

## **Appendix C Preliminary Hazard Analysis**

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# PRELIMINARY HAZARD ANALYSIS OF HORSLEY PARK METER STATION UPGRADE



**Prepared for: Jemena**  
**Document Number: 04-B395**  
**Revision 0**

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**10 March 2015**

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## Preliminary Hazard Analysis of Horsley Park Meter Station Upgrade

### Acknowledgment

The author would like to thank John Fisher, David Robertson and Josh Whitham for their assistance in preparing this report.

### Disclaimer

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Rev	Date	Description	Prepared By	Reviewed By	Authorised By
A	06/03/2015	Draft for Comment	Anne Lewis	Karin Nilsson	Karin Nilsson
B	09/03/2015	Final draft for Comment	Karin Nilsson	Karin Nilsson	Karin Nilsson
0	10/03/2015	Final report	Anne Lewis	Karin Nilsson	Karin Nilsson

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# EXECUTIVE SUMMARY

## E1 – Introduction

Jemena is proposing to upgrade its existing metering station at Horsley Park. The upgrade will be designed to accommodate up to 290 TJ/d of flow through the station inlet.

As one element of the planning approval process, Planager has been requested to prepare a *Preliminary Hazard Analysis* (PHA) in accordance with the NSW Department of Planning and Environment (DP&E) requirements set out in the Hazardous Industry Planning Advisory Paper (HIPAP) 6: *Guidelines for Hazard Analysis* and for the risk to be evaluated and compared with the risk criteria in use in NSW, as specified in HIPAP4: *Risk Criteria for Landuse Planning*.

This document has been prepared to inform the Environmental Impact Statement for the proposal. It provides details of the PHA undertaken for the for the proposed HPMS upgrade project. The risk assessment is based on current best practice methodologies and up-to-date data and input information.

## E2 – Aim and Scope

The aim of the PHA is to quantitatively determine the risk of a major incident at the HPMS affecting offsite land uses and to compare this risk with established risk criteria.

The equipment associated with the upgrade to the HPMS will be integrated into the existing metering station. As such, the present PHA assesses the risk associated with the entire HPMS from station inlet through to the outlet including both existing and new equipment.

## E3 – Results

The main hazard associated with the HPMS is associated with the conveyance of natural gas (predominantly composed of methane gas), which is a flammable gas held under pressure.

Hazards may arise in fixed plant, storage, and pipelines. The predominant mode in which a hazardous incident may be generated is associated with a leak. This would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or explosion incident. The factors involved are:

- Failure must occur causing a release. There are several possible causes of failure, with the main ones being corrosion and damage to the equipment due to physical interaction (mechanical damage);
- The released material must come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames some distance from the release;
- Depending on the release conditions, including the mass of material involved and how rapidly it is ignited, the results may be a localised fire (for

example a so called jet fire), a flash fire or an explosion of the vapour cloud formed through the release;

- Finally, for there to be a risk, people must be present within the harmful range (consequence distance) of the fire or explosion. How close the people are will determine whether any injuries or fatalities result.

Despite the fact that many of the assumptions in this PHA are conservative, the results of the risk assessment carried out for the HPMS show that the risk associated with the station is very low. The most stringent risk criteria, as required by the Department of Planning, are adhered to. The quantitative risk analysis showed that:

**Individual Risk of Fatality:** The risk of fatality associated with the HPMS at the boundary of the facility site is below the criterion for of one chance in a million per year (1 pmpy) at any residential development. The risk of fatality at the nearest residential dwelling is less than 0.5 pmpy, i.e. less than the risk criterion for sensitive development.

The risk of fatality at the nearest commercial or retail centre, active open space and the nearest industrial area are also well below the criterion of five, ten and fifty chances per million years respectively (5 pmpy, 10 pmpy and 50 pmpy).

**Propagation Risk:** The 50 pmpy propagation risk contour is never reached for the HPMS.

**Injury Risk:** The 50 pmpy injury risk contour is contained within the site boundary. The risk of injury at the nearest residential dwelling is 8pmpy, i.e. well below the criterion of 50 pmpy.

**Societal Risk:** The societal risk is consistently within the tolerable zone as per the DP&E's interim risk criteria for societal risk.

**Transport risk:** The review of road transport risks concludes that the risk associated with the transport of dangerous goods and potentially hazardous material to the site is negligible.

**Risk to the biophysical environment from accidental releases:** An accidental release of natural gas would not constitute an acute hazard to the biophysical environment. The risk to the biophysical environment from an accidental release at the HPMS is very low.

While the land on which the facility is located and the adjacent areas is currently unzoned, it is within the area covered by the Western Sydney Parklands and is therefore covered by *State Environmental Planning Policy (Western Sydney Parklands) 2009* (Ref 5). The location and the action of this planning policy substantially restrict what forms of future development would be permissible around the facility. It is therefore unlikely that the future land use would alter substantially from the existing and that population densities would increase.

## GLOSSARY

ALARP	As Low As Reasonably Practicable
DC	Direct Current
DP&E	Department of Planning and Environment
EGP	Eastern Gas Pipeline
FCV	Flow Control Valve
HAZID	Hazard Identification
HAZIDWD	Hazard Identification Word Diagram
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
HPMS	Horsley Park Meter Station
JGN	Jemena Gas Network
LAN	Local Area Network
LFL	Lower Flammable Limit
MAOP	Maximum Allowable Operating Pressure
MPag	Mega Pascal gauge (unit for pressure)
NG	Natural gas
PCV	Pressure Control Valve
PHA	Preliminary Hazard Analysis
PPE	Personal Protective Equipment
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheet
SGN	Sydney Gas Network
SLV	Station Limit Valve
SSV	Slam Shut Valve
TJ/d	terajoule per day
TNO	Netherlands Organisation for Applied Scientific Research
UPS	Uninterruptible Power Supply
WBH	Water Bath Heater

# REPORT

## 1 INTRODUCTION

### 1.1 BACKGROUND

The Eastern Gas Pipeline (EGP) is a DN 450, Class 900 gas transmission pipeline stretching from Longford to Horsley Park in New South Wales.

As a result of expansion opportunities Jemena is proposing to upgrade its existing metering station at Horsley Park. The upgrade will be designed to accommodate up to 290 TJ/d of flow through the station inlet (Ref 1).

The existing Horsley Park Meter Station (HPMS) has a capacity of around 208 TJ/d at 6 MPag station inlet pressure, with 177 TJ/d available to Sydney Gas Network (SGN) during peak periods, and the balance going to the Smithfield lateral, which supplies the Marubeni Power Station. Current equipment includes a liquid separator, two dry gas filters, three water bath heaters with a total heating capacity of 2000 kW, metering for SGN and separate pressure reduction skids for the SGN and Smithfield deliveries.

The station capacity into the SGN is to be upgraded in order to facilitate increased flows to this delivery point. The upgrade project consists of introducing a new skid-mounted filtration, heating, metering and pressure reduction station which will be tied into the existing station inlet piping for the new delivery capacity. The existing heating and regulation for the SGN and Smithfield lateral will be retained and the new skid mounted facilities will be designed for a flow rate of 120 TJ/d with minimum station inlet and outlet pressures at 5 MPag and 3.5 MPag, respectively.

The new skids will tie in to the pipework at the outlet of the existing regulator that supplies the SGN.

As one element of the planning approval process, Planager has been requested to prepare a *Preliminary Hazard Analysis* (PHA) in accordance with the NSW Department of Planning and Environment (DP&E) requirements set out in DP&E's Hazardous Industry Planning Advisory Paper (HIPAP) 6: *Guidelines for Hazard Analysis* (Ref 2) and for the risk to be evaluated and compared with the risk criteria in use in NSW, as specified in HIPAP4: *Risk Criteria for Landuse Planning* (Ref 3).

This document has been prepared to inform the Environmental Impact Statement for the proposal. It provides details of the PHA undertaken for the for the proposed HPMS upgrade project. The risk assessment is based on current best practice methodologies and up-to-date data and input information.

### 1.2 SCOPE AND AIM OF STUDY

The aim of the PHA is to quantitatively determine the risk of a major incident at the HPMS affecting offsite land uses and to compare this risk with established risk criteria.

The equipment associated with the upgrade to the HPMS will be integrated into the existing metering station. As such, the present PHA assesses the risk associated with the entire HPMS from station inlet through to the outlet including existing and new equipment.

Through the evaluation of likelihood and consequence of the major hazards, the risks to the landuses surrounding the site associated with the upgraded HPMS may be estimated and compared to the risk criteria in use in NSW (Ref 3).

The scope of this analysis includes the following;

- Systematic identification and documentation of the major hazards associated with the upgraded HPMS, based on the information supplied and relevant experience with similar processes;
- Establishment of the consequence of each identified hazard and determination as to their offsite effects. This process is generally qualitative, with relevant quantitative calculations/modelling being completed where necessary;
- Where offsite effects are identified, the frequency of occurrence is estimated based on historical data. If such data is unavailable, assumptions and qualitative discussions are presented;
- Determination of the acceptability (or otherwise) of the risk by comparison of the qualitative or quantitative assessment of the identified risks with the criteria specified in the NSW Department of Planning HIPAP No. 4 (Ref 3); and
- Identification of risk reduction measures as deemed necessary.

## 2 SITE AND PROCESS DESCRIPTION

### 2.1 SITE LOCATION AND SURROUNDING LAND USES

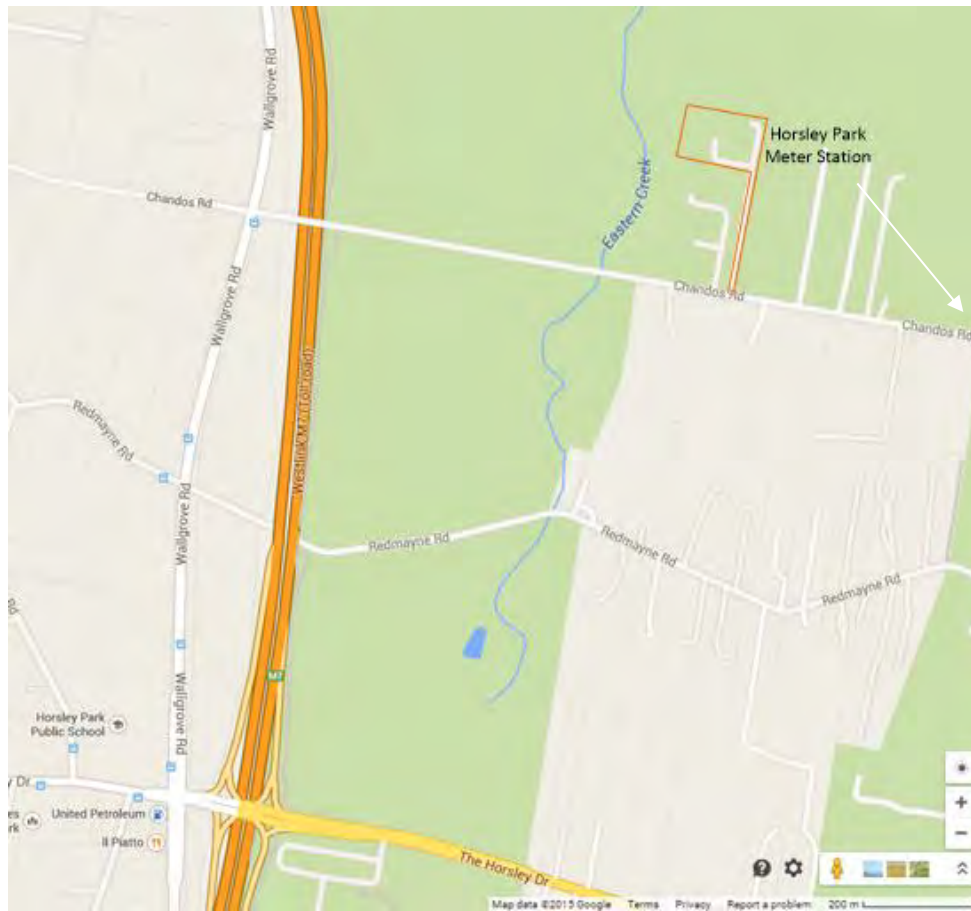
The Horsley Park Meter Station is located at 194-202 Chandos Road, Horsley Park. The project location is within the Fairfield local government area. The location of the station is shown in Figure 1.

The facility is located on Lot 3 in Deposited Plan 1002746 as shown in Figure 2. All works associated with the upgrade will occur within the boundaries of this property. The site is within the area covered by the Western Sydney Parklands. The facilities fall under the Eastern Gas Pipeline location classification of Rural Residential (R2) (Ref 4).

The facility is located 600m to the east of the Westlink M7 toll road. Eastern Creek runs in a northerly direction in a wooded area between the M7 and the facility. A Jemena Gas Network (JGN) gas facility is located directly south of the site (see Figure 2). A market garden is located directly east of the site and a quarry is located to the north.

Private residences are located approximately 250m to the South of the station along Chandos Road. The building to the East of the site is a farm shed and the residence for that property is located on Chandos Road. There are no schools, hospitals or other development referred to as *sensitive development* in HIPAP4 (Ref 3) within the potential hazardous impact zone of the development.

**Figure 1 – Site Location**



**Figure 2 – Location of property: Lot 3 in Deposited Plan 1002746**



*Data: Land and Property Information. Imagery: Jemena (Ref 5)*

## **2.2 SITE LAYOUT AND EQUIPMENT**

The Horsley Park Meter Station reduces and regulates the pressure of gas from the EGP and delivers that gas into the Central Trunk and another pipeline referred to as the Smithfield Lateral. The Central Trunk feeds the SGN. The Smithfield Lateral is an extension of the EGP and supplies high pressure gas to a large volume industrial gas user in the Smithfield area (Ref 5). The pipelines connected by the HPMS are shown in Figure 3.

**Figure 3 – Pipelines connected by the HPMS**



*Data: Land and Property Information. Imagery: Jemena (Ref 5)*

The upgrade to the HPMS involves the construction of additional gas flow conveyance, control and metering equipment and associated pipework within the boundaries of the existing station. To increase the overall capacity of the station a second run of pipework and gas conveyance control apparatus will be installed in parallel with the existing infrastructure.

The new section of pipework and apparatus will inject additional gas flows into the outlet of the existing regulator that supplies the SGN. All the new gas conveyance control equipment will be connected into the existing telemetry system and continually monitored at the existing Control Centre, which is located remotely from the site.

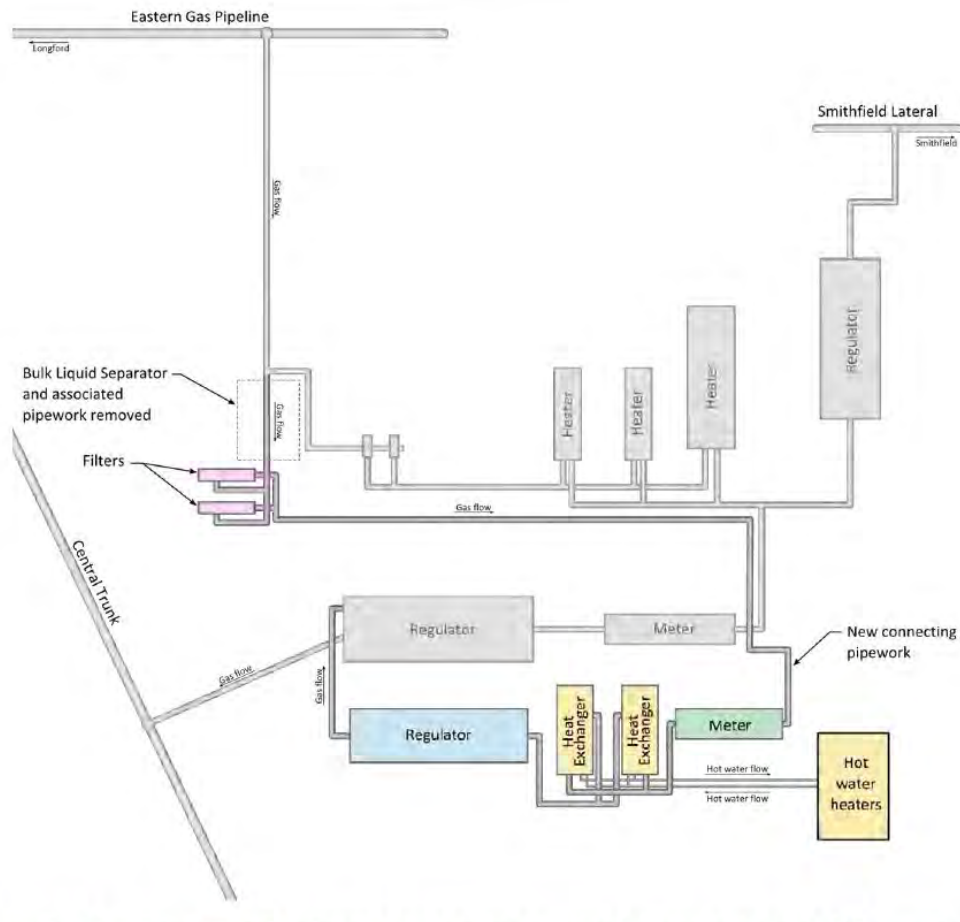
Once the upgrade is completed, the HPMS will comprise:

- Dry gas filters; two existing and one associated with the upgrade (the upgrade will also include the provision of a second, redundant filter).
- Three existing water bath heaters which heat the gas up prior to pressure reduction
- Two new hot water heater and heat exchanger packages for delivering the additional flow into the SGN.
- Existing and upgraded gas metering equipment to measure the amount of gas being delivered to the SGN.
- Gas regulators in the existing and new flow paths to reduce the pressure of gas from the EGP to the required pressures for the SGN and the Smithfield Lateral
- Associated existing and new connecting pipework

- Existing pipeline internal inspection tool receiving (EGP) and launching (Smithfield Lateral) apparatus
- Existing pipeline venting apparatus
- Existing and new site buildings and perimeter fencing.

A schematic of the upgraded facility is shown in Figure 4.

**Figure 4 – Schematic of upgraded HPMS**



Source: (Ref 5)

## 2.3 PLANT DESIGN AND OPERATION

### 2.3.1 Plant Design

The HPMS facilities are described in the HPMS Design Basis Manual (Ref 1) as follows:

#### *Station Inlet*

HPMS has an existing pig receiver with associated pipework and an actuated station inlet valve.

### *Existing Filtration System*

The current filtration set up at HPMS consists of a single liquid separator and two dry gas filters in parallel. The liquid separator will be removed from service as part of the tie in for the new delivery capacity as it is redundant and no longer required. The existing dry gas filtration will remain in service.

### *New Sydney Gas Network Delivery Leg Filtration*

The new horizontal dry gas filter required for supplying the additional flows to the SGN is sized for 120 TJ/d gas flow at the minimum station inlet pressure of 5 MPag. There is provision for the installation of a second redundant filter.

### *Existing HPMS Heating*

HPMS currently has three water bath heaters (WBH) providing heating of the process gas prior to metering and pressure regulation.

The existing heating will be retained for the existing SGN delivery leg. The control philosophy will be upgraded and integrated within the existing control system to ensure common station outlet temperature control and to achieve split operation of the two delivery legs to SGN.

### *New Sydney Gas Network Delivery Leg Heating*

Two identical hot water heater and heat exchanger packages will be provided, sized for the delivery of the additional flow into the SGN.

The shell and tube heat exchangers have gas flowing on the tube side, heated by hot water flowing through the shell side. Hot water is circulated in a closed loop system and heat is provided by the hot water heater package.

The two heat exchangers will be configured for parallel operation; this arrangement gives operational flexibility and the ability to fully utilise the heating duty from both heater packages.

The heater packages will be enclosed in an acoustically treated enclosure or building to minimise their contribution to the current noise level at the site.

### *Flow Metering*

The existing metering on the site services the existing delivery capacity to the SGN and is to be retained. The Smithfield lateral delivery has no metering.

### *New Sydney Gas Network Delivery Leg Flow Metering*

A new metering skid will be installed for the new SGN delivery leg. The new metering skid will consist of 100% redundant ultrasonic metering. The meters are configured with a cross-over and valving to allow the meters to be run in both series and parallel arrangements.

### *Existing Pressure Reduction*

Both the Sydney Gas Network and Smithfield runs currently have their own pressure reduction skids, each consisting of two identical runs operating in a duty/standby arrangement, surrounded by an acoustic enclosure.

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## *New Sydney Gas Network Delivery Leg Pressure Reduction*

A new pressure reduction skid will be included in the new flow path, sized for the design flows and operating pressure ranges. Each run will include an upstream actuated fail-closed slam-shut valve fitted with a pneumatic over-pressure trip, requiring manual on-site reset. Control valves for each run will be in an active/monitor arrangement. The active control valve will be fail-open and the monitor control valve will be fail-closed. Pressure relief has not been included as slam-shut valves with active/monitor control valves meet code requirement for pipeline protection. However provision for future installation of pressure relief is provided.

### **2.3.2 Site Buildings**

There is an existing dedicated control building on site housing (Ref 1):

- Lighting and power;
- Air conditioning;
- Fire detection and suppression;
- Intruder detection;
- Power distribution boards;
- DC power supplies and batteries;
- Station control panel;
- Fibre optic and communications panels; and
- Operator desk with LAN connection.

As part of station upgrade, there will be a new Plant Building to accommodate the hot water heaters and new separate compartment to house the new control wave micro RTUs. The new building will have the same infrastructure as the existing building.

## **2.4 PROCESS CONTROL**

The proposed system of process control of the HPMS is described in detail in the design basis manual (Ref 1). The design includes the following control modes:

- Station output control using the flow control valve skids in an arrangement where the lead duty Flow Control Valve (FCV) skid attempts to provide the required flow, cascading to the lag FCV skid if the overall station flow is not met. FCV flow control will be over-ridden by either a high station outlet pressure control mode and/or a low station outlet temperature control mode on a minimum select basis.
- High station outlet pressure control mode which acts to reduce the overall station flow rate when a nominated maximum outlet pressure is exceeded. In this mode, the lag skid flow is reduced first.
- Low station outlet temperature control mode which acts to reduce the flow through each FCV skid when a nominated low outlet temperature is exceeded. This will occur when either a station flow path heater capacity is insufficient, or if a duty heater goes offline. As flow is

reduced in this mode the lag FCV skid may be called into duty based on the flow control loop.

Heater control will be achieved using heater common outlet temperature upstream of the flow control / pressure reducing skid. A basic calculation algorithm determines the desired outlet temperature based on the station differential pressure and flow. A second control loop will monitor actual station outlet temperature and override the calculated value if the outlet temperature falls below a minimum nominated value. Within each heater group there will be a nominated lead and lag heater and control will cascade accordingly. Both flow path heater groups use the same station outlet temperature value and control algorithm however the loops will operate independently.

## 2.5 DESIGN AND OPERATING CONDITIONS

Table 1 below lists the design and operating conditions used in the basis of design (Ref 1).

**Table 1 – Design and Operating Conditions**

Parameter	Value
<i>Maximum Allowable Operating Pressure – this is the maximum design pressure</i>	
Design Pressure	14.985 MPag (upstream of station outlet shutdown valve) 6.895 MPag (downstream of station outlet shutdown valve)
<i>Normal operating pressure ranges.</i>	
Minimum Inlet Operating Pressure	5 MPag
Normal Inlet Operating Pressure	9 MPag
Maximum Inlet Operating Pressure	12 MPag
Minimum Outlet Operating Pressure	3.5 MPag
Normal Outlet Operating Pressure	4.3 MPag
Maximum Outlet Operating Pressure	6.895 MPag (piping MAOP)
Minimum Inlet Gas Temperature	13°C
Maximum Inlet Gas Temperature	23°C
Station Inlet Maximum Gas Flow Rate	328 TJ/d
Station Inlet Maximum Gas Flow Rate (Instantaneous)	361 TJ/d
JGN to SGN – New Run Maximum Flow Rate	120 TJ/d
JGN to SGN – New Run Minimum Flow Rate	30 TJ/d (control valves will lock up at lower flows)
New Run Gas Heating System	
- Gas Flow Rate	120 TJ/d
- Station Inlet Pressure	9 MPag
- Station Outlet Pressure	3.5 MPag

Parameter	Value
- Gas Inlet Temperature	13°C
- Gas Outlet Temperature	5°C
- Minimum Gas Outlet Temperature	2°C

The maximum and minimum design temperatures for all station piping and equipment are shown in Table 2 (Ref 1).

**Table 2 – Piping Classes and Design Temperatures**

Section	Class	Min Temp (°C)	Max Temp (°C)
From inlet valve to heater inlet	900	0	65
From heaters to inlet of pressure reduction valves	900	0	81
Downstream of active pressure reducing valve to Jemena Gas Network Train A tie -in	900	-45	65
Downstream of station outlet shutdown valve	600	0	65

## 2.6 STANDARDS AND LEGISLATION

All facilities handling dangerous goods need to comply with relevant NSW legislation.

Table 3 provides a list of relevant Codes and Standards for the HPMS.

**Table 3 – List of Relevant Codes and Standards**

Code/Standard Number	Title
API 5L	Specification for Line Pipe
API 6D	Pipeline Valves
API RP 521	Guide for Pressure Relieving and De-pressuring Systems
API RP 1102	Steel Pipelines Crossing Railroads and Highways
AS 1020	Control of Undesirable Static Electricity
AS1200	Pressure Equipment
AS 1210	SAA Unfired Pressure Vessels Code
AS 1271	Safety valves, other valves, liquid level gauges and other fittings for boilers and unfired pressure vessels
AS 1319	Safety Signs for the Occupational Environment
AS 1627.4	Abrasive Blast Cleaning of Steel
AS1697	Installation and Maintenance of Steel Pipe Systems for Gas
AS 1725	Chain Link Fabric Security Fencing and Gates
AS 1768	Lightning Protection
AS 1939	Degrees of Protection Provided by Enclosures for Electrical Equipment (IP Code)
AS 2380	Electrical Equipment for Explosive Atmospheres – Explosion Protection Techniques

Code/Standard Number	Title
AS 2832	Guide to the Cathodic Protection of Metals
AS2885 Parts 0, 1, 2, 3 and 5	High Pressure Pipeline Code
AS 3000	SAA Wiring Rules
AS 3008	Electrical Installation – Selection of Cables
AS 3862	External Fusion Bonded Epoxy Coating for Steel Pipes
AS 4041	Pressure Piping
AS 4564	Specification For General Purpose Natural Gas
AS 4645	Gas Distribution Network Management
AS 4853	Electrical Hazards on Metallic Pipelines
AS/NZS 60079.10.1	Explosive Atmospheres – Classification of Areas – Explosive Gas Atmospheres
AS/NZS 60079.1 AS/NZS 60079.11 AS/NZS 60079.17	Explosive Atmospheres – Electrical Installations Inspection and Maintenance
ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged Fittings NPS ½” Thru NS 24”
ASME B16.9	Steel Butt Welding Fittings
ASME B16.10	Face to Face and End to End Dimensions of Valves
ASME B16.20	Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral Wound and Jacketed
ASME B16.34	Valves – Flanged, Threaded and Welding End
ASME Section VIII	Unfired Pressure Vessels (acceptable alternative to AS 1210)
ASTM A193/4	Specification for Fasteners

Pipe fittings, supports, and all other ancillary items will also need to comply with appropriate Australian Standards whether referenced above or not.

## 2.7 SECURITY AND PROTECTION AGAINST UNLAWFUL ENTRY

Site lighting is designed to provide a safe work environment for after-hours call out and to provide a deterrent for unlawful access.

The site is surrounded by a 2.3 metre high galvanised chain wire and barbed wire fence. The Site can be accessed through two locked security gates (both already existing) at the Southern and Eastern perimeters.

Site security includes intrusion detection on the site fence, gate and control building doors and windows. These are connected back to the SCADA and to Jemena’s security monitoring service.

## **2.8 MANNING**

HPMS is highly automated and hence requires very little attendance in its day to day operation. The facilities are normally unmanned but are visited weekly (every 2-3 days) by Jemena staff (Ref 4).

2 technicians would visit the site on a quarterly basis and work for about 2 days at 8-10 hours per day carrying out minor maintenance.

Major maintenance would occur 1-2 times per year and would involve around 8 persons working 8-10 hours per day for 2-3 days each time.

The operation of the facility is controlled, operated and monitored continuously via telemetry at the Control Room for the Eastern Gas Pipeline using a supervisory control and data acquisition (SCADA) system. The Control Room is manned 24 hours a day, seven days a week, 365 days a year.

## **2.9 LIGHTNING PROTECTION**

Lightning protection is provided in the form of buried main earth grid installed around site, to minimise damage against lightning-induced faults.

All equipment is earthed through a running earth system to ground. Electrical equipment has surge diverters for protection of control system.

In times of electrical storm activity within 50km any open work permits for the facility are cancelled and work is made safe and ceased until weather passes.

### **3 SAFETY FEATURES**

The inherent risks associated with natural gas facilities are managed at HPMS in accordance with the principles of operational safety through design. The main philosophies that have been adopted to avoid potential high risk situations associated with the operation of the existing facility and the upgrade are to eliminate the potential risks through design and to ensure appropriate quality control during construction.

Specific safety features are reviewed below. These features are again detailed within the Hazard Identification Word Diagram (HAZIDWD) in Table 6 below together with the threats and potential consequences associated with these safety features.

Recommendations to further safeguards were identified during the preparation of this PHA. These recommendations are detailed in the HAZIDWD and are referred to in the text below.

#### **3.1 DETECTION OF AN UPSET CONDITION**

Conditions (temperatures, pressures, flows) at the facility are monitored from the Control Room located in Mount Waverley, Melbourne, Victoria. The control room is manned 24/7/365 by at least one operator. There is also another backup control room in Melbourne if for any reason the main control room cannot be accessed. In case of an upset condition at the facility, numerous alarms would initiate response by the control room operator who can respond; for example by activating isolation from the remote location of the control room – further details on plant isolation, refer Section 3.5.

#### **3.2 GAS LEAK PREVENTION AND PROTECTION**

The facility has been designed and constructed designed in accordance with the requirements of Australian Standards *AS2885.1 Design and construction of Pipelines gas and liquid petroleum* and *AS4041-2006 Pressure piping*.

Leaks of natural gas from pipes and equipment are prevented through the following features:

- Minimise number of piping flanges - welded connections to be used wherever possible.
- Non-destructive (x-ray) testing of welds during construction.
- Preventative maintenance on all valves and equipment associated with the station (including regular inspection of site equipment).
- Stringent requirements for material & fabrication inspection prior to fabrication of pipe.
- Hydrostatic testing of installation prior to commissioning.
- Prevention of mechanical failure (e.g. for the pipeline being hit by vehicle or projectile, or again by digging equipment) through the following:
  - Bollards are provided to protect above ground piping from access road.

- Marker tape above buried pipe provides pre-warning in case of digging.
- Thick-walled, well-supported pipe.
- Site is operated by Jemena – any work will be under direct supervision (incl. requirements to consult engineering prior to digging / trenching / placing load on site) and subject to work permits.
- Corrosion prevention achieved as follows:
  - Buried pipeline and pipes are coated. Above ground pipeline and pipes are painted.
  - Buried pipeline is provided with cathodic protection (with regular inspection and monitoring).
  - Thick wall pipe.
  - Natural gas is a clean hydrocarbon lowering the risk of internal corrosion.
  - Dry filtering of inlet gas stream removes corrosive particulates (<5 µm).
- Prevention of overpressure as follows:
  - Both existing and new slam-shut valves (SSVs) are fitted with a pneumatic over-pressure trip, requiring manual on-site reset. Fail-closed SSV.
  - Pipe will be designed to withstand considerable overpressure by being thick walled, welded & hydrotested.

### **3.3 SEPARATION DISTANCE**

Separation distance between the HPMS and sensitive locations aid in minimising the extent of damage should an incident occur.

### **3.4 CONTROL OF IGNITION SOURCES**

Ignition sources are controlled through:

- Design of site and equipment as per Hazardous Area requirements.
- Earthing of all equipment to an earth grid.
- All electrical equipment has surge diverters for protection of the control system.
- Permit to Work requirements (including Hot Work permit).
- No smoking or naked flames allowed on site, and no spark ignition vehicles allowed in designated hazardous areas.
- Fenced off area with warning signs as per Australian Standards requirements.

### **3.5 PLANT ISOLATION**

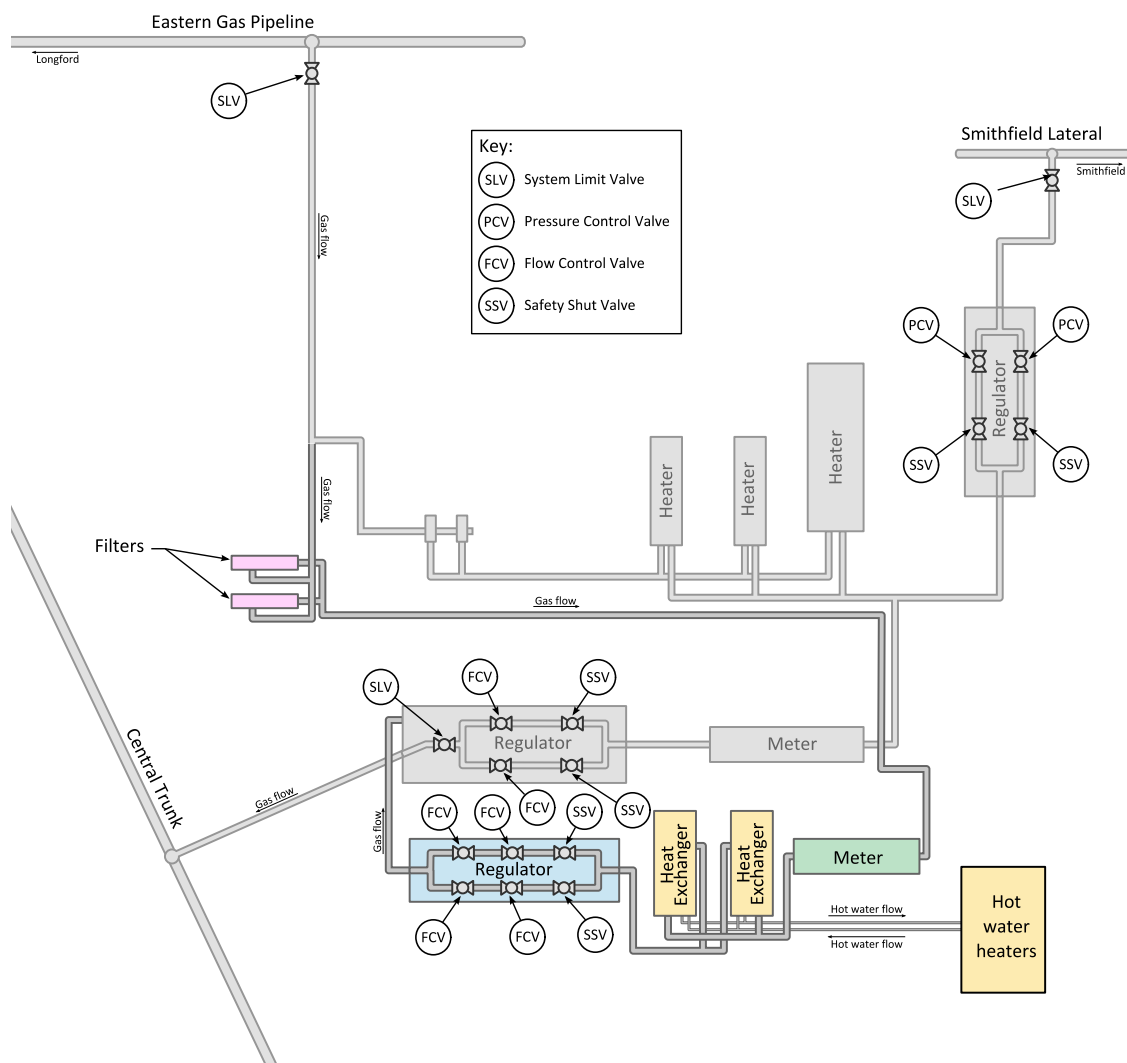
Numerous valves have been included in the pipework within the individual components of the facility to allow the facility to be isolated in the event of an

emergency or to take sections and components out of service for maintenance and repairs as required. The types of valves that can be used to isolate flow automatically and/or remotely are:

- Station Limit Valves (SLVs) – these valves are able to be actuated remotely from the Control Room to isolate the facility from the pipelines to which it is connected.
- Pressure Control Valves (PCVs) and Flow Control Valves (FCVs) – close off automatically when abnormal flow and pressure conditions are detected. These valves can also be actuated remotely from the EGP Control Room
- Slam Shut Valves (SSV) – these valves slam shut automatically under certain gas conditions and are installed as a failsafe measure.

The locations of these valves for both the existing facility and the upgrade are shown in Figure 5.

**Figure 5 – Automatic and remotely operated valves within the HPMS**



Source (Ref 5)

### **3.6 FIRE DETECTION AND SUPPRESSION**

The existing control building has a dedicated fire detection and suppression system consisting of smoke detection and Novec 1230 suppression systems. The detection systems are monitored via the SCADA. A warning beacon is provided above the door to warn personnel that the suppression system has activated.

The new plant building will be fitted with an equivalent fire detection and suppression system.

### **3.7 PREVENTION OF SPILL AND FIRE INVOLVING OTHER DANGEROUS GOODS**

Other than the natural gas that flow through the facility, only minor quantities of dangerous goods are kept onsite:

- A bunded Dangerous Goods cabinet contains some minor quantities (limited to no more than 20L containers) of oils, corrosion inhibitor, regular pesticides, and unleaded fuel for maintenance machinery and weed control.
- A self-contained bunded skid/pallet with around 200L of diesel fuel for use within the diesel generator as a backup power supply. The diesel generator is located in one of the control buildings and is run for a few hours once per month at low load to ensure that it is working. A mini tanker (or similar) is brought to site as required to top up the full tank (say once every 2-3 months).

Spill kits are available on site and would be used in the event of a spills.

### **3.8 FIRE PREVENTION – GENERAL**

Fire extinguishers are provided at the HPMS as required.

The existing Control Building and new Plant Building have been designed following the requirements under the Australian Building Code.

### **3.9 PREVENTION FROM EXPOSURE TO HARMFUL MATERIAL**

There will be very limited amounts and types of potentially harmful material available at the HPMS, limited to some material for use during maintenance of valving etc.

Compressed natural gas is harmful if allowed to escape, for example during maintenance activities, as it is highly pressurised and becomes very cold on release. These risks are well understood and managed by the people performing the maintenance tasks, and procedures and work permit systems are in place. There are also requirements for PPE, such as the use of gloves, safety glasses etc. Further, a Permit to Work system applies on site.

### **3.10 BUSH FIRE PROTECTION**

The HPMS site is gravelled and kept clear for several metres beyond the site perimeter.

### **3.11 PROTECTION IN CASE OF LOSS OF SERVICES**

Mains electrical power is supplied to the site. A standby diesel generator is installed to provide back-up power to critical equipment and controls of the site in the event of mains failure. Start-up of the generator / alternator is achieved automatically or remotely from the EGP Control Centre.

All critical instruments, safety systems, and control systems will be powered by a DC UPS (Direct Current Uninterruptible Power Supply), powered directly from a battery bank (24V DC). The battery bank can provide power for critical instrumentation, control and equipment for up to 24 hours.

Loss of mains power may cause equipment running on 240V and or 415V supply to shut down for a short period of time until mains is restored or the standby generator starts up.

Valves will be opened and shut using instrument air or natural gas. In case of failure of pressure to their solenoid valves, the valves will be designed to fail safely (either open or close depending on their duty).

### **3.12 PREVENTION OF FLOODING OF SITE**

Flooding in this area is regarded as a low risk scenario from a landuse planning point of view.

The drainage system at the HPMS will be considered in the detailed design, to avoid water ponding on site (Ref 4).

### **3.13 ROAD TRANSPORT RISKS**

Road transportation would use Chandos Rd and then turn north into the access road to the site. Under normal operating conditions the existing facility is unmanned and requires only infrequent vehicular access.

Increased site access is required during facility maintenance activities, including heavy vehicles trips associated with site deliveries. Such activities occur infrequently (Ref 5).

Once the construction work has been finalized and the upgraded site has been put into operation, the frequency of road transportation to the HPMS of dangerous goods and potentially hazardous material will be minimal.

## 4 STUDY METHODOLOGY

### 4.1 INTRODUCTION

The methodology for the PHA is well established in Australia. The assessment has been carried as per the DP&E's HIPAP No 6 (Ref 2) and HIPAP No 4 (Ref 3). These documents describe the methodology and the criteria to be used in PHAs, as required by the DP&E for major "potentially hazardous" development.

There are five stages in risk assessment (as per Ref 2):

**Stage 1. Hazard Identification:** The hazard identification includes a review of potential hazards associated with all dangerous and hazardous goods to be processed, used and handled at the facility. The hazard identification includes a comprehensive identification of possible causes of potential incidents and their consequences to public safety and the environment, as well as an outline of the proposed operational and organisational safety controls required to mitigate the likelihood of the hazardous events from occurring.

The tasks involved in the hazard identification of the proposed facility included a review of all relevant data and information to highlight specific areas of potential concern and points of discussion, including drafting up of preliminary hazard identification (HAZID) word diagram. The HAZID word diagram is then reviewed and complete in a workshop which included people with operational / engineering / risk assessment expertise. The review takes into account both random and systematic errors, and gives emphasis not only to technical requirements, but also to the management of the safety activities and the competence of people involved in them.

The final HAZID word diagram is presented in Section 5.3.

**Stage 2. Consequence and Effect Analysis:** The consequences of identified hazards are assessed using current techniques for risk assessment. Well established and recognised correlations between exposure and effect on people are used to calculate impacts. Refer Section 6.

**Stage 3. Frequency Analysis:** For incidents with significant effects, whether on people, property or the biophysical environment, the incident frequency are estimated, based on historical data. A probabilistic approach to the failure of vessels and pipes is used to develop frequency data on potentially hazardous incidents. Refer Section 7.

**Stage 4. Quantitative Risk Analysis:** The combination of the probability of an outcome, such as injury or death, combined with the frequency of an event gives the risk from the event. In order to assess the merit of the proposal, it is necessary to calculate the risk at a number of locations so that the overall impact can be assessed. The risk for each incident is calculated according to:

$$\text{Risk} = \text{Consequence} \times \text{Frequency}$$

Total risk is obtained by adding together the results from the risk calculations for each incident, i.e. the total risk is the sum of the risk calculated for each scenario.

The results of the risk analysis are presented in three forms:

- Individual Fatality Risk, i.e. the likelihood (or frequency) of fatality to notional individuals at locations around the site, as a result of any of the postulated fire and explosion events. The units for individual risk are probability (of fatality) per million per year. Typically, the result of individual risk calculations is shown in the form of risk contours overlaid on a map of the development area. For pipelines (as for other transport activities), the individual risk contours are best represented as risk transects, showing the risk as a function of the distance from the pipeline.
- Injury and irritation risk, i.e. the likelihood of injury to individuals at locations around the site as a result of the same scenarios used to calculate individual fatality risk.
- Societal risk takes into account the number of people exposed to risk. Whereas individual risk is concerned with the risk of fatality to a (notional) person at a particular location (person 'most at risk', i.e. outdoors), societal risk considers the likelihood of actual fatalities among any of the people exposed to the hazard. Societal risk are presented as so called *f-N curves*, showing the frequency of events (f) resulting in N or more fatalities. To determine societal risk, it is necessary to quantify the population within each zone of risk surrounding a facility. By combining the risk results with the population data, a societal risk curve can be produced

The risk results are then assessed against the guidelines adopted by DP&E (Ref 3).

**Stage 5. Risk reduction:** Where possible, risk reduction measures are identified throughout the course of the study in the form of recommendations.

## 4.2 SAFETY MANAGEMENT SYSTEMS

### 4.2.1 Safety Management in General

In quantitative risk assessments, incidents are assessed in terms of consequences and frequencies, leading to a measure of risk. Where possible, frequency data used in the analysis comes from actual experience, e.g. near misses or actual incidents. However, in many cases, the frequencies used are generic, based on historical information from a variety of plants and processes with different standards and designs.

As with any sample of a population, the quality of the management systems (referred to here as "safety software") in place in these historical plants will vary. Some will have little or no software, such as work permits, planned maintenance and modification procedures, in place. Others will have exemplary systems covering all issues of safe operation. Clearly, the generic frequencies

derived from a wide sample represent the failure rates of an "average plant". This hypothetical average plant would have average hardware and software safety systems in place.

If an installation which has significantly below average safety software in place is assessed using the generic frequencies, it is likely that the risk will be underestimated. Conversely, if a plant is significantly above average, the risk will probably be overestimated. However, it is extremely difficult to quantify the effect of software on plant safety. Incorporating safety software as a means of mitigation has the potential to significantly reduce the frequency of incidents and also their consequences if rigorously developed and applied. The risk could also be underestimated if safety software is factored into the risk assessment but is not properly implemented in practice. Practical issues also arise when attempting to factor safety software into the risk assessment – applying a factor to the overall risk results could easily be misleading as in practice it may be the failure of one aspect of the safety software that causes the accident, while all other aspects are managed exemplarily.

In this study it is assumed that the generic failure frequencies used apply to installations which have safety software corresponding to accepted industry practice and that this site has similar management practices and systems. This assumption it is believed, will be conservative in that it will overstate the risk from well managed installations.

#### **4.2.2 Safety Management System Implemented On Site**

Jemena have a commitment to workplace health and safety and have numerous policies and procedures to achieve a safe workplace.

The operation of the existing facility is continually monitored and controlled from a central control room via a supervisory control and data acquisition (SCADA) system.

An incident reporting and response system is established, providing 24 hour coverage.

The HPMS needs to comply with all codes and statutory requirements with respect to work conditions. Special precautions are observed as required by the site conditions, in particular, standards and requirement on the handling of pressurised, flammable gases. All personnel required to work with these substances are trained in their safe use and handling, and are provided with all the relevant safety equipment.

Emergency procedures have been developed and personnel are trained to respond to emergencies.

The site has an operations manager with overall responsibility and who is supported by experienced personnel trained in the operation, maintenance and support of the facility.

A Permit to Work system (including Hot Work Permit for any work that could provide an ignition source) and control of modification systems are in use on site to control work and to control plant and structure from substandard and potentially hazardous modifications.

Protective systems are inspected and tested to ensure they are, and remain, in a good state of repair and function reliably when required to do so. This will include scheduled testing of shutdown valves, trips and alarms, and relief devices.

All persons on the premises have been provided with appropriate personal protective equipment suitable for use with the specific hazardous substances.

A first aid station has been provided comprising an appropriate first aid kit and first aid instructions, i.e. Material Safety Data Sheets (MSDSs), for all substances kept or handled on the premises.

## 5 HAZARD IDENTIFICATION

### 5.1 HAZARDOUS MATERIALS

The natural gas metered by the facility is composed predominantly of methane gas (>92 mole %) with the residual mainly ethane (approx. 4 mole %) and carbon dioxide (<2 mole %). The properties of natural gas are represented by methane and are presented in Table 4.

**Table 4 - Properties of Methane Gas**

Molecular weight (g/mole)	17
Relative density of the gas (atmospheric temp. and pressure)	0.6
Heat of combustion (MJ/kg)	50
Flammable range (vol. % in air)	5 to 15
Ratio of specific heats (Cp + Cv)	1.31
Flash point	-218°C
Self-Ignition Temperature	>400°C

### 5.2 SUMMARY OF HAZARDS IDENTIFIED

The main hazard associated with the HPMS is related to a leak of natural gas which is a flammable gas held under pressure.

This would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or explosion incident. The factors involved are:

- Failure must occur causing a release. There are several possible causes of failure, with the main ones being corrosion and damage to the equipment due to physical interaction;
- The released material must come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames some distance from the release;
- Depending on the release conditions, including the mass of material involved and how rapidly it is ignited, the results may be a localised fire (for example a so called jet fire), a flash fire or an explosion of the vapour cloud formed through the release.
- Finally, for there to be a risk, people must be present within the harmful range (consequence distance) of the fire or explosion. How close the people are will determine whether any injuries or fatalities result.

Natural gas is a buoyant, flammable gas which is lighter than air (relative density of 0.6). On release into the open the non-ignited gas tends to rise rapidly at altitude where it will disperse to below hazardous concentration without encountering an ignition source. Ignition at the point of release is possible, in which case the gas may burn as a jet (or torch) flame. On release in an enclosed area (for example within the gas engine/compressor housing) it may burn or if an accumulation of gas occurs (e.g. due to a ventilation failure),

an explosion or a flash fire is possible. Combustion and/or explosion is only possible with a concurrent source of ignition.

The gas is non-toxic, posing only an asphyxiation hazard but will always be odourised so that it is olfactorily detectable at concentrations well below the flammable limit. Due to its buoyancy, any release of credible proportions from operations of this scale, in the open, would not present an asphyxiation hazard. With standard confined space entry procedures and appropriate security arrangements to prevent unauthorised access to any of the facilities the risk associated with asphyxiation from natural gas should be minimal.

Locally, the uncontrolled release of compressed gas at high pressure may be hazardous to personnel. These hazards, while of importance for people working in close proximity, do not have implications beyond the immediate location of the release unless the released gas is ignited. Therefore, the risk associated with release of non-ignited compressed gas does not form part of the scope of the present risk assessment. This potential risk would however need to be closely managed through job safety analysis (JSA) and/or other risk assessment practices used by management and operators of the facility (in accordance with NSW Workplace Health and Safety Act and its associated regulations (Ref 6).

A total of 15 hazards were reviewed in terms of their potential consequences and likelihoods, as listed in Table 5 below.

**Table 5 - Summary of Identified Hazards**

Number	Hazardous Event Potential
1-5	Release of flammable gas from a generic leak in pipes, heat exchanger tubing, valves and fittings into the atmosphere (various causes)
6	Explosion within piping or inside a vessel
7	Incident at site building
8	Malicious damage/ unauthorised operation
9	Flooding/ rain water
10	Lightning strike
11	Bush fire
12	Loss of services (electricity, instrument gas)
13	Differential settlement of pipework and/or equipment
14	Aircraft crash
15	Release of flammable gas into the atmosphere from JGN connecting pipe

### 5.3 HAZARD IDENTIFICATION WORD DIAGRAM

The Hazard Identification Word Diagram, included in Table 6 below, provides a summary of the hazardous incidents identified for the site (existing and proposed) and their associated mitigating features. Each section of the HPMS was reviewed, to determine the potentially hazardous scenarios relevant to that section.

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The hazard identification word diagram was compiled based on Planager's experience and literature search of comparable installations and facilities elsewhere.

**Table 6 – Hazard Identification Word Diagram**

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
<b>Natural Gas Piping and Equipment (New and Existing Plant)</b>						
1	Release of flammable gas from a generic leak in pipes, heat exchanger tubing, valves and fittings into the atmosphere	Corrosion (external or internal); flange or valve leak; failure in maintenance procedure	Release of odourised natural gas into the open. Dissipates into atmosphere. If ignition source then possible jet fire. Potential shutdown (closure of isolation valves due to reduced flow). Potential injury to personnel	Clean hydrocarbon. Dry gas filters remove corrosive particulates (<5µm). Tape or coating of hot tap fitting, valve and riser pipe. Cathodic protection system. Above ground piping is coated. Routine inspections for corrosion. Testing of valves. Approved vendor lists. Double block and bleed on some equipment. Hazardous area and intrinsic safety. Shell designed for tube rupture and safe vent to atmosphere. Corrosion inhibitor in water circuit.	Automatic and remote plant isolation using a system of SLVs, PCVs, FCVs and SSVs.  Redundancy in equipment (e.g. manual switch to standby heat exchanger on tube leak)  Emergency response plans.  Fire services intervention as required.	No further recommendations identified.

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
2	Release of flammable gas due to failure during design or construction	Design, material and/or construction defects	As above	Jemena and subcontractor quality and quality control procedures. Safety factors in Code. Hydrostatic proof testing. .	As above	No further recommendations identified.
3	Release of flammable gas due to impact	Mechanical damage caused by external impact e.g. from vehicle impact against exposed section of pipe; dropped object from crane	Possible damage to pipe. May lead to major failure / rupture. Fire incident – injury to personnel.	Site layout minimises/eliminates vehicle impacts, need to lift equipment over pipework. Bollards installed near road/equipment boundaries; Designated road access. Permits, inductions, training. Lifting plans and procedures (including requirement to isolate equipment if lift is necessary).	As above.	No further recommendations identified.
4	Release of gas due to propagation from neighbouring plant	Propagation damage from incident at neighbouring facility e.g. projectiles from incident explosive decompression; thermal radiation	Damage to equipment. Loss of supply.	Piping wall thickness. Separation distances.	As above.	No further recommendations identified.

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
5	Release of gas due to over-pressurisation	Operation / control systems error causes over-pressurisation	Stressing of pipe if pressure exceeds MAOP may lead to failure or rupture of pipeline / flanges / connections / filter.	Prevention of overpressure (OP) through control logic, trips and automatic shutdown. Pipe withstands considerable OP by being thick walled, welded & hydrotested. Separation distance to neighbouring landuses.	As above.	No further recommendations identified.
6	Explosion / flash within piping	Failure of maintenance activities creates ingress of air into natural gas piping and subsequent start-up without adequate purging along with construction debris may create spark	Possible explosion / flash. Due to the limited quantities of gas involved the effects of the explosion would however not be expected to pose a threat to nearby facilities or landuses.	This scenario is only theoretically possible during start-up, shut-down and maintenance operations; Piping normally operated at a positive pressure, preventing ingress of air; Prevention of ingress of air is considered throughout the design and operation of the facility (start-up, shut-down and maintenance procedures, Permits to Work).	As above	No further recommendations identified.

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
<b>Site Buildings</b>						
7	Incident at site building: - Control Building (existing) - Plant Building (new)	Electrical fire.	Damage to building causes financial loss and possible loss of control of site.	Fire detection and suppression system (VESDA). Buildings designed following the requirements under the Australian Building Code	Emergency response plans.  Fire services intervention as required.	No further recommendations identified.
<b>Whole Site</b>						
8	Malicious damage/ unauthorised operation	Sabotage / children / vandalism.	Small damage to an instrument line through to damage to pipeline leading to fire/explosion. Possible destruction of site. May loose supply to customers.	Security fence, locked gates, intruder alarms. Security patrols and reviews. Process monitoring (loss of supply)	Emergency response plans.	No further recommendations identified.
9	Flooding / rain water resulting in process upsets	Heavy rains	Possible damage to equipment. Isolation of site.	Site unlikely to flood. Site drainage/ stormwater management.	Emergency response plans.	No further recommendations identified.
10	Lightning strike	Lightning causes failure pipeline / equipment	Damage to pipeline causes release of gas. Lightning may ignite the gas leading to a fire.	Main earth grid around the station will protect against earthing strikes	Automatic and remote plant isolation using a system of SSVs, PCVs, FCVs and SSVs. Fire services intervention as required.	No further recommendations identified.

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
11	Bush fire causes damage to site	Bush fire in the area	Heat radiation may damage equipment, buildings etc.	The site is gravelled and kept clear for a few metres outside the perimeter fence	General bush fire mitigating measures by local fire services	No further recommendation identified
12	Loss of services (electricity, instrument gas)	Loss of electricity	Potential loss of control of site.	Site uninterruptible 24VDC back-up supply system powered by diesel generator	Powered equipment will restart automatically when diesel generator starts up	No further recommendations identified.
13	Differential settlement of pipework and/or equipment	Ground movement, subsidence	Damage to piping/ equipment caused by overstressing. Potential hazardous releases, fire/ explosion.	Safety factors in design. Design with adequate foundations for zero movement. Site technicians would notice support lift-offs.	Automatic and remote plant isolation using a system of SLVs, PCVs, FCVs and SSVs Emergency response plans  Fire services intervention as required.	No further recommendations identified.
14	Aircraft crash (e.g. patrol helicopter) results in process upsets, potential damage to process / storage facilities resulting in hazardous releases.	Aircraft crash	Potential damage to process / storage facilities resulting in hazardous releases, fire / explosion. Potential loss of life	General aircraft safety regulations make air crashes highly unlikely. Relatively small foot print of HPMS makes it unlikely to be hit even in case of a crash.	As above	No further recommendations identified.

N°	HAZARDOUS EVENT/ SITUATION	POSSIBLE CAUSE	CONSEQUENCES IMMEDIATE/ ULTIMATE	PREVENTED OR CORRECTED BY	EMERGENCY MEASURES/ MITIGATION	RECOMMENDATIONS
15	Release of flammable gas into the atmosphere	Corrosion of new buried pipeline connecting to JGN due to poor maintenance (JGN responsibility)	Release of odourised natural gas into the open. Dissipates into atmosphere. If ignition source then possible jet fire. Potential injury to personnel.	Coating and wall thickness. Corrosion protection system monitoring. Physical inspection.	As above	No further recommendations identified.

## 6 CONSEQUENCE ANALYSIS

A set of representative incident scenarios was determined, based on the current design of the HPMS, applicable codes and standards, and engineering practice. These scenarios include a range of the hazardous events that have some potential to occur in each area of the facility. In general, these events can be divided into the following categories:

- Moderate releases (punctures), characterised by a hole equivalent to 10% of the cross sectional surface area of the pipe diameter;
- Large releases (ruptures), characterised by a hole with a diameter equal to the pipe diameter or, for vessels and certain process equipment, a hole with a diameter equal to the diameter of the largest attached pipe;
- Minor failure of a vessel, characterised by a hole of 10mm equivalent diameter;
- Massive failure of a vessel, characterised by a release over 10 minutes of the full contents of the vessel;
- Catastrophic failure of a vessel, characterised by an instantaneous release of its contents.

### 6.1 MODELLING SOFTWARE

Consequence analysis was undertaken using the TNO (the Netherlands Organisation for Applied Scientific Research) consequence modelling software program *Effects*® (version 8.0). The TNO tools are internationally recognised by industry and government authorities.

The consequence models used within *Effects*® are well known and are fully documented in the TNO Yellow Book (Ref 7).

Essentially, an appropriate release rate equation is selected based on the release situation and initial state of the material. The atmospheric dispersion model for lighter-than-air releases is used to model dispersion behaviour for natural gas.

### 6.2 EVALUATION TECHNIQUES

#### 6.2.1 Leak Rates

The *Effects*® program models release behaviour for compressed gas, liquid or 2-phase releases from vessels, pipelines or total vessel rupture. Input data includes the type of release, location of release with respect to vessel geometry, pipe lengths etc. and initial conditions of the fluid (i.e. before release).

The release rate is assumed to remain constant until isolation can be achieved - this is a conservative approach as in reality there will be pressure reduction and hence reduction in leak rate.

## 6.2.2 Duration

The duration of a leak will depend on the hardware systems available to isolate the source of the leak, the nature of the leak itself and the training, procedures and management of the facility. While in some cases it may be argued that a leak will be isolated within one minute, the same leak under different circumstances may take 10 minutes to isolate. Under worst case conditions, such as where there are large quantities of materials between two isolating valves, the release may last even longer. In such cases, the release pressure and hence the release rate will decrease.

## 6.2.3 Dispersion Distances

A gas released will disperse in the atmosphere. At concentrations between 14% (upper flammable limit, UFL) and 5.5% (lower flammable limit, LFL) methane (the main constituent of natural gas) is flammable. The *Effects*® model is used to estimate the distance to which a release of methane will disperse to half the LFL for momentum driven (high pressure, high velocity releases). Feed rates for gas dispersion models are taken from gas release rates calculated by *Effects*®.

The *Effects*® consequence model is used to model the release of gas from a pressurized vessel or pipeline where the gas is emitted at high velocity.

## 6.2.4 Terrain Effects

Ground roughness effects the turbulent flow properties of wind, hence dispersion of a released material. Terrain effects are taken into account to some degree in dispersion modelling by use of a surface roughness length.

The roughness factor used for all release scenarios is described as *Low crops, occasional large objects* in the modelling software. This corresponds to a surface roughness factor of 0.1 m, appropriate to a plant located in a rural area, with some buildings, trees and fences in the vicinity, as well as some undulation of the surrounding land.

## 6.2.5 Time Periods

The time periods *Day* and *Night* are used and assumed to represent the periods 6 am - 5.59 pm and 6 pm - 5.59 am, respectively (used for societal risk calculations).

## 6.2.6 Distance to the Lower Flammable Limit

The length of the dispersing vapour cloud was calculated using *Effects*® (by TNO).

# 6.3 HEAT RADIATION AND EXPLOSION OVERPRESSURES

## 6.3.1 Modelling Techniques - Theory

### Heat Radiation

The effect or impact of heat radiation on people is shown in Table 7 below.

**Table 7 - Effects of Heat Radiation**

Radiant Heat Level (kW/m <sup>2</sup> )	Physical Effect (effect depends on exposure duration)
1.2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure
12.6	Significant chance of fatality for extended exposure High chance of injury
23	Likely fatality for extended exposure and chance of fatality for instantaneous (short) exposure
35	Significant chance of fatality for people exposed instantaneously

In *Effects*®, heat radiation effects are calculated based on flame surface emissive power (which is dependent on the quantity of material, its heat of combustion, flame dimensions and the fraction of heat radiated), as per the Yellow Book by TNO (Ref 7). The heat flux at a particular distance from a fire is calculated using the view factor method. The view factor takes into account the distance from the flame to the target, the flame dimensions and the orientation angle between the flame and the target.

The effect of heat radiation on a person is calculated from the probit equation which relates to the probability of fatality to the thermal dose received (i.e. the combined heat and exposure time) through the following equations.

$$\text{Probit Pr} = -36.38 + 2.56 \ln(tQ^{1.33})$$

With t = exposure time (sec) and Q = heat flux (W/m<sup>2</sup>).

And with the relationship between the probit value and the probability of fatality is calculated as follows:

$$\text{Probability of fatality} = \frac{1}{2} \left( 1 + \text{erf} \left( \frac{\text{Pr} - 5}{2^{0.5}} \right) \right)$$

### Overpressure

The effect or impact of overpressure is shown in Table 8 below.

**Table 8 – Effect of Explosion Overpressure**

Overpressure (kPa(g))	Physical Effect
3.5	90% glass breakage. No fatality, very low probability of injury
7	Damage to internal partitions & joinery 10% probability of injury, no fatality
14	Houses uninhabitable and badly cracked
21	Reinforced structures distort, storage tanks fail 20% chance of fatality to person in building
35	Houses uninhabitable, rail wagons & plant items overturned. Threshold of eardrum damage, 50% chance of fatality for a person in a building, 15% in the open

Overpressure (kPa(g))	Physical Effect
70	Complete demolition of houses Threshold of lung damage, 100% chance of fatality for a person in a building or in the open

In *Effects*®, the Multi Energy method is used to predict the overpressures from flammable gas explosions, as per the Yellow Book in (Ref 7). The key feature of the Multi-Energy method is that the explosion is not primarily defined by the fuel air mixture but by the environment in which the vapour disperses.

Partial confinement is regarded as a major cause of blast in vapour cloud deflagrations. Blast of substantial strength is not expected to occur in open areas. Strong blast is generated only in places characterized by partial confinement while other large parts of the cloud burn out without contributing to the blast effects. The vapour cloud explosion is not regarded as an entity but is defined as a number of sub-explosions corresponding to various sources of blast in the vapour cloud, i.e. each confined part of the cloud is calculated as a separate vapour cloud explosion.

The initial strength of the blast is variable, depending on the degree of confinement and on the reactivity of the gas. The initial strength is represented as a scale of 1 to 10 where 1 represents slow deflagration and 10 represents detonation. For explosions in process plant environments the initial strength is thought to lie between 4 and 7 on the scale.

### 6.3.2 Calculated Fire Dimensions

Flame dimensions will vary depending on the wind weather conditions. *Effects*® calculates the flame dimensions for each wind weather category and incorporates these into the risk assessment together with their respective probability of occurrence.

### 6.3.3 Calculated Blast Overpressure Dimensions

For a release of pressurised natural gas into an unconfined environment the chances of an explosion is extremely small (or of negligible risk).

A vapour cloud explosion is possible however if some degree of confinement is present, or if the gas cloud is massive.

## 6.4 POPULATION DENSITY

Societal risk assesses the risk of a hazardous event occurring in time and space with a human population. The population density of the surrounding area is entered into *Riskcurves*®, which is the TNO tool used for risk calculations, using the *Effects*® software for consequence calculations combined with the likelihood of the event. As per the convention the population at the HPMS compressor station itself is set at zero.

## 6.5 CONSEQUENCE CALCULATIONS

The estimated consequences for natural gas releases are shown in Appendix 1. Release rates and distances to heat radiation from jet fires and flash fires are provided in the tables in Appendix 1.

## 7 LIKELIHOOD ANALYSIS

### 7.1 FAILURE RATES

A summary of all incident scenarios that are incorporated into the hazard and risk assessment are listed in Appendix 1. The frequency of each postulated equipment failure was determined using the data in the table below.

The frequencies used for fixed plant are those in the database documented in the *Purple Book* by the Dutch TNO (Ref 8) and which is a worldwide recognised source of reference for QRAs of potentially hazardous industry.

**Table 9 - Equipment Failures and Associated Frequencies**

Type of Failure	Failure Rate (pmpy <sup>1</sup> )
<b>PIPELINES WITHIN FIXED PLANT</b>	
Leak (outflow is from a leak with an effective diameter of 10% of the nominal diameter, a maximum of 50 mm):	
< 75 mm	5 / m
> 75 mm but < 150 mm	2 / m
> 150 mm	0.5 / m
Guillotine fracture (full bore):	
< 75 mm	1 / m
> 75 mm but < 150 mm	0.3 / m
> 150 mm	0.1 / m
<b>PRESSURE VESSELS</b>	
Instantaneous release of the complete inventory	0.5
Continuous release of the complete inventory in 10 min at a constant rate of release	0.5
Continuous release from a hole with an effective diameter of 10 mm	10
<b>HEAT EXCHANGERS (TUBE, WITH NATURAL GAS IN TUBE)</b>	
Instantaneous release of the complete inventory	1
Continuous release of the complete inventory in 10 min at a constant rate of release	10
Continuous release from a hole with an effective diameter of 10 mm	10000

In the TNO methodology, failures of flanges are assumed to be included in the failure frequency of the pipeline; for that reason, the minimum length of a pipe is set at 10 metres.

### 7.2 IGNITION PROBABILITY

TNO's *The Purple Book* (8) gives the probabilities for ignition, as presented in Table 10 below. The probability increases as a function of the size of the release. For the smallest releases the ignition probability may be as low as 1-2%. Methane is considered to be of *low* reactivity, with correspondingly lower ignition probability.

<sup>1</sup> per million per year

**Table 10 – Probability of Ignition**

Release Rate for Continuous Source	Mass released for Instantaneous Source	On-plant Low Reactivity (Natural gas) Immediate ignition
<10 kg/s	<1000 kg	0.02
10-100 kg/s	1000-10,000 kg	0.04
>100 kg/s	>10,000 kg	0.09

The probability of delayed ignition of a formed flammable gas cloud, for on-plant incidents, is taken as per the methodology in the TNO Purple Book, by defining the potential ignition sources on the site and the environment and then applying a factor to account for the effectiveness (and strength) of the ignition source.

**Table 11 – Probability of Delayed Ignition**

Size Release (kg/s)	Probability of Delayed Ignition On-plant incidents
Small vapour cloud	0.1
Medium vapour cloud	0.22
Massive vapour cloud	0.33

The probability of an explosion is virtually zero for a natural gas leak out in the open. However, as a conservative assumption and as per the methodology in the TNO Purple Book, the probability of an explosion is taken as 40% of the total delayed ignition case, with flash fires accounting for the other 60% of cases.

The frequency of outcome of each individual incident scenario is listed in the spread sheet in Appendix 1.

## 8 RISK ASSESSMENT

The equipment associated with the upgrade to the HPMS will be integrated into the existing metering station. As such, the present PHA assesses the risk associated with the entire HPMS from station inlet through to the outlet including existing and new equipment.

### 8.1 RISK CALCULATIONS

The event frequency and hazard consequence data has been combined to produce estimates of risk using *Riskcurves*®, TNO's risk calculation and contour plotting program. Risk levels are calculated by considering each modelled scenario, and combining its frequency with the extent of its *harm footprints*.

*Riskcurves*® considers all scenarios, for each wind-weather combination, and sums their risk contributions across all points. It is then used to plot so-called *iso-risk contours* (i.e. lines of constant risk) to represent *individual risk*. Note that individual risk calculations conservatively assumes that a person is present at a given location, outdoors, all of the time (24 hours per day, 365 days per year), and takes no account of the individual occupancy of the area or the chance that people could escape or seek shelter indoors. In practice the actual risks to persons in these areas would be much lower, since people would only be present outdoors for a fraction of the time.

*Riskcurves*® is also used to plot so called *societal risk* profiles. Societal risk shows the frequency with which it is estimated that **N or more** fatalities will occur as a result of the facilities considered in so called *FN curves*. Societal risk essentially assesses the risk that a scenario will occur in time and in space with a human population.

Information on the frequency, location and consequences of each incident was extracted from the spread sheet and processed by the *Riskcurves*®, program. This program is designed to take consequence and frequency information and determine risk levels to individuals at all locations within a user-defined grid. From the output of *Riskcurves*®, risk contours are be drawn up on a site map.

*Riskcurves*® can determine risks to persons in the open or in buildings. For this study, risks in the open have been determined. In the case of radiation, persons are more at risk in the open due to the lack of shelter, while for explosions the risk is greater inside due to the potential for the building to collapse.

To assess injury risk and the potential for knock-on or domino incidents, *Riskcurves*® can also determine the frequency of exceeding a given level of heat radiation or explosion overpressure.

### 8.2 RISK CRITERIA

Having determined the risk from a development, it must then be compared with accepted criteria in order to assess whether or not the risk level is tolerable. If not, specific measures must be taken to reduce the risk to a tolerable level.

Where this is not possible, it must then be concluded that the proposed development is not compatible with the existing surrounding land uses.

### 8.2.1 Individual Risk Criteria

The individual fatality risk is the probability of fatality to a person or a facility at a particular point. It is usually expressed as chances per million per year (pmpy). It is assumed that the person will be at the point of interest 24 hours per day for the whole year. By convention in NSW, no mitigation is allowed, i.e. any possible evasive action that could be taken by a person exposed to a hazardous event, e.g. by walking out of a toxic cloud or a heat radiation. The assessment of fatality, incident propagation and injury risk should include all components contributing to the total risk, i.e. fire and explosion.

The DP&E uses a set of guidelines on acceptable levels or individual risk which are in line with the criteria used elsewhere in the world. These guidelines are published in the Hazardous Industry Planning Advisory Paper No. 4: *Risk Criteria for Land Use Safety Planning* (Ref 3). The criteria for maximum tolerable individual risk from a new development are shown in Table 12 below. The criteria have been chosen so as not to impose a risk which is significant when compared to the background risk we are already exposed to. This table shows the criteria for individual risk of fatality, injury and propagation of an incident.

**Table 12 – Criteria for Tolerable Individual Risk From A New Development**

Land Use		Maximum Tolerable Risk (pmpy <sup>2</sup> )
<b>Fatality risk criteria:</b>		
Hospitals, Schools, etc.		0.5
Residential areas, hotels, etc.		1
Offices, retail centres, etc.		5
Open space (active), recreation areas etc.		10
Neighbouring industrial areas		50
<b>Overpressure for Safety Distances:</b>		
Property damage and accident propagation	14 kPa(g)	50 Adjacent potentially hazardous installation, land zoned to accommodate such installations, or nearest public building
Injury risk levels	7 kPa(g)	50 At residential areas
<b>Maximum Heat Radiation:</b>		
Injury risk levels	4.7 kW/m <sup>2</sup>	50 At residential areas
Property damage and accident propagation	23 kW/m <sup>2</sup>	50 Adjacent potentially hazardous installation or land zoned to accommodate such installations

In order to put these risks into perspective, published information on the level of risk to which each of us may be exposed from day to day due to a variety of activities has been shown in Table 13 below. Some of these are voluntary, for which we may accept a higher level of risk due to a perceived benefit, while some are involuntary. Generally, we tend to expect a lower level of imposed or involuntary risk especially if we do not perceive a direct benefit.

**Table 13 – Risk to Individuals**

Activity / Type of Risk	Published levels of risk (pmpy <sup>2</sup> )
<b>VOLUNTARY RISKS (AVERAGED OVER ACTIVE PARTICIPANTS)</b>	
Smoking	5,000
Drinking alcohol	380
Swimming	50
Playing rugby	30
Travelling by car	145
Travelling by train	30
Travelling by aeroplane	10
<b>INVOLUNTARY RISKS (AVERAGED OVER WHOLE POPULATION)</b>	
Cancer	1,800
Accidents at home	110
Struck by motor vehicle	35
Fires	10
Electrocution (non-industrial)	3
Falling objects	3
Storms and floods	0.2
Lightning strikes	0.1

### 8.2.2 Societal Risk Criteria

*Societal risk* provides estimates of overall risk to the population. Societal risk takes into account whether an incident occurs in time and space with a population by taking into account the size of the population that would be affected by each incident. By integrating the risk by the local population density over spatial coordinates, the global risk for a given accident scenario is obtained. By adding up the several risk functions (one for each scenario), a global risk function is obtained. In order to estimate the number of people affected, the population density outside of the industrial site under review is determined. Therefore, two components are relevant, namely:

- The number of people exposed in an incident, and
- The frequency of exposing a particular number of people.

In the absence of published criteria in HIPAP 4 (Ref 3), the criteria in the Department of Planning have published a set of *interim* societal risk criteria (HIPAP 4) have been used for indicative purposes, as presented in Table 14.

**Table 14 – Interim Criteria for Tolerable Societal Risk, NSW**

Number of fatalities (N) [-]	Acceptable limit of N or more fatalities per year	Unacceptable limit of N or more fatalities per year
1	$3 \times 10^{-5}$	$3 \times 10^{-3}$
10	$1 \times 10^{-6}$	$1 \times 10^{-4}$
100	$3 \times 10^{-8}$	$3 \times 10^{-6}$
1000	$1 \times 10^{-9}$	$1 \times 10^{-7}$

<sup>2</sup> pmpy = per million per year

The societal risk criteria specify levels of societal risk which must not be exceeded by a particular activity. The same criteria are currently used for existing and new developments in NSW. Two societal risk criteria are used, defining acceptable and unacceptable levels of risk due to a particular activity. The criteria in Table 14 above are represented on the societal risk (f-N) curve as two parallel lines. Three zones are thus defined:

- Above the unacceptable/intolerable limit the societal risk is not acceptable whatever the perceived benefits of the development.
- The area between the unacceptable and the acceptable limits is known as the ALARP (as low as reasonably practicable) region. Risk reduction may be required for potential incidents in this area.

Below the acceptable limit, the societal risk level is negligible regardless of the perceived value of the activity.

In addition to quantitative criteria, qualitative guidelines are also given to ensure that off-site risk is prevented and where that is not possible, controlled. For new proposals, in addition to meeting the quantitative criteria, risk minimisation and use of best practice must be demonstrated. These terms imply:

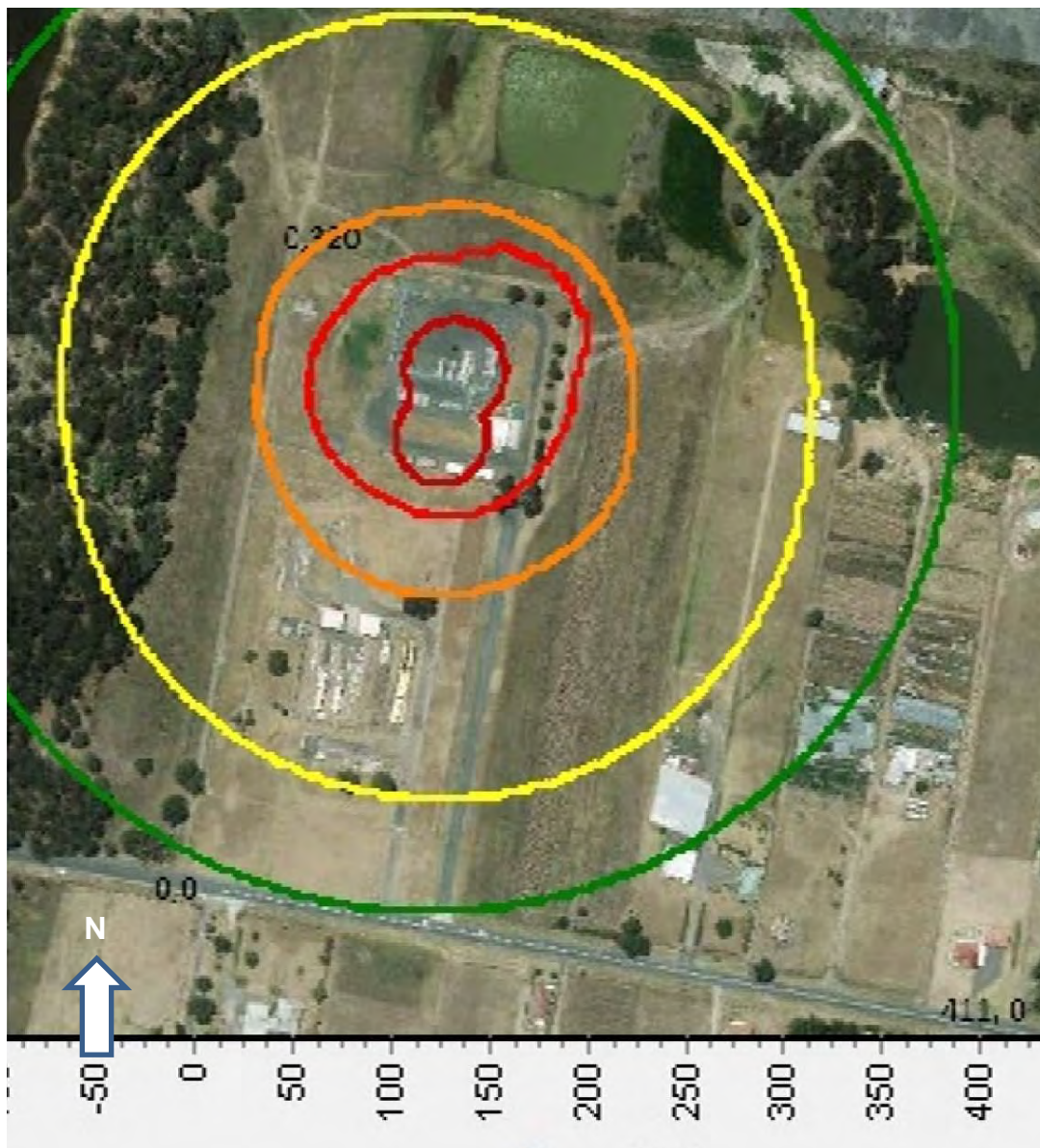
- **Risk Minimisation:** Risks should be reduced to As Low As Reasonably Practicable (ALARP), regardless of calculated risk levels and criteria.
- **Best Practice:** Industry best practicable should be used in the engineering design, and industry best practice management systems should be used for the operation of new plant.

## 9 RESULTS AND COMPARISON WITH RISK CRITERIA

### 9.1 INDIVIDUAL FATALITY RISK CALCULATION

Figure 6 below shows the individual fatality contours for risk associated with the HPMS. Note that all data used in this risk assessment are for a station operating 100% of the time at the maximum suction pressure of 12MPa(g) and a discharge pressure of 3.5MPa(g). The quantitative risk results are valid, though highly conservative. The risk contours have been overlaid on the existing plant layout but with the new plant included in the calculations (refer Appendix 1).

**Figure 6 - Individual Fatality Risk Contours**



LEGEND	<span style="color: red;">-----</span> Industrial criterion $50 \times 10^{-6}$ per year
	<span style="color: orange;">-----</span> Active open space criterion $10 \times 10^{-6}$ per year
	<span style="color: yellow;">-----</span> Commercial / Retail centre criterion $5 \times 10^{-6}$ per year
	<span style="color: green;">-----</span> Residential development criterion $1 \times 10^{-6}$ per year

### **9.1.1 Residential Buffer**

The risk of fatality of 1pmpy, corresponding to the criterion for residential development does not encroach into the residential development along Chandos Road.

The risk level at the site boundaries of the residences along Chandos Road is less than 0.4pmpy, or less than the criteria for sensitive development such as schools and kindergartens.

The criterion for residential development is satisfied.

The 1pmpy risk contour extends past the site boundary by 130m to the East, by 120m to the West, by 165m to the South and by 95m to the North. There are no residential developments in this area.

### **9.1.2 Offices, Retail Centres Buffer**

The risk of fatality of 5pmpy, corresponding to the criterion for offices and retail centres, extends past the site boundary by 45m to the East, by 5m to the West, by 65m to the South and by 35m to the North. There are no offices or retail centres in this area.

Hence the criterion for offices and retail centres is satisfied.

### **9.1.3 Open Space Buffer**

The risk of fatality of 10pmpy, corresponding to the criterion for open space (active), is contained within the site boundary to the West of the site and extends past the site boundary by 14m to the East, by 20m to the South and by 12m to the North. There are no active open spaces in this area.

Hence the criterion for active open space is satisfied.

### **9.1.4 Industrial Buffer**

The 50pmpy risk contour is fully contained within the site. Hence the criterion for industrial development is satisfied.

### **9.1.5 Sensitive Development Buffer**

The 0.5pmpy risk contour for sensitive development (such as schools, hospitals etc.) extends 195m to the East, 185m to the West, 20m to the South and 210m to the North of the site boundary.

There are no sensitive developments within this area and hence the criterion for sensitive development is satisfied.

## **9.2 SOCIETAL RISK CALCULATIONS – NATURAL GAS**

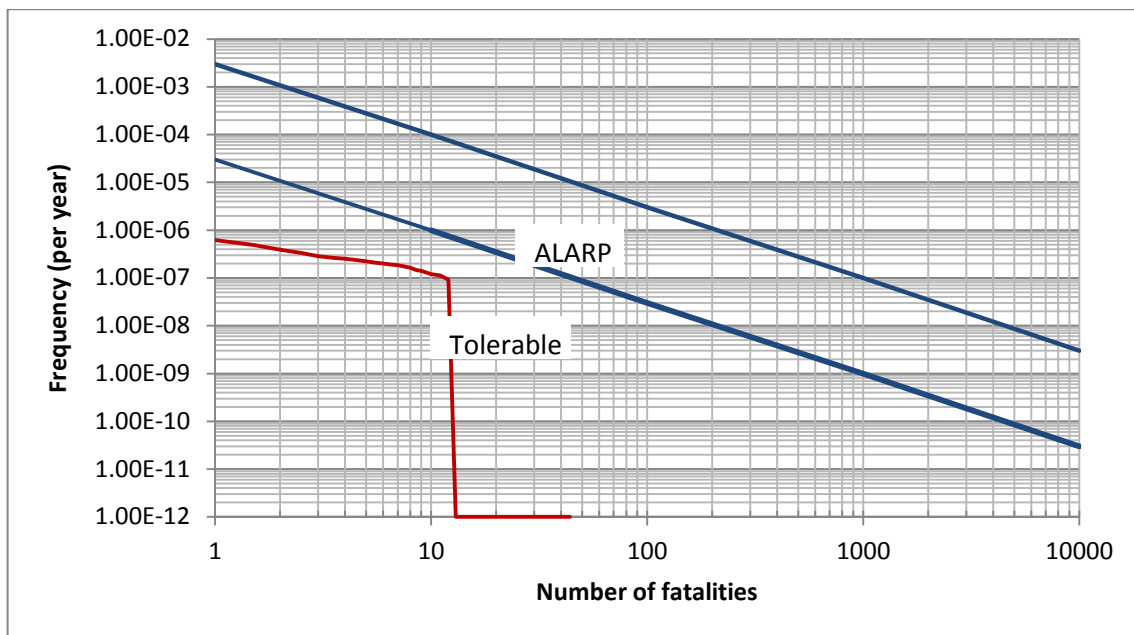
The above criteria for individual risk do not necessarily reflect the overall risk associated with any proposal. In some cases for instance, where the 1pmpy contour approaches closely to residential areas or sensitive land uses, the potential may exist for multiple fatalities as the result of a single accident. One

attempt to make comparative assessments of such cases involves the calculation of societal risk.

The societal risk graph is presented in Figure 7 below.

The societal risk for the upgraded facility is consistently within the tolerable risk zone.

**Figure 7 – Societal Risk**



### 9.3 PROPAGATION RISK CALCULATIONS

The risk for levels of heat radiation and overpressures which may be damaging to process equipment is defined as 23 kW/m<sup>2</sup> and 14 kPa as per the NSW Department of Planning risk criteria (Ref 3). The criterion for maximum risk of propagation at a neighbouring facility is 50pmpy. However, this level of risk is never reached within the HPMS. The criterion for maximum risk of propagation to neighbouring industrial development is satisfied.

### 9.4 INJURY RISK CALCULATIONS

The risk for levels of heat radiation and overpressures which may be injurious to people is defined as 4.75 kW/m<sup>2</sup> and 7 kPa as per the NSW Department of Planning risk criteria in (Ref 3). The criterion for maximum injury risk at a neighbouring residential area is 50pmpy. This level of risk is confined to the immediate location around the existing heaters, as presented in Figure 8 below, where the 50pmpy risk is shown as small dots rather than as a contour due to it's very small presence on site. The criterion for maximum risk of injury at neighbouring residential development is therefore satisfied.

**Figure 8 - Injury Risk Contours**



LEGEND      - - - - - Propagation risk criterion  $50 \times 10^{-6}$  per year

## 9.5 TRANSPORT RISK

The review of road transport risks concludes that the risk associated with the transport of dangerous goods and potentially hazardous material to the site is negligible.

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## 10 CONCLUSION AND RECOMMENDATIONS

### 10.1 OVERVIEW OF RISK

The main hazard associated with the HPMS is associated with the conveyance of natural gas (predominantly composed of methane gas), which is a flammable gas held under pressure.

Hazards may arise in fixed plant, storage, and pipelines. The predominant mode in which a hazardous incident may be generated is associated with a leak. This would generally only have the potential to cause injury or damage if there was ignition, which resulted in a fire or explosion incident. The factors involved are:

- Failure must occur causing a release. There are several possible causes of failure, with the main ones being corrosion and damage to the equipment by external agencies;
- The released material must come into contact with a source of ignition. In some cases this may be heat or sparks generated by mechanical damage while in others, the possible ignition source could include non-flame proof equipment, vehicles, or flames some distance from the release;
- Depending on the release conditions, including the mass of material involved and how rapidly it is ignited, the results may be a localised fire (for example a so called jet fire), a flash fire or an explosion of the vapour cloud formed through the release.
- Finally, for there to be a risk, people must be present within the harmful range (consequence distance) of the fire or explosion. How close the people are will determine whether any injuries or fatalities result.

### 10.2 SUMMARY OF RISK RESULTS

Despite the fact that many of the assumptions in this PHA are conservative, the results show that the risk associated with the HPMS very low. The most stringent risk criteria, as required by the Department of Planning, are adhered to. The quantitative analysis showed that:

**Individual Risk of Fatality:** The risk of fatality associated with the HPMS at the boundary of the facility site is below the criterion for of one chance in a million per year (1 pmpy) at any residential development. The risk of fatality at the nearest residential dwelling is less than 0.5 pmpy, i.e. less than the risk criterion for sensitive development.

The risk of fatality at the nearest commercial or retail centre, active open space and the nearest industrial area are also well below the criterion of five, ten and fifty chances per million years respectively (5 pmpy, 10 pmpy and 50 pmpy).

**Propagation Risk:** The 50 pmpy propagation risk contour is never reached for the HPMS.

**Injury Risk:** The 50 pmpy injury risk contour is contained within the site boundary. The risk of injury at the nearest residential dwelling is 8pmpy, i.e. well below the criterion of 50 pmpy.

**Societal Risk:** The societal risk is consistently within the tolerable zone as per the DP&E's interim risk criteria for societal risk.

**Transport risk:** The review of road transport risks concludes that the risk associated with the transport of dangerous goods and potentially hazardous material to the site is negligible.

**Risk to the biophysical environment from accidental releases:** An accidental release of natural gas would not constitute an acute hazard to the biophysical environment. The risk to the biophysical environment from an accidental release at the HPMS is very low.

While the land is currently unzoned, it is within the area covered by the Western Sydney Parklands and is therefore covered by *State Environmental Planning Policy (Western Sydney Parklands) 2009* (Ref 5). The location and the action of this planning policy substantially restrict what forms of future development would be permissible around the facility. It is therefore unlikely that the future land use would alter substantially from the existing and that population densities would increase.

### **10.3 ASSUMPTIONS**

The risk assessment carried out in this study assumed that the facility will be operated with appropriate consideration to safety and safety management at all stages. Including the following:

1. Ensure minimum flange joints and length of gas pipelines during detail design work. Burial of pipes wherever possible. Use of welded connections wherever possible.
2. Ensure Operations and Maintenance manual address preventive maintenance requirements of all valves.
3. Appropriate pressure relief to handle full flow.

## 11 REFERENCES

1. **EnviroPlan.** Preliminary Environmental Impact Assessment: Horsley Park Meter Station Upgrade. 2014. Rev 0. RP\_0029\_01.
2. **Jemena.** Horsley Park Meter Station Upgrade, Design Basis Manual. 2014. Rev F. GTS-590-DG-DN-001.
3. **Department of Planning and Environment.** Hazardous Industry Planning Advisory Paper No. 6: Guidelines for Hazard Analysis. 2011.
4. **Department of Planning and Environment.** Hazardous Industry Planning Advisory Paper No. 4: Risk Criteria for Land Use Safety Planning. 2011.
5. **LogiCamms.** Preliminary SMS Report, Jemena, Horsley Park Metering Station Upgrade. 2014. Revision A. 51-64450-0001-RA.
6. **NSW Government.** NSW Work Health and Safety Act 2011 and its associated legislation, including but not limited to the Dangerous Goods Regulations, Construction Safety Regulations, and the Factories Shops and Industries Regulations.
7. **Committee for the Prevention of Disasters, TNO.** *Yellow Book, Methods for the Calculation of the Physical Effects of the Escape of Dangerous Material, CPR 14E, Parts 1 & 2.* 3rd edition 1997.
8. **Uijt de Haag P.A.M. (Dr), Ale B.J.M. (Dr).** *Publication Series on Dangerous Substances (PGS 3), Guidelines for quantitative risk assessment.* s.l. : Ministerie van VROM Ministerie van Verkeer en Waterstaat, December 2005.
9. **Fairfield City Council.** Fairfield Local Environmental Plan 2013. *Fairfield City Council.* [Online] 2013. [Cited: 13 February 2015.] <http://www.legislation.nsw.gov.au/>.

## Appendix 1

# Consequence and Likelihood Assessment

## Preliminary Hazard Analysis of Horsley Park Meter Station Upgrade

## Appendix 1 - Consequence and Likelihood Assessment

EXINHEAT	=	Existing inlet to Heaters
EXOUTHTOAGLPCV	=	Existing heater to PCV
EXOUTAGLPCV	=	Existing outlet from PCV
NEWINPCV	=	New AGL inlet to PCV
NEWOUTPCV	=	AGL
EXF01/02	=	Existing filters F-01/02
NEWF03/04	=	New filter F-03/04
EXH1/2/3	=	Existing heaters H1/2/3
NEWHE1/2	=	New heaters HE1/2
EXLIQSEP	=	Existing liquid separator
EXSMITINPCV	=	Existing Smithfield from heater to inlet PCV
EXSMITOUTPCV	=	Existing Smithfield outlet PCV

EQUIPMENT	PIPE LENGTH	LEAK FREQ.	JET FIRE FREQ.	FLASH FREQ.	EXPLOSION FREQ.	GAS PRES.	DIAM ORIF.	OUTFLOW
	metres	t/yr	t/yr	t/yr	t/yr	kPa	m	kg/s
EXINHEAT	62.58	6.26E-06	5.63E-07	1.61E-06	2.50E-07	1.20E+04	0.400	604.44
EXINHEAT	62.58	3.13E-05	1.25E-06	4.13E-06	1.25E-06	1.20E+04	0.050	24.15
EXOUTHTOAGLF	40.32	4.03E-06	3.63E-07	1.04E-06	1.61E-07	1.20E+04	0.300	293.92
EXOUTHTOAGLF	40.32	2.02E-05	8.06E-07	2.66E-06	8.06E-07	1.20E+04	0.050	24.11
EXOUTAGLPCV	14	1.40E-06	1.26E-07	3.61E-07	5.60E-08	3.50E+03	0.350	126.82
EXOUTAGLPCV	14	7.00E-06	1.40E-07	4.20E-07	2.80E-07	3.50E+03	0.050	7.03
NEWINPCV	84.2	8.42E-06	7.58E-07	2.17E-06	3.37E-07	1.20E+04	0.250	185.73
NEWINPCV	84.2	4.21E-05	1.68E-06	5.56E-06	1.68E-06	1.20E+04	0.050	24.02
NEWOUTPCV	25.2	2.52E-06	2.27E-07	6.50E-07	1.01E-07	3.50E+03	0.250	54.28
NEWOUTPCV	25.2	1.26E-05	2.52E-07	7.56E-07	5.04E-07	3.50E+03	0.050	6.99
EXF01/02	-	1.00E-06	9.00E-08	2.58E-07	4.00E-08	1.20E+04	0.200	106.44
EXF01/02	-	1.00E-06	9.00E-08	2.58E-07	4.00E-08	1.20E+04	0.010	1.01
EXF01/02	-	2.00E-05	4.00E-07	1.20E-06	8.00E-07	1.20E+04	0.010	1.01
NEWF03/04	-	1.00E-06	9.00E-08	2.58E-07	4.00E-08	1.20E+04	0.200	106.44
NEWF03/04	-	1.00E-06	9.00E-08	2.58E-07	4.00E-08	1.20E+04	0.010	1.01
NEWF03/04	-	2.00E-05	4.00E-07	1.20E-06	8.00E-07	1.20E+04	0.010	1.01
EXH1/2/3	-	3.00E-06	2.70E-07	7.74E-07	1.20E-07	1.20E+04	0.250	185.73
EXH1/2/3	-	3.00E-05	2.70E-06	7.74E-06	1.20E-06	1.20E+04	0.001	0.01
EXH1/2/3	-	3.00E-02	6.00E-04	1.80E-03	1.20E-03	1.20E+04	0.010	1.01
NEWHE1/2	-	2.00E-06	1.80E-07	5.16E-07	8.00E-08	1.20E+04	0.500	1050.00
NEWHE1/2	-	2.00E-05	1.80E-06	5.16E-06	8.00E-07	1.20E+04	0.010	1.01
NEWHE1/2	-	2.00E-02	4.00E-04	1.20E-03	8.00E-04	1.20E+04	0.010	1.01
EXSMITINPCV	22.15	6.65E-06	5.98E-07	1.71E-06	2.66E-07	1.20E+04	0.150	52.36
EXSMITINPCV	22.15	4.43E-05	1.77E-06	5.85E-06	1.77E-06	1.20E+04	0.047	20.07
EXSMITOUTPCV	14.75	4.43E-06	1.77E-07	5.84E-07	1.77E-07	3.50E+03	0.150	15.22
EXSMITOUTPCV	14.75	2.95E-05	1.18E-06	1.77E-06	1.18E-06	3.50E+03	0.047	5.85

EQUIPMENT	CLOUD (KG) low crop opccational large object; duration release 1800s		HEAT RADIATION		
	D4	F2	22Kw/M2	12.5Kw/M2	4.7Kw/M2
EXINHEAT	88371.0	708240.0	202	270	442
EXINHEAT	513.3	4534.8	32	43	70
EXOUTHTOAGL	28002.0	259310.0	149	199	326
EXOUTHTOAGL	513.3	4534.8	32	43	70
EXOUTAGLPCV	7299.2	68015.0	101	220	136
EXOUTAGLPCV	513.3	602.0	18	24	40
NEWINPCV	13466.0	126820.0	123	164	269
NEWINPCV	513.3	4534.8	32	43	70
NEWOUTPCV	1876.3	16977.0	71	95	155
NEWOUTPCV	513.3	602.0	18	24	40
EXF01/02	5518.0	51181.0	96	129	211
EXF01/02	0.0	0.0	6	9	14
EXF01/02	0.0	0.0	6	9	14
NEWF03/04	5518.0	51181.0	96	129	211
NEWF03/04	0.0	0.0	6	9	14
NEWF03/04	0.0	0.0	6	9	14
EXH1/2/3	13466.0	126820.0	123	164	269
EXH1/2/3	0.0	0.0	6	9	14
EXH1/2/3	0.0	0.0	6	9	14
NEWHE1/2	2.1E+05	1.4E+06	255	340	557
NEWHE1/2	0.0	0.0	6	9	14
NEWHE1/2	0.0	0.0	6	9	14
EXSMITINPCV	1769.4	16007.0	40	94	153
EXSMITINPCV	513.3	4534.8	32	43	70
EXSMITOUTPCV	245.2	2129.6	41	54	89
EXSMITOUTPCV	53.0	444.6	18	24	40