SCANDPOWER Risk Management

Lloyd's Register

M E M O

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From:	Philip Skinner Albert Shim	**Copy:**	Chris Ritchie Andrew Hartcher Derek Mullins
Project no.:	AUS0195440-1	**Date:**	28 May 2013
Subject:	**DETAILED REVIEW OF CRAWFORD'S PRELIMINARY HAZARD ANALYSIS (PHA)**		

1. SUMMARY

The preliminary hazard analysis (PHA) for Crawfords Freightlines Pty Ltd, Sandgate Ammonium Nitrate Storage Facility has adequately met the requirements of the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Hazard Analysis*. The methodology adopted for the risk assessment, estimation of consequences and selection of accident likelihood data for hazardous incidents is typical, appropriate and consistent with other similar ammonium nitrate (AN) quantitative risk assessments (QRAs). The Department considers the methodology of the PHA to be acceptable.

The proposed development meets the risk criteria set out in the Department's Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 *Risk Criteria for Land Use Safety Planning*. However, it should be noted that the 10 pmpy (per million per year) individual risk contour, west of Crawfords encroaches over a Council owned land. We understand that part of this land is leased to a private entity for the purpose of a Golf Driving Range and as such it should be considered as open space land use.

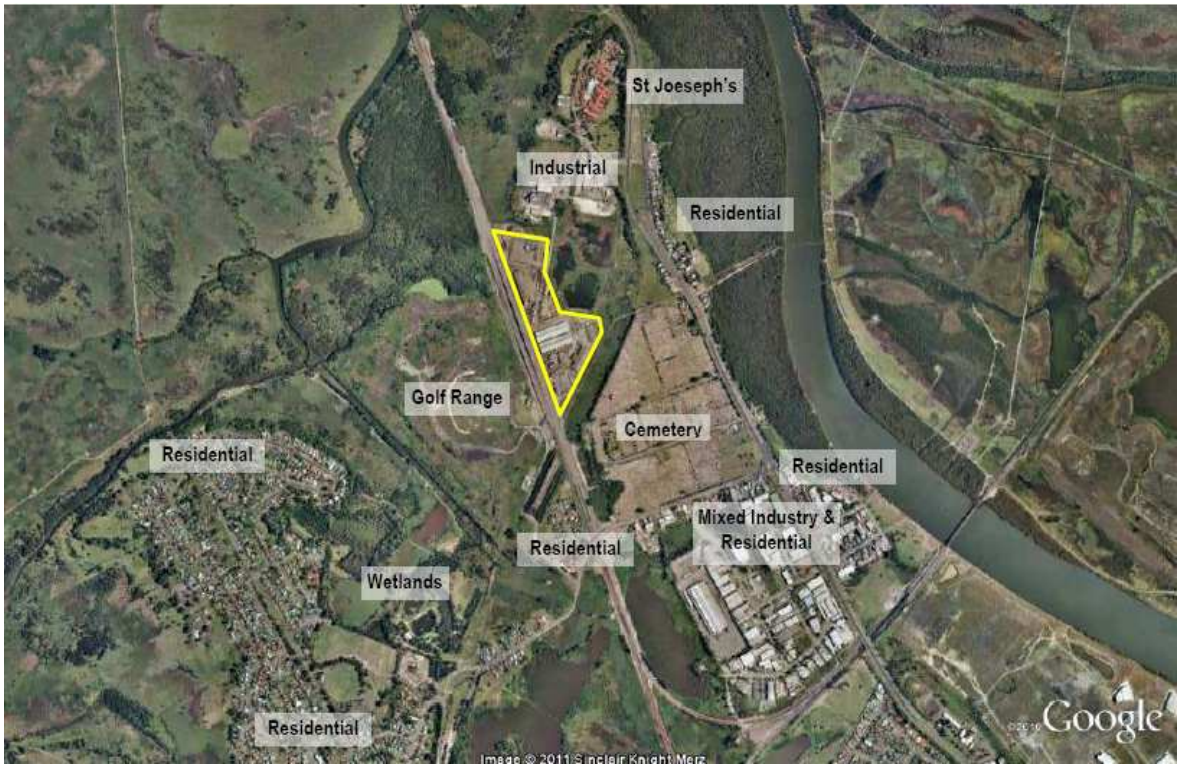
To avoid a potential land use safety conflict, Crawfords was requested to demonstrate that suitable arrangements will be in place to prohibit public access to the Off-site Restricted Access Area, supplemented with written approval from the Director-General every 12 months from the date of approval.

2. BACKGROUND

Crawfords Freightlines Pty Ltd (Crawfords) operate a storage and distribution depot at Lot 12 Old Maitland Road, Sandgate, NSW. It is proposed to store a maximum quantity of 13 500 tonne AN at this facility in flexible bags of approximately 1 tonne per bag.

The site is situated in a small industrial area surrounded by a golf range, other industrial premises and a cemetery. There are some residential areas beyond the surrounding areas, including a residential aged care home, St Joseph's (sensitive land use area) to the north-east. The following diagram shows the surrounding land uses.

Figure 1 Surrounding land uses



The majority of the storage will be indoors across 3 warehouses (Shed A, B and C) and a small quantity outdoor in a containerised storage. AN will be received: by trucks from Port of Newcastle and Orica, Kooragang island; and, by train from Port of Sydney. AN in flexible bags and bulk AN will be distributed from the facility to Hunter Valley and other NSW mining areas by trailer vehicles and B-doubles. AN shipping containers will also be distributed by road or rail to the Port of Newcastle or Port of Sydney for export.

3. METHODOLOGY

The AN storage and distribution depot is a "potentially hazardous industry" as defined under the provisions of State Environmental Planning Policy No. 33 Hazardous and Offensive Development (SEPP 33). Therefore a Preliminary Hazard Analysis (PHA) was prepared to assess the risk to people, property and the environment.

The methodology of the PHA as required by the Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 *Hazard Analysis* shall incorporate:

1. *Identification of the nature and scale of all hazards at the facility, and the selection of representative incident scenarios;*
2. *Analysis of the consequences of these incidents on people, property and the biophysical environment;*
3. *Evaluation of the likelihood of such events occurring and the adequacy of safeguards;*
4. *Calculation of the resulting risk levels of the facility; and*
5. *Comparison of these risk levels with established risk criteria and identification of opportunities for risk reduction.*

All of the above elements were adequately addressed in the PHA. As part of the assessment process, a detailed comparison of this PHA and other similar AN establishments in NSW was conducted by the Department.

4. HAZARD IDENTIFICATION

The PHA has identified the following as major hazardous materials with the potential for offsite safety or environmental effects:

1. Ammonium nitrate; and
2. Nitrogen oxides

The hazardous incidents involving these materials have the potential to cause injury or fatalities to people, damage to property or the biophysical environment. This includes events such as fires, explosions and toxic gas releases.

The hazard identification is considered comprehensive and includes the causes, consequences, control and mitigation measures for each identified hazardous incident in a format similar to a hazard identification word diagram. These were used to develop accident scenarios that were considered for consequence and frequency analysis and are clearly tabulated in the PHA report.

A public submission raised the question why the hazards associated with transfer of AN flexible bags in shipping containers by rail are absent from the PHA. Additional modelling was undertaken to estimate the impact of these hazards on the overall risk contour and it was demonstrated that accidents related to rail operations would not impact on the overall risk contours.

5. CONSEQUENCE ANALYSIS

Each of the incident scenarios that may have potential offsite impacts were estimated in the PHA. This was performed using industry accepted correlations and commercial software (Ausplume). The selection of key parameters used in performing the analysis was chosen based on a detailed review of various sources.

5.1 Ammonium Nitrate Explosions

The consequence analysis was conducted predominantly according to SAFEX International's *Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate*.

The consequence of an AN explosion (i.e. overpressure) was conducted using a TNT equivalency method. This is an industry standard approach for conducting consequence

modelling for an AN explosion. This was supplemented with empirical data from DEOP 103 – Defence Explosive Ordnance Manual, Department of Defence (Australia).

The report presented typical overall TNT equivalency values from various sources, which ranged from 5% to 32%. Some of the sources suggested the use of a single value as representative, i.e. the overall TNT equivalency did not vary for different explosion mechanisms. The selection of SAFEX values was considered to be appropriate for the analysis.

During the assessment process, the Department requested justification of Crawfords' interpretation of the SAFEX guidelines with regards to the equivalent TNT mass assumed in the PHA. Crawfords provided justification and amended their analysis.

Additionally, the Department questioned Crawfords proposed AN stack separation of 3 metres. Although this meets the requirements of AS 4326 and WorkCover, it is not as conservative as the distances specified in SAFEX or in some Australian jurisdictions. The Department sought additional information from WorkCover for the rationale behind the 3 metre separation and was advised that the quoted separation distance does not eliminate the possibility of propagation from another explosion. Subsequently, Crawfords revisited their proposed arrangement of AN stacks and amended their calculations. The worst case scenario was increased from an explosion involving one stack, to an explosion involving half the storage in a warehouse, which is a more conservative approach.

An assessment of the selection of the overall TNT equivalency and overpressure consequence distance results are comparable to the values used in other studies and in most cases, the results are marginally more conservative. The Department is satisfied with the approach and results of the AN consequence modelling.

5.2 Toxic Gases from a fire involving Ammonium Nitrate

Hazardous Industry Planning Advisory Paper (HIPAP) No. 4 *Risk criteria for Land Use Safety Planning* does not define specific impairment criteria for toxic gas exposures. The selection of a suitable criteria for cumulative individual fatality risk, injury or irritation should be based on a thorough search of available and known dose-effect relationships. The Department considers Crawfords selection of impairment criteria to be conservative and appropriate for this development.

The consequence analysis for the impact of the release of toxic gases from the thermal decomposition of AN was determined using Ausplume, a Gaussian plume dispersion model developed by the Environment Protection Authority. Although Ausplume is used mainly for the assessment of continuous emissions, it is still valid in this application.

Based on the results presented in the PHA, this event was not a major contributor to off-site fatality risk. The Department notes that this is consistent with the findings of other AN QRAs and is acceptable.

Overall, the Department considers the methodology and results of the consequence analysis to be appropriate for this development.

6. FREQUENCY ANALYSIS

The frequency analysis was conducted using the data and methods suggested by SAFEX and the UK Health and Safety Executive.

During the assessment process, the Department requested clarification on Crawfords estimation of explosion frequencies for each AN stack. Additionally, the Department questioned their justification of reducing the frequencies on the basis that their site is a storage facility and not a manufacturing facility. In response to the questions, Crawfords made adjustments to their assumptions and recalculated their results.

Further clarification was sought regarding the use of AN storage accident frequencies for AN truck incidents. Crawfords provided justification that in the absence of reported frequencies specifically for AN truck incidents, the AN storage accident frequencies were used as an indicative value and adjusted to reflect truck operations. The Department considers this to be appropriate as the resulting value is conservative with respect to historical data and consistent with other similar AN QRAs.

Taking into account that the facility has a single gate for vehicles, and to ensure that the risks from accidents at the gate are minimised, the Department also requested information on the measures to be implemented to reduce the likelihood of an accident. The Applicant confirmed that:

- As a result of a recent modification to the entry and access road configuration, the inbound and outbound traffic at the gate is separated;
- On-site traffic flow defined to facilitate forward movement of heavy vehicles;and
- Additional signage and speed limits are also in force.

The Department considers that the above measures will further minimise the risk of traffic accidents at the gate of the facility.

The total combined explosion frequency for AN in storage at the Crawfords facility was estimated in the PHA to be 42 per million per year (pmpy). This was compared against various sources available in the public domain. Where applicable, the total frequency was determined for a facility equivalent in size to that proposed by Crawfords, i.e. 3 bagged stores and 1 containerised storage.

Four sources of data were reviewed:

1. Historical Accident Data

   Historical accidents relevant to this site for ammonium nitrate accidents include the Toulouse, 2001 and Cherokee, 1973 accidents. The total number of operating years used to determine the frequency of an explosion per year was based on several published QRAs quoting 400 storage sites per year over the last 40 years. This gives a historical accident rate of 62.5 pmpy for either an explosion of a bulk pile of off-spec AN due to contamination or an explosion of one stack of AN due to a fire, with a combined total of 125 pmpy per site. It should be noted that this includes facilities that may store larger quantities of AN.

2. SAFEX

The combined frequencies using base data suggested by SAFEX are estimated in

Table 1.

Table 1 Total AN explosion frequency according to base SAFEX frequencies for a Crawfords equivalent site

Store	Contamination [10^{-6} /yr]	Fire [10^{-6} /yr]	High Energy Impact [10^{-6} /yr]	Pile / Stacks	Total frequency [10^{-6} /yr]
AN Bags or Containers (Per stack up to 2,500 tonnes)	25	-	5	7	210
	-	25 (no pallets)	-	6	150
	-	50 (with pallets)	-	1	50
				Total	410

The AN explosion frequency according to base SAFEX data is estimated at 410 pmpy. It should be noted that this frequency is derived from poorly managed and substandard facilities (particularly Cherokee and Toulouse) and SAFEX allows for a reduction based on implementation of 'best practice' control measures.

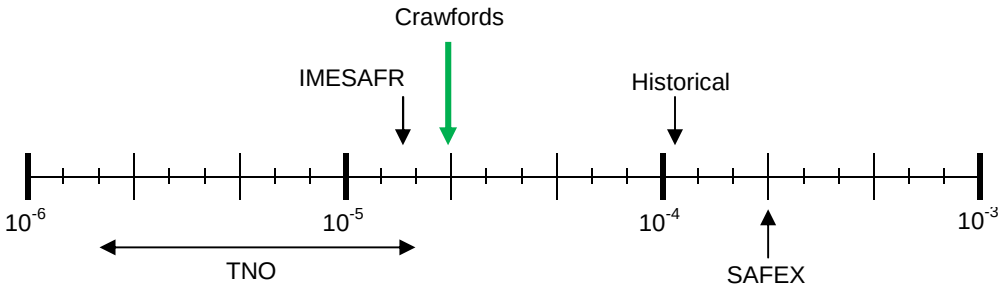
3. TNO Purple Book

Similarly, using the frequency quoted by TNO for a mass detonation from the storage of high explosives[1] (10 pmpy per store), the total explosion frequency for a Crawfords equivalent site is 30 pmpy. However as this is for high explosives, it is assumed that for AN, it could be up to a magnitude lower.

4. IMESAFR

Using the frequency quoted by IMESAFR for an AN explosion[2] (9.3 pmpy per store), the total explosion frequency for a Crawfords equivalent site is ~ 28 pmpy.

The frequencies from the various sources are summarised below.



From the above, it can be seen that the total explosion frequency used in the PHA for Crawfords is more conservative than some other sources (IMESAFR, TNO). Furthermore, it is still ~30% of the historical explosion frequency, despite storing less AN than one of the sites on which these frequencies were based (> 30,000 tonnes at Toulouse). The explosion frequencies quoted by SAFEX were derived from poorly managed and substandard facilities (particularly Cherokee and Toulouse). SAFEX allows for a reduction to the base frequencies

[1] *Section 3.28 Storage of Explosives,TNO Purple Book*
[2] *Institute of Makers of Explosives Safety Analysis for Risk (IMESAFR) software*

based on implementation of 'best practice' control measures. The calculated frequency based on values reported by SAFEX is already conservative at four times the historical average. Therefore the total combined frequency for Crawfords (10% of SAFEX) is justifiable.

It is concluded that the frequency analysis is within reasonable limits of the historical average and is appropriate for the Crawfords facility.

7. RISK

The off-site risks posed by the hazardous incidents have been estimated using the results of the consequence and frequency analysis. The risks to people and property were represented as a consequence distance to specified levels of overpressure and toxic impact. The following risks were estimated and presented in manner to assess compliance against the relevant criteria from HIPAP No. 4 *Risk Criteria for Land Use Safety Planning*:

1. Individual fatality risk;
2. Risk of injury from toxic impact and explosion overpressure;
3. Risk of irritation from toxic impact;
4. Risk of property damage and accident propagation; and
5. Societal risk.

The risk to the biophysical environment was qualitatively assessed.

8. FINDINGS & CONCLUSION

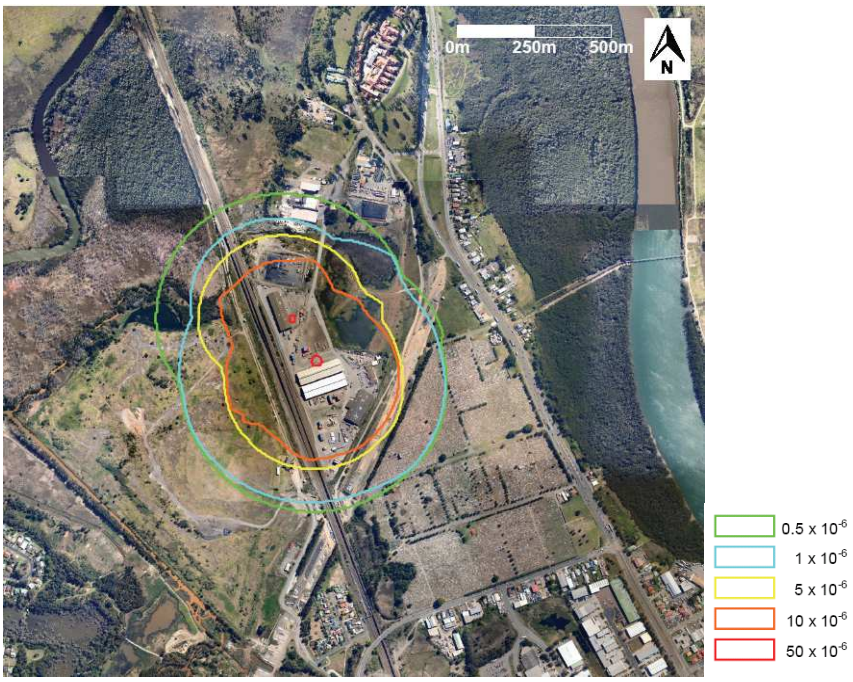
In an earlier review of the PHA, the 50 pmpy criterion for cumulative individual fatality risk extended to the nearby Scafflink facility and the 10 pmpy contour extended to the Golf Driving Range. Further risk reduction measures were proposed by Crawfords, which resulted in a reduced off-site risk as shown in the latest revision (Rev 4).

Some of the key risk reduction measures proposed by Crawfords include:

1. Optimising AN storage arrangements, i.e. maximising appropriate segregation of AN stacks wherever practicable to prevent an explosion involving the entire store;
2. Fire protection systems;
3. Procedures for preventing the contamination of AN; and
4. Refurbishment of the storage buildings with existing timber.

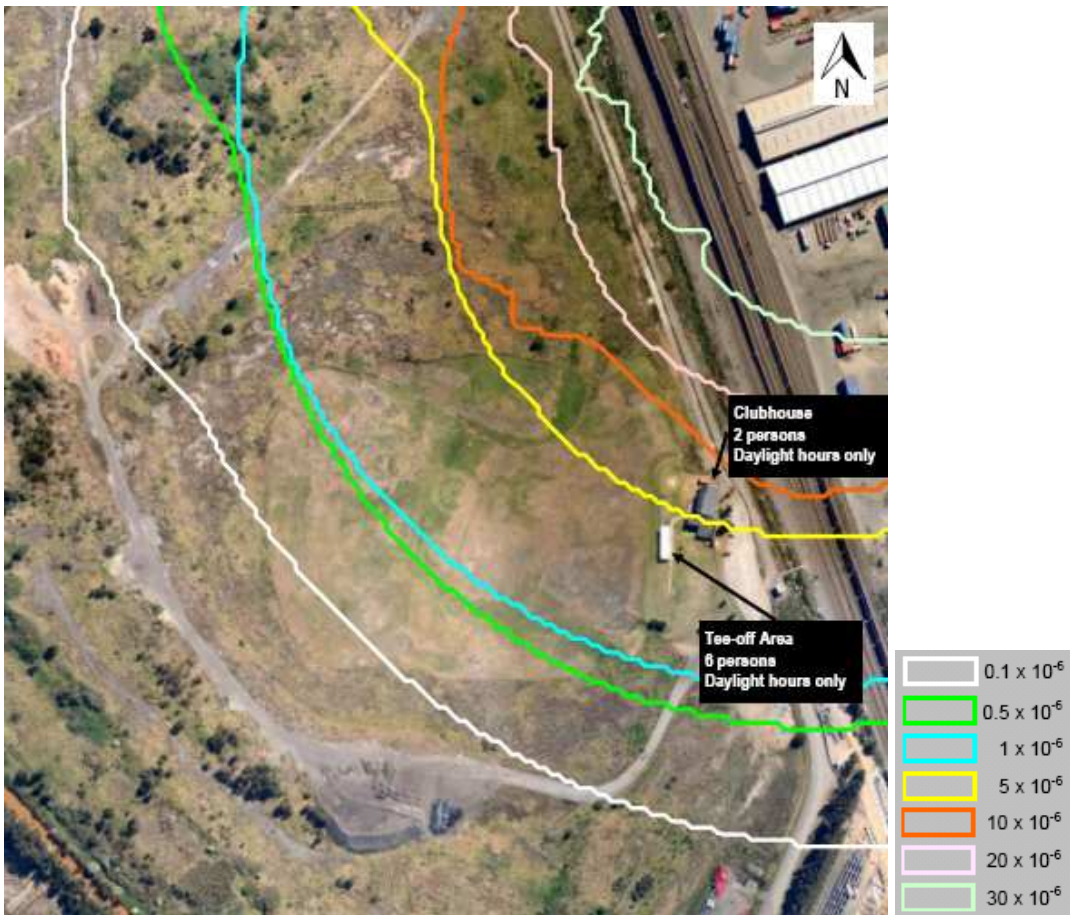
The figure below shows the cumulative individual fatality risk criteria for Crawfords proposed facility.

Figure 2 Cumulative Individual Fatality Risk



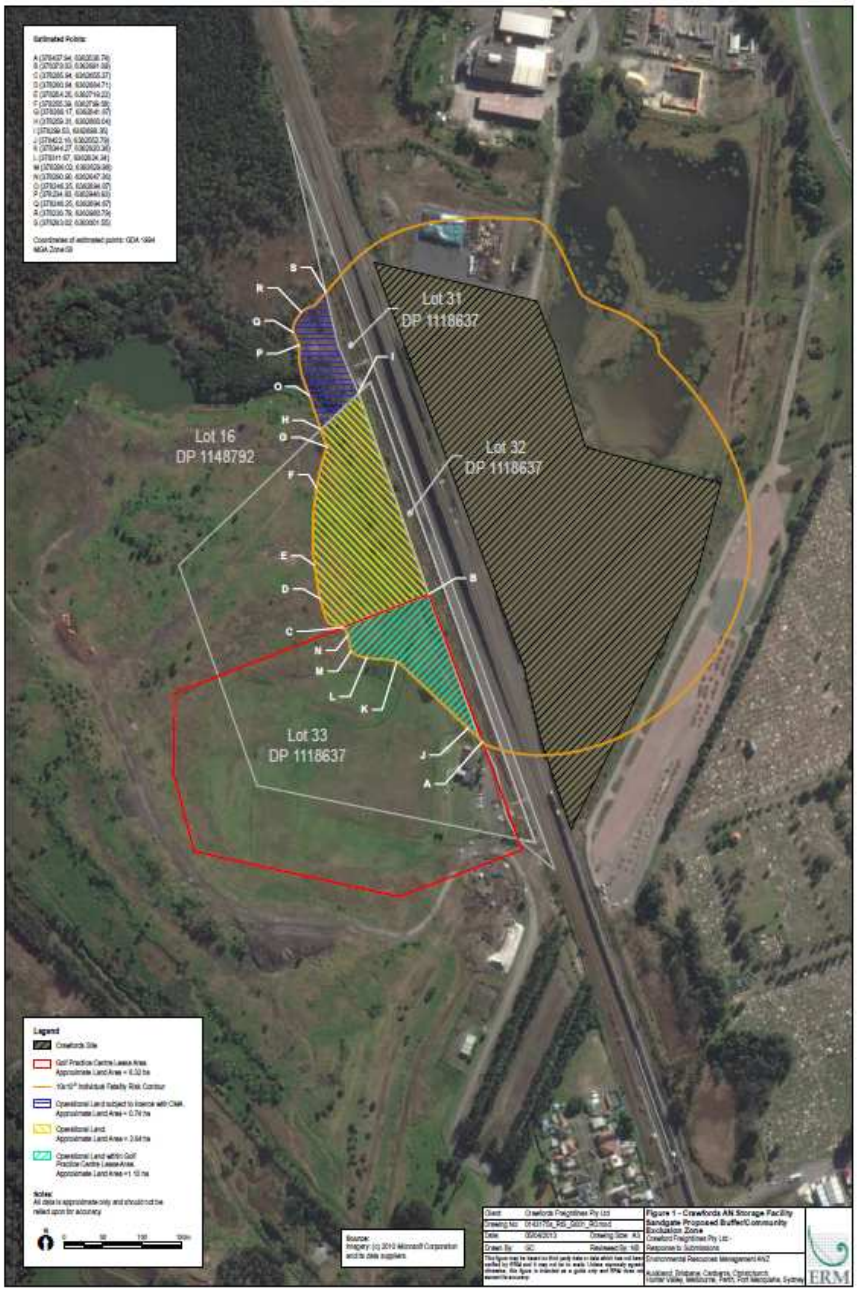
The contour for the active open space criterion (viz. orange line at 10 pmpy) extends approximately 250 m beyond the west boundary. We understand that part of this land is leased to a private entity for the purpose of a Golf Driving Range and as such it should be considered an open space land use. Consequently, the Department requested additional information on the magnitude of the risk and potential presence of people at this area. This is detailed in the next figure.

Figure 3 Cumulative Individual Fatality Risk (Golf Driving Range)



At the boundary to the area zoned for active open space, the risk level reaches 30 pmpy and reduces to 10 pmpy prior to reaching the clubhouse. The area within the golf driving range where the 10 pmpy criterion is exceeded, is not normally occupied. The area affects two parcels of land, both owned by Newcastle City Council. Crawfords is currently in consultation with the leaseholder of the golf driving range and Newcastle City Council regarding this issue. To ensure that the public access to the area is restricted, an appropriate Condition of Approval is imposed.

Figure 4 Lots affected by the Active Open Space Criterion



The methods used to conduct the risk analysis and selection of appropriate key parameters are appropriate. Crawfords has included practical control and mitigation measures. It would be difficult to justify any further risk reduction without reducing the maximum AN storage quantity on site. However, as this analysis was conservatively based on the maximum capacity being stored 100% of the time, periods of low storage would reduce the risk from the levels presented in the PHA. The Department considers this to be an appropriate and conservative approach compliant with the principles of HIPAP No. 6.

Indicative societal risk criterion is presented in HIPAP No. 4 *Risk Criteria for Land Use Safety Planning* and incorporates the ALARP (As Low As Reasonably Practicable) approach. The results of the PHA show that the societal risk for this facility lies in the ALARP region. Within this region, the emphasis is on reducing the risks as far as practicable towards the negligible region.

Crawfords has identified in the PHA the measures to be adopted to reduce the risk to ALARP. The results of the societal risk are also indicative of the low population density in the immediate surroundings of the facility. The Department is satisfied with the results of the societal risk estimated in the PHA.

In light of the recent accident at West, Texas in April 2013, all relevant findings and recommendations from all official investigation report/s (if available) are required by Condition of Approval to be addressed post preliminary hazard analysis.

Based on the information provided, the Department concluded that:

1. The cumulative individual fatality risk at the nearest active open space (10 pmpy criterion) encroaches beyond the boundary to the west of the facility and therefore additional measures ensuring restriction of public access are imposed;
2. All the remaining risk criteria; including risk to property damage and biophysical environment are compliant; and
3. Societal risk is As Low As Reasonably Practicable.

Assuming that all safety control measures listed in the PHA are implemented and maintained, the Department is satisfied that the facility will not pose unacceptable risks to the surrounding land uses. The following conditions of consent are recommended to ensure this is met:

1. Prior to the commencement of any operation, the Applicant must, to the satisfaction of the Director-General, demonstrate that suitable arrangements are in place to prohibit public access to the Off-Site Restricted Access Area as labelled and illustrated in Figure 4. As part of demonstrating the suitable arrangements for the Off-Site Restricted Access Area are in place, the Applicant must:
   - provide evidence that each landowner within the Off-Site Restricted Access Area has been consulted and agrees with the proposed measures, including Council and the lessee of Part Lot 33 DP 1118637 (i.e. the Sandgate Golf Practice Centre);
   - provide details of the measures proposed to prohibit public access, such as secure fencing and signage; and
   - investigate and detail options to purchase or secure land within the Off-Site Restricted Access Area in perpetuity.

2. The Applicant must obtain the written approval of the Director-General of the arrangements for the Off-Site Restricted Access Area in Condition 1 above:
   - every 12 months from the Director-General's approval of Condition 1 above (i.e. the yearly anniversary); and
   - at any time any arrangement established under Condition 1 above changes or is modified.

3. In any case, the Applicant shall not store more than 13,500 tonnes of ammonium nitrate on the site at any one time.

4. The Applicant shall maintain the appropriate ammonium stack separation distance, as recommended by SAFEX International *Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate* or better, to prevent involvement of more than half the storage capacity of each storage building in an explosion.

Pre-construction

5. At least one month prior to the commencement of construction of the proposed project (except for construction of those preliminary works that are outside the scope of the hazard studies), or within such further period as the Director-General may agree, the Applicant shall prepare and submit for the approval of the Director-General the studies set out under subsections (a) to (c) (the pre-construction studies) of this Condition. Construction, other than of preliminary works, shall not commence until approval has been given by the Director-General and, with respect to the Fire Safety Study, approval has also been given by Fire and Rescue NSW.

a) CONSTRUCTION SAFETY STUDY
A Construction Safety Study, consistent with the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 7, 'Construction Safety'*. For projects in which the construction period exceeds six (6) months, the commissioning portion of the Construction Safety Study may be submitted two months prior to the commencement of commissioning.

b) FIRE SAFETY STUDY
A Fire Safety Study for the proposed project. This study shall cover the relevant aspects of the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 2, 'Fire Safety Study Guidelines'* and the New South Wales Government's *'Best Practice Guidelines for Contaminated Water Retention and Treatment Systems'*. The study shall also be submitted for approval to Fire and Rescue NSW.

c) FINAL HAZARD ANALYSIS
A Final Hazard Analysis of the proposed project, consistent with the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 6, 'Hazard Analysis'*. The FHA shall:

- address all relevant findings and recommendations from all official investigation report/s (if available) on the accident at West, Texas in April 2013;
- re-evaluate and confirm all relevant data and assumptions from the Preliminary Hazard Analysis; and
- re-evaluate and confirm all control measures proposed for the prevention and mitigation of incidents, particularly those controls relevant to ammonium nitrate.

Pre-commissioning

6. The Applicant shall develop and implement the plans and systems set out under subsections (a) to (c) of this Condition. No later than two months prior to the commencement of commissioning of the proposed project, or within such further period as the Director-General may agree, the Applicant shall submit, for the approval of the Director-General, documentation describing those plans and systems. Commissioning shall not commence until approval has been given by the Director-General.

a) TRANSPORT OF HAZARDOUS MATERIALS
Arrangements covering the transport of hazardous materials including details of routes to be used for the movement of vehicles carrying hazardous materials to or from the proposed development. The routes shall be selected in accordance with the Department of Planning' draft 'Route Selection' guidelines. Suitable routes identified in the study shall be used except where departures are necessary for local deliveries or emergencies.

b) EMERGENCY PLAN
A comprehensive Emergency Plan and detailed emergency procedures for the proposed project. This plan shall include consideration of the safety of all people outside of the project who may be at risk from the project, including any assets and employees occupying the area operated by Scafflink. The plan shall be consistent with the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 1, 'Emergency Planning'*.

c) SAFETY MANAGEMENT SYSTEM
A document setting out a comprehensive Safety Management System, covering all on-site operations and associated transport activities involving hazardous materials. The document shall clearly specify all safety related procedures, responsibilities and policies, along with details of mechanisms for ensuring adherence to the procedures. Records shall be kept on-site and shall be available for inspection by the Director-General upon request. The Safety Management System shall be consistent with the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 9, 'Safety Management'*.

Pre-startup

7. PRE-STARTUP COMPLIANCE REPORT
One month prior to the commencement of operation of the project, the Applicant shall submit to the Director- General, a report detailing compliance with Conditions 4 and 5 of this Schedule, including:

a) dates of study/plan/system submission, approval, commencement of construction and commissioning;
b) actions taken or proposed, to implement the recommendations and safety-related control measures in the studies/plans/systems; and
c) responses to each requirement imposed by the Director-General under Condition 10 of this Schedule.

Post-startup

8. POST-STARTUP COMPLIANCE REPORT
Three months after the commencement of operation of the project, the Applicant shall submit to the Director- General, a report verifying that:

a) the transport routes specified under Condition 5(a) are being followed;
b) the Emergency Plan required under Condition 5(b) is effectively in place and that at least one emergency exercise has been conducted; and
c) the Safety Management System required under Condition 5(c) has been fully implemented and that records required by the system are being kept.

Ongoing

9. HAZARD AUDIT
Twelve months after the commencement of operations of the proposed project and every two years thereafter, or at such intervals as the Director-General may agree, the Applicant shall carry out a comprehensive Hazard Audit of the proposed project and within one month of each audit submit a report to the Director-General.

The audits shall be carried out at the Applicant's expense by a qualified person or team, independent of the project, approved by the Director-General prior to commencement of each audit. Hazard Audits shall be consistent with the Department of Planning's *Hazardous Industry Planning Advisory Paper No. 5, 'Hazard Audit Guidelines'* (HIPAP No. 5).

The audit reports shall, in addition to the requirements provided in HIPAP No 5:

- address all relevant findings and recommendations from all official investigation report/s (if available) on the accident at West, Texas in April 2013, and make recommendations if necessary;
- Report on the findings of the audit in relation to compliance with the current version of AS 4326 - the Storage and handling of oxidizing materials and the relevant provisions of the current version of the SAFEX International *Good Practice Guide: Storage of Solid Technical Grade Ammonium Nitrate*;

The audit report must be accompanied by a program for the implementation of all recommendations made in the audit report. If the Applicant intends to defer the implementation of a recommendation, reasons must be documented.

On-site Risks

10. The Applicant shall ensure that the Construction Safety Study (see Condition 4(a) of this Schedule), the Final Hazard Analysis (see Condition 4(b) of this Schedule), Safety Management System (see Condition 5(c) of this Schedule) and the Emergency Plan (see Condition 5(b) of this Schedule) for the site include an assessment and evaluation of all hazards that could contribute to both on site and off-site risks to the satisfaction of WorkCover NSW. All maps showing the risk contours for on site and off-site risks shall be included in each of the aforementioned documents.

11. FURTHER REQUIREMENTS
    The Applicant shall comply with all reasonable requirements of the Director-General in respect of the implementation of any measures arising from the reports submitted in respect of Conditions 4 to 9 of this Schedule inclusive, within such time as the Director-General may agree.