hazard/risk are not further quantified in this FHA. These other hazards are briefly discussed and included in Section 6.6.

6.2 Hazardous Chemicals

6.2.1 Screening of Chemicals

Hazardous chemicals are substances, mixtures, and articles that can pose a significant risk to health and safety if not managed correctly. They may have health hazards, physical hazards, or both in a workplace health and safety context. Dangerous goods are hazardous chemicals that are flammable, combustible, explosive, toxic, corrosive, oxidising, water-reactive, or have other hazardous properties. Dangerous goods can cause fire and/or explosion events, serious injury, death, and large-scale damage in the context of handling, transport, and storage.

The plant will handle, transport, and store only minor quantities of operation and maintenance chemicals as listed in Table 6.1. The risks associated with the operation and maintenance chemicals are more relevant in the context of workplace health and safety, and are not further assessed in the hazard analysis, Ref. [1].

Table 6.1: Operation and Maintenance Chemicals Present at Site

Chemical	Physical Form	Hazard Class	Major Hazard
Carbon dioxide, CO_2	Liquefied gas	2.2	Non-flammable, non-toxic gas
Nitrogen, N_2	Compressed gas	2.2	Non-flammable, non-toxic gas
Sulphur hexafluoride, SF_6	Compressed gas	2.2	Non-flammable, non-toxic gas
Acetone, C_3H_6O	Liquid	3	Flammable liquid
Aerosol (propellant)	Compressed gas	2.1	Flammable gas
Hydrochloric acid, HCl	Liquid	8	Corrosive
Sulphuric acid, H_2SO_4	Liquid	8	Corrosive
Sodium hydroxide, NaOH	Liquid	8	Corrosive
Chlorine remover, e.g. sodium bisulphate, $NaHSO_4$	Solid	8	Corrosive
Anti-scaling agent	Liquid	Not regulated	-
Anti-foaming agent	Liquid	Not regulated	-
Lubricating oil (hydrocarbons)	Liquid	Not regulated	-
Control oil (hydrocarbons)	Liquid	Not regulated	-
Transformer oil (hydrocarbons)	Liquid	Not regulated	-

The plant will handle, transport, and store major quantities of principal chemicals as listed in Table 6.2. The risks associated with the principal chemicals are fully credible in the context of land use safety planning and are further assessed in this hazard analysis. The chemical storage location, type of container, unit capacity of container, storage quantity, storage pressure, and storage temperature are also detailed in Table 6.2. The hazardous aspects of each of the principal chemicals are further described in subsequent sections.

Table 6.2: Principal Chemicals Present at Site

Chemical	Physical Form	Hazard Class	Major Hazard	Storage Location	Type of Container	Unit Capacity of Container	Approximate Maximum Quantity Stored Onsite	Storage Pressure	Storage Temperature
Diesel	Liquid	3	Flammable liquid	Diesel Storage Tank Area	Storage tank	1845 m^3	3690 m^3	Atmospheric	Ambient
Hydrogen, H_2	Compressed gas	2.1	Flammable gas	Hydrogen Storage Area	Gas tube trailer	10 tubes x 32 kg	320 kg	165 bar.g	Ambient
					Gas cylinder pack	15 cylinders x 0.53 kg	15.9 kg	137 bar.g	Ambient
Natural gas	Compressed gas	2.1	Flammable gas	Fuel gas supply line from power station boundary, running along the western boundary of the plant, before splitting to each of the two gas turbines	Fixed pipework with pipeline diameter of 300 mm, pipeline length of approx. 253 m, pipeline flow rate between 3,600 and 73,800 kg/hr, depending on the requirement of the gas turbines	17.9 m^3	17.9 m^3	44 bar.g	30°C

6.2.2 Fuel Gas (Natural Gas)

Natural gas is a ADG7 Class 2.1 (flammable gas) substance. The natural gas supplied to the Hunter Power Station could be rich gas or lean gas, depending on the predominant supply to the Sydney market in years to come. The plant will be designed for two cases of natural gas composition as outlined in the following Table 6.3.

Table 6.3: Natural Gas Composition

Component	Lean Gas (1) (mol%)	Rich Gas (1) (mol%)
Methane	98.52	90.93
Ethane	0.02	5.24
Propane	0.00	0.74
n-Butane	0.00	0.04
i-Butane	0.00	0.03
n-Pentane	0.00	0.01
i-Pentane	0.00	0.01
n-Hexane	0.00	0.01
Heptane	0.00	0.02
Octane	0.00	0.00
Nitrogen	1.24	0.87
Carbon dioxide	0.22	2.10
Hydrogen	0.00	0.00

Notes:

1) Rich gas typically comes from conventional gas fields such as offshore Gippsland, and these fields are in decline. Replacement gas could come from new conventional gas sources, e.g. Coal Seam Gas (CSG) from Queensland, or come from a Liquefied Natural Gas (LNG) import facility such as Port Kembla; CSG and LNG are largely lean gases.

6.2.3 Fuel Oil (Diesel)

Diesel is a ADG7 Class C1 (combustible liquid) substance. The diesel supplied to the Hunter Power Station is extra low sulphur type (sulphur content < 10 mg/kg), which meets the requirements stipulated in the *Australian Fuel Quality Standards Determination 2019*. The diesel composition applied in the FHA is outlined in the following Table 6.4, which is based on the 'Diesel Sample' composition provided in Gexcon's *Effects*/ *Riskcurves* software chemical database.

Table 6.4: Diesel Composition

Component	Diesel (wt%)
n-Octane	1.00
n-Nonane	2.00
n-Decane	5.00
n-Undecane	10.00
n-Dodecane	15.00
n-Tridecane	20.00
n-Tetradecane	30.00
n-Pentadecane	10.00
n-Hexadecane	7.00

6.2.4 Hydrogen Gas

Hydrogen is a ADG7 Class 2.1 (flammable gas) substance. Hydrogen is an extremely flammable gas and burns with invisible flame. Hydrogen has a low ignition energy whereby escaping hydrogen gas may ignite spontaneously. Hydrogen gas under pressure may explode if heated. Hydrogen may form explosive mixtures with air, with flammability/ explosive limit normally ranging between 4 to 77 vol%. Hydrogen may react violently with oxidising agents.

6.3 Hazardous Systems

Table 6.5 presents the results of the hazard identification procedure, indicating the facilities/initiating events studied that could lead to fire and explosion events, possible causes, potential consequences, and safeguards/ control measures that will be put in place.

Table 6.5: Hazard Identification for Hunter Power Station

No.	Facility/ Initiating Event	Cause	Consequence	Safeguard
1.	Uncontrolled release of fuel gas (natural gas) from fixed equipment, pipework, valves, flanges, instrument connections	▪ Corrosion (external or internal) ▪ Material or construction defect ▪ Mechanical damage caused by external impact, e.g. vehicle or dropped object ▪ Excessive wear and tear ▪ External fire, e.g. from neighbouring facilities/ arson ▪ Vandalism/ malicious damage by intruders ▪ Incorrect operation by Operators	Release of flammable gas leading to jet fire, fireball, flash fire, and/ or explosion if ignited	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation and venting valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to gas turbine enclosure for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system and Emergency Response Plan (ERP) ▪ Trained operators and operating procedures

No.	Facility/ Initiating Event	Cause	Consequence	Safeguard
2.	Release of fuel oil (diesel) from diesel tanker, hose, and coupling during diesel tanker unloading activity	▪ Hose failure due to: – Corrosion (external or internal) – Material or construction defect – Excessive wear and tear ▪ Human error, e.g. operator does not connect hose securely, operator forgets to disconnect hose before driver drives off, etc.	Release of combustible liquid leading to pool fire if ignited	▪ Hose coupling is camlock type, which makes secure and leak-proof hose-and-pipe connections. ▪ The diesel tanker unloading is a fully manned operation (needs to be done under significant operator supervision). ▪ The diesel tanker unloading follows Standard Operating Procedure (SOP), including inspection of hose prior to each diesel tanker unloading and driver is on standby during diesel tanker unloading. ▪ Spillage/leak containment by diesel tanker parking bay which is designed as a retention area. The diesel tanker parking bay is a slabbed area, where the slab is designed to fall to a washdown collection sump pit with heavy-duty grating, the edge of the slab to join to kerb upstand, and each end of the slab to join to road pavement. ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided in the vicinity of the diesel tanker parking bay ▪ Fire hose reels provided in the vicinity of the diesel tanker parking bay ▪ Fire hydrants provided in the vicinity of the diesel tanker parking bay ▪ Portable fire extinguishers provided in the vicinity of the diesel tanker parking bay ▪ Enforcement of vehicle speed limit in the plant ▪ Plant emergency communication system and Emergency Response Plan (ERP) ▪ Trained operators and operating procedures

No.	Facility/ Initiating Event	Cause	Consequence	Safeguard
3.	Release of fuel oil (diesel) from fixed equipment, pipework, valves, flanges, instrument connections	▪ Corrosion (external or internal) ▪ Material or construction defect ▪ Mechanical damage caused by external impact, e.g. vehicle or dropped object ▪ Excessive wear and tear ▪ External fire, e.g. from neighbouring facilities/ arson ▪ Vandalism/ malicious damage by intruders ▪ Incorrect operation by Operators	Release of combustible liquid leading to pool fire if ignited	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main diesel lines for emergency shutdown ▪ Spillage/ leak containment by bunding/ kerbing provided for diesel facilities including diesel unloading pumps, diesel storage tanks, diesel forwarding pumps, and diesel forwarding filters ▪ Fire detectors fitted to main diesel areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system and Emergency Response Plan (ERP) ▪ Trained operators and operating procedures

No.	Facility/ Initiating Event	Cause	Consequence	Safeguard
4.	Release of hydrogen gas from hydrogen storages (hydrogen tube trailer or hydrogen gas cylinder pack)	▪ Corrosion (external or internal) ▪ Material or construction defect ▪ Mechanical damage caused by external impact, e.g. vehicle or dropped object ▪ Excessive wear and tear ▪ External fire, e.g. from neighbouring facilities/ arson ▪ Vandalism/ malicious damage by intruders ▪ Incorrect operation by Operators	Release of flammable gas leading to jet fire, fireball, flash fire, and/ or explosion if ignited	▪ Each tube in hydrogen trailer is protected with bursting disc and pressure relief valve. ▪ Pressure relief valves fitted downstream of connecting fixed piping and pressure reduction panels to provide overpressure protection ▪ Gas detectors fitted to respective manifold (tube trailer manifold and gas cylinder manifold) for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to respective manifold (tube trailer manifold and gas cylinder manifold) for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided in the vicinity of the hydrogen storage areas ▪ Fire hose reels provided in the vicinity of the hydrogen storage areas ▪ Fire hydrants provided in the vicinity of the hydrogen storage areas ▪ Portable fire extinguishers provided in the vicinity of the hydrogen storage areas ▪ Enforcement of vehicle speed limit in the plant ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system and Emergency Response Plan (ERP) ▪ Trained operators and operating procedures

No.	Facility/ Initiating Event	Cause	Consequence	Safeguard
5.	Release of hydrogen gas from fixed equipment, pipework, valves, flanges, instrument connections	▪ Corrosion (external or internal) ▪ Material or construction defect ▪ Mechanical damage caused by external impact, e.g. vehicle or dropped object ▪ Excessive wear and tear ▪ External fire, e.g. from neighbouring facilities/ arson ▪ Vandalism/ malicious damage by intruders ▪ Incorrect operation by Operators	Release of flammable gas leading to jet fire, fireball, flash fire, and/ or explosion if ignited	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Downstream of the hydrogen storage area, the connecting fixed piping and pressure reduction panels are fitted with pressure relief valves to provide overpressure protection. ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system and Emergency Response Plan (ERP) ▪ Trained operators and operating procedures

6.4 Credible Outcome Events

6.4.1 Jet Fire

A jet fire occurs when a flammable liquid or gas, under some degree of pressure, is ignited after release, resulting in the formation of a long stable flame, normally directional in nature. Jet flames can be very intense and can impose high heat loads on nearby plant and equipment.

6.4.2 Pool Fire

A pool fire occurs if a flammable or combustible liquid accumulates in a pool on the ground, and vapours caused by evaporation are subsequently ignited. The resultant fire covers the whole pool area. The thermal radiation from pool fires tends to attenuate rapidly with distance from the flame surface; as such, thermal effects are relatively localised.

6.4.3 Fireball

Fireballs can occur when large quantities of flammable gases are released violently and ignited, resulting in a rising ball of flame. The thermal radiation intensity at the surface of a fireball tends to be very high. Although the duration of a fireball is normally short, dangerous levels of thermal radiation can be experienced at considerable distances from the fireball.

6.4.4 Flash Fire

A flash fire occurs when a cloud of flammable gas mixed with air is ignited. If the cloud is sufficiently large, it is also possible that the flame may accelerate to a sufficiently high velocity for a Vapour Cloud Explosion (VCE) to occur. Though very brief, a flash fire can seriously injure or kill anyone within the burning cloud. Its effects are confined almost entirely to the area covered by the burning cloud. Incident propagation, sometimes called domino effects, can occur through ignition of materials or structures within the burning cloud.

6.4.5 Vapour Cloud Explosion (VCE)

Explosions can occur through a variety of mechanisms, but in each case, damage or injury is caused by a pressure wave which is created by rapid expansion of gases. The magnitude of the pressure wave is usually expressed in terms of blast overpressure. However, in order to properly predict the destructive capacity, it is necessary to consider the rate of increase/decrease in pressure as the wave passes.

Explosions involving flammable gases are of particular concern in industrial facilities. Explosions can occur if a mixture of a flammable gas and air within the range of the flammability/explosive limits is ignited. The magnitude of overpressure developed is strongly influenced by factors such as:

- Degree of confinement
- Size of the cloud
- Degree of turbulence
- Combustion properties of the gas
- Location of ignition source relative to the cloud

Explosions may also occur as a result of catastrophic rupture of a pressurised vessel, ignition of dust clouds, thermal decompositions, runaway reactions, and detonation of high explosives such as trinitrotoluene (TNT). Both blast waves and projectile fragments may result.

6.5 Scenarios Assessed in FHA

Table 6.6 tabulates the scenarios assessed in the FHA, covering all the hazardous facilities within the power station boundary. The following operations have been considered in the Final Hazard Analysis, however were not taken forward for detailed assessment for the reasons stated below:

- Diesel tanker loading, performed as a non-routine maintenance item and on an as-needed basis (see Section 3.3.1). The risk associated with the diesel tanker loading process is not expected to contribute to credible offsite risks; hence, not further assessed in the FHA.
- Diesel polishing, performed as a routine preventive maintenance item as an automated closed loop process (see Section 3.3.3). The risk associated with the diesel polishing process is not expected to contribute to credible offsite risks; hence, not further assessed in the FHA.
- Diesel transfer, performed on an as-needed basis (see Section 3.3.3). The risk associated with the diesel transfer process is not expected to contribute to credible offsite risks; hence, not further assessed in the FHA.

Appendix B provides the Piping and Instrumentation Diagrams (P&IDs) marked up with the sections assessed in the FHA.

Table 6.6: Scenarios Assessed in FHA

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m^3)	Modelled Volume (m^3)	Modelled Inventory (kg)	Pump Rate (kg/s)	Maximum Pipe Size
S001_HPS_ISO_DSEL	Hunter Power Station - Release from 50m^3 diesel tanker	Liquid	25	Atmospheric	763.45	8.6 (1)	6565.67	Not applicable	Not applicable
S002_HPS_HOS_DSEL	Hunter Power Station - Release from 4 inch diesel unloading hose	Liquid	25	Atmospheric	763.45	8.6 (1)	6565.67	Not applicable	Not applicable
S003_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Unloading Pump and connected piping up to Diesel Fuel Storage Tank	Liquid	25	2.5	763.45	8.6 (1)	6565.67	21.21	150 mm
S004_HPS_TNK_DSEL	Hunter Power Station - Release from 1845m^3 Diesel Fuel Storage Tank	Liquid	25	Atmospheric	763.45	1845	1408565.25	Not applicable	Not applicable
S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	Liquid	25	7.8	763.45	1845	1408565.25	38.30	200 mm
S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	Liquid	25	7.8	763.45	1845	1408565.25	38.30	200 mm
S007a/b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	Liquid	25	84.8	763.45	1845	1408565.25	19.11	150 mm
S008_HPS_SDV_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)	Compressed gas	30	44	35.004	552.79	19350	Not applicable	Not applicable
S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	Compressed gas	30	44	35.004	552.79	19350	Not applicable	300 mm
S010a/b_HPS_VES_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	Compressed gas	30	44	35.004	5.65	197.94	Not applicable	Not applicable
S011a/b_HPS_VES_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater	Compressed gas	30	44	35.004	2.51	87.97	Not applicable	Not applicable
S012a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Heater and connected piping	Compressed gas	200	40.9	19.09	1964.38	37500	Not applicable	250 mm
S013a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Cartridge Filter and connected piping up to Shut Off Valve within Gas Turbine Fuel Gas Supply Unit	Compressed gas	200	38.1	17.802	2106.50	37500	Not applicable	250 mm

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m^3)	Modelled Volume (m^3)	Modelled Inventory (kg)	Pump Rate (kg/s)	Maximum Pipe Size
S014a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	Compressed gas	200	38.1	17.802	2106.50	37500	Not applicable	250 mm
S015a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from 5m^3 Drips Tank and connected piping	Liquid	25	1	727.89	5	3639.45	Not applicable	Not applicable
S016a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from Fuel Gas Knockout Pot (liquid segment) and connected piping	Liquid	30	44	724.16	2.83	2047.51	Not applicable	Not applicable
S017a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from Filter Coalescer (liquid segment) and connected piping	Liquid	30	44	724.16	1.26	910.01	Not applicable	Not applicable
S018_HPS_TRL_H2	Hunter Power Station - Release from Hydrogen Tube Trailer, 10 tubes per trailer	Compressed gas	25	165	12.279	26.06	320	Not applicable	Not applicable
S019_HPS_GCY_H2	Hunter Power Station - Release from Hydrogen Cylinder Pack, 15 cylinders per pack	Compressed gas	25	137	10.366	0.77	7.95	Not applicable	Not applicable
S020_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment before pressure regulation	Compressed gas	25	230	16.504	3.03	50	Not applicable	25 mm
S021_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure regulation	Compressed gas	25	50	4.0245	12.42	50	Not applicable	25 mm
S022_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure reduction up to SDV upstream of Generator Hydrogen Gas Control Panel	Compressed gas	25	8	0.72796	68.69	50	Not applicable	32 mm
S023a/b_HPS_PIP_H2	Hunter Power Station - Power Island No. 1/2 - Release from Generator Hydrogen Gas Control Panel and charging to generator cooling circuit	Compressed gas	25	5	0.48618	102.84	50	Not applicable	65 mm

Note:

1) Capacity of one, largest compartment of the diesel tanker

6.6 Other Hazards

The other types of the hazards for the Hunter Power Station that are excluded from this FHA are listed and briefly discussed in this section.

Electrical faults can cause overheating, sparking and a fire. However, electrical fires are only likely to have minor, localized impact and smoke/fire detection and active fire protection should be effective in controlling such incidents. This FHA does not extend to evaluation of electrical fire and explosion.

A range of other hazards were assessed in the PHA, Ref. [1], and HAZOP reports. These were concluded to either not contribute to credible offsite risk from the station or result in major offsite impact, hence are not further assessed in this FHA:

- Extreme weather events (bushfire, earthquake, flooding), leading to equipment damage. The potential impacts were assessed to be contained within the site, Ref. [1].
- Aircraft (fixed wing, helicopter, or ultra-light) entering restricted airspace and losing control and crashing at site, leading to equipment damage. There should be no impact or safety concerns as assessed in the *Aeronautical Impact & Risk Assessment of the Plume Rise* report for the power station, Ref. [11], provided to Civil Aviation Safety Authority (CASA) and aviation stakeholders.
- Hazardous events on adjacent industrial properties, leading to equipment damage. There should be no impact as there are currently no known adjacent industrial applications, Ref. [1].
- Gas turbine failure resulting in uncontrolled release of rotating parts or projectiles, leading to fire and explosion. The fire and explosion effects are most likely localised to the affected gas turbine unit with risk expected to be limited to onsite, Ref. [1].
- Gas turbine generator failure resulting in uncontrolled release of kinetic energy, leading to fire and explosion. The fire and explosion effects are most likely localised to the affected gas turbine generator unit with risk expected to be limited to onsite, Ref. [1].
- Transformer failure resulting in uncontrolled release of electrical energy, leading to fire and explosion. The fire and explosion effects are most likely localised to the affected transformer unit with risk expected to be limited to onsite, Ref. [1].
- Plant hazards for equipment containing the process with the potential for localised but severe hazardous effects resulting from a process incident of 1) high kinetic energy rotodynamic machinery and 2) Pressure equipment. For the purpose of this FHA which is primarily used for land planning purpose, these hazards are not quantified in this FHA. Snowy Hydro will actively monitor and close the recommendations made in the relevant HAZOP reports to mitigate these hazards and risks, Ref. [21], [22], and [23].

7. Consequence Analysis

7.1 Overview

Consequence analysis involves source term modelling necessary to characterise the initial release and physical effects modelling to determine the extent or magnitude of potential hazardous outcomes. The subsequent sections describe the modelling software and techniques used with key inputs and assumptions; and provide the results of the consequence analysis.

7.2 Modelling Software

Gexcon's *Riskcurves Version 11.5* software was used to perform calculations to predict the following:

- Source characteristics, i.e. initial release rate
- Physical effects of the escape of hazardous substances, i.e.
  - Distance to specific thermal radiation contours resulting from fire events
  - Distance to Lower Flammability Limit (LFL) contour associated with flammable gas clouds/ flash fire events
  - Distance to specific overpressure contours resulting from Vapour Cloud Explosion (VCE) events

The models within the software package are based upon 'Yellow Book', Ref. [12], 'Green Book', Ref. [13], and 'Purple Book', Ref. [14], or may have been adapted to more recent theoretical insights, which provide a sound, scientific, and transparent basis to perform the consequence analysis works.

7.3 Material/ Composition Screening

As described in Section 6.2.2, the natural gas supplied to the Hunter Power Station could be rich gas or lean gas, depending on the predominant supply to the Sydney market in years to come, or a gas mixed with hydrogen (of an undetermined percentage) in the future. Two cases of gas composition have been considered in the engineering design works and this FHA, namely Lean Gas and Rich Gas (see Table 6.3).

For each case of the gas compositions, a full bore release event from piping (pipe diameter: 300 mm, operating pressure: 44 bar.g, operating temperature: 30°C) was modelled using Gexcon's *Riskcurves Version 11.5* software. The consequence modelling results are presented in the following Table 7.1.

Table 7.1: Natural Gas Composition Screening Exercise – Consequence Modelling Results

Outcome Event	Harm Level	Weather	Maximum Hazard Distance, d (m)	
			Lean Gas	Rich Gas
Jet fire	4.7 kW/m^2	B2 Day	375	353
Jet fire	4.7 kW/m^2	D5 Day	340	322
Jet fire	4.7 kW/m^2	F1 Night	409	382
Flash fire	LFL	B2 Day	518	527
Flash fire	LFL	D5 Day	661	688
Flash fire	LFL	F1 Night	1674	1748
VCE	7 kPa	B2 Day	1073	1107
VCE	7 kPa	D5 Day	1079	1123
VCE	7 kPa	F1 Night	1729	1814

It can be gathered from the consequence modelling results that:

- In terms of Fatality Risk, Rich Gas will likely give more conservative results in view of the longer distance to LFL concentration contour;
- In terms of Injury Risk due to thermal radiation impact, Lean Gas will likely give more conservative results in view of the longer distance to 4.7 kW/m^2 thermal radiation contour;
- In terms of Injury Risk due to explosion overpressure impact, Rich Gas will likely give more conservative results in view of the longer distance to 7 kPa explosion overpressure contour; and
- An off-design case was also modelled using Lean Gas and 10% hydrogen to assess the likely impacts. The results for this case were always less than the worst case out of either the Rich or Lean Gas for each event outcome, and thus was not the dominating fuel.

When the plant becomes operational in 2023, the natural gas received will mostly be 'Rich Gas' in the short to medium term. Rich Gas was modelled as the base case in this FHA for this purpose. Any material differences in the risk results as a result of receiving Lean Gas in the future are discussed in Section 10.6.

7.4 Release Size

A quantitative risk assessment generally covers accidental releases from a range of possible hole sizes, from small, medium, large, to instantaneous release (for equipment)/ full bore release (for piping). HIPAP No. 6, Ref. [2], does not specify the hole sizes to be applied in the hazard analysis. This FHA adopts a hole size distribution of 10mm, 25mm, 75mm, and catastrophic failure/ guillotine, which are largely representative to most of the typical industry installations, with exceptions to certain equipment items. Table 7.2 lists the hole sizes modelled for accident scenarios identified for the Hunter Power Station, which are considered in line with industry best practice for quantitative risk assessment.

Table 7.2: Hole Sizes Modelled

Accident Scenario	Hole Size Modelled	Remark/ Industry Best Practice for Quantitative Risk Assessment
Failure of diesel tanker	▪ 10mm diameter hole (10mm) ▪ 25mm diameter hole (25mm) ▪ 75mm diameter hole (75mm) ▪ Catastrophic failure (R)	For tank containers (ISO tankers), representative hole sizes are to be modelled.
Failure of diesel tanker unloading hose	▪ 10mm diameter hole (10mm) ▪ Full bore release (R)	For hoses and couplings, representative hole sizes are to be modelled.
Failure of diesel storage tank	▪ 150mm diameter hole (150mm) ▪ 500mm diameter hole (500mm) ▪ Catastrophic failure (R)	For large vessels with a capacity greater than 450 m^3 which operate at ambient temperature and pressure, hole sizes to be modelled shall be as specified in United Kingdom Health and Safety Executive (UK HSE)'s *Failure Rate and Event Data for use within Risk Assessments (02/02/19)* (hereinafter referred to as 'UK HSE FRED 2019'), Ref. [15].
Failure of diesel supply lines	▪ 10mm diameter hole (10mm) ▪ 25mm diameter hole (25mm) ▪ 75mm diameter hole (75mm) ▪ Full bore release (R)	For fixed pipework with valves, flanges, instrument connections, pumps, and/ or filters, representative hole sizes are to be modelled.

Accident Scenario	Hole Size Modelled	Remark/ Industry Best Practice for Quantitative Risk Assessment
Failure of fuel gas knockout pot, fuel gas filter coalescer, or drips tank	▪ 10mm diameter hole (10mm) ▪ 25mm diameter hole (25mm) ▪ 75mm diameter hole (75mm) ▪ Catastrophic failure (R)	For pressure vessels, representative hole sizes are to be modelled.
Failure of fuel gas supply lines	▪ 10mm diameter hole (10mm) ▪ 25mm diameter hole (25mm) ▪ 75mm diameter hole (75mm) ▪ Full bore release (R)	For fixed pipework with valves, flanges, instrument connections, heaters, and/ or filters, representative hole sizes are to be modelled.
Failure of hydrogen tube trailer	▪ One tube valve fails and releases one tube content (S) ▪ One tube ruptures and releases one tube content (L) ▪ All tube valves fail and releases all tubes content (R)	For gas tube trailers, the type of events modelled are based upon SEMATECH, Inc.'s *Comparative Analysis of a Silane Cylinder Delivery System and a Bulk Silane Installation (ESH B001)*, Ref. [16].
Failure of hydrogen gas cylinder pack	▪ Catastrophic failure of the first cylinder (R) ▪ Failure of the remaining N-1 cylinders by means of a 5mm diameter hole (5mm)	For gas cylinder packages, the type of events modelled are based upon Dutch National Institute for Public Health and the Environment (RIVM)'s *Modelling gas cylinders from Risk Calculations Manual BEVI*, Ref. [17].
Failure of hydrogen supply lines	Segment with maximum pipe size of ø25mm: ▪ 10mm diameter hole (10mm) ▪ Full bore release (R) Segment with maximum pipe size of ø32mm/ ø65mm: ▪ 10mm diameter hole (10mm) ▪ 25mm diameter hole (25mm) ▪ Full bore release (R)	For fixed pipework with valves, flanges, instrument connections, and/ or filters, representative hole sizes are to be modelled.

7.5 Release Rate

The Gexcon's *Riskcurves Version 11.5* software package includes a series of release models that caters for different states of material (gas, liquefied gas, or liquid) at different loss of containment (LOC) scenarios (G1: Instantaneous release, G2: Release in 10 minutes, or G3: Leak).

The following release models were selected based on relevance to the accident scenarios identified for the Hunter Power Station, and used to perform calculations to predict the source characteristic in terms of release rate:

- Liquid LOC Scenario Leak (G3)
- Liquid LOC Scenario Instantaneous Release (G1)
- Gas LOC Scenario Leak (G3)
- Gas LOC Scenario Instantaneous Release (G1)

For non-instantaneous leaks from a storage tank/ pressure vessel/ road tanker, the leak was assumed to occur at a point that produces the highest discharge rate, i.e. from the bottom of the tank/ vessel/ tanker, as a conservative approach.

For pipework transferring liquids, the full bore release rate was taken as the rated pumping capacity, or as 1.5 times the nominal pumping rate (increase due to loss of pressure head [1]), in line with 'Purple Book', Ref. [14].

For flammable substances, the representative release rate was taken as the release rate averaged during the first (out of five) period of the release in which 20% of the total released mass is released, in line with 'Purple Book', Ref. [14]. The release rate was assumed to remain constant; this is considered a conservative approach as in reality, there will be pressure reduction due to isolated/ limited inventory and hence a reduction in the rate of leak. Credit is not claimed for isolation of releases in the FHA.

For continuous releases from a storage tank/ pressure vessel/ road tanker, these were modelled as a hole in the wall with a sharp orifice, in line with 'Purple Book', Ref. [14]; the discharge coefficient used was C_d=0.62. For continuous releases from pipework, these were modelled as if a constant pressure is present upstream and a discharge coefficient of C_d=0.62. For full bore releases from pipework, the discharge coefficient used was C_d=1.0.

7.6 Release Duration

In this FHA, the release duration was limited to a maximum of 30 minutes, and effects were calculated using only the mass released in the first 30 minutes following the start of the release to the environment, in line with 'Purple Book', Ref. [14]. This is considered a conservative approach as in reality, there will be emergency shutdown valves provided to allow isolation of the process segment in as short a time as possible to limit the inventory that could be released. Credit is not claimed for these isolations of releases in this FHA.

7.7 Jet Fire Modelling

The jet fire model within Gexcon's *Riskcurves Version 11.5* software was used to calculate the flame dimensions and heat radiation from a jet fire occurring upon direct ignition of a continuous outflow of gas material at the Hunter Power Station. The jet fire model calculates the shape of the fire as a frustum or cone, which can be at a specific height from the receiver. The jet fire model utilises Chamberlain relations (as the material released is in gas state) to derive typical expanded diameter and shape of the cone. Jet fires were modelled as horizontal, which is parallel to the wind direction, in line with industry practice for quantitative risk assessment, Ref. [14]. This is also considered a conservative approach as horizontal jet fires generally release longer and wider flames than vertical ones; hence, will represent a higher risk.

7.8 Pool Fire Modelling

The pool fire model within Gexcon's *Riskcurves Version 11.5* software was used to calculate the flame dimensions and heat radiation from a burning pool of liquid material at the power plant. The pool fire model supports two methods of calculation, i.e. "Yellow Book" method, which describes the pool fire as a tilted horizontal cylinder with a heat radiating surface, and "Two-zone Pool Fire" method, which describes the pool fire in two zones, a clear part and a sooty part of the flame, which have dedicated Surface Emissive Power (SEP) values. The latter "Two-zone Pool Fire" method was selected and used in this FHA. Table 7.3 lists the liquid pool areas modelled for accident scenarios identified for the Hunter Power Station. Where applicable, bunding/ kerbing design was taken into consideration in the pool fire modelling.

[1] Commonly referred to in industry as pump shut-off head

Table 7.3: Liquid Pool Areas Modelled

Accident Scenario	Liquid Pool Area Modelled	Remark
▪ Failure of diesel tanker ▪ Failure of diesel tanker unloading hose	162 m^2	The Diesel Tanker Parking Bay is designed as a retention area (26 m L x 6.22 m W). The Diesel Tanker Parking Bay is a slabbed area where the slab is designed to fall to a washdown collection sump pit with heavy-duty grating, the edge of the slab to join to kerb upstand, and each end of the slab to join to road pavement.
Failure of diesel unloading pump	76 m^2	The Diesel Unloading Pump x 2 are located within a kerbed area (11.6 m L x 6.5 m W).
Failure of diesel storage tank	1701 m^2	The Diesel Storage Tank x 2 are located within a bund (33.6 m L x 50.6 m W) designed to hold 110% capacity of a single storage tank.
▪ Failure of diesel forwarding pump ▪ Failure of diesel forwarding filter	164 m^2	The Diesel Forwarding Pump x 3 and Diesel Forwarding Filter x 2 are located within a kerbed area (8 m L x 20.4 m W).
Failure of fuel oil supply line to each gas turbine (power island)	1500 m^2	Free spreading pool to a maximum area of 1500 m^2 based on 'Yellow Book', Ref. [12]
Failure of gas turbine fuel oil system	1500 m^2	Free spreading pool to a maximum area of 1500 m^2 based on 'Yellow Book', Ref. [12]
Failure of drips tank	500 m^2	The liquid pool area was estimated from the drips tank capacity (5 m^3) that could be released, considering a liquid pool thickness/ depth of 1 cm.
Failure of fuel gas knockout pot (liquid segment)	126 m^2	The liquid pool area was estimated from the maximum condensate inventory within the fuel gas knockout pot (1.26 m^3) that could be released, considering a liquid pool thickness/ depth of 1 cm.
Failure of fuel gas filter coalescer (liquid segment)	126 m^2	The liquid pool area was estimated from the maximum condensate inventory within the fuel gas filter coalescer (1.26 m^3) that could be released, considering a liquid pool thickness/ depth of 1 cm.

7.9 Fireball Modelling

The gas fireball model within Gexcon's *Riskcurves Version 11.5* software was used to calculate the flame dimensions and heat radiation from a fireball occurring upon direct ignition of an instantaneous release of pressurised gas material at the plant. The model describes the fireball as a growing and rising phenomenon, resulting in a time-dependent radius, height, and heat radiation. The heat radiation footprint is always circular. Apart from the fire phenomenon, the model also incorporates an explosion overpressure calculation although these impacts are commonly less dominating.

7.10 Flash Fire Modelling

Natural gas or hydrogen gas released from the power plant will be dispersed in the surrounding area under the influence of atmospheric turbulence. The neutral gas dispersion explosive mass (NGDE) model within Gexcon's *Riskcurves Version 11.5* software was used to calculate the LFL concentration contour associated with the flammable gas dispersion. The NGDE model is based on the Gaussian plume model, which takes no account of the difference in density between the gas and ambient air. The NGDE model is appropriate as natural gas and hydrogen gas are lighter than air in nature (with the latter being a lot lighter). The gas dispersion will always be passive whereby the cloud will only move in the wind direction with exception for the first part of the jet release, which was modelled as a turbulent free jet that may blow the gas upwards.

Concentration averaging time as a field in the NGDE model is the duration over which the plume concentration and plume width are calculated/ averaged to take into account the effect of meandering of wind. For flammable substances, the concentration averaging time used is 20 seconds, which is the industry practice in quantitative risk assessment, Ref. [14].

The NGDE model applies only to open terrain, and the roughness of the terrain/ influence of trees, houses, etc. plays a role in the gas dispersion behaviour. The Project site surroundings are intended for general and heavy industry uses with the rest being rural landscapes. These areas are typically characterised by a low population density with spread-out small settlements and infrastructure. A surface roughness length of 100 mm was adopted in this FHA, which corresponds to a terrain described as 'Low crops, occasional large obstacles' that is considered to be representative of the Project site surroundings. This approach is consistent with other project sites of a similar setting.

Flash fire is the result of delayed ignition of a flammable gas cloud drifting away from the source. Flash fires are not characterised by flame dimensions and heat radiation, instead they are represented by the footprint of the LFL concentration contour.

7.11 Explosion Modelling

The multi-energy model within Gexcon's *Riskcurves Version 11.5* software was used to calculate the magnitude of overpressure generated from a Vapour Cloud Explosion (VCE) event involving flammable gases at the plant. The multi-energy model is a so-called 'blast curve' method that describes the strength of an explosion event based on two important parameters:

- The blast curve number describing the typical strength (1- Very weak deflagration to 10- Detonation)
- The amount of flammable mass that is captured inside a confined/ congested area, which is determined by the combination of two fields, 'Total mass in flammable range' and 'Fraction cloud involved in explosion' to yield that part of the flammable gas cloud which has drifted into the confined/ congested area

For explosion events occurring within a confined and congested space, curve number 7 to 10 is recommended by 'Yellow Book', Ref. [12] (see Table 7.4). For gas release in the gas turbine enclosure, curve number 10 was applied in the explosion modelling in this FHA as a conservative approach.

For explosion events occurring in an outdoor area/ unconfined and less congested space, curve number 2 to 3 is recommended by 'Yellow Book', Ref. [12] (see Table 7.4). For gas release outside the gas turbine enclosure (where the other gas facilities are not built within a compartment/ walls/ barriers), curve number 3 was applied in the explosion modelling in this FHA as a conservative approach.

Table 7.4: Multi-energy Method – Blast Source Strength Factors and Associated Curve Number

Blast Strength Category	Ignition Strength [1]	Obstruction [2]	Parallel Plane Confinement [3]	Curve Number
1	H	H	C	7 - 10
2	H	H	U	7 - 10
3	L	H	C	5 - 7
4	H	L	C	5 - 7
5	H	L	U	4 - 6
6	H	N	C	4 - 6
7	L	H	U	4 - 5
8	H	N	-	4 - 5
9	L	L	C	3 - 5
10	L	L	U	2 - 3
11	L	N	C	1 - 2
12	L	N	U	1

Notes:

1) **High (H)**: The ignition source is, for instance, a confined vented explosion. This may be due to the ignition of part of the cloud by a low energy source, for example, inside a building.

   Low (L): The ignition source is a spark, flame, hot surface, etc.

2) **High (H)**: Closely packed obstacles within gas cloud giving an overall volume blockage fraction (i.e. the ratio of the volume of the obstructed area occupied by the obstacles and the total volume of the obstructed area itself) in excess of 30% and with spacing between obstacles less than 3 m.

   Low (L): Obstacles in gas cloud but with overall blockage fraction less than 30% and/ or spacing between obstacles larger than 3 m.

   None (N): No obstacles within gas cloud.

3) **Confined (C)**: Gas clouds, or part of it, are confined by walls/ barriers on two or three sides.

   Unconfined (U): Gas cloud is not confined, other than by the ground.

7.12 Worst Case Consequences

Table 7.5 tabulates the worst case scenario zones as identified from the sitewide consequence modelling outcome and are summarised below:

- Worst case pool fire is generated from the 1845 m^3 Diesel Fuel Storage Tank, in the event of release forming a liquid pool confined within the bund (1701 m^2). The maximum distance to 4.7 kW/m^2 thermal radiation contour is 85 m; the maximum offsite distance is 37 m.
- Worst case jet fire is generated from the incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (⌀300 mm), in the event of full bore release (R). The maximum distance to 4.7 kW/m^2 thermal radiation contour is 117 m; the maximum offsite distance is 105 m.
- Worst case fireball is generated from the Fuel Gas Knockout Pot and connected piping, in the event of catastrophic failure (R). The maximum distance to 4.7 kW/m^2 thermal radiation contour is 101 m; the maximum offsite distance is 76 m.
- Worst case flash fire is generated from the Hydrogen Tube Trailer, in the event of all tube valves fail and releases all tubes' content (R). The maximum distance to LFL concentration contour is 611 m; the maximum offsite distance is 569 m.
- Worst case VCE is generated from the Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors, in the event of full bore release (R) within the gas turbine enclosure. The maximum distance to 7 kPa explosion overpressure contour is 104 m; the maximum offsite distance is 36 m.

Table 7.5: Worst-Case Scenario Zones

Hazard Type	Worst-Case Scenario			Worst-Case Scenario Offsite		
	Outcome ID	Maximum Hazard Distance (m)	Maximum Offsite Distance (m)	Outcome ID	Maximum Hazard Distance (m)	Maximum Offsite Distance (m)
Pool fire	S004_HPS_TNK_DSEL_150mm_PF_4.7 kW/m2_B2	85	37	S004_HPS_TNK_DSEL_150mm_PF_4.7 kW/m2_B2	85	37
	S004_HPS_TNK_DSEL_500mm_PF_4.7 kW/m2_B2	85	37	S004_HPS_TNK_DSEL_500mm_PF_4.7 kW/m2_B2	85	37
	S004_HPS_TNK_DSEL_R_PF_4.7 kW/m2_B2	85	37	S004_HPS_TNK_DSEL_R_PF_4.7 kW/m2_B2	85	37
Jet fire	S008_HPS_SDV_RICH_R_JF_4.7 kW/m2_F1	117	87	S009_HPS_PIP_RICH_R_JF_4.7 kW/m2_F1	117	105
	S009_HPS_PIP_RICH_R_JF_4.7 kW/m2_F1	117	105			
Fireball	S010a_HPS_VES_RICH_R_FB_4.7 kW/m2_F1	101	76	S010a_HPS_VES_RICH_R_FB_4.7 kW/m2_F1	101	76
	S010b_HPS_VES_RICH_R_FB_4.7 kW/m2_F1	101	59			
Flash fire	S018_HPS_TRL_H2_R_FF_LFL_F1	611	569	S018_HPS_TRL_H2_R_FF_LFL_F1	611	569
VCE	S014a_HPS_PIP_RICH_R_VCE_7 kPa_F1/B2/D5	104	36	S014a_HPS_PIP_RICH_R_VCE_7 kPa_F1/B2/D5	104	36
	S014b_HPS_PIP_RICH_R_VCE_7 kPa_F1/B2/D5	104	21			

Property damage and accident propagation scenarios with the greatest consequences are listed in Table 7.6 and are summarised below.

- The pool fire event with worst property damage and accident propagation impact is generated from the 1845 m^3 Diesel Fuel Storage Tank, in the event of release forming a liquid pool confined within the bund (1701 m^2). The maximum distance to 23 kW/m^2 thermal radiation contour is 50 m; the maximum offsite distance is 2 m.
- The jet fire event with worst property damage and accident propagation impact is generated from the incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (ø300 mm), in the event of full bore release (R). The maximum distance to 23 kW/m^2 thermal radiation contour is 98 m; the maximum offsite distance is 86 m.
- The fireball event with worst property damage and accident propagation impact is generated from the Fuel Gas Knockout Pot and connected piping, in the event of catastrophic failure (R). The maximum distance to 23 kW/m^2 thermal radiation contour is 46 m; the maximum offsite distance is 21 m.
- The VCE event with greatest distance to 14 kPa explosion overpressure contour is generated from the Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors, in the event of full bore release (R) within the gas turbine enclosure. For this event, the maximum distance to 14 kPa explosion overpressure contour is 69 m; the maximum offsite distance is 1 m. The VCE event with the worst offsite distance due to 14 kPa explosion overpressure contour is generated from the Fuel Gas Knockout Pot and connected piping, in the event of catastrophic failure (R). For this event, the maximum distance to 14 kPa explosion overpressure contour is 33 m; the maximum offsite distance is 8 m.

Table 7.6: Property Damage and Accident Propagation Scenario Zones

Hazard Type	Escalation Scenario			Escalation Scenario Offsite		
	Outcome ID	**Maximum Hazard Distance (m)**	**Maximum Offsite Distance (m)**	**Outcome ID**	**Maximum Hazard Distance (m)**	**Maximum Offsite Distance (m)**
Pool fire	S004_HPS_TNK_DSEL_150mm_PF_23 kW/m2_D5	50	2	S004_HPS_TNK_DSEL_150mm_PF_23 kW/m2_D5	50	2
	S004_HPS_TNK_DSEL_500mm_PF_23 kW/m2_D5	50	2	S004_HPS_TNK_DSEL_500mm_PF_23 kW/m2_D5	50	2
	S004_HPS_TNK_DSEL_R_PF_23 kW/m2_D5	50	2	S004_HPS_TNK_DSEL_R_PF_23 kW/m2_D5	50	2
Jet fire	S008_HPS_SDV_RICH_R_JF_23 kW/m2_F1	98	68	S009_HPS_PIP_RICH_R_JF_23 kW/m2_F1	98	86
	S009_HPS_PIP_RICH_R_JF_23 kW/m2_F1	98	86			
Fireball	S010a_HPS_VES_RICH_R_FB_23 kW/m2_F1/B2/D5	46	21	S010a_HPS_VES_RICH_R_FB_23 kW/m2_F1/B2/D5	46	21
	S010b_HPS_VES_RICH_R_FB_23 kW/m2_F1/B2/D5	46	4			
VCE	S014a_HPS_PIP_RICH_R_VCE_14 kPa_F1/B2/D5	69	1	S010a_HPS_VES_RICH_R_VCE_14 kPa_F1/B2/D5	33	8
	S014b_HPS_PIP_RICH_R_VCE_14 kPa_F1/B2/D5	69	- (within boundary)			

A complete list of all the outcome events that have potential offsite impact is provided in Appendix C. This includes all the harm contours, i.e. contours at threshold levels that may cause fatality, injury, and property damage and accident propagation, that extend beyond the Hunter Power Station site boundary.

8. Estimation of Likelihood of Hazardous Events

8.1 Overview

The estimation of likelihood involves the determination of failure frequency of identified process sections and the determination of frequency of potential hazardous outcome events resulting from the failure cases. Estimation of likelihood usually relies on published generic data and/ or site historical data to establish the frequencies. The subsequent sections in this FHA describe the techniques/ data used in the estimation of failure frequencies and event frequencies and provide the results of this estimation of likelihood step.

An issue with obtaining relevant failure rate or historical data is its applicability to the system under analysis. Although using plant-specific failure rate data for the specific equipment under investigation is preferred, this information is often not available even for mature existing plants. The failure of pipes, vessels, and other plant equipment can be due to a range of factors such as corrosion, poor maintenance, maloperation, etc. The potential for such factors to cause equipment failures can be eliminated or mitigated by effective safety and maintenance management systems.

Generally, it is not possible to adequately quantify the effects of safety management systems on the failure frequency of equipment. Therefore, risk analysis usually rely on generic failure rate data (some of which are available in the public domain) to estimate the likelihood of hazardous events. Considering that the Hunter Power Station is designed and will be constructed and installed in accordance with the relevant Australian and International standards, and a series of process safety studies has been conducted, it was considered that using generic failure rate data methodology for the likelihood analysis is appropriate for the land use planning objective.

8.2 Failure Frequency Analysis

In this step, the failure frequency of each of the identified process sections was derived using '*Parts Count Methodology*'. In this parts count process, equipment items, e.g. pipework, valves, flanges, instrument connections, vessels, pumps, filters, heat exchangers, etc., were systematically counted and recorded. Then, the number of each equipment item was multiplied with the failure rate per equipment item, and these products were summed to establish the total failure frequency for that process section.

HIPAP No. 6, Ref. [2], does not specify the sources of failure rate data to be applied in the hazard analysis. This FHA utilises UK HSE FRED 2019, Ref. [15], as the main source of failure rate data, and refers to other suitable sources if UK HSE FRED 2019, Ref. [15], does not contain the required information, which is considered in line with industry practice for quantitative risk assessment. The following sub-sections describe the failure rate data applied in this FHA to derive the failure frequencies for all the accident scenarios identified for the Hunter Power Station. For the purposes of standardising the hole sizes for the various equipment, the failure or release frequency for the 10 mm hole has been adjusted to suit. This has been done in accordance with industry practice for QRAs.

8.2.1 Road Tanker

For road diesel tankers, the failure rate data for 'Tank Containers (ISO Tankers)' available in UK HSE FRED 2019, Ref. [15], was applied, as presented in Table 8.1.

Table 8.1: Failure Rate Data – Tank Container (ISO Tanker)

Scenario	Scenario Frequency (per tanker year)	Remark	Scenario in FHA	Scenario Frequency in FHA (per tanker year)
4 mm diameter hole	3E-04	This includes releases due to the valve being left open by the operator.	10 mm diameter hole (10mm)	3.6E-04
13 mm diameter hole	6E-05			
25 mm diameter hole	3E-05		25 mm diameter hole (25mm)	3E-05
50 mm diameter hole	3E-05		75 mm diameter hole (75mm)	3E-05
Catastrophic failure	4E-06	With no pressure relief system	Catastrophic failure (R)	4E-06

8.2.2 Hose and Coupling

For diesel tanker unloading hoses and couplings, the failure rate data for 'Hoses and Couplings' available in UK HSE FRED 2019, Ref. [15], was applied, as presented in Table 8.2.

Table 8.2: Failure Rate Data – Hose and Coupling

Scenario	Scenario Frequency (per transfer)	Remark	Scenario in FHA	Scenario Frequency in FHA (per transfer)
5 mm diameter hole	1.3E-05	Basic facilities, i.e. one pullaway prevention system such as wheel chocks and pressure/ leak tests to prevent transfer system leaks and bursts, but have no pullaway mitigation	10 mm diameter hole (10mm)	1.4E-05
15 mm diameter hole	1E-06			
Guillotine failure	4E-05		Full bore release (R)	4E-05

8.2.3 Large Atmospheric Tank

For diesel storage tanks, the failure rate data for 'Large Vessels, Tank Volume Category: 4000 - 450 m^3' available in UK HSE FRED 2019, Ref. [15], was applied, as presented in Table 8.3.

Table 8.3: Failure Rate Data – Large Vessel, Tank Volume Category: 4000 - 450 m^3

Scenario/ Scenario in FHA	Scenario Frequency (per tank year)
Minor release – 150 mm diameter hole (150mm)	2.5E-03
Major release – 500 mm diameter hole (500mm)	1E-04
Catastrophic failure (R)	5E-06

8.2.4 Pressure Vessel

For fuel gas knockout pots, fuel gas filter coalescers, and drips tanks, the failure rate data for 'Pressure Vessels' available in UK HSE FRED 2019, Ref. [15], was applied, as presented in Table 8.4.

Table 8.4: Failure Rate Data – Pressure Vessel

Scenario	Scenario Frequency (per vessel year)	Remark	Scenario in FHA	Scenario Frequency in FHA (per vessel year)
6 mm diameter hole	4E-05	-	10 mm diameter hole (10mm)	5E-05
13 mm diameter hole	1E-05	-		
25 mm diameter hole	5E-06	-	25 mm diameter hole (25mm)	5E-06
50 mm diameter hole	5E-06	-	75 mm diameter hole (75mm)	5E-06
Catastrophic failure	4E-06	Median failure	Catastrophic failure (R)	4E-06

8.2.5 Pipework

For fixed pipework, the failure rate data for 'Pipework' available in UK HSE FRED 2019, Ref. [15], was applied, as presented in Table 8.5.

Table 8.5: Failure Rate Data – Pipework

Equipment Item	Scenario	Scenario Frequency (per metre year)	Scenario in FHA	Scenario Frequency in FHA (per metre year)
Pipework – 0 to 49 mm diameter	3 mm diameter hole	1E-05	10 mm diameter hole (10mm)	1E-05
	25 mm diameter hole	5E-06	25 mm diameter hole (25mm)	5E-06
	Guillotine	1E-06	Full bore release (R)	1E-06
Pipework – 50 to 149 mm diameter	3 mm diameter hole	2E-06	10 mm diameter hole (10mm)	2E-06
	25 mm diameter hole	1E-06	25 mm diameter hole (25mm)	1E-06
	Guillotine	5E-07	Full bore release (R)	5E-07
Pipework – 150 to 299 mm diameter	4 mm diameter hole	1E-06	10 mm diameter hole (10mm)	1E-06
	25 mm diameter hole	7E-07	25 mm diameter hole (25mm)	7E-07
	1/3 pipework diameter hole	4E-07	75 mm diameter hole (75mm)	4E-07
	Guillotine	2E-07	Full bore release (R)	2E-07
Pipework – 300 to 499 mm diameter	4 mm diameter hole	8E-07	10 mm diameter hole (10mm)	8E-07
	25 mm diameter hole	5E-07	25 mm diameter hole (25mm)	5E-07
	1/3 pipework diameter hole	2E-07	75 mm diameter hole (75mm)	2E-07

Equipment Item	Scenario	Scenario Frequency (per metre year)	Scenario in FHA	Scenario Frequency in FHA (per metre year)
	Guillotine	7E-08	Full bore release (R)	7E-08

8.2.6 Gas Tube Trailer

Failure rates associated with gas tube trailers are not available in UK HSE FRED 2019, Ref. [15]. A suitable source was used, as described below.

The hydrogen tube trailer is considered as a pressure vessel. The failure rate data for 'pressure vessel' available in 'Purple Book', Ref. [14], was applied, as presented in Table 8.6.

Table 8.6: Failure Rate Data – Gas Tube Trailer

Scenario	Scenario Frequency (per year)	Scenario in FHA	Scenario Frequency in FHA (per year)
Continuous release from a hole with an effective diameter of 10 mm	1E-05	One tube valve fails and releases content (S)	1E-05
Continuous release of the complete inventory in 10 minutes at a constant rate of release	5E-07	All tube valves fail and releases content (R)	5E-07
Instantaneous release of the complete inventory	5E-07	One tube ruptures and releases content (L)	5E-07

8.2.7 Gas Cylinder Package

Failure rates associated with gas cylinder packages are not available in UK HSE FRED 2019, Ref. [15]. A suitable source was used, as described below.

For a gas cylinder package having N cylinders, the failure rate data available in RIVM's *Modelling gas cylinders from Risk Calculations Manual BEVI*, Ref. [17], was applied, as presented in Table 8.7.

Table 8.7: Failure Rate Data – Gas Cylinder Package Having N Cylinders

Scenario/ Scenario in FHA	Scenario Frequency (per year)
Catastrophic failure of the first cylinder (R)	5E-07
Failure of the remaining N-1 cylinders by means of a 5 mm diameter hole (5mm)	(N-1) x 5E-07

8.2.8 Other Equipment Items

For valves, flanges, instrument connections, pumps, filters, and heaters, the failure rate data available in The International Association of Oil & Gas Producers (OGP)'s *Risk Assessment Data Directory – Process release frequencies*, Ref. [18], was applied, as presented in Table 8.8.

Table 8.8: Failure Rate Data – Valve, Flange, Instrument Connection, Pump, Filter, Heater

Equipment Item	**Scenario**	**Scenario Frequency (per year)**	**Scenario in QRA**	**Scenario Frequency in QRA (per year)**
Flange – 2" diameter (50 mm)	1 to 3 mm diameter hole	2.6E-05	10 mm diameter hole (10mm)	3.36E-05
	3 to 10 mm diameter hole	7.6E-06		
	10 to 50 mm diameter hole	4.0E-06	25 mm diameter hole (25mm)	2.0E-06
	50 to 150 mm diameter hole	-	Full bore release (R)	2.0E-06
	>150 mm diameter hole	-		
Flange – 6" diameter (150 mm)	1 to 3 mm diameter hole	3.7E-05	10 mm diameter hole (10mm)	4.8E-05
	3 to 10 mm diameter hole	1.1E-05		
	10 to 50 mm diameter hole	3.0E-06	25 mm diameter hole (25mm)	3.0E-06
	50 to 150 mm diameter hole	2.0E-06	75 mm diameter hole (75mm)	1.0E-06
	>150 mm diameter hole	-	Full bore release (R)	1.0E-06
Flange – 12" diameter (300 mm)	1 to 3 mm diameter hole	5.9E-05	10 mm diameter hole (10mm)	7.6E-05
	3 to 10 mm diameter hole	1.7E-05		
	10 to 50 mm diameter hole	4.7E-06	25 mm diameter hole (25mm)	4.7E-06
	50 to 150 mm diameter hole	6.1E-07	75 mm diameter hole (75mm)	6.1E-07
	>150 mm diameter hole	1.7E-06	Full bore release (R)	1.7E-06
Manual Valve – 2" diameter (50 mm)	1 to 3 mm diameter hole	2.0E-05	10 mm diameter hole (10mm)	2.77E-05
	3 to 10 mm diameter hole	7.7E-06		
	10 to 50 mm diameter hole	4.9E-06	25 mm diameter hole (25mm)	2.45E-06
	50 to 150 mm diameter hole	-	Full bore release (R)	2.45E-06
	>150 mm diameter hole	-		
Manual Valve – 6" diameter (150 mm)	1 to 3 mm diameter hole	3.1E-05	10 mm diameter hole (10mm)	4.3E-05
	3 to 10 mm diameter hole	1.2E-05		
	10 to 50 mm diameter hole	4.7E-06	25 mm diameter hole (25mm)	4.7E-06
	50 to 150 mm diameter hole	2.4E-06	75 mm diameter hole (75mm)	1.2E-06
	>150 mm diameter hole	-	Full bore release (R)	1.2E-06
Manual Valve – 12" diameter (300 mm)	1 to 3 mm diameter hole	4.3E-05	10 mm diameter hole (10mm)	6.0E-05
	3 to 10 mm diameter hole	1.7E-05		
	10 to 50 mm diameter hole	6.5E-06	25 mm diameter hole (25mm)	6.5E-06
	50 to 150 mm diameter hole	1.2E-06	75 mm diameter hole (75mm)	1.2E-06
	>150 mm diameter hole	1.7E-06	Full bore release (R)	1.7E-06

Equipment Item	Scenario	Scenario Frequency (per year)	Scenario in QRA	Scenario Frequency in QRA (per year)
Actuated Valve – 2” diameter (50 mm)	1 to 3 mm diameter hole	2.4E-04	10 mm diameter hole (10mm)	3.13E-04
	3 to 10 mm diameter hole	7.3E-05		
	10 to 50 mm diameter hole	3.0E-05	25 mm diameter hole (25mm)	1.5E-05
	50 to 150 mm diameter hole	-	Full bore release (R)	1.5E-05
	>150 mm diameter hole	-		
Actuated Valve – 6” diameter (150 mm)	1 to 3 mm diameter hole	2.2E-04	10 mm diameter hole (10mm)	2.86E-04
	3 to 10 mm diameter hole	6.6E-05		
	10 to 50 mm diameter hole	1.9E-05	25 mm diameter hole (25mm)	1.9E-05
	50 to 150 mm diameter hole	8.6E-06	75 mm diameter hole (75mm)	4.3E-06
	>150 mm diameter hole	-	Full bore release (R)	4.3E-06
Actuated Valve – 12” diameter (300 mm)	1 to 3 mm diameter hole	2.1E-04	10 mm diameter hole (10mm)	2.73E-04
	3 to 10 mm diameter hole	6.3E-05		
	10 to 50 mm diameter hole	1.8E-05	25 mm diameter hole (25mm)	1.8E-05
	50 to 150 mm diameter hole	2.4E-06	75 mm diameter hole (75mm)	2.4E-06
	>150 mm diameter hole	6.0E-06	Full bore release (R)	6.0E-06
Instrument Connection	1 to 3 mm diameter hole	1.8E-04	10 mm diameter hole (10mm)	2.48E-04
	3 to 10 mm diameter hole	6.8E-05		
	10 to 50 mm diameter hole	2.5E-05	25 mm diameter hole (25mm)	1.25E-05
			Full bore release (R)	1.25E-05
Centrifugal Pump – Inlet 50 to 150 mm diameter	1 to 3 mm diameter hole	3.4E-03	10 mm diameter hole (10mm)	4.4E-03
	3 to 10 mm diameter hole	1.0E-03		
	10 to 50 mm diameter hole	2.9E-04	25 mm diameter hole (25mm)	2.9E-04
	>50 mm diameter hole	5.4E-05	75 mm diameter hole (75mm)	2.7E-05
			Full bore release (R)	2.7E-05
Reciprocating Pump – Inlet 50 to 150 mm diameter	1 to 3 mm diameter hole	2.1E-03	10 mm diameter hole (10mm)	3.3E-03
	3 to 10 mm diameter hole	1.2E-03		
	10 to 50 mm diameter hole	7.4E-04	25 mm diameter hole (25mm)	7.4E-04
	>50 mm diameter hole	5.0E-04	75 mm diameter hole (75mm)	2.5E-04
			Full bore release (R)	2.5E-04
Heat Exchanger, Air Cooled – Inlet 50 to 150 mm diameter	1 to 3 mm diameter hole	1.0E-03	10 mm diameter hole (10mm)	1.49E-03
	3 to 10 mm diameter hole	4.9E-04		
	10 to 50 mm diameter hole	2.4E-04	25 mm diameter hole (25mm)	2.4E-04
	>50 mm diameter hole	1.1E-04	75 mm diameter hole (75mm)	5.5E-05
			Full bore release (R)	5.5E-05

<table>
<tr><th>Equipment Item</th><th>Scenario</th><th>Scenario Frequency (per year)</th><th>Scenario in QRA</th><th>Scenario Frequency in QRA (per year)</th></tr>
<tr><td rowspan="5">Filter – Inlet 50 to 150 mm diameter</td><td>1 to 3 mm diameter hole</td><td>1.3E-03</td><td rowspan="2">10 mm diameter hole (10mm)</td><td rowspan="2">1.81E-03</td></tr>
<tr><td>3 to 10 mm diameter hole</td><td>5.1E-04</td></tr>
<tr><td>10 to 50 mm diameter hole</td><td>1.9E-04</td><td>25 mm diameter hole (25mm)</td><td>1.9E-04</td></tr>
<tr><td rowspan="2">>50 mm diameter hole</td><td rowspan="2">5.5E-05</td><td>75 mm diameter hole (75mm)</td><td>2.75E-05</td></tr>
<tr><td>Full bore release (R)</td><td>2.75E-05</td></tr>
<tr><td rowspan="5">Filter – Inlet >150 mm diameter</td><td>1 to 3 mm diameter hole</td><td>1.3E-03</td><td rowspan="2">10 mm diameter hole (10mm)</td><td rowspan="2">1.81E-03</td></tr>
<tr><td>3 to 10 mm diameter hole</td><td>5.1E-04</td></tr>
<tr><td>10 to 50 mm diameter hole</td><td>1.9E-04</td><td>25 mm diameter hole (25mm)</td><td>1.9E-04</td></tr>
<tr><td>50 to 150 mm diameter hole</td><td>3.5E-05</td><td>75 mm diameter hole (75mm)</td><td>3.5E-05</td></tr>
<tr><td>>150 mm diameter hole</td><td>2.0E-05</td><td>Full bore release (R)</td><td>2.0E-05</td></tr>
</table>

8.3 Event Frequency Analysis

8.3.1 Event Tree

The frequencies of potential hazardous outcome events were estimated using the Event Tree Analysis (ETA) method. In this method, each initiating event was taken through a sequence of events (forward logic) to determine the possible hazardous outcome events. Figure 8.1 and Figure 8.2 present the event trees applied in the FHA, which identifies the range of hazardous outcome events that may be expected from an accidental release of flammable gas and flammable liquid at the plant, respectively.

Figure 8.1: Event Tree Applied in FHA for Loss of Containment of Flammable Gas

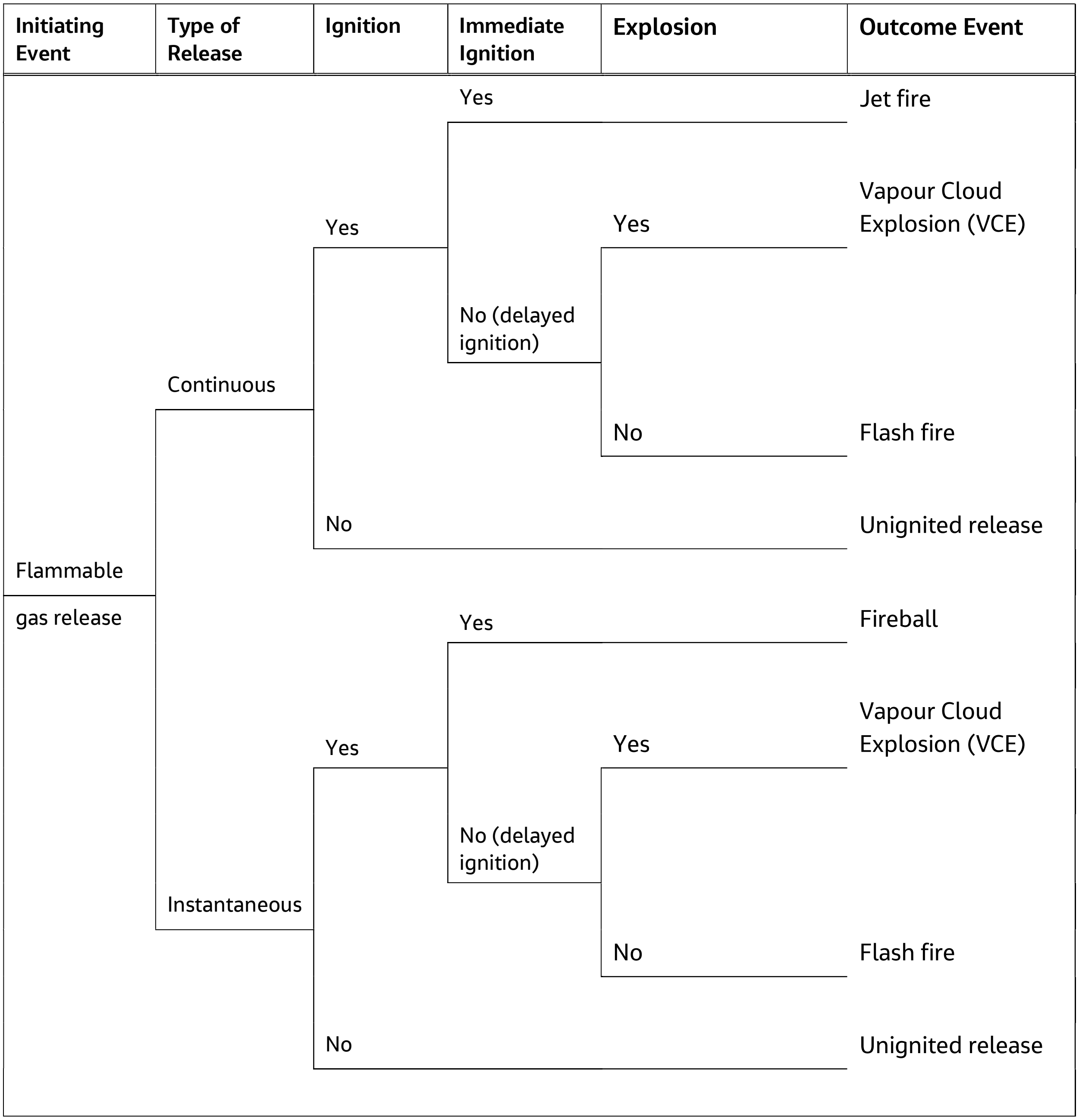
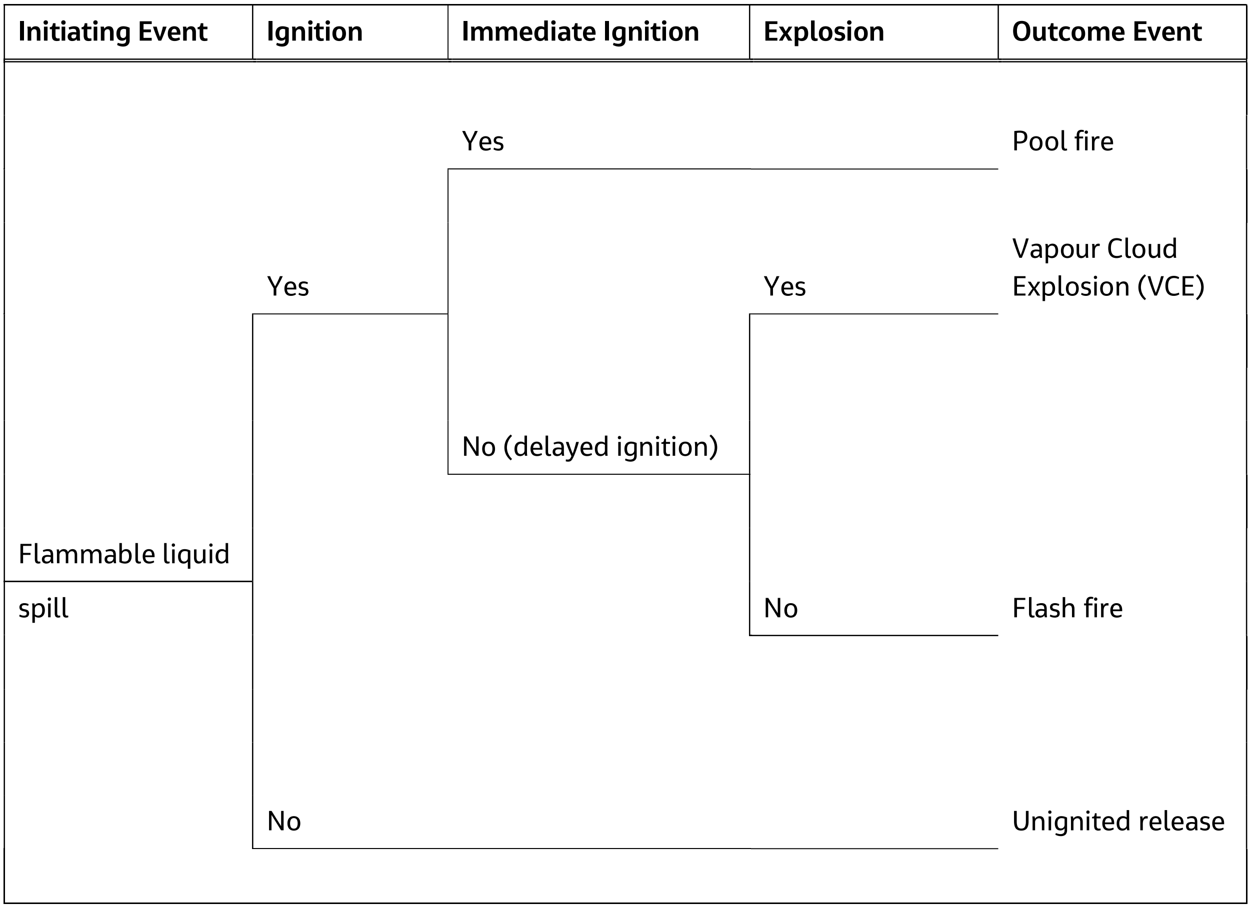


Figure 8.2: Event Tree Applied in FHA for Loss of Containment of Flammable Liquid



8.3.2 Event Tree Branch Probability

To determine the hazardous outcome event frequency from the initiating event frequency/ failure frequency, each branch of the event tree was assigned a probability. The following sub-sections describe the event tree branch probabilities applied in the FHA, sources of which are based on industry best practice for quantitative risk assessments.

8.3.2.1 Ignition Probability

Look-up correlations have been developed by professional bodies to assign ignition probabilities to accidental flammable releases in a quantitative risk assessment. The Energy Institute, London (EI)'s *Guidance on assigning ignition probabilities in onshore and offshore quantitative risk assessments*, Ref. [19], contains a series of simple, mass release rate-based ignition probability look-up correlations for a range of representative onshore and offshore scenarios. The various situations therein were reviewed, and the following scenarios were selected and used in this FHA as applicable:

- Scenario No. 8: Large Plant Gas LPG (Gas or LPG release from large onshore plant)
- Scenario No. 11: Large Plant Confined Gas LPG (Gas or LPG release from a large confined or congested onshore plant)
- Scenario No. 30: Tank Liquid - diesel, fuel oil (Liquid release from onshore tank farm of liquids below their flash point, e.g. diesel or fuel oil)
- Scenario No. 10: Large Plant Liquid Bund (Liquid release from large onshore plant where spill is bunded)

Table 8.9 to Table 8.12 detail the application of Scenario No. 8, 11, 30, and 10, respectively, along with data points for the respective function/ curve relating ignition probability to mass release rate.

Table 8.9: Scenario No. 8 and Ignition Probabilities as a Function of Mass Release Rates

Scenario No. 8 – Large Plant Gas LPG (Gas or LPG release from large onshore plant)	
Application: Releases of flammable gases, vapour or liquids significantly above their normal (NAP) boiling point from large onshore outdoor plants (plant area above 1,200 m^2, site area above 35,000 m^2)	
Mass Release Rate (kg/s)	**Ignition Probability**
0.1	0.0011
0.3	0.001627
0.5	0.001953
0.7	0.002201
1	0.0025
3	0.0075
5	0.0125
7	0.0175
10	0.025
30	0.075
50	0.125
70	0.175
100	0.25
300	0.65
500	0.65
700	0.65
1000	0.65
3000	0.65
5000	0.65
7000	0.65
10000	0.65

Table 8.10: Scenario No. 11 and Ignition Probabilities as a Function of Mass Release Rates

Scenario No. 11 – Large Plant Confined Gas LPG (Gas or LPG release from a large confined or congested onshore plant)	
Application: Releases of flammable gases, vapour or liquids significantly above their normal (NAP) boiling point from large onshore plants (plant area above 1,200 m^2, site area above 35,000 m^2), where the plant is partially walled/ roofed or within a shelter or very congested	
Mass Release Rate (kg/s)	**Ignition Probability**
0.1	0.0011
0.3	0.001627
0.5	0.001953
0.7	0.002201
1	0.0025
3	0.009463
5	0.017572
7	0.026416
10	0.040695
30	0.154035
50	0.28603
70	0.43
100	0. 481537
300	0.682423
500	0.7
700	0.7
1000	0.7
3000	0.7
5000	0.7
7000	0.7
10000	0.7

Table 8.11: Scenario No. 30 and Ignition Probabilities as a Function of Mass Release Rates

Scenario No. 30 – Tank Liquid - diesel, fuel oil (Liquid release from onshore tank farm of liquids below their flash point, e.g. diesel or fuel oil)	
Application: Releases of combustible liquids stored at ambient pressure and at temperatures below their flash point (e.g. most gas oil, diesel, fuel oil storage tanks) from onshore outdoor storage area 'tank farm'. This look-up correlation can be applied to releases from tanks and low-pressure transfer lines or pumps in the tank farm/ storage area. However, it should not be used for high-pressure systems (over a few barg).	
Mass Release Rate (kg/s)	**Ignition Probability**
0.1	0.001
0.3	0.001012
0.5	0.001017
0.7	0.001021
1	0.001025
3	0.001104
5	0.001144
7	0.00117
10	0.001426
30	0.0024
50	0.0024
70	0.0024
100	0.0024
300	0.0024
500	0.0024
700	0.0024
1000	0.0024
3000	0.0024
5000	0.0024
7000	0.0024
10000	0.0024

Table 8.12: Scenario No. 10 and Ignition Probabilities as a Function of Mass Release Rates

Scenario No. 10 – Large Plant Liquid Bund (Liquid release from large onshore plant where spill is bunded)	
Application: Releases of flammable liquids that do not have any significant flash fraction (10 % or less) if released from large onshore outdoor plants (plant area above 1,200 m^2, site area above 35,000 m^2) and where the liquid releases from the plant area are suitably bunded or otherwise contained	
Mass Release Rate (kg/s)	**Ignition Probability**
0.1	0.0011
0.3	0.001596
0.5	0.001898
0.7	0.002127
1	0.0024
3	0.005843
5	0.008837
7	0.011605
10	0.015492
30	0.037716
50	0.05
70	0.05
100	0.05
300	0.05
500	0.05
700	0.05
1000	0.05
3000	0.05
5000	0.05
7000	0.05
10000	0.05

As hydrogen (H_2) is a very reactive substance; the ignition probability from the look-up correlation was doubled, subject to a maximum of 1, in line with the approach specified in EI's *Guidance on assigning ignition probabilities in onshore and offshore quantitative risk assessments*, Ref. [19].

8.3.2.2 Immediate/ Delayed Ignition Probability

For flammable gas release, a 50:50 distribution between immediate and delayed ignitions was applied in the FHA, which is based on EI's *Guidance on assigning ignition probabilities in onshore and offshore quantitative risk assessments*, Ref. [19].

For flammable liquid release, a 30:70 distribution between immediate and delayed ignitions was applied in the FHA, which is based on EI's *Guidance on assigning ignition probabilities in onshore and offshore quantitative risk assessments*, Ref. [19].

8.3.2.3 Explosion Probability

Table 8.13 presents the explosion probabilities as a function of release rates applied in the FHA, which are based on Flemish Government's *Background Information – Appendix to Handbook Failure Frequencies 2009 for drawing up a safety report*, Ref. [20].

Table 8.13: Explosion Probabilities as a Function of Release Rates

Release Rate		**Probability of Explosion**			
Continuous (kg/s)	**Instantaneous (kg)**	**Group 0 (1)**	**Group 1 (2)**	**Group 2 (3)**	**Group 1 (4)**
< 10	< 1000	0.2	0.2	-	-
10 - 100	1000 - 10000	0.3	0.2	-	-
> 100	> 10000	0.4	0.2	-	-

Notes:

1) Group 0: The product is in a gaseous state, the product is above the atmospheric boiling point or the atmospheric boiling point of the product is lower than or equal to -25°C.
2) Group 1: The product is at or above the flash point, but below the atmospheric boiling point.
3) Group 2: The product is at a temperature which is less than 35°C below the flash point.
4) Group 3: The product is at a temperature which is 35°C or more below the flash point.

8.4 Operating Factor

The Hunter Power Station is permitted to operate at a capacity factor of up to 10% (876 hours) per year on natural gas and up to 2% (175 hours) per year on diesel. For the remaining 88% of the time in a year, the gas turbines will be in a non-generating state. While the gas turbines are not operating, it has been assumed that natural gas will remain within the plant up to the main Double Block and Bleed (DBB) valves local to each gas turbine. The operator will purge/ vent the gas downstream of the last block valve, but the other piping upstream remains charged with gas. As an initial (conservative) approach to the FHA, all processes, including downstream of the DBB valves local to each gas turbine, were considered to be pressurised/ charged all the time; i.e. no operating factors applied in the frequency analysis in this FHA.

8.5 Presence Factor

As described in Section 3.3.1, the diesel road tanker will enter the power station site during and or after each diesel run to refill the diesel fuel in the diesel storage tanks. The failure frequency calculated for a diesel road tanker is adjusted for the portion of time that the diesel tanker is present within the power station per annum. Table 8.14 derives the presence factor applied in the determination of failure frequency for the diesel tanker.

Table 8.14: Presence Factor for Diesel Tanker

Parameter	**Designation**	**Value**
Frequency of gas turbine running on diesel	[A]	175 hours per year
Repetition of each diesel run	[B]	3 consecutive days
Duration of each diesel run	[C]	Up to 10 hours per day
Diesel consumption per 3-day diesel run	[D]	2 x 1845 m^3 (diesel storage tank unit capacity)
Diesel consumption rate	[E]=[D]/ ([B]x[C])	123 m^3/hr

Parameter	Designation	Value
Capacity of diesel tanker	[F]	50 m^3 (diesel tanker unit capacity)
Number of diesel tankers received per year	[G]=[A]x[E]/ [F]	431
Unloading duration per diesel tanker	[H]	1 hour
Presence factor	[G]x[H]/ (365 days x 24 hours)	0.049201

8.6 Parts Count Record

The parts count record for each of the accident scenarios identified for the Hunter Power Station are presented in Appendix D. Regarding pipe lengths, these were estimated based on designated pipe routing overlaid on the plant layout. The pipe lengths estimated for this FHA were generally aligned with the plant designer's final detailed design, with the exception of a few areas where there were minor differences. Jacobs have assessed these differences and determined that they will have no material impact on the overall risk result conclusions.

8.7 Failure Frequency and Event Frequency

The failure cases assessed for each of the accident scenarios identified for the Hunter Power Station, along with the failure frequencies, are presented in Appendix E. Potential hazardous outcome events resulting from the failure cases are also presented in Appendix E, along with the event frequencies.

9. Risk Analysis

9.1 Overview

Risk is the likelihood of any defined adverse outcome. The risk of a particular outcome at a specific location can be estimated by summing the likelihood of all events that could lead to that outcome at that location. Depending on the particular outcome, e.g. fatality to an individual, injury to an individual, and damage to a property and accident propagation, this is known as individual fatality risk, individual injury risk, and property damage and accident propagation risk, respectively. It is also possible to estimate the total number of people affected by each possible accident; this is known as societal risk. For this FHA, risk calculations were performed using Gexcon's *Riskcurves Version 11.5* software.

From a risk analysis perspective associated with a Final Hazard Analysis, the risk calculations are calculated to determine the overall Project or sitewide risk, i.e. the risk representing the entire power station. While worst case consequences are described and analysed in Section 7.12, these consequences (following integration with their likelihood of occurrence) may or may not contribute significantly to the sitewide risk. For example, the worst case flash fire (generated from the Hydrogen Tube Trailer in the event that all tube valves fail and releases all the content) is associated with a distance to LFL concentration contour that could extend offsite by more than 500 m. Nevertheless though, the likelihood of occurrence is very low (in the order of 10^{-9}), and as such, its risk level is not dominating and hence is not the top contributor to the overall Project risk (see Table 10.1 to Table 10.3).

Risk results were then compared against all relevant criteria. HIPAP No. 4, Ref. [3], sets out risk criteria to be considered when assessing the risks posed by a potentially hazardous development to the surrounding land uses, which were adopted in this FHA. HIPAP No. 4 guideline suggests risk criteria for various types of risk. Individual risk/ property damage risk criteria are suggested, which considers the acceptability of a particular level of risk to an exposed individual/ property. Societal risk criteria are suggested, which takes into account society's aversion to accidents which can result in multiple fatalities.

The subsequent sections describe the various risk calculations and risk criteria.

9.2 Individual Fatality Risk

'Individual fatality risk' is the risk of death to a person at a particular point. The calculation of individual fatality risk involves the use of correlations to establish a connection between the various effects/ consequences and fatality probabilities. Table 9.1 describes the correlations adopted in the calculation of fatality risk in this FHA.

Table 9.1: Fatality Risk Calculation – Correlations Used

Effect/ Consequence	Correlation to Fatality Probability	Remark
Thermal radiation from fire, e.g. fireball, jet fire, pool fire	Probit function: $Pr = -36.38 + 2.56 \ln (q^{4/3} \times t)$ where: Pr is the probit value to be converted to a percentage of mortality q is the thermal radiation level [W/m^2] t is the exposure duration [s], which is assumed to be maximum 20 seconds	The probit formula used is from 'Green Book', Ref. [13].
Flash fire	LFL concentration – 100% chance of fatality to a person in the open	The relation used is based on industry practice for quantitative risk assessment.

Effect/ Consequence	Correlation to Fatality Probability	Remark
Overpressure from explosion, e.g. VCE	▪ 35 kPa (5 psi) – 15% chance of fatality to a person in the open ▪ 70 kPa (10 psi) – 100% chance of fatality to a person in the open	The relation used is based on HIPAP No. 4, Ref. [3].

Table 9.2 presents the criteria applied in the FHA for assessment of individual fatality risk, which are based on HIPAP No. 4, Ref. [3], recommendation.

Table 9.2: Individual Fatality Risk Criteria

Land Use	Suggested Criteria
Hospitals, schools, child-care facilities, old age housing development	Should not be exposed to individual fatality risk level of 0.5×10^{-6} per year
Residential developments and places of continuous occupancy such as hotels and tourist resorts	Should not be exposed to individual fatality risk level of 1×10^{-6} per year
Commercial developments including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres	Should not be exposed to individual fatality risk level of 5×10^{-6} per year
Sporting complexes and active open space areas	Should not be exposed to individual fatality risk level of 10×10^{-6} per year
Industrial sites	Should not be exposed to individual fatality risk level of 50×10^{-6} per year

9.3 Individual Injury Risk

'Individual injury risk' is the risk of injury to a person at a particular point. The calculation of individual injury risk is set around certain levels of effects/ consequences that may cause injury to people but may not necessarily cause fatality.

For calculation of injury risk due to thermal radiation from fire (e.g. fireball, jet fire, pool fire), 4.7 kW/m^2 is set as the injurious level in this FHA, which is in line with the suggestion in HIPAP No. 4, Ref. [3]. Based on HIPAP No. 4, Ref. [3], a thermal radiation level of 4.7 kW/m^2 will cause pain in 15 to 20 seconds and cause injury after 30 seconds' exposure (at least second-degree burns will occur).

For calculation of injury risk due to overpressure from explosion (e.g. VCE), 7 kPa is set as the injurious level in this FHA, which is in line with the suggestion in HIPAP No. 4, Ref. [3]. Based on HIPAP No. 4, Ref. [3], an explosion overpressure level of 7 kPa will cause damage to internal partitions and joinery but can be repaired, and the probability of injury is 10% with no fatality.

Table 9.3 presents the criteria applied in the FHA for assessment of individual injury risk, which are based on HIPAP No. 4, Ref. [3], recommendation.

Table 9.3: Individual Injury Risk Criteria

Land Use	Injurious Level	Suggested Criteria
Residential and sensitive use areas	4.7 kW/m^2 thermal radiation level	Should not exceed a risk level of 50×10^{-6} per year

Land Use	Injurious Level	Suggested Criteria
Residential and sensitive use areas	7 kPa explosion overpressure level	Should not exceed a risk level of 50 x 10^{-6} per year
Residential and sensitive use areas	Toxic concentration which could be seriously injurious to sensitive members of the community following a relatively short period of exposure	Should not exceed a risk level of 10 x 10^{-6} per year
Residential and sensitive use areas	Toxic concentration which will cause irritation to eyes or throat, coughing, or other acute physiological responses in sensitive members of the community	Should not exceed a risk level of 50 x 10^{-6} per year

9.4 Property Damage and Accident Propagation Risk

'Property damage and accident propagation risk' is the risk of an accident at the installation causing damage to buildings and propagating to a neighbouring industrial operation, and hence, initiating further hazardous incidents (the so-called 'domino effect'). The calculation of property damage and accident propagation risk is set around certain levels of effects/ consequences that may trigger another accident at another neighbouring plant.

For calculation of property damage and accident propagation risk due to thermal radiation from fire (e.g. fireball, jet fire, pool fire), 23 kW/m^2 is set as the damage/ propagation level in this FHA, which is in line with the suggestion in HIPAP No. 4, Ref. [3]. Based on HIPAP No. 4, Ref. [3], a thermal radiation level of 23 kW/m^2 will cause spontaneous ignition of wood after a long exposure, cause unprotected steel to reach thermal stress temperatures that may cause structural failure, and require pressure vessel to be relieved or failure could occur.

For calculation of property damage and accident propagation risk due to overpressure from explosion (e.g. VCE), 14 kPa is set as the damage/ propagation level in this FHA, which is in line with the suggestion in HIPAP No. 4, Ref. [3]. Based on HIPAP No. 4, Ref. [3], an explosion overpressure level of 14 kPa may cause damage to piping and (low-pressure) equipment at a neighbouring plant, and cause house uninhabitable and badly cracked.

Table 9.4 presents the criteria applied in the FHA for assessment of property damage and accident propagation risk, which are based on HIPAP No. 4, Ref. [3], recommendation.

Table 9.4: Property Damage and Accident Propagation Risk Criteria

Land Use	Damage/ Propagation Level	Suggested Criteria
Neighbouring potentially hazardous installations, or land zoned to accommodate such installations	23 kW/m^2 thermal radiation level	Should not exceed a risk level of 50 x 10^{-6} per year
Neighbouring potentially hazardous installations, or land zoned to accommodate such installations	14 kPa explosion overpressure level	Should not exceed a risk level of 50 x 10^{-6} per year

9.5 Societal Risk

'Societal risk' is defined as the frequency that a group of a specific size becomes a lethal victim to a single event or a range of events. Societal risk is presented in a FN-curve, which is obtained by plotting the frequency at which such events might kill N or more people (F), against the number of lethal victims (N). The FN-curve is depicted as a two-dimensional graph, using a logarithmic scale on both X-axis and Y-axis.

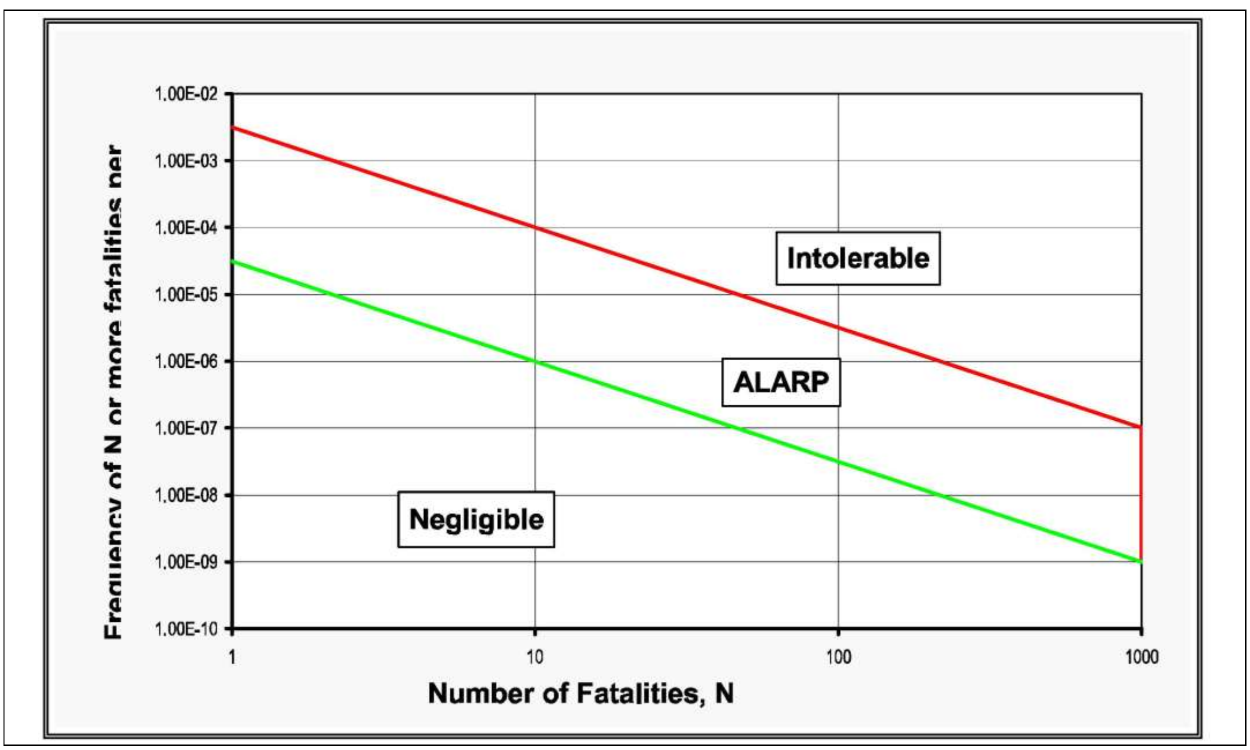
To perform societal risk calculations, the risk model within the software package was set up based on the following key input:

- **Population (society) exposed to risk**. Section 2.4 describes the external populations around the Project site. Each population was entered into the risk model by adding a polygon and defining the polygon's area/ shape, population density at day, and population density at night. The population on the Project site itself was not included in the societal risk calculation; this is the convention in societal risk calculation whereby the population on the site that is the source of risk is not included in the total population.
- **Inside fraction**. 'Inside fraction' is a measure of the portion of population that is inside (houses, buildings, etc.) and therefore, has some degree of protection from harmful effects such as thermal radiation. The following inside fractions were applied in the societal risk calculation, which are in line with industry practice for quantitative risk assessments:
  - 90% of the day-time populations is inside
  - 95% of the night-time populations is inside

Figure 9.1 presents the criteria applied in the FHA for assessment of societal risk, which are based on HIPAP No. 4, Ref. [3], recommendation. The suggested societal risk criteria incorporate the broad As Low As Reasonably Practicable (ALARP) principle approach, reflecting the following three societal risk bands:

- **Negligible**. Within the 'Negligible' region, provided other individual risk criteria are met, societal risk is not considered significant.
- **ALARP**. Within the 'ALARP' region, the emphasis is on reducing risks as far as possible towards the 'Negligible' region. Provided other quantitative and qualitative criteria of HIPAP No. 4, Ref. [3], are met, the risks from the activity would be considered tolerable.
- **Intolerable**. Within the 'Intolerable' region, the activity is considered undesirable, even if other individual risk criteria are met.

Figure 9.1: Societal Risk Criteria



10. Presentation of Risk Results

10.1 Overview

This section presents the risk results to enable assessment against all relevant criteria. For individual and property damage risks, the results are commonly presented as contours, which connect points of equal risk around the Hunter Power Station. For societal risk, the result is commonly presented as a graph, called an F-N curve, which is a plot of cumulative frequency (F) versus consequences measured as number of fatalities (N).

This section also highlights the top risk contributors associated with the various types of risk.

In addition, this section discusses the sensitivity of the results to a potential change in a key assumption, i.e. the composition of the natural gas fuel supplied to the plant, where Rich Gas was modelled as the base case in the FHA. A sensitivity analysis was carried out to determine the effect of using Lean Gas on the risk results.

10.2 Individual Fatality Risk

Figure 10.1 presents the individual fatality risk contours generated for the Hunter Power Station.

- The 0.5 x 10^{-6} per year contour extends outside the site boundary largely across the western side, with an offsite distance of 57 metres. This contour encroaches lands zoned as heavy industrial and rural landscape, but does not reach any hospitals, schools, child-care facilities, or old age housing development.
- The 1 x 10^{-6} per year contour extends outside the site boundary again largely across the western side, with an offsite distance of 39 metres. This contour encroaches lands zoned as heavy industrial and rural landscape but does not reach any residential developments and places of continuous occupancy such as hotels and tourist resorts.
- The 5 x 10^{-6} per year contour extends slightly outside the site boundary in the Northwest direction, with offsite distance of 5 metres. This contour encroaches lands zoned as heavy industrial, but does not reach any commercial developments including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres.
- The 10 x 10^{-6} per year contour is confined entirely within the site boundary and does not reach any sporting complexes and active open space areas.
- The 50 x 10^{-6} per year contour is confined entirely within the site boundary for industrial land use.

The top risk contributors associated with Individual Fatality Risk are listed in Table 10.1. The harm footprints integrated with harm frequencies to generate the Individual Fatality Risk are detailed in Appendix F.

Figure 10.1: Individual Fatality Risk Contours

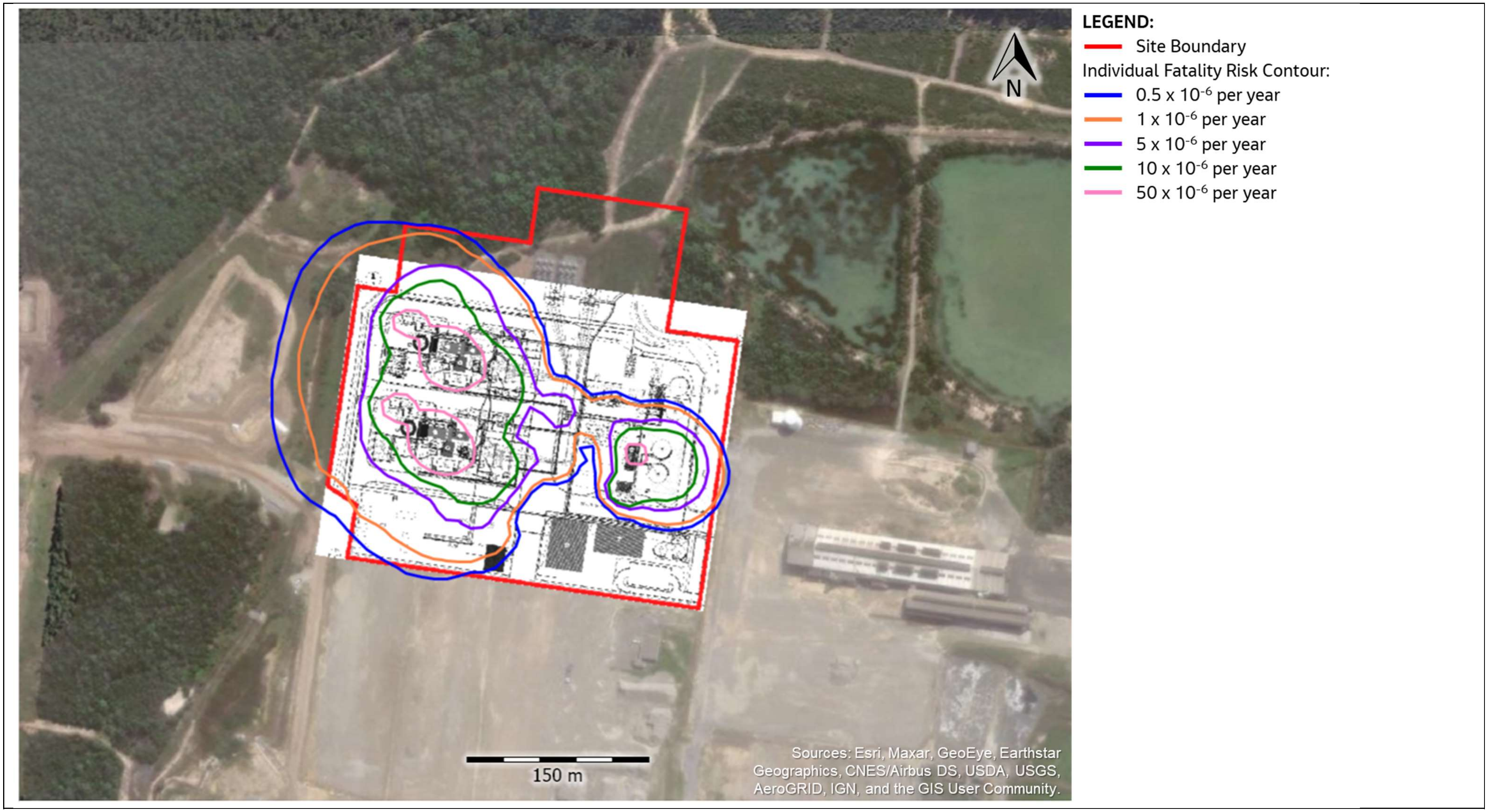


Table 10.1: Top Risk Contributors Associated with Individual Fatality Risk

No.	Section ID	Section Description	Failure Case	Individual Risk (per year)	Risk Contribution (%)
1.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	R	9.02E-07	46.5
2.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	75mm	3.97E-07	20.55
3.	S012b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Heater and connected piping	R	2.82E-07	14.6
4.	S011b_HPS_VES_RICH	Hunter Power Station - Power Island No. 2 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater	75mm	1.08E-07	5.59
5.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	25mm	8.56E-08	4.42
6.	S010b_HPS_VES_RICH	Hunter Power Station - Power Island No. 2 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	75mm	5.23E-08	2.7
7.	S020_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment before pressure regulation	10mm	3.84E-08	1.98
8.	S012b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Heater and connected piping	75mm	2.04E-08	1.05
9.	S008_HPS_SDV_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)	R	2.04E-08	1.05

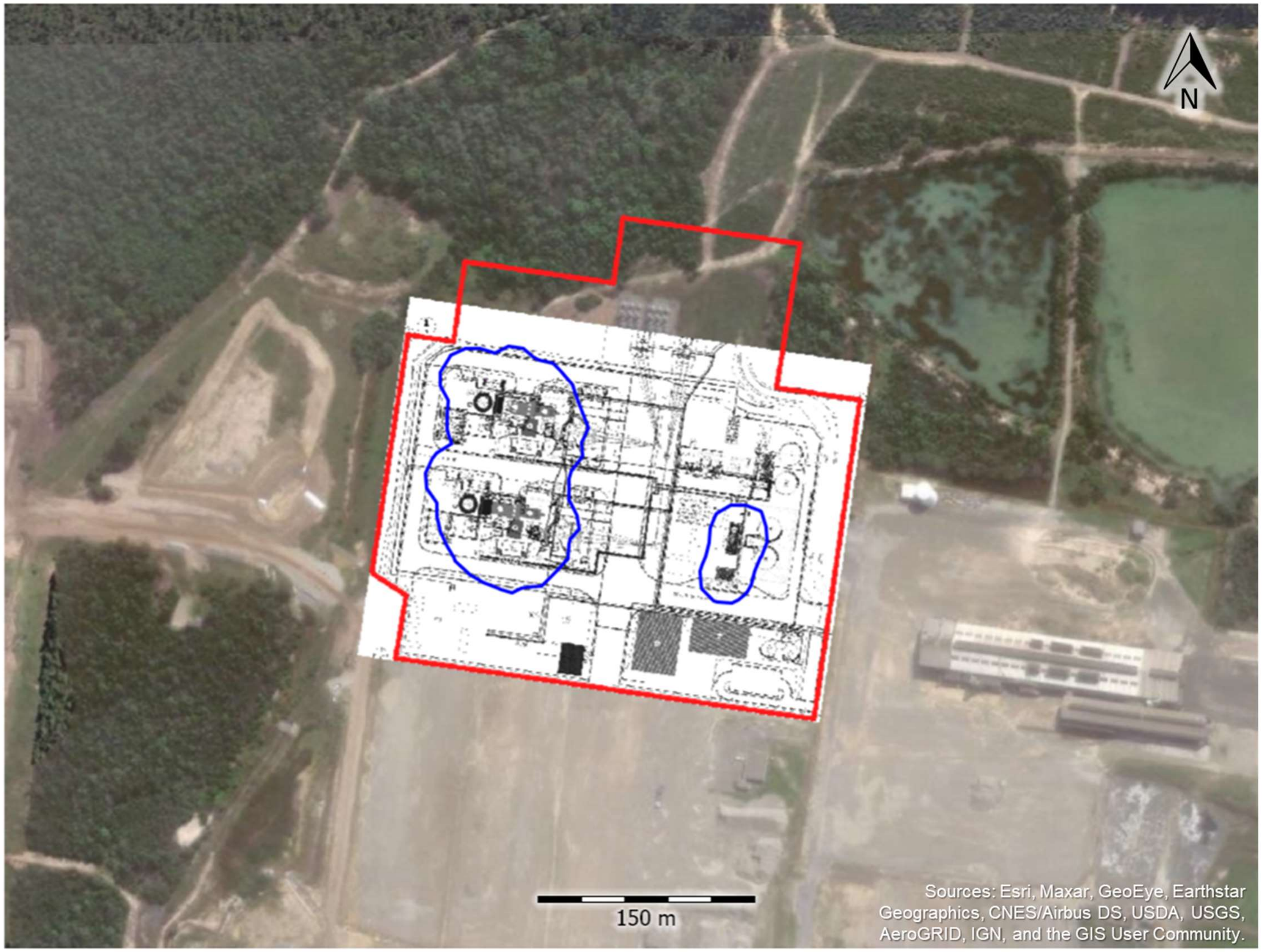
10.3 Individual Injury Risk

Figure 10.2 presents the individual injury risk contour for the thermal radiation threshold, generated for the Hunter Power Station.

- The 50 x 10^{-6} per year contour for 4.7 kW/m^2 thermal radiation threshold is confined entirely within the site boundary and does not extend to any residential or sensitive use areas.
- For individual injury risk due to 7 kPa explosion overpressure threshold, the iso-risk level of 50 x 10^{-6} per year is not reached.

The top risk contributors associated with Individual Injury Risk due to thermal radiation impact are listed in Table 10.2. The harm footprints integrated with harm frequencies to generate the Individual Injury Risk are detailed in Appendix F.

Figure 10.2: Individual Injury Risk Contour, Risk from 4.7 kW/m^2 Thermal Radiation Threshold



LEGEND:

- Site Boundary

Individual Injury Risk Contour, Risk from 4.7 kW/m^2 Thermal Radiation Threshold:

- 50 x 10^{-6} per year

Table 10.2: Top Risk Contributors Associated with Individual Injury Risk due to Thermal Radiation Impact

No.	Section ID	Section Description	Failure Case	Individual Risk (per year)	Risk Contribution (%)
Analysis Point within Power Island					
1.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	25mm	1.21E-04	26.3
2.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	25mm	9.55E-05	20.8
3.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	R	8.71E-05	19
4.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	R	6.88E-05	15
5.	S014b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	R	1.58E-05	3.44
6.	S014a_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	R	1.40E-05	3.04
7.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	75mm	8.29E-06	1.8
8.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	75mm	6.54E-06	1.42
9.	S015b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 2 - Release from 5m3 Drips Tank and connected piping	R	6.01E-06	1.31
10.	S013b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Cartridge Filter and connected piping up to Shut Off Valve within Gas Turbine Fuel Gas Supply Unit	R	5.73E-06	1.25

No.	Section ID	Section Description	Failure Case	Individual Risk (per year)	Risk Contribution (%)
<u>Analysis Point within Diesel Facilities</u>					
1.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	10mm	7.87E-05	50.8
2.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	25mm	2.38E-05	15.4
3.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	R	2.25E-05	14.5
4.	S004_HPS_TNK_DSEL	Hunter Power Station - Release from 1845m3 Diesel Fuel Storage Tank	150mm	1.20E-05	7.75
5.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	75mm	1.01E-05	6.52
6.	S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	75mm	3.90E-06	2.52
7.	S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	R	1.95E-06	1.26

10.4 Property Damage and Accident Propagation Risk

Figure 10.3 presents the property damage and accident propagation risk contour for thermal radiation threshold, generated for the Hunter Power Station.

- The 50 x 10^{-6} per year contour for 23 kW/m^2 thermal radiation threshold is confined entirely within the site boundary and does not extend to neighbouring potentially hazardous installations or land zoned to accommodate such installations.
- For property damage and accident propagation risk due to 14 kPa explosion overpressure threshold, the iso-risk level of 50 x 10^{-6} per year is not reached.

The top risk contributors associated with Property Damage and Accident Propagation Risk due to thermal radiation impact are listed in Table 10.3. The harm footprints integrated with harm frequencies to generate the Property Damage and Accident Propagation Risk are detailed in Appendix F.

Figure 10.3: Property Damage and Accident Propagation Risk Contour, Risk from 23 kW/m^2 Thermal Radiation Threshold

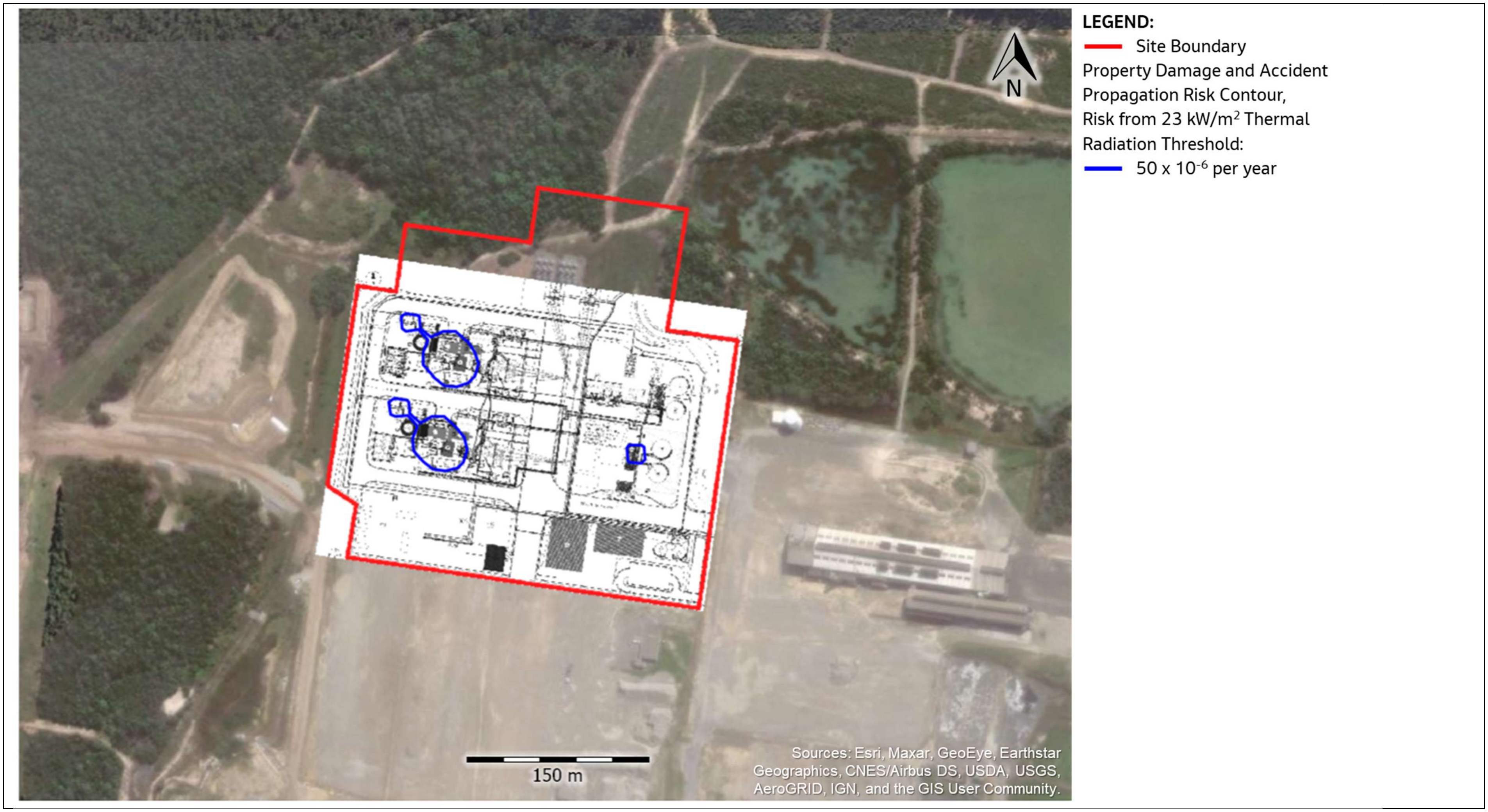


Table 10.3: Top Risk Contributors Associated with Property Damage and Accident Propagation Risk due to Thermal Radiation Impact

No.	Section ID	Section Description	Failure Case	Individual Risk (per year)	Risk Contribution (%)
Analysis Point within Power Island No. 1					
1.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	10mm	6.66E-04	65.8
2.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	25mm	1.84E-04	18.2
3.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	R	1.33E-04	13.1
4.	S007a_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	75mm	1.26E-05	1.25
Analysis Point within Power Island No. 2					
1.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	10mm	6.66E-04	66.2
2.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	25mm	1.84E-04	18.3
3.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	R	1.33E-04	13.2
4.	S007b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	75mm	1.26E-05	1.26
Analysis Point within Diesel Facilities					
1.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	10mm	2.84E-05	27.9
2.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	25mm	2.38E-05	23.4

No.	Section ID	Section Description	Failure Case	Individual Risk (per year)	Risk Contribution (%)
3.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	R	2.25E-05	22.1
4.	S004_HPS_TNK_DSEL	Hunter Power Station - Release from 1845m3 Diesel Fuel Storage Tank	150mm	1.20E-05	11.8
5.	S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	75mm	1.01E-05	9.92
6.	S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	75mm	2.17E-06	2.14
7.	S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	25mm	1.11E-06	1.09
8.	S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	R	1.09E-06	1.07

10.5 Societal Risk Results

The FN-curve was not activated or generated from the societal risk calculation as part of this analysis, primarily because the lands in the vicinity of the power station are largely zoned as 'Rural Landscape' (unoccupied), 'Heavy Industrial', and 'General Industrial', which have a very low population density. The power station boundary is at a minimum over one kilometre away from the closest land users (other than commercial/ industrial) considered to be a sensitive receptor or having continuous occupation; i.e. the risk from the power station does not reach the closest residence and is contained within the industrial areas. Thus, the power station is not expected to give rise to societal concerns, over a potential to create multiple fatalities, due to being below the FN-curve limits.

10.6 Sensitivity Analysis

As described in Section 7.3, Rich Gas was modelled as the base case in the FHA. To gauge any material differences in the risk results as a result of potentially receiving Lean Gas in the future, the risk calculation analysis was re-run using Lean Gas. The resulting risk contours all remain in compliance with all the HIPAP No. 4, Ref. [3], criteria as confirmed in the following Table 10.4.

Table 10.4: Sensitivity Case Risk Results Assessment

Risk Type	Risk Contour	Risk Criterion Met?
Individual Fatality Risk	0.5×10^{-6}	Yes. This contour does not reach any hospitals, schools, child-care facilities, or old age housing development.
Individual Fatality Risk	1×10^{-6}	Yes. This contour does not reach any residential developments and places of continuous occupancy such as hotels and tourist resorts.
Individual Fatality Risk	5×10^{-6}	Yes. This contour does not reach any commercial developments including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres.
Individual Fatality Risk	10×10^{-6}	Yes. This contour does not reach any sporting complexes and active open space areas.
Individual Fatality Risk	50×10^{-6}	Yes. This contour is contained within the site boundary for industrial land uses.
Individual Injury Risk (due to thermal radiation impact)	50×10^{-6}	Yes. This contour is confined within the site boundary and does not extend to any residential and sensitive use areas.
Individual Injury Risk (due to explosion overpressure impact)	50×10^{-6}	Iso-risk level is not reached
Property Damage and Accident Propagation Risk (due to thermal radiation impact)	50×10^{-6}	Yes. This contour is confined within the site boundary and does not extend to neighbouring potentially hazardous

Risk Type	Risk Contour	Risk Criterion Met?
		installations or land zoned to accommodate such installations.
Property Damage and Accident Propagation Risk (due to explosion overpressure impact)	50×10^{-6}	Iso-risk level is not reached

11. Risk Assessment

11.1 Overview

The section presents an assessment/ comparison of the risk results against the relevant criteria.

11.2 Comparison with Qualitative Risk Criteria

Criterion (a): All 'avoidable' risks should be avoided

The Project site is located in the small suburb of Loxford in the Hunter Valley region of New South Wales, approximately 3 km north of the town of Kurri Kurri. The location of the power station is on the location of a decommissioned aluminium smelter and it is within a future industrial estate that will incorporate both general and heavy industrial operation. There are no residential and sensitive areas in close proximity to the Project site. The closest residential-zoned lands are within Heddon Greta and Cliftleigh, located approximately 2.5 km east of the Project site. There are some sparse, rural residential properties to the south and south-east of the Project site, the nearest being located on Dawes Avenue, Loxford, which is approximately 1.15 km south-east of the Project site. From a land use planning perspective, the site location is considered as appropriate for the Project.

In terms of the technology, the design being implemented by Snowy Hydro does not involve any unproven or novel technology or methods. The hazards and risks associated with the un-known or un-proven technology has been avoided.

Criterion (b): The risk from a major hazard should be reduced wherever practicable, irrespective of the numerical value of the cumulative risk level from the whole installation.

The top contributors to the resultant risk/ Individual Fatality Risk have been identified in Table 10.1. The safeguards associated with these top risk contributors were also reviewed in Table 11.1. The safeguards were considered as relevant and appropriate in reducing the associated hazard and risk.

The worst case scenarios have been identified in Table 7.5. The safeguards associated with these worst case scenarios were also reviewed in Table 11.2. The safeguards were again considered as relevant and appropriate in reducing the associated hazard and risk.

As part of the risk management and to keep the risk ALARP, Snowy Hydro has conducted a number of process safety studies such as HAZOPs, LOPA and Safety in Designs for the Project to further improve the process safety on site and to reduce the hazards and safety risk. Snowy Hydro will actively monitor and close out the action items/ recommendations raised in each of these process safety studies.

Table 11.1: Top Contributors to Resultant Risk (Individual Fatality Risk) and Associated Safeguards

No.	Section ID	Section Description	Failure Case	Safeguard
1.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	R	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)
2.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	75mm	
3.	S012b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Heater and connected piping	R	
4.	S011b_HPS_VES_RICH	Hunter Power Station - Power Island No. 2 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater	75mm	
5.	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	25mm	
6.	S010b_HPS_VES_RICH	Hunter Power Station - Power Island No. 2 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	75mm	
8.	S012b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Heater and connected piping	75mm	
9.	S008_HPS_SDV_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)	R	

No.	Section ID	Section Description	Failure Case	Safeguard
7.	S020_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment before pressure regulation	10mm	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Downstream of the hydrogen storage area, the connecting fixed piping and pressure reduction panels are fitted with pressure relief valves to provide overpressure protection. ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system

No.	Section ID	Section Description	Failure Case	Safeguard
				▪ Emergency Response Plan (ERP)

Table 11.2: Worst Case Scenarios and Associated Safeguards

Hazard Type	Section ID	Section Description	Failure Case	Safeguard
Pool fire, 4.7 kW/m^2 thermal radiation contour	S004_HPS_TNK_DSEL	Hunter Power Station - Release from 1845m^3 Diesel Fuel Storage Tank	150mm/ 500mm/ R	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main diesel lines for emergency shutdown ▪ Spillage/ leak containment by bunding/ kerbing provided for diesel facilities including diesel unloading pumps, diesel storage tanks, diesel forwarding pumps, and diesel forwarding filters ▪ Fire detectors fitted to main diesel areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)

Hazard Type	Section ID	Section Description	Failure Case	Safeguard
Jet fire, 4.7 kW/m^2 thermal radiation contour	S008_HPS_SDV_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)	R	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)
	S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	R	
Fireball, 4.7 kW/m^2 thermal radiation contour	S010a_HPS_VES_RICH	Hunter Power Station - Power Island No. 1 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	R	
	S010b_HPS_VES_RICH	Hunter Power Station - Power Island No. 2 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	R	

Hazard Type	Section ID	Section Description	Failure Case	Safeguard
Flash fire, LFL concentration contour	S018_HPS_TRL_H2	Hunter Power Station - Release from Hydrogen Tube Trailer, 10 tubes per trailer	R	▪ Each tube in hydrogen trailer is protected with bursting disc and pressure relief valve. ▪ Pressure relief valves fitted to downstream connecting fixed piping and pressure reduction panels to provide overpressure protection ▪ Gas detectors fitted to respective manifold (tube trailer manifold and gas cylinder manifold) for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to respective manifold (tube trailer manifold and gas cylinder manifold) for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided in the vicinity of the hydrogen storage areas ▪ Fire hose reels provided in the vicinity of the hydrogen storage areas ▪ Fire hydrants provided in the vicinity of the hydrogen storage areas ▪ Portable fire extinguishers provided in the vicinity of the hydrogen storage areas ▪ Enforcement of vehicle speed limit in the plant ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)

Hazard Type	Section ID	Section Description	Failure Case	Safeguard
VCE, 7 kPa explosion overpressure contour	S014a_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	R	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)
	S014b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 2 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	R	

<u>Criterion (c): The consequences (effects) of the more likely hazardous events (i.e. those of high probability of occurrence) should, wherever possible, be contained within the boundaries of the installation.</u>

For the purpose of this FHA, 25 mm hole diameter leak scenarios were taken to represent the 'more likely' scenarios to occur on the site. Based on a review of all 25 mm hole diameter leak scenarios, several worst-case consequences/ effects were found to be not entirely contained within the site boundary, as listed in Table 11.3. Where the consequence contour was not able to be entirely contained within the site boundary, the maximum estimated offsite distances were in some cases minor and towards the western boundary of the site (which is not marked as having any future development activities) and the overall risk contour for that event did not exceed the criteria required.

The safeguards associated with these consequences/ effects were also reviewed in Table 11.3. The safeguards were considered as relevant and appropriate in reducing the associated consequences/ effects.

Table 11.3: More Likely Hazardous Events with Offsite Consequences/ Effects

Scenario ID	Scenario Description	Hazard Type	Harm Level	Weather Category	Hazard Distance (m)	Maximum Offsite Distance (m)	Safeguard
S008_HPS_SDV_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	F1	38	8	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)
S008_HPS_SDV_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	B2	35	5	
S008_HPS_SDV_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	D5	31	1	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Flash Fire	LFL	F1	15	3	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	F1	38	26	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Flash Fire	LFL	B2	15	3	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	B2	35	23	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Flash Fire	LFL	D5	15	3	
S009_HPS_PIP_RICH_25mm	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot); 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	D5	31	19	
S010a_HPS_VES_RICH_25mm	Hunter Power Station - Power Island No. 1 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping; 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	F1	34	9	
S010a_HPS_VES_RICH_25mm	Hunter Power Station - Power Island No. 1 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping; 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	B2	31	6	
S010a_HPS_VES_RICH_25mm	Hunter Power Station - Power Island No. 1 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping; 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	D5	28	3	

S011a_HPS_VES_RICH_25mm	Hunter Power Station - Power Island No. 1 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater; 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	F1	34	4	
S011a_HPS_VES_RICH_25mm	Hunter Power Station - Power Island No. 1 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater; 25 mm diameter hole size	Jet Fire	4.7 kW/m^2	B2	31	1	
S016a_HPS_VES_C10H22_25mm	Hunter Power Station - Power Island No. 1 - Release from Fuel Gas Knockout Pot (liquid segment) and connected piping; 25 mm diameter hole size	Pool Fire	4.7 kW/m^2	B2	26	1	
S022_HPS_PIP_H2_25mm	Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure reduction up to SDV upstream of Generator Hydrogen Gas Control Panel; 25 mm diameter hole size	Flash Fire	LFL	F1	147	79	▪ Asset design in accordance with relevant codes/ standards/ guidelines/ regulations/ acts ▪ Basic process control of various deviations involving flow, level, pressure, temperature, contamination/ composition, corrosion/ erosion ▪ Downstream the hydrogen storage, the connecting fixed piping and pressure reduction panels are fitted with pressure relief valves to provide overpressure protection. ▪ Isolation valves fitted to main gas lines for emergency shutdown ▪ Gas detectors fitted to main gas areas for detection of minor and major gas release events to trigger safe executive actions ▪ Fire detectors fitted to main gas areas for detection of a fire event to trigger safe executive actions ▪ Fire alarm system including manual call points, alarm bells, and strobe lights provided at various locations as required ▪ Fire hose reels provided at various locations as required ▪ Fire hydrants provided at various locations as required ▪ Portable fire extinguishers provided at various locations as required ▪ Site fencing and locking with controlled/ authorised personnel access only ▪ Site surveillance and monitoring through Closed-Circuit Television (CCTV) video camera installation at strategic locations across the site ▪ Plant emergency lighting system ▪ Plant emergency communication system ▪ Emergency Response Plan (ERP)
S023a_HPS_PIP_H2_25mm	Hunter Power Station - Power Island No. 1 - Release from Generator Hydrogen Gas Control Panel and charging to generator cooling circuit; 25 mm diameter hole size	Flash Fire	LFL	F1	125	46	
S023b_HPS_PIP_H2_25mm	Hunter Power Station - Power Island No. 2 - Release from Generator Hydrogen Gas Control Panel and charging to generator cooling circuit; 25 mm diameter hole size	Flash Fire	LFL	F1	125	24	

Criterion (d): Where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.

While this FHA assesses the risks associated with the Hunter Power Station only, the study recognises that there will be a potentially hazardous development, i.e. the gas supply infrastructure under the scope of a third party (APA Group), located adjacent to the Hunter Power Station. The Kurri Kurri Storage Station which incorporates a Compressor Station and Delivery Station (otherwise referred to as the Gas Receiving Station) will be built adjacent to the Hunter Power Station. APA has considered the cumulative impact of the plant in Section 7.3 "Propagation Risk" of their Preliminary Hazard Analysis[2] which was undertaken as part of their EIS assessment and concluded with the following:

> *A DN400 mm flange fire (jet fire or flash fire, depending on proximity of flanged connection to site boundary) at the compressor station and delivery station has the potential for off site propagation impacts on neighbouring industrial zoned land including the HPP. HIPAP 4 requires that the frequency of thermal radiation impacts at adjacent industrial facilities does not exceed 50 x 10^{-6} per year (refer to Table 6.1). As the estimated frequency of propagation impacts associated with a DN400 mm flange fire (i.e. approximately 1.25 x 10^{-6}) is less than 50 x 10^{-6} fatalities/year, the compressor station and delivery station are considered to meet the HIPAP 4 propagation risk criteria.*
>
> *It should be noted that no hazardous events associated with the HPP were identified in Hunter Power Project Hazard and Risk Assessment (Jacobs, 2021) with impacts that could result in propagation to the compressor station and delivery station (referred to as the Gas Receiving Station in the Jacobs report (2021)) at a frequency exceeding HIPAP 4 criteria.*

Subsequently, their PHA has demonstrated that the Hunter Power Station and neighbouring gas supply infrastructure are relatively independent in terms of the cumulative risk and hence there is not a requirement to undertake a fully integrated FHA between the neighbouring facilities, nor is it an approval condition in the Infrastructure Approval B.12(c) for the Hunter Power Station. It is anticipated that if the APA project receives planning approval, they will progress to detailed design and conduct their own FHA which will include confirming the conclusion with respect to the cumulative impact of the facilities.

11.3 Comparison with Quantitative Risk Criteria

11.3.1 Individual Fatality Risk

The Hunter Power Station's individual fatality risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as confirmed in the following Table 11.4.

Table 11.4: Individual Fatality Risk Assessment

Criterion Description	This Plant		
	Individual Fatality Risk Contour (per year)	**Maximum Offsite Distance (m)**	**Criterion Met?**
Hospitals, schools, child-care facilities and old age housing development should not be exposed to individual fatality risk levels in excess of half in one million per year (0.5 x 10^{-6}).	0.5 x 10^{-6}	57	Yes. This contour extends to lands zoned to heavy industrial and rural landscape only.

[2] Dated March 2022 and noted as "FINAL"

Criterion Description	This Plant		
	Individual Fatality Risk Contour (per year)	**Maximum Offsite Distance (m)**	**Criterion Met?**
Residential developments and places of continuous occupancy, such as hotels and tourist resorts, should not be exposed to individual fatality risk levels in excess of one in a million per year (1×10^{-6} per year).	1×10^{-6}	39	Yes. This contour extends to lands zoned to heavy industrial and rural landscape only.
Commercial developments, including offices, retail centres, warehouses with showrooms, restaurants and entertainment centres, should not be exposed to individual fatality risk levels in excess of five in a million per year (5×10^{-6} per year).	5×10^{-6}	5	Yes. This contour extends to lands zoned to heavy industrial only.
Sporting complexes and active open space areas should not be exposed to individual fatality risk levels in excess of ten in a million per year (10×10^{-6}).	10×10^{-6}	-	Yes. This contour is confined within the site boundary.
Individual fatality risk levels for industrial sites at levels of 50 in a million per year (50×10^{-6} per year) should, as a target, be contained within the boundaries of the site where applicable.	50×10^{-6}	-	Yes. This contour is confined within the site boundary.

11.3.2 Individual Injury Risk

The Hunter Power Station's individual injury risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as confirmed in the following Table 11.5.

Table 11.5: Individual Injury Risk Assessment

Criterion Description	This Plant		
	Individual Injury Risk Contour (per year)	**Maximum Offsite Distance (m)**	**Criterion Met?**
Incident heat flux radiation at residential and sensitive use areas should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year.	50×10^{-6}	-	Yes. This contour is confined within the site boundary.
Incident explosion overpressure at residential and sensitive use areas should not exceed 7 kPa at frequencies of more than 50 chances in a million per year.	50×10^{-6}	- [Note: This iso-risk level is not reached]	- [Note: This iso-risk level is not reached]

11.3.3 Property Damage and Accident Propagation Risk

The Hunter Power Station's property damage and accident propagation risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as confirmed in the following Table 11.6.

Table 11.6: Property Damage and Accident Propagation Risk Assessment

Criterion Description	This Plant		
	Property Damage and Accident Propagation Risk Contour (per year)	**Maximum Offsite Distance (m)**	**Criterion Met?**
Incident heat flux radiation at neighbouring potentially hazardous installations or at land zoned to accommodate such installations should not exceed a risk of 50 in a million per year for the 23 kW/m^2 heat flux level.	50×10^{-6}	-	Yes. This contour is confined within the site boundary.
Incident explosion overpressure at neighbouring potentially hazardous installations, at land zoned to accommodate such installations or at nearest public buildings should not exceed a risk of 50 in a million per year for the 14 kPa explosion overpressure level.	50×10^{-6}	- [Note: This iso-risk level is not reached]	- [Note: This iso-risk level is not reached]

11.3.4 Societal Risk

Societal risk is not generated for the Hunter Power Station as confirmed in the following Table 11.7.

Table 11.7: Societal Risk Assessment

Criterion Description	This Plant	
	Region that F-N Curve Falls Into	**Criterion Met?**
The societal risk criteria applied are based on the As Low As Reasonably Practicable (ALARP) approach, reflecting three societal risk bands, i.e. negligible, ALARP, and intolerable (see Section 9.5 with Figure 9.1 for complete details).	- [Note: F-N curve is not generated]	- [Note: F-N curve is not generated]

12. Conclusions

This FHA has concluded that the Hunter Power Station satisfies the risk criteria for land use safety planning as stipulated in HIPAP No. 4, Ref. [3].

The Hunter Power Station's individual fatality risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as described below:

- The 0.5 x 10^{-6} per year contour extends outside the site boundary largely across the western site boundary, with a maximum offsite distance of 57 metres. This contour encroaches lands zoned to heavy industrial and rural landscape, but does not reach any hospitals, schools, child-care facilities, or old age housing development.
- The 1 x 10^{-6} per year contour extends outside the site boundary largely across the western site boundary, with a maximum offsite distance of 39 metres. This contour encroaches lands zoned to heavy industrial and rural landscape but does not reach any residential developments and places of continuous occupancy such as hotels and tourist resorts.
- The 5 x 10^{-6} per year contour extends slightly outside the site boundary in the Northwest direction, with a maximum offsite distance of 5 metres. This contour encroaches lands zoned to heavy industrial, but does not reach any commercial developments including offices, retail centres, warehouses with showrooms, restaurants, and entertainment centres.
- The 10 x 10^{-6} per year contour is confined entirely within the site boundary, satisfying the criterion that this contour must not reach any sporting complexes and active open space areas.
- The 50 x 10^{-6} per year contour is confined entirely within the site boundary, satisfying the criterion that this contour must be contained within the site boundary for industrial land uses.

The Hunter Power Station's individual injury risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as described below:

- The 50 x 10^{-6} per year contour for 4.7 kW/m^2 thermal radiation threshold is confined entirely within the site boundary and does not extend to any residential and sensitive use areas.
- Iso-risk level of 50 x 10^{-6} per year for 7 kPa explosion overpressure threshold is not reached.

The Hunter Power Station's property damage and accident propagation risks, as determined in this FHA, satisfy all the HIPAP No. 4, Ref. [3], criteria as described below:

- The 50 x 10^{-6} per year contour for 23 kW/m^2 thermal radiation threshold is confined entirely within the site boundary and does not extend to neighbouring potentially hazardous installations or land zoned to accommodate such installations.
- Iso-risk level of 50 x 10^{-6} per year for 14 kPa explosion overpressure threshold is not reached.

The top contributors to the offsite risk/ individual fatality risk were identified in Table 10.1. The safeguards associated with these top risk contributors were reviewed in Table 11.1, and the safeguards were considered as relevant and appropriate in reducing the associated hazard and risk.

Regarding societal risk, the FN-curve was not activated or generated from the societal risk calculation as part of this analysis, primarily because the lands in the vicinity of the power station are largely zoned as 'Rural Landscape' (unoccupied), 'Heavy Industrial', and 'General Industrial', which have a very low population density. The Hunter Power Station boundary is at a minimum over one kilometre away from the closest land users (other than commercial/ industrial users) considered to be a sensitive receptor or having continuous occupation; i.e. the risk from the power station does not reach the closest residence and is contained within the industrial areas. Thus, the power station is not expected to give rise to societal concerns, over a potential to create multiple fatalities, due to being below the FN-curve limits.

The societal risk calculation in this FHA was based on the currently available population data. The societal risk result will change as the population around the site changes over time. Should there be significant increase in the population around the study area, this FHA should be revisited.

While this FHA assesses the risks associated with the Hunter Power Station only, the study recognises that there will be a potentially hazardous development, i.e. the gas supply infrastructure under the scope of third party (APA Group), located adjacent to the Hunter Power Station. The Kurri Kurri Storage Station which incorporates a Compressor Station and Delivery Station (otherwise referred to as the Gas Receiving Station) will be built adjacent to the Hunter Power Station. Subsequently, the APA PHA has demonstrated that the Hunter Power Station and neighbouring gas supply infrastructure are relatively independent in terms of the cumulative risk and hence there is not a requirement to undertake a fully integrated FHA between the neighbouring facilities. It is anticipated that if the APA project receives planning approval, they will progress to detailed design and conduct their own FHA which will include confirming the conclusion with respect to the cumulative impact of the facilities.

13. References

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Appendix A. Meteorological Data for Site

Appendix B. Marked-up Piping and Instrumentation Diagrams (P&IDs)

Appendix C. Offsite Consequences/ Domino Information

Appendix D. Parts Count Record

Table D.1: Parts Count Record

Section ID		**S001_HPS_ISO_DSEL**	**S002_HPS_HOS_DSEL**	**S003_HPS_PIP_DSEL**	**S004_HPS_TNK_DSEL**	**S005_HPS_PIP_DSEL**
Section Description		**Hunter Power Station - Release from 50m3 diesel tanker**	**Hunter Power Station - Release from 4 inch diesel unloading hose**	**Hunter Power Station - Release from Diesel Unloading Pump and connected piping up to Diesel Fuel Storage Tank**	**Hunter Power Station - Release from 1845m3 Diesel Fuel Storage Tank**	**Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System**
Large Vessel, Tank Volume Category: 4000 - 450 m3	Nos.				2	
Pressure Vessel	Nos.					
Hose and Coupling	Number of transfers per year		431			
Pipework - 0 to 49 mm diameter	Length (m)					
Pipework - 50 to 149 mm diameter	Length (m)			72		15
Pipework - 150 to 299 mm diameter	Length (m)			10		87
Pipework - 300 to 499 mm diameter	Length (m)					
Tank Container (ISO Tanker)	Nos.	1				
Flange - 2" diameter (50 mm)	Nos.			1		3
Flange - 6" diameter (150 mm)	Nos.			38		26
Flange - 12" diameter (300 mm)	Nos.					30
Manual Valve - 2" diameter (50 mm)	Nos.			4		12
Manual Valve - 6" diameter (150 mm)	Nos.			13.5		7
Manual Valve - 12" diameter (300 mm)	Nos.					8.5
Actuated Valve - 2" diameter (50 mm)	Nos.			1		4
Actuated Valve - 6" diameter (150 mm)	Nos.			2.5		1
Actuated Valve - 12" diameter (300 mm)	Nos.					4.5
Instrument Connection	Nos.			4		10
Centrifugal Pump - Inlet 50 to 150 mm diameter	Nos.					2
Reciprocating Pump - Inlet 50 to 150 mm diameter	Nos.			1		
Heat Exchanger, Air-cooled - Inlet 50 to 150 mm diameter	Nos.					
Filter - Inlet 50 to 150 mm diameter	Nos.					
Filter - Inlet >150 mm diameter	Nos.					1
Gas Cylinder Package Having N Cylinders	Nos.					
Gas Tube Trailer	Nos.					

Section ID		S006_HPS_PIP_DSEL	S007a/b_HPS_PIP_DSEL	S008_HPS_SDV_RICH	S009_HPS_PIP_RICH	S010a/b_HPS_VES_RICH
Section Description		**Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System**	**Hunter Power Station - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors**	**Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)**	**Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)**	**Hunter Power Station - Release from Fuel Gas Knockout Pot (gas segment) and connected piping**
Large Vessel, Tank Volume Category: 4000 - 450 m3	Nos.					
Pressure Vessel	Nos.					0.5
Hose and Coupling	Number of transfers per year					
Pipework - 0 to 49 mm diameter	Length (m)		140			
Pipework - 50 to 149 mm diameter	Length (m)		60			
Pipework - 150 to 299 mm diameter	Length (m)	490	20			
Pipework - 300 to 499 mm diameter	Length (m)				253	19
Tank Container (ISO Tanker)	Nos.					
Flange - 2" diameter (50 mm)	Nos.		533			2
Flange - 6" diameter (150 mm)	Nos.		29			
Flange - 12" diameter (300 mm)	Nos.		1	10	23	9
Manual Valve - 2" diameter (50 mm)	Nos.		21	8	36	10.5
Manual Valve - 6" diameter (150 mm)	Nos.		5			
Manual Valve - 12" diameter (300 mm)	Nos.			3	8	3
Actuated Valve - 2" diameter (50 mm)	Nos.		86.5			0.5
Actuated Valve - 6" diameter (150 mm)	Nos.		6			
Actuated Valve - 12" diameter (300 mm)	Nos.		0.5	1	1.5	0.5
Instrument Connection	Nos.		58		1	3
Centrifugal Pump - Inlet 50 to 150 mm diameter	Nos.					
Reciprocating Pump - Inlet 50 to 150 mm diameter	Nos.		1			
Heat Exchanger, Air-cooled - Inlet 50 to 150 mm diameter	Nos.					
Filter - Inlet 50 to 150 mm diameter	Nos.		1			
Filter - Inlet >150 mm diameter	Nos.					
Gas Cylinder Package Having N Cylinders	Nos.					
Gas Tube Trailer	Nos.					

Section ID		S011a/b_HPS_VES_RICH	S012a/b_HPS_PIP_RICH	S013a/b_HPS_PIP_RICH	S014a/b_HPS_PIP_RICH	S015a/b_HPS_VES_C10H22
Section Description		**Hunter Power Station - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater**	**Hunter Power Station - Release from Gas Turbine Fuel Gas Heater and connected piping**	**Hunter Power Station - Release from Gas Turbine Fuel Gas Cartridge Filter and connected piping up to Shut Off Valve within Gas Turbine Fuel Gas Supply Unit**	**Hunter Power Station - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors**	**Hunter Power Station - Release from 5m3 Drips Tank and connected piping**
Large Vessel, Tank Volume Category: 4000 - 450 m3	Nos.					
Pressure Vessel	Nos.	0.5				1
Hose and Coupling	Number of transfers per year					
Pipework - 0 to 49 mm diameter	Length (m)				60	80
Pipework - 50 to 149 mm diameter	Length (m)			40	140	20
Pipework - 150 to 299 mm diameter	Length (m)		91	60	120	
Pipework - 300 to 499 mm diameter	Length (m)	36				
Tank Container (ISO Tanker)	Nos.					
Flange - 2" diameter (50 mm)	Nos.	5	9	17	214	12
Flange - 6" diameter (150 mm)	Nos.		8		23	
Flange - 12" diameter (300 mm)	Nos.	26	12	18	10	
Manual Valve - 2" diameter (50 mm)	Nos.	16.5	4	4.5	24	17
Manual Valve - 6" diameter (150 mm)	Nos.					
Manual Valve - 12" diameter (300 mm)	Nos.	11				
Actuated Valve - 2" diameter (50 mm)	Nos.	0.5	0.5	3	1	0.5
Actuated Valve - 6" diameter (150 mm)	Nos.				4	
Actuated Valve - 12" diameter (300 mm)	Nos.	0.5	1.5	4.5	1.5	
Instrument Connection	Nos.	5	2	10	14	3
Centrifugal Pump - Inlet 50 to 150 mm diameter	Nos.					
Reciprocating Pump - Inlet 50 to 150 mm diameter	Nos.					
Heat Exchanger, Air-cooled - Inlet 50 to 150 mm diameter	Nos.		1			
Filter - Inlet 50 to 150 mm diameter	Nos.					
Filter - Inlet >150 mm diameter	Nos.			1		
Gas Cylinder Package Having N Cylinders	Nos.					
Gas Tube Trailer	Nos.					

Section ID		S016a/b_HPS_VES_C10H22	S017a/b_HPS_VES_C10H22	S018_HPS_TRL_H2	S019_HPS_GCY_H2	S020_HPS_PIP_H2
Section Description		**Hunter Power Station - Release from Fuel Gas Knockout Pot (liquid segment) and connected piping**	**Hunter Power Station - Release from Filter Coalescer (liquid segment) and connected piping**	**Hunter Power Station - Release from Hydrogen Tube Trailer, 10 tubes per trailer**	**Hunter Power Station - Release from Hydrogen Cylinder Pack, 15 cylinders per pack**	**Hunter Power Station - Release from Hydrogen Supply Piping, segment before pressure regulation**
Large Vessel, Tank Volume Category: 4000 - 450 m3	Nos.					
Pressure Vessel	Nos.	0.5	0.5			
Hose and Coupling	Number of transfers per year					
Pipework - 0 to 49 mm diameter	Length (m)	11	7			45
Pipework - 50 to 149 mm diameter	Length (m)					
Pipework - 150 to 299 mm diameter	Length (m)					
Pipework - 300 to 499 mm diameter	Length (m)					
Tank Container (ISO Tanker)	Nos.					
Flange - 2" diameter (50 mm)	Nos.	4	11			25
Flange - 6" diameter (150 mm)	Nos.					
Flange - 12" diameter (300 mm)	Nos.					
Manual Valve - 2" diameter (50 mm)	Nos.	10	23			10
Manual Valve - 6" diameter (150 mm)	Nos.					
Manual Valve - 12" diameter (300 mm)	Nos.					
Actuated Valve - 2" diameter (50 mm)	Nos.	2	8			1
Actuated Valve - 6" diameter (150 mm)	Nos.					
Actuated Valve - 12" diameter (300 mm)	Nos.					
Instrument Connection	Nos.	3	2			2
Centrifugal Pump - Inlet 50 to 150 mm diameter	Nos.					
Reciprocating Pump - Inlet 50 to 150 mm diameter	Nos.					
Heat Exchanger, Air-cooled - Inlet 50 to 150 mm diameter	Nos.					
Filter - Inlet 50 to 150 mm diameter	Nos.					1
Filter - Inlet >150 mm diameter	Nos.					
Gas Cylinder Package Having N Cylinders	Nos.				2	
Gas Tube Trailer	Nos.			1		

Section ID		S021_HPS_PIP_H2	S022_HPS_PIP_H2	S023a/b_HPS_PIP_H2
Section Description		**Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure regulation**	**Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure reduction up to SDV upstream of Generator Hydrogen Gas Control Panel**	**Hunter Power Station - Release from Generator Hydrogen Gas Control Panel and charging to generator cooling circuit**
Large Vessel, Tank Volume Category: 4000 - 450 m3	Nos.			
Pressure Vessel	Nos.			
Hose and Coupling	Number of transfers per year			
Pipework - 0 to 49 mm diameter	Length (m)	28	394	60
Pipework - 50 to 149 mm diameter	Length (m)			20
Pipework - 150 to 299 mm diameter	Length (m)			
Pipework - 300 to 499 mm diameter	Length (m)			
Tank Container (ISO Tanker)	Nos.			
Flange - 2" diameter (50 mm)	Nos.	16	10	21
Flange - 6" diameter (150 mm)	Nos.			6
Flange - 12" diameter (300 mm)	Nos.			
Manual Valve - 2" diameter (50 mm)	Nos.	5.5	2.5	7
Manual Valve - 6" diameter (150 mm)	Nos.			1.5
Manual Valve - 12" diameter (300 mm)	Nos.			
Actuated Valve - 2" diameter (50 mm)	Nos.	1.5	2	3
Actuated Valve - 6" diameter (150 mm)	Nos.			0.5
Actuated Valve - 12" diameter (300 mm)	Nos.			
Instrument Connection	Nos.	2	2	2
Centrifugal Pump - Inlet 50 to 150 mm diameter	Nos.			
Reciprocating Pump - Inlet 50 to 150 mm diameter	Nos.			
Heat Exchanger, Air-cooled - Inlet 50 to 150 mm diameter	Nos.			
Filter - Inlet 50 to 150 mm diameter	Nos.	1		2
Filter - Inlet >150 mm diameter	Nos.			
Gas Cylinder Package Having N Cylinders	Nos.			
Gas Tube Trailer	Nos.			

Appendix E. Failure Frequency and Event Frequency

Table E.1: Failure Cases and Outcome Events Assessed in FHA

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m^3)	Modelled Volume (m^3)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
S001_HPS_ISO_DSEL	Hunter Power Station - Release from 50m3 diesel tanker	Liquid	25	Atmospheric	763.45	8.6	6565.67	10 mm diameter hole (10mm)	4.44E-06	Pool fire	S001_HPS_ISO_DSEL_10mm_PF	1.79E-08
								25 mm diameter hole (25mm)	3.70E-07	Pool fire	S001_HPS_ISO_DSEL_25mm_PF	1.55E-09
								75 mm diameter hole (75mm)	3.70E-07	Pool fire	S001_HPS_ISO_DSEL_75mm_PF	2.33E-09
								Catastrophic failure (R)	4.93E-08	Pool fire	S001_HPS_ISO_DSEL_R_PF	4.72E-10
S002_HPS_HOS_DSEL	Hunter Power Station - Release from 4 inch diesel unloading hose	Liquid	25	Atmospheric	763.45	8.6	6565.67	10 mm diameter hole (10mm)	1.51E-03	Pool fire	S002_HPS_HOS_DSEL_10mm_PF	6.09E-06
								Full bore release (R)	4.32E-03	Pool fire	S002_HPS_HOS_DSEL_R_PF	3.64E-05
S003_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Unloading Pump and connected piping up to Diesel Fuel Storage Tank	Liquid	25	2.5	763.45	8.6	6565.67	10 mm diameter hole (10mm)	8.02E-03	Pool fire	S003_HPS_PIP_DSEL_10mm_PF	1.68E-05
								25 mm diameter hole (25mm)	1.12E-03	Pool fire	S003_HPS_PIP_DSEL_25mm_PF	4.20E-06
								75 mm diameter hole (75mm)	3.19E-04	Pool fire	S003_HPS_PIP_DSEL_75mm_PF	5.82E-06
								Full bore release (R)	4.30E-04	Pool fire	S003_HPS_PIP_DSEL_R_PF	1.70E-05
S004_HPS_TNK_DSEL	Hunter Power Station - Release from 1845m3 Diesel Fuel Storage Tank	Liquid	25	Atmospheric	763.45	1845	1408565.25	150 mm diameter hole (150mm)	5.00E-03	Pool fire	S004_HPS_TNK_DSEL_150mm_PF	1.20E-05
								500 mm diameter hole (500mm)	2.00E-04	Pool fire	S004_HPS_TNK_DSEL_500mm_PF	4.80E-07
								Catastrophic failure (R)	1.00E-05	Pool fire	S004_HPS_TNK_DSEL_R_PF	2.40E-08
S005_HPS_PIP_DSEL	Hunter Power Station - Release from Diesel Forwarding Pumps, Diesel Forwarding Filter, and connected piping up to SDV prior to diesel distribution to Gas Turbine Fuel Oil System	Liquid	25	7.8	763.45	1845	1408565.25	10 mm diameter hole (10mm)	2.07E-02	Pool fire	S005_HPS_PIP_DSEL_10mm_PF	7.83E-05
								25 mm diameter hole (25mm)	1.47E-03	Pool fire	S005_HPS_PIP_DSEL_25mm_PF	2.39E-05
								75 mm diameter hole (75mm)	2.02E-04	Pool fire	S005_HPS_PIP_DSEL_75mm_PF	1.01E-05
								Full bore release (R)	4.50E-04	Pool fire	S005_HPS_PIP_DSEL_R_PF	2.25E-05
S006_HPS_PIP_DSEL	Hunter Power Station - Release from diesel distribution to Gas Turbine Fuel Oil System	Liquid	25	7.8	763.45	1845	1408565.25	10 mm diameter hole (10mm)	4.90E-04	Pool fire	S006_HPS_PIP_DSEL_10mm_PF	1.85E-06
								25 mm diameter hole (25mm)	3.43E-04	Pool fire	S006_HPS_PIP_DSEL_25mm_PF	5.57E-06
								75 mm diameter hole (75mm)	1.96E-04	Pool fire	S006_HPS_PIP_DSEL_75mm_PF	9.80E-06
								Full bore release (R)	9.80E-05	Pool fire	S006_HPS_PIP_DSEL_R_PF	4.90E-06

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m³)	Modelled Volume (m³)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
S007a/b_HPS_PIP_DSEL	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Oil Inlet Filter, Gas Turbine Main Fuel Oil Pump, and Fuel Oil Manifold up to combustors	Liquid	25	84.8	763.45	1845	1408565.25	10 mm diameter hole (10mm)	7.01E-02	Pool fire	S007a/b_HPS_PIP_DSEL_10mm_PF	6.68E-04
								25 mm diameter hole (25mm)	5.08E-03	Pool fire	S007a/b_HPS_PIP_DSEL_25mm_PF	1.85E-04
								75 mm diameter hole (75mm)	3.48E-04	Pool fire	S007a/b_HPS_PIP_DSEL_75mm_PF	1.27E-05
								Full bore release (R)	3.66E-03	Pool fire	S007a/b_HPS_PIP_DSEL_R_PF	1.33E-04
S008_HPS_SDV_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from SDV at Power Station Battery Limit)	Compressed gas	30	44	35.004	552.79	19350	10 mm diameter hole (10mm)	1.43E-03	Jet fire	S008_HPS_SDV_RICH_10mm_JF	1.30E-06
										Flash fire	S008_HPS_SDV_RICH_10mm_FF	1.04E-06
										VCE	S008_HPS_SDV_RICH_10mm_VCE	2.60E-07
								25 mm diameter hole (25mm)	1.04E-04	Jet fire	S008_HPS_SDV_RICH_25mm_JF	3.23E-07
										Flash fire	S008_HPS_SDV_RICH_25mm_FF	2.58E-07
										VCE	S008_HPS_SDV_RICH_25mm_VCE	6.46E-08
								75 mm diameter hole (75mm)	1.21E-05	Jet fire	S008_HPS_SDV_RICH_75mm_JF	3.12E-07
										Flash fire	S008_HPS_SDV_RICH_75mm_FF	2.19E-07
										VCE	S008_HPS_SDV_RICH_75mm_VCE	9.37E-08
								Full bore release (R)	4.77E-05	Jet fire	S008_HPS_SDV_RICH_R_JF	1.22E-06
										Flash fire	S008_HPS_SDV_RICH_R_FF	8.56E-07
										VCE	S008_HPS_SDV_RICH_R_VCE	3.67E-07
S009_HPS_PIP_RICH	Hunter Power Station - Release from incoming fuel gas line from Kurri Kurri Storage Station/ Delivery Station (release from downstream of SDV at Power Station Battery Limit up to SDV upstream of Fuel Gas Knockout Pot)	Compressed gas	30	44	35.004	552.79	19350	10 mm diameter hole (10mm)	4.08E-03	Jet fire	S009_HPS_PIP_RICH_10mm_JF	3.70E-06
										Flash fire	S009_HPS_PIP_RICH_10mm_FF	2.96E-06
										VCE	S009_HPS_PIP_RICH_10mm_VCE	7.40E-07
								25 mm diameter hole (25mm)	4.14E-04	Jet fire	S009_HPS_PIP_RICH_25mm_JF	1.28E-06
										Flash fire	S009_HPS_PIP_RICH_25mm_FF	1.03E-06
										VCE	S009_HPS_PIP_RICH_25mm_VCE	2.57E-07
								75 mm diameter hole (75mm)	7.77E-05	Jet fire	S009_HPS_PIP_RICH_75mm_JF	2.01E-06
										Flash fire	S009_HPS_PIP_RICH_75mm_FF	1.40E-06
										VCE	S009_HPS_PIP_RICH_75mm_VCE	6.02E-07
								Full bore release (R)	1.80E-04	Jet fire	S009_HPS_PIP_RICH_R_JF	4.61E-06
										Flash fire	S009_HPS_PIP_RICH_R_FF	3.23E-06
										VCE	S009_HPS_PIP_RICH_R_VCE	1.38E-06

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m³)	Modelled Volume (m³)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
S010a/b_HPS_VES_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Fuel Gas Knockout Pot (gas segment) and connected piping	Compressed gas	30	44	35.004	5.65	197.94	10 mm diameter hole (10mm)	2.30E-03	Jet fire	S010a/b_HPS_VES_RICH_10mm_JF	2.00E-06
										Flash fire	S010a/b_HPS_VES_RICH_10mm_FF	1.60E-06
										VCE	S010a/b_HPS_VES_RICH_10mm_VCE	4.00E-07
								25 mm diameter hole (25mm)	1.57E-04	Jet fire	S010a/b_HPS_VES_RICH_25mm_JF	4.46E-07
										Flash fire	S010a/b_HPS_VES_RICH_25mm_FF	3.57E-07
										VCE	S010a/b_HPS_VES_RICH_25mm_VCE	8.93E-08
								75 mm diameter hole (75mm)	1.65E-05	Jet fire	S010a/b_HPS_VES_RICH_75mm_JF	4.21E-07
										Flash fire	S010a/b_HPS_VES_RICH_75mm_FF	2.95E-07
										VCE	S010a/b_HPS_VES_RICH_75mm_VCE	1.26E-07
								Catastrophic failure (R)	1.01E-04	Fireball	S010a/b_HPS_VES_RICH_R_FB	2.51E-05
										Flash fire	S010a/b_HPS_VES_RICH_R_FF	2.01E-05
										VCE	S010a/b_HPS_VES_RICH_R_VCE	5.02E-06
S011a/b_HPS_VES_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Filter Coalescer (gas segment) and connected piping up to Shut Off Valve upstream of Gas Turbine Fuel Gas Heater	Compressed gas	30	44	35.004	2.51	87.97	10 mm diameter hole (10mm)	4.85E-03	Jet fire	S011a/b_HPS_VES_RICH_10mm_JF	4.22E-06
										Flash fire	S011a/b_HPS_VES_RICH_10mm_FF	3.38E-06
										VCE	S011a/b_HPS_VES_RICH_10mm_VCE	8.45E-07
								25 mm diameter hole (25mm)	3.44E-04	Jet fire	S011a/b_HPS_VES_RICH_25mm_JF	9.75E-07
										Flash fire	S011a/b_HPS_VES_RICH_25mm_FF	7.80E-07
										VCE	S011a/b_HPS_VES_RICH_25mm_VCE	1.95E-07
								75 mm diameter hole (75mm)	4.00E-05	Jet fire	S011a/b_HPS_VES_RICH_75mm_JF	1.02E-06
										Flash fire	S011a/b_HPS_VES_RICH_75mm_FF	7.14E-07
										VCE	S011a/b_HPS_VES_RICH_75mm_VCE	3.06E-07
								Catastrophic failure (R)	1.91E-04	Fireball	S011a/b_HPS_VES_RICH_R_FB	2.10E-05
										Flash fire	S011a/b_HPS_VES_RICH_R_FF	1.68E-05
										VCE	S011a/b_HPS_VES_RICH_R_VCE	4.20E-06
S012a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Heater and connected piping	Compressed gas	200	40.9	19.09	1964.38	37500	10 mm diameter hole (10mm)	4.35E-03	Jet fire	S012a/b_HPS_PIP_RICH_10mm_JF	3.47E-06
										Flash fire	S012a/b_HPS_PIP_RICH_10mm_FF	2.78E-06
										VCE	S012a/b_HPS_PIP_RICH_10mm_VCE	6.94E-07
								25 mm diameter hole (25mm)	4.71E-04	Jet fire	S012a/b_HPS_PIP_RICH_25mm_JF	1.17E-06
										Flash fire	S012a/b_HPS_PIP_RICH_25mm_FF	9.33E-07

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m³)	Modelled Volume (m³)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
										VCE	S012a/b_HPS_PIP_RICH_25mm_VCE	2.33E-07
								75 mm diameter hole (75mm)	1.10E-04	Jet fire	S012a/b_HPS_PIP_RICH_75mm_JF	3.67E-06
										Flash fire	S012a/b_HPS_PIP_RICH_75mm_FF	2.57E-06
										VCE	S012a/b_HPS_PIP_RICH_75mm_VCE	1.10E-06
								Full bore release (R)	1.71E-04	Jet fire	S012a/b_HPS_PIP_RICH_R_JF	8.46E-06
										Flash fire	S012a/b_HPS_PIP_RICH_R_FF	5.92E-06
										VCE	S012a/b_HPS_PIP_RICH_R_VCE	2.54E-06
S013a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Cartridge Filter and connected piping up to Shut Off Valve within Gas Turbine Fuel Gas Supply Unit	Compressed gas	200	38.1	17.802	2106.50	37500	10 mm diameter hole (10mm)	8.66E-03	Jet fire	S013a/b_HPS_PIP_RICH_10mm_JF	6.74E-06
										Flash fire	S013a/b_HPS_PIP_RICH_10mm_FF	5.39E-06
										VCE	S013a/b_HPS_PIP_RICH_10mm_VCE	1.35E-06
								25 mm diameter hole (25mm)	6.53E-04	Jet fire	S013a/b_HPS_PIP_RICH_25mm_JF	1.49E-06
										Flash fire	S013a/b_HPS_PIP_RICH_25mm_FF	1.19E-06
										VCE	S013a/b_HPS_PIP_RICH_25mm_VCE	2.97E-07
								75 mm diameter hole (75mm)	8.08E-05	Jet fire	S013a/b_HPS_PIP_RICH_75mm_JF	2.49E-06
										Flash fire	S013a/b_HPS_PIP_RICH_75mm_FF	1.74E-06
										VCE	S013a/b_HPS_PIP_RICH_75mm_VCE	7.46E-07
								Full bore release (R)	3.25E-04	Jet fire	S013a/b_HPS_PIP_RICH_R_JF	1.61E-05
										Flash fire	S013a/b_HPS_PIP_RICH_R_FF	1.13E-05
										VCE	S013a/b_HPS_PIP_RICH_R_VCE	4.82E-06
S014a/b_HPS_PIP_RICH	Hunter Power Station - Power Island No. 1/2 - Release from Gas Turbine Fuel Gas Pressure Control Unit, Gas Turbine Fuel Gas Flow Control Unit, and Fuel Gas Manifold up to combustors	Compressed gas	200	38.1	17.802	2106.50	37500	10 mm diameter hole (10mm)	1.61E-02	Jet fire	S014a/b_HPS_PIP_RICH_10mm_JF	1.25E-05
										Flash fire	S014a/b_HPS_PIP_RICH_10mm_FF	9.99E-06
										VCE	S014a/b_HPS_PIP_RICH_10mm_VCE	2.50E-06
								25 mm diameter hole (25mm)	1.42E-03	Jet fire	S014a/b_HPS_PIP_RICH_25mm_JF	3.23E-06
										Flash fire	S014a/b_HPS_PIP_RICH_25mm_FF	2.59E-06
										VCE	S014a/b_HPS_PIP_RICH_25mm_VCE	6.47E-07
								75 mm diameter hole (75mm)	9.79E-05	Jet fire	S014a/b_HPS_PIP_RICH_75mm_JF	3.01E-06
										Flash fire	S014a/b_HPS_PIP_RICH_75mm_FF	2.11E-06
										VCE	S014a/b_HPS_PIP_RICH_75mm_VCE	9.04E-07
								Full bore release (R)	8.97E-04	Jet fire	S014a/b_HPS_PIP_RICH_R_JF	4.44E-05
										Flash fire	S014a/b_HPS_PIP_RICH_R_FF	3.11E-05
										VCE	S014a/b_HPS_PIP_RICH_R_VCE	1.33E-05
S015a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from	Liquid	25	1	727.89	5	3639.45	10 mm diameter hole (10mm)	2.66E-03	Pool fire	S015a/b_HPS_VES_C10H22_10mm_PF	4.58E-06

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m³)	Modelled Volume (m³)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
	5m3 Drips Tank and connected piping							25 mm diameter hole (25mm)	5.36E-04	Pool fire	S015a/b_HPS_VES_C10H22_25mm_PF	1.50E-06
								75 mm diameter hole (75mm)	5.00E-06	Pool fire	S015a/b_HPS_VES_C10H22_75mm_PF	7.85E-08
								Catastrophic failure (R)	2.05E-04	Pool fire	S015a/b_HPS_VES_C10H22_R_PF	1.02E-05
S016a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from Fuel Gas Knockout Pot (liquid segment) and connected piping	Liquid	30	44	724.16	2.83	2047.51	10 mm diameter hole (10mm)	1.91E-03	Pool fire	S016a/b_HPS_VES_C10H22_10mm_PF	1.33E-05
								25 mm diameter hole (25mm)	1.56E-04	Pool fire	S016a/b_HPS_VES_C10H22_25mm_PF	4.77E-06
								75 mm diameter hole (75mm)	2.50E-06	Pool fire	S016a/b_HPS_VES_C10H22_75mm_PF	1.25E-07
								Catastrophic failure (R)	1.13E-04	Pool fire	S016a/b_HPS_VES_C10H22_R_PF	5.63E-06
S017a/b_HPS_VES_C10H22	Hunter Power Station - Power Island No. 1/2 - Release from Filter Coalescer (liquid segment) and connected piping	Liquid	30	44	724.16	1.26	910.01	10 mm diameter hole (10mm)	4.10E-03	Pool fire	S017a/b_HPS_VES_C10H22_10mm_PF	2.84E-05
								25 mm diameter hole (25mm)	2.58E-04	Pool fire	S017a/b_HPS_VES_C10H22_25mm_PF	7.91E-06
								75 mm diameter hole (75mm)	2.50E-06	Pool fire	S017a/b_HPS_VES_C10H22_75mm_PF	1.25E-07
								Catastrophic failure (R)	2.32E-04	Pool fire	S017a/b_HPS_VES_C10H22_R_PF	1.16E-05
S018_HPS_TRL_H2	Hunter Power Station - Release from Hydrogen Tube Trailer, 10 tubes per trailer	Compressed gas	25	165	12.279	2.61	32	One tube ruptures and releases content (L)	5.00E-07	Fireball	S018_HPS_TRL_H2_L_FB	8.33E-08
										Flash fire	S018_HPS_TRL_H2_L_FF	6.66E-08
										VCE	S018_HPS_TRL_H2_L_VCE	1.67E-08
						26.06	320	All tube valves fail and releases content (R)	5.00E-07	Jet fire	S018_HPS_TRL_H2_R_JF	1.58E-09
										Flash fire	S018_HPS_TRL_H2_R_FF	1.26E-09
										VCE	S018_HPS_TRL_H2_R_VCE	3.16E-10
						2.61	32	One tube valve fails and releases content (S)	1.00E-05	Jet fire	S018_HPS_TRL_H2_S_JF	3.16E-08
										Flash fire	S018_HPS_TRL_H2_S_FF	2.53E-08
										VCE	S018_HPS_TRL_H2_S_VCE	6.33E-09
S019_HPS_GCY_H2	Hunter Power Station - Release from Hydrogen Cylinder Pack, 15 cylinders per pack	Compressed gas	25	137	10.366	0.05	0.53	Catastrophic failure of the first cylinder (R)	1.40E-05	Fireball	S019_HPS_GCY_H2_R_FB	1.99E-09
										Flash fire	S019_HPS_GCY_H2_R_FF	1.59E-09
										VCE	S019_HPS_GCY_H2_R_VCE	3.99E-10
						0.72	7.42	Failure of the remaining N-1 cylinders by means of a 5mm diameter hole (5mm)	1.00E-06	Jet fire	S019_HPS_GCY_H2_5mm_JF	1.47E-08
										Flash fire	S019_HPS_GCY_H2_5mm _FF	1.18E-08
										VCE	S019_HPS_GCY_H2_5mm _VCE	2.94E-09
S020_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply	Compressed gas	25	230	16.504	3.03	50	10 mm diameter hole (10mm)	4.19E-03	Jet fire	S020_HPS_PIP_H2_10mm_JF	8.54E-06
										Flash fire	S020_HPS_PIP_H2_10mm_FF	6.83E-06

Section ID	Section Description	State	Temperature (°C)	Pressure (bar.g)	Density (kg/m³)	Modelled Volume (m³)	Modelled Inventory (kg)	Failure Case	Failure Frequency (per year)	Outcome Event	Outcome Event ID	Event Frequency (per year)
	Piping, segment before pressure regulation									VCE	S020_HPS_PIP_H2_10mm_VCE	1.71E-06
								Full bore release (R)	7.44E-04	Jet fire	S020_HPS_PIP_H2_R_JF	6.17E-06
										Flash fire	S020_HPS_PIP_H2_R_FF	4.94E-06
										VCE	S020_HPS_PIP_H2_R_VCE	1.23E-06
S021_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure regulation	Compressed gas	25	50	4.0245	12.42	50	10 mm diameter hole (10mm)	3.75E-03	Jet fire	S021_HPS_PIP_H2_10mm_JF	4.55E-06
										Flash fire	S021_HPS_PIP_H2_10mm_FF	3.64E-06
										VCE	S021_HPS_PIP_H2_10mm_VCE	9.09E-07
								Full bore release (R)	6.00E-04	Jet fire	S021_HPS_PIP_H2_R_JF	1.27E-06
										Flash fire	S021_HPS_PIP_H2_R_FF	1.02E-06
										VCE	S021_HPS_PIP_H2_R_VCE	2.54E-07
S022_HPS_PIP_H2	Hunter Power Station - Release from Hydrogen Supply Piping, segment after pressure reduction up to SDV upstream of Generator Hydrogen Gas Control Panel	Compressed gas	25	8	0.72796	68.69	50	10 mm diameter hole (10mm)	5.47E-03	Jet fire	S022_HPS_PIP_H2_10mm_JF	5.47E-06
										Flash fire	S022_HPS_PIP_H2_10mm_FF	4.37E-06
										VCE	S022_HPS_PIP_H2_10mm_VCE	1.09E-06
								25 mm diameter hole (25mm)	2.05E-03	Jet fire	S022_HPS_PIP_H2_25mm_JF	2.48E-06
										Flash fire	S022_HPS_PIP_H2_25mm_FF	1.98E-06
										VCE	S022_HPS_PIP_H2_25mm_VCE	4.95E-07
								Full bore release (R)	4.75E-04	Jet fire	S022_HPS_PIP_H2_R_JF	6.80E-07
										Flash fire	S022_HPS_PIP_H2_R_FF	5.44E-07
										VCE	S022_HPS_PIP_H2_R_VCE	1.36E-07
S023a/b_HPS_PIP_H2	Hunter Power Station - Power Island No. 1/2 - Release from Generator Hydrogen Gas Control Panel and charging to generator cooling circuit	Compressed gas	25	5	0.48618	102.84	50	10 mm diameter hole (10mm)	7.09E-03	Jet fire	S023a/b_HPS_PIP_H2_10mm_JF	7.09E-06
										Flash fire	S023a/b_HPS_PIP_H2_10mm_FF	5.67E-06
										VCE	S023a/b_HPS_PIP_H2_10mm_VCE	1.42E-06
								25 mm diameter hole (25mm)	8.64E-04	Jet fire	S023a/b_HPS_PIP_H2_25mm_JF	9.58E-07
										Flash fire	S023a/b_HPS_PIP_H2_25mm_FF	7.67E-07
										VCE	S023a/b_HPS_PIP_H2_25mm_VCE	1.92E-07
								Full bore release (R)	3.29E-04	Jet fire	S023a/b_HPS_PIP_H2_R_JF	7.49E-07
										Flash fire	S023a/b_HPS_PIP_H2_R_FF	5.99E-07
										VCE	S023a/b_HPS_PIP_H2_R_VCE	1.50E-07

Appendix F. Harm Footprints and Harm Frequencies

Appendix G. List of Materials Collected as part of Study

Appendix H. Qualifications and Experience of Hazard Analysis Team