PERMANENT AVIATION FUEL FACILITY

FURTHER INFORMATION

Per Clause 8(1) of the Environmental Impact Assessment Ordinance, Environmental Protection Department (EPD) has asked Airport Authority for further information, most of which was presented to the Advisory Council on the Environment prior to its meeting of 19 April 2007.

Further information consists of the following Annexes attached hereto:

Question #1: Clarification of how the various causes by external sources and/or natural hazards to the identified "Potentially Hazardous Scenarios" have been considered in the EIA report and confirmation of the applicability of these causes to the 100% instantaneous tank failure scenario. Clarification of whether the overall results and conclusions of the Quantitative Risk Assessment (QRA) will be affected.

Response: See ANNEX 1

Question #2: Clarification of whether lightning strike will cause explosion of PAFF tanks leading to "rocketing" of tanks.

Response: See ANNEX 2

Question #3: Clarification of the reasons to adopt the PAFF project-specific frequencies of 100% instantaneous tank failure in the EIA report and the applicability of using the generic frequencies recommended in some overseas' guidebooks in the QRA for 100% instantaneous tank failure of the PAFF project in Hong Kong. Detailed comparison with, for example, the alternative frequencies suggested by the HSL report submitted by one commenter regarding the use of different tank failure frequencies.

Response: See ANNEX 3

Question #4: Clarification of the reasonableness of assumptions adopted in the EIA for the PAFF project-specific frequencies of 100% instantaneous tank failure, including the applicability of historical incidents, the estimation of worldwide tank population, and the relevance of natural hazards, human factors and/or unforeseeable factors, etc. Clarification of whether and how the overall results and conclusions of the Quantitative Risk Assessment (QRA) will be affected.

Response: See ANNEX 4

Question #5: Confirmation of whether the structural integrity of the safety features adopted in the PAFF project will undermine the assumptions adopted in the hazard assessment. Clarification of whether the features and design in the PAFF project will prevent the recurrence of incidents similar to that at Buncefield.

Response: See ANNEX 5

Question #6: In the light of the refusal by UK Planning Authority on the Portland Port Ltd hazardous substances consent application (the Portland case), clarification of the applicability of the Portland case to the PAFF project in Tuen Mun Area 38 site.

Response: See ANNEX 6

<u>Other Information</u>

ANNEX 7:
- Overview of Issues relating to Hazard Assessment

ANNEX 8:
- Responses to Public Comments related to Hazard Assessment

ANNEX 9:
- Reponses to comments tabled by Shiu Wing Steel Limited in 13 March 2007 Meeting of TMDC

ANNEX 10:
- Responses to Public Comments related to Marine Ecology

Airport Authority Hong Kong
2 May 2007

Question #1: Clarification of how the various causes by external sources and/or natural hazards to the identified "Potentially Hazardous Scenarios" have been considered in the EIA report and confirmation of the applicability of these causes to the 100% instantaneous tank failure scenario. Clarification of whether the overall results and conclusions of the Quantitative Risk Assessment (QRA) will be affected.

Response:

The EIA Report has identified and considered all potential scenarios, stated in the Table 1.1 attached. In doing so, it has complied with the scope of the Study Brief which required consideration of the hazardous scenarios associated with the receiving, storage and export of Jet A1.

The identified 100% instantaneous tank failure scenario, is the only identified scenario at the tank farm which could have a significant off-site impact on the neighbouring land if it occurred. It is important to understand the nature of this specific scenario, which is therefore also covered in this response.

Natural hazards, and their relevance to the 100% instantaneous tank failure scenario, are discussed in paragraphs 10.6.2.17 to 10.6.2.22 of the EIA. These include: earthquake, typhoon, flooding, lightning, subsidence, landslide and tsunami. As noted in Paragraph 10.6.2.22 "*The historical experience for tanks of similar, or weaker, design to the PAFF tanks (see Section 10.6.3) is sufficiently large to have confidence that any significant susceptibility to natural hazards would already have been seen in the historical population.*" Thus the overall frequencies identified for 100% instantaneous failure, and other failures, in the EIA already cover the natural hazards identified. Nonetheless, the issues have been reviewed to identify that there are no specific issues that would lead to any requirement to modify the identified scenario frequencies to take specific account of these events. Of the natural causes discussed, earthquake does specifically figure in the historical incidents in Section H3.2 of the EIA, although within more seismically active locations.

In terms of aircraft impact, the main potential hazard comes from the volume of aircraft activity from Hong Kong International Airport and there are no significant identified landing sites for aircraft or helicopters local to the PAFF. No aircraft or helicopter impact incidents leading to 100% instantaneous tank failures were identified in the historical incidents. Nonetheless, a cautious assessment of the potential aircraft impact frequency was made in the EIA, including a cautious assessment that this would also lead to ignition. This is detailed in Section H3.6 of the EIA. Lesser impacts due to smaller aircraft or helicopters are also likely to result in lesser scenarios than a major impact from a large aircraft.

External causes, and their relevance to the 100% instantaneous tank failure scenario, are considered in paragraphs 10.6.2.23 and 10.6.2.24 of the EIA. These include: vandalism, sabotage, terrorist attack and acts of war. All of the above scenarios are considered to be correctly represented within the 100% instantaneous tank failure frequency estimated based on historical data.

Explosions in nearby facilities may generate missiles and both the explosion hazards from furnaces and boilers and the associated missile hazards may be significant to personnel working near to them. Most missiles from explosions have ranges of less than 200m so are unlikely to impact the PAFF tanks. Some missiles may have ranges of up to 1 km, but are unlikely to fail the plate material at the bottom of the tanks (over 1 inch thick steel). However, missiles from adjacent sites could potentially impact the PAFF tanks, and this was reviewed in the early stages of development of the QRA. The PAFF tank walls are very strong (around 1 inch thick steel at the base) and are not easily susceptible to perforation or failure due to the likely potential missiles. Small missiles such as stray bullets or bolts from an explosion, would not have the energy to perforate the tank walls. A large failure would require a large missile with a very high energy and even missiles of order 1m diameter would not be considered sufficient to lead to a 100% instantaneous tank failure in general (the tanks are not brittle and so propagation to a 100% instantaneous failure would not occur).

As an example, a typical impact energy required for perforation of a 1m diameter hole in 1 inch thick steel (still not a 100% instantaneous tank failure) is ~5 MJ. This is equivalent to a hard[1] 4 tonne missile (1m diameter solid steel sphere) hitting the tank at 50 m/s (180 kph). No source of such a missile in the vicinity to the PAFF has been identified.

Overall, the adjacent missile impact hazards are completely covered within the frequency assessments for the identified scenarios for the PAFF tanks.

Further information is also provided in Response to Question #4.

What is this 100% Scenario and why is it important?

During the Judicial Review lodged by Shiu Wing Steel Limited challenging Director of Environmental Protection’s decision to have approved the PAFF EIA Report and have granted the Environmental Permit, the scenario of instantaneous or near instantaneous loss of a 100% of a tank’s content (“100% Scenario”) was the most important element as the Court of Final Appeal hearings and judgment were based on this 100% Scenario.

[1] Note: Greater energies are required for perforation by “soft” missiles that will deform significantly on impact. This would apply, for example to plates from boiler explosions and vehicles, including small aircraft.

However, it should be noted that during these hearings, particularly in the Court of First Instance and partly in the Court of Appeal, this 100% Scenario was fairly loosely used encompassing various meanings. The Court of Appeal therefore defined this 100% Scenario in its judgment (paragraph 18) that 100% Scenario "... is the momentum surge resulting in overtopping of the bund that so worries SWS, for any flow of fuel onto mill's site carries with it the obvious danger of a conflagration at the mill with the resulting risk to the lives of those working there. A scenario which would cause such a surge and overtopping would be what has been referred to in this appeal, as well as in the court below, as catastrophic tank failure, meaning an instantaneous, or almost instantaneous, loss of the entire contents of a tank such as to result in significant overtopping of the bund" . The Court of Final Appeal judgment (paragraph 37) further defined the 100% Scenario as "..a catastrophic tank failure involving an instantaneous or almost instantaneous loss of the entire contents of a tank resulting in a surge of fuel that would significantly overtop and flow on to the steel mill's site where it would be ignited with resultant risk to life."

This 100% Scenario is important because it was the only case put forward by Shiu Wing Steel Limited in the Court of Final Appeal stating that the EIA Report (2002) had not quantified the hazard to life of this Scenario, in effect alleging that in this Scenario the fuel would go off site into the neighbouring facilities such as the steel mill and then igniting and causing fatalities. In all other cases the fuel is contained within the PAFF site. The other cases of instantaneous loss of content where fuel would not go offsite include: (a) if the tank is not 100% full, meaning that it is partially full. It should be noted as stated in the PAFF EIA Report (2007) that because of the operational reasons the tanks would not be full all the time but would be 100% full only 40% of the time; and (b) if the speed of flow from the tank is slower than instantaneous as in the case of a 1 metre high by 10 metre wide hole in a tank or a split of 1 metre high all the way around the base of the tank. In all these cases of "instantaneous loss", the fuel would be contained within the PAFF site except for some potential splashing immediately close to the site boundary (and certainly not flow into the steel mill).

The above is an important distinction because many historical incidents termed catastrophic are far less severe than the scenario of concern and would not generate the same potential consequences.

So what is this 100% Scenario?

The 100% Scenario refers to the loss of fuel from a tank with the tank 100% full of fuel such that the failure of the tank would be instantaneous or near instantaneous meaning it splits in matter of seconds whereby the speed of flow of fuel would be so great as to cause a surge of fuel similar to a tsunami. For the steel mill, this is only relevant for the tanks adjacent to the mill. The surge would have to go over the bund wall, two impervious walls and a landscape bund, all within the PAFF site, and then it would have to go over the elevated public road into the boundary of the mill and then into the steel mill building where it would have to overtop the step and come in contact with the hot works to ignite. This really is the worst possible, though highly incredible, scenario as explained below, but has been quantified in EIA Report (2007) because of Court of Final Appeal's judgment.

How can this 100% Scenario happen?

The PAFF EIA Report (2007) states that this 100% Scenario (which can have impact offsite such as to the steel mill) can take place as demonstrated by a 1/30 scale physical model for the tank nearest to the steel mill, undertaken by the Airport Authority: (a) either by the whole tank being lifted up and the column of fuel standing which then flows creating a surge with a part of it flowing off site. In this case, fuel would not be expected to reach the hot processes such as the furnace and hot metal route in the steel mill building so it is likely that it would not be ignited even if such an incident occurred; (b) or by the tank nearest to the steel mill unzipping precisely in the direction of the steel mill creating a 10 metre wide complete gap from top to bottom on that side of the tank (on the assumption that the tank would remain intact and would not be forced backwards which is unlikely to occur under the laws of physics) with the fuel surging offsite, over the public road into the mill and coming in contact with the hot works and then igniting.

The circumstances of physical tests with 1/30 scale model were idealized to create the worst possible flows. In practice the extent of the flows would be expected to be less even if a tank instantaneously unzipped all the way up on one side.

It should be noted however that the PAFF tanks are not susceptible to the following main mechanisms that could generate a 100% instantaneous failure:

(a) Low temperature embrittlement. There was an agreement by all parties in the courts that because of climate of Hong Kong and the product stored, low temperature embrittlement cannot happen at the PAFF. Furthermore, it should be noted that the modern metallurgy of the tank and weld materials and the fact that the tank plates are staggered, make the 100% unzipping scenario very improbable, and even more so in one particular direction such as the direction of the steel mill.
(b) A major explosion within a tank. However, the bulk fuel vapour within the PAFF tanks is below the explosive range.

Taking into account this, and the history of tank failures in which there are no cases, not even one, where Jet A1 fuel tank has failed causing instantaneous or near instantaneous loss of a 100% of a tank's content, that are relevant to Jet A1 storage at the PAFF, the PAFF EIA Report (2007) shows that the frequency of fatalities due to these types of 100% Scenario is close to 1×10^{-9} per year, that is, once in around a billion years, an extremely low probability of such an event occurring and thereby causing fatalities.

Table 1.1 Potential Hazardous Scenarios for the PAFF

ID	Scenario
	Marine Transport (Within ~500m of the Jetty)
M1	Fire due to rupture/leak of Jet A1 from loaded vessel
M2	Vessel collision involving tanker with subsequent fire and sinking
M3	Cargo explosion on tanker
	Jetty Transfer
J1	Fire due to rupture/leak of Jet A1 from loaded vessel
J2	Fire due to rupture/leak of loading arm during unloading
J3	Fire due to rupture/leak of jetty equipment
J4	Fire due to rupture/leak of jetty riser
J5	Fire due to rupture/leak of submarine pipeline from jetty to Tank Farm ESDV
	Tank Farm Storage
T1	Fire due to discharge from tank vent
T2	Tank head fire / explosion in tank head space
T3	Multiple tank head fires
T4	Tank failure due to overpressure
T5	Explosion in empty tank (under maintenance)
T6	Bund fire
T7	Fire outside bund due to rupture/leak of pumps, pipework and fittings
T8	Fire on sea due to release through drainage
T9	Fire due to instantaneous tank wall failure, subdivided as follows: T9As Instantaneous release from bottom seam failure with tank 90-100% full T9Bs Instantaneous release from bottom seam failure with tank 60-90% full T9Cs Instantaneous release from bottom seam failure with tank 35-60% full T9Ds Instantaneous release from bottom seam failure with tank <35% full T9Az Instantaneous release from tank unzipping with tank 90-100% full T9Bz Instantaneous release from tank unzipping with tank 60-90% full T9Cz Instantaneous release from tank unzipping with tank 35-60% full T9Dz Instantaneous release from tank unzipping with tank <35% full T9Aa Instantaneous release due to aircraft impact with tank 90-100% full T9Ba Instantaneous release due to aircraft impact with tank 60-90% full T9Ca Instantaneous release due to aircraft impact with tank 35-60% full T9Da Instantaneous release due to aircraft impact with tank <35% full
T10	Fire due to multiple tank failure
T11	Boilover
T12	Fire due to release from top of tank due to overfilling
T13	Vapour cloud explosion / flash fire
T14	Fire due to 10% instantaneous release from the top of a tank
	Pipeline Transfer
P1	Fire on sea due to release/leak from submarine pipeline

Question #2: Clarification of whether lightning strike will cause explosion of PAFF tanks leading to "rocketing" of tanks.

Response:

As reported by AAHK, there has been no fire incident due to lightning on the airport fuel tank farm at Chek Lap Kok since the airport opened in 1998. This is despite the high incidence of lightning in the area. The number of monthly average lightning strikes within the HKIA (28 sq km) in 2006 was 30, giving an average of 1.1 strikes per sq km per month. The average for Hong Kong as a whole was 1.4 strikes per sq km per month. As is clear from this data, lightning strikes to tanks are to be expected both at the airport and at the PAFF.

Lightning strike to a tank is a normal expectation and the PAFF tanks will be designed against static, stray currents and lightning according to the relevant international standard (API RP 2003). A lightning strike is not expected to lead to either a tank head fire or to rocketing of the tank. In a lightning strike on a tank, sparks are formed mainly at discontinuities in the electrical path. Since the steel shell of a cone roof tank is a good conductor, lightning currents will generally flow harmlessly around the tank shell to earth. Sparks may be formed particularly around vents. This may potentially ignite a flammable mixture if present at the vent as is often the case for petrol or crude oil tanks, for example, but not for Jet A1 tanks at the PAFF. Sparks may also be formed within a tank, particularly due to poorly designed instrumentation and/or instrument earthing arrangements. If a flammable mixture is present in the tank head space, then an explosion within the tank may result due to such a spark within the tank or at a vent. Jet A1 in a PAFF tank will not however produce a bulk flammable vapour within the tank head space. Ignition around the rim seals of floating roof tanks are also common due to lightning because of the electrical discontinuity at the seal leading to sparks in a location where flammable vapour is often present. However, the PAFF tanks do not have floating roofs, so this major source of tank ignition does not apply.

Without the possibility of a bulk flammable vapour within the tank, the possibility of a large explosion in the tank head space that could lead to the tank rocketing is minimal. In reviewing the incident history, this has never happened for a tank containing Jet A1 or comparable flammable liquid, but the event has still been included within the 100% instantaneous tank failure frequency.

The PAFF tanks are designed to API 650, and include a weak shell to roof joint designed so that the tank would fail preferentially at the roof joint rather than the floor joint, so still containing the liquid, even if such an explosion were to occur within the tank. This safety feature is most relevant to tanks where a bulk flammable vapour can be present in the vapour space, but is included within the design of the PAFF tanks anyway.

It is not impossible for small regions of flammable vapour to exist, or be generated by a lightning discharge itself. Therefore, the possibility of ignition due to lightning strike has been addressed in the EIA process and is included within the assessed tank fire frequencies, specifically the tank head fire frequencies addressed under Scenario T2 (Section 10.5.3 of EIA).

Question #3: Clarification of the reasons to adopt the PAFF project-specific frequencies of 100% instantaneous tank failure in the EIA report and the applicability of using the generic frequencies recommended in some overseas' guidebooks in the QRA for 100% instantaneous tank failure of the PAFF project in Hong Kong. Detailed comparison with, for example, the alternative frequencies suggested by the HSL report submitted by one commenter regarding the use of different tank failure frequencies.

Response:

In its email to ACE members dated Monday, 16 April 2007 entitled "Serious flaws in PAFF's EIA report", HSL/SWS confirms and accepts the analysis in the EIA, in particular the modelling and analysis of the potential consequences from a hypothetical worst case analysis of a 100% instantaneous failure of one of the PAFF tanks. SWS however quote maximum numbers of fatalities out of context in this hypothetical worst case by not referring to the extremely low frequencies predicted for the incidents. SWS also note that the EIA has considered the ignition sources inside the steel mill in some detail. It should be noted that this hypothetical worst case scenario was assumed only because the Court of Final Appeal (CFA) required the assessment.

It may also be noted that the 1/30 scale modelling of the flows due to 100% instantaneous failure is very much a hypothetical worst case convenient for laboratory tests, as discussed in the EIA report. In particular, the remainder of the tank wall in the model test remains in place following an unzipping event and this unphysically constrains the liquid to flow out of the tank towards the steel mill only. In the very few identifiable events where this has occurred, the tank wall moved backwards, as required by the laws of physics, resulting in a less directional flow. This substantiates the argument that in the case of PAFF, it would result in less flow into SWS.

Whilst accepting the assessment of consequences and potential ignition sources, the e-mail questions the frequency used in the EIA Report for the 100% instantaneous failure incident and suggests that it is 1000 times (or 1×10^3) too low.

This assertion is based mainly on a failure by HSL/SWS to take account of the project and site specific factors for the PAFF and the use of "catastrophic" tank failure frequencies to apply to "100% instantaneous tank failures". It should be borne in mind that such "100% instantaneous tank failures" are only a small proportion of "catastrophic" failures. Of these, lesser failures, including a 1m high split all the way around the base of the tank, do not generate any significant off-site flows for the PAFF as demonstrated in the physical modelling for the PAFF. The really extreme scenario of "100% instantaneous tank failures" involving unzipping of a tank in the direction of the steel mill with a 10 metre complete gap from top to bottom on that side of the tank, is the one in which the fuel could flow into the steel mill and ignite causing fatalities. But as stated above, it assumes that the tank stays in place which cannot happen under the laws of physics, so the EIA analysis is pessimistic.

HSL/SWS challenges the frequency used for 100% instantaneous tank failure stating that this is a serious flaw in the PAFF EIA Report. HSL/SWS has suggested that EIA adopt a frequency of 4.8×10^{-6} /yr (Glossop) or 5×10^{-6} (Dutch Purple Book).

For a catastrophic tank failure releasing 10% of the tank contents, EIA has adopted a similar frequency of 6.6×10^{-6} /yr. Other catastrophic failures, releasing up to 100% of the tank's contents, are likely to result in a bund fire if ignited; EIA has adopted a frequency of 1.2×10^{-5}/yr for 6 tanks which easily includes the catastrophic failure frequencies above (ignition of Jet A1 in a bund is unlikely).

Note that, in connection with the Purple Book figure, Section 4.5 of the Purple Book [5] specifically states "*If a spill of liquid occurs in a bund, its characteristics have to be taken into account. If the walls of the bund are sufficiently high, the bund prevents the spreading of the liquid pool and the dimensions of the pool are restricted to those of the bund. An effective pool radius, R_{pool}, is then calculated from the bund area, A_{bund}, using the equation: $R_{pool} = \sqrt{(A_{bund} / \pi)}$.*" That is, the instantaneous release identified in the Purple Book would lead to a spill contained within the PAFF bund, not momentum overtopping of the bund (which is not mentioned in the Purple Book).

The frequency of 4.8×10^{-6} /yr derived by HSL (Glossop), refers to catastrophic tank failure for generic atmospheric pressure storage tanks rather than 100% instantaneous failure of the specific tanks, storing the specific substance (Jet A1) in the specific environment of the PAFF in Hong Kong, i.e. it includes failures of tanks at low temperatures, where the wall material may be brittle, where the contents may generate an explosive mixture within the tank vapour space and in much more seismically active regions than Hong Kong. Similarly, the catastrophic failure rate derived by Glossop also applies to all hole sizes above 1m, which is fall less than required to produce a failure resulting in significant off-site flows modelled for the PAFF tanks[2].

CFA in its judgment stated that a QRA for the 100% instantaneous failure of a tank **must be both generic and specific**. EIA has therefore reviewed available **generic** information and then made adjustments as per the CFA judgment based on the **specificity** of the PAFF project. SWS insists that a **generic** frequency for "catastrophic" tank failure[2] must be used for "100% instantaneous failure of a PAFF tank". This is where AA and SWS have a fundamental difference. The

[2] Glossop in the HSL study defines "catastrophic failure" as anything resulting in a release larger than an equivalent hole size of 1m in diameter. This gives a release area 300 times smaller than the unzipping case for a PAFF tank and 4,000 times smaller than the complete loss of the PAFF tank wall.

Airport Authority (AA) approach is the accepted and proper EIA methodology which satisfies in full the CFA judgment requirement of both **generic and specific** assessments. The examples by HSL/SWS in their public comment (#1303) (attached as Figures 2, 3 and 4) show catastrophic tank failures, but these do not represent 100% instantaneous failures. Figure 2 shows a tank base failure whilst being purged with nitrogen, the laboratory experiment has shown that in such an event, no fuel would flow into the steel mill. Figure 3 shows a tank roof shearing off but this would not result in 100% instantaneous loss of a tank's content. Similarly, Figure 4 shows a rupture of a poorly maintained tank that would also not result in 100% instantaneous loss of the tank contents. HSL/SWS have basically mixed up the catastrophic tank failure with 100% instantaneous loss of the contents of a tank.

The failure frequency in the PAFF EIA is based on a site **specific** assessment of the 100% instantaneous failure frequency for the PAFF storage tanks, taking into account:

- The material stored (Jet A1 which does not produce a flammable vapour under ambient conditions in Hong Kong).
- The ambient temperatures and temperature of the Jet A1 (meaning that low temperature embrittlement is not an issue).
- The conditions of the PAFF site.
- The construction and operation of the tanks.
- Historical catastrophic and 100% instantaneous tank failures and their causes.
- An estimate of the applicable world-wide tank population.
- The differences between catastrophic and 100% instantaneous failures required to overtop the PAFF bunds.

Detailed differences are given in Attachment A. The 11 incidents cited by SWS in its public comment (#1303) are part of this **generic** frequency, but not part of the frequency for the PAFF tanks, because none of the incidents are applicable to a 100% instantaneous failure of one of the PAFF tanks. The incidents are discussed in Attachment B.

The table below compares the frequencies used for different tank failures by HSL/SWS and in the EIA.

Type of Tank Release	Frequency per tank-year		Comments
	HSL	EIA	
Large Release from Tank	1.1×10^{-4}	4.5×10^{-4}	HSL major release from Glossop, EIA from Table 10.38
Catastrophic Failures for Generic Tanks	$\sim 5 \times 10^{-6}$	6.6×10^{-6}	EIA cautiously taken as 10% release from tank top in EIA Scenario T14 and within EIA bund fire Scenario T6.
100% Instantaneous Failures for Generic Tanks	$\sim 5 \times 10^{-6}$ (as above)	1.5×10^{-7}	EIA based on 11 incidents in 2,400,000 tanks over 30 years (Section H3.2 – figure not specifically quoted in EIA). Similar to Davies figure of 2×10^{-7}.
100% Instantaneous Failure of a PAFF Tank Containing Jet A1 in Hong Kong	$\sim 5 \times 10^{-6}$ (as above)	5×10^{-9}	No 100% instantaneous failures applicable to PAFF tanks. Causes: • Low temperature embrittlement • Explosion in head space • Seismic failure (not instantaneous) in high seismic risk area None applicable to PAFF tanks (30% chance assumed) EIA Section H3.5
PAFF also includes a number of additional safety features such as weak roof to shell joint, staggered plates, base anchors and multiple containment systems.			

Thus the EIA Report concludes that the frequency for a 100% instantaneous failure of a PAFF tank containing Jet A1 is best represented by a figure of 5×10^{-9} per year.

Whilst there is reasonable agreement over the figures used for large and catastrophic (but not 100% instantaneous) failures that could release a large volume, up to the entire tank contents, into the bund, the assessments differ over the specific case of a 100% instantaneous failure of a PAFF tank containing Jet A1.

HSL/SWS use the same generic frequency to cover a range of cases addressed specifically in the EIA from catastrophic failure of a generic tank to 100% instantaneous tank failure specifically of a PAFF tank.

For a generic tank (which may store petrol or crude oil for example, and may operate in sub-zero temperatures in seismically active areas) the EIA has implicitly assessed a 100% instantaneous failure frequency of 1.5×10^{-7} per year. Since the emphasis is on assessing the event frequency for a PAFF tank this is not stated explicitly in the EIA, but may be derived as follows:

- 11 incidents possibly associated with a 100% instantaneous failure in Section H3.2;
- a world-wide population of 2,400,000 tanks identified in Section H3.4;
- a nominal 30 years of experience identified in Section H3.5;

– giving 11 / 2,400,000 / 30 = 1.5×10^{-7} per year.

The 11 incidents identified in Section H3.2 are also discussed in that section of the EIA. It is concluded that "*All of these incidents include significant causative factors that are not present for the PAFF tanks.*" (H3.2.1.7 of the EIA). These incidents have been further reviewed following the public comments on the EIA and further details in particular the incident descriptions are attached to this note as Attachment B for information.

It may be noted that, of the 11 incidents identified, only 4 were clearly identified in the EIA as including momentum overtopping of the bund and that 2 of those were outside the nominal experience period considered (in 1924 and 1957), so the above estimate may also be rather conservative. However, this frequency is similar to the figure of 2×10^{-7} /year from Davies/Wilkinson ([23], [15]) which was specifically undertaken to look at bund effectiveness.

In assessing the frequency of 100% instantaneous failure appropriate to a PAFF tank, the EIA has reviewed the historical incidents identified, with the conclusion that none of them had causes that were applicable to 100% instantaneous failure of a PAFF tank. This is based simply on:

- The PAFF tanks are not susceptible to low temperature embrittlement
- Jet A1 does not produce a flammable vapour in the PAFF tank head space which could lead to an explosion.
- The PAFF tanks are not situated in a high seismic risk area and the seismic failures reported (e.g. California) were probably not instantaneous.

Since none of the failures identified are applicable to the PAFF tanks, some judgment has to be made about how likely a failure would have been to have been seen that was applicable. In this case a nominal 30% chance assumed has been assumed in the assessment (EIA Section H3.5).

Thus EIA Report concludes that the frequency for the 100% instantaneous tank failure incident is best represented by a figure of 5×10^{-9} per year.

However, it may still be noted that no convincing argument has yet been made about how such a 100% instantaneous failure could occur for a PAFF tank, so the above may still be considered pessimistic.

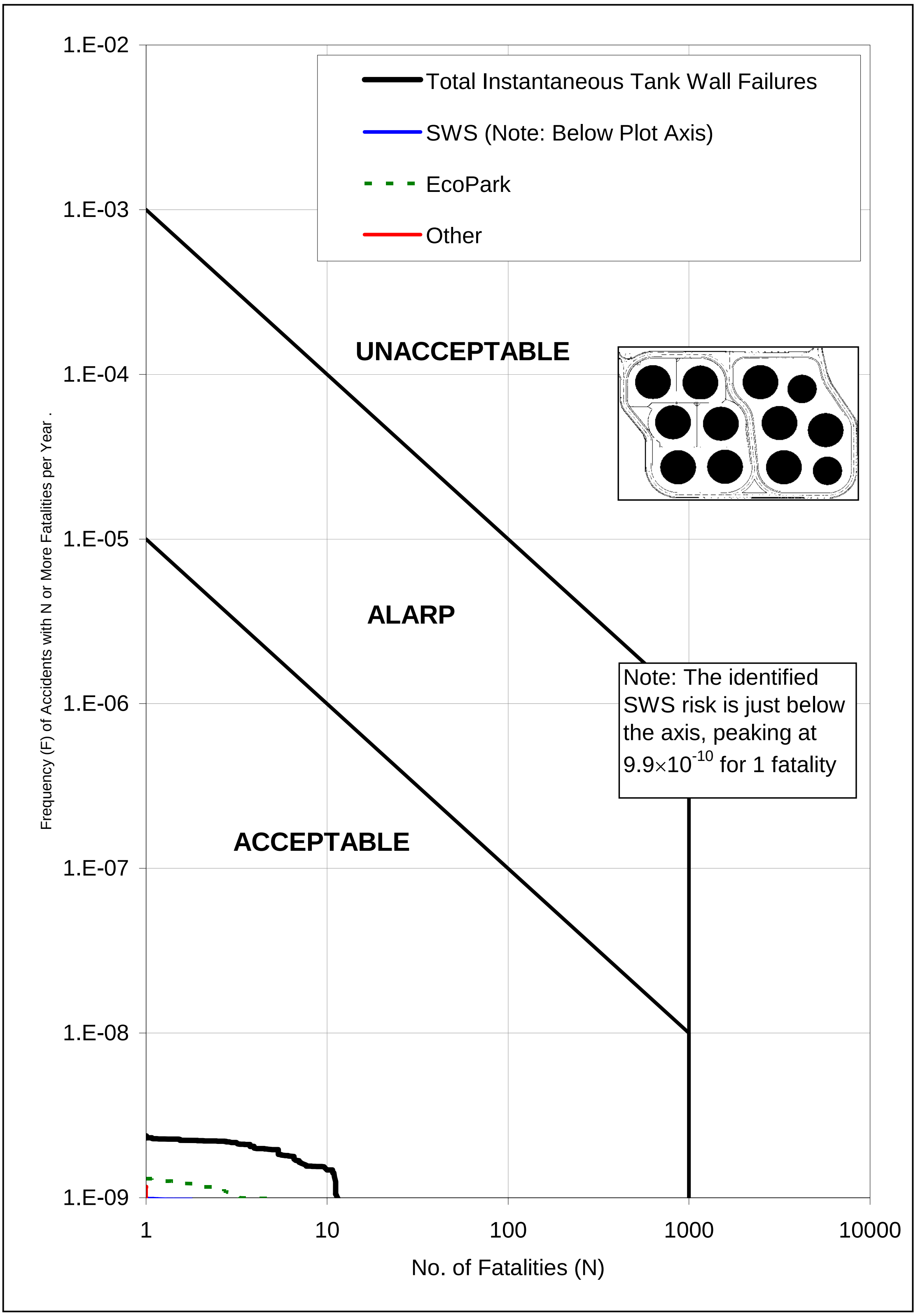
It should also be noted that most of the fuel farms across the world would fall into the ALARP region because they usually contain a mixture of fuels, viz, diesel, petrol, LPG, etc., as do the Tsing Yi fuel farms. AA does not agree with the SWS assessment that the F-N curve falls in the ALARP region, or SWS's assertion that if the predicted F-N curve was in the ALARP region (based on their assessment) then "*measures must be introduced to move it to within the 'Acceptable' region*". According to the Technical Memorandum criteria, "*Risks within ALARP Region Should Be Mitigated To As Low As Reasonably*

Practicable". This does not mean that they must be moved to within the "Acceptable" region, but that risks which fall within the ALARP region (even after mitigation) may be accepted providing the risks are as low as reasonably practicable. This is a very important distinction as risks from very many facilities around the world would fall within the ALARP region and yet the risks are tolerated.

That is, whilst the EIA report confirms that the PAFF risks fall completely within the Acceptable Region, even if the risks from the PAFF did fall in the ALARP region, then it would still be normal to accept them providing they as low as reasonably practicable.

It should be further noted that hypothetically even if the adjustment predicted for site specific factors (compared to HSL's suggested generic catastrophic tank failure frequency) was only a factor of 10 in place of 1000, the societal risk would still fall in the Acceptable Region of the F-N Curve of Annex 4 of the Technical Memorandum of the EIAO.

Figure 1



1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-08
1.E-09
Frequency (F) of Accidents with N or More Fatalities per Year .
1
10
100
1000
10000
No. of Fatalities (N)
Total Instantaneous Tank Wall Failures
SWS (Note: Below Plot Axis)
EcoPark
Other
UNACCEPTABLE
ALARP
ACCEPTABLE
Note: The identified SWS risk is just below the axis, peaking at 9.9×10-10 for 1 fatality

<u>Figure 2</u>- Rupture of tank at shell-to-bottom weld (BP, 2005b)

<u>Figure 3</u> - Tank internal explosion caused by lightning strike (BP, 2005b)

Figure 4 - Example of rupture of a poorly-maintained tank

Attachment A

100% INSTANTANEOUS TANK FAILURE FREQUENCY

This is a brief note in response to the note to ACE members from Pong Yeng on Mon, 16 Apr 2007 18:42:05 -0700 (PDT) entitled "Serious flaws in PAFF's EIA report" [1].

100% INSTANTANEOUS TANK FAILURE FREQUENCY

2.1 SWS CONCERN

SWS challenges the frequency used for 100% instantaneous tank failure stating that this is a serious flaw in the PAFF EIA Report. SWS has suggested that AA adopt a frequency of 4.8×10^{-6} /yr (Glossop [3]) or 5×10^{-6} (Dutch Purple Book [5]).

For a catastrophic tank failure releasing 10% of the tank contents, AA has adopted a similar frequency of 6.6×10^{-6} /yr. Other catastrophic failures, releasing up to 100% of the tanks contents, are likely to result in a bund fire if ignited; AA has adopted a frequency of 1.2×10^{-5} /yr for 6 tanks which easily includes the catastrophic failure frequencies above (ignition of Jet A1 in a bund is unlikely).

The Court of Final Appeal (CFA) in its judgment stated that a QRA for the 100% instantaneous failure of a tank must be both generic and specific. AA has therefore reviewed available generic information and then made adjustments as per the CFA judgment based on the specificity of the PAFF project. SWS insists that a generic frequency for "catastrophic" tank failure must be used for "100% instantaneous failure of a PAFF tank". This is where AA and SWS have a fundamental difference.

Detailed differences are discussed below.

2.2 TANK POPULATION

The SWS note [1] suggests that the figure of 600,000 tanks in the US used in the EIA is incorrect. The more authoritative source they quote (API Publication 301 [2]) estimates a total US tank population of 700,073, which is higher than that used in the EIA (and would result in a lower failure frequency estimate). The small difference (17%) is not surprising since the figure used in the EIA is based on a quote from the US Environmental Protection Agency (also an authoritative source) in Prokop [4]. In deriving a lower tank population for their analysis, HSL [3] have been selective in the use of the API data without quoting the total figure estimated by the API report [2].

2.3 DUTCH CATASTROPHIC TANK FAILURE FIGURE

The SWS note [1] identifies the Dutch Authorities figure for catastrophic failure (i.e. the Dutch Purple Book [5]). The atmospheric pressure storage tank failure frequency is described in the Purple Book as follows: "*The failure frequencies of atmospheric tanks are based on expert judgment. The base failure rate of catastrophic rupture of a single containment atmospheric tank is assumed to be ten times higher than the base failure rate of catastrophic rupture of a storage pressure vessel, i.e.* 1×10^{-5} *per year.*" (Paragraph 3.A.2.3 of [5]). This is then divided equally between an instantaneous case and a continuous case to give 5×10^{-6} /yr each.

The Dutch Purple Book [5] also prescribes the consequence analysis to be done for each case which it notes that "*If a spill of liquid occurs in a bund, its characteristics have to be taken into account. If the walls of the bund are sufficiently high, the bund prevents the spreading of the liquid pool and the dimensions of the pool are restricted to those of the bund.*" That is, the bund is assumed to contain the release. Bund over-topping due to momentum surge is not mentioned in the Purple Book.

The failure frequency from the Purple Book (1×10^{-5} /yr allowing for both instantaneous and continuous releases of the full tank contents) is therefore applicable to a liquid pool contained within one of the PAFF primary bunds. For one of the PAFF bunds containing 6 tanks, this would give a frequency of a major release to the bund of 6×10^{-5} /yr. Allowing for the ignition probability[3], the bund fire frequency of 1.2×10^{-5} /yr used in the EIA (Section 10.5.7 of EIA) is much higher than would be expected for the tanks alone based on the Purple Book figure (less than 3.9×10^{-6} /yr since the ignition probability would be less than 0.065[3]). The EIA also includes an additional scenario of a 10% instantaneous release from the top of a tank (Scenario T14 described in Section 10.5.15 of the EIA) at a frequency of 6.6×10^{-6} /yr per tank (just above the instantaneous tank failure frequency in the Purple Book).

Overall, the PAFF EIA therefore takes a more cautious approach both in relation to the frequency of a contained bund fire that would be associated with ignition of the nominally "instantaneous loss of containment" scenario in the Purple Book and also in relation to treating significant liquid flows outside the bund due to momentum surge from a 100% instantaneous tank failure scenario.

2.4 UK AUTHORITIES CATASTROPHIC FAILURE FIGURE

In land use planning advice for flammable storage, HSE do not normally consider the frequency with which an incident may occur, but only consider the potential extent of the worst case event based on bund overtopping. HSL quote a figure

[3] Note: The Purple Book does not give an ignition probability appropriate for Jet A1, but suggests 0.065 for the largest instantaneous release of a flammable liquid having a flash point less than 21°C (Table 4.5 of [5] – the ignition probability for Jet A1 would be expected to be much lower).

for catastrophic tank failure of 4.8×10^{-6} /yr based on their own analysis [3] undertaken for HSE, which is very close to the Purple Book figure of 5×10^{-6} /yr.

Glossop [3] in the HSL study defines “catastrophic failure” as anything resulting in a release larger than an equivalent hole size of 1m in diameter. This gives a release area 300 times smaller than the unzipping case for a PAFF tank and 4,000 times smaller than the complete loss of the PAFF tank wall. A PAFF tank failure of 174 times the flow area of the HSL criterion (1m high split around the floor seam) was shown in the physical tests to produce only small off-site flows that would not impact SWS.

The frequency derived by HSL (Glossop) [3], refers to catastrophic tank failure for generic atmospheric pressure storage tanks rather than 100% instantaneous failure of the specific tanks, storing the specific substance (Jet A1) in the specific environment of the PAFF in Hong Kong, i.e. it includes failures of tanks at low temperatures, where the wall material may be brittle, where the contents may generate an explosive mixture within the tank vapour space and in much more seismically active regions than Hong Kong.

The use of this failure frequency for a 100% instantaneous failure of a tank is therefore potentially very pessimistic and its use for a 100% instantaneous failure of a PAFF tank potentially far more pessimistic. It is however in line with the frequencies of the other catastrophic tank failure events assessed for the PAFF tanks in the EIA report.

2.5 FAILURE FREQUENCY ASSESSMENT IN THE EIA REPORT

The EIA report reviews available information on catastrophic tank failures (Appendix H4 of EIA). In Section H3.2 (Appendix H3 of EIA) 11 incidents are identified as relevant to an instantaneous release from a storage tank (but not necessarily relevant to the PAFF tanks); other catastrophic failures were clearly not 100% instantaneous. All of the 11 incidents identified include significant causative factors that are not present for the PAFF tanks:

- Failure due to low temperature embrittlement (temperatures in Hong Kong and the temperature of the Jet A1 would not lead to embrittlement of the steel and metallurgical improvements have also been made to tank construction for cases elsewhere where it could occur).
- Failure if the floor seam due to a major explosion in the vapour space (Jet A1 does not produce a flammable vapour under the PAFF storage conditions and a weak shell to roof seam is now standard to avoid this).
- Seismic failure (probably not instantaneous) in seismically much more active areas than Hong Kong such as California.

It is concluded that none of these failures occurred due to causes that are directly applicable to the PAFF tanks. Whilst a catastrophic failure may lead to a release filling a PAFF bund, 100% instantaneous failure is extremely unlikely.

The PAFF tank 100% instantaneous failure frequency in the EIA is based on a judgment that there is a nominal 30% chance that an incident should have occurred in the experience history that was relevant to the PAFF tanks. This is divided by a cautious estimate of the world-wide tank population (and experience period) to obtain the 100% instantaneous failure frequency for a PAFF tank of 5×10^{-9} /yr.

SWS INTERPRETATION OF ALARP REGION

In relation to the SWS assertion that if the predicted F-N curve was in the ALARP region (based on their assessment) then "*measures must be introduced to move it to within the 'Acceptable' region*" [1] it is important to understand the actual wording of the Technical Memorandum criteria. According to the Technical memorandum criteria, "*Risks within ALARP Region Should Be Mitigated To As Low As Reasonably Practicable*". This does not mean that they must be moved to within the "Acceptable" region, but that risks which fall within the ALARP region (even after mitigation) may be accepted providing the risks are as low as reasonably practicable. This is a very important distinction as risks from very many facilities around the world would fall within the ALARP region and yet the risks are tolerated.

That is, even if the risks from the PAFF did fall in the ALARP region, then it would still be normal to accept them providing they as low as reasonably practicable.

CONCLUSION

The failure frequency for 100% instantaneous failure of a PAFF tank used in the EIA has been derived based on sound historical incident data and tank population data for the specific case of a PAFF tank. It is line with the requirements of the CFA judgment that the QRA must be both must be both generic and specific. The frequency derived is much lower than for a "catastrophic" failure of a general tank because:

- Most catastrophic failures are less dramatic than the 100% instantaneous scenario required to produce significant effects outside the PAFF.
- The PAFF tanks lack the causes that have lead to 100% instantaneous failures in the past, based on simple physical principles:
  - The tank material is not brittle at the storage temperatures
  - Jet A1 does not produce a flammable vapour at the storage temperatures.

Although the note from SWS [1] suggests that "*AA is acting irresponsibly by refusing to address the risks and hazards identified in the EIA*" AA has actually assessed the risks extensively and in detail and concluded that the risk levels at the PAFF lie entirely within the acceptable region of the Technical Memorandum criteria. Nothing in the SWS note [1] would change that conclusion.

REFERENCES

[1] Note to ACE members from Pong Yeng on Mon, 16 Apr 2007 18:42:05 -0700 (PDT) entitled “Serious flaws in PAFF's EIA report”.

[2] Aboveground storage tank survey, API Publication Number 301, 1991.

[3] Failure rates for atmospheric storage tanks for land use planning, RAS/01/06, Michael Glossop, Health and Safety laboratory, May 2001.

[4] The Ashland Tank Collapse, Prokop, J., Hydrocarbon Processing, 1988, Vol 67, Part 5, pp105-108.

[5] Guideline for quantitative risk assessment, ’Purple book’, CPR 18E, Publication Series on Dangerous Substances (PGS 3).

[6] The Hong Kong EIAO Technical Memorandum (http://www.epd.gov.hk/epd/eia/english/legis/memorandum) (accessed 4/12/02).

Attachment B

INCIDENT INFORMATION

1. INTRODUCTION

This note provides additional details of the 11 (or 12) incidents which HSL/SWS [7] suggest should be included in the calculation of 100% instantaneous failure frequency for a PAFF tank.

INCIDENT INFORMATION

Incident information is provided below for the incidents based on the information provided in the EIA report (section H3.2), the background documentation and additional information held within the MHIDAS database, plus an incident in Antwerp in 2005 identified in HSL's comments on the EIA [7].

None of the incidents identified are applicable to a 100% instantaneous failure of one of the PAFF tanks. The incidents are discussed below:

Incident	Description and Comment
Ponca City 1924	This failure involved a 117 foot (36m) diameter 41 foot 10 inch high 80,000 bbl crude oil tank at the Maryland Refining Co. at Ponca City on December 19th 1924. The tank had a welded base consisting of 1/4 and 5/8 inch plates welded to an angle ring. The shell was of riveted construction and consisted of seven rings between 5/8 inch and 1/4 inch thickness. The tanks were surrounded by earth bunds 9ft high Reports of the incident included a fire a small explosion and a tank rupture, all approximately simultaneous. The outrush of oil overtopped the earth bund surrounding the tank (shown as 9 ft. (2.75m) high) and some of the bunds surrounding adjacent tanks. After the fire, the condition of the tank was described as follows: "*Roof, shell and bottom were entirely separate. The bottom was disturbed very slightly, and the roof lay almost covering it. The first ring of the shell was torn from the second ring a distance of about 180 ft. and separated entirely from the angle to the base, to which it had been electrically welded. The sheets from the second ring to the roof were torn along an irregular line, offset by distances as much as the length of two or three sheets (each sheet about 18 ft. long). The shell was pushed back, to the south, to the earth dike surrounding the tank. The roof showed no large fissure that would indicate any explosion.*" The initiating failure was described as follows: *"The main break in the lower ring, which is believed to be the starting point of the rupture, was a clean break, practically square to the length of the plating, located about 6 ft. from a vertical joint, and at or near a joint in the curb angle.*"

Incident	Description and Comment
	According to a report "*A view of the accident held by some of the oil company people is that the accident resulted from a break in the lower shell ring, possibly due directly to the sharp drop in temperature causing contraction of the shell while the oil in the interior and the plating of the bottom were still at a temperature not much below 60 deg.; and that the outrush of oil through the break or the tearing of the metal created a spark which set fire to the oil vapour.*" The weather conditions were described as follows: "*A long period of mild weather had preceded. A day before the accident the temperature dropped from about 60 deg. F., and on the morning of Dec 19th it was 4 below zero." (i.e. a sudden temperature drop from 16°C to -20°C)* No fatalities or injuries noted but the resulting fire destroyed adjacent tanks. Very old tank designed to different standards with low temperature failure (brittle fracture), therefore not applicable to PAFF tanks.
Meraux 1957	According to the MHIDAS records: "*While a tank gager was closing a valve through which gasoline was being pumped into a 14,000 bbl aboveground gasoline storage tank, the tank collapsed and caused a wave of gasoline to spread over dikes to adjacent storage tanks. The gager was killed. Fire immediately broke out and involved eight other tanks containing 47,000 barrels of gasoline, 10,000 barrels of diesel oil and 2,100 barrels of fuel oil. Cast iron fittings failed releasing additional flammable liquids. When the tank of origin ruptured it fell across a dike spilling gasoline into a drainage ditch where four railroad cars were located at a loading rack. Burning liquid spread 300 feet through the drainage ditch between dikes of uninvolved tanks, rupturing product pipelines elevated above the ditch, involving product pump houses located in the ditch and also a 1,000 gpm fire pump located in the same ditch."* Given the presence of cast iron fittings brittle failure is the likely cause. Very old tank designed to different standards and subject to brittle failure. Therefore not applicable to PAFF tanks.
Umm Said 1977	According to the MHIDAS records: "*A carbon steel tank of single wall construction with external lagging and containing 37,000 m^3 of liquid propane at atmospheric pressure and refrigerated to -42°C in a tank farm of this natural gas liquids separation plant failed catastrophically on 3 April 1977. The escaping liquid propane boiled as it hit the sand and overflowed the standard sized bund around the 2 propane tanks of this unit. The material entered the adjacent operating separation plant and was ignited as a major fire which destroyed the tank farm and the*

Incident	Description and Comment
	adjacent separation plant. The plant had been opened in 1975 and had experienced leakage problems in the tank farm which held both butane and propane under refrigeration and also petrol. 7 people were killed, 13 injured and the value of the damage was put at £40m." Whilst there is no listed failure mode, brittle fracture is possible for carbon steel at low temperature. The bund had inadequate capacity. Views differ on the effect that a full capacity bund would have had. Liquefied gas tank of significantly different design to PAFF tanks and failure probably attributable to brittle fracture. Bund capacity also inadequate. Therefore not applicable to PAFF tanks.
Floreffe 1988	Catastrophic rupture of 48 year old diesel tank on initial fill, after it had been relocated and reconstructed. Testing included only partial x-ray of welds and hydrotest to 5 feet (i.e. about 10% of tank height - 100% is now normal practice). According to Lees [9] "The investigation found that the rupture occurred due to low temperature embrittlement initiated at a flaw in the tank shell base metal, about 20 cm up from the bottom". No fire or fatalities are listed. Note: this is probably the most famous bund overtopping incident, also referred to as the Ashland or Monongahela tank collapse after the company and the river. Very old, reconstructed, tank to different standards and not fully hydrotested with low temperature failure (brittle fracture), therefore not applicable to PAFF tanks.
US, 1970	Failure of a shell to floor seam due to lightning igniting vapour in slop oil tank. PAFF tanks do not have vapour in the flammable range because the Jet A1 is stored below its flash point. Weak shell-to-roof seam also acts as mitigation. Therefore not applicable to PAFF tanks.
Addyston, 1976	On March 28, 1976, a methanol storage tank in Addyston, Ohio, ruptured and collapsed. According to the MHIDAS records: "*At approximately 5:08 am a bolt of lightning struck a 600,000 gallon, fixed dome, steel methanol storage tank. The tank contained 500,000 gallons (1,893 cubic metres) of methanol at the time. The walls of the tank separated from its support base, and the entire tank was lifted, intact, to approximately 80 feet abovegrade, violently spewing its contents in all directions. The tank was surrounded by a dike area, but the dike's capacity was insufficient to hold such a rapid release of liquid. The tank landed on a dike east of its original location and damaged an adjacent 600,000 gallon ancryolantril [sic] storage tank. The contents of both tanks were immediately ignited. The methanol immediately overflowed all of its dikes. As fire fighters responded to a*

Incident	Description and Comment
	call from plant personnel, they could see a wall of flames approximately one-quarter of a mile long in a drainage ditch immediately north of the ruptured tank. Additionally, the dike around another 600,000 gallon methanol storage tank, immediately west of the ruptured tank, was flooded entirely and became engulfed in flames. The second methanol tank was empty at the time.... The fire in the dike area caused an internal vapor-air explosion in the second methanol tank that blew off the tank's fixed dome [roof] at its weak joint point. The dome landed dangerously close to fire fighters who were applying hose streams to cool the tank, but no-one was injured." PAFF tanks do not have vapour in the flammable range because the Jet A1 is stored below its flash point. Weak shell-to-roof seam also acts as mitigation. Therefore not applicable to PAFF tanks.
US, 1978	Three tanks failed catastrophically in an earthquake. No further details available. Seismic failure remains a possibility for the PAFF tanks, although Hong Kong has a much lower seismic hazard than USA, particularly California (Richmond). Events therefore are not completely impossible, but would be much less likely for PAFF tanks. Seismic failure of a tank may also not cause an instantaneous release.
Richmond 1989	Earthquake ruptured a gasoline storage tank. The spill was contained in the bund and was not ignited. This failure occurred in the 1989 Loma Prieta (magnitude 7.1) earthquake, described as the worst earthquake to strike the San Francisco Bay area since 1906 [8]. Seismic failure remains a possibility for the PAFF tanks, although Hong Kong has a much lower seismic hazard than USA, particularly California (Richmond). Events therefore are not completely impossible, but would be much less likely for PAFF tanks. Seismic failure of a tank may also not cause an instantaneous release.
1992 EPA	*"In a 1992 incident, while workers were welding the outside of a tank empty of liquid, the residual vapour in the storage tank exploded and propelled the tank upwards and into the adjacent river. Three workers were killed and one was injured." [10]* PAFF tanks do not have vapour in the flammable range because the Jet A1 is stored below its flash point. Weak shell-to-roof seam also acts as mitigation. Therefore not applicable to PAFF tanks.
1994 EPA	*"In a 1994 incident, during a grinding operation on a tank holding petroleum-based sludge, the tank was propelled upwards, injuring 17 workers and spilling its contents over a containment berm into a nearby*

Incident	Description and Comment
	river." [10] PAFF tanks do not have vapour in the flammable range because the Jet A1 is stored below its flash point. Weak shell-to-roof seam also acts as mitigation. Therefore not applicable to PAFF tanks.
1995 EPA	*"In a 1995 incident, during a welding operation on the outside of the tank, the combustible vapour inside two large, 30-ft. diameter by 30-ft. high, storage tanks exploded and propelled the tanks upwards - one landing more than 50 feet away. The flammable liquid inside was instantly released and ignited, resulting in a massive fire that caused five deaths and serious injuries." [10]* PAFF tanks do not have vapour in the flammable range because the Jet A1 is stored below its flash point. Weak shell-to-roof seam also acts as mitigation. Therefore not applicable to PAFF tanks.
Antwerp, Belgium, 2005	On 25th October 2005 in Kallo, a suburb or Beveren, port area of Antwerp a major failure of a crude oil tank occurred at TotalFina. According to the MHIDAS records: "*A leak occurred in a 40 million litres (10.5 million US gallons) crude oil tank. By nightfall, at least 35 million litres (9.2 million US gallons) were estimated to have leaked out and were threatening to overwhelm the retention basin. As a result of the leak there was a pungent smell throughout the region, extending to the Dutch province of North Brabant, where several hundred people complained of eye and throat irritation.*" The fire brigade blanketed the oil with foam and inhabitants of the immediate surroundings were advised to keep their windows closed. No fire, injuries or fatalities were reported. This is an additional incident cited by HSL [7]. Although the failure is major, it is clearly not a 100% instantaneous failure and is therefore not applicable to a 100% instantaneous failure of a PAFF tank.

The three EPA incidents listed above were the subject of an EPA alert and the identified hazards were reviewed in the EIA report (Paragraph H4.7.1.5 of the EIA report). It was noted that the EPA identified incidents relate to storage of petroleum liquids that generate flammable vapours within the tank and "all occurred in older, atmospheric steel storage tanks" [10]. The alert further notes that "A properly designed and maintained storage tank will break along the shell-to-top seam. Then, the fire would more likely be limited to the damaged tank and the contents would not be spilled." [10]. Recommendations are made in the alert, including design to standards such as API 650 and maintenance to API 653. The potential hazards identified in the alert [10] are all inapplicable to the PAFF or addressed in the design, as follows:

Identified Hazard [10]	ESR Comment for PAFF Tanks
“Atmospheric storage tanks that do not meet API-650 or other applicable codes and contain flammable liquids or liquids that may produce combustible vapour.”	PAFF tanks are designed to API 650 and contain Jet A1, which does not produce a flammable vapour under ambient conditions because it is stored below its flash point. Inapplicable.
“Tanks with corrosion around the base and/or steel tanks whose base is in direct contact with ground and exposed to moisture.”	PAFF tanks will be constructed on a plinth, above the bund floor rather than in direct contact with the ground and water should drain away. Allowed for in design.
“Tanks or associated structures (e.g., pipes) with weakened or defective welds”	PAFF tanks are designed to API 650 and will be maintained to API 653 and incorporate corrosion allowances in both wall and floor plates [11]. Allowed for in design.
“Tanks used to store mixtures containing water and flammables where the water phase is at the tank bottom and may contribute to internal bottom corrosion.”	PAFF tanks will contain Jet A1 product which should not be delivered with significant water contamination. PAFF tanks are designed to API 650 and will be maintained to API 653 and incorporate corrosion allowances in both wall and floor plates [11]. Inapplicable and allowed for in design.
“Tanks containing combustible vapour and not equipped with flame arrestors or vapour control devices to limit emissions.”	PAFF tanks contain Jet A1, which does not produce a flammable vapour under ambient conditions because it is stored below its flash point. Inapplicable.
“Possible ignition sources near tanks containing combustible vapour.”	PAFF tanks contain Jet A1, which does not produce a flammable vapour under ambient conditions because it is stored below its flash point. Hazardous area classification limits ignition sources local to the tanks. Inapplicable and allowed for in design.

REFERENCES

[7] PA#01323 Comments on Environmental Impact Assessment for Permanent Aviation Fuel Facility, 15 03 07.

[8] San Francisco Earthquake History 1915-1989, http://www.sfmuseum.org/alm/quakes3.html

[9] Loss prevention in the process industries, second edition, F P Lees, 1996. Specifically pages 16/152-153 and Appendix 1/60.

[10] Catastrophic Failure of Storage Tanks, EPA Chemical Safety Alert, EPA 550-F-97-002b, May 1997.

[11] Affirmation of Brian Robert Gillon, in the High Court of The Hong Kong Special Administrative Region Court of First Instance, Constitutional and Administrative Law List, HCAL No 184 of 2002, 15th August 2003.

ANNEX 4

Question #4: Clarification of the reasonableness of assumptions adopted in the EIA for the PAFF project-specific frequencies of 100% instantaneous tank failure, including the applicability of historical incidents, the estimation of worldwide tank population, and the relevance of natural hazards, human factors and/or unforeseeable factors, etc. Clarification of whether and how the overall results and conclusions of the Quantitative Risk Assessment (QRA) will be affected.

Response:

1. INTRODUCTION

This response addresses in particular the assumptions used and basis adopted for the hazard assessment conducted by the Airport Authority Hong Kong as compared with those used and adopted by other different parties contained in the public comments on the EIA report; specifically Comment PA#01323 (HSL) [7].

HSL [7] suggest that the "*EIA Report has grossly underestimated the frequency of catastrophic failure of a tank*" and "*Had the calculation of the catastrophic tank failure frequency been carried out on a true cautious best estimate approach, the overall F-N curve for the PAFF moves significantly upwards from the 'Acceptable' region of Annex 4, to the 'ALARP' region.*"

It is concluded that the difference between the 100% instantaneous tank failure frequencies used in the EIA (5×10^{-9} /yr) and by HSL (2.8×10^{-6} /yr [7]) is based on:

- HSL's inclusion of incidents not relevant to the 100% instantaneous failure of a PAFF tank.
- HSL's use of a catastrophic tank failure frequency which includes much smaller failures than the 100% instantaneous case required by the Court of Final Appeal (CFA).
- HSL's use of a lower estimate of tank population based on less than 10% of the US tanks identified in the survey they quote (i.e. only the large ones) and no other tanks world-wide.

The overall differences between HSL's assessment [7] of 100% instantaneous failure frequency and the estimate in the EIA are:

- A factor of ~30 for the inclusion of events not applicable to100% instantaneous failure of the PAFF tanks.
- A factor of ~6 for the different estimates of US tank population.
- A factor of ~4 for the not including any tanks outside the US.

These three factors need to be included together to produce a societal risk level that significantly enters the ALARP region of the Technical Memorandum criteria.

However, the HSL assessment [7] is based on generic information and can be stated to be grossly pessimistic for the PAFF tanks as it fails to take account of the details of the PAFF project, as required by CFA which states that "*The historical data must be adjusted, however, to take account of the specific features of the instant project.*" (Para 53 of [18]).

For the sake of argument, even if HSL's 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr is used (Figure 1), the Initial Development is completely acceptable and the Final Development (beyond year 2025) is also acceptable, providing the risks for the Final Development are kept As Low As Reasonably Practicable[4]. In fact, using the SWS/HSL assessment (which AA considers grossly pessimistic and unreasonable) the final development still only falls within the ALARP region by a factor of 3.

HSL also suggest an even higher 100% instantaneous failure frequency of 1×10^{-5} /yr [7]. This is considered to have no valid basis since it is based on an erroneous interpretation of earthquake failure data.

The reasons for the main differences cited above between the assessments are:

- HSL include incidents not relevant to a 100% instantaneous failure of a PAFF tank in making their estimate of a "catastrophic" release frequency and have failed to take into account the specific properties of Jet A1 (it is a Class 2 liquid stored below its flash point) and the specific circumstances of the PAFF location.
- HSL's frequency estimate refers to "catastrophic" failures rather than "100% instantaneous" failures. HSL's definition of "catastrophic" failure [3] includes failures much smaller (300 to 4,000 times smaller) than 100% instantaneous. However, HSL [7] apply this catastrophic failure rate to 100% instantaneous failure of the PAFF tanks. This is grossly pessimistic and is not in line with the definition of 100% instantaneous failure of the CFA.
- HSL [7] base their frequency estimate on a tank population of 97,800 in the US only, whereas the EIA bases the frequency estimate on a tank population of 600,000 in the US, leading to an estimate of 2,400,000 tanks world-wide. Since the frequency of failures is derived from the number of incidents divided by the tank population, then a lower population leads to a higher frequency estimate.

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[4] Based on using HSL's predicted "catastrophic" tank failure frequency of 2.8×10^{-6} /yr to apply to "100% instantaneous" tank failure instead of the EIA figure of 5×10^{-9} /yr specifically for 100% instantaneous failure of a PAFF tank. HSL [7] also suggest an even higher failure frequency based on a grossly pessimistic assessment of seismic risk, which is not included in Figure 1.

- HSL have excluded over 90% of the US tank population estimated in the "*more authoritative source of information*" they quote [2] (the total number of tanks in the US estimated in this source is 700,073 [2] which this is greater than the US tank population used in the EIA). In their analysis, HSL ([3], [7]) have eliminated a very large proportion of the tank population, which is considered pessimistic.
- HSL fail to include any tanks outside the US in their tank population estimate, although failures outside the US are cited; the EIA has taken a cautious approach to assessing the world-wide tank population.
- HSL have also grossly over-estimated the 100% instantaneous failure frequency due to earthquake again by using a frequency for a much smaller failure (moderate loss) to apply the 100% instantaneous case. HSL follow the same approach to continue with their criticisms towards the assessment related to typhoons and aircraft impact. This is very pessimistic and leads to an overstatement of the risks.

In summary:

- The EIA assessment provides a more appropriate and soundly based cautious best estimate for the risk levels at the PAFF than that of HSL [7].
- The assumptions used by HSL [7] are not in line with the CFA judgment.
- The criticisms put forward by HSL [7] do not contain anything which would significantly alter our views on the risk levels at the PAFF, which lie entirely within the acceptable region of the Technical Memorandum criteria.

Natural hazards, including earthquakes, typhoons and lightning are included within the risk assessment in the EIA and form part of the overall societal risk assessment in the F-N curves. (see also Response to Question 1).

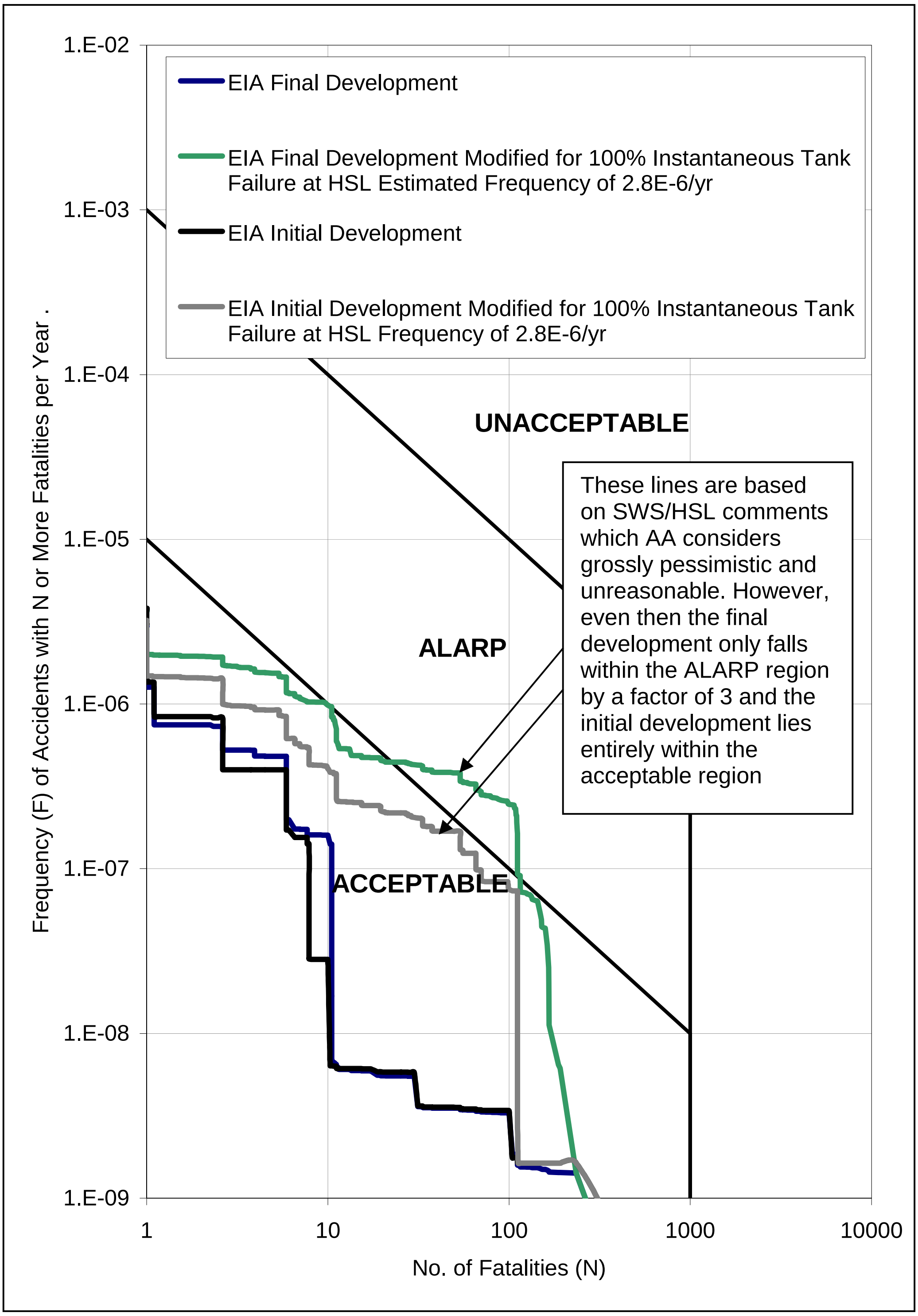


Figure 1: Comparison of EIA and HSL Total Societal Risk Estimates for PAFF[4]

2. DIFFERENCES IN ASSUMPTIONS

2.1 100% INSTANTANEOUS TANK FAILURE FREQUENCY

HSL assert (first paragraph of 3-1 [7]) that the "*EIA has grossly underestimated (by three orders of magnitude, or a factor of 1000) the frequency of catastrophic failure of a tank.*" The report then goes on to consider the "*flaws in EIA estimate of catastrophic failure frequency*". These are discussed below

2.1.1 Tank Populations

The EIA has taken a tank population for the United States of 600,000, based on Prokop [4], which HSL [7] claim as unreliable. This is similar to the total number of 700,073 tanks estimated in the US in the API survey [2].

The total number of tanks world-wide of 2,400,000 in the EIA is estimated on the assumption that the US accounts for ¼ of the tanks. This factor is based on the proportion of the world's petroleum consumed by the US (EIA Para H3.4.1.8); the proportion produced by the US is much lower and would lead to a higher world-wide tank population estimate.

The lower the tank population, the higher the predicted incident frequency will be.

HSL [7] base their assessment on their own analysis of the tank population (Glossop 2001 [3]). In this they derive a population for the number of above ground tanks >450 m^3 in the US of 62,500, which they then increase by a factor of 50% to account for tanks in the chemical sector to give a figure of 97,800. HSL [7] make no allowance for the population of tanks outside the US.

These figures are clearly much lower than those used in the EIA. However, HSL [7] fail to mention that the actual number of tanks estimated in the US in the API survey (1991 edition [2]) is 700,073, i.e. 17% higher than the estimate from Prokop [4] used in the EIA report and ten times higher than the HSL [7] figure. It may also be noted that in relation to tanks at production facilities (over 80% of the total) the API survey says "*The estimation of the total number of tanks in the U.S. in the production sector on this survey is probably an under-estimate of the actual U.S. total...*" [2].

The HSL (Glossop [3]) figure of 62,500 tanks ignores over 90% of the tanks in the API survey on the basis of their size. Such a major departure from the total number of tanks in the API survey appears potentially very pessimistic.

Glossop's cut-off in tank size also includes interpolation of the API study and is inconsistent with HSL's own commentary on the EIA in which they consider that a failure of a "*small tank in lubricating oil service*" is relevant to the PAFF EIA (HSL 3-1.4 "Case Study" [7]).

The total figure of 700,073 tanks in the API survey is not mentioned in either HSL's failure rate analysis (Glossop [3]) or HSL's comments on the EIA [7].

HSL, in their comments on the EIA [7], also say that "*HSE's criticisms are documented in Glossop (2001)*". We note that these are actually HSL's criticisms (HSL is an agency of the HSE) rather than HSE's criticisms since the report referenced [3] is actually an HSL report and not an HSE publication. Glossop [3] criticises the Prokop frequency by reference to a perceived disparity between the population of tanks in the UK and the US. He cites the failure rates published in Davies [23] of $<2\times10^{-5}$ /yr based on no major incidents in an estimated 150,000 tank years of operation in the UK in past 50 years (quoted value is the statistical upper limit on the actual failure rate) and the failure rate estimated from Prokop of 2×10^{-7} /yr based on two tank failures in USA in period 1968-1988 and a tank population of 600,000, as discussed earlier. These two figures in Davies [23] are derived from different sources. Glossop [3] says "*It is believed that there might be an error in these calculations as the values for the number of atmospheric vessels in the UK and USA are 3000 and 600000 respectively. It is believed that it is unlikely that there is such a significant difference in the number of atmospheric vessels present in these countries.*" Certainly, we would agree with the second half of the statement, but the major discrepancy is actually because the UK figure relates to a single company rather than the whole of the UK tank population – although this is made clear by the reference in the original work [15] the reference only appeared as "private communication" in the Davies paper [23]. Presumably this is the cause of Glossop's confusion at the apparent discrepancy in tank populations and leads to a criticism of the Prokop based failure frequency and population based on a completely invalid comparison by Glossop.

Glossop derives a catastrophic failure frequency of 3.0×10^{-6} /yr for the UK tank population by dividing a single collapse of a water tank in 1998 by his estimate of the population of oil and chemical storage tanks in the UK derived by reference to the API survey and ratios between the expected numbers of tanks in the UK and US [3]. Water tanks are not typically built to the same specification as petroleum tanks and Glossop, in assessing this catastrophic frequency, appears to have completely ignored this fact and also completely ignored the population of water tanks in the UK. The basis of Glossop's [3] estimate is therefore grossly unsound.

Glossop's basis for a catastrophic failure frequency for tanks in the US has a better statistical basis, but does include failures of tanks containing water, asphalt, gasoline, acid solvents, creosote, diesel and oil, and relates to "*catastrophic*" failure rather than "*100% instantaneous failure*" (see Section 2.1.2 for more detail).

In the EIA report, comparisons were also made with estimates of other tank populations and total storage capacity data to examine their consistency with the tank population from Prokop. This was found to be consistent with available information. This remains the case, and it is also consistent with the API survey [2].

Most of the “instantaneous” failure incidents identified in Section H3.2 of the EIA occurred in the US. Of the most important events involving momentum overtopping of the bund, one out of the four occurred in the Middle East (Umm Said 1977), whilst the other 3 occurred in the US in 1924 (Ponca City), 1957 (Meraux) and 1988 (Floreffe). Although all four events are considered in the EIA, it is apparent that only two events (Umm Said and Floreffe) occurred over the nominal 30 year experience period considered; one was in the US and one in the Middle East. 100% instantaneous tank failures have been extremely rare, even for tanks which may be susceptible to them, so it is difficult to apply good quality statistical analysis to the data. However, it is clear that events outside the US are included.

The EIA has assessed (H3.4.1.8 of the EIA) that the US accounts for between 10% and 25% of the tanks world-wide. The EIA has cautiously assessed the world-wide tank population based on 25% of all tanks being present in the US, to give the lowest world-wide population estimate and hence the highest overall 100% instantaneous tank failure frequency.

To ignore all tanks outside the US when the failures of importance are so large and events outside the US have clearly been reported is considered to be unreasonable, however it has been recognised in the EIA that caution is appropriate in considering the applicable world-wide tank population and this has been included in the EIA assessment.

The situation may be summarised as:

- The tank population HSL suggests [7] is based on less than 10% of the total numbers of above ground atmospheric pressure storage tanks estimated in the US in the API survey [2]. Although some reduction may be appropriate, HSL have assumed a very large reduction without mentioning its extent.
- The tank population in the EIA is based on the estimate for the US tank population from Prokop [4]. The API survey [2] estimate of the total tank population in the US is 17% higher than this. The EIA has not included any uplift for tanks in other industries (if the same 50% uplift used by HSL [7] to account for other industries is included, this is equivalent to the EIA tank population for the US being based on 57% of the API survey population [2]).
- The tank population HSL [7] suggest makes no allowance for any tanks in the rest of the world. The EIA cautiously assumes that the US accounts for 25% of the tanks in the world based on the proportion of the worlds petroleum consumed by the US. An alternative, particularly since a high proportion of tanks in the US are associated with production, would be to assume the US only accounted for 10% of tanks in the world based on the proportion of the worlds oil production which comes from the US.
- ESR considers that, at an absolute minimum, HSL must include a factor of at least 4 to obtain an applicable world tank population estimate of 97,800 × 4 = 391,200. ESR considers that this is at the very lowest end of the spectrum of figures that could be justified and is highly conservative.

- The upper end of the spectrum may be assessed by taking the total numbers of tanks from the API survey, including the 50% uplift for other industries (which is probably conservative), and allowing for the US representing only 10% of the world tanks based on the US share of oil production. This would lead to an upper estimate of 700,073 × 1.5 × 10 = 10,000,000.
- The EIA estimate of world tank population of 2,400,000 is 6 times the lowest estimate and one quarter of the upper estimate. It could be viewed as a reasonable compromise between the most pessimistic and most optimistic assessments based on the available figures from the EIA, the HSL comments [7] and the API survey [2].

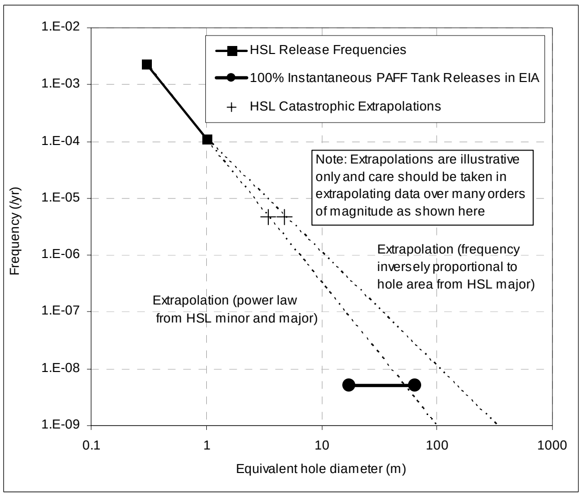
2.1.2 Definitions of Catastrophic and 100% Instantaneous Failures

Glossop [3] in the HSL study defines "catastrophic failure" as anything resulting in a release larger than an equivalent hole size of 1m in diameter. This is a very important distinction because this is a long way from the equivalent hole sizes of an instantaneous failure of one of the PAFF tanks. These are compared below.

Failure	**Hole Size (m^2)**	**Notes**
HSL Catastrophic definition [3]	> 0.78	1m diameter
Instantaneous loss of PAFF Tank (Test A*)	3,200	Whole wall
Unzipping of PAFF tank (Test B*)	235	10m wide
Failure at base 1m high by 10m wide (Test D*)	10	Offsite flows were only small
Failure 1m high around floor seam (Test E*)	137	
* Tests refer to the physical modelling used for the EIA (EIA Table 10.48)		

The PAFF tank unzipping failure is approximately 300 times the flow area of the HSL criterion for a catastrophic failure and the flow area for the loss of the whole PAFF tank wall is over 4,000 times the HSL criterion. A PAFF tank failure of 174 times the flow area of the HSL criterion (1m high split around the floor seam) was shown in the physical tests to produce only small off-site flows that would not impact SWS.

The effects of the extrapolations of data are shown in the adjacent figure using the power law derived directly from the HSL [3] minor and major release sizes and frequencies and also by assuming the frequency is inversely proportional to hole area. Within these limits, the hole size one might assume for the HSL catastrophic failure frequency of 4.8×10^{-6} /yr is 3-5m (~10-20 m^2). Whilst such failures are "catastrophic" they are much smaller than the 100% instantaneous failure



sizes for the PAFF tanks. Compared to these extrapolations from Glossop's figures, the frequencies used for the size of release required for a 100% instantaneous failure of a PAFF tank are realistic (rather than optimistic as asserted by HSL [7]). However, one should always be cautious with extrapolating data, particularly when the data is very limited and the extrapolation is over many orders of magnitude. The main point to note is that the frequencies for "catastrophic" failure and "100% instantaneous failure" should be different because the definitions of the incidents are different; HSL [7] have not allowed for this.

The HSL analysis [7], therefore introduces a potentially very large degree of pessimism by treating all catastrophic (>1m equivalent diameter) failures as equivalent to 100% instantaneous releases.

It should also be recalled that the scenario of concern to the court was *"catastrophic failure of a fuel storage tank with instantaneous or almost instantaneous loss of a 100% of the tank's contents."* (Para 16 [18]). This is not the same as the definition used by HSL as the basis on which they have derived a frequency for the scenario.

HSL in the detailed findings of their 2002 report also stated "*In summary, the Hazard Assessment fails to consider the scenario of catastrophic tank failure (i.e. instantaneous loss of the full inventory of the tank), which could lead to significant bund overtopping and risk to neighbouring sites.*" (Para 63 of [17]). As shown in the physical tests conducted for the PAFF facility, and as discussed above, significant liquid loss overtopping of the PAFF boundary is only expected from 100% instantaneous failure scenarios and not smaller, but still catastrophic, scenarios. It is therefore important to correctly assign a frequency for "*100% instantaneous failure*" rather than all "catastrophic" failures. This is also noted in the EIA (Section H3.1.1), but, in selecting the failure frequency for the analysis, HSL [7] have failed to make this distinction.

2.1.3 Numbers of Incidents

HSL (3-1.4 [7]) say that "*the upper estimate applied for catastrophic tank failure frequency is based on flawed analysis which overlooks and omits certain key issues.*" These are then discussed in HSL's following points [7].

The first point to note is that the estimate in the EIA is the frequency of "*instantaneous tank failure*" and not "*catastrophic*" failure. As noted in the EIA (Section H3.1.1) it is very important to distinguish between "catastrophic" failures and 100% instantaneous failures, in the assessment for the PAFF. HSL [7] have not done this, as discussed in Section 2.1.2 above and as noted for the incidents referred to by HSL [7] below.

2.1.3.1 Failure to Take Into Account Relevant Incidents

HSL (3-1.4a [7]) suggest that all 11 incidents in Table H3.2 of the EIA should be included in deriving a "catastrophic" tank failure frequency for the PAFF.

However, only 4 of the incidents were identified as involving bund overtopping due to the momentum of the release (3 in the US, one elsewhere) and all included significant causative factors that are not present for the PAFF tanks. HSL's apparent view [7] that all of these failures should be considered for the PAFF tanks is inappropriate:

- If the PAFF tanks were constructed of a material brittle at ambient temperatures or the Jet A1 was stored well below $0^{o}C$ then the brittle failures may be applicable. However, as HSL say in their 2002 report [17] on the previous EIA "*The EIA report is correct to state that low temperature embrittlement and boilover are not relevant to Hong Kong and storage of aviation fuel*". (Para 59 of [17]).
- If the vapour in the PAFF tanks was above the lower flammability limit under ambient conditions then the incidents involving ignition of flammable vapour inside the tanks leading to an explosion overpressure may also be relevant.
- If Hong Kong was an area of high seismicity then the failures in an earthquake may also be more relevant. This is discussed in Section 2.1.5.

It is important to note the words of the court of final appeal in this context: "*a QRA, in order to satisfy the exigencies of Annex 4, must be both generic and project-specific, that the methodology searches for the relevant scenarios in the history of projects of the same genus - and thus identifies scenarios for the purposes of para.(i) - then quantifies risk by reference to that history and the specific features of the instant project – the QRA for the purposes of para.(ii).*" (Para 72 of [18]). This has been done in the EIA, but HSL [7] appear to have ignored the specific features of the instant project.

HSL cite a number of examples of catastrophic failures [7]:

- The note on BP tank failure in 2005 (HSL Figure 3.1 [7]) covers the failure of tanks in fire and correctly identifies the need for caution in fire fighting tanks exposed to fire. This is not relevant to a 100% instantaneous failure of the PAFF tanks as considered in the EIA since it occurred during a fire rather than suddenly and without warning.
- The rupture of a shell to bottom weld due to overpressure during purging (HSL Figure 3.2 [7]) is not relevant to a 100% instantaneous failure of the PAFF because there would be very little product inside during the purging operation and the PAFF tanks have open vents rather than PV valves so they are not effectively sealed and therefore much more difficult to overpressure.
- The tank internal explosion caused by lightning strike (HSL Figure 3.3 [7]) is not relevant to a 100% instantaneous failure of the PAFF because the tank contained MTBE (Methyl Tert-Butyl Ether). MTBE is a component of gasoline with a flash point around $-28^{o}C$. Unlike Jet A1 in the PAFF tanks, MTBE will form a flammable vapour which can be ignited. It may also be noted that the tank still has a largely intact wall except at the top (Figure 3.3 of HSL Comments [7]), despite this major failure.

For the reasons identified above, none of the above incidents are relevant to the consideration of a 100% instantaneous failure of one of the PAFF tanks.

2.1.3.2 Failure to take into account incidents with unknown causes

HSL Comment 3-1.4(b) [7] notes four catastrophic failures which have occurred in the past due to unknown or non-specific causes. It is implied that these should be taken into account. For the four cases identified, we have noted the following, based on the additional data records held in MHIDAS [33]:

Incident	Original Description	Further Information
El Dorado 1980	Solvent tank ruptured. Cause cited as mechanical failure.	According to reports at the time, the blaze involved three tanks containing petroleum solvents, which would therefore potentially be expected to have flammable vapour above the liquid. In one report "*a tank ruptured causing sparks that ignited petroleum solvent inside*", a second report based on information from a Refinery spokesman however states "*...fires began late yesterday afternoon at the Getty Refinery and Marketing Co. refinery when one of the tanks exploded. The resulting fire set off a blaze in the second tank. Two hours later the side of one of the tanks burst, triggering a series of explosions that set a third tank on fire.*" Clearly, the actual causes therefore involved an explosion in the tank head space and a failure under fire attack. Unlike Jet A1 at the PAFF the liquid stored, may reasonably have been expected to produce a flammable vapour. There is no mention of any bund overtopping or loss outside a bund as might be expected if the releases had been 100% instantaneous. There were 4 injuries and no fatalities.
Colon, 1986	Light crude oil storage tank ruptured, spilling contents. Cause not cited.	The detailed records state that "*Storage tank ruptured spilling entire contents of 240,000 barrels of light crude oil. The force of oil ruptured dyke allowing oil; to flow into refinery area. Oil entered drains and overloaded oil/water separator allowing oil to enter Las Minas Bay (20-30,000 barrels)*." The spill did not ignite despite it being light crude oil, which would be easy to ignite, and spilling into a refinery area, which may have been expected to contain some potential ignition sources. There are no reports of any injuries or fatalities. The HSE report on secondary containment failure [16] cites "*inadequate bund design*" as the secondary containment issue for this event, noting "*The force of the oil caused a section of the bund wall to collapse*" and the "*design was*

		inadequate for the transient hydrodynamic loads which it experienced." In the case of the PAFF, the bunds are reinforced concrete and sunken in, giving much improved integrity for the containment of the contents of one tank.
El Segundo, 1993	Fuel oil tank ruptured and bund held all but a few percent of the spill, which entered a storm drain.	A report at the time states "*A storage tank at the Los Angeles Water and Power Company in El Segundo, Calif, spilled 2.52m gallons of No. 6 fuel oil on July 29. All but 5,000 gallons were contained in a berm that surrounded the tank. The oil that did leak out flowed into the storm water sewer system, reached a point within 40 yards of Santa Monica Bay and was stopped by a natural berm of sand at the mouth of the storm drain. Clean-up crews used vacuum trucks to remove oil from the storm drain and the berm. The storage tank, containing 8.4m gallons of oil ruptured due to an "unknown cause," according to a report from the United States Coast Guard.*" Based on the report, 0.2% of the tank contents were not contained by the bund in this case and the incident is variously referred to as a leak or a rupture, so it is not clear how rapid the release was. However, the loss of such a small fraction over the bund wall implies that this incident was not of the 100% instantaneous variety being considered here. The fuel did not ignite and no fatalities or injuries resulted.
Fawley, 1993	Bunker oil tank developed a 15ft split and spilled oil. Mist blown onto cars and houses by strong wind, but no ignition.	The detailed records note that the HMIP report on the incident says "*the leak happened due to a fracture of the tank wall and floor joint.*" The release was actually a fine mist and one report notes "*A 20,000 tonne storage tank developed a 15ft split, allowing ships' bunker oil to spill into a surrounding reservoir*" and "*strong winds carried oil mist into a residential area and it landed on cars and houses*". There is no suggestion that the release was instantaneous, but was rather a spray release from a split over some time. The fuel did not ignite and no fatalities or injuries resulted.

As a result, ESR consider it entirely reasonable to omit these failures from the potential failures of interest to a 100% instantaneous failure of a PAFF tank; one (El Dorado) occurred due to an explosion of flammable vapour within the tank, one (Colon) involved a failure of the bund wall due to the oil flow rather than any implication that the incident was sufficiently rapid to overtop the bund (the tank also contained crude oil which has many differences to the refined product Jet A1 stored in the PAFF tanks and is typically stored in floating roof tanks), one (Fawley) was definitely not instantaneous, and one (El Segundo) was very unlikely to have been instantaneous due to the very small percentage loss outside the bund.

2.1.3.3 Over-reliance on the adoption of modern standards

HSL [7] suggest that "*there is too much reliance on modern design standards in an attempt to justify factoring down the historical frequency of catastrophic tank failures*" (HSL 3-1.4(c) [7]). However, the two particular points which make 100% instantaneous failure less likely for the PAFF tanks are:

- The properties of the Jet A1 at ambient temperatures in Hong Kong, meaning that it does not form a flammable vapour above its surface.
- The ambient temperature in Hong Kong and storage conditions being such that the tanks wall material will not be brittle.

These two factors are fundamental to the PAFF operation rather than associated specifically with the design standards and directly affect the fundamental failure mechanisms associated with 100% catastrophic failure. Human errors would therefore have to overcome these inherent physical barriers to lead to a 100% instantaneous failure.

It might also be noted that the Dutch guidelines on risk assessment suggest instantaneous failure frequencies for double and full containment tanks of 1.25×10^{-8} /yr and 1×10^{-8} /yr (Table 3.5 of [5]), although the populations of these tanks (used primarily for refrigerated storage) are much lower than those of above ground atmospheric storage tanks. The suggested failure frequencies must therefore be based on a reliance on the different construction and the associated standards. Therefore, reliance on improvements in design, even if it were a major part of the basis for the 100% instantaneous failure rate of a PAFF tanks, is certainly not unique.

The example of the failure of the poorly maintained Belgian tank (HSL Figure 3.4 [7]) shows that, although the failure is major, it is clearly not a 100% instantaneous failure since the tank wall, although badly distorted, is still largely intact.

The case study of a lubricating oil tank failure of the shell to base seam (HSL 3-1.4(c) [7]) involved a number of issues not relevant to the PAFF tanks: air will not be injected for mixing in the PAFF tanks and the PAFF tanks include open vents rather than a PV valve that could stick. The discussion of the incident also makes it clear that this did not involve the sudden loss of the entire tank wall, but rather a break around the tank base, since a vacuum was then formed inside the tank. This is analogous to the failure around the tank base considered in the physical model Test E, resulting in only a small loss outside the PAFF boundary, rather than a major loss due to 100% instantaneous failure.

Similarly, the Buncefield incident, although lessons have been learned and incorporated in the PAFF design, has little direct relevance to the PAFF, as discussed in Appendix H4.8 of the EIA.

2.1.4 HSL Estimate of Catastrophic Failure Frequency

HSL [7] suggest that the "*EIA Report has grossly underestimated the frequency of catastrophic failure of a tank*" and "*Had the calculation of the catastrophic tank failure frequency been carried out on a true cautious best estimate approach, the overall F-N curve for the PAFF moves significantly upwards from the 'Acceptable' region of Annex 4, to the 'ALARP' region.*"

It should be recognised that if an assessment is made sufficiently pessimistic, it is always possible to over-estimate the risks such that they appear higher on the criteria plot. However, in ESR's opinion, the HSL assertion above is not correct.

It might also be noted that in their 2002 report [17] HSL asserted (Para 71 of [17]): "*Finally, it should be noted that, as with any QRA study, there is a significant margin of error associated with these risk estimates (typically plus or minus an order of magnitude). Given this margin of error, the F-N curve (Figure 3.1) spans the unacceptable and ALARP regions of the Risk Guidelines. These errors should be taken into account in the demonstration that risks have been reduced ALARP.*"

Clearly the above statement from HSL's 2002 assessment grossly overstates the risks even in comparison to their more recent assessment. It is ESR's view that in their recent assessment [7], HSL have once again grossly overstated the risks. In particular:

- HSL [7] suggest that 11 incidents should be taken into account in assessing the failure frequency. As discussed in Section 2.1.3 these, and other incidents cited by HSL [7], are not relevant to a 100% instantaneous failure of a PAFF tank for very good reasons associated with the fuel stored and the conditions it is stored under.
- HSL [7] have failed to take into account the specific properties of Jet A1 (it is a Class 2 liquid stored below its flash point) and the specific circumstances of the location despite HSL considering low temperature embrittlement (one of the main failure mechanisms for 100% instantaneous releases historically) "*not relevant to Hong Kong and storage of aviation fuel*". (Para 59 of [17]).
- HSL [7] have confused "catastrophic" failures with "100% instantaneous" failures that could lead to bund overtopping and a significant off-site flow of fuel, as discussed in Section 2.1.2. HSL [7] have therefore used a "catastrophic" failure frequency which grossly overstates the frequency of a "100% instantaneous" failure.
- Based on their own research report [3], HSL have greatly reduced the tank population that is taken into account, as discussed in Section 2.1.1. This is despite the fact that the total tank population in the US in the "*more*

authoritative source of information" [7] quoted by HSL ([2] 1991 edition) actually estimates a greater number of above ground storage tanks in the US than is estimated in the EIA.

- HSL [7] also fail to take account of any tanks outside the US in calculating the tank population, although failures outside the US are cited. The EIA has taken a cautious approach to assessing the world-wide tank population.
- HSL [7] have also grossly over-estimated the 100% instantaneous failure frequency due to earthquake again by using a frequency for a much smaller failure to apply the 100% instantaneous case and also by suggesting that the seismic hazard in the area is much higher than identified by the Hong Kong SAR Geotechnical Engineering Office, as discussed in Section 2.1.5.

As a result, HSL [7] suggest two failure frequencies for a PAFF tank. The first is based on their analysis of the data, as discussed above, and concludes that a frequency of 2.8×10^{-6} /yr is appropriate. This may be compared with a frequency of 5×10^{-9} /yr in the EIA report, derived specifically for the PAFF tanks. The second figure of 1×10^{-5} /yr is based on including a grossly pessimistic assessment of the 100% instantaneous failure frequency due to earthquake, as discussed in Section 2.1.5.

Figure 2 shows a comparison of the results from the EIA with those modified for HSL's [7] suggested 100% instantaneous tank failure frequencies for the Initial Development (8 tanks) and

Figure 3 shows the same information for the Final Development (12 tanks). The basis is the same as shown in HSL's comments [7]

HSL [7] suggest that the 100% instantaneous failure frequency should be a factor of between 560 and 2000 greater than the frequency identified in the EIA. On this basis HSL [7] evaluate results that fall within the lower part of the ALARP region for some of the cases considered.

If all other calculations remain unchanged, as per the HSL comments on the EIA [7], the 100% instantaneous release frequency for a PAFF tank would need to exceed 3×10^{-6} for the initial development and 1×10^{-6} /yr for the final development, in order that the total societal risk would not fall entirely within the acceptable region of the Technical Memorandum Criteria.

Based on HSL's [7] assessed frequency for 100% instantaneous tank failure of 2.8×10^{-6} /yr, the risk from the PAFF:

- is entirely within the acceptable region for the initial development.
- is within the acceptable region for the final development except between 20 and 100 fatalities where it would enter the lower part of the ALARP region.

That is, HSL [7] are saying, based on their overall assessment of a 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr, that the Initial Development is completely acceptable and the Final Development is also acceptable, providing the risks for the Final Development are kept As Low As Reasonably Practicable.

With only a factor of 3 reduction in the 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr suggested by SWS/HSL the final development would also fall entirely within the acceptable region of the Technical Memorandum criteria.

However, as discussed above, the SWS/HSL assessment is grossly pessimistic for the PAFF tanks and fails to take account of the details of the PAFF project, as required by CFA which states that "*The historical data must be adjusted, however, to take account of the specific features of the instant project.*" (Para 53 of [18]). HSL's suggested upper estimate of the 100% instantaneous release frequency for a PAFF tank of 1×10^{-5} /yr [7] appears to be grossly pessimistic and not soundly based, as discussed in Section 2.1.5.

2.1.5 Earthquake Induced Failures

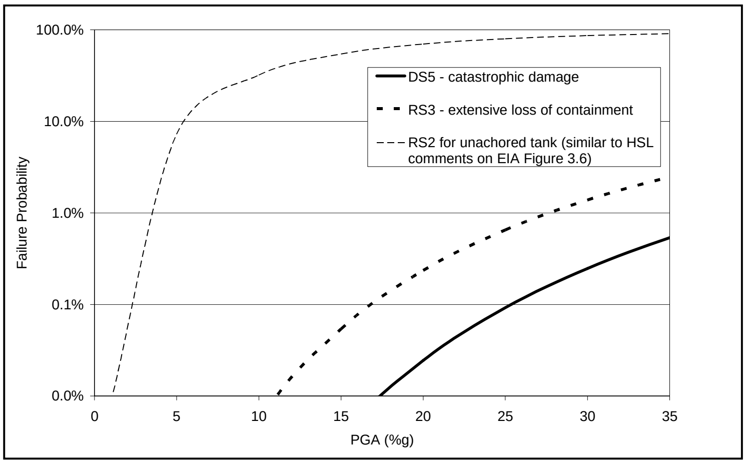
HSL point out (HSL 4-1.1 [7]), based on CEDD information [26], that "*Hong Kong is an area of low-to-moderate seismic risk*". CEDD further point out in the same publication [26] that "*There is little evidence of significant recent fault activity in Hong Kong, either onshore or offshore*." and "*The possibility of significant earthquake damage to slopes, retaining walls and reclamations in Hong Kong is low.*" [26]. Before noting (as per HSL [7]) that "*Earthquake risk cannot be regarded as negligible*", the note goes on to say "*The earthquake hazard in Hong Kong is therefore considered to be very much lower than in areas such as Japan, Taiwan and the western USA which lie close to the earth's more seismically active zones along the crustal plate boundaries.*" [26].

In comparison, the one earthquake failure in Table H3.2 of the EIA for which we have a specific location occurred in Richmond, (near San Francisco) California (and the others were in the USA). As noted in the EIA Report (Para 10.6.2.17) "*the spill was stated to be contained within the bund and not ignited*"; there is no suggestion of bund overtopping due to the momentum of the release. This failure occurred in the 1989 Loma Prieta (magnitude 7.1) earthquake, described as the worst earthquake to strike the San Francisco Bay area since 1906 [8].

The seismic risk around California includes a PGA (Peak Ground Acceleration) of >0.32g with a 2% probability of occurrence in 50 years [27]. The HSL note on the EIA (HSL 4-1.1 [7]) suggests a similar PGA with a similar return period for Hong Kong (0.35g with a 2% probability of occurrence in 50 years) may be applicable, but this seems to over-state the risk.

HSL [7] go on to cite work on atmospheric steel tank fragility by Salzano and co-workers, suggesting that such tanks have "*around an 80% probability of catastrophic failure*" for the peak ground acceleration HSL identify in the Tuen Mun area with a 2% chance of exceedance in 50 years (2 ms^{-2}) [7]. This would imply a catastrophic failure frequency for atmospheric steel tanks in a low-to-moderate seismic risk region of 3×10^{-4} /yr. Even applying this to the HSL's identified US tank population of 97,800 would imply that catastrophic large tank failures were occurring approximately monthly in the US. Using the estimate of world-wide tank population in the EIA report, this would suggest tanks were failing catastrophically in earthquakes around the world at a rate of more than one per day. Clearly, there is something wrong with this assessment and HSL rightly suggest that this "*may be considered as over-conservative*" [7]. HSL then go on to suggest that the failure frequency should be between 10^{-5} and 10^{-6} per year, but provide little basis. This also appears inconsistent as their own analysis of catastrophic failures in the US (a more seismically active location) since their analysis in Glossop [3] would imply that seismic failures were already included in HSL's estimates of catastrophic failure frequency based on a more seismically active location and that they contribute between 12.5% and 21% of that frequency (depending on whether their 1978 incident is counted as 1 or 3 incidents).

Based on HSL's own analysis [7], this would place the frequency of catastrophic failure between 10^{-7} and 10^{-6} /yr for the US, and identify that it is already included in their catastrophic failure frequency estimate. ESR would expect that the risk of a catastrophic tank failure due to earthquake in low-to-moderate seismic risk region of Hong Kong would be lower.



To put the analysis in perspective the Geotechnical Engineering Office, of The Hong Kong SAR [30], estimate the PGA with a 2% probability of occurring in 50 years for Kowloon is 180gal (0.18g) and more recent work by Salzano and co-workers [28] has provided probit [5] relationships for the failure of atmospheric steel storage tanks. Fragility curves derived from this work [28] are shown adjacent for anchored steel storage tanks (such as the PAFF tanks) and a comparative line similar to that used in HSL's comments on the EIA [7]. The estimated failure probability for Damages State 5 (catastrophic damage) at 0.18g is 0.014% (the RS-2 curve for moderate loss to an unanchored tank at 0.2g gives a failure probability of 70% similar to that identified by HSL [7]). Combining these figures together would give a failure probability for catastrophic damage of $0.02/50 \times 0.00014 = 6 \times 10^{-8}$ /yr.

The above estimate for catastrophic damage to a PAFF tank is far removed from HSL's frequency estimate of 10^{-6} to 10^{-5} /yr [7] and it is still not clear what proportion of such failures would be 100% instantaneous. It is clear that, as also discussed in Section 2.1.2 in relation to the general frequencies used, HSL [7] have again identified a frequency for a failure much less severe than 100%

[5] A probit is simply a mathematical means of deriving a probability from basic data.

instantaneous failure and then used it directly to represent 100% instantaneous failure. Whilst this is certainly a cautious approach it is also very pessimistic and leads to a large overstatement of the risks.

Analysis such as that above, based on generic tank fragility models, is necessarily approximate, particularly at low failure probabilities. However, it does serve to demonstrate, together with the limited number of catastrophic failures that were caused by earthquakes in more seismically active regions, that the risk of 100% instantaneous failure of a PAFF tank due to earthquake is adequately represented within the derived 100% instantaneous failure frequency within the EIA.

2.1.5.1 Other Points Related to Seismic Failures

In Section 4-1.1 of their comments HSL [7] also produce photographs of the tank farm fire at Izmit refinery in Turkey. These show fires and late tank failures in a fire due to an earthquake and do not represent 100% instantaneous failures. Such fire scenarios are included elsewhere in the EIA, as is a loss from the top of the tanks such as the one described by HSL [7] due to sloshing.

In suggesting that the statement in the EIA report that "*There remains a small possibility that an earthquake could lead to an instantaneous failure of the tank, but this would be at a much lower frequency than indicated by the two earthquake failures reviewed in Appendix H4*", "*is not supported in any way in the EIA report*", HSL [7] are ignoring the foregoing discussion in the EIA report and that the seismic risk in Hong Kong is lower than in regions such are California.

HSL [7] appear to agree with the statement in the EIA report that "*Also, from ESR's experience, the magnitude of the ground acceleration would need to be sufficient that the level of damage elsewhere in the vicinity would also be massive*" (EIA report 10.6.2.20). However HSL's suggestion that this is being used as "*a reason for accepting failure in the PAFF*" (HSL 4-1.2 [7]) is entirely untrue; the EIA report does not claim that this is a reason for accepting failure in the PAFF.

2.1.6 Typhoon Events and Aircraft Impact

HSL state that "*the probability and consequence of typhoon events should have been included in the 2007 EIA Report*" (HSL 4-1.2 [7]). As stated in the EIA Report, the basis of design includes typhoon conditions. The tanks are also anchored. HSL [7] have identified two losses of oil from tanks in the area affected by Hurricane Katrina; one 4000 m^3 and one 5400 m^3 (i.e. about 15% of the capacity of one of the PAFF tanks). There are several large refineries in this area and the limited nature of the losses reported, provides added confidence in the durability of such tanks in very high winds. HSL [7] do not identify any 100% instantaneous losses resulting in overtopping of the bund due to momentum surge due to typhoons/hurricanes. Given the severity of Hurricane Katrina and the damage caused then this would appear to provide strong support for the strength of such tanks against typhoons and that typhoon events are adequately included within the overall 100% instantaneous failure frequency.

HSL [7] question the assessment of aircraft impact noting that it seems "*wholly unrealistic to suggest that the wings of an aircraft that could be as large as an Airbus A380, flying out of control, would not cause massive immediate damage to several tanks*". It should be noted that the frequency of aircraft impact on the PAFF tanks is less than once per billion years, allowing for 700,000 aircraft movements per year in 2040. The number of Airbus A380 aircraft flying in and out of HKIA is a matter for speculation, but it would be expected that this would be only a small fraction of the total aircraft movements. The impact frequency for an Airbus 380 on the PAFF tanks would therefore be extremely small. It is also notable that HSL [7] use the term "*massive immediate damage*" rather than 100% instantaneous failure and there is no dispute that damage to the tanks impacted would occur. However, as can be seen in HSL's Figure 3.3 [7] for an MTBE tank following an internal explosion, for example, atmospheric pressure steel storage tanks such as the ones at the PAFF can withstand major impacts and deformation without leading to 100% instantaneous failure. A more detailed investigation, that covered the size and type of aircraft, more detailed impact calculations and included more up to date (and less conservative) impact frequencies (see EIA Para H3.6.1.9) would be expected to confirm the results of the EIA or reduce the predicted risks from aircraft impact, which are already below the axis of the technical memorandum criteria. ESR do not think that such an analysis is warranted here.

2.2 POOL SPREADING OUTSIDE BUND

This is discussed in HSL comments section 5 (5-1.1 and 5-1.2) [7].

HSL Item 5-1.1 [7]: Security of wall construction. It is agreed that a breeze block type wall is not appropriate to provide a high level of integrity for the security walls. The comment on breeze block type construction in Paragraph 10.5.13.5 of the EIA was erroneously retained from the previous EIA. Elsewhere (10.1.2.8, 10.5.13.5, 10.10.1.8) the walls are referred to as "impervious". The two security walls are in fact both reinforced concrete and this is depicted in the approved drawings [22]. The drawings also show details of the gates and the sealing provided for any Jet A1 spill.

In terms of bund integrity, it may be noted that the bund wall is sunken in, providing a high degree of integrity due to the buttressing affect of the ground behind it, in addition to the reinforced concrete construction. Thus the strength suggestions from the identified Paragraph 143 of the UK HSE guidance on storage of flammable liquids (HSE 1998) have all been implemented in the PAFF design both for the bund wall and the additional security walls.

Item 5-1.2 [7]: Bund overtopping volumes. HSL [7] do not dispute the adequacy of the physical modelling on which the assessment has been based. However there appear to be a number of misinterpretations of the results in this section:

- The second paragraph of this HSL comment suggests that a lesser scenario of 10% loss from the top of a tank (T14 see EIA 10.5.15) would result in a flow of 700 m^3 onto the SWS site. In the EIA, no flow of Jet A1 is predicted onto the SWS site for this scenario. 350 m^3 is however predicted to flow to the sea via the stormwater drains with a small proportion of this via the drainage system between the outer security wall and the landscape bund.
- The sealing of the access gates has been considered in the design and the assessment, noting that there is an elevation change, sealing and stormwater drainage immediately outside the gate. Hence there is a means of both sealing to contain any liquid and a means of draining any leakage through the gates.
- The recent improvements made by AAHK to the layout of the PAFF (Table 3.2) (namely additional security wall, landscaping bund and 'wave wall' design) are stated to have been ineffective in materially reducing the hazard to neighbouring sites. HSL [7] provide no valid basis for this statement. These specific features were incorporated within the 1/30 scale tests conducted and the results of the tests (Table 10.49 of the EIA) clearly show substantial retention of liquid between the primary and tertiary walls. These features therefore do make a material difference.
- The comment related to the cost benefit analysis is taken out of context as the positioning of any further wall would be close to the existing ones and hence would be expected to make little difference. It should also be noted that the normal practice for a tank farm is to have a single bund wall and a site fence. The two security walls and landscape bund are in addition to normal practice. Contrary to the bullet points raised by HSL [7], the PAFF is employing inherently safer design in having a bund capacity greatly exceeding the standards, bunds partly sunken below ground level, additional "passive" protection such as the two security walls and landscape bund. It is also inherently safer than many tank farms because it stores only Jet A1, which is much less hazardous than petrol, for example.

It may also be noted that there are only a small number of events, even within the idealised and pessimistic modelling of a 100% instantaneous failure scenario used, that would result in a flow that could impact the SWS hot metal route. This is because the flow from a 10m wide spilt up the tank wall directly opposite SWS is assumed to be constrained by the rest of the tank remaining in position. In fact, as happened in the Ashland tank collapse (see EIA 10.6.7.5), the tank wall will open out and be pushed backwards which would lead to less flow into SWS.

It may also be noted that the Dutch guidelines on risk assessment specifically state "*If a spill of liquid occurs in a bund, its characteristics have to be taken into account. If the walls of the bund are sufficiently high, the bund prevents the spreading of the liquid pool and the dimensions of the pool are restricted to those of the bund.*" (Section 4.5 of [5]). It is not therefore always the case, that bund over-topping due to momentum surge is considered in a QRA, although it is in the UK.

Overall, we can find no sound basis for HSL's three criticisms of the integrity of the secondary and tertiary containment (HSL 5 [7]) and consider that the assessment remains a reasonable, and in ESR's view very pessimistic, assessment of the potential flows of Jet A1 outside the PAFF from a 100% instantaneous failure.

2.3 IGNITION PROBABILITY

HSL comment on the ignition sources identified outside the PAFF within the Shiu Wing Steelworks (HSL 2 [7]). This is treated extensively within the EIA (Appendix H5 of the EIA) including analysis of the potential ignition sources within both Shiu Wing Steelworks and the EcoPark. It is agreed that if Jet A1 flows into certain areas within Shiu Wing steelworks then there is a strong chance of ignition and in some cases an ignition probability of 1 is used within the EIA to reflect this. This has been fully incorporated in the assessment in the EIA.

In their 2002 analysis [17] HSL used a global ignition probability of 0.6 in their assessment of 100% instantaneous failures, based on information that was considered to overestimate the probability by the authors of the paper [23] and which was based mainly on releases of highly flammable or liquefied gases, capable of generating potentially large flammable gas clouds. This leads to further pessimism in HSL's 2002 assessment [17], but in their comments on the EIA [7], their revised results are based on the more appropriate modelling of ignition, taking specific account of the potential ignition sources surrounding the PAFF, in the EIA.

2.4 COMPLIANCE WITH RELEVANT CODES

HSL state that "*The PAFF does not comply with the recommendations of current international good practice in tank farm design*" (HSL 8 [7]). In particular HSL cite guidance that the total quantity of fuel held within a bund should not exceed 60,000 m^3 in Part 2 of the IP model code of safe practice.

Guidance from relevant standards is cited in the EIA report where appropriate. The guidance on total storage capacity in a bund for distribution terminals in IP MCSP Part 2 as noted by HSL [7] is permitted to be exceeded under both the Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10), and the part of the IP Model Code of Safe Practice most relevant to the PAFF, i.e. Part 19, "Fire precautions at petroleum refineries and bulk storage installations" (Ref 26 of EIA S10). Note, Part 19 of the MCSP has been updated in January 2007, after the submission of the EIA, but the wording on this subject remains the same [34].

The new edition of Part 19 also includes the following statement in Section 4.8.3 [34] on storage tank layout / secondary containment. "*Normally, good tank design and operations good practice should prevent large product releases. Catastrophic tank failure is one possibility, but is usually considered a low probability event. Although considerable research has been aimed at the subject* *of bund overtopping, good bund design and minimising the potential for large releases in the first instance should significantly reduce the probability of such an event.*"

The PAFF is different to a typical distribution terminal in that it stores a single product (Jet A1) imports only via its own marine jetties and exports via a dedicated single product pipeline; the PAFF does not distribute Jet A1, it receives it for, stores it for, and supplies it to HKIA only. Part 2 of the cited IP Model Code of Safe Practice covers distribution terminals that may store multiple products, import and export by multiple routes including, road and rail loading facilities, single and multi-product pipelines, in addition to the types of facilities that will be present at the PAFF. IP Part 19 is therefore the more appropriate IP code to consider, and Fire Services Department (FSD) has been satisfied after having given in-depth consideration to this matter.

The recommendation of the total capacity in the bund in IP Part 19 is a general recommendation and covers all product classes I, II and III. Jet A1 is classed as Class II(1) within the IP code and as such represents a lower risk than Class I, Class II(2) or Class III(2) product and accordingly relaxation of the recommendations is permitted as indicated in IP Part 19 clause 3.4.2.1.

The Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10) is more specific in differentiating between the classes of product and places a similar limit on Class I products only. No limit is placed on the volume of Class II products.

Also note that National Fire Protection Association (NFPA) 30 Flammable and Combustible Liquids Code places no restriction on the maximum quantity of any class.

The normal recommendation for total capacities of tanks in a single compound of 60,000 m^3 for a bulk storage site in IP Part 19 may be exceeded provided that an assessment indicates no significant increased risk of pollution or hazard to people. This restriction has been discussed with FSD as part of the review and FSD has been satisfied.

The EIA report provides a quantitative assessment of the hazard to life and the results lie well within the acceptable region of the criteria in the EIAO-TM, satisfying the requirement for an assessment. It may also be noted that the larger overall capacity of the bunds at the PAFF (at least 156% of the capacity of the largest tank) compared to requirements for 100% or 110% in the codes, which would probably be followed closely if individual tank bunds were used due to space constraints, provides an additional safeguard against the 100% instantaneous rupture case of particular interest to HSL/SWS. This is in two forms:

- The higher bund capacity relative to a single tank provides a greater safety margin against overflow from a single tank contents due to the higher retention capacity.
- For many cases, the flow from a hypothetical 100% instantaneous tank rupture would be away from the nearest bund wall and the additional distance plus the presence of other tanks as obstacles to the flow would reduce the level of bund overtopping.

The PAFF containment system also includes a number of additional safeguards not specifically required by the standards (e.g. [34]):

- The bunds are sunken in relative to the surrounding ground, providing a higher degree of integrity compared to a freestanding bund wall.
- The bund walls are vertical, and include a “wave wall” design to reduce momentum overtopping of released liquid.
- Two additional impervious security walls constructed of reinforced concrete are included to further reduce the liquid lost off-site even in the extremely unlikely event of a 100% instantaneous tank failure. These security walls have been shown to retain significant liquid volumes within the site walls in the event of a 100% instantaneous tank failure in the physical model tests conducted for the PAFF (Table 10.49 of EIA).
- Outside the security walls, a further landscape bund is included which will further reduce any flow off-site towards SWS or in other directions.

Contrary to the suggestion by HSL/SWS [7] that the risk levels are increased due to storing more than 60,000 m^3 in a bund, the risk levels are actually expected to be reduced compared to simple arrangement of a single bund per tank containing 110% of the tank contents plus a site fence at 15m from the tank wall.

In suggesting that the risk levels are increased due to storing more than 60,000 m^3 in a bund, HSL/SWS [7] have assumed a significantly reduced overall storage capacity for the site, but with the same enhanced containment and additional safety features of the PAFF design. This does not provide a reasonable comparison of like facilities.

The layout of the Denver facility is cited by HSL [7] as good practice. However, there are vast amounts of open land available in Colorado compared to Hong Kong and it is therefore to be expected that the PAFF will be more economically laid out. Nonetheless, the spacing of the tanks and the boundary at the PAFF exceed the relevant codes and the risk levels are well within the acceptable region of the technical memorandum criteria.

CONCLUSIONS

In conclusion, the HSL assessment [7] is considered grossly pessimistic. However, even using HSL’s assessed 100% instantaneous failure frequency of

2.8×10^{-6} /yr, the initial development would still fall entirely within the acceptable region of the Technical Memorandum criteria and the final development would only enter the lower part of the ALARP region only.

HSL's higher 100% instantaneous failure frequency of 1×10^{-5} /yr [7] is considered to have no valid basis since it is based on an erroneous interpretation of earthquake failure data.

The overall differences in HSL's assessment [7] of 100% instantaneous failure frequency and the estimate in the EIA are:

- A factor of ~6 for the different estimates of US tank population.
- A factor of ~4 for the not including any tanks outside the US.
- A factor of ~30 for the inclusion of events not applicable to100% instantaneous failure of the PAFF tanks.

All of these three factors need to be included together to produce a societal risk level that significantly enters the ALARP region of the Technical Memorandum criteria. With only a factor of 3 reduction in the 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr suggested by SWS/HSL both the initial and the final development would fall entirely within the acceptable region of the Technical Memorandum criteria.

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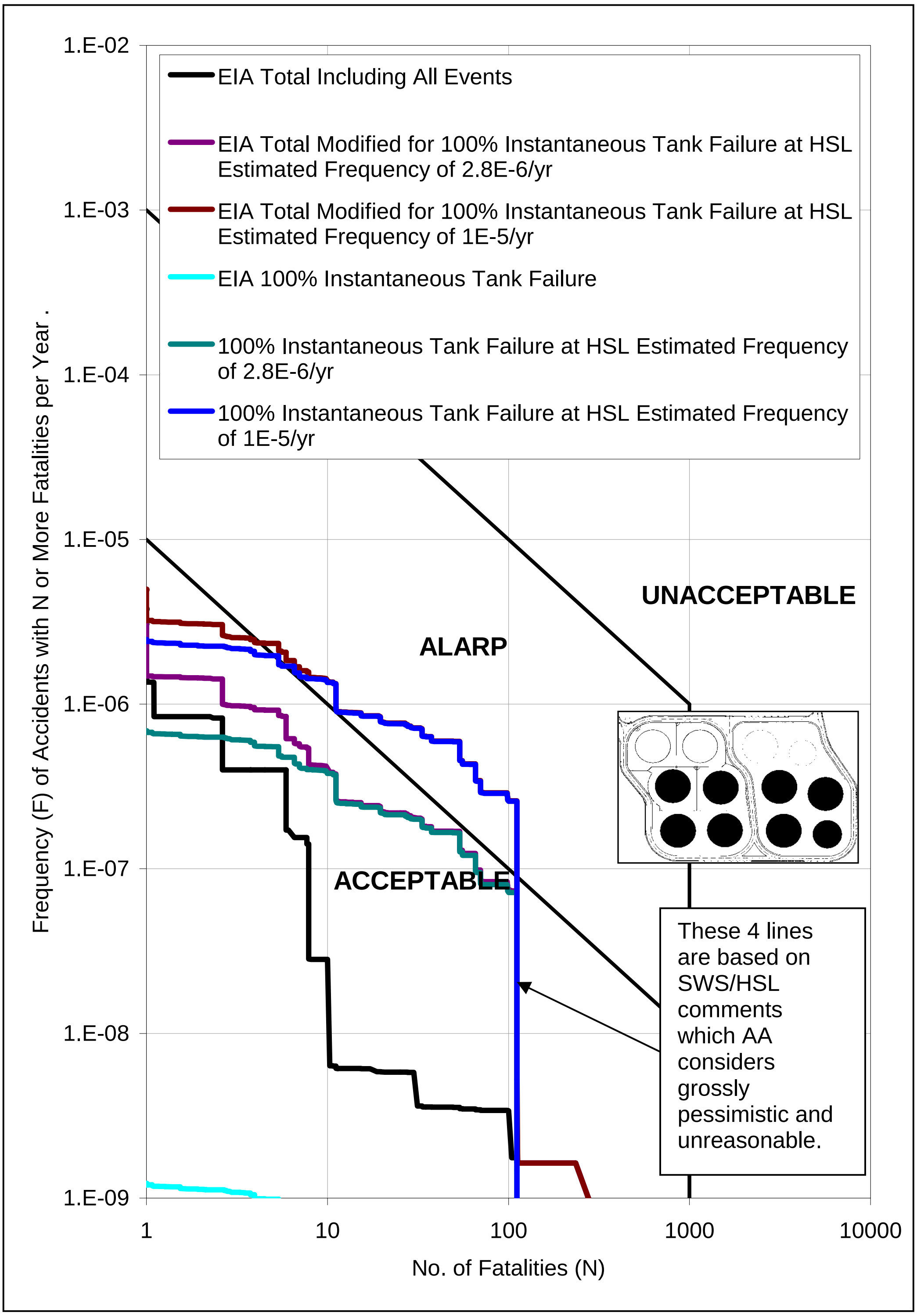


Figure 2: Comparison of EIA and HSL Societal Risk Estimates For Initial PAFF Development

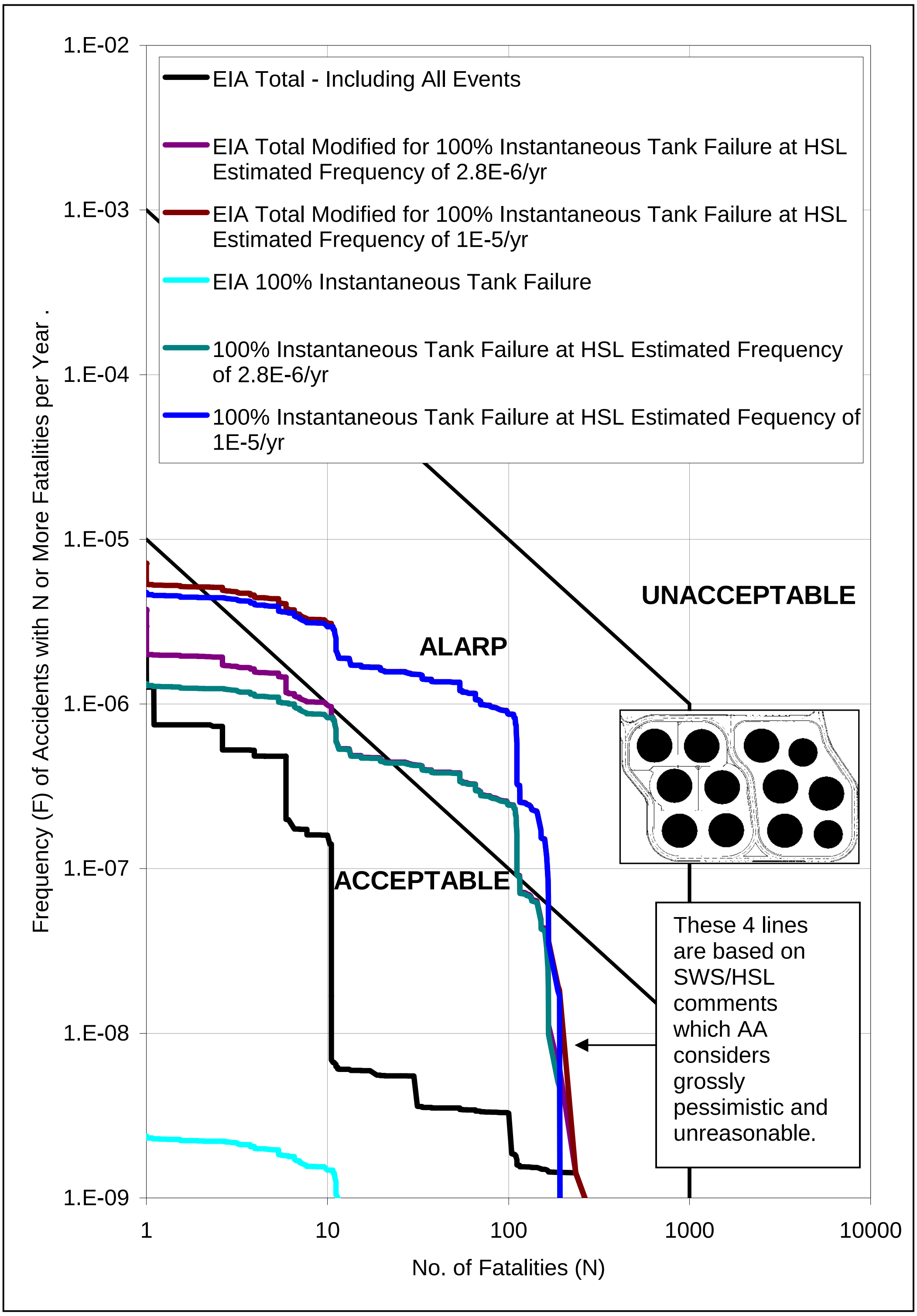


Figure 3: Comparison of EIA and HSL Societal Risk Estimates For Final PAFF Development

ANNEX 5

Question# 5: Confirmation of whether the structural integrity of the safety features adopted in the PAFF project will undermine the assumptions adopted in the hazard assessment. Clarification of whether the features and design in the PAFF project will prevent the recurrence of incidents similar to that at Buncefield.

Response:

The safety features of the PAFF have been reviewed in the EIA and their effects on the risks from the PAFF have been assessed based on their effectiveness. The PAFF has many fire protection and mitigation measures that have been adopted in consultation with FSD. However, the main concern expressed has been over the potential off-site impact in the extremely unlikely event of a 100% instantaneous failure of one of the PAFF tanks.

The safety measures of particular relevance to avoiding such a failure are:

- The physical properties of Jet A1, which does not generate a flammable vapour under ambient conditions in Hong Kong
- The environmental conditions in Hong Kong being such that low temperature embrittlement of the tank wall material is not relevant.
- The lower seismic hazard in Hong Kong compared to where seismic tank failures (not necessarily instantaneous) have occurred (e.g. California).
- Design standards for the tanks, particularly API 650 and API RP 2003, including weak shell to roof joint, full height hydrotest and lightning protection.

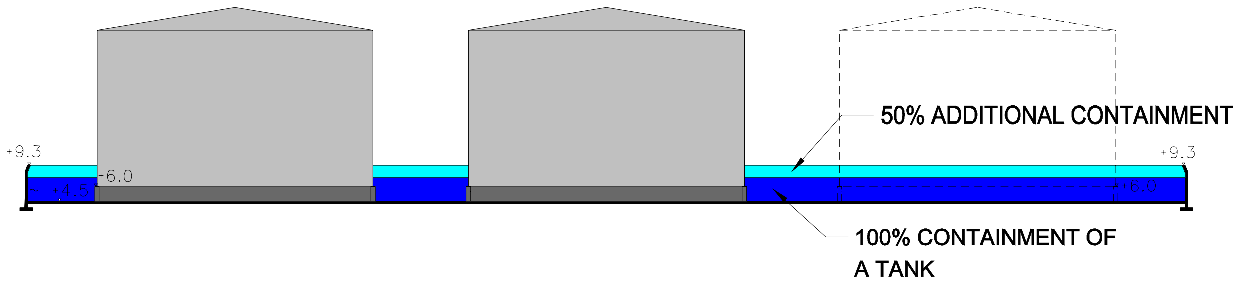
The effects of these on the predicted frequency for a 100% instantaneous failure of a PAFF tank are discussed in the response to Question #4. The first three are specific factors applicable to the PAFF tanks rather than engineered safety features and are the main basis for the assessment of the 100% instantaneous failure frequency specifically appropriate to the PAFF tanks.

The safety measures of particular relevance to mitigating the effects of such a failure are:

- The separation distances between the tanks and the surrounding facilities.
- The containment systems in place at the PAFF.

The separation distances are based physically upon the design and are not susceptible to structural failure. The distance between the tanks and the PAFF boundary which is 28.5 metres (compared to 10 metres required under Hong Kong standards and 15 metres according to some international standards).

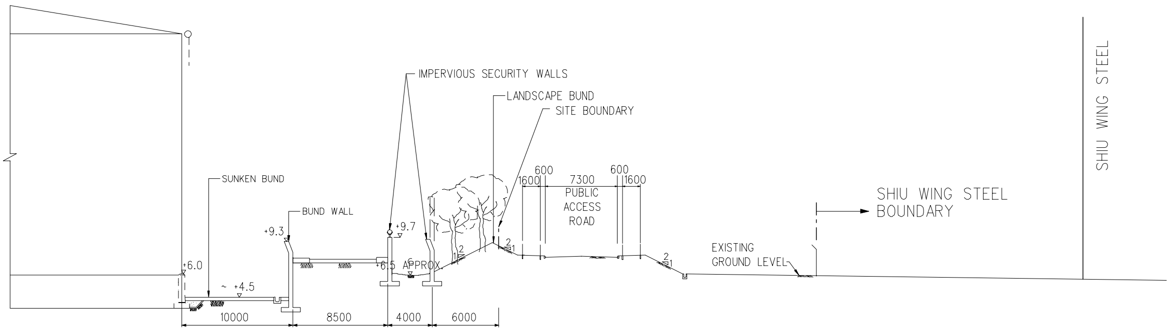
The containment capacity of the bunds surrounding the tanks exceeds the normal standards (over 150% compared to standards of 100% and 110%) and includes a containment capacity of 100% of one of the tank contents below ground level.



The PAFF has two additional impervious security walls which provide additional containment. A comment indicating that these were of breeze block type construction was erroneously retained from the previous EIA in paragraph 10.5.13.5 of the EIA. Elsewhere (10.1.2.8, 10.5.13.5, 10.10.1.8) the walls are referred to as “impervious” and it is agreed that a breeze block type wall is not appropriate to provide a high level of integrity for the security walls. The two security walls are in fact both reinforced concrete and this is depicted in the approved drawings [22].

The sealing of the access gates has been considered in the design and the assessment, noting that there is an elevation change, sealing and stormwater drainage immediately outside the gate. Hence there is a means of both sealing to contain any liquid and a means of draining any leakage through the gates. The approved drawings [22] show details of the gates and the sealing provided for any Jet A1 spill.

The primary bund wall is sunken in, as noted above, providing a high degree of integrity due to the buttressing affect of the ground behind it, in addition to the reinforced concrete construction. Thus the strength suggestions from the identified Paragraph 143 of the UK HSE guidance on storage of flammable liquids (HSG 176) noted by SWS/HSL have all been implemented in the PAFF design both for the bund wall and the additional security walls.



Beyond the second reinforced concrete security wall, there is an additional landscape bund which will provide additional containment for any liquids escaping over the primary bund wall and the two security walls. This is a simple earth mound as shown in the diagram, rather than a reinforced concrete structure.

It may also be noted that the normal practice for a tank farm is to have a single bund wall and a site fence. The two security walls and landscape bund are in addition to normal practice. Contrary to the bullet points raised by HSL [7], the PAFF is employing inherently safer design in having a bund capacity greatly exceeding the standards, bunds partly sunken below ground level, additional “passive” protection such as the two security walls and landscape bund. These specific features were incorporated within the 1/30 scale tests conducted for the PAFF and the results of the tests (Table 10.49 of the EIA) clearly show substantial retention of liquid between the primary and tertiary walls. These features therefore do make a material difference to this scenario.

The PAFF is also inherently safer than many tank farms because it stores only Jet A1, which is much less hazardous than petrol, for example.

Overall, we can find no sound basis for HSL’s criticisms of the integrity of the secondary and tertiary containment (HSL 5 [7]) and consider that the assessment is a reasonable, and in ESR’s view very pessimistic, assessment of the potential flows of Jet A1 outside the PAFF from a 100% instantaneous failure.

BUNCEFIELD

The Buncefield incident has been reviewed as part of the PAFF EIA and it’s relevance to the PAFF is discussed in sections 10.5.14 and H4.8 of the EIA. The relevant text on the Buncefield incident from Section 10.5.14 of the EIA is reproduced below for information:

“*10.5.14.2 The incident involved overfilling of a gasoline tank resulting in a large flow of gasoline down the side of the tank. The vapour cloud is understood to have formed due to fragmentation of the flow into* *droplets and the increased evaporation of the lighter components as a result (H4.8.1.8).*

10.5.14.3 *There are a number of important differences between the storage of Jet A1 at the PAFF and the overflow of gasoline at Buncefield that started the incident:*

- *The fuel released was gasoline containing about 10% butane and having a vapour pressure close to 100 kPa. This may be compared to the vapour pressure of Jet A1 of <0.1 kPa at 20^{o}C (see section 10.2.1); the fuel released at Buncefield would produce a mixture greatly above the lower flammability limit whilst Jet A1 at the PAFF would produce a mixture well below the lower flammability limit. An overflow of Jet A1 could not therefore support the generation of a flammable vapour cloud in the same way as the overflow of gasoline at Buncefield.*

- *The weather conditions were calm, cold and stable which would promote flammable gas dispersion over longer distances. These conditions are unlikely at the PAFF.*

- *A water/ice mist was formed due to the evaporative cooling from the gasoline vaporisation and the high humidity (~99% RH) and low temperature (~0^{o}C). This may have enhanced the explosion overpressure. These conditions are reasonably common around Buncefield, but not applicable at the PAFF.*

- *Ignition of the vapour cloud probably occurred within a building, which may have enhanced the overpressure. Formation of a significant flammable vapour cloud in the open and its ingress into a building at flammable levels would not occur with Jet A1 at the PAFF (heating of Jet A1 liquid within a furnace and its ignition is possible but would not provide a flammable cloud outside to propagate the explosion).*

10.5.14.4 *The first factor identified is the most important to the applicability of this type of incident to the PAFF. The gasoline released at Buncefield is capable of forming a flammable vapour cloud that could drift over some distance and be ignited. Jet A1 stored at the PAFF would not form a flammable vapour cloud under the same release from the top of the tank. Some spray may be formed that could burn, but no flammable cloud would be formed that could drift off site.*"

Although it is important to learn from past incidents such as Buncefield, it is also important to understand the simple physical differences between the material involved in the explosion at Buncefield and the material stored at the PAFF.

HSL discuss the Buncefield incident (HSL 7 [7]) and suggest that "*It is premature to even consider approving the construction of the PAFF at TMA 38 at this stage*", because the UK HSE is conducting a review of its policy and land use planning procedures. Aside from the fact that the UK HSE's land use planning procedures will apply in the UK and not Hong Kong (Hong Kong has completely different procedures based on the Environmental Impact Assessment Ordinance (EIAO)), it is also clear that the main incident (explosion) at Buncefield was associated with petrol storage and not Jet A1, which would behave significantly differently. This has been reviewed already in the EIA Report (Section H4.8 of the EIA) and it may also be noted that the HSE has recently issued a consultative document specifically on development control around petrol depots [31], not flammable liquid storage such as Jet A1 at the PAFF.

In terms of HSL's assertion that: "*The above is relevant to the PAFF as aviation fuel comes under the category of 'flammable liquids'. In the case of the PAFF the concern is aviation fuel spilling off-site where it could be heated by the numerous hot surfaces present at SWS and the EcoPark, leading to the formation of a vapour cloud and possible explosion.*" [7], The following should be noted:

- Whilst Jet A1 at the PAFF is categorised as a flammable liquid, petrol is categorised as a highly flammable liquid and there is a significant difference in their behaviour, as discussed in the EIA (e.g. Section 10.2.1 of the EIA).
- Flammable vapour production is expected to be very limited, as discussed in the EIA Report (Section H5.3.2). Although, if large quantities of Jet A1 are raised to high temperatures (e.g. 90^{o}C) then a flammable vapour will be formed above the surface and the Jet A1 would be easy to ignite, it is first necessary to transfer sufficient heat to the flowing Jet A1. As discussed in Section H5.3.2 this is unlikely.

Although it is always appropriate to exercise caution and to review past incidents in aiming to improve on future safety, there does not appear to be a sound basis for suggesting that "*It is premature to even consider approving the construction of the PAFF at TMA 38 at this stage*". For the PAFF, appropriate lessons have been learned from Buncefield.

Question #6: In the light of the refusal by UK Planning Authority on the Portland Port Ltd hazardous substances consent application (the Portland case), clarification of the applicability of the Portland case to the PAFF project in Tuen Mun Area 38 site.

Response:

This case cited by HSL (HSL 6 [7]) concerned the refusal of Weymouth and Portland Borough Council in the UK to grant consent for the storage of flammable substances at an existing tank farm, because HSE advised that the use was considered incompatible with the adjacent use by Weymouth & Portland National Sailing Academy (WPNSA – then called Weymouth & Portland Sailing Academy (WPSA)). The WPNSA is a major facility, directly adjacent to tank farm boundary, intended to attract large numbers of the public including the disabled and children. For example, WPNSA will host the sailing events for the London 2012 Olympic Games [32].

HSL state that the Public Inquiry into the Portland Port Ltd (PPL) hazardous substances consent application "*has striking similarities to the PAFF case.*" (HSL 6-1.1 [7]). Although it concerned the storage of kerosene at a tank farm, there are also a number of striking differences between this case and the PAFF:

- The inquiry was under UK planning regulation. In this, the planning authority is the local authority, which is advised by HSE (and will take HSE's views into account but does not have to abide by them).
- The UK land use planning system does not require a QRA for flammable storage facilities, whereas the Hong Kong EIAO does. Therefore there was no requirement to consider a QRA for the facility.
- As noted in the Inquiry conclusions, in land use planning advice for flammable storage, HSE do not normally consider the frequency with which an incident may occur, but only consider the potential extent of the worst case event based on bund overtopping. For the PAFF a QRA was specifically required to compare with the individual and societal risk criteria in the Technical Memorandum. No such requirement exists in the UK which has no specific societal risk criteria (although there is some guidance).
- The HSE's concerns were related to the adjacent land use for WPNSA and its use "*by the public, including the disabled and children, on a potentially large scale on occasions*" This is an entirely different land use to that adjacent to the PAFF which is treated differently by HSE for land use planning purposes.
- The tanks were sited much closer to the site boundary than the PAFF tanks are to the PAFF boundary and the WPNSA buildings were also close to the site boundary.

- The HSE did not express a concern over the adjacent land use for a boat yard, which would potentially include hot works and a large number of workers being present, but which falls under a different category of land use which is much more similar to the steelworks and EcoPark.
- The location of the tank farm and sailing academy are quite unusual in that it is at the end of a sandbar with a main road connecting Portland to the mainland. The WPNSA location meant that large numbers of people could be gathered on a narrow strip of beach between the tank farm and the sea, which could make rapid escape very difficult. This is not the case for the PAFF.
- The tanks considered at Portland were old tanks (believed to be at least 50 years old) of riveted/bolted construction. As discussed below, there are specific issues with these types of tank and ESR have previously assessed this type of tank as having higher release frequencies than the general tank population.

The tanks considered at Portland were old tanks (believed to be at least 50 years old) of riveted/bolted construction. These tank types are substantially different to those proposed for the PAFF and it is quite surprising to see generic tank failure frequencies being cited for this tank type in the Inquiry.

For example, in assessing the probability of a major failure for an old 10,000 bbl (~1500 m^3) cone roof tank of bolted construction, ESR recently assessed the probability of a major failure at 2×10^{-3} /yr based on an examination of the details of the tank [25]. This compares to HSL's major failure frequency of 1.1×10^{-4} /yr (Glossop [3]), i.e. ESR assessed the risks of a specific type of tank similar to those at Portland as being over 10 times greater than HSL suggest. The comparison is not ideal since the tank in question contained crude oil, which would also raise the risk level if considered in detail, but was not adjacent to public facilities such at the boating club at Portland (it was neither in UK nor Hong Kong). Nonetheless, this underlines the importance of treating the specific type and circumstances of the tank.

In summing up Tester (Para 12.16 of Annex A of HSL comments on EIA [7]) says:

"*I have given careful consideration to the Appellant's arguments concerning the inevitability of the predicted consequences occurring if a protection concept approach is adopted (11.6). I do not accept that the approach means that the predicted consequences are inevitable, but recognize that it relies on judgment as to whether an event is credible, <u>and that a QRA is to be generally preferred in this respect</u>. However, in this case, for the reasons I have explained, I can see no justification for overriding the HSE advice that the adjacent land uses would be incompatible.*" (underlining added for emphasis).

It is clear that the Inquiry concluded that a QRA was the preferred approach, as is the requirement under the Hong Kong EIAO, but that it did not see a justification for overriding HSE's advice on this occasion. It is also clear that the land use considered incompatible adjacent to the storage was very different from that of the Shiu Wing Steelworks or the EcoPark and involved large scale outdoors public gatherings, including children and the disabled, in a location where escape from any incident could be very difficult.

Although superficially there may appear to be similarities with the adjacent land uses for the PAFF, EcoPark and Shiu Wing Steel, the details, and the reasons for the decision are in fact very different. For an adjacent industrial land use no objection was raised by HSE.

Other Information

Overview of Issues relating to Hazard Assessment

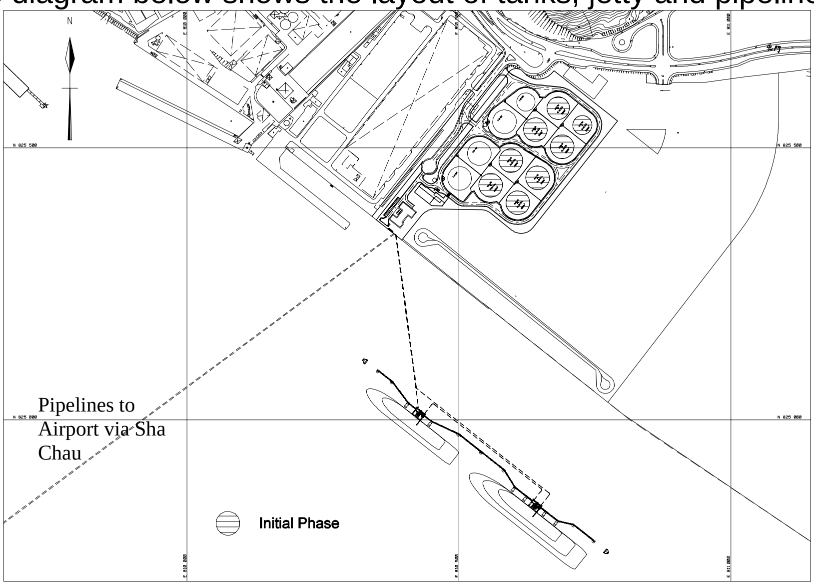
This overview of the Permanent Aviation Fuel Facility (PAFF) focuses on its safety and hazard to life assessment as detailed in the EIA Report.

Why does Hong Kong need PAFF?

- Hong Kong International Airport (HKIA) is the pride of Hong Kong and needs a steady supply of fuel for the nearly 400 departing flights each day.
- PAFF will replace the existing temporary fuel receipt facility at Sha Chau, which will reach capacity in 2009.
- The granting of Sha Chau's temporary use was conditional upon expediting the PAFF.
- Aviation makes a large contribution to Hong Kong's economy, which in 2005 directly accounted for 3%, or $40 billion, of our gross domestic product and made an indirect contribution of $106 billion (8% of GDP).
- HKIA provides about 60,000 jobs and about three times more indirect employment opportunities.

What is PAFF?

- PAFF is a receipt and storage facility for aviation fuel to ensure continuous and sufficient supply for aircraft operations.
- Aviation fuel (Jet A1) is a much safer fuel than other common fuels like petrol and LPG.
- Aviation fuel will be delivered to PAFF by tankers with double hulls using pilots and tugs, and supplied to the airport by undersea pipelines, raising the overall safety of the fuel supply process, as compared with Sha Chau.
- The diagram below shows the layout of tanks, jetty and pipelines.



Photomontage of PAFF in 2009

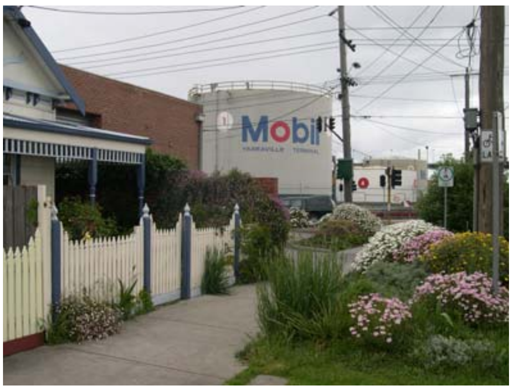
Characteristics of Aviation Fuel (Jet A1)

- Jet A1 is similar to kerosene which is used for domestic heating and cooking worldwide.
- It is safe to handle and difficult to ignite. Its characteristics are very different from more hazardous fuels such as petrol and LPG.
- Its flash point is >38ºC. Thus it does not produce a flammable vapour at ambient temperatures, unlike petrol (flash point -42ºC) and LNG (flash point -188ºC).
- PAFF is not a PHI (potentially hazardous installation) unlike petrol or LPG fuel depots.
- PHI as defined in the Hong Kong Planning Standards and Guidelines, does not cover Jet A1 which is a relatively non-hazardous material.

Fuel Storage

There are many cases where fuel tanks including those storing relatively more hazardous fuels like petrol and LPG are located next to industrial and residential developments, and even in the proximity of the high temperature works, like furnaces. Some examples worldwide and locally are shown below.

Refinery showing proximity of hot furnace and tanks, Netherlands



Houses adjacent to tanks, Melbourne, Australia

Industrial facilities adjacent to tanks, Melbourne, Australia

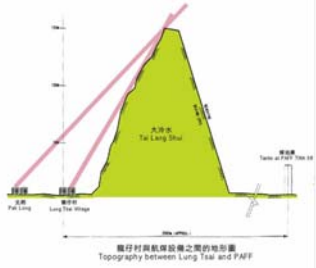
Industrial developments, dockyards close to fuel depots, Tsing Yi

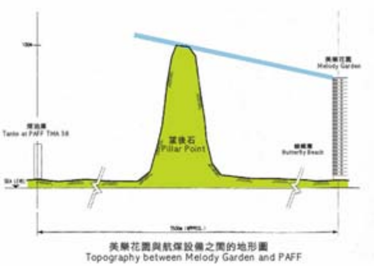
Industrial and residential developments close to Towngas Plant, Tai Po

Industrial and residential developments close to CRC oil depot, Chai Wan

As for PAFF in Tuen Mun Area 38:

- It is located in a Special Industries Area which in landuse terms includes fuel depots
- It is safe to be co-located with neighbouring industrial facilities, like the Shiu Wing Steel Mill and the EcoPark
- It is well away (2 to 3 kilometres) from residential developments with intervening high terrain, thus posing no risk to the Tuen Mun residential community





Previous EIA/Judicial Review

- An exhaustive site search for PAFF concluded that Area 38 in Tuen Mun was the only suitable site. The Airport Authority prepared the PAFF EIA Report for this site.[6]
- Upon approval of the EIA Report, the Environmental Permit (EP) for PAFF was granted in August 2002.
- In November 2002, Shiu Wing Steel Ltd lodged a judicial review, which was heard by the Court of First Instance in September 2003 and by the Court of Appeal in September 2004. Both courts ruled in favour of the Director of Environmental Protection.
- In July 2006, the Court of Final Appeal (CFA) ruled that a quantitative risk assessment (QRA) should be conducted even for a very unlikely scenario of an instantaneous loss of a 100% of a tank's contents.
- The court recognized that other issues have already been addressed, comments have been obtained and evaluated, hence there was no need to go back to square one.
- The Airport Authority stopped all construction at the PAFF site on the day the Court of Final Appeal issued its ruling.
- The completed works include piling for the jetty (potentially more disruptive to marine life, like dolphins), formation of site, replanting of trees and foundation of some tanks.
- A revised environmental impact assessment, which addresses the 100% loss scenario, was available for public inspection from 23 February to 24 March 2007.

How safe is PAFF?

- Safety is the No. 1 priority of the Airport Authority and the aviation industry as a whole, particularly because HKIA currently handles 800 departing and arriving flights daily, with large aircraft on average carrying about 100,000 litres of aviation fuel each.
- The Airport Authority revised the EIA report addressing the Court of Final Appeal's concern and updating several other aspects of the assessment, including the new EcoPark and changes to the area near the PAFF site. The Buncefield incident in the UK was also considered.
- The assessment for the 100% instantaneous release scenario included a thorough review of historical incidents and a physical model at 1/30 scale of the worst case scenarios.

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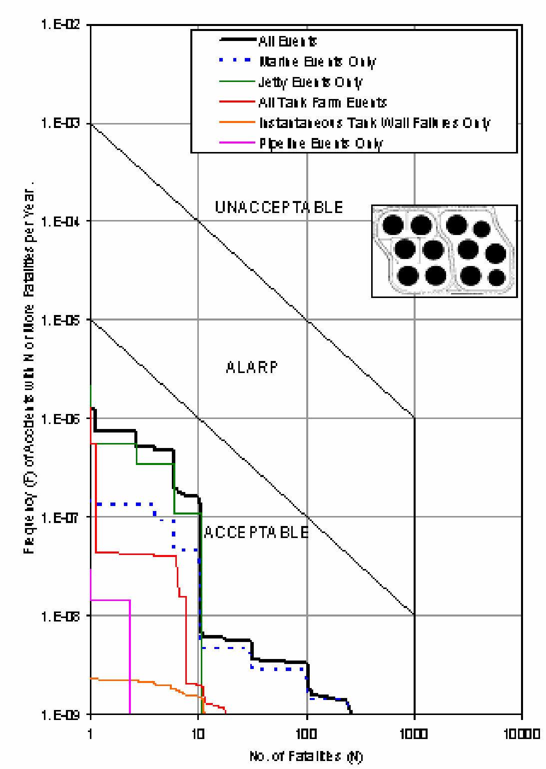
[6] Under Hong Kong Environmental Impact Assessment Ordinance (EIAO), quantitative risk assessment is required for a facility such as PAFF with Jet A1. This is not universally true around the world, for example, the UK Health and Safety Executive (HSE), an authority similar to EPD in the UK, does not specifically require a quantitative risk assessment for a facility like the PAFF.

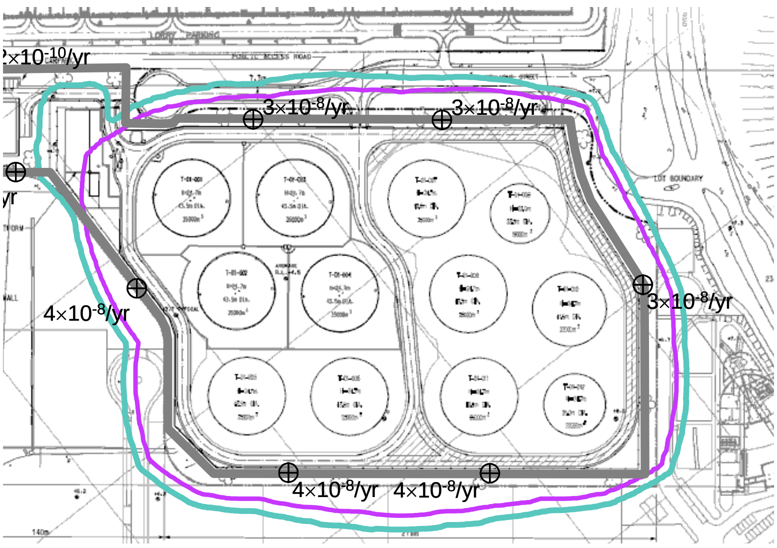
- The report concluded that the risk from the PAFF is very low and well within the acceptable region according to the Technical Memorandum of EIAO.
- PAFF is one of the safest fuel storage facilities in the world.

Societal Risk Results



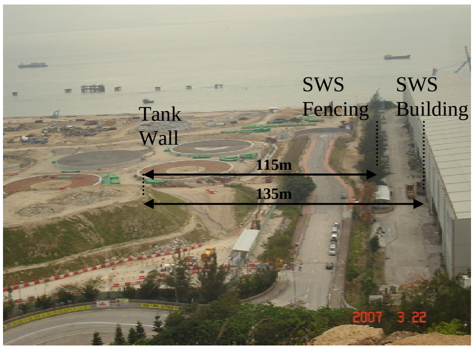
- All risk levels shown are very low
- 100% tank scenario risks are extremely low
- Jet A1 does not produce flammable vapour and is difficult to ignite
- PAFF has extensive safety features including spill containment

Individual Risk Results



- Maximum off-site risks to neighours on fence line is 4 x 10^{-8} per year i.e. 250 times lower than the acceptable criterion of 1 x 10^{-5} per year
- In real life, an individual's risk of death in a traffic accident is about 1 x 10^{-4} per year
- 100% instantaneous scenario included but risks are extremely low
- No significant risk outside PAFF boundary

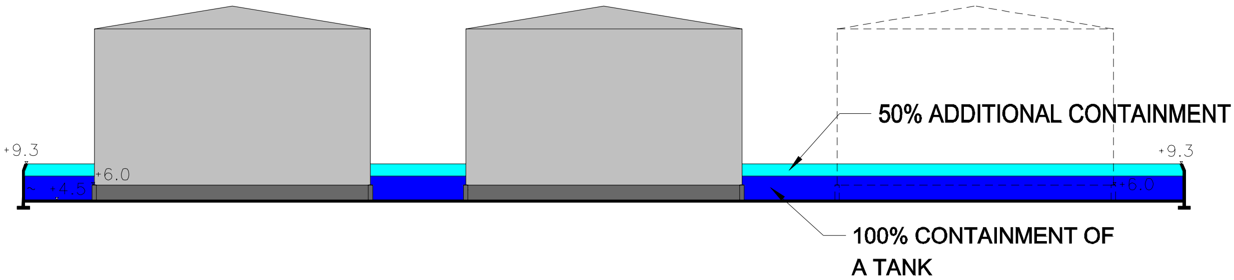
- PAFF is equipped with extensive safety features endorsed by the Fire Services Department, including a spill-containment system.
- It meets or exceeds Hong Kong and international standards for:
  - The distance between the tanks and the PAFF boundary which is 28.5 metres (compared to 10 metres required under Hong Kong standards and 15 metres according to some international standards)



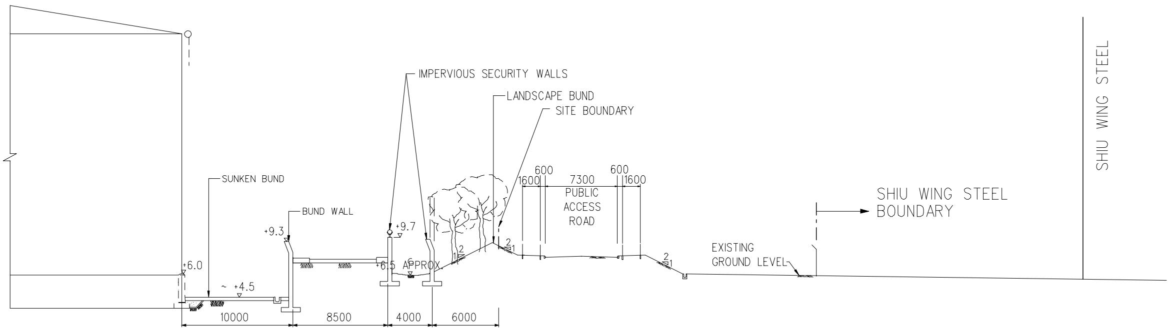
Initial Phase

Final Phase

  - The containment capacity of the bunds surrounding the tanks (over 150% compared to standards of 100% and 110%)
  - Having bunds that are beneath the surrounding ground level, for added integrity



  - Having two additional impervious security walls
  - Having a landscape bund



- Comprehensive security, shutdown and fire-fighting systems

- ➢ PAFF will be operated effectively and controlled by well experienced and conscientious management.
- ➢ PAFF will reduce the level of marine traffic carrying Jet A1 from 2009 by at least 80%, from about 1,100 to 150 vessels a year, in the Ma Wan Channel, Urmston Road and Sha Chau and Lung Kwu Chau Marine Park.
- ➢ PAFF will receive larger tankers with double hulls using pilots and tugs, thus further reducing marine traffic risks
- ➢ Mitigation measures will minimize risks to the marine environment, including Chinese white dolphins.

Can PAFF be delayed?

- ➢ Demand for aviation fuel will exceed the capacity of the Sha Chau facility by 2009
- ➢ If PAFF is not available by then, there will be fuel rationing and a reduction in the number of flights, airlines and destinations served by HKIA. This will have an adverse impact on the aviation industry and Hong Kong's economy.

Conclusion

- ➢ PAFF is one of the safest fuel storage facilities in the world.
- ➢ It will have no unacceptable environmental impacts.
- ➢ The probability of the PAFF posing a hazard to life is extremely low.
- ➢ Aviation is an important engine of Hong Kong's economic growth.
- ➢ HKIA's role as a leading international and regional hub depends on a reliable, steady supply of aviation fuel. To safeguard this role, PAFF must be in operation by 2009.

Responses to Public Comments related to Hazard Assessment

1 **PA#00001**

Reasons for objection:

1. Fuel depot should not be placed between the steel mill (hot works) and EcoPark (open flame) as it will increase the chance of explosion.	There are many cases where fuel depots storing relatively hazardous fuels like petrol and LPG are located next to industrial areas and even in the proximity of high temperature works, like furnace. Location of PAFF next to steel mill and EcoPark therefore is not uncommon.
2. The steel mill and EcoPark are located less than 100 metres away from the PAFF. If there is any explosion at PAFF, thousands of injuries or casualties will be caused. EIA should give human life prime consideration.	International and local codes only require a safety distance of 10m to 15m between the tanks and PAFF fuel depot boundary. In almost all cases of accidents, fuel could be contained within the site. Likelihood of accidents causing offsite fatalities is extremely low. EIA has already given human life prime consideration by undertaking extensive analysis.
3. Numbers of severe oil depot incidents happened in the past few years. Having the PAFF in the area is like installing a bomb which would threaten the lives to the people around.	In order to compare various incidents, it is necessary to first understand the various characteristic of fuels, the surrounding environment and causes of accident. It should be noted that Jet A1 cannot ignite easily and does not give off a flammable vapour that could lead to an explosion i.e. it is relatively less hazardous than other fuels, such as LPG and petrol. In addition, Hong Kong ambient environment is different from say UK, thus generalization of stating that fuel depot will threaten the lives of people is not appropriate.

Comments	Responses
4. Large oil tankers which pass through Ma Wan Channel and Tuen Mun waters would pose impact to the already busy marine traffic and the people living along the coast line. This is the reason why Tuen Mun was not chosen before, but why it is acceptable now?	Currently about 1000 number of vessels transit through Ma Wan Channel and Urmston Road to transport aviation fuel from Tsing Yi to Sha Chau. When PAFF is operational, the number could be reduced to about 150 as larger vessels which are double hull and with pilot will be used. It is a reduction of 80% of current marine traffic.
5. If explosion happens at the PAFF, it would cause significant impact and damage to not only TM but also HK direct. It will cause unrecoverable damages and loss of human life and economy. Therefore, it should be isolated from open flame operation and residents.	See responses 1 and 2 and 3 above.
6. PAFF was ruled non-compliance to EIAO and thus illegal. AA should respect CFA judgment and find another location for PAFF.	PAFF was ruled non-compliant on the ground that a QRA for 100% instantaneous loss of a tank's content was not included.

2 **PA#00004**

Comments	Responses
Reasons for objection: 1. Building the PAFF next to the heavy industrial facilities with open flame and high temperature operations is a very severe mistake as it threatens the lives of thousands of people around and ignores the fact that fuel and fire could not be located adjacent to each other.	See responses 1 and 2 to Comment No. 1.
2. Although AA emphasizes that the design of the PAFF meets the international safety standards, incidents did	The definition of Special Industries Area includes fuel depot because PAFF is compatible with such land uses.

	Comments	Responses
	happen at other oil depots in the world recently. This proves that similar incidents could happen even if the oil depots have met the international safety standards. Therefore, to prevent serious injuries and causalities in case of any incidents, PAFF should be away from any ignition sources, away from steel mill and EcoPark. Being a special industries area, TMA 38 is not compatible with the development of PAFF.	
	3. The safety of PAFF does not only affect the TM residents but would also affect the economy and reputation of HK. Therefore, the process should be done with thorough assessment and consideration and thus cannot be based on the urgency of the PAFF. ACE Members should ensure the EIAO is strictly enforced and be accountable for the responsibility entrusted by people to protect the life of general public.	Safety is of paramount important to the aviation industry and in particular to AAHK, thus AAHK is proceeding with the PAFF because the risks posed by PAFF are extremely low.
3	**PA#00355** (Very similar to Comment No. 2 (PA#00004), except it has the following additional comments)	
	• AA proposes to develop one of the largest fuel depots at heavy industrial area at TMA38 and located just between the steel mill and EcoPark. This obviously violates the principle that fuel and fire can not be co-exist. It is a serious mistake. We emphasize "no risk" should be acceptable. How about the lives of thousand working at the steel mill and the EcoPark. Just this single argument would be strong enough for EPD to reject AA application.	It is not true that PAFF is the largest fuel depot. There are many larger fuel depots in the world and there are two depots in Tsing Yi, 95% of the size of PAFF.

Comments	Responses
• We believe TM residents (as well as the Chinese White Dolphins) will not be willing to accept this high risk and dangerous facility as a new year gift. We hope DEP will not repeat the mistake made before and reject the application for the PAFF.	Risks posed by PAFF are extremely low. PAFF will be one of the safest fuel facilities in the world.
4 **PA#00861**	
• Clause 10.2.3 regarding the "Potential Hazardous Scenarios" did not comply with the requirements of Clause 1.2.5 (ii) and (ix) of EIA study brief which require the identification of the risks and hazards to life related to the transport and storage of the aviation fuel and the impact to the environment (or vice versa). For example, the accident at the power station in 1992 caused the death of two engineers and the fragments of the explored hydrogen tanks did reach the road near TMA38; incident at SWS at Tseng Kwan O in 1995; fires did happen in recycling parks in other countries. Thus the hazard to life section has to fully comply with the requirements if the Study Brief and Technical Memorandum and undertaking the QRA. The whole EIA Report lacks such assessment. The answer why PAFF cannot be built at the airport is simply because it poses threat to the aircraft movement.	All potential hazards scenarios identified have been assessed, whatever the cause leading to the scenario. The offsite explosion and its impact on PAFF have already been covered in the assessment of the scenarios. The only scenario which can cause significant offsite impact is 100% instantaneous release of a tank's content (100% QRA). The causes stated in the comment would not lead to a 100% QRA and would therefore not have any off-site risk.
5 **PA#01097**	
It is always AA plan to have the huge fuel depot next to the	Three interim reports and an initial report on the Buncefield

Comments	Responses
steel mill and EcoPark. Before the final investigation report of the Buncefield incident, AA has submitted the revised EIA Report and start the public inspection process.	incident make the nature and causes of the incident clear. These have been reviewed and discussed in the EIA.

6 **PA#01099**

	Content of EIA Report	Marks	Comments
10 & 11	Hazard to Life Assessment and Fuel Spillage Risk Assessment	0 Mark - Not Passed	• The Report has not identified the hazards to life per the requirements of the EIAO • Seriously violate the safety principle that fuel and fire (ignition sources) cannot be adjacent to each other • Fuel vessels will pose adverse impact to the Ma Wan Channel and the water outside Tuen Mun

Responses:

- Because the EIA Report had met the requirements of the Study Brief and the Technical Memorandum of the EIAO, that is why EPD allowed the EIA Report to be subjected to public inspection.
- There are many examples where fuel depots are located next to industrial facilities with furnaces.
- See response 4 to Comment No. 1.

7 **PA#01154** (tabled in TMDC meeting of 13 March 2007)

Response circulated to ACE EIA Subcommittee on 19 March 2007 and attached herewith as Part 3B to Annex C.

	Comments	Responses
8	**PA#01319**	
	• TM is a very populated community. Fuel depot should not be placed close to the residential area. Power plant and fuel depot will significantly increase the potential danger. It is the reason why the depots at Tsing Yi have to be removed.	PAFF will be located well away (2 to 3km) from residential developments with intervening terrain, posing no risk to Tuen Mun residential community.
9	**PA#01320**	
	Continuous explosions of fuel depots were happened repeatedly in other countries. Who will be responsible for the accident in case it did happen? AA? Planning Department or EPD?	Explosions in fuel depots do occur because of various causes, that is why hazard to life assessment is vital. PAFF will pose extremely low risk to neighboring facilities. If there is an accident, the party causing the accident would be responsible.
10	**PA#01323** (It is the comprehensive comment submitted by SWS with HSL inputs)	See ANNEXES 3 to 6
11	**PA#02658**	
	1. AA is planning to conduct the third runway. The aircraft impact frequency in Appendix H3.6 should take into account of the possible runway.	The aircraft impact frequency has already been considered in the long term growth of the airport. 3rd runway will not increase traffic, it will facilitate traffic.
	2. A serious accident (an explosion) occurred at CLP's power plant 10 years ago. The explosion caused some large objects to fly away for more than 1km. If there is similar incident, some large objects may fly away to the	See response to Comment No.4.

Comments	Responses
PAFF which is less than 1km from the power plant and destroy the tank, causing 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Thus Section 10 should include a QRA of incidents of similar nature.	
3. There are also other industrial establishments in the vicinity of the PAFF such as EcoPark and steel mill, causing explosion of same kind and leading 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.
4. An accident occurred some 10 years ago involved a helicopter which carried out construction/maintenance works for CLP's pylon. The helicopter fell to the ground and kill people in the helicopter. As the PAFF is only some 800m away from CLP's pylon, there is a risk that similar accident will occur and the helicopter may strike the fuel tank and destroy it, causing 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.
5. The PAFF is just 1km from the Castle Peak Firing Range. There is a risk that the fuel tank is accidentally shot from the firing range, 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.

Comments	Responses
6. The individual risk and societal risk in Section 10 should take account of the scenario in items 2 to 6 above and should also take account of other hazard or potential hazard installations in the vicinity, including the CLP's power station, the industrial establishment in the EcoPark, as well as a possible chlorine storing facility in Area 40, Tuen Mun.	The hazard to life assessment has already taken into account the causes in items 2 to 6.
12 **PA#01343**	
The EIA Report did not address the potential danger toward the steel mill and the power plant. It also do not comply with the requirements of Clause 1.2.5 (ii) and (ix) of EIA study brief. If the site is surrounded by potentially hazard installation, the hazard to life section has to fully comply with the requirements if the Study Brief and Technical Memorandum and undertaking the QRA. The whole EIA Report lacks of such assessment.	PAFF is not a potentially hazardous installation and the risks posed by it are extremely low. It is not incompatible with the neighboring facilities.
The proposed PAFF is located at TMA38 and close to the high temperature operated facility. Airport Authority repeatedly proclaims that the design of PAFF has met the international standards. However, large tank explosions did happen in recent years. This has demonstrated that even though the facility has met the international standards, catastrophic accident cannot be avoided. As a result, aviation fuel storage facility must be located away from the high temperature operation facility to reduce the casualties in the event of accident.	The conclusion of the EIA Report shows that the risks posed by PAFF are extremely low.

Comments		Responses
13	**PA#01391**	
	As you will be aware, we and our workers are extremely concerned at the PAFF and the implications for our safety.	
	We are currently preparing our comments on the EIA Report. We are aware that certain members of the community believe that in conducting their review of the EIA Report, they should simply review those sections that relate to the QRA carried out in respect of the 100% loss scenario. This is apparently on the basis that the remainder of the EIA Report has already been approved by the EPD.	
	However, in the judgment of June 2006, the CFA quashed the EPD's decision to approve the previous EIA Report. The effect of this is that the previous approval no longer stands. It is for that reason that the AA has had to submit a new EIA Report, the entirety of which has been issued for public consultation.	CFA judgment stated that issues other than 100% QRA have been addressed, comments have been obtained and evaluated, and hence there was no need to go back to square one.
	We are, of course, confident that the Sub-Committee will not share the views of the community as expressed above and that it will consider all aspects of the EIA Report and the AA's proposals. We are also certain that in so doing, the Sub-Committee will appreciate the serious defects in the EIA Report (over and above those that relate to the 100% loss scenario) which according to the estimate by AA, could have potentially fatal consequences for those working at our mill and the other facilities adjacent to the	

	Comments	Responses
	PAFF.	
	In this regard, the Sub-Committee should be aware that we have been advised by our expert (HSL in England) that the EIA grossly underestimates the likelihood of realization of the 100% loss scenario; and when considering the above in the context of the serious potential consequences of the 100% loss scenario (up to 189 fatalities at our premises), this invalidates AA's choice of TMA 38 as the appropriate site for the PAFF (Section 2 of the EIA Report).	See ANNEXES 3 and 4.
	We would therefore urge the Sub-Committee to ensure that it considers all elements of the EIA Report (including issues of site selection).	
14	**PA#01598**	
	Our comments are:	
	1. AA proposes to develop one of the largest fuel depots at heavy industrial area at TMA38. This obviously violates the safety principle that fuel and fire can not be co-existed. It is a serious mistake.	See response 1 to Comment No.1.
	2. Please consider the safety and hazard to life for people living in Tuen Mun.	Safety and hazard to life of the people in Tuen Mun have been considered.

Comments	Responses
1. Clause 10.2.3 regarding the "Potential Hazardous Scenarios" of the EIA Report has not complied with Clauses 2.1 (ii) and (ix) of EIA Study Brief which state: *ii) to identify and describe elements of community and environment likely to be affected by the Project and/or likely to cause adverse impacts to the Project, including natural and man-made environment and the associated environmental constraints; and* *ix) to identify the risk due to the transportation and storage of the aviation fuel and to propose measures to mitigate the impact.* The EIA report has not identified clearly the risk and hazards associated with the transport and storage of aviation fuel and its impact towards the current environment and it also fail to address how the current environment will impact to PAFF. For example, the Report did not identify the potential risk/hazard toward PAFF from the steel mill, EcoPark, cement plant, and power station. Similarly, the Report also did not identify the same with respect of the marine risks/hazards. Because of the lack of consideration to this important aspect, the Report cannot fully reflect the risks associated with PAFF at TMA38 and thus lead to the wrong decision on the site selection.	The EIA Report has identified and considered all potential scenarios, stated in Table 10.2 (attached). In doing so, it has complied with the scope of the Study Brief which required consideration of the hazardous scenarios associated with the receiving, storage and export of Jet A1. Although the surrounding environment was reviewed, no risks to the PAFF from the surrounding facilities in particular steel mill and EcoPark were identified which would affect the quantification of the risks from the identified hazardous scenarios or contribute any further hazardous scenarios, except features of the surrounding land, ignition sources and populations. These are all covered in detail ins Section 10 of the EIA Report. The EIA Report has clearly identified the risks due to the transportation and storage of the aviation fuel for the facilities within the scope of the Study Brief, as noted in Para 10.2.3.1 and as discussed further in paras 10.2.3.2 to 10.2.3.4. In the opinion of AA and their consultant, the risks associated with the PAFF at TMA 38 are fully reflected in the EIA report and no risk levels have been identified that would lead to any question over the site selection.
2. As PAFF will be the largest fuel depot in the world and according to EIA Annex H9.3 regarding Event Tree for	Fuel farms for aviation fuel and other fuels vary in size according to the requirements of the facility and the local

Comments	Responses
Tank 003, the anticipated casualties would be 189. This also violates Clause 3.3.1.1 of EIA Study Brief which states *3.3.1.1"The EIA study shall take into consideration with clear and objective comparison of the environmental benefits and disbenefits of different sitings and alignment options, and also with or without the proposed developments. The applicant shall compare the main environmental impacts and provide reasons for selecting the proposed system and the part environmental factors played in the selection shall be described. This is particularly relevant to the size and location of the facility, submarine pipeline alignment, construction method, number and size of the fuel tanks and pier*. ***In formulating the preferred options, the Applicant shall seek to avoid adverse environmental effects to the maximum practicable extent***.*"*	circumstances. HKIA is one of the largest airports in the world and it is to be expected that a large fuel tank farm will be required. However, it is not the largest fuel depot in the world: even at Tsing Yi the storage capacity is about 3 times as great as the PAFF and two of the individual depots at Tsing Yi have capacities of about 95% of the PAFF and store a variety of fuels. The size of the PAFF is not therefore particularly unusual. The event trees cover even extremely improbable events. The frequency of the event leading to the 189.2 potential fatalities in the Event Tree for Tank 003 unzipping is 6.74×10^{-11} /yr. This is well below the acceptable criteria in the EIAO-TM and also well below the axis of the criteria plot. Risks at this level are of no significance in the evaluation of siting options. Section 2 of the EIA Report covers site selection, which provides environmental comparisons for all sites considered. See Table 2.1b attached.
3. To assess the effectiveness of the relevant measures, could AA please provide the detailed information on the design of the tanks (Permanent Aviation Fuel Farm PAFF/LC/01/DSG/G/0201 cRev.D by Leighton Contractor (Asia) Ltd.)	Reference in the EIA report is only made to identify that certain design features noted in the EIA report are also already identified in the design documents for the PAFF. Relevant information is already included in the EIA Report.

Comments

4. <u>The high temperature areas and potential ignition sources inside SWS and EcoPark</u>

EIA Report has identified in Annex H5 Table 2.1, the high temperature areas and ignition sources at steel mill and EcoPark. Although aviation fuel is less hazardous than petrol, AA did acknowledge in Annex H.5.3.4.4 that if aviation fuel did spill into the steel mill and reach the over 1000°C steel piles, the fuel would be ignited (see Dig. 1.1 below). However, AA did not further assess the consequences of that particular event but rely only on the subjective judgment from ESR stating that "by no means certain to happen".

According to the simulation experiment done by the Health and Safety Laboratory (UK), a subsidiary of Health and Safety Executive, flammable cloud could be formed in this event. When this flammable cloud meets the high temperature point in the steel mill, it would be ignited and flash back which will lead to pool fire (see Diagram. 1.2 below). History proved that no designer can predict all the accidents. Therefore, all regulations and standards have to be continuously revised after different accidents. How can people ensure the safety to human life just based on the current design?

Responses

In paras H5.3.2.4 to H5.2.3.8 the situation of hot-works in the steel mill coming in contact with Jet A1 is analysed and it is concluded that, it may be possible for the hot metal route to ignite a pool of Jet A1 below it. The conclusion applies specifically to a static pool of Jet A1 under the worst circumstances identified that being for Jet A1 to instantaneously flow into the mill from unzipping of the tank, the probability of which is extremely low. It is noted in para H5.3.2.8 that various factors including the flow of Jet A1 which is inherent to the scenario of concern will make it less likely that the Jet A1 will ignite. Nevertheless, a probability of ignition for Jet A1 in this location of 0.5 has been used in the assessment (see Item B in table under H5.3.4.5) to reflect the uncertainty. The consequences and frequency of an event being ignited in this area have been fully incorporated within the assessment.

The analysis of the potential for ignition by the hot metal route in the EIA report appears entirely consistent with the results from HSL as stated in the comment provided.

The update of standards is a continuing process. A risk assessment, based on identification and quantification of

Comments

Table 1: The high temperature areas and potential ignition sources inside SWS and EcoPark

Location	**Hot Temperature / Ignition Sources**	**Temperature**
SWS (HSL, 2003a) (HSL, 2003b)	Reheat furnace Steel Cutting Area Welding Area Cooling Bed Steel storage (East of the mill) Electric arc Goods Vehicles General electric equipment	1100^{o}C 1000^{o}C 1200^{o}C $<610^{o}$C $>90^{o}$C -- -- --
EcoPark (EIA Report Note1)	Kitchen, venting, generator Heating reduction facilities for element mercury phosphor powder Melting pot for glass Burning equipment for glass product Electric arc Reheating / rolling channel Aluminum /copper/ Zinc recovery Furnace	370-480^{o}C 375-1200^{o}C 1500^{o}C 500^{o}C 1540^{o}C 1200^{o}C 327-1083^{o}C 125-175^{o}C

Responses

hazardous scenarios may reveal that additional measures to those in the standards are appropriate for a particular facility, or that the location of a facility is unacceptable. This is not the case for the PAFF, where the safety measures in place are in excess of the requirements of the relevant standards and the risk levels are well within the acceptable region of the EIAO-TM criteria.

Comments

5. Site selection and comparison of the alternatives

Site	**No of people within 200 m of PAFF**
Tai O	None
East of Soko Islands	None
Kau Yi Chau	None
Sham Shui Kok	Roads
Sham Wat	Sham Wat Village
Tsing Yi	Existing employees: Shell = 137 Caltex = 155 Esso = 97 CPRC = 160 Mobil = (don't know) If PAFF is located adjacent to the above facilities, the max no of people affected would be 315
TMA 38	Steel Mill = 529 PAFF road = 2 Lung Mun Road = 14 Eco Park = 1200 (max)*Note 1 Total = 1745
TM West	None

*Note 1: About 9 hectares of EcoPark is within 200m of PAFF (EIA104/2005). The estimation is based on the population density of HK of which each worker in every 75m^2. PAFF EIA Report estimates that there would be 750 workers in EcoPark

Responses

The site selection is fully covered in Section 2 of the EIA report.

The site selection process is necessarily made based on a less detailed analysis than the assessment for the site that is selected. Nonetheless, nothing in the detailed assessment for the selected PAFF site, including the assessment of hazard to life, raises any doubts over the adequacy of the site selection. Furthermore, ACE has been updated on the PAFF site selection in 1995, 1998, 2000 and 2001.

The issue of concern to the CFA was that '*the EIA report did not contain a quantitative risk assessment ("QRA" – a term to be examined presently) which embraced the scenario of a catastrophic failure of a fuel storage tank with instantaneous or almost instantaneous loss of a 100% of the tank's contents.*' (Para 16 of the CFA judgment). The CFA judgment did not envisage '*going back to square one*' for the hazard to life assessment, noting that '*issues other than the QRA for "all hazardous scenarios" have already been addressed, comments have been obtained and evaluated*' (Para 93 of the CFA judgment).

A revised EIA has therefore been produced including an appropriate QRA for the scenario of 100% instantaneous tank failure. In line with the CFA judgment, the revised EIA does not go back to square one to revisit issues, such as

Comments	**Responses**
Phase I and II.	site selection, that were addressed, and for which comments received were evaluated, during the original EIA process. The CFA judgment does not call such issues in the original EIA into question, only the lack of a QRA for a 100% instantaneous tank failure. The EcoPark population is based on the best available information at the time the revised EIA was prepared rather than a simple average population density (para H8.2.1.1)
6. <u>Weighting in the Site Selection</u> According to EIA Report Table A33, hazard to life constitutes 19.75% of the total weighting, water quality/marine ecology constitute 50% of the total. If these two elements constitute together, i.e. each will constitute about 35%. With this revised weighting, TM38 would be the 2nd highest in risk category. It implies that the EIA report is just a manipulation of number and does not take 'human life' as the prime consideration.	The site selection process is necessarily made based on a less detailed analysis than the assessment for the site that is selected. Nonetheless, nothing in the detailed assessment for the selected PAFF, including the assessment of hazard to life, site raises any doubts over the adequacy of the site selection. Weightings of various environmental factors were made based on careful consideration and for hazards to life on the fact that in case of accident at the tank farm, Jet A1 would be contained within the PAFF site in almost all of the hazardous scenarios. Please see also the answer to Point 5 above. Safety is of paramount importance to the aviation industry and AAHK is totally committed to the safety of the PAFF.

Comments	**Responses**
7. <u>International examples quoted in the EIA Report</u> All the examples of aviation fuel depots of international airport quoted in the EIA Report are located far from residential area and industrial area without any flame fire and high temperature operation near by. One of the examples is the aviation fuel farm of Denver International Airport which has a capacity of $63,000m^3$ located in a 3.8 hectares area (see Diagrams. 2.1 and 2.2) while PAFF has a capacity of $388,000m^3$ within 6.75 hectares. It shows that PAFF area is less than 2 times of Denver's area but having 6 times of capacity over Denver's.	Compared to Colorado where vast amount of open land is available compared to Hong Kong, it is to be expected that the facility in Hong Kong will be more economically laid out. Even then, the spacing of the tanks and the boundary at the PAFF exceed the relevant codes. The size of the PAFF, its layout and proximity to flame, fire and high temperature are not particularly unusual and occur commonly for storage in refineries around the world. A Jet A1 fuel depot will in general present a much lower risk to its neighbours than a similar depot storing petrol due to the nature of the product. The EIA report hazard to life assessment does not quote examples of aviation fuel depots (only incidents have been quoted) and the effects of the adjacent facilities have been fully accounted for in the hazard to life assessment. The resulting risk levels are well within the acceptable region of the criteria in the EIAO-TM. In addition to the safety distance of the tanks from the PAFF boundary, PAFF design meets and exceeds HK and international standards, in particular: i) containment capacities of the bunds; ii) by having two additional impervious security walls; iii) a landscape bund (a bund plus fence is usual) and the bunds are sunken, thus improving integrity; and iv) comprehensive security, shutdown and fire fighting systems. Please see also the Response to Question 2.

Comments

Although EIA report follows the Model Code of Safe Practice of Institute of Petroleum, it does not comply with clause 2.4.12 of IP205 which says *"the total capacity of tanks in a bund should not exceed 60,000m^3."* Each tank with over 60,000m^3 should have individual bund as a mitigation measure. PAFF has only two bunds of which each contains 6 oil tanks. This is obviously a violation of the current safety standards.

Responses

This is similar to the HSL/SWS comments that state that "*The PAFF does not comply with the recommendations of current international good practice in tank farm design*" (HSL 8 [7]). In particular HSL cite guidance that the total quantity of fuel held within a bund should not exceed 60,000 m^3 in Part 2 of the IP model code of safe practice.

Guidance from relevant standards is cited in the EIA report where appropriate. The guidance on total storage capacity in a bund for distribution terminals in IP Model Code of Safe Practice (MCSP) Part 2 as noted by HSL [7] is permitted to be exceeded under both the Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10), and the part of the IP MCSP most relevant to the PAFF, i.e. Part 19, "Fire precautions at petroleum refineries and bulk storage installations" (Ref 26 of EIA S10). Note, Part 19 of the MCSP has been updated in January 2007, after the submission of the EIA, but the wording on this subject remains the same [34].

The new edition of Part 19 also includes the following statement in Section 4.8.3 [34] on storage tank layout / secondary containment. "*Normally, good tank design and operations good practice should prevent large product releases. Catastrophic tank failure is one possibility, but is usually considered a low probability event. Although*

Comments	**Responses**
	considerable research has been aimed at the subject of bund overtopping, good bund design and minimising the potential for large releases in the first instance should significantly reduce the probability of such an event." The PAFF is different to a typical distribution terminal in that it stores a single product (Jet A1) imports only via its own marine jetties and exports via a dedicated single product pipeline; the PAFF does not distribute Jet A1, it receives it for, stores it for, and supplies it to HKIA only. Part 2 of the cited IP Model Code of Safe Practice covers distribution terminals that may store multiple products, import and export by multiple routes including, road and rail loading facilities, single and multi-product pipelines, in addition to the types of facilities that will be present at the PAFF. IP Part 19 is therefore the more appropriate IP code to consider, and Fire Services Department (FSD) has been satisfied after having given in-depth consideration to this matter. The recommendation of the total capacity in the bund in IP Part 19 is a general recommendation and covers all product classes I, II and III. Jet A1 is classed as Class II(1) within the IP code and as such represents a lower risk than Class I, Class II(2) or Class III(2) product and accordingly relaxation of the recommendations is permitted as indicated in IP Part 19 clause 4.8.3 [34].

Comments	Responses
	The normal recommendation for total capacities of tanks in a single compound of 60,000 m^3 for a bulk storage site in IP Part 19 [34] may be exceeded provided that an assessment indicates no significant increased risk of pollution or hazard to people. This restriction has been discussed with FSD as part of the review and FSD has been satisfied; considerations include improved fire fighting access provided by remotely operated foam canons. The Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10) is more specific in differentiating between the classes of product and places a similar limit on Class I products only. No limit is placed on the volume of Class II products. Also note that National Fire Protection Association (NFPA) 30 Flammable and Combustible Liquids Code places no restriction on the maximum quantity of any class. The EIA report provides a quantitative assessment of the hazard to life and the results lie well within the acceptable region of the criteria in the EIAO-TM, satisfying the requirement for an assessment. It may also be noted that the larger overall capacity of the bunds at the PAFF (at least 156% of the capacity of the largest tank) compared to requirements for 100% or 110% in the codes, which would probably be followed closely if individual tank bunds were used due to space constraints, provides an additional safeguard against the 100% instantaneous rupture case of

Comments

Responses

particular interest to HSL/SWS. This is in two forms:

- The higher bund capacity relative to a single tank provides a greater safety margin against overflow from a single tank contents due to the higher retention capacity.
- For many cases, the flow from a hypothetical 100% instantaneous tank rupture would be away from the nearest bund wall and the additional distance plus the presence of other tanks as obstacles to the flow would reduce the level of bund overtopping.

The PAFF containment system also includes a number of additional safeguards not specifically required by the standards (e.g. [34]):

- The bunds are sunken in relative to the surrounding ground, providing a higher degree of integrity compared to a freestanding bund wall.
- The bund walls are vertical, and include a “wave wall” design to reduce momentum overtopping of released liquid.
- Two additional impervious security walls constructed of reinforced concrete are included to further reduce the liquid lost off-site even in the extremely unlikely event of a 100% instantaneous tank failure. These security walls have been shown to retain significant liquid volumes

Comments | **Responses**

within the site walls in the event of a 100% instantaneous tank failure in the physical model tests conducted for the PAFF (Table 10.49 of EIA).

- Outside the security walls, a further landscape bund is included which will further reduce any flow off-site towards SWS or in other directions.

Contrary to the suggestion by HSL/SWS [7] that the risk levels are increased due to storing more than 60,000 m^3 in a bund, the risk levels are actually expected to be reduced compared to simple arrangement of a single bund per tank containing 110% of the tank contents plus a site fence at 15m from the tank wall.

In suggesting that the risk levels are increased due to storing more than 60,000 m^3 in a bund, HSL/SWS [7] have assumed a significantly reduced overall storage capacity for the site, but with the same enhanced containment and additional safety features of the PAFF design. This does not provide a reasonable comparison of like facilities.

Table 10.2 Potential Hazardous Scenarios for the PAFF

ID	Scenario
	Marine Transport (Within ~500m of the Jetty)
M1	Fire due to rupture/leak of Jet A1 from loaded vessel
M2	Vessel collision involving tanker with subsequent fire and sinking
M3	Cargo explosion on tanker
	Jetty Transfer
J1	Fire due to rupture/leak of Jet A1 from loaded vessel
J2	Fire due to rupture/leak of loading arm during unloading
J3	Fire due to rupture/leak of jetty equipment
J4	Fire due to rupture/leak of jetty riser
J5	Fire due to rupture/leak of submarine pipeline from jetty to Tank Farm ESDV
	Tank Farm Storage
T1	Fire due to discharge from tank vent
T2	Tank head fire / explosion in tank head space
T3	Multiple tank head fires
T4	Tank failure due to overpressure
T5	Explosion in empty tank (under maintenance)
T6	Bund fire
T7	Fire outside bund due to rupture/leak of pumps, pipework and fittings
T8	Fire on sea due to release through drainage
T9	Fire due to instantaneous tank wall failure, subdivided as follows: T9As Instantaneous release from bottom seam failure with tank 90-100% full T9Bs Instantaneous release from bottom seam failure with tank 60-90% full T9Cs Instantaneous release from bottom seam failure with tank 35-60% full T9Ds Instantaneous release from bottom seam failure with tank <35% full T9Az Instantaneous release from tank unzipping with tank 90-100% full T9Bz Instantaneous release from tank unzipping with tank 60-90% full T9Cz Instantaneous release from tank unzipping with tank 35-60% full T9Dz Instantaneous release from tank unzipping with tank <35% full T9Aa Instantaneous release due to aircraft impact with tank 90-100% full T9Ba Instantaneous release due to aircraft impact with tank 60-90% full T9Ca Instantaneous release due to aircraft impact with tank 35-60% full T9Da Instantaneous release due to aircraft impact with tank <35% full
T10	Fire due to multiple tank failure
T11	Boilover
T12	Fire due to release from top of tank due to overfilling
T13	Vapour cloud explosion / flash fire
T14	Fire due to 10% instantaneous release from the top of a tank
	Pipeline Transfer
P1	Fire on sea due to release/leak from submarine pipeline

Table 2.1b Operational Phase Environmental Comparison

Criteria		Weighting	Site 1 Bluff Point	Site 2 East of Soko Islands	Site 3 Kau Yi Chau	Site 4 Sham Shui Kok	Site 5 Sham Wat	Site 6 Tsing Yi	Site 7 Tuen Mun Area 38	Site 8 Tuen Mun West
Air Quality	Max Score	**5**								
Operational Air Quality Impacts		5.00	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	Very low (1.0)	Very low (1.0)	Very low (1.0)
	Score out of 5		**5.00**	**5.00**	**5.00**	**4.00**	**5.00**	**5.00**	**5.00**	**5.00**
Noise	Max Score	**10**								
Above Ground Nose Impacts		2.00	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	Very low (1.0)	Very low (1.0)	Very low (1.0)
Underwater Noise Impacts		8.00	Low (0.75)	Very low (1.0)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Very low (1.0)
	Score out of 10		**8.00**	**10.00**	**8.00**	**7.50**	**6.00**	**10.00**	**10.00**	**10.00**
Water Quality	Max Score	**15**								
Water Quality Impacts		15.00	Low (0.75)	Low (0.75)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Low (0.75)
	Score out of 15		**11.25**	**11.25**	**11.25**	**11.25**	**7.50**	**15.00**	**15.00**	**11.25**
Ecology	Max Score	**20**								
Marine Faunal Impacts		20.50	Low (0.75)	Very high (1.0)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Low (0.75)
	Score out of 20		**15.00**	**20.00**	**15.00**	**15.00**	**10.00**	**20.00**	**20.00**	**15.00**
Risk	Max Score	**35**								
Hazard of Life		19.25	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	High (0.25)	Low (0.75)	Low (0.75)
Environmental Risk		15.75	Medium (0.5)	High (0.25)	Low (0.75)	Low (0.75)	Medium (0.5)	Low (0.75)	Low (0.75)	Low (0.75)
	Score out of 35		**27.13**	**23.19**	**31.06**	**26.25**	**27.13**	**16.63**	**26.25**	**26.25**
Landscape and Visual	Max Score	**15**								
Landscape Resource		6.00	High (0.25)	Medium (0.5)	Low (0.75)	Low (0.75)	High (0.25)	Low (0.75)	Very low (1.0)	Low (0.75)
Visual Impacts		9.00	High (0.25)	Medium (0.5)	Low (0.75)	High (0.25)	High (0.25)	Low (0.75)	Low (0.75)	Low (0.75)
	Score out of 15		**3.75**	**7.50**	**11.25**	**6.75**	**3.75**	**11.25**	**12.75**	**11.25**
Maximum Score		**100**								
Score(out of 100)			**70.13**	**76.94**	**81.56**	**70.75**	**59.38**	**77.88**	**89.00**	**78.75**
RANKING			**7**	**5**	**2**	**6**	**8**	**4**	**1**	**3**

Responses to Public Comments related to Marine Ecology

Comment	Response
PA#01403	
XXX urges the Director of Environmental Protection to reject the EIA report of the proposed Permanent Aviation Fuel Facility (PAFF) for Hong Kong International Airport as we consider it will pose unacceptable impacts to the marine environment. The reasons for rejecting the EIA report are explained as follows.	Please find below some responses to the comments made which explain that we consider that relevant and recent data has been used in the EIA assessment and a thorough review of all this data does not provide any evidence to suggest that there has been accumulation of contaminants over the years. In addition to this, we have obtained the sediment quality reports for the 2 maintenance dredging events for the AFRF since its commission. It should be noted that such works could not be undertaken without the prior agreement and approval of the Country and Marine Parks Board and also the relevant Dumping at Sea Ordinance requirements. In both cases, CMPB gave their approval. While the results from these surveys were not included in the EIA, the results do not provide any different information which would change the conclusion of the EIA. In fact the sediment quality testing results fully concur with the data used in the assessment in the EIA, showing that the majority of metals do not occur in concentrations above the LCEL. Some slightly elevated levels of Arsenic were noted as also detailed in the EIA and this would be expected as this material is naturally occurring in this area. However, as with previous data the levels were well below the UCEL and did not cause the samples to fail biological tests. In terms of POPs, the most recent SQR prepared in April 2004 for

Comment	Response
	the AFRF included testing for PAHs, PCBs and TBT (DDT and DDE was not required by EPD) in accordance with the current sampling and testing requirements. However, none of the POPs were detected at all in the proposed dredging area with all samples being below the analytical detection limit. Again, this concurs with the data reviewed for the EIA. Only 2 sets of data, AAHK's non-statutory monitoring around the airport platform and EPD routine monitoring of the area in general detected POPs at all but these were all well below the LCEL and there was no evidence of accumulation as suggested by the comments made. It is important to note that all PAFF project specific sediment sampling did not detect POPs at all. As such, these are not considered contaminants of concern in the area and for this project and no further assessment was required.
Section 6 Water Quality **6.2.5 Baseline Sediment Quality** XXX considers that the water modeling is based on outdated and incomprehensive information and hence have grave concern over the accuracy of the water quality impact assessment. The EIA makes use of the data of sediment samples collected within Sha Chau and Lung Kwu Chau Marine Park undertaken in 1995, and states that there is no reason to suspect that sediments in the area (Sha Chau) should be more contaminated at the present time. However, XXX considers that this is not a valid argument because the sediments at areas	The assessment was based on a large set of monitoring data and results from as recent as 2006 have been incorporated (Tables 6.3, 6.4 and 6.5; Section 6.25.14). Figure 6.4 summarises the data reviewed and also the year of the data collection. The latest area-wide data for the North-Western Water Control Zone as a whole (1995-2004 as presented in Tables 6.4 and 6.5) and project site specific data collected along the proposed works area conducted in 2006 and presented in Sections 6.2.5.14 - 6.2.5.15, have been adopted in the assessment and this information was

Comment	Response
between PAFF site and the boundary of Sha Chau and Lung Kwu Chau Marine Park were found with elevated levels of metal (Arsenic) in 2006 (Figure 6.1). Furthermore, Sha Chau has been subjected to constant estuarine influence from Pearl River, and the fact that the Pearl River has been subjected to high levels of pollution from factories over the past 12 years. Therefore, we believe that the current sediment quality within Sha Chau and Lung Kwu Chau Marine Park could potentially be different from data presented in the EIA report.	presented in Section 6.2.5. It is notable that EPD has monitored the area for over ten years. Table 6.4 summarised the maximum concentration of contaminates recorded in EPD's routine monitoring in the area between 1995-1999 while Table 6.5 presents the same for the period between 2000-2004. From EPD's results, it was clear that the sediment chemistry of the area has remained more or less the same in the recent ten years and there is no evidence to suggest that there has been any significant accumulation of contaminants in the area. Project specific data collected in 1995 followed and complied with the relevant testing criteria in force when the study was conducted. The more recent studies including the 2006 sediment quality testing of the proposed dredging area as described in 6.2.5.14 and 6.2.5.15 follows the criteria currently in force (i.e., ETWB TCW 34/2002) and included POPs such PAHs and PCBs. POPs were not generally detected (only one sample had total PCBs above the detection limit but the concentrations were well below the LCEL) in the recent studies of the area and this suggested that POPs have not accumulated in the sediment in the area. The details of the recent sediment testing works are presented in Appendix K of the report. Other studies in the area (especially the EM&A works in the area for East Sha Chau Contaminated Mud Pits) concluded similarly that the water and sediment quality of the area remains more or less the same over time (Section 6.2.5.17). Both the historical and current data of the study area have been reviewed during the

Comment	Response
	assessment and there is no evidence to suggest the sediment quality of the area changed significantly over time.
It is clear that the project proponent has failed to update the assessment results of sediment in the Marine Park. As these outdated data were used in the water quality modeling, XXX considers that the EIA cannot comply with the assessment methodology as specified in Annex 16 of Technical Memorandum TM. We are doubtful of the accuracy of the water modeling results as shown in table 6.7a and 6.7b.	As presented in the report and discussed above, recent project specific data has been collected and incorporated in the assessment (Section 6.2.5.14 – 6.2.5.15). It should also be noted that for impact assessment purposes, a worse case scenario (6.4.6.17) was adopted which included assuming all contaminants in the sediment were all category M, close to the upper assessment criteria (i.e., UCEL), which we know is not the case in reality from the actual specific sediment testing along the pipeline alignment (Sections 6.2.5.14 – 6.2.5.15 and Appendix K). The assessment results clearly demonstrate that there has been no build-up of contaminants and no sensitive receivers in the area would be adversely affected (Tables 6.7a and 6.7b). In reality, the worse case scenario overestimated the likely impacts of the project and indeed the project specific sampling and testing indicated that the majority of the sediment to be dredged was category L only and while a few samples slightly exceeded LCEL, they were far from the UCEL. Thus, although the assessment provided a conservative assessment it still concluded that no unacceptable impacts would occur.
In addition, XXX considers that the lack of assessment on the Persistent Organic Pollutants (POPs) baseline concentration in sediment in Marine Park and on estimated POPs elevation in water column render the water quality assessment inconclusive.	POPs such as TBT, PAHs (including 16 components) and PCBs (including 18 congeners) were tested in the project specific testing (2006) and data is presented in Appendix K. As POPs were generally not detected, there was no reason to conclude that the area was contaminated with organic pollutants which could be

Comment	**Response**
▪ According to the EIA paragraphs 6.2.5.8 and Figure 6.4, only the concentration of seven metals but not the concentration of PAHs and PCBs are tested against the sediment sample collected in the designated Marine Park. PAHs and PCBs are two examples of POPs; the potential environmental impact of POPs refers to the fact that some POPs could be accumulated along the food chain and thus exposure to POPs may pose adverse impacts to marine mammals in the long-term[1]. The need for assessing level of POPs in Marine Park sediment is further supported by the fact that PAHs and PCBs are identified as a contaminant in the ETWB Technical Circular 34/2002 and the Stockholm Convention that is applicable to HKSAR. In particular, there is recent evidence to indicate probable new inputs of DDT into the marine ecosystem of Hong Kong's southern waters, with the potential source coming from the Pearl River Estuary[2]. Given that the Sha Chau and Lung Kwu Chau Marine Park is closer to the Pearl River, it is reasonable to believer the marine ecosystem in the study area could also be susceptible to DDT bioaccumulation.	possibly released from disturbed sediment. Section 6.2.5.8 refers to the 1995 study in which testing of POPs was not required by the relevant standard (TC 1-1-92) in force at that time, however, these results were also compared and reviewed against the current standard (ETWB TCW 34/2002) as presented in Section 6.2.5.9. The more recent studies (1995, 2000 and 2003) of the North Western Waters included in the EIA assessment did include testing for POPs as required by the current standard (ETWB TCW 34/2002) and the results also confirmed that POPs were generally not detected. PAHS were not detected in all the samples tested, total PCBs were detected in only 1 out of the 26 samples tested but the level 0.4 µg/kg was way significantly below the LCEL of 23 µg/kg. This information has been summarised in Sections 6.2.5.10 – 6.2.5.12. Indeed these three studies also tested for organochlorine pesticides (15 components including DDT and DDE) but none were detected. While it is acknowledged that the Pearl River could potentially be a carrier of POPs from the Mainland, there is no evidence to suggest POPs are accumulating in the study area.
• Also, the water modeling fails to estimate the elevations of POPs concentration in the "maximum predicted depth averaged suspended sediment concentrations" (Table 6.7a and 6.7b).	Please see response above. As POPs are not generally recorded in the area, there is no reason to suspect there would be significant release due to the project.

Comment	**Response**
6.9 Cumulative Impacts According to the EIA study of CLP's LNG Terminal, the proposed submarine gas pipeline will be laid along the western boundary of Sha Chau and Lung Kwu Chau Marine Park and it is expected that the installation of this submarine gas pipeline will start from January 2008. Since "the proposed timescale for PAFF pipeline dredging is currently between September 2007 and February 2008" (EIA paragraph 6.9.6), there is an overlap of time schedule on the proposed dredging between PAFF and LNG terminal projects. XXX considers that an assessment of the cumulative water quality impact from the two projects is essential given the sensitivity of the receivers, yet the EIA fails to do so and hence fails to comply with the section 3.2.1 and 3.3.2 and 3.3.5.3 (subsection "Modeling Assessment", item "q") of the PAFF Study Brief (ESB-072/2001). We also disagree with the argument in paragraph 6.9.5 that "it has been modeled in the EIA of the new Contaminated Mud Pits (CMPs) at East Sha Chau that there would be no significant adverse impacts to the sensitive receivers during its operations and hence given the short duration of dredging works for pipelaying, it is unlikely that PAFF will cause any significant cumulative impacts". We consider that the EIA must look at the impacts from all the concurrent projects as a whole but not individually.	While there was no fixed commencement date defined in the CLP's LNG project, the tentative programme indicated that dredging for the pipeline will not start until the 13th month of the project (Annex A3 of the LNG EIA study). We note the project cannot commence without an Environmental Permit (EP) and assuming an EP is issued now, the dredging works will not commence until April 2008 and thus will not overlap with PAFF. It should be noted that the PAFF was proposed well before the proposed new pits at East of Sha Chau. As such, the EIA study for the proposed new pits at East of Sha Chau has also included modelling of PAFF effects in the cumulative impacts assessment and it also concluded that no unacceptable adverse impacts are expected.
Section 7. Ecology **7.6 Prediction and Evaluation of Construction Phase**	

Comment	Response
Impacts **7.6.6Sha Chau and Lung Kwu Chau Marine Park** XXX considers it completely unacceptable to have the existing aviation fuel receiving facility (AFRF) maintained as emergency backup after the PAFF is constructed. The project proponent should make sure that PAFF will not fail instead of having existing facilities as backup. AFRF was always intended to be temporary and continued damage to a very sensitive area is not justifiable. According to Annex 16 of TM, Sha Chau and Lung Kwu Chau Marine Park is a "Recognized Site of Conservation Importance". Together with the fact that the one of the key purposes of Marine Park Ordinance Cap. 476 is to protect, restore and enhance marine life and marine environment, we consider that the proposed regular dredging inside the Marine Park was not acceptable.	As clearly stated in Paragraph 3.6 of the EIA Report, in order to sustain continuous fuel supply to the airport, it is strategically necessary to maintain the existing aviation fuel reception facilities at Sha Chau as an emergency backup. This strategic need was recognised when the facility was gazetted in 1995. As a standing practice, any proposed dredging will have to gain approval from the Country and Marine Parks Board who may impose conditions to minimise any possible impacts, if any, to the marine life and marine environment as low as possible. The assessment of the potential impacts associated with the maintenance dredging for the AFRF has been fully covered in a separate EIA "Proposed Aviation Fuel Receiving Facility At Sha Chau: Environmental Impact Assessment", ERM (1995). Notwithstanding, it should be noted that all elements of the fuel handling, storage and transportation systems at the proposed PAFF will be designed to minimise the risk of failure and the resultant leaks and spills to the lowest practicable level.
7.6.3Disturbance to the Benthic Habitat and Habitat Loss The annelids, mollusks and anthropods comprised the majority of the individuals in Northwestern waters including the study area (Table 7.1a, 7.1b, 7.1c and 7.1d) (EIA paragraph 7.4.4.2). Soft gorgonian coral Ellisella gracilis is also found in the Marine Park. Dredging activities inside the Marine Park will destroy these slow-growing soft-bottom communities and this violates	It is noted only solitary colonies of soft corals are present in the area (Section 7.4.7.2) and they are not particularly susceptible to high suspended solid loadings as they do not possess symbiotic zooxanthellae (7.6.4.5). Furthermore, the area is periodically subject to high suspended solids due to the Pearl River discharge and the presence of these soft corals in the area indicate they are

Comment	Response
the key purpose of the Marine Park Ordinance Cap. 476.	tolerant to high levels of suspended solids. The suspended solids generated due to the project will be within the range of natural variation and therefore unlikely to cause significant adverse impacts to the species present in the area.
7.6.4Disturbance to Corals The EIA report states that protected hard corals of Faviidae family are found near Sha Chau at about 1.2 km to the southwest of the proposed dredging site, but does not specify which species and the coverage of individual species. This has serious implications because some uncommon coral species of the family Faviidae are found in the western waters of Hong Kong according to the "AFCD Field Guide to Hard Corals of Hong Kong". The EIA study states that the toxicity (particular Arsenic) and mortality of hard corals due to sedimentation impacts are dependent on the species of coral present. Without knowing the exact species, it would also be difficult to assess the sedimentation impact on coral (EIA paragraph 7.6.4.6) in accordance with Annex 8 of TM.	It should be noted that the area is naturally subject to periodic high suspended solids (Section 7.6.4.1) and the suspended solids generated due to the project will be short term and within the range of natural variation and is thus unlikely to cause significant adverse impacts (Section 7.6.4.5). Modelling also suggest that the impacts will be highly localised and does not predict that there would be any substantial accumulation of re-deposited sediments likely to adversely affect the benthic ecology or particularly susceptible species such as corals (Section 6.4.6.9). In addition, the majority of species detected in the area are ahermtypic and as such not as susceptible to suspended solids (Sections 7.6.4.4 and 7.6.4.5)
7.6.5Disturbance to Indo-Pacific Humpback Dolphins XXX considers that there is inadequate assessment of POPs to explicitly address its potential environmental impact on the Chinese white dolphin. According to the distribution map of Chinese white dolphin from AFCD[3], the sightings of Chinese white dolphin at the proposed	Based upon our responses above, recent project specific data demonstrated that the proposed dredging area is not contaminated with persistent organic pollutants such as TBT, PCBs and PAHs (Section 6). As such, the persistent organic pollutants are not contaminants of concern for this project and no further assessment as a result of these materials from dredging

Comment	Response
dredging site for the PAFF submarine pipelines are among one of the highest in Hong Kong. Given that sediment at seabed in close proximity to the Tuen Mun Area 38 i.e. sediment at station MVA1, MVA2, MVA3, MVA4 are all categorized as moderately contaminated and some of these samples even have elevated level of mercury and lead (see figure 6.4), we are concerned that elevated levels of metals could be released into the water column, causing potential adverse impact to the Chinese white dolphins and fishes which their potential food source i.e. fishes (Lam, P.K.S, 2006 in footnote no. 1). XXX disagrees with the EIA's conclusion that the sediment found in the study area is generally uncontaminated and considers it fail to address the issue.	operations is required. However, the assessment of potential impacts associated with fuel spills have been addressed in Section 11.3.3. Some of the sediment samples were classified as Category M due to the presence of arsenic which slightly exceeded the LCEL. It should, however, be noted that arsenic in the region is naturally elevated due to the geology of its catchment areas. Only very few samples were noted with concentrations of heavy metals slightly higher than the LCEL, the percentage of exceedances is low and they only marginally exceed the assessment criteria. For the project specific pipeline sediment testing (Appendix K) POPs were not detected in the samples tested and for other data, as noted above, only one sample had total PCBs above the detection limit but the concentrations were well below the LCEL. Based on EPD's long term monitoring and project specific testing (Tables 6.4 and 6.5), it is therefore concluded that the sediment in the project area was generally uncontaminated. Furthermore, the assessment undertaken in the EIA was based on a worse case scenario (which included assuming potential contaminants in the sediment were all close to UCEL) as described above and no adverse impacts were predicted (please refer to our response to Section 6.2.5).
7.6.7Cumulative Ecological Impacts (Marine Ecology and Indo-Pacific Humpback dolphin) XXX considers that the EIA fails to adequately assess the	Please refer to our responses above, especially for Section 6.2.5,

Comment	Response
cumulative impacts to the marine ecology and Chinese white dolphin. While the EIA states that cumulative impacts could potentially arise from the concurrent dredging for PAFF submarine pipelines, at the East Sha Cha Contaminated Mud Pits, backfilling at the North of Brothers Marine Borrow Area, and dredging for the proposed LNG submarine gas pipelines (EIA paragraph 6.9.6), the EIA concludes that there is no cumulative impacts on marine ecology and Chinese white dolphin arising from the four projects because "project-specific impacts are not expected to result in unacceptable impacts to water quality" (EIA paragraph 7.6.7.3). In fact, a number of factors constituting cumulative impacts are mentioned in the EIA such as whether there is "a prolonged period of impacts", "an increased intensity of the impact" and "induced synergistic impacts" (EIA paragraph 7.6.7.2). However, the EIA makes no effort to conduct cumulative impacts assessment based on these factors, XXX therefore finds the EIA's conclusion and the supporting reason unconvincing. We remain concerned that the concurrence dredging of the four projects could pose unacceptable impacts to marine ecology and Chinese white dolphin in terms of elevated levels of suspended sediments, metals and POPs in the water column.	6.9, and 7.6.5. It should be noted that suspended solids elevation would be highly localised and confined to the bed layer and well within the range of natural variability for Northwestern waters and hence does not represent any ecological concern (Section 7.6.4.5). As explained above, concurrent dredging is unlikely but should this occur, the dredging rate will be restricted to avoid cumulative impacts (Section 6.9 and also the EIA report for the other proposed projects).
7.7 Prediction and Evaluation of Operational Phase Impacts **7.7.2 Disturbance to the Benthic Habitat** It has been stated that maintenance dredging is not required for the PAFF project which severely contradicted with the EIA	Due to the water depth of the Urmston Road and the size of the vessels berthing at PAFF, we do not anticipate that there is a

Comment	Response
paragraph 7.6.6.2 and 7.6.6.3 where dredging for the access channel will be required “once every 3-4 years”. XXX considers that the project proponent should clarify the need for maintenance dredging for access channel to the future emergency backup in Sha Chau.	need to undertake maintenance dredging for the jetty and along the pipeline as stated in paragraph 7.6.7.2 of the EIA Report. However, in order to maintain the aviation fuel facility off Sha Chau as an emergency back-up, maintenance dredging may periodically be required along the turning basin and access channel if water depth is not sufficient for loaded vessels. The assessment of the potential impacts associated with the maintenance dredging for the AFRF has been fully covered in a separate EIA “Proposed Aviation Fuel Receiving Facility At Sha Chau: Environmental Impact Assessment”, ERM (1995). Any such maintenance dredging cannot be undertaken without consultation and approval from the Marine and Country Parks Board and compliance with other Government legislation and requirements for this type of work.
Section 12 Fisheries **12.5.2 Potential Impacts** XXX is dismayed by the simplistic conclusion in the EIA that there are potential positive effects of dredging to fisheries resources based on the fact that invertebrate prey dredged up could provide food source for fish. This is equivalent to saying that there are benefits to wild animals being killed on roads by cars as other animals can feed on their cavasses: Dredging involves massive destruction of physical and living habitat, high levels of mortality to organisms in the area and numerous side effects such as suspended sediments clogging fish gills and slow recovery of the area.	The potential negative impacts of dredging have been discussed throughout the report and the assessment and conclusions made on this basis. There is, however, some evidence to suggest potential positive effects to certain species and it was considered that this should be included to present a balanced view.