Annex 5A

Tables of Assumptions

5A TABLES OF ASSUMPTIONS

This section summarises the assumptions adopted in this QRA study. These are broadly categorised as surrounding population, meteorological data, failure frequency, ignition probability, explosion probability, and consequence end-point criteria assumptions.

5A.1 SURROUNDING POPULATION

5A.1.1 Land Population

Based on a review of aerial maps, there is no land based population (building development) in the vicinity of BPPS. The nearest industrial facilities in Lung Kwu Sheung Tan are about 1.4 km away and the nearest proposed residential development in Lung Kwu Tan reclamation area is about 800 m from the site boundary of BPPS. With reference to the detailed consequence analysis, all potential hazardous consequences are not able to reach any land based population (building development) in the vicinity to BPPS. Therefore, land based population (building development) will not affect the societal risk levels of the Project and therefore not considered in this QRA study.

5A.1.2 Road Traffic Population

The population estimation for Lung Kwu Tan Road is based on 2014 Annual Traffic Census which is the latest available road traffic data. The Annual Average Daily Traffic (AADT) value is 4,170 vehicles per day for station number 5481 from Lung Fai Street to Tsang Kok. The average vehicle speed and average persons per vehicle were assumed as 50 km hr^{-1} and three (3) respectively in this QRA study.

As a conservative approach, it was assumed the annual traffic growth at Lung Kwu Tan Road as one (1) % from 2014 to the proposed operational phase year of 2nd CCGT unit in 2035.

The traffic flow of Yung Long Road was assumed as 10% of day-time traffic flow from Lung Kwu Tan Road, and 10% of day-time traffic flow was assumed during the night-time in this QRA study.

5A.1.3 Marine Vessel Population

The marine vessels in 2011 and 2021 were extrapolated based on 2003 data which was prepared by BMT, and the marine population was estimated with reference to BMT's Marine Impact Assessment report (1).

(1) BMT Asia Pacific Ltd, Marine Impact Assessment for Black Point & Sokos islands LNG Receiving Terminal & Associated Facilities, Pipeline Issues, Working Paper #3, Issue 6, May 2006

The marine vessel data in 2011 and 2021 were used to estimate the marine traffic population at years 2016, 2019, 2020, 2034 and 2035.

Table 5A.1 Population at Risk

Marine Vessel Type	Population	Fatality Probability	Population at Risk
Ocean-Going Vessel	21	0.1	2
Rivertrade Coastal Vessel	5	0.3	2
Fast Ferries	450	0.3	135
	350	0.3	105
	280	0.3	84
	175	0.3	53
	105	0.3	32
	35	0.3	11
Tug and Tow	5	0.9	5
Others	5	0.9	5

Table 5A.2 Fast Ferry Population Distribution for Day and Night Time Periods

Population	Population at Risk	% of Day Trips	% of Night Trips	% of All Trips (= 0.75 × day + 0.25 × night)
450	135	5	-	3.75
350	105	5	-	3.75
280	84	30	-	22.50
175	53	60	30	52.50
105	32	-	50	12.50
35	11	-	20	5.00

Stationary Marine Population

Other stationary marine vessel population such as that for the Urmston Road Anchorage area are more than 1,000 m from BPPS, with reference to the detailed consequence analysis, all potential hazardous consequences cannot reach other stationary marine vessel population. Therefore, no other stationary marine population is taken into account in this QRA study.

5A.2 METEOROLOGICAL DATA

Table 5A.3 Data from Sha Chau Weather Station (2010 - 2014)

	Day				Night			
Wind Speed (m s^{-1})	**2.5**	**3.0**	**7.0**	**2.0**	**2.5**	**3.0**	**7.0**	**2.0**
Atmospheric Stability	**B**	**D**	**D**	**F**	**B**	**D**	**D**	**F**
Wind Direction								
0°	0.076	0.006	0.135	0.002	0.000	0.006	0.120	0.010
30°	0.011	0.004	0.058	0.002	0.000	0.006	0.098	0.009
60°	0.008	0.005	0.010	0.002	0.000	0.006	0.029	0.010
90°	0.045	0.010	0.053	0.005	0.000	0.014	0.124	0.028
120°	0.073	0.007	0.146	0.004	0.000	0.008	0.247	0.023

	Day				Night			
150°	0.016	0.003	0.027	0.002	0.000	0.003	0.045	0.011
180°	0.032	0.003	0.035	0.002	0.000	0.002	0.048	0.011
210°	0.079	0.006	0.066	0.004	0.000	0.003	0.093	0.014
240°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
270°	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
300°	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.001
330°	0.030	0.003	0.025	0.002	0.000	0.003	0.022	0.005

5A.3 FAILURE FREQUENCY

Table 5A.4 Release Event Frequencies

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Pipe size 600 mm to 750 mm	i) 10 & 25mm hole	Liquid/ Gas	1.00E-07	per meter-year	Hawksley
	ii) 50 & 100mm hole	Liquid/ Gas	7.00E-08	per meter-year	Hawksley
	iii) Full bore rupture	Liquid/ Gas	3.00E-08	per meter-year	Hawksley
Pipe size 150 mm to 500 mm	i) 10 & 25mm hole	Liquid/ Gas	3.00E-07	per meter-year	Hawksley
	ii) 50 & 100mm hole	Liquid/ Gas	1.00E-07	per meter-year	Hawksley
	iii) Full bore rupture	Liquid/ Gas	5.00E-08	per meter-year	Hawksley
Storage Tank (Single-containment tank)	i) 10 mm hole	Liquid	1.00E-04	per tank-year	Purple Book
	ii) Catastrophic	Liquid	5.00E-06	per tank-year	Purple Book
Storage Tank (Double-containment tank)	i) Catastrophic	Liquid	1.25E-08	per tank-year	Purple Book
	ii) Partial failure*	Liquid	1.25E-08	per tank-year	Purple Book
Pressure Vessel	i) 10 mm hole	Liquid/ Gas	1.00E-05	per vessel-year	Purple Book
	ii) Catastrophic	Liquid/ Gas	5.00E-07	per vessel-year	Purple Book
Cylinder	i) Catastrophic	Gas	1.00E-06	per cylinder-year	Purple Book
	ii) Partial failure*	Gas	2.60E-06	per cylinder-year	Journal of hazardous material
Road Tanker	i) Catastrophic	Liquid/ Gas	5.00E-07	per road tanker-year	Purple Book
	ii) Leak#	Liquid/ Gas	5.00E-07	per road tanker-year	Purple Book
Pumps	i) Leak	Liquid	1.00E-04	per year	COVO Study
	ii) Full bore rupture	Liquid	1.00E-05	per year	COVO Study
Frequency of spontaneous truck fire	-	-	4.00E-09	per truck-km	Refer to PHI QRA
Truck rollover frequency	-	-	1.90E-07	per truck-km	Refer to PHI QRA
Truck impact frequency	-	-	4.00E-07	per truck-km	Refer to PHI QRA
Conditional probability of vessel rupture in traffic accident	-	-	4.25E-03	-	DNV QRA Report
Conditional probability of large leak on vessel in traffic accident	-	-	4.00E-03	-	DNV QRA Report

Equipment	Release Scenario	Release Phase	Release Frequency	Unit	Reference
Conditional probability of small leak (all sizes including pipe, valve etc.) in traffic accident	-	-	1.50E-01		DNV QRA Report
Driver fails to put out the fire with vehicle fire extinguisher	-	-	5.00E-01	per demand	Fire services fail to prevent BLEVE
Unloading Arm	i) Leak^	Liquid/ Gas	4.05E-03	per year	COVO Study
	ii) Full bore rupture	Liquid/ Gas	4.05E-05	per year	COVO Study
Truck accident frequency (for construction vehicle impact)	-	-	5.90E-07	per truck-km	Refer to PHI QRA

Note:
*: 10 mm and 25 mm hole releases are assumed as the representative hole size releases for the partial failure of Storage Tank with double containment tank design and cylinder.
#: 25 mm hole release is assumed as the representative hole size release for the continuous release from a hole the size of the largest connection.
^: 10 mm, 25 mm, 50 mm and 100 mm hole releases are assumed as the representative hole size releases for the leak hole size of the unloading arm.

5A.4 IGNITION PROBABILITY

Table 5A.5 Ignition Probabilities Assumed for Natural Gas

	Immediate Ignition	Delayed Ignition 1	Delayed Ignition 2	Delayed Ignition Probability	Total Ignition Probability
Small leak	0.02	0.045	0.005	0.05	0.07
Large leak/rupture	0.10	0.200	0.020	0.22	0.32

For isolation failure scenarios, the delayed ignition probabilities given in *Table 5A.5* are doubled. The longer duration and larger inventory release from a non-isolated release is assumed to make it more likely that ignition takes place.

Table 5A.6 Ignition Probabilities Assumed for Distillate Oil

	Immediate Ignition	Delayed Ignition Probability	Total Ignition Probability
Small leak	0.01	0.02	0.03
Large leak/ rupture	0.02	0.06	0.08

For isolation failure scenarios, the delayed ignition probabilities given in *Table 5A.6* are doubled. The longer duration and larger inventory release from a non-isolated release is assumed to make it more likely that ignition takes place.

Table 5A.7 Ignition Probability for Hydrogen

Ignition Probability	Small Leak	Large Leak
Immediate Ignition	0.5	0.9
Delayed Ignition	0.5	0.9

5A.5 EXPLOSION PROBABILITY

Table 5A.8 Probability of Explosion Given Ignition

Leak Size (Release Rate)	Explosion Probability Given Ignition
Minor (< 1 kg s^{-1})	0.04
Major (1 – 50 kg s^{-1})	0.12
Massive (> 50 kg s^{-1})	0.30

5A.6 CONSEQUENCE END-POINT CRITERIA

5A.6.1 Thermal Radiation of Jet Fire, Fireball and Pool Fire

Table 5A.9 Levels of Harm for 20-second Exposure Time to Heat Fluxes

Incident Thermal Flux (kW m^{-2})	Fatality Probability for 20-second Exposure Time	Equivalent Fatality Probability for Area between Radiation Flux Contours
9.8	1%	17%
19.5	50%	77%
28.3	90%	97%
35.5	99.9%	

5A.6.2 Flash Fire

With regard to flash fires, the criterion chosen is that a 100% fatality is assumed for any person outdoor within the flash fire envelope. The extent of the flash fire is assumed to be the dispersion to its LFL.

5A.6.3 Overpressure

Table 5A.10 Effect of Overpressure - Purple Book

Explosion Overpressure	Fraction of People Dying	
	Indoor	Outdoor
> 0.3 barg	1.000	1
> 0.1 to 0.3 barg	0.025	0

5A.6.4 Fireball

The flammable mass for fireball modelling was conservatively estimated by the initial flow rate continuing for ten seconds even though the initial release rate is decreasing rapidly in case of full-bore rupture scenario of pipeline.

Persons caught in the open area within the fireball diameter have been assumed to be 100% fatality.

5A.6.5 Toxicity Effect of Carbon Dioxide

Table 5A.11 Carbon Dioxide Toxic Concentration at various Fatality Levels

Fatality Level	Concentration (ppm)
90%	107,713
50%	91,933
1%	68,902