

ENVIRONMENTAL RISK ASSESSMENT IN SUPPORT OF COMAH AND PPC

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There is an increasing need to develop better methods for undertaking environmental risk assessments. Many companies have developed simple qualitative methods, but are wary of undertaking more detailed and quantitative assessments. This paper proposes a means of undertaking more robust environmental risk assessments, developed to address the environmental risk requirements in COMAH and PPC.

KEYWORDS: environment, risk assessment, COMAH, PPC

INTRODUCTION

There is an increasing need to establish formal methods for the identification of environmental hazards and assessment of environmental risks, in particular for Control of Major Accident Hazards (COMAH) safety reports and Pollution Prevention and Control (PPC) applications. Many companies have developed environmental risk methods based on simple risk matrices but are wary of undertaking more detailed and quantitative environmental risk assessments. This paper proposes a practical way forward for environmental risk assessment, including quantitative assessments, developed for COMAH safety reports, but which can be also be used to develop the accident management plans and support the Best Available Techniques (BAT) assessments required under PPC. In particular the paper covers:

- The background to environmental risk assessment
- An overview of the approaches used
- Pitfalls and problems with environmental risk assessment.
- A practical approach adopted for COMAH and PPC
- Case studies

BACKGROUND TO ENVIRONMENTAL RISK ASSESSMENT

Unlike safety risk assessment, the requirement for undertaking formal environmental risk assessment has not been an explicit requirement in the regulations until recently. Hence, compared to safety risk assessment, environmental risk assessment is less well developed and less well understood. There are a number of problems peculiar to environmental risk assessment that make it more challenging to risk assessment professionals. In particular in the assessment of consequences and the acceptability of risk.

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In more recent environmental legislation, the need for formal environmental risk assessment has been more explicitly asked for. In particular in the COMAH and the PPC regulations and the Environment Agency has responded by producing guidance on how to undertake the assessments required.

Despite the issue of guidance, the general lack of background in formal environmental risk assessment has led to the standard of environmental risk work undertaken in support of COMAH Safety Reports to be poor and has often not met the requirements of the regulator, requiring re-appraisal of the work and in many cases the complete re-submission of the risk assessment. Under PPC, the guidance has been easier to apply since the requirements are more qualitative than quantitative, hence the submissions have generally been more acceptable.

The approach recommended for environmental risk assessments usually mirrors that used for safety risk assessment and normally addresses seven basic questions:

- What can go wrong? This requires some form of environmental hazard identification.
- How often? An estimate of impact frequency is required.
- What gets out and how much? An evaluation of the size of release is required.
- Where does it go? The environmental pathways must be identified and the dispersion and deposition of the pollutant estimated.
- What are the consequences? The sensitive receptors likely to be affected must be identified and the impact of the accident estimated.
- What are the risks? Determination of the risk level and assessment of significance is required.
- What risk management is required on the basis of ALARP (As Low As Reasonably Practicable)?

OVERVIEW OF THE RISK ASSESSMENT METHODS FOR PPC AND COMAH

Under PPC, there is a need to produce Accident Management Plans, as defined in Section 2.8 of the application templates. The structure of the template is familiar to most risk practitioners and is shown in Table 1. Guidance on the production of accident management plans is provided in the various sector PPC guidance notes and the associated application

Table 1. Example of the accident management plan format for PPC

Event N°	Accident or Abnormal Release Event	Initiating Event	Initial Consequence Loss and Pathway Affected	Eventual Consequence	Frequency of Occurrence	Controls to Prevent/Minimise Possibility of Event Occurring	Actions Planned to Mitigate Effect of the Event

templates. From this, there may be a need to look in more detail at the more significant environmental risks, especially where these are not covered by the COMAH environmental risk assessment. Under PPC, accident analysis is also required as part of the assessment to establish BAT. Guidance on such analysis is provided in the BAT Guidance Note H1[1]. The objective of this assessment is to establish whether a particular option carries significant environmental risks arising from plant accidents compared to other options.

The objective of a COMAH environmental risk assessment is to identify the environmental hazards presented by an operation and provide an assessment on whether such hazards can give rise to a major accident to the environment (MATTE). The guidance states that all MATTEs must be identified, irrespective of what controls are in place to reduce the frequency of the MATTE. Where MATTEs are identified, the risks require further assessment to establish whether the frequency or consequence can be reduced, such that the residual risks are ALARP.

The approach adopted should follow that presented in the Competent Authority guidance document on environmental risk assessment[2] and what constitutes a MATTE should be based on DETR guidance issued in support of COMAH[3]. Other important points in the guidance that have a significant bearing on the COMAH risk assessment are:

- A MATTE must involve a dangerous substance (as defined in the COMAH regulations), but not necessarily impact arising directly from contact with a "dangerous substance". For example, the dangerous substance may be involved in a fire that causes the release of a substance that is not defined as "dangerous" in the regulations, but which may still cause a MATTE.
- It is acceptable to initially undertake a qualitative assessment of the risks moving through to more quantitative assessment when, because of the scale or complexity of the risk, more detailed assessment is required.
- Those MATTEs with a frequency less then $1 \times 10^{-6}\ yr^{-1}$ (i.e. less than one in a million years) may be screened out and do not require any further ALARP assessment. The aim being to focus the ALARP assessments on the more significant risks.

PITFALLS AND PROBLEMS WITH ENVIRONMENTAL RISK ASSESSMENT

The COMAH guidance acknowledges that the depth of an environmental risk assessment may not be as great as that for a safety risk assessment, mainly because of a paucity of data available to establish whether MATTEs are likely and at times a degree of subjective judgement is required. Particular problems are:

1. Often details on the most sensitive receptors are not known in a certain area.
2. Information may not be available on the pollutant concentrations that are likely to have an adverse effect on the receptors identified. This is particularly the case when needing to determine the impact due to wet deposition.
3. Whether an effect is adverse or not may depend on the recovery time for the receptor, and this is often unknown.

4. Dispersion modelling to establish consequences in the aqueous environment can be expensive.
5. Cost/benefit analysis is less developed for environmental assessments than for safety assessments.

As a result of these difficulties the consequence assessments tend to err on the side of pessimism and this may be a problem if significant costs are involved in order to reduce the risk. Generally, one will start off with a with a more simple pessimistic consequence assessment. If this shows the risk to be unacceptable, then rather than considering risk reduction options, it may be better to consider more detailed consequence assessment to confirm if the risk is indeed significant e.g. by undertaking detailed water modelling to ascertain the environmental concentrations. Alternatively, further detailed searches to establish better toxicity data may yield data that indicates the assessment has been overly pessimistic.

A PRACTICAL APPROACH FOR COMAH AND PPC ENVIRONMENTAL RISK ASSESSMENTS

In line with the guidance, the following approach has been adopted for COMAH environmental risk assessments by AK EHS & Risk:

1. A hazard identification (hazid) is undertaken to produce a list of environmental hazards. As part of the hazid, events with low consequence are screened out. This hazid can then be used to develop the accident management plans required under PPC, particularly if an initial review of event frequency is also undertaken at the hazid stage.
2. For the remaining more hazardous events, these are grouped into release categories. For each release category, the hazardous event with the likely worst case consequences is selected.
3. Detailed consequence assessment work is undertaken on the worst case events. Where possible this is quantitative in nature. The objective being to establish whether an event has the potential to cause a MATTE. If the worst case event in the group does not give rise to a MATTE, the other events in the group are not considered further. If the worst case event does give rise to a MATTE, the next worst case event is then considered and this repeated until the event considered does not cause a MATTE.
4. This gives a list of MATTEs, which are then each assessed to determine whether the risk is ALARP.

These steps are discussed further in the following sections.

HAZID

The AK EHS & Risk hazid approach involves a series of meetings with key site personnel, postulating a series of loss of containment scenarios that could have environmental consequences e.g. storage tank failure, pipe leakage, pump failure etc. This identifies both the sources and the environmental pathways that may cause a MATTE. In preparation for the hazid, the main environmental receptors at risk need to be identified.

An initial qualitative review of environmental consequences and frequencies is undertaken as part of the hazid. The former to screen out those hazardous events considered to have a low or very low consequence to the environment, to reduce the subsequent assessment work required for the COMAH risk assessment. The latter is done mainly to help produce the accident management plans for PPC or support other BAT assessment work required under PPC.

This qualitative review is often based on criteria used by the client. An example of criteria is presented in Table 2.

EVENT GROUPING

In order to simplify the COMAH risk assessment, the remaining events from the screening exercise are grouped into a number of event categories, dependant on the release pathway and the nature of the release e.g. was it liquid or vapour/gas, water soluble etc. This may also be used if other significant environmental risks require further investigation under PPC.

The events are then ranked in each category according to their potential environmental impact to establish the worst case event for the detailed assessment of risk. An example of event grouping from one study is as follows:

Category 1: Events leading to ammonia emissions to air.
Category 2: Events leading to acid fume emissions from acid storage systems.
Category 3: Events leading to the release of toxics following a fire
Category 4: Events leading to contamination of unmade ground.
Category 5: Events leading to the loss of soluble material to site drain system.

Table 2. Example of risk matrix criteria

	Severity	Frequency
Very low	Minor effects — contained within vicinity of plant.	Inconceivable in the plant's lifetime.
Low	Effect localised and short term e.g. odour nuisance.	Difficult to imagine in the plants life time.
Medium	Breach of consent or an environmental assessment level.	Event could happen in the plant's lifetime.
High	Some discernible environmental damage e.g. to a SSSI.	Event is very likely to happen at least once in the plants lifetime.
Very High	MATTE e.g. adverse effect likely to more than 10% or 0.5 hectares of a SSSI.	Event has already occurred.

DETAILED CONSEQUENCE ASSESSMENT

For accidental emissions to the atmosphere, the consequence assessment required to identify MATTEs under COMAH or other significant risks under PPC, will normally involve dispersion modelling to establish ground level concentrations of pollutants. Both ADMS and PHAST have been used for this. ADMS is used particularly to establish deposition rates. The ground level concentrations can then be compared with, for example, the short-term Environmental Assessment Level (EAL) or LC50 data to establish the potential for a MATTE.

For accidental emissions to the site drains some allowance is made for dilution in the drains. This gives the release concentration at the outfall. A dispersion rate can then be taken from Reference 1 and the environmental concentration estimated using the mixing rules that are also in Reference 1. These concentrations can again be compared to the relevant toxicity data to establish the MATTE potential or risk. More detailed modelling is generally not required, particularly in view of the complexity and cost of water dispersion modelling, although the regulator could insist on it if the risk (i.e. the frequency of a MATTE) is believed to be high.

For accidental emissions to ground, risks to the environment are normally assessed from a review of available data on the site geology and hydrogeology and establishing the half-lives of the chemicals involved in the groundwater environment. Judgements on risk are then based on:

- The quantities lost.
- Retention times within the groundwater system.
- The half-lives for the substances.

There are three types of substance that can be lost to drain or unmade ground which need to be considered and the consequence assessment will be somewhat different for each. These are:

1. Water soluble substances.
2. Substances immiscible or largely immiscible in water and less dense than water.
3. Substances immiscible or largely immiscible in water and denser than water.

The outcome from this detailed consequence assessment work should be a list of all MATTEs and/or other significant environmental risks associated with a process.

RISK ACCEPTABILITY

Where potential MATTEs, or in the case of PPC other significant risks have been identified, investigation of further risk reduction measures is required. This involves making judgements on whether the risk is acceptable, bearing in mind the controls that are in place and the cost of additional controls. This usually requires some form of frequency analysis followed by cost-benefit analysis, the latter involving determining a range of options for risk reduction and establishing the costs and the reduction in risk for each option. Judgements should, if possible, be quantitative (e.g. using incremental cost analysis) or semi-quantitative (e.g. using multi-attribute analysis). Qualitative judgements may not be acceptable to the regulator, especially for high levels of risk.

Under COMAH, detailed assessment of the frequency is allowed to eliminate those MATTEs with a frequency less than $1 \times 10^{-6}\ yr^{-1}$ from further risk assessment. This is in line with the guidance and pre-supposes that these low frequency risks are ALARP. The frequency assessment can be done using the techniques used in safety risk assessments e.g. fault and event tree analysis.

As a general rule, the event trees should give consideration to mitigatory defences such as the use of bunds on storage vessels. However some site inspectors may prefer not to allow consideration of the bund in the frequency calculation, possibly based on past experience with poor bund maintenance on the site. This should be checked with the inspector before undertaking the risk assessment. It is important that the basis of each frequency calculation is clearly stated to allow the site inspector to challenge the frequency, if required. This will also allow quick review of the frequencies if there are any changes to plant hardware or management systems, thus allowing assessment of the effect of any change on the safety report or PPC permit.

It is debatable whether MATTEs with a frequency less than $10^{-6}\ yr^{-1}$ should nevertheless be considered in the development of the off-site emergency plans. Companies AK EHS & Risk have dealt with to date have tended not to consider them further, although in time the Environment Agency may dispute this tendency not to consider them further.

CASE STUDIES

CASE STUDY 1

This is based on an environmental risk assessment undertaken in support of a COMAH safety report for a chemicals company and for production of their PPC accident management plan. The site processes a range of acidic, flammable and environmentally toxic chemicals, storing all of these in bulk. Its drains run to controlled waters and there is a Site of Special Scientific Interest (SSSI) near to the site.

A series of environmental hazid meetings were undertaken to establish what loss of containment incidents could give rise to a MATTE. This involved assembling a team comprising operations and site environmental staff, led by an AK EHS & Risk Chairperson. Hazids were undertaken for each of the plant areas and involved operations staff from the relevant plant area. An example of the hazid output is provided in Table 3. The accident management plans for PPC were then derived from this output.

For the COMAH risk assessment, the frequency and consequence of the events considered were plotted on risk matrices to help give an early idea of the significant risks and to aid the screening of events. An example of a matrix developed for this project is shown in Figure 1. The shaded areas on the matrices show those events (indicated by their Hazid event number) that have the potential to cause a MATTE at a frequency

Table 3. Case 1 – example of the environmental hazid output

Accident or Abnormal Release Event	Initiating Event	Initial Consequence/loss and Pathway Affected	Eventual Consequence	Frequency of Occurrence	Controls to Prevent/Minimise Possibility of Event Occurring	Actions Planned to Mitigate Effect of the Event
Rupture of bulk storage tank Event Number 5.1.1	Vent blockage. Vacuum Impact by dropped object. Missile impact. External corrosion.	Air: Not volatile. Water/Land: Contained within bund.	Notifiable	Unlikely	Luted pressure relief system on tank. Vessel inspections carried out. Crane operations done under procedures and risk assessment Operators trained.	Vessel bunded. No valve on bund wall If bund fails, loss will be contained Frequency of concurrent bund failure considered to be extremely unlikely.
Tanker rupture (delivery once per month) Event Number 5.1.2	Corrosion. Impact by dropped object. Vehicle impact. Missile impact.	Drains into the effluent tank where it can be trapped and dealt with.	Notifiable	Unlikely	Drivers training. Driver and operator are present during offloading. Crane operations done under procedures and risk assessment, Site speed limits.	Hardstanding area that drains into the effluent plant. Emergency response procedures in place. Emergency training done. Emergency equipment in place.
Tank Overflow Event Number 5.1.3	Level instrument failure. Operator error.	Contained in bund.	Minor	Possible	High alarm.	As above
Fire/ Explosion Event Number 5.1.4	Flammable material (Flash Point 32°C)	Air — Some breakdown to ammonia as well as normal combustion products and smoke.	Notifiable. May be Significant.	Unlikely	Hot work permit system in place. Zone 1 area. Earthing in place. Flame arrester on tank.	Fire fighting systems Emergency response procedures in place. Emergency training in place. Emergency equipment in place.

Likelihood	Minor	Notifiable		Significant		Major
Probable						
Possible	1.1.10J 1.2.4F 1.3.7F 1.3.9H	1.1.7F		1.3.6D		
Unlikely		1.2.1A 1.2.3D 1.3.1aA 1.3.1bA 1.3.2A	1.3.3aC	1.1.2C 1.1.4B 1.1.5B 1.1.6C 1.1.9H	1.2.2A 1.2.5H 1.3.3bA 1.3.5A 1.3.8G	1.1.1A 1.1.3A
Extremely Unlikely	1.1.11 I 1.1.12 I 1.3.11H			1.1.8G 1.1.13J 1.1.14G 1.3.10A		
Consequence	Minor	Notifiable		Significant		Major

Note: The terms used in this matrix are based on the matrix in Guidance Note H1 (Reference 1)

Figure 1. Risk matrix output

greater than 1×10^{-6} yr^{-1}. The letters at the end of the event numbers indicate the type of incident, i.e.

A. Catastrophic failure
B. Guillotine (of pipe)
C. Hole/rupture (non-specific)
D. Hole (12 mm)
E. Hole (6 mm) — not used in this assessment
F. Pinhole
G. Overflow
H. Valve left open/fails open
I. Fire/Ignition
J. Other

The higher consequence events were then categorised as shown in Table 4 and the worst case event from each category selected for detailed risk assessment.

For possible acid gas releases to air, PHAST was used to establish the release rates and environmental impacts. ADMS was used to establish the consequences of wet deposition (during rainfall). The probability of rainfall was taken into account when establishing the frequency of impacts, as was the probability of the wind blowing in the direction of the adjacent SSSI. Those events that had impact frequencies less than 1×10^{-6} yr^{-1} were discounted from further analysis.

Table 4. Case 1 — event categorisation

Category	Sub-Category	HAZID Event Numbers	Worst Case Events Considered
Aerial Emission	Acid Storage System	1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.5, 1.1.6, 1.1.9, 1.2.2, 1.2.5.	Worst case will be loss from storage tanks – Event 1.1.1.
	Toxic product(s) from chemical breakdown in fire	2.1.8, 3.1.7.	Need to look at: 2.1.8 — Aromatic derivative fire. 3.1.7 — Organic compound fire.
Loss to Unmade Ground	Loss of water soluble chemicals	None identified.	
	Loss of more dense water insoluble chemicals	None identified.	
	Loss of less dense water insoluble chemicals	5.11.3, 6.13.2, 6.13.3.	5.11.3 — Heavy Alcohol. 6.13.2 — Gas Oil.
Loss to Sea Via the Site Drains	Loss of water soluble chemicals	2.5.2, 3.1.8, 6.1.3, 6.2.2, 6.2.3, 6.2.7, 6.8.3, (Methanol Store), 6.12.2 (methanol distillation), 6.12.5.	6.2.2 — Methanol.
	Loss of more dense water insoluble chemicals	2.1.2, 2.1.3, 2.1.9.	2.1.2 — Aromatic derivative.
	Loss of less dense water insoluble chemicals	2.4.2, 2.4.3, 2.7.7 (from amine reactors), 4.5.6, 5.11.1, 5.11.2, 5.11.3, 6.13.2, 6.13.3.	4.5.6 — Heavy Alcohol. 5.11.1— Heavy Alcohol.

The most significant meteorological parameters governing the atmospheric dispersion of pollutants following a loss of containment event are as follows:

- Wind speed affects plume dispersion by increasing the initial dilution of pollutants and by inhibiting plume rise.
- Atmospheric stability, which is a measure of the atmospheric and the upward progression of the plume. Maximum ground level concentrations usually occur when atmospheric conditions are stable and dispersion is suppressed. Pasquill-Gifford classification F indicates a very stable atmosphere with a boundary layer height of around 100 m. These conditions produce higher concentrations at greater distances downwind. F stability typically occurs at night, or early in the evening during summer. Conditions such as neutral stability (D) are more common in the UK (about 80% of time) and allow more effective dispersion of the pollutant cloud producing lower vapour concentrations at distant receptors.

F2 (stability condition F and 2 m/sec windspeed) and the more common D5 conditions were used to model the atmospheric dispersion.

For releases into the ground, an assessment of the mobility of the chemical and its half-life indicated the likely impact at the local SSSI. Table 5 summarises the impact assessment.

Table 5. Case 1 — assessment of impact via the ground pathway

Chemicals of Concern	Environmental Fate (Ground)	Environmental Fate (Water)
Gas Oil	Low mobility in soils, vaporisation from moist soils. Biodegradation in soil 65% of theoretical BOD in 10 days. Degradation by-products considered to be heavy fraction hydrocarbon residues, CO_2 and water.	High absorbent to sediments, vaporisation from water surface, vaporisation half-life 4 hours in turbulent flow, 5 days in laminar flow. Biodegradation in water 75% of theoretical BOD in 24 hours. Degradation by-products considered to be heavy fraction hydrocarbon residues (BTEX, PAHs), CO_2 and water.
Heavy Alcohol	Moderate to low mobility in soils, slow vaporisation from moist soils. Biodegradation in soil 67% of theoretical BOD in 5 days. Degradation by products considered to be heavy fraction hydrocarbon residues, CO_2 and water.	High absorbent to sediments, slow vaporisation from water with half-life 1.1 days in turbulent flow to 12 days in laminar flow. Biodegradation 67% of theoretical BOD in 5 days. Degradation by-products considered to be heavy fraction hydrocarbon residues, CO_2 and water.

For releases into the sea, via the site drain system, dispersion of the material in the sea was estimated from a MIKE 21 computer dispersion model that was already in use by the client.

The outcome from the detailed risk assessment is summarised in Table 6.

For the predicted MATTEs, options for risk reduction were derived for each MATTE and considered in detail. Most of the risks could readily be reduced to acceptable levels by installing better containment systems around tanker off-loading facilities. For the acid gas emissions to atmosphere, a review against industry best practice was undertaken and further improvements identified for more detailed cost-benefit analysis. The cost benefit analysis was mainly based on analysis of impacts on people since human populations were closer to the site than the SSSI and hence were more at risk. This approach was accepted by the regulator.

CASE STUDY 2

For another company, we needed to quickly generate accident management plans for their PPC application. To expedite matters we used their COMAH work as the format since the hazids developed were similar to the accident management plans required for PPC. The COMAH tables were extremely detailed and thus allowed rapid development of them to produce the accident management plans required. This was done as a desktop study and did not require further hazid group sessions.

Table 6. Case 1 — summary of environmental risks

Substance	Events	Potential MATTE with Frequency $>10^6$ yr^{-1}	Comment
Acid Gas	1.1.1: Tank rupture. 1.1.2: 50 mm hole in tank. 1.1.4: Road tanker hose rupture. 1.1.6: Hole in supply pump. 1.1.9: Open end during offloading. 1.2.2: Heater line rupture. 1.2.5: Open end at purge point.	Yes	For loss to atomosphere.
	1.1.3: Road tanker rupture. 1.1.5: Supply line rupture.	No	Frequency less than 1×10^{-6} yr^{-1}.
Aromatic Derivative	2.1.2: Tanker rupture. 2.1.9: Loss in firewater run-off.	Yes	Loss to sea via the site drains.
	2.1.3: Hose rupture.	No	Loss likely to be contained in kerbed area.
	2.1.8: Fire and release of toxic substances to atmosphere.	No	Frequency less than 1×10^{-6} yr^{-1}.
Organic	3.1.7: Fire and release of toxic substances.	No	Frequency less than 1×10^{-6} yr^{-1}.
	3.1.8: Loss in firewater run-off.	No	Loss unlikely to reach sea drains. Kerbing to be reviewed.
Heavy Alcohol	5.11.3: Line rupture.	No	For loss to ground.
	4.5.6: Loss in firewater run-off.	No	Loss to sea considered unlikely in view of drains layout.
	5.11.1: Tank rupture. 5.11.2: Tanker/Hose rupture.	Yes	For loss to sea via drains.
Gas Oil	6.13.2: Tanker rupture. 6.13.3: Line rupture.	No	Frequency of loss to sea drain less than 1×10^{-6} yr^{-1}.
	6.13.2: Tanker rupture. 6.13.3: Line rupture.	No	For loss to ground.
Methanol	6.2.2: Tanker rupture. 6.2.12: Equipment rupture/failure. 6.2.3: Hose rupture. 6.2.7: Loss in firewater run-off. 6.8.3: Loss in firewater run-off. 6.12.5: Loss in firewater run-off.	No	Loss to sea via drains.

However it should be noted that using existing hazops or hazids to derive accident management plans or the hazids required for COMAH environmental risk assessment can be problematical, depending on how detailed the original assessments are. In particular it needs to be questioned whether the environmental consequences were assessed in the original review meetings. If they were, it needs to be established whether the consequence criteria used are suitable for the purposes of PPC and COMAH. If they were not, it needs to be established whether the safety consequence assessments are detailed enough to be able to derive environmental consequences.

CASE STUDY 3

A BAT assessment was undertaken on a number of storage systems on a large scale chemical plant. This was supported by an environmental risk assessment. This initially used risk matrices developed for the site COMAH risk assessments. Significant hazardous events were identified from these and assessed further to establish their environmental consequences and their likelihood of occurrence, quantifying these where possible. The resulting consequences and frequencies were then plotted onto a matrix showing the acceptability of risks i.e. showing whether the risks were acceptable or needing further assessment. This allowed the BAT assessment to focus on those areas where the risks were greatest.

The assessment involved:

- The use of tank data sheets, photographs and Piping and Instrumentation Diagrams (P&IDs).
- Identification of the environmental hazards associated with the stored chemicals and assessment of the likelihood of a chemical reaching the local river following loss of containment.
- Assessment of the tank maintenance requirements.
- Use of company systems used to identify tank criticality rating, determined from consideration of the environmental, safety and operational risks arising from equipment failure.

An example of the BAT risk assessment output is provided in Table 7.

CONCLUSION

The environmental risk assessments undertaken in support of COMAH safety reports have often needed to be re-worked and re-submitted to the regulator, to fully reflect the requirements of the guidance. This paper outlines an approach for undertaking the assessments which is in line with the guidance and which has been looked on favourably by the regulator. The approach has also learnt itself to undertake work in support of PPC applications, in particular, for producing the accident management plans and elements of the BAT assessments required.

Table 7. Case 2 — example of the risk assessment output

Accident or Abnormal Release Event	Initiating Event	Consequence of Occurrence	Likelihood of Occurrence	Measures to Prevent Occurrence	Measures to Mitigate Consequences of Occurrence	Acceptability of Event
Pin hole line leak above ground	Mechanical failure e.g.: through corrosion or erosion.	**Minor.** Small spill in tank vicinity. Spill would be contained within kerbed area and drain to the Effluent Pit.	**Fairly Unlikely.** Corrosion resistance data not available for stainless steel but inspections indicate corrosion is not an issue.	Tank is subject to maintenance inspection every 6 years. Leaks would be visible and would normally be detected by operations staff during daily plant routines.	Tank installed within a kerbed area with drainage channels directed to Effluent Pit.	**Acceptable**
Overfill	Failure of level equipment. Failure of shut off valve (manual or automatic). Overfill from tanker discharge.	**Noticeable** Spill in tank vicinity. Spill would drain via drainage channels to the Effluent Pit.	**Fairly Probable** The tank has one level instrument. The level instrument is subject to a 3 yearly maintenance field check. Prior to roadtanker discharge the ullage is checked to ensure adequate capacity exists in the tank for roadtanker discharge.	Level instrument is subject to a 3 yearly maintenance field check. Roadtanker offloading is supervised by plant personnel.	Overfill from tank would enter the Effluent Pit.	**Consider additional risk control measures.** For example, add level instrument to maintenance schedule.

However, for the assessment to be fully accepted by the regulator, the assessor also has to adequately address the pitfalls that are inherent to environmental risk assessment.

REFERENCES

1. Environment Agency/SEPA, Version 6 July 2003, Environmental Assessment and Appraisal of BAT — IPPC Horizontal Guidance Note H1.
2. COMAH Competent Authority, Version 2 December 1999, Guidance on Environmental Risk Assessment Aspects of COMAH Safety Reports.
3. DETR, July 1999, Guidance on the Interpretation of Major Accident to the Environment for the Purposes of the COMAH Regulations.