Addressing the Challenges of Applying the CDOIF Guideline for Environmental Risk Tolerability in Risk Assessments for COMAH Establishments

Carolyn Nicholls and Robert Ritchie, Risk and Hazard Management Consultants, RAS Ltd, 73 New Crane Street, Chester, CH1 4JE

The *Chemical and Downstream Oil Industries Forum* (CDOIF) *Guideline - Environmental Risk Tolerability for COMAH Establishments*, v2.0 has become the preferred methodology guidance by the Competent Authority (CA) for environmental risk assessments (ERA) for operators of sites covered by the Control of Major Accident Hazards (COMAH) Regulations.

Whilst the availability of the guideline has its benefits, such as promoting industry wide consistency in the accepted method for risk assessment in a field that can sometimes rely on little data and a lot of interpretation, application of the guideline does present some challenges.

One example of these challenges involves the application of Phase 1a (screening) of the guideline, which provides the foundation for the detailed ERA, but appears to require too much attention to environmental features which are not credibly within range of the hazards associated with the site in question. For instance, the guideline suggests that Major Accident to the Environment (MATTE) screening is performed for all features within 10 km without considering inevitable attenuation processes such as entrainment and evaporation which prevent the majority of the surrounding features from being reached. This would lead to additional time and resource being dedicated to predicting unmitigated consequences of harm that cannot credibly occur and could be avoided by identifying credible receptors using rationality and sound judgement.

The approach of RAS Ltd has been to use the CDOIF Guideline to develop a method which has been successfully used in a number of COMAH risk assessments. This paper seeks to raise some of the issues encountered when applying the methodology of the guideline and to highlight areas in which clarification on the expected approach would be beneficial to operators, ERA practitioners and the regulator. Examples are used, drawing from experience of establishments of varying complexities, from fuel storage sites to chemical manufacturing facilities, to demonstrate how we have addressed some of the challenges in using the guideline and ultimately helped to enable operators to understand and manage their environmental risk effectively.

1) Introduction

The *Chemical and Downstream Oil Industries Forum* (CDOIF) *Guideline - Environmental Risk Tolerability for COMAH Establishments*, v2.0 (CDOIF, 2015), henceforth referred to as 'the guideline', has become the preferred methodology guidance by the Competent Authority (CA) for environmental risk assessments (ERA) for operators of sites covered by the Control of Major Accident Hazards (COMAH) Regulations (HM Government, 2015). CDOIF defines itself as "*a collaborative venture formed to agree strategic areas for joint industry / trade union / regulator action aimed at delivering health, safety and environmental improvements with cross-sector benefits*" (CDOIF, 2015).

Whilst the availability of the guideline has its benefits, such as promoting industry wide consistency in the accepted method for risk assessment in a field that can sometimes rely on little data and a lot of interpretation, application of the guideline does present some challenges. We have used the guideline for several years and have extensive experience of preparing and submitting successful safety cases for COMAH establishments. As a result of this, we have identified some areas in which interpretations of the intended approach to CDOIF ERA are being made both on our part and by others.

The intention of this paper is to raise some of the issues encountered when applying the methodology and highlight areas in which clarification on the expected approach would be beneficial to operators, ERA practitioners and the regulator. Suggested approaches to dealing with such challenges are explored using examples which draw from our experience of establishments of varying complexities, from fuel storage sites to chemical manufacturing facilities. Discussion is included on how we have addressed some of the challenges in using the guideline and ultimately helped to enable operators to understand and manage their environmental risk effectively.

2) Background to COMAH Environmental Risk Assessment and the CDOIF Guideline

Prior to exploring some of the challenges and nuances of the approach to ERA suggested by the guideline, it is useful to consider the regulatory background to ERA in the context of major accident hazards (MAH). In time, the regulatory background to ERA has evolved, ascribing increasing emphasis to the importance of understanding the risks posed by COMAH establishments to the surrounding environment. This is, in our view, a positive development as the significance of protecting the environment goes hand in hand with the importance of protecting its inhabitants, be they humans or wildlife. The background and evolution of the regulations is discussed here, together with a summary of the historical approach taken, prior to the guideline, when assessing the risk posed by industrial establishments to the environment.

2.1) Regulations and the Environment

COMAH Regulation 5 (1) (HM Government, 2015) states that "*Every operator must take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment*". This is preceded by a similar requirement under Regulation 4 of the 1999 COMAH Regulations (HM Government, 1999) and can be traced back to Regulation 4 (2) of The Control of Industrial Major Accident Hazards (CIMAH) Regulations 1984 (HM Government, 1984) (implementing the original Seveso Directive (EEC, 1982), which required manufacturers in control of industrial activities to

provide evidence including documents to show that they had identified major accident hazards, taken adequate steps to prevent such major accidents and limited their consequences to persons and the environment.

The Seveso II Directive (EC, 1996) was developed based on lessons from process safety incidents in the 1980s with the intention of preventing major accidents and limiting their impact for both people and the environment. This resulted in the 1999 COMAH Regulations (HM Government, 1999) in the UK which were superseded by the 2015 COMAH Regulations (HM Government, 2015). Seveso was the driving force behind the development of the COMAH Regulations and has significantly impacted, in a positive manner, the way in which both safety and environmental assessments are carried out and assessed.

The current COMAH Regulations (HM Government, 2015) define a 'major accident' as "*an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment to which these Regulations apply, and leading to serious danger to human health or the environment (whether immediate or delayed) inside or outside the establishment, and involving one or more dangerous substances*". From an environmental point of view, the COMAH Regulations do not define "*serious danger*", although they do set out a series of criteria for the notification of a major accident to the European Commission which include damaged area thresholds for permanent or long-term damage to terrestrial habitats, significant or long-term damage to freshwater and marine habitats and significant damage to an aquifer or underground water. It should be noted that the Seveso III Directive (EU, 2012) does not appear to require the characterisation of duration of harm any more 'accurately' than using these broad descriptors; permanent, long term and significant.

Whilst the wording of what is currently Regulation 5 (1) has evolved since 1984, the core principles remain the same; making 'best efforts' to prevent major accidents and limit their consequences to the environment (and people) should they occur. These 'best efforts' were originally termed "*adequate steps*" and are now referred to as "*all measures necessary*". However, this regulation alone, in its various iterations, does not define adequate steps or all measures necessary. The CA clarifies its position on this in its "*All Measures Necessary" - Environmental Aspects* guidance (CA, 2016) which was developed alongside discussions with industry representatives via CDOIF. This guidance is aimed at helping environmental regulators when deciding whether or not COMAH Regulation 5 (1) has been met by the operator of a given COMAH establishment.

The concept of all measures necessary is linked to that of reducing risk to a level that is As Low As Reasonably Practicable (ALARP); demonstrating that that the risk associated with a hazardous establishment is ALARP is a key factor that is scrutinised by the CA during formal assessment of COMAH Safety Reports. In theory, once a prediction of the level of risk is made, an infinite amount of time, effort and money could be spent in attempting to reduce that risk to zero. However, in reality this is not sensible or practicable as organisations do not have unlimited resources to be able to do this, and completely removing the risk would likely involve removing the establishment entirely. The ALARP principle addresses this issue by introducing the idea of demonstrating that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained. Demonstration is often made in the form of cost-benefit analysis (CBA) calculations, which we have discussed in other papers.

The guidance for duty holders on the COMAH Regulations (L111) (HSE, 2015) elaborates on what is expected of an operator in order to comply with Regulation 5 (1) and points out that the regulations do not require a quantified risk assessment when demonstrating that the risk is ALARP, but that it may help with risk prioritisation. Whilst quantified risk assessment is not a requirement, the expected and accepted approach to demonstrating ALARP for COMAH establishments is some form of risk analysis and consideration of prevention and mitigation. The L111 guidance on Regulation 5 (1) suggests that the findings of a risk assessment together with appropriate preventative and mitigation measures will usually provide sufficient evidence to demonstrate safe operation. The depth of analysis can range from qualitative, through semi-quantitative up to quantitative. The extent, as sanctioned by the CA in their "*All Measures Necessary*" guidance (CA, 2016), will depend on the scale and nature of the major accident hazards presented by the establishment, the installations and activities on it and the risks posed to neighbouring populations and the environment. In other words, the risk assessment will need to be site specific and proportionate to the hazards and associated risks.

To summarise, operators are required to take all measures necessary to prevent and limit the environmental consequences of major accidents. A risk assessment facilitates the determination of what the necessary measures are. Following a risk assessment, an argument can be put together to demonstrate that the risk is in fact tolerable and ALARP. However, if different operators perform ERA significantly differently to one another, then the final picture of what measures are reasonable will not look the same.

2.2) Historical Approach to Environmental Risk Assessment

As it is a requirement for operators to carry out an ERA to show that they are taking all measures necessary, it is important to establish the way in which this is carried out and assessed. Expectations for an ERA are set out in the CA's COMAH Safety Report Assessment Manual (SRAM) (CA, 2015). This targeted guidance presents the framework for safety report assessment but does not explicitly determine the way in which one should be carried out. This section sets out the history surrounding changes to ERA guidance.

A Department of the Environment, Transport and the Regions (DETR) tool published in 1998 (DETR, 1998) was developed initially to aid the assessment of risk associated with aquatic environments. In order to quantify the consequences of accidental releases to these environments the Environmental Harm Index (EHI) method was developed, which focussed on the extent, severity and duration of harm. The EHI method contributed greatly to the management of environmental risk, however it was limited as it was only applicable to releases to water and required dispersion modelling. In order to address the issue of environmental consequence thresholds, the DETR produced new guidance in 1999; *Guidance on the Interpretation of Major*

Accident to the Environment for the Purposes of the COMAH Regulations (DETR, 1999). This included thresholds for harm to the environment, otherwise known as major accident to the environment (MATTE). This guidance covered a much wider suite of environmental receptors and provided greater resolution on the potential harm associated with accidental releases.

The 1999 DETR guidance highlights three key aspects which should be considered when determining whether an event constitutes a MATTE; the extent of the contamination or damage to habitats, species or communities, the severity of the effects and the likely duration of any effects. Section 4.2 of the DETR 1999 guidance sets out criteria and thresholds that define a MATTE to different types of environmental receptor, depending on the designation, sensitivity and value of the receptor. Receptors are categorised across 12 tables ranging from Sites of Special Scientific Interest (SSSI) to freshwater and estuarine habitats. Each table defines the medium (land/water), the type/designation of receptor(s) covered and then provides descriptions and justifications for the MATTE extent, severity and duration thresholds.

Prior to the introduction of the guideline there was also a wide range of other guidance and information which could be drawn from when preparing a COMAH Environmental Risk Assessment. This included but was not limited to the following:

- CIRIA Report 164 - Design of containment systems for the prevention of water pollution for industrial incidents (CIRIA, 1997). This focussed on the engineering of containment systems to reduce the volume of runoff following a release of hazardous material, with or without firewater application. It should be noted that the most recent version of this guidance, CIRIA 736, was published in 2014 (CIRIA, 2014) and is a useful reference when preparing ERAs.
- EI - Environmental Risk Assessment of Bulk Liquid Storage Facilities (EI, 2009). This Energy Institute risk assessment tool considers the vulnerability of the site by posing a series of questions with pre-defined answers which are rated Low, Medium or High.
- PPG28 - Pollution Prevention Guidelines Controlled Burn (EA, 2007).

Table 1 Summary of historical ERA guidance

Guidance	Positives	Negatives
CIRIA Report 164, 1997	- Suggested that hazard ratings should be given to sources, pathways and receptors, and suggested how these might be combined to give an overall site rating. - Useful guidance on the pathway stage of the environment assessment including migration time, drainage links, drainage capacity and water treatment.	- Details considerations to be made for each but does not suggest how to rate them. Only an indication of what might constitute a major or minor incident is provided. - Lacking in source and receptor guidance. - Lacking in guidance surrounding the assessment of groundwater as a pathway and/or receptor.
EI, 2009	- Questions on vulnerability which consider the type of material, vulnerability of groundwater and nearby ecological systems compared on a risk matrix. - Questions on pollution prevention measures which consider primary, secondary and tertiary containment compared on a risk matrix.	- Can only be used as a screening tool.
PPG28, 2007	- Lists aspects to be considered in determining the sensitivity of receiving water, or air environment and then groups considerations into high, medium or low sensitivity.	- Focussed on controlled burn which may not be an appropriate consideration for some sites.

As shown in Table 1 above, there was a significant breadth of guidance available to aid in the completion of an environmental risk assessment. However, this guidance does not cover all the areas required to effectively assess the risk to the environment. Thus, it was identified that there was a clear gap which needed to be addressed. The CDOIF Guideline represents a methodology for ERA which aims to fill the gaps remaining between historical and existing guidance.

2.3) The CDOIF Guideline

The *CDOIF Guideline - Environmental Risk Tolerability for COMAH Establishments*, v2.0 (CDOIF, 2015) aims to support the process of ERA for the purpose of compliance with the COMAH Regulations (HM Government, 2015). The COMAH SRAM (COMAH Competent Authority, 2015) now includes significantly more detail on what is expected of an ERA and refers to the CDOIF Guideline as a benchmark. This section of the paper gives an overview of the guideline only to give context to the points raised later; readers should look to the guideline document itself when applying the method.

Background on the CDOIF Guideline

The guideline is intended as a reference to be used when carrying out COMAH ERAs, with the objective of providing a common ERA methodology for both operators and the CA. In essence, the guideline builds on the MATTE definitions that were originally outlined in the 1999 DETR guidance and provides a suggested methodology around this for predicting environmental risk. CDOIF have published a range of guidance on a variety of subjects, including the environmental risk tolerability guideline which is the product of discussions held between the CA and industry representatives. The aim was to develop a clear and consistent suggested approach to be taken when performing ERA. The guideline was developed by a series of different working groups, formed in 2010, specialising in and focussing on agreeing an approach to be taken in

specific areas. The outputs of these working groups were then put together in 2013 to form the overall methodology and the guideline. The guideline is intended as a reference to support a screening process for those preparing ERAs as part of COMAH compliance.

The guideline affirms that it is neither a replacement for the 1999 DETR guidance, nor an authoritative interpretation of the law, but that CA inspectors may refer to it in making judgements about an operator's compliance with the law. Additionally, following the guideline is not compulsory and those preparing COMAH ERAs are free to do so by other means. Although in practise, it appears that the Environment Agency (EA) strongly favour the presentation of ERAs incorporating all phases of the methodology outlined in the guideline.

Phased Approach

The suggested approach is split into three main phases, shown in Figure 1 below, taken from the guideline (CDOIF, 2015):

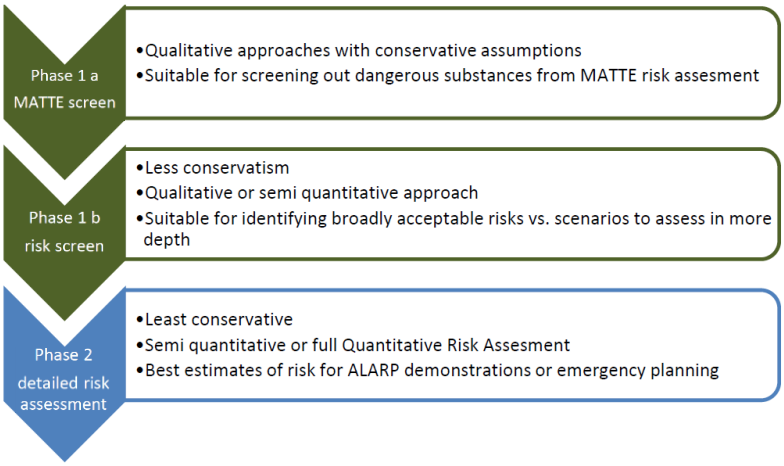

Figure 1 Summary of the three-phase ERA approach suggested by CDOIF

This method can be summarised more specifically as follows:

1. Phase 1a: Determine the unmitigated consequences to all receptors
2. Phase 1a: Rule out any receptors for which unmitigated consequences do not amount to a MATTE (i.e. sub-MATTE)
3. Phase 1b: Determine the aggregated unmitigated risk posed by the establishment as a whole to receptors which do have the potential to experience a MATTE (i.e. the risk to a receptor based on all of the sources/hazards which could cause a MATTE to it)
4. Phase 1b: Rule out any receptors for which the aggregated unmitigated risk is broadly acceptable
5. Phase 2: For any receptors at tolerable if ALARP or intolerable risk, perform Phase 2 detailed assessment, now accounting for mitigation (incorporating probabilities of failure of mitigatory barriers)
   - At this stage, assumptions made in Phase 1a and Phase 1b can be refined
   - Unmitigated risk and the tolerability thresholds for MATTEs can be compared
   - Additionally, it is possible to approximate the risk gap between the unmitigated and mitigated risks to each receptor
6. Phase 2: For any mitigated risks that are within the tolerable if ALARP risk region, a demonstration that the risk is in fact ALARP is required.

Phase 1a Unmitigated Consequence Prediction

Section 6 of the guideline provides details of how Phase 1 could be approached. Phase 1a requires unmitigated consequences to be predicted. The guideline defines unmitigated consequence as "*the potential consequence from credible scenarios before any mitigation measures are employed. This is essentially the worst credible consequence associated with the credible scenario, (with no protection layers in place) and is used to establish tolerability thresholds*". The unmitigated consequence is therefore that which could theoretically occur to a receptor in the absence of risk reduction measures such as preventative layers that reduce the frequency of a hazardous event from occurring, or mitigation layers which reduce the consequences of a hazardous event that does occur.

Receptors are described by one of four broad groups; terrestrial habitats, freshwater habitats, marine habitats and groundwater bodies. Within these, there is a range of specific types of receptor. Receptors are categorised by CDOIF based on the tables within the 1999 DETR guidance; where the DETR guidance has 12 tables (categories) of receptor, the guideline splits these across 15 categories. MATTEs are then defined based on the extent and severity (area) and duration (time to recovery) of harm. Severity and duration each fall independently into categories one to four with increasing impact. If either the severity or duration falls into category one, then the overall consequence is sub-MATTE, regardless of the other parameter. If both severity and duration fall into any category other than one, then there is MATTE potential. CDOIF is not concerned with the tolerability of sub-MATTE harm to the environment and anything that is predicted to result in sub-MATTE consequences can be filtered out of the assessment. MATTEs are rated A through D with increasing consequence. Different types of receptors are assigned different severity and duration MATTE thresholds. The risk tolerability thresholds set out by CDOIF differ depending on the level of MATTE experienced by a receptor; the greater the consequence, the more stringent the tolerability limit.

Phase 1b Frequency Estimation and Risk Tolerability

Phase 1b of the methodology suggests that screening is performed to identify any unmitigated consequences for which the unmitigated risk posed by the establishment as a whole is broadly acceptable. These cases can then be ruled out from requiring further, more detailed, Phase 2 assessment. Any unmitigated risk that is tolerable if ALARP or intolerable will require Phase 2 assessment.

In order to estimate the unmitigated risk, the unmitigated frequency needs to be quantified. This is the frequency with which an unmitigated MATTE consequence might occur in the absence of any prevention or mitigation and involves summing all the raw release frequencies for all source equipment such as tanks and pipework etc., which could result in a MATTE.

Once the unmitigated MATTE frequency is known, it can be compared to MATTE tolerability limits set out by CDOIF. Tolerability limits for establishment risk posed to a given receptor are defined using a matrix in Section 6.2.1.4 and in Table 4.3 of the guideline and are derived from the 1999 DETR guidance, a DETR harm report (DETR, 1998) and a verification exercise based on 10 years of major accident hazard data in the UK (CDOIF, 2015).

Phase 2 Detailed Assessment

It should be noted that the guideline suggests those preparing ERAs for complex establishments may wish to go directly to a detailed Phase 2 assessment, without carrying out Phase 1 screening. Phase 2 assessment is not covered in detail by the guideline, other than in six bullet points at the end of the document. However, Phase 2 assessment is relevant in the context of comparing unmitigated risk to mitigated risk, but is of primary importance in understanding risk and managing it to a level that is ALARP.

The risk gap between the unmitigated (Phase 1a) and mitigated (Phase 2) risk is a key aspect which the guideline suggests is important to recognise as an evaluation of the amount of risk reduction provided by existing mitigatory measures. It states that this gap is an illustration of the importance of maintaining such measures.

In summary, the guideline has built on existing guidance on MATTE definition and determination and has sought to provide a consistent set of risk tolerability criteria. The 1999 DETR guidance discussed in Section 2.2 provides criteria defining the minimum level of harm amounting to a MATTE. The guideline takes this a step further by introducing different levels of MATTE and by separating the extent and severity of harm parameters from the duration of harm parameters.

3) Challenges in Environmental Risk Assessment using the CDOIF Guideline

Operators of COMAH establishments need to perform a risk assessment in order to determine the risk profile of their establishment. This can then be used to inform the required demonstration that the risks are indeed tolerable and ALARP as well as any decisions that are made regarding additional necessary measures to be implemented to ensure that the risk is ALARP. Ideally, all operators would perform risk analysis in a similar manner in order to allow meaningful comparison between establishments. The guideline aims to provide a framework within which consistency can develop. This is very much a positive, as such consistency was previously lacking. We have used the guideline for several years and have extensive experience of preparing and submitting successful safety cases for COMAH establishments. As a result of this, we have identified some areas in which interpretations of the intended approach to CDOIF ERA are being made both on our part and by others. This gives rise to the potential for significant inconsistencies to creep back in.

Some of the key challenges and potential pitfalls encountered when preparing ERAs based on the guideline are explored and discussed here, drawing from our experience of establishments of varying complexities, from fuel storage sites to chemical manufacturing facilities. The sections that follow discuss four key areas in which challenges have been encountered and are:

1. Environmental Features Versus Credible Receptors
   - Discusses the potential misinterpretation of guidance in the COMAH SRAM and CDOIF Guideline
   - Distinguishes a difference between environmental features and receptors in order to help achieve an appropriate level of proportionality in the number of receptors to assess under CDOIF Phase 1a MATTE screening
2. Pathways and Unmitigated Consequences in Phase 1a Screening
   - Looks at the different approaches that have been taken to predicting the unmitigated consequences to receptors in Phase 1a
3. Reality Check: Unmitigated Risk and Non-Credible Unmitigated Releases
   - Explores the drive for all release cases, however small the hole or however negligible the likelihood and risk contribution, to be included in the risk picture in Phase 1a
   - Provides an example of a successful approach that has been used to address this issue in Phase 2 detailed assessment and which has been accepted by the EA
4. Using Threshold Concentrations Such as Predicted No Effect Concentrations (PNECs)
   - Discusses the scope for uncertainty in risk assessment in the context of consequence calculations using threshold concentrations such as PNECs
   - Highlights the dangers of making definitive conclusions based on seemingly precise or accurate calculations.

3.1) Environmental Features Versus Credible Receptors

This challenge considers the potential for misinterpretation of guidance in the COMAH SRAM and CDOIF Guideline and seeks to distinguish a difference between environmental features and receptors in order to help achieve an appropriate level of proportionality in the number of receptors assessed under CDOIF Phase 1a MATTE screening. A tried and tested approach to identifying credible environmental receptors is suggested.

Phase 1a of the CDOIF methodology involves screening receptors for MATTE potential with the aim of filtering out any sub-MATTEs and identifying which receptors could experience a MATTE in the absence of mitigation measures. In practise, this requires conservative estimations of the severity and duration of harm associated with a given hazard. Before this can be done though, the range of potential receptors to be screened needs to be identified. The COMAH SRAM guidance associated with technical criterion 13.4 states that: "*The area over which pathways and receptors should be identified depends on the nature of potential major accidents. It would be expected that a range of up to 10 km would be reasonable*". In our experience, when preparing the descriptive aspects of COMAH Safety Reports, the EA has generally favoured the description of all environmental features within 10 km of an establishment. This preference is presumably linked to the SRAM guidance and the guideline. The CDOIF methodology for screening picks up on this, stating that "*when considering receptors with MATTE potential, note that the Safety Report Assessment Manual (SRAM) indicates that it is reasonable to screen within 10 km of the establishment. However, for linear pathways (such as rivers) this distance may be longer*".

CDOIF make a very important point about linear pathways, alluding to the potential for aqueous pathways with greater conductivity to carry hazardous material to receptors further than 10 km from the source relative, say, to an overland liquid flow pathway. However, the challenge arises from the potential misinterpretation of the reference to 10 km in both the guideline and the SRAM. The guideline, ERA practitioners, CA Safety Report assessors and operators would all benefit from clarification as to what the expectations are. It is our experience that the expectation of assessors is that:

- The descriptive aspects of a COMAH report should present all environmental features within 10 km of an establishment and that
- Phase 1a MATTE screening be performed for all those environmental features within 10 km (and further for more conductive pathways).

However, our interpretation is that the emphasis is on the dependency of the area on the nature of the potential major accidents, i.e. that when identifying receptors, it is reasonable to report only those receptors which are within range of the hazards. Whilst the SRAM guidance does quote 10 km, this refers to the area over which pathways and receptors should be identified and does mean that absolutely all environmental features that happen to be within 10 km of an establishment should be included, regardless of whether or not these features are within credible range of hazards. The key point is that the area to look at depends on the nature of the potential major accidents. This implies that the area over which to consider pathways and receptors for a site with relatively short-range hazards would be proportionate to those hazard ranges and the opposite for a site with hazards that could be further reaching. It should be noted that the position of individual safety report assessors does vary and that this apparent expectation is not universal. In one recent case, for a Lower Tier COMAH storage and distribution warehouse, a CDOIF based ERA supported by an identification of credible receptors, and not including all features within 10 km, was accepted by and received compliments from the EA.

The important distinction to make is therefore the difference between surrounding environmental features and receptors. We adopt the position that a receptor is an environmental feature within credible range of any hazard associated with a COMAH establishment and that not all environmental features are receptors from the point of view of a given establishment. Whilst this may seem somewhat pedantic, it is an important issue as not doing so could be resulting in a disproportionate amount of time, money and effort being spent by operators, consultants and the regulator on assessing hazards and consequences that do not exist, with little or no benefit. It should be noted that if any particularly sensitive features are identified just beyond the estimated credible hazard range, then these would still be included in the Phase 1a assessment. Figure 2 below illustrates the differences between surrounding environmental features and credible receptors identified based on consideration of the nature of the hazards at a theoretical establishment.

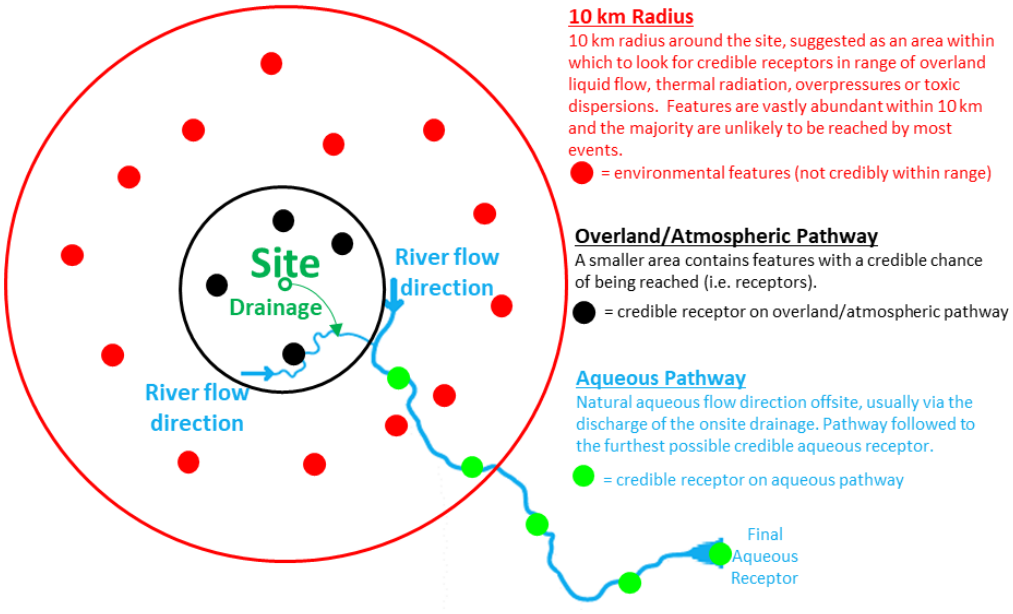

Figure 2 Illustration of the proposed concept for credible receptor identification

Presently, it appears that including all environmental features within at least 10 km of an establishment in the descriptive aspects of a COMAH Safety Report is an expectation. There is, arguably, little benefit in doing this other than possibly acknowledging the presence of various features in the vicinity of an establishment. The number of surrounding features within 10 km can be vast; for example, the number of listed buildings or areas of Biodiversity Action Plan (BAP) priority habitat can exceed 1,000. Listed buildings will all be designated for different reasons, specific to the building in question. Assessing 1,000 listed buildings or individual areas of BAP priority habitat in MATTE screening would not be practical or sensible, however conservative or high level the approach. The same goes for all other surrounding environmental features, the main argument against doing so being that the majority of these features simply cannot credibly be reached by any hazards from the establishment.

The furthest distance from source within range of a hazard is a notional point beyond which the hazard is no longer of concern and is, in reality, a blurred or imprecise/moving point which depends heavily on the specific substance, pathway and prevailing conditions. It can be thought of as the point beyond which the hazard has attenuated sufficiently such that it no longer poses a threat. As a general rule, it follows that the further from the source, the greater the level of attenuation and the less potent the hazard. Although, situations can be thought up in which this is not always true. For example, taking the case of a light non-aqueous phase liquid, if this were to enter a stream or river and float on the surface of moving water, there is the possibility that it could accumulate at some point downstream, where the river profile and currents allow (e.g. on one side of a knee or meander in the river where there may be eddy currents and differences in flow velocity relative to the rest of the river). However, this is too complex to account for in the early high-level stages of an ERA and may be too unpredictable even with the help of bespoke computational fluid dynamics (CDF) modelling. It may therefore be more sensible to employ higher-level calculations and modelling, where trusted, in conjunction with experience-based judgement.

It is nevertheless necessary to account for the credibility of features becoming receptors (i.e. experiencing any level of harm/damage) before then performing Phase 1a MATTE screening to determine the credibility of any MATTE level harm. Whilst this adds another step to the ERA prior to CDOIF Phase 1a, it serves to significantly condense the number of features that are taken through MATTE screening as receptors. Once all surrounding environmental features have been identified, a high-level pathway analysis is performed. Analogous to the principle of gradually decreasing conservatism advocated by the guideline, the high-level pathway analysis seeks to use conservative assumptions in order to estimate the worst-case extents of different types of hazard and therefore to identify which environmental features could be receptors within credible range.

Different types of pathway may lead to different receptors, and the extent to which hazards can reach along these different pathways must be judged in different ways; examples of pathways considered include:

- Overland flow of liquid (leading to surface, sub-surface and water-based receptors),
  - Using lidar data and topography contours to predict the direction and extent of overland liquid flow,
- Atmospheric dispersion of toxic gases and/or combustion products,
  - Conservative estimates for the extent of dispersion, e.g. using validated modelling software,
- Thermal radiation from ignited events such as pool, flash and spray/jet fires,
  - Conservative estimates for the extent of thermal radiation, e.g. using validated modelling software and accounting for the potential for overland flow and spread of pool fires,
- Overpressures from explosions,
  - Conservative estimates for the extent of thermal radiation, e.g. using validated modelling software
- Linear aqueous pathways, i.e. releases of material that could enter watercourses,
  - Considering the potential for liquid releases to enter watercourses, e.g. looking at where drainage systems on and surrounding the site lead to and making a judgement as to how far downstream to continue.

Of these pathways, the linear aqueous route is the most challenging. In the absence of commissioning bespoke CFD modelling with a view to estimating the extent to which each specific substance could migrate downstream, it is difficult to confidently pinpoint a distance beyond which a release to a surface watercourse would not exceed discernible or concerning levels. In theory, given the 'right' substance, prevailing conditions and watercourse profile, an establishment in a central location in the UK could be the source of a release that migrates all the way downstream through various watercourses and reaches the sea. This prompts the question of where to draw the line on proportionality and where to stop; if a release can travel from the middle of the UK to the sea, then could it theoretically travel even further afield? It is unlikely that operators will have the appetite or budget to commission bespoke modelling at this stage of an assessment and it is not consistent with the principle of taking an initially qualitative approach. Seeing as non-CFD predictive modelling for other pathways has been used, it might be reasonable to suggest something similar for the linear aqueous pathway. However, this pathway is likely to be very site specific and difficult to simulate such that any meaningful results are obtained. The current alternative relies on conservative judgement, based on an appraisal of the substances involved, the inventories and the properties (such as average flow velocity) of watercourse(s) in question. For example, a release of a given quantity of a very soluble biodegradable substance might reasonably be expected to attenuate below harmful concentrations well before a smaller release of a non-biodegradable light non-aqueous phase liquid of relatively low volatility. In estimating the maximum distance downstream, the behaviour of the hazardous substances in the environment therefore needs to be considered.

We have successfully put this approach of identifying credible environmental receptors into practise for a wide range of different operators whose COMAH reports have been accepted by the CA. The process of refining environmental features down into a list of credible receptors makes a substantial and positive difference to the amount of time, resource, money and effort required for the first stage (Phase 1a) of the CDOIF assessment.

3.2) Pathways and Unmitigated Consequences in Phase 1a Screening

This issue looks at the different approaches that have been taken to predicting the unmitigated consequences to receptors in Phase 1a. Examples are used to highlight that the importance of considering attenuation along pathways to receptors and the influence this can have on the ultimate effect assessed at the receptors.

Once the list of credible receptors has been identified, Phase 1a MATTE screening can begin. Discussions with EA/CDOIF representatives have confirmed that the unmitigated consequence prediction in Phase 1a MATTE screening is expected to consider the maximum single inventories of each hazardous substance as well as larger 'multi-tank' inventories. This is because isolation of releases is a form of mitigation and a situation could conceivably arise in which the entire single inventory of a given substance could be released, namely, but not limited to, catastrophic tank failure. Loss of containment of the entire 'multi-tank' inventory of a given substance (or substances, e.g. different substances in adjacent vessels in the same bund) is vanishingly less likely but the discussions have also confirmed that this should not be overlooked when selecting inventories to assess in MATTE screening. The thinking behind this has been justified as being based on the theoretical potential for a leak to occur from pipework which is common to multiple vessels, or that an escalation event such as a bund fire could impact and result in leaks from multiple vessels. Additionally, it is summarised by CDOIF as follows: "*If a high-level consequence assessment shows that a loss of >50 tonnes of dangerous substance direct to a river is required to exceed MATTE thresholds, then scenarios involving much smaller releases from primary containment (e.g. a spill <1 tonne) could be screened out from further assessment of MATTE risk to the river*".

Whilst this is a good idea, a great amount of front end effort is required to justify such a conclusion, so is this approach really helping and saving effort? Rather than a challenge, it appears to be a misconception that screening based on the full quantity of a substance, or developing MATTE threshold quantities, saves effort. Difficulty arises from the "*high-level consequence assessment*" and the loss directly to the receptor. The objective or temptation is to establish that the worst-case quantity for release cannot result in MATTE level harm. But how much justification is needed to support such a bold claim? This raises the question as to how exactly the severity and duration of harm thresholds that the guideline builds on from the 1999 DETR criteria are intended to be used. Is the expectation that a high-level environmental identification (ENVID) approach, analogous to a hazard identification (HAZID), should be taken or is more justification and not such a high-level approach expected? The guideline does suggest a tick and cross table for MATTE potential and that this could refer to footnotes justifying the predictions made, but does not indicate the depth of justification that might be expected. Although MATTE screening is intended as a high-level stage of assessment, if receptors are to be ruled out on the grounds of predicted sub-MATTE harm, it is logical to expect a reasonable degree of justification to support this.

Without such justification, there is no way of scrutinising the sub-MATTE conclusion made for certain receptors and there is a greater risk that receptors at credible risk of MATTE level harm are ruled out in error. Our experience has been that EA inspectors are looking for robust and reasoned justifications in support of the predicted consequences, be that sub-MATTE or MATTE level harm. To this end, our approach to Phase 1a MATTE screening incorporates detailed arguments and reasoning in the form of a discussion of the factors influencing the severity and duration of harm to each credible receptor from each hazard. This provides a greater level of confidence in the shortlist of credible potential MATTEs to be taken forward to Phase 1b risk screening and ultimately Phase 2 assessment. Our solution to the necessity for confidence in ruling out events as sub-MATTE has been to front-end load the assessment by including detailed justification for the predictions made in Phase 1a MATTE screening. The misconception appears to be that Phase 1a is quick and easy, as supported by evidence from other assessments which have later resulted in more work in the long run for operators who receive RFIs asking for more detail.

Whilst predicting whether or not MATTE harm is a credible possibility, a further issue that arises is the approach of directly applying a hazard to a receptor regardless of the pathway from the source. This becomes a greater issue for receptors located further from the source, i.e. on the fringes of the hazard radius, where the hazard has attenuated the most. It is therefore proposed that when predicting the severity and duration of harm to a receptor in MATTE screening, some credit could be allowed for natural attenuation of a hazard as it travels along a pathway to a receptor and that the natural limits imposed by a pathway be accounted for at least to some extent. Not doing this could result in unrepresentative and overly conservative conclusions from MATTE screening.

Taking an example of a soluble substance with aquatic toxicity (N.B. CDOIF highlights that substances should not be ruled out purely on the grounds that they do not have a hazard statement such as H400 or H411 indicating properties hazardous to the environment), it is assumed that there is a credible pathway for a release of this substance to enter a surface watercourse (e.g. through a drainage and effluent treatment system in which barriers such as detection and isolation fail). On the far bank of the watercourse, further downstream, is a receptor (e.g. an area of mudflats). If the direct application approach suggested by CDOIF is to be taken when predicting the severity (area) of harm, then a theoretical situation has to be imagined whereby the entire inventory of the soluble substance 'lands' on the mudflats. Whereas, in reality, this is not possible as the substance could only conceivably reach the mudflats via the estuary, in which it would dilute along the way. How much it may dilute along the way is very unpredictable and will depend heavily on the characteristics of the estuary and the prevailing conditions, e.g. incoming/outgoing tide, flow velocity and currents. It may even be the case that the pathway through the estuary to the mudflats is of minimal conductivity, but the receptor will have been screened in on the grounds that harm reaching it cannot be ruled out. The unpredictable nature of the dispersion of the substance in the estuary might be seen as an argument in support of the direct application approach, however, predicting the severity of harm based on a theoretical direct application to the receptor is likely to be grossly over conservative. Therefore, in the absence of bespoke CFD modelling for a spectrum of different prevailing conditions, it may be reasonable to assume that the entire area of mudflats within range of the river could be reached at some concentration by the soluble substance with aquatic toxicity. This may result in a high severity category. However, it may then be arguable that the receptor would not experience a sufficient toxic dose (i.e. form a specific

concentration for a sufficient period of time) such that recovery from any harm caused takes a long time. Conversely, if the direct application approach were used, then the initial concentration (and overall toxic dose) theoretically experienced by the receptor could be much higher and result in MATTE potential on the grounds of duration of harm.

If the same receptor is then considered from the point of view of a light non-aqueous phase liquid (LNAPL), the direct application approach (to the mudflats) might predict the severity of harm in the same way as for the case with the soluble substance. However, if the pathway is considered, then the LNAPL entering the estuary would float downstream on the surface and come into contact with only a limited portion of the mudflats depending on the water level and currents etc. For example, a floating plume of LNAPL carried downstream by an outgoing tide might only come into contact with a narrow strip of the mudflats if the currents carried the plume/slick over to the opposite bank. In this case, the area affected might reasonably be expected to be less than that for a dissolved release, but the toxic dose could be higher due to the concentration of the substance when it comes into contact with the receptor.

To summarise, whilst there is no easy answer or comprehensive approach to take when predicting consequences, pathways to receptors and the associated behaviour and scope for attenuation along the way to receptors do need to be given some consideration when estimating the severity and duration of harm during Phase 1a MATTE screening, otherwise grossly unrealistic consequences may be predicted. Whilst MATTE screening is intended to be conservative and high-level, ignoring the pathway and attenuation mechanisms along the way to a receptor could result in misleading predictions of MATTE level harm.

3.3) Reality Check: Unmitigated Risk and Non-Credible Unmitigated Releases

This challenge explores the drive for absolutely all release cases, however small the hole or however negligible the likelihood, to be included in the risk picture in Phase 1 and Phase 2. This is where the unmitigated frequency of all sources that could ultimately result in a MATTE to a given receptor is totalled and included in the unmitigated risk. In some instances, the EA has requested the inclusion of all release frequencies, for all hole sizes, to be applied to a MATTE consequence involving the entire inventory of a given substance. It is our view that the credibility of smaller hole sizes remaining indefinitely unisolated for such extended periods of time is minimal and is not a realistic situation to assess. An example is provided here of a successful approach that has been used to address this issue in Phase 2 detailed assessment and which has been accepted by the EA.

The omission of certain large release volumes from consideration based on the view that it couldn't possibly happen is a historical oversight for some establishments in ERAs produced prior to the introduction of the guideline. Those advocating the guideline aim to combat this with encouragement to consider releases of the largest single and multi-vessel inventories. We believe that the additional emphasis that is put on ensuring that the worst-case outcomes of an accident are considered is vital in the process of obtaining a full and meaningful picture of the environmental risk posed by an establishment. However, difficulties arise in the quest to predict unmitigated risk. What is reasonable to consider in this unmitigated picture?

We do consider the largest single inventories of each substance (often a storage tank) as well as the relevant multi-tank inventories when performing Phase 1a MATTE screening. This is generally done, as suggested in the guideline, by predicting the severity and duration of harm associated with a release of the entire inventory towards each of the receptors that have been identified as credibly within range. The approach of directly applying a hazard to a receptor, ignoring all mitigation, but crucially also the pathway to the receptor, is promoted both in the guideline and has been supported by some EA inspectors. However, in some instances, it has been necessary to account for attenuation in order to maintain a realistic prediction.

Once the unmitigated consequence has been estimated in Phase 1a, the unmitigated risk needs to be predicted (Phase 1b). This involves estimating the frequencies with which each potential MATTE could occur, ignoring any preventative layers that could, if successful, reduce the frequency of the MATTE, or mitigation layers which could reduce the consequences. It is important, in the context of mitigated (Phase 2) risk assessment, to note that mitigation, reducing consequences, may not necessarily always be sufficiently effective to reduce the consequence as far as sub-MATTE level harm and that this will be site/mitigation measure specific. An accepted approach to release case modelling and frequency estimation for safety risk assessment is to consider a range of representative hole sizes from which hazardous material could escape primary containment.

An accepted approach in estimating the unmitigated frequency of a given MATTE is to sum all frequencies for releases from all representative hole sizes for all equipment at an establishment from which the substance in question could be released. The same process is then carried out for all other substances which could cause the same level of MATTE to a given receptor and a grand total release frequency for all MATTE sources can be calculated. This establishment release frequency is then treated as the unmitigated frequency with which a MATTE could occur to a given receptor, from all relevant sources/substances that could cause it.

The unmitigated risk tolerability is then determined based on the criteria outlined by the guideline. In our experience, the unmitigated risk has been intolerable on all occasions, for all establishments, regardless of type and size of establishment. This brings into question what the real value and purpose of unmitigated risk screening is and whether efforts in predicting this are justified. In fact, the unmitigated frequency has always been so high that the unmitigated risk is well into the intolerable region. This is potentially emotive and surprising to some operators, even though it does not account for the pathways to receptors (see Section 3.3) or the probability of success/failure of preventative or mitigatory layers. In all cases, for all establishments with MATTE potential, a Phase 2 detailed analysis has therefore been required. This suggests that all of these establishments rely heavily on the preventative and mitigatory layers in place to achieve a level of risk that is not intolerable.

Whilst it has been encouraged that all release frequencies from all hole sizes are included in the unmitigated risk in Phase 1b risk screening, our experience of submitting Phase 2 detailed assessments has shown that it is acceptable to screen out hole sizes from which the entire inventory of a storage vessel could not credibly be released. One example of this is a case involving a relatively large storage tank of fuel with a small hole. The release rate from this hole was estimated using a predictive model and was taken as the initial (highest) release rate based on a theoretical hole (12.5 mm diameter in this case) at the base of the tank and using the maximum liquid head height in the tank. Even using the initial release rate, an inventory equivalent to that of a static full tank would have taken more than one year to escape. Whilst it may in some cases be acceptable to consider pin hole releases going undetected for such a long period of time (e.g. underground), a 12.5 mm hole going undetected for more than one year is somewhat improbable. Additionally, the consequences of a release of the entire inventory at such a low flow rate would likely be very different to those of a very large or catastrophic release. Similar is true of transfer operations, where various people are involved in reconciliation by various means, such that the idea of a release continuing beyond 24 hours becomes inconceivable.

In Phase 2 assessment, we therefore address this credibility issue by ruling out totally unisolated (i.e. indefinitely long) releases from certain smaller hole sizes, depending on the release rate and scope for detection and isolation. This approach has been successfully used in multiple COMAH ERAs that have been accepted by the EA. It should however be noted that we do account for the potential for larger holes with higher release rates to remain totally unisolated. Taking one site as an example, one of the cases considered in Phase 2 assessment involved pipework with a supply of fuel in excess of 10,000 m^3. The site has multiple methods of detection in place for releases, including hydrocarbon detection, pressure alarms, flow alarms, movement alarms and human visual detection. A number of alarms on site initiate an ESD, which can also be initiated remotely from the site. Based on all of this, it was assumed that releases could be isolated within 30 minutes (although in reality it could occur much sooner, in around 5 minutes). There is the potential that isolation within 30 minutes could fail. In this case, it is not considered credible to assume that a release is then completely unisolated, as there would be other opportunities for detection and isolation. As such, a second isolation time was applied to represent a release that is isolated, but much later than the 30 minutes assumed. Six hours was selected as it is half the length of the longest operator shift. This is considered the longest time that would go by without an operator site tour or a shift handover, either of which would provide opportunity for detection of a release. Again, there is always the potential for this to fail and so releases that are not isolated within six hours are then treated as unisolated, with the exception of those from small and medium holes. It was not deemed realistically credible for releases from these holes to remain totally unisolated such that the entire available inventory is released. There is a notional probability that failure to detect and isolate within any amount of time will gradually approach (but never quite reach) zero. The frequency of truly unisolated smaller hole size releases will therefore also approach zero and will have a negligible contribution to the mitigated risk picture. It is nether practical nor beneficial to direct efforts at quantifying such small and immeasurable release frequencies and so in the case of this example, the line was drawn at six hours.

Finally, our experience has shown that the unmitigated risk in Phase 1b, for MATTEs predicted by Phase 1a, is always intolerable and that detailed Phase 2 analysis is therefore always required. This may be due to the nature of the establishments assessed, although this is unlikely as we have performed Phase 1 assessments for an extensive range of different establishments including small lower tier regional airport fuel storage facilities, national fuel distribution terminals and entire upper tier oil refineries as well as lower and upper tier speciality chemical manufacturing sites and even non-COMAH establishments refining sugar. The benefit of Phase 1a MATTE screening is that it rules out any receptors which are not predicted to experience MATTE level harm, even if they were reached by hazards from a site. Phase 1b does not appear to provide any benefit to the risk assessment process other than allowing for a very approximate view of the risk gap between unmitigated and mitigated risk. Phase 1 uses high-level conservative assumptions whereas Phase 2 allows refinement and less conservatism. Comparison of unmitigated and mitigated risks may therefore not be particularly meaningful or useful.

One solution might be to opt out of performing Phase 1b risk screening and just use Phase 1a to identify which receptors have the potential to experience a MATTE and therefore take forward to Phase 2. This may not be something that is well received, as the EA have assigned significant value to determining unmitigated risk, i.e. to enable the risk gap between unmitigated and mitigated risk to be used as an indicator of the level of reliance on mitigation measures. It is our view that the difference in conservatism/depth between the two arguably makes the outcome unreliable and unmeaningful.

3.4) Using Threshold Concentrations Such as PNECs

An overarching theme which is most relevant and important across all fields of risk assessment is that of uncertainty. The value of the results, conclusions and actions taken following a risk assessment is heavily dependent on the assumptions made during the risk analysis. There lies an opportunity for a high level of uncertainty to arise during ERA within the context of the COMAH Regulations. Although this is by no means a reason to completely avoid quantification, we must be careful not to give ourselves false confidence with something that, on the face of it, sounds more accurate simply because it is based on calculations, when the basis of those calculations is as unjustified as the qualitative alternative.

Picking up on the example of a soluble substance with aquatic toxicity from Section 3.2, it is assumed that there is a credible pathway for a release of this substance to enter a surface watercourse (e.g. through a drainage and effluent treatment system in which barriers such as detection and isolation fail). For the purpose of this example, the watercourse is an estuary, the entire area of which is designated as a Ramsar site. This puts the estuary, as a receptor, into DETR Table 2 (and CDOIF Appendix 4, Table 4.1, Row 2) for the purposes of severity (area) of harm prediction.

The guideline encourages concentration calculations as a tool for the high-level screening in Phase 1a and refers to the Predicted No Effect Concentrations (PNECs) of substances, i.e. a theoretical concentration below which no effect is expected: "*If the Predicted Environmental Concentration (PEC) of a chemical (e.g. concentration at receptor due to release and*

dispersion following an accident scenario) is lower than the PNEC, then it can be concluded the chemical poses no environmental risk".

The severity (area) of harm to the Ramsar site in the estuary could be approximated using a rough dilution calculation. For example, using a threshold concentration for a specified effect such as the PNEC, above which effects may be possible. The volume of water required to dilute a particular quantity of hazardous material to the PNEC could be calculated. On comparison with the dimensions and average discharge rate of the estuary, a conclusion might then be made as to whether or not any environmental risk is posed. If the available volume of water in the estuary is greater than that required to dilute to the PNEC, then it might be concluded that no environmental risk is posed. The flaw in this is that no release to a receptor will become instantaneously and uniformly diluted below the PNEC. There will be a period before this, during which the PNEC is exceeded. The severity of harm associated with a theoretical solution at the PNEC could be calculated (i.e. the area covered by this volume of water) by setting an average depth. This area might then be compared to the severity categories in CDOIF Appendix 4, Table 4.1, Row 2 in order to determine whether or not the severity is high enough such that there is MATTE potential. If the severity category is two, three or four, then there is MATTE potential. However, this would be a prediction of the severity category if such an instantaneous uniform dilution were possible and would depend on the very approximate estimation of the average depth available into which the substance may dilute. The severity of harm would be different depending on which concentration of interest was selected and at what point in time the 'snapshot' of the attenuating plume of pollutant was imagined.

The duration of harm associated with an instantaneously dilute solution over a large area would likely be lower than that for a more concentrated solution over a smaller area. Additionally, using threshold concentrations such as the PNEC or LC_{50} (the concentration at which 50% of a test population of a specific species is vulnerable to the hazardous substance over a set period of time) is not necessarily useful. LC_{50} data for aquatic toxicity provided on safety data sheets (SDSs) frequently relates to one specific species (often rainbow trout) and corresponds to the toxic dose experienced by a test population at that concentration over a prolonged period of time (often 96 hours). Even if the LC_{50} or another threshold concentration were to be exceeded, the exposure duration is unlikely to be sufficient such that the toxic dose is experienced. If a receptor experienced a concentration greater than the PNEC, the effect on the receptor would most likely not be sufficient to give rise to a MATTE, i.e. some effect, but not necessarily a MATTE level effect. For each individual species, a release quantity can be imagined for which a notional MATTE threshold concentration, or more specifically dose, might be experienced under idealised conditions. This cannot be replicated in the natural environment where the concentration profile and location of a dispersing plume of material will be ever changing. The implication of this is that predicting the effects of a release to the natural environment can only be very approximate and it is advisable not to rely too heavily on calculations based on assumptions giving momentary theoretical 'snapshots' of an attenuating release.

That isn't to say that back of the envelope calculations aren't useful. Using threshold concentrations in this manner may still be useful in approximating a buffer area somewhere within which there is a smaller area where harm may be severe enough to be considered a MATTE, provided the effects are severe enough to result in sufficient duration to give a MATTE. It is therefore suggested that this sort of approach be used as a first-pass approximation from which the severity can be revised based on judgement, experience and historical incident data.

For LNAPLs such as Jet A1 and diesel, we have estimated the severity of harm based on an assumed thickness of a homogenous floating slick on the surface of water or resting on the surface of land. Any portion of the hydrocarbon mixture that is soluble is disregarded based on the low solubility and subsequent dilute nature of any solution extending over a wider area than the undissolved floating slick.

For releases of LNAPLs to groundwater, a similar approach has been adopted and has been accepted by the EA. For soluble substances, taste and odour thresholds have been used in an analogous way to that described above for soluble releases to surface water, i.e. a volume of groundwater required to dilute to a concentration of interest is calculated and then an area derived by setting a depth into which the substance could dissolve.

3.5) Other Challenges

Finally, some other issues to raise briefly include risk tolerability and emergency planning. Whilst the CDOIF Guideline has introduced a suggested standard set of establishment risk tolerability criteria, these are to be applied regardless of the size of an establishment. Doing so could present problems for large sites such as oil refineries with multiple installations, where the establishment risk is likely to be higher than for a small lower tier establishment, i.e. the criteria may be too stringent for the largest establishments and too lenient for smaller sites. Future consideration might therefore be given to the potential for different tolerability criteria for different establishments, e.g. one set for small sites, one for average and one for larger sites. Additionally, if not already the case, it may be beneficial for the EA to work back from individual receptors, dividing the risk to determine how much a given establishment might contribute to the risk. There could be some areas with a high concentration of industrial activity in which receptors are subjected to much higher risk than other areas.

It may seem logical to look to CDOIF based ERAs as a source of information for emergency planning. However, this form of ERA does not lend itself easily to emergency planning as it jumps to worst-case outcomes, often missing out event progression which is a key factor to consider in emergency response.

4) Conclusions

The complex and subjective nature of environmental risk assessment means that developing and applying a common framework is a significant challenge. The introduction of the *Chemical and Downstream Oil Industries Forum* (CDOIF) *Guideline - Environmental Risk Tolerability for COMAH Establishments*, v2.0 (CDOIF, 2015) has made a valuable

contribution towards efforts to promote greater consistency in environmental risk assessment. However, the use of the guideline has presented some challenges and grey areas which have resulted in variances in interpretation leading to differing approaches being taken by those assessing risk and by the regulator. The purpose of this paper was to identify some of the key challenges encountered when preparing environmental risk assessments for COMAH establishments, based on the methodology set out in the guideline. This was done through the suggestion of some approaches to dealing with these challenges and indicating areas where clarification or further work may be necessary. The overarching aim being to contribute towards the common goal of developing a more consistent framework within which to predict environmental risk, so that the various risk results across different establishments become more comparable and true representations of the risk. A number of challenges were raised, and solutions suggested, including the need for clarification on the approach to take when identifying receptors to assess under Phase 1a of the methodology. The importance of credibility and ensuring that the events described and analysed in an assessment relate to the real-world progression of a major accident was discussed, with emphasis on areas in which assessments could easily deviate from reality.

Having an established approach to environmental risk assessment is an important step forward in ensuring that establishments have an accurate understanding of their risks, and are able to apply a proportionate approach to managing the risks to levels that are As Low As Reasonably Practicable. It is hoped that the challenges raised and suggested solutions to some of these issues may be taken on board in the next iteration of the CDOIF Guideline.

Despite this, it is important to bear in mind that all establishments are different, the environmental risk picture is unique, and a one-size fits all approach is not always appropriate for this type of assessment. The guidelines in place should therefore be used as a preferred primary approach to achieve consistency throughout the industry, but due consideration should also be given to the circumstances of the site and how the guidelines should be interpreted with this in mind to ensure the assessment is reliable, realistic and proportionate.

5) References

CDOIF (Chemical and Downstream Oil Industries Forum), 2015, Guideline [on] Environmental Risk Tolerability for COMAH Establishments v2.0.

CIRIA (Construction Industry Research and Information Association), 1997, CIRIA Report 164: Design of containment systems for the prevention of water pollution from industrial incidents.

CIRIA (Construction Industry Research and Information Association), 2014, CIRIA Report 736: Containment systems for the prevention of pollution: Secondary, tertiary and other measures for industrial and commercial premises.

COMAH Competent Authority, 2015, Control of Major Accident Hazards Regulations 2015 (COMAH) Safety Report Assessment Manual (SRAM) - 2015, accessed online January 2018, http://www.hse.gov.uk/Comah/guidance.htm

COMAH Competent Authority, 2016, “All Measures Necessary”- Environmental Aspects (Guidance for Competent Authority Inspectors and officers).

DETR (Department of Environment, Transport and the Regions), 1998, Management of Harm to the Environment: Criteria for the Management of Unplanned Releases.

DETR (Department of Environment, Transport and the Regions), 1999, Guidance on the Interpretation of Major Accident to the Environment for the Purposes of the COMAH Regulations.

EA (Environment Agency), 2007, Pollution Prevention Guidelines, Controlled Burn: PPG28.

EC (European Communities), 1996, Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances.

EEC (European Economic Community), 1982, Council Directive 82/501/EEC of 24 June 1982 on the major-accident hazards of certain industrial activities.

EI (Energy Institute), 2009, Environmental risk assessment of bulk storage facilities: A screening tool.

EU (European Union), 2012, Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance.

HM Government, 1984, The Control of Industrial Major Accident Hazards Regulations 1984, SI 1984/1902.

HM Government, 1999, Control of Major Accident Hazards Regulations 1999, SI 1999/743.

HM Government, 2015, Control of Major Accident Hazards Regulations 2015, SI 2015/483.

HSE (Health and Safety Executive), 2012, Failure Rate and Event Data for use within Risk Assessments (28/06/2012), accessed online January 2018, www.hse.gov.uk/landuseplanning/failure-rates.pdf

HSE (Health and Safety Executive), 2015, The Control of Major Accident Hazards Regulations 2015, Guidance on Regulations, L111, Third Edition.

HSE (Health and Safety Executive), HSE principles for Cost Benefit Analysis (CBA) in support of ALARP decisions, accessed online, January 2018, http://www.hse.gov.uk/risk/theory/alarpcba.htm