OneSteel

Responses to OneSteel submission

We thank OneSteel for its comments on the Terminal and Transport PHAs and for provision of the results of its own investigators so that we could more fully respond to OneSteel's concerns. We would be pleased to discuss our response if further clarification is required.

1. **Consequence contours, population and risk assessment**

   a. Consequence contours

   Consequence modelling was carried out as part of the Stage 3 HAZOP to identify both internal and external scenarios which could lead to adverse effects.

   This modelling identified two primary scenarios contributing to potential offsite risk in a fuels terminal: tank top fires and loss of containment scenarios which then might lead to flash fires, vapour cloud explosions and bund pool fires.

   For a tank fire, the primary impact is heat radiation. Figure 1 shows the 4.7 kW/m^2 heat radiation plot at 1.5m height for a single tank fire for a wind speed of 10 m/s (easterly). Figure 2 is a compilation of heat radiation contours for all tanks close to the railway line on the western boundary of the site, with a wind speed of 10 m/s and various (generally easterly) wind directions, also presented as 4.7 kW/m^2 contours.

   The presentation of heat radiation intensity for a consequence analysis is representative of a single wind speed and is therefore typical. In practice, for the QRA, the consequence is calculated for each of 84 different wind speed/direction and atmospheric stability combinations.

Figure 1 Single Tank-top fire, ND16 – heat radiation of 4.7 kW/m^2 at 1.5m height

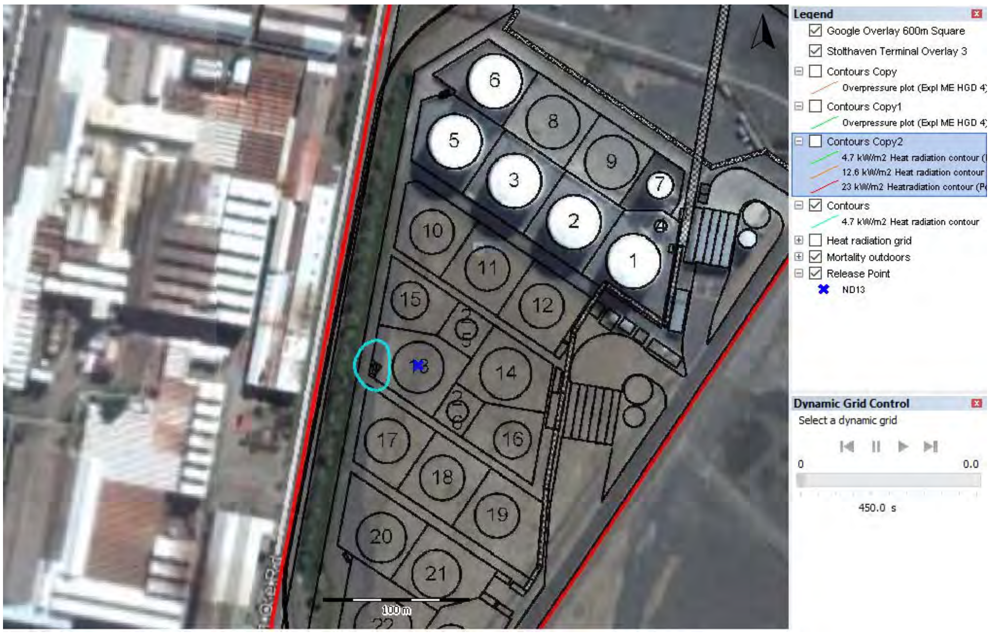

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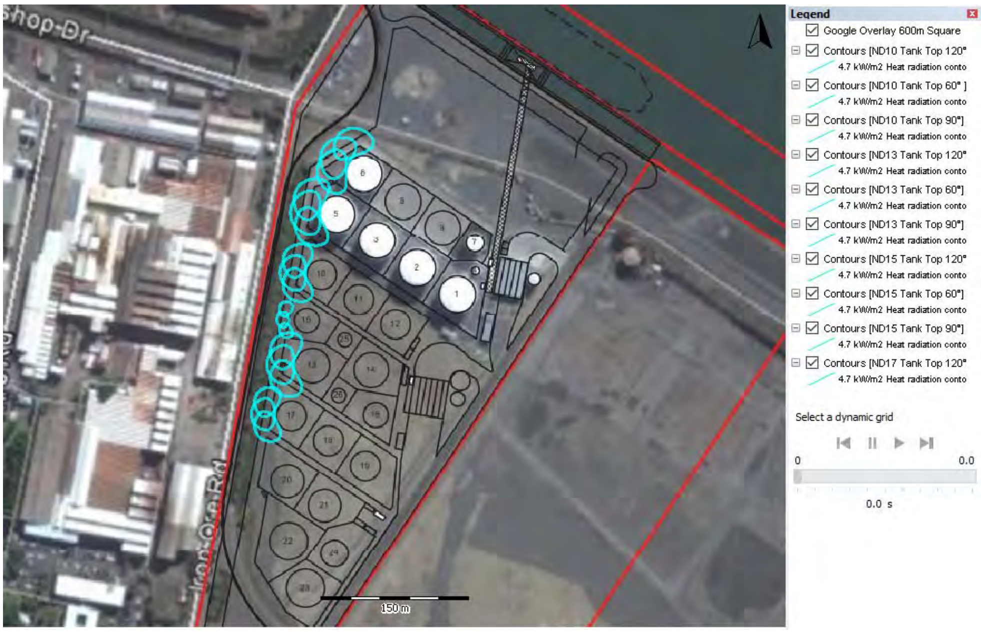
Figure 2 Tank-top fires on western perimeter – heat radiation at 4.7 kW/m² at 1.5m height



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In the event of either a compound or a full bund spill, there are various possible consequences depending on the quantity, sources of ignition and weather conditions. If the spill is ignited, the resultant pool fire will increase in area until the compound or bund is covered in fire.

Figure 3 shows the extent of heat radiation contours (at 4.7, 12.6 and 23 kW/m²) for a full bund fire in the largest petrol bund (easterly wind).

Figure 3 Full Bund Fire - Extent of Heat radiation contours (Easterly wind)

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TNO Effects® and Riskcurves® programs allow defined mixtures to be used in consequence modelling. This is in contrast with less sophisticated programs that require “representative” materials to be used. Other PHAs in NSW have used n-hexane, toluene and n-octane as representative chemicals. These will not result in the prediction of flammable vapour clouds as the vapour pressure of these alkanes are low compared with petrol. The present QRA uses a multi-component definition for petrol, diesel and jet fuel. Results for petrol are similar to those using n-pentane, which TNO recommends if a representative chemical is used.

For some weather conditions (primarily Class F stability and low wind speeds), a dense flammable cloud is predicted using Effects® and this will disperse downwind. The extent of the cloud will depend on wind speed and atmospheric stability. As there are 11 separate scenarios and 84 separate combinations of wind speed/direction and atmospheric stability, it would clearly be onerous to present the results of consequence analysis for all 9,240 instances.

Consequence analysis using EFFECTS® showed that flammable vapour clouds are only produced under Pasquill stability classes E and F. For the purpose of demonstration, various outputs are presented for the following conditions:

- Stability Class F
- Wind speed 2.0 m/s
- Wind direction (from) 90°

It should be noted that all scenarios are carried forward into RiskCurves® regardless of the consequence analysis. RiskCurves® internally calculates effects for every combination of wind speed/direction and atmospheric stability, using the same models as EFFECTS®. If a flammable gas cloud is predicted, the program will determine whether the dispersion is neutral or dense vapour and will calculate the area of the flammable cloud. For all grid points within the cloud, a fatality is assumed (flash fire). It will also calculate the effects of a vapour cloud explosion, and apply a probit to determine fatality for all grid points.

Figure 4 shows the extent of a flammable vapour cloud for a full bund petrol spill in the largest bund for F2.0 conditions (easterly wind).

Figure 4 Extent of Flammable Cloud – F2.0 Easterly

Figure 5 shows the overpressure contours (at 7 kPa, 15 kPa and 35 kPa) resulting in ignition of a vapour cloud for F2.0 conditions (easterly wind).

Figure 5 Incident Overpressure Contours – F2.0 Easterly

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Figure 6 shows the dynamic concentration grid at 180 s, at which time the flammable vapour cloud is well beyond the site boundary (the brown area represents the area at ground level with a concentration greater than the lower explosive limit). It is assumed that the vapour cloud will find a source of ignition as the fully formed vapour cloud moves beyond the site boundary.

Figure 6 Dynamic Concentration Grid at 180 s – F2.0 Easterly

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In all cases of ignition, whether by immediate ignition or as a result of a flash fire or vapour cloud explosion, a full bund fire will result, the effects of which are as shown in Figure 3, above.

As stated in Section A.6, the total ignition probability for Buncefield-type spills, including bund spills not due to overflow events, is taken as 1.0.

The vapour pressure of jet fuel is low and does not result in VCE scenarios.

b. Population assumptions and risk assessment

We believe that there is misunderstanding about what the individual risk contours provided in the PHA represent. These are iso-probability contours for a particular criterion (e.g. for a fatality or for exposure to a particular level of consequence) as defined in HIPAP 4.

The individual risk contours represent the risk to a person stationed at a particular location, 24 hours per day, seven days per week. They are not based on population density at that location. If a location is on the 1×10^{-6} pa individual fatality risk contour (See Figure 2 of the PHA) this means that the exposed individual is subject to a risk of fatality of one in a million per year. If two or ten people are located at the same point, they are each subject to this individual risk. The number of people at the point is irrelevant to the individual risk. Thus, in line with process safety risk assessment convention, no population data has been assumed to develop the PHA individual risk contours.

To explain further: there are two broad categories of risk:

- Individual concerns
- Societal concerns

Individual concerns relate to risks affecting people personally; societal concerns are those associated with hazards that could cause widespread or large scale detriment or the occurrence of multiple fatalities in a single event.

In establishing the scope of the PHA, the DP&E considered that for this type of facility, and given its location relative to residential areas, that individual risk should be calculated for an "average" facility but that, from its experience, societal risk calculation would be of no benefit. We agreed with that approach.

Therefore, the PHA provides individual risk contours for the "average" facility which are compared with HIPAP 4 criteria in Section 6 of the report. These criteria relate to individual fatality risk (with levels assigned according to the particular land use) and individual injury risk (with levels assigned for residential and sensitive land use area). Risk of property damage to neighbouring industrial operations is presented in terms of heat radiation and explosion overpressure contours and again compared with the appropriate criteria. In all cases, the appropriate HIPAP 4 criterion is met.

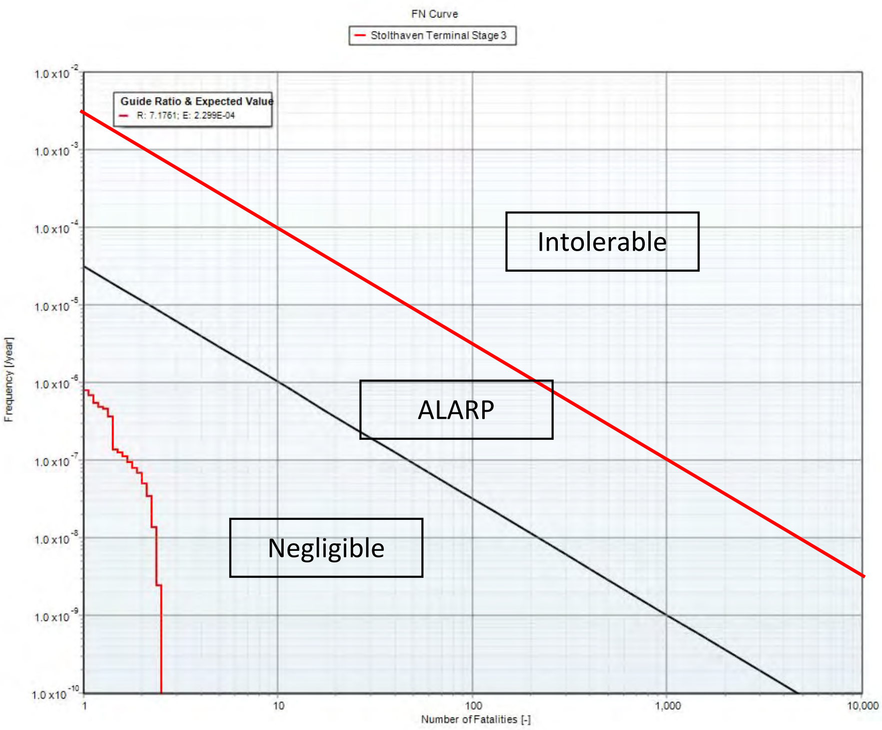
To establish the risk to individual OneSteel employees, the probability is read from the iso-probability contour from the appropriate figure provided in the PHA. In all cases, this will be less than the HIPAP 4 criteria for individual risk in residential areas. To estimate the actual individual fatality risk, the risk read from the plot should then be adjusted to represent the actual exposure based on the number of hours present per year divided by 8760.

To account for high population densities, societal risk is usually presented as an FN Curve and takes into account day and night population. The curve represents the probability of accidents involving more than one fatality. There is no firm requirement under HIPP 4, but indicative and provisional criteria are provided in HIPAP 4 Figure 3. An FN curve has been produced for you based on the following information:

- your advice that the long-term average population is 700 employees per day on the OneSteel site;
- published population density data for the Mayfield residential area;
- the projected number of personnel (including drivers) on the Stolthaven site (day and at night);
- similar population figures have been assumed for the proposed adjacent terminal;
- assumed population density for the Other Port Related Activity areas (25/ha day, 2/ha night);
- assumed population density for the Intertrade Site (50/ha day, 2/ha night).

It will be appreciated that actual population density information is not yet available for the undeveloped port areas, and the above numbers may be somewhat conservative.

Figure 7 FN Curve for Stolthaven Newcastle Terminal Stage 3



Inspection of Figure 7 shows that the calculated FN curve is well below the indicative negligible level of HIPAP 4. This is what would be expected for a fuels terminal located in an industrial area and separated from high density residential land use. This was anticipated by DP&E based on its experience with other fuels terminals and was the reason why it did not require the PHA to examine societal risk.

2. Toxic Air Emissions

Smoke Plumes

The primary adverse effects of incidents in a fuel storage terminal relate to the flammability of the products. These effects are fire radiation, flash fires and explosion overpressure.

In the event of a full bund unignited spill, the concentration of benzene in the flammable vapour cloud will just reach PAC-1 levels of benzene in the flammable vapour cloud at the OneSteel site boundary under low-speed high atmospheric stability conditions. PAC-1 (Protective Action Criteria – Level 1) is a level at which there are mild, transient health effects. However, the flammable vapour cloud at this point is in a non-controlled (ignition-source) area and will be ignited. The impact of ignition is clearly far greater than the short-term toxic effect.

The overwhelming importance of heat and explosion overpressure effects means that PHAs for fuels storage facilities do not take toxic effects into account. The Air Quality Impact Assessment concerns the discharge of benzene and other toxic components during normal operations.

For any fire event, a smoke plume will rise from the burning fuel. A review of photographs and video clips of major incidents involving petrol/diesel tank-top and full bund fires confirms that the intense heat of combustion results in a smoke plume that rises continuously in the downwind direction, dispersing at height.

We have prepared some calculations of plume rise for bent-over, hot buoyant plumes using the methods of Briggs, as described in Beychok[1]. The results are provided in Tables 1 and 2 for smoke plumes resulting from both a major petrol bund fire and a single petrol tank-top fire (ND13).

It can be seen from the tables that for all average wind speed/atmospheric stability pairs, the plume rise exceeds the height of the mixing layer within 500-1,000m distance downwind of the fire. This means that the plume punches through the turbulent mixing layer into the relatively non-turbulent layer above. This removes the smoke and associated carbon oxides from the turbulent layer which would otherwise contribute to downwind ground level concentrations.

A NASA EIS submission for a ground-based test rocket site[2] states that *"when pollutants are emitted above the mixing height, they are slowly dispersed and do not tend to mix with the air below"*.

No adverse impacts are anticipated in downwind residential areas.

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[1] Fundamentals of Stack Gas Dispersion, Milton R Beychok, 1994

[2] NASA Supplemental Final EIS Space Shuttle Advanced Solid Rocket Motor Program, August 1990, Appendix B-1

Table 1 Plume Rise for large full bund spill (Mid Petrol Bund)

Stability Class	A	B	C	D	E	F
Wind Speed m/s	1.3	2.7	4.3	7.7	3.5	1.9
Mixing Height	1,500	1,500	1,000	500	149	53
Distance downwind m	Vertical plume rise (m)					
25	523	252	158	88	194	358
50	830	400	251	140	308	568
100	1,317	634	398	222	489	901
200	2,091	1,007	632	353	777	1,019
500	3,852	1,855	1,164	650	983	1,019
1,000	6,114	2,944	1,849	1,032	983	1,019
1,500	8,012	3,858	2,422	1,353	983	1,019
2,000	9,706	4,673	2,934	1,639	983	1,019
3,000	12,718	6,124	3,845	2,147	983	1,019
5,000	17,878	8,608	5,405	3,018	983	1,019

Table 2 Plume Rise for a single tank fire (ND13)

Stability Class	A	B	C	D	E	F
Wind Speed m/s	1.3	2.7	4.3	7.7	3.5	1.9
Mixing Height	1,500	1,500	1,000	500	149	53
Distance downwind m	Vertical plume rise (m)					
25	298	143	90	50	111	204
50	473	228	143	80	176	323
100	751	361	227	127	279	514
200	1,191	574	360	201	443	581
500	2,194	1,057	663	370	560	581
1,000	3,484	1,677	1,053	588	560	581
1,500	4,565	2,198	1,380	771	560	581
2,000	5,530	2,662	1,672	934	560	581
3,000	7,246	3,489	2,191	1,223	560	581
5,000	10,186	4,904	3,079	1,720	560	581

Petrol Additive NMA

Since submission of the PHA in March 2016, Stolthaven has introduced a new petrol additive at the request of one of its clients. The product is n-methylaniline (NMA) which is a Class 6.1 substance.

As NMA is a toxic substance, this has been included in the revised PHA submitted to the Department of Industry and the Environment on 30 June 2016. The product will be stored close to the petrol road tanker gantry in a 50m^3 steel storage tank.

The individual contribution to the Individual Fatality contour is shown as iso-probability contours in Figure 8, below. Iso-probabilities for mild, transient effects are presented in Figure 9.

N-methylaniline (NMA) has an Australian workplace TWA exposure limit of 0.5 ppm (2.2 mg/m3). This is the maximum allowable workplace concentration for exposure 8 hours per day, five days per week.

Figure 8 Individual Fatality Contours (Toxic Inhalation, NMA)

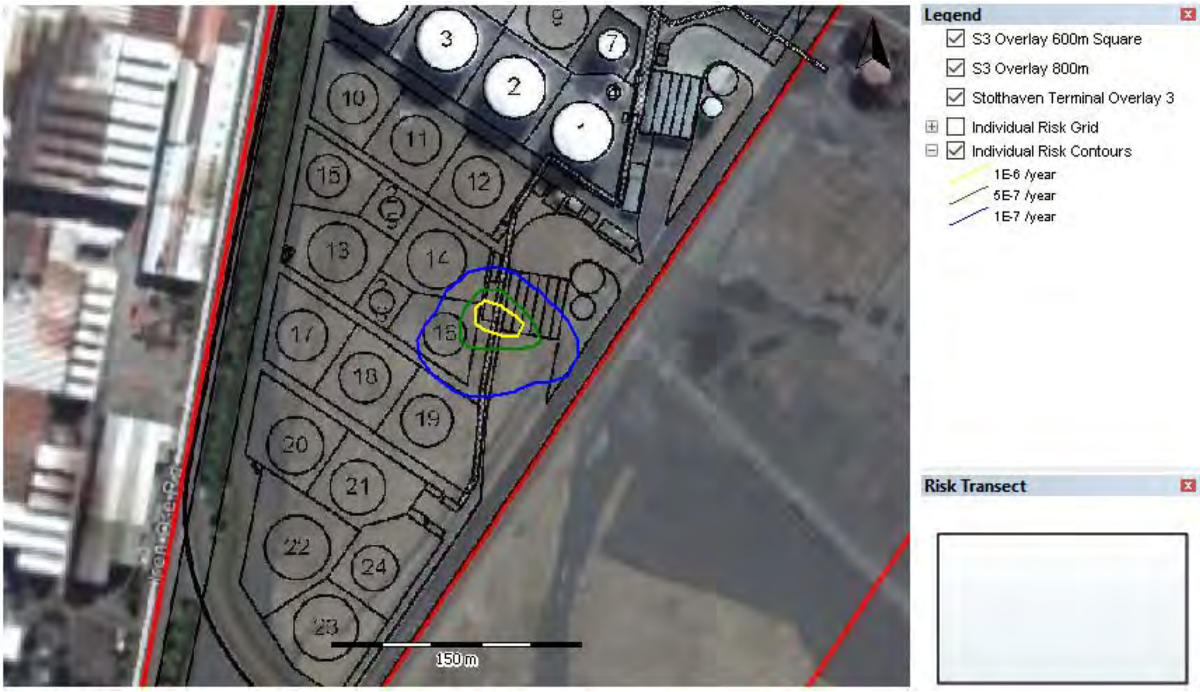

Figure 9 Individual Injury Contours (Toxic Inhalation, Mild Transient Effects)

The US National Institute for Occupational Safety and Health (NIOSH) has assigned an IDLH value of 100 ppm. This value represents a concentration which would allow escape without loss of life or immediate irreversible effects with an exposure of 30 minutes.

To assess the effects of acute inhalation of toxic substances, “probit functions” describe the mathematical relationship between the concentration of a substance, the duration of exposure and the impact on the exposed population. Probit functions have been produced for 46 substances by the Dutch National Institute for Public Health and the Environment. These were originally based on using LC50 as the Point of Departurei. A more rigorous method is now in place for the revision of probit functions but this requires high quality inhalation toxicological data. NMA is not included in the Dutch list of toxic substances for which there is a probit. There is a paucity of high quality inhalation toxicity data for n-methylaniline.

For the purposes of this QRA, probit functions were derived using one tenth of the IDLH value for fatality (10 ppm, 30 minutes) and the PAC-1 (Protective Action Criterion Level 1) value for mild, transient effects (0.5 ppm for 30 minutes). The use of one tenth of the IDLH value is probably very conservative, as generally, the IDLH was previously taken as one tenth of the LC50 value, which was the normal Point of Departure used for constructing the probit function. The use of the PEL-1 value is also probably conservative, as this is the same as the maximum concentration which workers may be exposed for forty hours per week, according to Australian and international criteria. Use of a concentration exponent of 1.0 is also a conservative assumption for concentrations below the Point of Departure.

The probit functions are (expressed in concentration units of kg/m3 and time units of seconds):

Lethality:

$$Pr = 7.52 + \ln (C1 \times t)$$

Mild, transient effects:

$$Pr = 10.507 + \ln (C1 \times t)$$

Inspection of Figure 8 shows that the Individual Fatality Risk at a level of 1×10^{-7} pa is contained within the terminal site boundaries. Inspection of Figure 9 shows that the exposure equivalent to 30 minutes at the TWA level for personnel on the OneSteel site will be less than one in a million per year.

3. Inappropriate emphasis on so-called ‘advanced’ controls

It was a requirement of the DP&E that the PHA reflect risks associated with a hypothetical “average” facility in terms of design, operation and maintenance. The risk reduction measures included in Section 9 of the report have been termed “advanced” controls to highlight differences from the “average” terminal using historical failure rates and the terminal Stolthaven intends to develop.

HIPAP 6 requires that, even when a facility complies with established risk criteria, the implementation of technically feasible recommendations should be implemented which reduce risk levels without significantly affecting the viability of the project.

It should also be noted that discharge of parcels from marine tankers to storage tanks is a manual process. Therefore, the primary focus to minimise the initiation of hazardous situations during discharge is to ensure that transfers are planned and continuously monitored with continuous communication of all those involved in the transfer. Whilst these may be seen as lower orders of controls by some they are extremely important to terminalling operations and it was a failure of these control procedures that led to both the Buncefield and COPECO major incidents.

Review of the Buncefield disaster shows that failures included:

- No agreed transfer plan;
- No control by the terminal over the rate at which the transfer was made;
- Inadequate communications between the remote pumper and the terminal;
- Inadequate maintenance of the primary level indication instrument;
- Failure to stop transfer when the receiving tank level flat-lined, even though the tank was continuing to be filled;
- Failure to monitor the tank level in the receiving tank;
- Inadequate maintenance of the independent tank level alarm, which was rendered ineffective;
- No automatic closure of the receiving tank valve;
- Inadequate lighting, CCTV coverage and monitoring to detect tank overflow;
- Lack of gas detection instrumentation to detect overflow and provide an alarm;
- Inadequate bunds which allowed secondary containment to fail and hence increase the extent of the spill.

Though there are many high-level control measures that failed in this incident, the root causes were failure of the procedural controls in both operations and maintenance.

The “recommendations” of Section 9 have already been incorporated in Stolthaven’s engineering drawings (P&IDs) and form the basis on which the Safety Case will be prepared. Such measures as flammable gas alarms, change of level alarms and provision for foam application directly to the bunds are features that are not routinely included in terminals internationally or in Australia.

The impact of the risk reduction measures is presented in Section 6, particularly Figure 9, of the PHA. OneSteel should note that the Consequence contours will not change from those provided in paragraph 1.a above. What changes is the probability that the consequence might occur. The risk, being the product of consequence and probability, is thus decreased.

4. Other comments included in OneSteel consultant observations

a. Emergency Plan

Stolthaven will develop an Emergency Plan (EP) with the emergency services, PON, the local authority, neighbouring facilities and the community and this will be submitted as part of the Safety Case. The terminal development will not be allowed to operate without approval of the Safety Case, which is reviewed by WorkSafe NSW and the Fire & Rescue, NSW.

The EP will identify credible emergency scenarios and the required resources and response to each scenario. The EP will define the command structure and responsibilities, notification, communications procedures and warning systems.

The EP will cover all scenarios identified as part of Stolthaven's hazard identification processes, including those with extremely low probabilities.

b. OneSteel and other External Ignition Sources

For ignition within the terminal, ignition probabilities are based on the OPG Risk Assessment Data Directory. This assumes a low probability of immediate ignition and a probability of delayed ignition (for flash fires and VCEs) depending on the rate of release.

For Buncefield-type spills (i.e. those that result in a flammable vapour cloud outside of the terminal boundary), the total ignition probability is taken as 1.0. Thus, all possible sources of ignition have been taken into account outside the Stolthaven site, including OneSteel sources.

A fire in a loco, furnace flames or a general fire on the OneSteel site would not increase the risk of knock-on to the Stolthaven site in normal operation.

The separation of vegetation from the tall tanks (~20m separation) on the western side of the site, and the fact that the head space in the internal floating roof tanks is not flammable means that knock-on from a vegetation fire is highly unlikely. Stolthaven is checking this scenario (with a westerly wind) as part of the Fire Safety Study. On-site firefighting equipment can be used to direct water to a fire outside the site to tackle such a scenario. Vegetation management has not yet been addressed, but is one mitigation strategy to reduce risk.

5. Transport PHA

As for the Terminal PHA, we repeat that, by convention, individual risk contours presented in the Transport PHA do not take population into account, by convention. Individual risk contours represent the risk of an exposed person 24 hours per day, 7 days per week.

Presented in the PHA are individual fatality risk contours for three locations, north and southbound along Industrial Drive and a location within the industrial zone along Ingall Street. The transect presented for Ingall Street is transportable to other locations, such as Steelworks Road.

We have prepared the iso-probability contours and a risk transit in Steelworks Road (Figure 10, below). The individual fatality 1×10^{-7} pa contour does not reach the northern kerb line. The risk to occupants of buildings to the north of Steelworks Road are therefore subjected to a lower risk than is required for sensitive land use and residential area under the HIPAP 4 criteria.

Figure 11 below shows the consequence contours for a 1,500kg spill of petrol on Steelworks road for a loaded petrol tanker leaving the Stolthaven site (flammable vapour cloud at maximum extent – blue; incident heat radiation at 23 kW/m^2 – red, and incident overpressure of 14 kPa – purple). The range of spill sizes and spill frequencies considered in the QRA is provided in Table 11 of the PHA. The frequency of accidents involving a spill and the size of the spill are both likely to be less on this low speed road, so that the risk contours of Figure 10 are likely to be quite conservative.

Figure 10 Individual Fatality Risk Transect and Iso-probability Contours (Steelworks Road)

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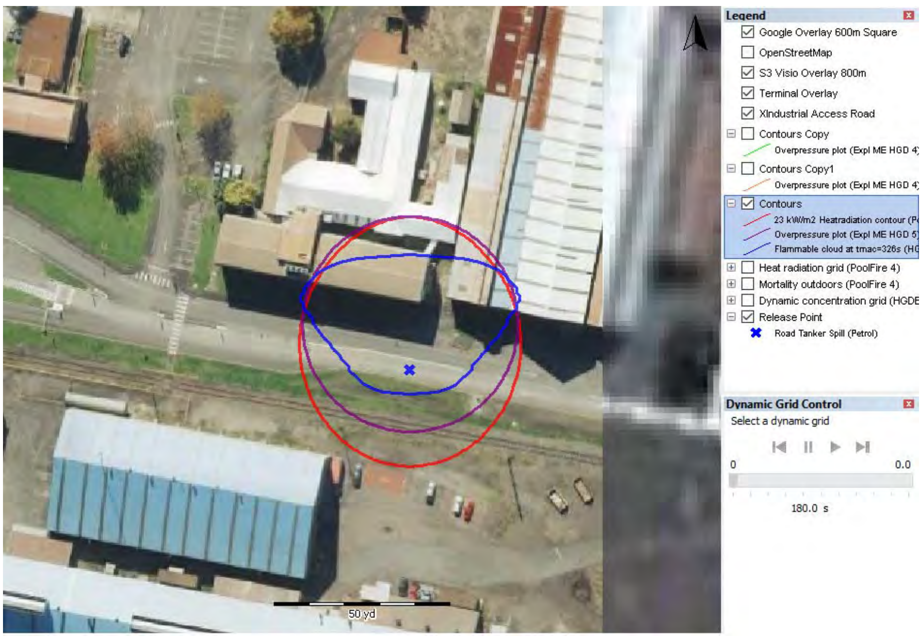
Figure 11 23 kW/m2 (blue), flash fire and 14 kPa Contours (southerly wind)



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Individual injury risk and risk of property damage and accident propagation contours were provided in our preliminary PHA submission. We were asked to remove these for consistency with other transport PHAs submitted to DP&E.

[i] Method for derivation of probit functions for acute inhalation toxicity RIVM Report 2015-0102.