Recommendations on land use planning and the control of societal risk around major hazard sites

Buncefield Major Incident Investigation Board

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Foreword

This is the third of the Board's reports to make recommendations for future action to ensure the effective management and regulation of major accident risk at COMAH sites. Without doubt the subject matter – land use planning and societal risk – has proved the most difficult and technically challenging that the Board has addressed. It is also the longest of the three reports because we have made a particular effort to help make our conclusions and recommendations intelligible beyond the narrow community of practitioners.

In our previous reports containing recommendations the direction of travel was always clear; the judgement call was about how far and how fast. With land use planning on the other hand we have been conscious that it is also about balancing several disparate interests – strategic, economic, social, safety and environmental. The understanding of the risks involved is an important step in reaching decisions and this has led us to address the very technical subject of risk assessment and try to shed some light on it. At the end of the day land use planning and societal risk necessarily entail political judgements. What we are proposing is a tool for flexible, transparent decision making which we believe will assist in achieving more consistent outcomes for the system for land use planning around major hazard sites in the future.

What has encouraged us in developing our ambitious stance is the conviction that there are important benefits to be secured. A more cohesive system, greater collaboration between interested parties and more refined risk assessment tools can enable industries to provide the products we need, while maintaining the levels of safety that everyone expects in a developed society and avoiding the unnecessary blighting of development opportunities. We also believe that wider understanding of the subject and the challenges it poses is crucial to gain acceptance for the decisions that emerge from the process. We trust our report, as well as recommending worthwhile improvements, serves to advance that better understanding.

Lord Newton of Braintree
Chair of the Buncefield Major Incident Investigation Board

Executive summary

In this report we give our views on how the planning system around major hazard sites can be improved in the aftermath of the Buncefield explosions and fires of 11 December 2005.

We explain in the Introduction the approach that can be found in our previous reports for preventing major incidents such as occurred at Buncefield. Preventing major incidents depends upon the proper design and operation of major hazard installations. Limiting their impacts on people and the environment in an event relies on adequate emergency preparedness and response measures. We believe fundamentally that the land use planning system around major hazard sites needs to be more integrated with the Control of Major Accident Hazards Regulations 1999 (COMAH) regulatory system for major hazard sites in Britain than is currently the case. Thus, the principle of decisions being taken by the local planning authority and in line with broader development plans for the region is sound enough, but a weakness is the separation between the COMAH regulatory system and the system for developing advice to planning authorities. The roles of the COMAH Joint Competent Authority and the site operators in the planning system around major hazard sites therefore need to be remodelled. The national benefits of strategic sites like Buncefield should be more integrated with the needs of the local economy.

In Part 1 we focus on improving the way that all the stakeholders in the planning system for major hazard sites are organised. We develop the case for integrating the land use planning and the COMAH systems to achieve sensible consistency in the measures for safety and environmental protection around major hazard sites. In our view this can be achieved in part through greater technical involvement from the site operators. We also believe planning decisions should in future take account of the societal risks of fatal accidents from major incidents by incorporating the size and distribution of the population around the site using a technique known as quantified risk analysis (QRA). Our preferred system is one where the planning authority takes decisions that are informed by expert technical submissions on risks and control measures, including from the emergency responders, and we see the Competent Authority being responsible for the standards of technical submissions, and for the standards of the controls to be achieved by the planning decision process.

Thus Recommendation 1 calls for a wide-ranging review of the system for land use planning around major hazard sites to begin without delay. The review should include the system for granting hazardous substances consent and the incorporation of societal risk into land use planning decision making. We make it clear that we are calling for a new approach that is applicable to all major hazard sites since the issues involved are not confined to Buncefield-type sites alone.

In addition, we make several recommendations on the economic issues raised by Buncefield for the continued co-location of major hazard sites with large communities. Because we call for the COMAH and land use planning systems to be more integrated we believe that increased burdens on site operators will be minimised. The costs of risk reduction measures also need to be considered in relation to the commercial beneficiaries of the measures. We call as well for the revised planning system to be systematically and clearly explained to the general public.

Notwithstanding our call for a wide-ranging review to begin without delay, we have in Part 2 identified a number of primarily technical issues relating to the assessments that inform land use planning decisions around major hazard sites. These need to be

Figure 1 Caravan park next to Canvey Island depot, near the Thames Estuary, Southern England

addressed in parallel with the wide-ranging review if changes to the system are to be delivered within five years. We explain that the simplified, generic approach to risk assessment currently used around flammable storage sites needs to be replaced by a site-specific assessment of risks, using QRA methods, leading to a planning system that is more responsive to the levels of risk posed by each particular site. This is a necessary response to the improvements in risk controls. Specific examples are in moving away from expressing harm in terms of 'dangerous dose or worse' to a risk of fatality, in aligning the risk assessment in the COMAH safety report system with land use planning, and in setting priorities on the management of sites to ensure continuing integrity of the control measures incorporated in the planning decisions. We also address some of the anomalies attaching to the hazardous substances consents system, eg on dormant sites.

Moving to a QRA approach is also necessary for societal risk to be taken into account in a consistent way in Britain, ie to ensure that broadly similar levels of risk receive broadly similar responses in the planning system.

We call on the key stakeholders – some of whom have had little involvement to date – to demystify the concept of societal risk and to envisage a future system where they support the planning authority in coming to transparent decisions on what level of societal risk can be accepted in a planning application. This should be subject to guidance on tolerability limits developed by HSE and agreed nationally. We also call for the planning authorities to be suitably resourced to develop the expertise and procedures necessary for their role.

We commissioned a report from the engineering consultancy Det Norske Veritas to describe what a risk-based system incorporating societal risk might look like at a flammable storage site. The results of this work confirmed that a fully risk-based land use planning system around such sites is feasible, and is used elsewhere in Europe. We summarise the findings in Part 2 and in Annex 10.

We conclude our report by addressing retrospective applications of this method since it is inevitable there will be some places where the societal risk will be of concern due to developments which have already taken place. These locations will need to be managed through a specific and proportionate response.

Introduction

Background

1 This report sets out recommendations concerned with land use planning around high-hazard industrial facilities regulated under the Control of Major Accident Hazards Regulations 1999 (COMAH) and addresses the related concept of societal risk. The recommendations are made by the independent Investigation Board, chaired by Lord Newton of Braintree, set up to supervise the investigation into the explosions and fires at the Buncefield oil storage depot, Hemel Hempstead, Hertfordshire on 11 December 2005. The Health and Safety Commission[1] directed the investigation using its powers under section 14(2)(a) of the Health and Safety at Work etc Act 1974.

2 Item five of the investigation's terms of reference required us to 'make recommendations for future action to ensure the effective management and regulation of major incident risk at COMAH sites. This should include consideration of off-site as well as on-site risks and consider prevention of incidents, preparations for response to incidents and mitigation of their effects'.

3 Our Initial Report, published on 13 July 2006,(ref 1) identified four principal work streams that would form the basis for our continuing work and developing recommendations. Those work streams are:

- design and operation;
- emergency preparedness for, and response to, incidents;
- advice to planning authorities; and
- examination of the Health and Safety Executive's (HSE's) and the Environment Agency's roles in regulating the activities on the Buncefield site.

4 This report concentrates on the third of these – the system for land use planning around major hazard sites in Britain.[2] It builds on the broad conclusions set out in paragraphs 80–86 of our Initial Report, but ranges more widely over the key components of the planning system around major hazard sites, not just HSE's contribution to it. The platform for this report has been two consultation exercises conducted in 2007 and our consideration given to the issues raised in responding. The first consultation document was *Proposals for revised policies for HSE advice on development control around large-scale petrol storage sites* CD211(ref 2) published by HSE in February 2007. The second consultation document was *Proposals for revised policies to address societal risk around onshore non-nuclear major hazard installations* CD212,(ref 3) published April 2007 by HSE on behalf of a government-wide task group co-ordinated by the Cabinet Office. Our responses to both these consultations can be found on the Buncefield website www.buncefieldinvestigation.co.uk. HSE's conclusions from CD211 were published on 4 December 2007 and from CD212 on 30 January 2008, both available on HSE's website www.hse.gov.uk.

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1 The Health and Safety Commission merged with the Health and Safety Executive on 1 April 2008. The roles and functions of the Commission have now transferred to the 'new' HSE.

2 Our remit is to address the major hazards system regulated by the COMAH Competent Authority whose jurisdiction applies in England, Wales and Scotland and we use the term 'Britain' in this sense throughout the report. We hope that the Office of the First Minister and Deputy First Minister for Nothern Ireland will nonetheless find our report useful.

The Board's approach

5 The impacts of the explosions and fires – physical, environmental, strategic and economic – were very extensive. As we said in paragraph 80 of our Initial Report, one of the starkest issues raised by the event is the location of sites with such major hazard potential alongside neighbouring residential and commercial development.

6 Major hazard sites are identified for regulatory purposes by the nature and quantities of the materials they handle, and are subject to the COMAH regime (see Annex 3). Many of these sites are essential for maintaining the supply of products which we rely on and take for granted. Buncefield was an important link in delivering fuel supplies for ground and air transport, especially for Heathrow airport. The strategic importance of major hazard sites must be balanced by high standards of safety and control.

7 The point we made in paragraph 63 of our Initial Report was that no harm can arise so long as there is no failure of primary containment of the fuel in its storage tanks. There needs to be a clear hierarchy underpinning the various safety, environmental and planning controls.[3] The starting point for us is therefore the proper design, installation, operation and maintenance of the equipment intended to maintain primary containment, allied with a consistent approach to ensuring its integrity.

8 The potential for a major incident can only be reduced, not entirely eliminated, as there will always be some degree of residual risk in any industrial operation. The means of early detection of loss of fuel from a tank therefore needs to be integrated with appropriate secondary and tertiary containment measures[4] to prevent the release from escalating into a serious incident. The Board published its conclusions and 25 recommendations on integrity management, incident prevention and control measures in its fifth report *Recommendations on the design and operation of fuel storage sites*(ref 4) on 29 March 2007.

9 For top-tier sites, COMAH requires the preparation of both on-site and off-site emergency plans to minimise as far as possible the consequences of a major incident. The Board published its conclusions and 32 recommendations on emergency planning and preparedness in its sixth report *Recommendations on the emergency preparedness for, response to and recovery from incidents*(ref 5) on 17 July 2007. The first of these recommendations is for operators to revise their emergency plans to take into account scenarios such as vapour cloud explosions and severe multi-tank fires that, before Buncefield, had not been considered credible by the sector or the Competent Authority. Subsequent recommendations deal with the necessary arrangements for managing on-site and off-site incidents.

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3 Operators are required to control the major hazard risk preferably by its elimination, or by reducing it, or otherwise by protecting against it.

4 Secondary containment is enclosed areas around storage vessels (often called bunds) created usually by concrete or earth walls. Their purpose is to hold any escaping liquids and any water or chemicals used in firefighting. Tertiary containment includes things such as drains designed to limit the passage of chemicals off site and raised kerbs to prevent liquids that have breached the bunds from escaping into the general area around the site.

We also call for improved communications between the operators and the communities surrounding major hazard sites to ensure practical and realistic understanding of the risks and the arrangements for their control. These reports reflect a much wider perspective than hitherto towards the hazards that need to be considered in both design and operation of sites, as well as in emergency planning.

10 Further mitigation of the off-site consequences of a major incident is achieved by controlling the uses to which land in the immediate vicinity of major hazard sites can be put. In this context land use planning takes into consideration the extent of the danger posed beyond the boundaries of the site and the size and nature of any proposed development. It seeks to balance the need for making best use of the land available for development with the protection of those who will occupy or use these developments. It is this subject that this report addresses.

11 One response to the Buncefield incident, and the serious structural damage the explosion caused in the vicinity, was to call for a widened restriction to development around this and similar sites. Another response was to seek to limit the hazard potential of such sites in the light of proposed commercial and social developments around them. Such reactions are understandable but we believe the real need is to balance safety with strategic and economic considerations, and this is our general approach.

12 This balance has to meet rising expectations for provision of housing and employment on the one hand and on the other hand the rising expectation (especially after Buncefield) of being safe at home and at work. We consider that the land use planning system at major hazard sites has not kept pace with these changes in society and in Part 1 we call for a wide-ranging review. We also set out key areas meriting attention and, by way of introduction, an outline description of the constituents of the system. We go on in Part 2 to make more detailed recommendations where we believe it is necessary to provide clarity.

An overview of the land use planning system around major hazard sites

What we see

13 It was clear at the outset of our investigation that land use planning (taken as a whole, and not just HSE's role in it) was the most complex and sensitive issue to be addressed. The planning history of the Buncefield site and neighbouring developments (see Annex 4, reproduced from the Initial Report) tells its own story. The site opened some 40 years ago, before a specialised planning system around major hazard sites had developed. There were few houses and no commercial buildings in the immediate vicinity. Since then activities within the site have intensified, and as Annex 4 shows, both residential and commercial development has taken place outside. The purpose of the land use planning system is to control the uses to which land in the immediate vicinity of major hazard sites can be put and to be responsive to changes in risk presented by such sites. Prior to Buncefield the planning advice at flammable storage sites would not have covered the likelihood of a violent explosion. Equally, the risk control measures and the emergency response arrangements at such sites would not have been primarily directed at the possibility of a large flammable vapour cloud. This suggests that the system for giving planning advice around major hazard sites should be integrated with the regulatory system for controlling the risks of major hazards to humans and the environment created by the site itself, which has been the subject of our fifth and sixth reports.

Figure 2 Oil depot in Shore Street, Kirkwall. Note the proximity of houses, business premises and a public road

14 In considering the planning system around major hazard sites we have sought to address the following:

- Does the system balance safety and economic development appropriately?
- How well does it work?
- What might an exemplary system look like?
- Is such a system feasible and can it be justified in terms of cost?
- If so, what actions are required and by whom?

15 The fundamental principle of the land use planning system is that decision making is the responsibility of the local planning authority, usually the local authority. The planning authority reaches decisions on applications for development in the vicinity of major hazard sites having taken account of relevant social, economic and safety factors and generally determined in accordance with the development plan in that part of the country.[5] The Competent Authority provides the advice about suitability on grounds of safety and environmental impact and its role is as adviser under the requirements of the Seveso II Directive,(ref 6) not as decision maker. We believe the principle of decision making by the local planning authority supported by specialist advice is sound.

16 Beyond that, though, the system is showing its age after three decades of application. Economic activity has intensified and major hazard sites are usually of national strategic importance. Much of Britain is densely populated and non-nuclear major hazard industrial sites tend to be in areas of high population density where the demand for land to build houses, business premises and leisure facilities is intense. Building more houses is a high political priority, and such housing must be accompanied by employment opportunities and associated infrastructure.[6] The planning bill currently under public consideration draws attention to the need to facilitate (speed up) strategic economic development. The national land use planning system around major hazard sites must balance the sometimes opposing pressures of local and national strategic economics and this clearly requires an understanding of the individual and societal risks created by the co-location of high-hazard sites and humans.

17 In our view the planning system around high-hazard sites has not adapted sufficiently in response to these pressures. We see a current system:

- that makes insufficient demands of site operators who create the major hazard risks;
- that does not consult site operators about potential developments in the immediate vicinity of their sites;
- where the processes and criteria used for land use planning and COMAH safety report assessment do not match;

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5 Section 38(6) of the Planning and Compulsory Purchase Act 2004 requires decisions to be made in accordance with the development plan unless material considerations indicate otherwise.

6 For example, Dacorum Borough Council, the planning authority for the Buncefield site, has estimated that for the latest spatial plan for 12 000 new houses near to Buncefield to be viable, 18 000 new jobs will be needed.

- which has no means of taking account of the total population at risk in the immediate vicinity of the site;

- where HSE is not routinely consulted in the critical early stages of regional development planning, and when it is consulted is not always able to respond adequately;

- where the underpinning technical assessment processes need updating to bring into effect a significant body of HSE work relating to assessment methodologies;

- that takes little account of local site conditions in terms of actual inventories present, the standard of integrity management and the impact of the regulatory regime;

- that has a serious anomaly in not including gasoline pipelines; and

- that is poorly understood by the public and many of the stakeholders.

What we propose

18 We want to see a system that is more integrated and more consistent. We have structured our report into two main parts. Part 1 considers the organisation of the system and how it can be made more integrated. It identifies deficiencies in the current organisational process and points to where improvements can be achieved. However, it also recognises that the system runs across various parts of central and local government and that such improvements may not be easily achieved. We therefore recommend a wide-ranging review to deal with the limitations of the system in its present form, which we identify in this report, including those mentioned in paragraph 17.

19 Our preference is for a system where the site operator plays a much greater part in informing the planning authorities of the major hazards risks and their control measures; where key stakeholders such as the emergency responders have an input; and where the planning authority takes a clear and expert lead in the decision-making process.

20 We see the role of HSE as agreeing the methods by which the planning consultation zones are derived, including the practical information that needs to be considered by the planning authority, but no longer being responsible for the actual technical assessment. HSE should adopt the role of regulatory overseer to the new regime aligning with the Competent Authority's functions under the COMAH Regulations. It will be necessary to give public assurance that the site operators' input into the system is sensibly technical and objective, and we see HSE as providing the regulatory technical oversight in this regard.

21 We see a strong link between the revised planning requirements we are calling for and the requirements for preparing on-site and off-site emergency response plans, for which the COMAH Competent Authority is the enforcing authority. We see as inevitable the integration of the planning system around major hazard sites with the COMAH regime. This will deliver, for the first time, an integrated regime for the control of major hazard risks at industrial sites in Britain.

22 Part 2 of our report looks at the risk assessment process that provides the technical underpinning of the system and how it is applied in practice. Ultimately, risk assessment involves judgement but we also advocate the much wider use of a method known as quantified risk assessment if planning is to be more responsive

to the risks at major hazard sites. Quantified risk assessment (QRA) is not new and is already used in COMAH assessments and widely used offshore, particularly for comparing the risk impacts of different options. In the context of land use planning around major hazard sites it can be a tool for decision-making that enables the total local population at risk at specific sites to be taken into account, and can help deliver consistent planning advice across industry sectors. Taken as a whole, implementing all our recommendations (in Parts 1 and 2) will address the limitations we have identified in the current system.

What we consider to be the benefits

23 Why are we proposing organisational and technical changes to the current land use planning system at high-hazard sites? These changes will come at a price, so what do we consider are the main benefits of our proposals? Firstly, as we say in paragraph 18, our proposals address the deficiencies we have described. The resulting system should be better tailored to 21st century circumstances and deliver improved social and economic benefits.

24 In moving to a planning system based on assessing the risks on a site-by-site basis, what might success look like? We anticipate in the planning system a relationship between the major hazard site and its surrounding community and natural environment where:

- unnecessary blights on development opportunities are minimised;
- economic and/or social development[7] of the area around a site can increase in response to improving the major hazard risk controls on the site;
- incorporating new knowledge and invention in building design and construction and other measures can reduce the vulnerability of the surrounding populations;
- account can be taken of the impact of risk reduction measures as the improved controls are applied;
- site operators can vary production throughputs, product inventories etc in response to suitable measures for increasing control of major hazard risks;
- site inspection and enforcement by the Competent Authority is targeted in the most appropriate way to give public assurance that the major hazard risks are continuing to be adequately controlled;
- degradation of the facilities, and other major changes on- and off-site are properly accounted for, as time goes by, in relation to their impact on the major hazard risk controls;[8]

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7 This is analogous to the control of the design of the on-site buildings at major hazard installations. We envisage measures to adequately reduce major hazard risks to allow increased off-site development will be costly and address the economics of this in Part 1, paragraph 55 et seq.

8 The safety report is resubmitted on a five-year cycle and account needs to be taken of any changes that affect the major hazard risks.

Figure 3 View of the AZF chemical plant in the south-west suburbs of Toulouse, which exploded on 21 September 2001, killing 30 people

- the relationship of the hazard to the vulnerable population will be consistent and capable of comparison between sites, and therefore easier for the planning authority to explain its decision to local people why, for example, a new development will not be approved even though there are already buildings/homes in that area;
- highest risk aspects can be targeted, ie decisions can be taken as to where the greatest impact on the risk levels can be made to optimise off-site and on-site risks;
- technical considerations and assumptions underpinning COMAH regulation of industrial sites are the same as for planning purposes;
- of necessity site operators are consulted on impact of new developments to risk;
- societal risk is inextricably linked to the planning system around major hazard sites; and
- an integrated approach to regional/development/spatial plans can be taken by all stakeholders in the planning stages, rather than incrementally.

25 What are the potential drawbacks of our preferred system? One significant issue will be the period required for transition to a revised system, which will have significant implications for HSE, the industry, Communities and Local Government (CLG) and relevant ministers of the devolved administrations and planning authorities. In addition, a risk-based approach will not significantly reduce the consultation distances without the improvements to the control measures we have recommended in our fifth report on design and operation of fuel storage sites. Nonetheless, we are clear that the advantages in moving to a more integrated and consistent risk-based planning system around major hazard sites outweigh the disadvantages and therefore that the costs and effort involved in developing the system are justified. There will be technical imperfections in any revised arrangements, but no more so than the current system, and these should improve quickly as our other recommendations take effect and improved failure frequency data becomes available.

What needs to be done?

26 Much of what we say is not new but previous ideas for improvements have not always been taken forward. We judge the reasons include resource constraints and competing priorities within the relevant government departments.

27 We recognise that moving from the current system to one that is more integrated and responsive to risk will take time. It will require the commitment of local planning authorities and operators, and a greater involvement of the emergency responders, public representatives, and the regional agencies and business forums. As this field spans a number of policy areas and there does not appear to be a clear point of responsibility, we expect specific ministers in the relevant administrations to be given the lead.

28 Because any transition will take time, we want to see both the wide-ranging review of the organisation and the more detailed technical recommendations taken forward in parallel. We consider the review should begin without delay if we are to have a system fit for 21st century circumstances within a reasonable time frame.

29 The key objectives of economic development, planning policy and risk assessment must be balanced in the national interest. The Buncefield incident caused massive damage to homes and businesses and illustrated the devastating potential of major hazard sites. Equally, in the loss of half of Heathrow airport's fuel supply, it showed the strategic importance of such sites to the UK economy. Major hazard facilities such as refineries, fuel depots and chemical plants are generally of high strategic importance and tend to be cheek by jowl with large populations. Challenges to the restrictions placed on development in the vicinity of such sites are continuing to arise, as they have done in the past but perhaps with more frequency. There is no justification for settling for over-cautious restrictions as a long-term solution. But equally, in moving to a new planning regime that is responsive to risk, there will need to be public assurance that retrospective action will be taken where there are concerns for the societal risk around certain sites. Such retrospective action has been taken, eg in the Netherlands and France in response to the Enschede,[9] and Toulouse[10] disasters.

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9 On 13 May 2000, the fireworks warehouse, operated by SE Fireworks exploded in Enschede, north-east Netherlands. 23 people were killed and nearly 1000 were injured.

10 On the 21 September 2001, Shed 221 storing ammonium nitrate on a plant operated by AZF exploded in Toulouse, SW France. 30 people were killed and nearly 9000 were injured.

30 We wish to make it clear that we are calling for a new approach that is applicable to all major hazard sites, as it is not sensible to artificially restrict changes to Buncefield-type sites only. We acknowledge that this is a sweeping stance to take and that progress towards this goal will needs a serious and energetic cross-government effort, eg to get the different parties on board, some of whom will have had little or no past involvement in land use planning. The key players in the new system must also be able to incorporate economic factors into decision-making involving societal risk in development applications. Those principally involved – CLG and the devolved administrations, HSE, the planning authorities and COMAH dutyholders – will require some room to propose a programme for retrospective application that is practical and proportionate. Also, because there are national civil security issues attaching to many major hazard sites, Cabinet Office and the primary authorities for civil contingencies in the devolved administrations must become involved too. The priority now is to begin work on all fronts. Buncefield has served as a call for the difficulties to be confronted with a sense of urgency and priority.

Part 1
Improving the organisation of the land use planning system around major hazard sites

31 Site operators require planning permission from the planning authority and a Hazardous Substances Consent from the hazardous substances authority (HSA) (both are usually the local planning authority). HSE is a statutory consultee for both and either 'advises against' or 'does not advise against'. That advice has to be taken into consideration by the planning authority before making its decision. If approval is given, it may be with conditions. Enforcement under both controls is also the responsibility of the planning authority. This has led to difficulties in the past for planning authorities trying to enforce conditions recommended by HSE and in practice conditions are rarely attached to consents nowadays. However, the hazardous substances consent sets a maximum inventory of defined hazardous substances that can be held on site.

32 To expedite the issuing of hazardous substances consents to meet changes in regulatory requirements a system of deemed consents was agreed whereby operators could apply for streamlined consent for up to twice the average stored inventory on their site. This scheme was extended, we believe, at the introduction of COMAH as further sites came into jurisdiction. Since then, changes to other regulations, which provide definitions of generic categories of substance and qualifying threshold quantities which are in turn used by hazardous substances regulations, went through without deemed consent. However, the last consultation in 2005 on changes to the substances and quantities covered specifically by hazardous substances consent – prompted by changes to the Seveso II Directive – sought to rule out deemed consents. We understand that industry responses were not in favour of this and the changes proposed have yet to be implemented. The work by HSE to map the revised consultation distances around all the sites with deemed consents is not yet completed.

Figure 4 A view across the ex-Royal Naval Air Station and the oil storage tanks – Portland, Dorset, Southern England. The end of Chesil Beach can be seen on the left of the picture. Weymouth is across the bay joined by a road bridge, shown above the tank farm

33 Once hazardous substances consent has been granted, the HSA passes the papers to HSE who defines on a map the area within which planning authorities have to consult HSE for other planning applications (the 'consultation distance'). HSE also sets three zones within the consultation distance which are the basis for HSE's advice. Ultimately, HSE will either 'advise against' or 'not advise against' as it does for hazardous substances consent. (See Annex 4 for more information on this subject.)

34 Subsequently, when individual applications are submitted for off-site developments that are within the Consultation Distance, the planning authority has to make the decision having taken advice from HSE. Where the planning authority approves an application against HSE advice, and an opportunity has been provided for HSE to explain the nature of the risks to the planning authority, then HSE can invite the Secretary of State for CLG, and the relevant minister in Wales, to 'call in' the decision for review. In Scotland, a planning authority wishing to proceed against HSE's advice has to notify the planning application to the Scottish ministers who may call it in for their own decision.

A more integrated system

35 The first area we believe merits attention is the way in which major hazard risk assessment under the COMAH regime and the general planning system around major hazard sites operate together. Plainly, these two systems are essential components of the decision-making process but they are not consistent.

36 The first example of inconsistency derives from HSE having to conduct its technical assessments on information provided in applying for a consent. HSE has expressed concerns that the information is not always adequate for its purposes and the timeframe in which it is expected to formulate its advice too short. More fundamentally, HSE bases its risk/hazard assessment on the maximum consented quantity, which can significantly exceed the quantities actually stored. Also, where companies have generic consents to store substances, HSE bases the assessment on the most hazardous substance within that generic consent.

37 Both situations – maximum consented volumes and most hazardous substance – can produce larger zones and consultation distances than the actual circumstances may require. Companies are sometimes prepared to work with HSE and planning authorities to take steps to reduce the large consented inventories but this is not always the case and it is not legally required of the operator. Larger consented quantities are valuable to companies and there are difficulties for the planning authorities in reducing these because of compensation issues. Uncertainty also arises where consents exist but have not been used, or where operations have ceased and future intentions are not clear. This is because unless specific steps are taken to revoke or withdraw it, the consent remains with the land.

38 We understand these issues and others have been reviewed and options for change have been produced by HSE. The outcomes of the review were shared with the cross-government task group considering societal risk (see paragraph 4) but we are unsure whether any further action was intended.

39 Another inconsistency between the two regimes is what legally constitutes a change of use from the point of view of the planning system and what changes might be significant from a risk point of view. This is because the planning system defines a range of 'use classes', and change of use within a single class does not generally require new planning permission. Some developments involving change within a single planning use class would alter HSE's advice had it been part of the original application, for instance because it increases the number of people present or introduces people of different vulnerability to the risks presented by the site.

However, such changes will not often be considered by HSE because its advice is, generally speaking, only given for the use described in the original application, and not for others in the same planning use class.

Societal risk

40 Societal risk is an established concept for taking into account the total population at risk. A report in 1983[ref 7] noted that people perceive 'high consequence hazards' as different from hazards which do not have the potential to injure many people at once. A number of multiple fatality industrial incidents over the last 40 years illustrate this point, and as with Flixborough[11] and Piper Alpha,[12] have led to improvements in standards of major hazard risk control and changes to the regulatory system. Even where the individual risk is low, societal risk can remain significant and be the main driver for risk reduction measures. Following the Buncefield incident, where fortunately there were no fatalities, there has been intense public reaction due to the extreme damage to the vicinity, the disruption to national fuel supplies, and the losses sustained by residents and businesses.

41 In our Initial Report (paragraph 86) we noted the incremental development around Buncefield and observed that cumulative risk should receive more attention given that the system for generating planning advice currently focuses on developments subject to planning approval as they arise. Incremental development around Buncefield is described in Annex 4, which depicts all building development by type from the mid-1960s to 2005.

42 Our Initial Report acknowledged the cross-government work on this issue being co-ordinated by the Cabinet Office which began before the Buncefield incident. That work informed a consultation exercise (CD212) which addressed societal risk and raised questions about how it could be applied in practice. We welcomed this first public consultation on societal risk.

43 Our response to CD212 (available on the Buncefield Investigation website) made clear that we viewed land use planning and societal risk as inextricably linked. We concluded that societal risk should be integrated into the land use planning system around major hazard sites so that it registers and responds to the cumulative effects of serial planning decisions. We also supported the idea that HSE should be consulted by planning authorities during the preparation of development plans so that information about societal risk could be considered at this stage. This does happen to some extent at the moment but HSE's input to development planning is inconsistent and needs placing on a more formal basis. The important contribution HSE should make in planning around major hazard sites should also be emphasised in the planning statements issued as guidance for planning authorities by CLG and the devolved administrations.

44 The summary of findings from CD212 (published by HSE on 30 January 2008) shows that a large majority of respondents were in favour of taking account of societal risk in both the assessment and provision of on-site control measures and the decision-making process for land development around sites. Furthermore, most

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11 In 1974 an explosion at the Nypro caprolactam plant at Flixborough killed 28 workers and led to the establishment of the Advisory Committee on Major Hazards (ACMH). See Annex 6.

12 In 1988 a series of explosions that followed an initial release of gas from a compressor module on the Piper Alpha North Sea platform east of Aberdeen killed 167 workers and two rescuers.

respondents agreed that societal risk should be considered when drawing up local development plans as well as when considering individual planning applications.

45 Finally, we observed that treatment of societal risk in CD212 was very general and qualitative and that more detailed work is needed to resolve technical issues and achieve effective, workable policies and procedures. In short, we call for societal risk, whatever the current deficiencies in its estimation and application, to be integrated into the land use planning system around major hazard sites. Ministers agreed, following the consultation on CD212, that HSE should include societal risk in its land use planning advice. HSE has indicated that the next stage of the exercise is to focus on more detailed consultation with the planning authorities to establish detailed procedures. We welcome this general commitment from government and ask that the means of implementing it is pursued without delay.

Roles, contributions and collaboration

46 The third area meriting attention is to look at the roles of the main players in the system and how they interrelate. In paragraph 15 we stated our support for the fundamental principle of the land use planning system, namely local decision making. That said, there is a lack of clarity in some of the roles in practice and the contributions from the main players are not optimal. The work of the Advisory Committee on Major Hazards (ACMH – see Annex 6) was groundbreaking in its time, but we consider that their principles should now be revisited. We have argued earlier that the pressures on the system have intensified severely since the ACMH era and this justifies a wide-ranging review of roles and contributions.

Contribution of site operators

47 Site operators have limited involvement in the off-site planning process once they have once received their hazardous substances consent from the HSA. Little is demanded of them as far as the land use planning system around major hazard sites is concerned, despite their unique knowledge of the site risks and their responsibility under COMAH for systematically assessing their operations for major hazard potential, including those that could have off-site consequences. For 'top-tier' COMAH sites this assessment process is formalised in requiring a safety report to be submitted to the Competent Authority.

48 In our previous reports we have called on operators to improve their risk controls and enhance their emergency preparedness and support to off-site emergency response planning. It is therefore entirely consistent for operators to also conduct the main risk assessment process for land use planning and thereby contribute more effectively to the information on which the planning authority will make its planning decisions. In return they will be informed and consulted about relevant developments on a more formal basis than at present.

Role of HSE

49 Currently it is HSE that designates the consultation distance based on the information it receives from the planning authority arising from the operator's application for a hazardous substances consent. Following what we have said above, the call should be made on site operators to undertake the necessary technical assessments from which the risk zone contours would be derived. It would be more consistent and effective for HSE to set the standards for technical contributions by COMAH operators to the planning system around major hazard sites, and to check that the operators do so adequately. We understand that in the Netherlands there is a prescribed methodology which site operators are required to follow in conducting assessments for land use planning purposes (see Annex 7).

50 Such an approach in Britain would ease the demand on HSE's technical resources and bring alignment with the COMAH regime, placing the responsibility for the risk assessments on the operator who creates the major hazard risk in the first place. HSE should then become the national custodian of risk assessment methodologies and standards. In that role it should systematically gather and analyse information about major incidents nationally and internationally. HSE should also have a systematic approach to reviewing assessment methods, gathering such information as it needs to inform this process. For site-specific situations HSE's role should be to check assessments conducted by the site operator against the standard methodology, but we believe its role should not be to conduct the assessments itself.

51 With respect to planning authorities HSE's role is formally to act as adviser but the reality must look different to many planning authorities. Nominally, they reach decisions on planning applications having considered all relevant factors, of which advice from HSE is but one. However, as local democratic representatives, it is difficult for them to go against negative safety advice. Furthermore, HSE has the option where its advice is not taken to invite the Secretary of State to 'call in' the application. Historically this option has been rarely exercised; but there are no published criteria HSE uses for so doing, and in consequence HSE may sometimes be perceived as offering advice while having available a further sanction if that advice is not followed. HSE also becomes involved in negotiations with developers, planning authorities and communities where planning advice is problematic, although it is unclear to us how this actually aligns with HSE's responsibilities. In any case this conveys a strong impression that in reality, HSE is in overall control of the planning decision.

Role of planning authorities

52 The planning authorities take decisions on planning applications having taken into account the interests of the local community (both business and residential), the interests of the developer and relevant safety and environmental considerations. This includes advice from HSE regarding developments within the consultation distance of a major hazard site. Of recent years this advice has been available in the vast majority of cases through a software tool developed by HSE. This is known as PADHI (Planning Advice for Developments near Hazardous Installations).

53 HSE advice, though, only takes account of the potential to cause human harm because its remit is limited to occupational health and safety. No account is taken of damage to property and disruption to personal lives and economic activity, but we believe it should and that the Buncefield event amply demonstrates why. If a wider view of 'harm' is taken, then the planning authority will need to seek advice from other organisations in addition to HSE.

54 The above briefly illustrates the complexity of the decisions planning authorities can be faced with. There is guidance to planning authorities in the various administrations[13] on how to balance the various considerations in reaching their decisions, but not sufficient guidance on how to balance safety considerations in relation to other issues around major hazard sites – there needs to be greater clarity and transparency over how decisions are reached. Decisions that will increase the population around major hazard sites should be clearly explained to all those

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13 In Scotland, Circular 5/1993 describes HSE's advisory role regarding health and safety grounds for refusal or imposing conditions. General guidance on determining planning applications, including whether a consideration is material and the weight to be given to it, is in Scottish Planning Policy 1 – the Planning System. In Wales, Annex A of National Assembly for Wales Circular 20/01 provides guidance on the role of HSE in relation to planning applications.

affected. More resources may be required to assist planning authorities to interpret specialist advice and to fully understand the wider impacts of their decisions and we return to this point in Part 2.

A more collaborative approach

55 The difficulties sketched out above suggest that more interaction and iteration should be designed into the planning process. The Dutch operate a system that brings together the main interested parties in an attempt to reach mutually satisfactory conclusions (see Annex 7) and the French are developing a similar system. In our response to CD212 we supported as eminently sensible the idea mooted of operators, developers and planning authorities getting together to consider the implications of an intended development before difficult issues related to societal risk arose. We believe this more collaborative approach merits closer examination, not just confined to societal risk issues.

56 For problematic applications the planning authority could bring together the developer, the site operator, representatives of the local residential and business communities, relevant regulatory bodies and the various organisations represented on the Regional Resilience Forum, and other relevant stakeholders, eg insurers. The planning authority, while retaining the responsibility for the final decision, could then act more in the role of processing the expert advice it receives before coming to a decision. This would go a long way to securing greater transparency in the planning decision making around major hazard sites. HSE for its part can suggest practical strategies to reduce risk and offer advice on ideas being considered. It may be that modest changes and concessions by some of the parties present will enable the development to proceed. With this collaborative approach to reaching decisions, the consultation distance and the zones within it need not act as such a rigid determinant of HSE advice, provided the safety implications of an intended solution are recognised and accepted by all parties. In this way HSE can remain in a genuinely advisory role and the question of call-in should not arise.

57 This chimes with a wider point made in our sixth report[ref 5] (in paragraphs 26–27 and Recommendations 8 and 9 under the heading 'Warning and informing the public') which reinforces the need to maintain continuing communication between the site operator and the residents and businesses in the vicinity of major hazard sites. By its very nature, such communication requires joint working with the local authority and integration with the plans of Category 1 responders.[14] The essence is to establish an ongoing relationship between site operators, those who in the worst circumstances could be affected by their operations and those bodies with key responsibilities for emergency planning and response. Were such arrangements in place, then the collaborative approach to land use planning decision making we are suggesting should be a relatively straightforward extension to it.

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[14] Category 1 responders are organisations at the core of the response to most emergencies (eg emergency services, local authorities, NHS bodies and the Environment Agency/Scottish Environment Protection Agency). Category 1 responders are subject to the full civil protection duties under the Civil Contingencies Act 2004. Category 2 responders are other organisations that are likely to be involved in emergencies such as HSE, utilities and transport companies.

Figure 5 Flames are seen behind a house next to the Buncefield oil depot on 12 December 2005 in Hemel Hempstead, England

Conclusion

58 We conclude that land use planning policy and practice has developed in a piecemeal fashion and this part of the report has illustrated our view in three areas. Our concern is that the current system has not kept pace with the intensification of pressures on it and does not fully serve the local and national interests in striking the best balance between safety for local communities and maintaining economic activity. Our observations are not intended as criticism of any of the individual organisations involved; the issue is the cohesiveness of the system as a whole.

59 We are therefore calling for a wide-ranging review of the planning system around major hazard sites. We believe that many people already acknowledge the deficiencies we have identified (and more) and that ideas for improvements have been proposed but not yet taken forward. We want to see a review conducted with urgency independent of other recommendations in this report. The review should at a minimum make recommendations that deliver a more integrated system that incorporates societal risk, and better balances and harnesses the contributions of the main parts of the system.

60 In preparing our responses to CD211 and CD212 and in developing this report, we reached a number of detailed conclusions that we set out below. We expect the review we call for to include the following:

- site operators[15] – those that create the major hazard risks and manage the control measures – should play a new and significant part in the land use planning process;
- societal risk should be considered in land use planning applications;
- the land use planning system around major hazard sites should not just consider direct physical harm to people but should have regard to the wider consequences and incorporate other harms to communities, including those arising from the potential impact to property, livelihoods, amenities and the environment;
- HSE should be consulted by planning authorities during the preparation of development plans and provide relevant advice so that information about societal risk can be considered at this stage;
- planning legislation and land use classes should be reviewed and amended as necessary to ensure that proposed developments of significance to the risk assessments within the consultation distance of COMAH sites always become subject to the revised system – including changes of use to, or significant changes in population numbers at, existing buildings;
- improvements should be made to the standard of hazardous substances consent papers received from planning authorities and the short times specified within which HSE is expected to respond to these;
- HSE should systematically gather and analyse information about major incidents nationally and internationally. It should also systematically review risk assessments methods for use in the land use planning system around major hazard sites, gathering such information as it needs to inform this process.

Recommendation 1 We recommend a cross-government and wide-ranging review of the land use planning system around non-nuclear major hazard sites in Britain. The review should include:

- the system for hazardous substances consents;
- the system for determining planning applications around major hazards sites;
- the relationship between planning applications around major hazard sites and development plans and planning;
- the scope of hazardous installations to which the land use planning system should be applied; and
- the integration of societal risk into the planning system around major hazard sites.

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15 Site operators would normally be dutyholders under the COMAH Regulations and therefore be responsible at the outset for identifying the major hazard scenarios, calculating the likelihood and degrees of harm arising from them, and for establishing the preventive or mitigatory measures to reduce risks on the site as low as reasonably practicable.

The aim of the review should be to revise the planning system around major hazard sites in Britain to produce a more consistent and transparent system across the non-nuclear, onshore major hazards sector. The system should be responsive to levels of risk presented at each site. It should ascribe responsibilities to dutyholders and the relevant authorities, including in the devolved administrations, in a proportionate and targeted manner. A minister should be responsible in each administration for seeing the review is carried out.[16]

The review should be commenced without undue delay in order to implement its conclusions within a reasonable timeframe. Wherever feasible, work on revising the elements of the system should be undertaken simultaneously rather than sequentially.

Recommendation 2 The review should take account of our approach to improving the control of major hazard risks at major hazard sites.

Our approach integrates:

- integrity levels of the major hazard sites in relation to containment of dangerous substances and process safety;
- mitigation against the effects of a major incident on off-site populations and installations;
- preparedness for emergency response to limit the escalation of potential major incidents;
- land use planning; and
- the regulatory system for inspection and enforcement under COMAH and other relevant law.

Economic considerations

61 Further support for a collaborative approach comes from the economic standpoint because of the interdependency between containment measures, emergency preparedness and controlling the uses to which land in the immediate vicinity of major hazard sites can be put. This means that the risk of loss of containment, the level of which is defined by on-site measures, needs to be considered in tandem with land use planning and societal risk, as both affect the overall level of risk posed by a major hazard site. If land use planning and loss of containment risks are considered separately then it is possible that land use planning restrictions could be too stringent, constraining economic development and the building of homes or amenities beyond what is necessary to achieve an acceptable level of risk.

62 So, as we remarked in our response to CD211, the economic case for land use planning should capture all the variables in the crucial measures of the costs and benefits of restricted development, including costs to the industry and wider society. There are many potential economic models of how to represent such an integrated system. Recommendation 3 calls for a comprehensive assessment of the economic costs and benefits inherent to the planning system around major hazard sites.

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16 In Recommendation 10 of our sixth report we call for a minister to be responsible, *inter alia*, for seeing that lessons learned from major incidents – and therefore our recommendations – are carried out.

63 Another way of looking at this is to consider who creates the risk around major hazard sites. Clearly, at new sites this is the site operator. At existing sites those who decide to develop the surrounding land could be deemed responsible for at least increasing the societal risk of those exposed to the major hazard. Also HSE's analysis of replies to CD212 states that most respondents favoured the person or organisation causing the increase in risk to pay for any additional measures.

Recommendation 3 We recommend that the economic case for a revised land use planning system around major hazard sites arising from the wide-ranging review should consider the full range of the costs and benefits of restricted development, including costs to the relevant industry sectors, local businesses and regional economies, and the use of land for housing and public amenity.[17] This should be undertaken as part of the wide-ranging review called for in Recommendation 1.

64 We have noted some early thinking around use of market-based mechanisms identified in HSE's economics working paper.(ref 8) Such mechanisms would involve risk trading or compensation for risk, providing funds for risk reduction measures, and allowing developments of economic or social importance to go ahead, while ensuring that effective risk management takes place to offset any increase in risk.

65 One difficulty with such market-based mechanisms is the incremental nature of containment costs. If they are large, a 'free rider' problem can arise, whereby no developments go ahead until one developer pays for the next level of containment measures. At this point other developers may develop land capitalising on the containment expenditure of another. Were developers to form an alliance, covering containment costs jointly, then this problem would become less significant. However, one consequence may still be that land is not developed within the most beneficial timescale.

66 Another source of difficulty arises from site operators knowing more about the risks of containment failure than the surrounding community. To address this, the Competent Authority could make available information on the levels of risk posed by each site to developments located within the consultation distance. Doing so would facilitate the use of market-based mechanisms and support the collaborative approach to planning decision-making we are advocating. Such an approach to risk information would also allow more informed understanding of why certain planning decisions are taken – eg to not allow further development in an already populated neighbourhood next to a site. This will be of interest to insurers, to potential developers, to business risk managers and to public representatives having an interest in societal risk within their communities, although there may be difficulties where security issues preclude the release of certain information.

67 Recommendation 4 acknowledges that, notwithstanding such difficulties, these ideas should be considered further so that an economic appraisal can be conducted for a system that incorporates both societal risk and the probability of containment failure as part of the wide-ranging review of the land use planning system around major hazard sites we are advocating.

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17 See the Board's response to the regulatory impact assessment accompanying CD211, available on the Buncefield website www.buncefieldinvestigation.co.uk.

Recommendation 4 We recommend that the use of market-based mechanisms identified in HSE's recently published economics working paper,[ref 8] are considered further to assess their potential application within the revised land use planning system around major hazard sites. We would expect HSE to co-ordinate this work with the wider economics community having an interest in the planning system.

Public understanding

68 We believe that there is insufficient public understanding of the planning system in general, even among key stakeholders, though the diligent can quarry such information from the web. Lack of basic understanding is compounded by the lack of clarity in roles of those involved. It is important to make the system more comprehensible if it is to command respect. The planning bill that is under current scrutiny presents an opportunity to develop greater public understanding of the planning system, although it is intended to apply only in England and Wales with just some minor consequential changes in Scotland. The review we are recommending provides a further excellent opportunity to advance public understanding in the planning system around major hazard sites, by using web-based materials and other media to explain the revised system in an accessible way to lay readers.

69 While we believe that HSE is an obvious candidate for developing a guide to planning around major hazard sites, having produced a considerable body of excellent public guidance, the Department for Business, Enterprise and Regulatory Reform (BERR) and the devolved administrations have significant and differing interests and should play a strong part in producing the guidance we call for in Recommendation 5.

Recommendation 5 We recommend that the workings of the revised land use planning system around major hazard sites are described in guidance in a form accessible to the general public. The guidance should have ownership of all the key government stakeholders, including the devolved administrations.

Figure 6 Aerial picture of oil storage tanks at West Thurrock, east of London. Note the London orbital motorway (M25) on the left of the picture and occupied commercial buildings towards the top. The tidal flats of the River Thames are at the bottom (north) of this picture

Part 2
Risk assessment and other technical issues

70 In this part we argue in favour of adopting a consistent approach for the land use planning system around major hazard sites in Britain which is responsive to the risks derived from specific sites. It examines risk assessment, the key subject which provides the technical underpinning for the system, and some related technical issues. Risk assessment in this context is the computational tool for determining the balance between the control of risk to people, the environment and property, and the development of land for social and economic benefit. This important contribution has come principally from HSE through its expertise in risk assessment and its provision of advice to the planning authority based on that expertise.

71 Attention was first drawn to the disaster potential of major chemical installations in 1967. This led in time to a requirement on the planning authority to consult the health and safety regulator on proposals to develop land in the vicinity of major hazard installations. This procedure was given particular impetus by the Flixborough disaster in 1974. Fuller background appears in Annex 6.

72 HSE's contribution, based on assessment calculations, is to set the consultation distance round major hazard sites within which the planning authorities are required to ask for HSE's advice on any intended developments and to divide the area within this into three zones. The technical basis on which this is done was documented in 1989 in the risk criteria document.[ref 9] Although only published as a discussion document, this has since been used by HSE as the basis for its policy in various settings, including at planning appeals. There have been subsequent refinements, but the main features remain essentially unchanged.

73 As pointed out in paragraph 3 of Annex 5, risks generated on site can only be reduced but they cannot be eliminated, and there will be some degree of residual risk off site. HSE's assessments for land use planning purposes assume that all necessary steps have been taken by the operator to comply with relevant environmental, safety and health regulations and the measures described in the COMAH safety report. The risk assessments for land use planning are the residual risks under these circumstances.

Risk analysis techniques for establishing land use planning zones

74 All such techniques need to consider three aspects in making an assessment. The first is to identify events – fires, explosions and toxic releases – that could have major hazard potential. Next the consequences of each event need to be estimated in terms of human harm. Finally frequencies need to be assigned to such events using published sources of failure rates, for instance, and presented as the chance per year of such an event occurring. Generally speaking, the more severe the event the less its likelihood but the greater its consequences in terms of human harm.

75 From this it can be seen that risk assessment requires difficult judgements based on formulating assumptions, estimating probabilities of infrequent events and incorporating the uncertainty surrounding these. Underestimating the likelihood of major events may lead to unacceptable levels of risk to those in the vicinity of a major hazard site, while overestimating it may lead to unnecessary blighting of otherwise economically viable land. Risk assessments have to be conducted to a high standard to be credible to planning authorities and we therefore say more about the current techniques and judgements involved before introducing our conclusions and recommendations.

Simplified risk approach

76 In the years following the Flixborough incident HSE adopted a hazard-based approach for setting zone boundaries: a site-specific risk-based approach was not generally feasible at that time. This approach is nevertheless risk based, albeit in a simplified and semi-qualitative form. For clarity, we will use the term 'simplified risk assessment'. The aim of this approach is to achieve a separation between developments and the site which provides a very high degree of protection against the more likely smaller events, while also giving very worthwhile (sometimes almost total) protection against unlikely but foreseeable larger scale events. This approach was endorsed by the Advisory Committee on Major Hazards at the time, and became one of its fundamental principles for controlling major industrial risks in built-up areas.

77 To apply the approach in practice involves the identification and selection of a single major event – fire or explosion. Its effectiveness depends to a considerable degree on the identification of the most appropriate worst-case event that dominates the risk scenario. Then a separation distance is determined based on a 'dangerous dose', a term defined by HSE (see Annex 8) which spans fire, explosive and toxic events. The risk assessed in this way is that of an individual at a particular place being exposed to a dangerous dose or worse.

Quantified risk approach

78 Planning enquiries have, over the years, concluded that HSE's advice should take specific account of the likelihood of death or injury to the public. HSE has responded by developing techniques to quantify the risks associated with hazardous installations, based on a range of foreseeable failure scenarios. The method is widely used for toxic releases, such as the unintentional loss of containment of chlorine gas being stored on a chemical plant. The risk to an individual in a specific location is the summation of the risks arising from these different scenarios. This process is known as quantified risk analysis (QRA) and we refer to it as the QRA approach. The 1989 risk criteria document sets out HSE policy, and the reasons for criteria adopted in this approach, and the Cullen Report[ref 10] in 1990 on the Piper Alpha disaster strongly advocated the use of QRA for operational safety and risk reduction purposes (see Annex 6). As a result numerous techniques have been developed for applying QRA to major hazard risk control.

Estimation of consequences

79 HSE, in doing both simplified and quantified risk assessments for land use planning purposes, uses 'dangerous dose or worse' as its measure of consequence in terms of human harm (see Annex 8). Most other organisations and countries use a measure based on the risk of fatality and as does HSE it in its tolerability of risk guidance.[ref 11] The use of 'dangerous dose or worse' has implications which we will return to in paragraphs 97–99 in terms of being able to compare risks and therefore achieve broadly similar advice in response to broadly similar risks.

Comparison of the two approaches

80 In 1998 HSE initiated a fundamental review of its involvement in land use planning (Annex 9). A subsequent project to implement the findings of the fundamental review examined HSE's use of simplified and quantified risk analysis. The resulting report identified key advantages and disadvantages of each approach and some of these are summarised below. It made a range of recommendations to improve the consistency of simplified risk analysis, where this is adopted, but also urged HSE to continue to perform research into QRA methods so that some of the reasons for having to resort to the simplified approach could be resolved.

81 In summary, simplified risk analysis is usually appropriate where:

- there is insufficient information for QRA or some of the available information contains a high degree of uncertainty;
- the surrounding population density and demand on land use are low; or
- it would generate similar results (in terms of the sizes of land use planning zones and the advice given) to those from QRA, as might be presumed where there is a single risk source. After Buncefield, this would be unlikely at COMAH top-tier sites.

82 There are also objective criticisms to the simplified risk approach, a number of them put in the 1989 risk criteria document,[ref 9] such as:

- vagueness in terminology, for example 'a very high degree of protection', 'worthwhile (sometimes almost total) protection', 'unlikely but foreseeable';
- the resulting protection can be excessively restrictive in terms of land use;
- some arbitrariness and lack of transparency in selection of the worst-case event, and through this, potential inconsistency in treatment between installations; and
- the difficulty of comparing the degree of protection achieved with that for other everyday risks.

83 A further review following the 1998 fundamental review noted that if a site has both hazards that are analysed by the simplified risk approach and hazards that are analysed by QRA it is very difficult to add the two together to get an overall risk from the site.

84 The advantage of QRA, coupled with use of appropriate risk criteria, is that it deals with the objections to the simplified approach set out in the two previous paragraphs. However, use of QRA is not without its own difficulties. For example, assigning frequencies to rare events, such as major equipment failures, can introduce a high degree of uncertainty. Also the resources required for performing full QRA will be greater than for the simplified approach (though the time and costs are much less than they once were).

Evolution of analysis techniques

85 A large number of major hazard sites in the UK have been subject to simplified risk analysis. The majority of these sites, about 650, store or handle flammable materials such as liquefied petroleum gas and petrol.

86 Because the QRA approach is to be preferred wherever the standard of data and the computational effort justifies it, the first transition to a QRA approach occurred with toxic substances in the early 1980s, following criticism of the simplified risk approach at a public inquiry. QRAs for flammable substances, though, are more complex because of the range of events (flash fire, jet fire, pool fire, vapour cloud explosion) that have to be considered and allocating frequencies to these events is subject to significant uncertainty. HSE has devoted considerable effort to developing QRA techniques for flammable substances but its adoption has not yet been achieved on a routine basis.

87 However, there are examples where the transition has been made for flammable substances. For many years the land use planning zones for natural gas pipelines were set as simple multiples of a pre-calculated distance. We understand that these zones were criticised by the sector and HSE committed to moving to a more transparent risk basis. Methodologies were developed to make the zones round all these pipelines fully risk based and these have now been used for land use planning decision making on the natural gas network for some five years.

Consistency and potential improvements

88 Amid all the technical complexity we believe it important to have a clear guiding principle to pursue. The necessary principle is that assessments conducted for individual sites should compare the risks presented in a consistent way and thereby result in broadly similar advice being given in response to broadly similar risks.

89 There are a number of current shortcomings to the present system which cover the assessment techniques and the inputs to these calculations, and influences or circumstances which might vary from one site to another. The consequence in each case can be that the actual risk presented by a specific site is not properly assessed, thereby potentially leading to inconsistency. The ones that have come to our attention are:

- the continuing use of simplified risk assessment for most flammable materials rather than QRA;
- the use of 'dangerous dose' for consequence estimation rather than the risk of fatality;
- no account taken of the total population at risk within the vicinity.
- little account taken of standards on site and the quality of integrity management, nor credit given for risk reduction measures;
- little account taken of the impact of the regulatory regime;
- assessments based on consented quantities and the 'worst in class' substance in a generic category, and not on the actual inventories; and
- drawing a distinction between those already at risk in the proximity of a site and new developments.

90 We recognise that there must be confidence that the risk reduction measures and quality of site management have some permanence. Permissions for developments, once granted, cannot be withdrawn as a result of a decay in standards on site. However, there are ways of tackling this which we consider below. We also recognise that pursuit of the consistency principle has practical and resource implications which we address later.

A preferred way forward in reaching planning decisions

91 In a number of places in this report we have identified weaknesses in the current system when applied to modern-day situations. We have also identified improvements that are quite self-evidently needed. In Recommendation 1 we call for these to be addressed in a review. We also have become convinced, over the two and a half years of our work, that an integrated system for control of major hazard risks is needed to bridge the gaps and remove the inconsistencies that have developed over the years in the various parts of the system for controlling major hazard risks in the UK, eg between land use planning and COMAH regulation. We address this aspect in our second recommendation. Below we address our preferences for the future planning system around major hazard sites.

Figure 7 Polmont, west of Edinburgh, Scotland: skiers descend Polmont artificial ski slope run by Falkirk District Council against a backdrop of the Grangemouth oil refinery

92 We call for the recommendations below to be dealt with in conjunction with the wide review and to encourage those responsible to immediately start work on the things that can be tackled right away. Our recommendations below are based on what we have learned of the planning system, and are informed by the recommendations in our fifth[ref 4] sixth[ref 5] and seventh[ref 12] reports, and also the ongoing investigation into deep root causes, and into the regulation of Buncefield by the Competent Authority. To test our thinking we commissioned an expert report on what a system would look like that was consistently applied in the major hazards sector (and based on actual conditions), and integrated within an overall system for control of the industrial major hazard risks. We also wanted to learn whether such a system would be feasible, and whether it is in operation anywhere else.

93 The work encouraged us that the recommendations we call for below are feasible and beneficial. We outline the aims and conclusions of the work in paragraphs 121–126 ('Application to major hazard sites'). A more detailed summary of the report is at Annex 10.

94 The conclusion from earlier in this part of our report is that quantified risk assessment should be employed and we call for this in Recommendation 6. There are numerous applications of QRA and we provide an example of an approach at a Buncefield-like site in Annex 10. Given the range of QRA available, we do not envisage any major hazard sites where the data are insufficient or too uncertain, or the required effort and resource are not justified to apply a quantified risk-based approach to land use planning. The key impacts of its introduction will be to achieve consistency of approach across all major hazard sites in Britain, and to align with the COMAH regulatory system. The transition to QRA for toxic substances occurred some time ago and we acknowledge that HSE has devoted considerable effort to developing QRA techniques for flammable substances. Its adoption, though, has not yet been achieved on a routine basis.

95 Buncefield has created an opportunity for HSE to commit to this transition without encountering undue resistance from other stakeholders. Where there are significant uncertainties in important data, then research should be commissioned to resolve them and sharing of incident frequency data should be commenced without delay. We address this in Recommendation 7. We would expect the industry, in the light of Buncefield, to share frequency data without the need to change legislation. We understand there will be an EU Directive requiring sharing of incident frequency data, which in principle we welcome.

96 We also believe that the resource premium for undertaking site-specific QRA as against simplified risk analysis is not as significant as it once was. With commitment in principle now and the early commissioning of the necessary research, the sector should be in a position within five years to make the transition in practice to use of QRA for flammable substances.

Recommendation 6 We recommend HSE adopts a policy for the consistent application of formal risk assessment of land use planning applications around major hazard sites that is responsive to levels of risk at particular sites.

Recommendation 7 Priority should be given to improving source terms and frequency data relevant to QRA at major hazard sites. This should include:

- improvements in defining major hazard scenarios at flammable storage sites called for in Recommendation 1 of our sixth report;(ref 5)
- improving recording and sharing of incident data and improvements to investigation of root causes of incidents and near misses called for in Recommendations 23–25 of our fifth report;(ref 4) and
- integrating the outcomes of the explosion mechanism project group set up in response to our seventh report.(ref 12)

We call on the COMAH operators and the Process Safety Leadership Group[18] to take the lead in delivering these outcomes, and the Competent Authority to give technical support.

Estimating consequences of an event

97 Paragraph 79 explains that for land use planning purposes HSE uses 'dangerous dose or worse' as its measure of consequence in terms of human harm. This arose out of the 1989 report on risk criteria.(ref 9) We understand that HSE is probably unique in this respect and that most other organisations and countries use a measure based on the risk of fatality. However, we acknowledge that HSE's introduction of the dangerous dose or worse concept was entirely sensible in its time (see Annex 8). The use of dangerous dose or worse has become a barrier to comparing the risks presented by different sites, regardless of whether simplified risk analysis is used or QRA. One reason for this is that at flammable storage sites the 'or worse' portion is of greater consequence than at a toxic site. In other words the risk of a fatality at a flammables storage site is more likely than other kinds of harm, and therefore the dangerous dose concept prevents comparisons of individual risk between sites handling different hazardous substances. In contrast, the use of risk of fatality allows more ready comparison of risks, provided a consistent methodology is used, making it in our view the best approach for risk determination in the future.

[18] The Process Safety Leadership Group was established in August 2007, replacing the Buncefield Standards Task Group.

98 In addition, the results of simplified and quantitative risk-based analyses cannot be added because the level of risk associated with the simplified risk-based zones is not known and the risks from different types of hazard at the same site cannot be combined. Thus at large establishments, such as oil refineries, current HSE practice is to perform simplified risk analysis for some parts of the establishment, and QRA for others. In principle, applying QRA to different parts of a site and using risk of fatality as the harm criterion allows combination of the risks to give a total risk in the vicinity of the site. It also allows comparison against other risks of everyday life.

99 Finally, criteria for assessing societal risk are based on the concept of the risk of fatality to varying numbers of people. For instance, the HSE criterion in R2P2[ref 13] considers the chance of an event causing 50 or more fatalities. In Part 1 we have recommended that societal risk is integrated into the land use planning system around major hazard sites. Plainly, this cannot happen while the land use planning system still uses dangerous dose as its harm criterion.

Recommendation 8 We recommend that HSE universally adopts individual risk of fatality as the criterion for expressing the consequence of events, in preference to the risk of receiving a dangerous dose or worse.

Reliability of engineered systems

100 A key motivator in pursuing these land use planning issues derives from our overall approach, as explained in the Introduction. If across-the-board improvements are achieved in primary containment, then credit should accrue for this. In the very first recommendation of our report for the design and operation of fuel storage sites,[ref 4] we call on the sector and the Competent Authority to agree a consistent method of determining the safety system performance in terms of the probability of failure. We see this as the starting point for assessing, in broad terms, the risk category for a particular site for the purposes of planning advice. It follows that the pursuit of better and best practices produces an economic benefit beyond that of increased reliability of on-site operations.

101 There will be relatively few entirely new large-scale sites built in the UK and therefore the means of achieving risk reduction and the extent of the reduction reasonably achievable will continue to vary from site to site. However, what the planning system requires is that the major hazard risks from sites are determined in a consistent way, assuming all reasonably practicable measures have been taken to reduce the risks. Guidance already exists on how to account for reliability of engineered systems and human actions. This presents the site operator with options on how to achieve the desired degree of reliability, taking into account any nearby sensitive populations or resources and the nature and intensity of operations at the site.

Recommendation 9 We recommend that the risk assessment methodology and criteria for land use planning purposes align with those for risk assessment under the COMAH regime. The methodology should take account of the reliability of the engineered systems designed to achieve improved standards of primary containment, as called for in Recommendation 1 of our fifth report. The methodology should also incorporate a realistic major incident scenario in the light of Buncefield (explosions, multi-tank fires) as called for in Recommendation 1 of our report making recommendations for emergency preparedness etc.[ref 5] Account should also be taken of the vulnerability of the surrounding population and any mitigatory measures that apply to people or buildings and other physical assets.

The Competent Authority should see that these revisions are carried out to a satisfactory standard and that appropriate guidance is issued to ensure the necessary improvements to risk assessments are delivered in practice.

Roles of the site operator and the Competent Authority

102 The arrangements for maintaining the site at the required level of safety and environmental integrity must be robust to give ongoing assurance of the basis of the planning consent. It is the primary duty of the site operator, as the risk creator, to be the risk controller. The level of maintenance, testing and inspection, and upgrading required will depend on many factors, not least the age of the plant. HSE has reported(ref 14) a lowering of the integrity of the major hazard risk controls on ageing facilities offshore. While we have not sought specific evidence, there is strong anecdotal evidence that a similar situation exists to some degree onshore.[19] Plant operated beyond its design date may self-evidently be more prone to failure or less reliable than more modern systems. Engineering standards will change particularly in response to an incident such as Buncefield. On individual sites, changes to process or to management systems (eg by corporate mergers or large-scale contractorisation) can infringe the safety integrity levels required. We have already made recommendations relating to maintenance, testing and inspection in our design and operations report;(ref 4) Recommendation 10 partly repeats Recommendation 2 of that report to indicate the importance of alignment between our series of reports and their recommendations. At some major hazard facilities there may be a number of operated sites[20] where the management of some aspects of major hazard risk controls must be suitably shared between the operators.

Recommendation 10 Operators of major hazard sites should, as a priority, review and amend as necessary their management systems for maintenance of equipment and systems to ensure their continuing integrity in operation. Where there are a number of operators at a facility (as there were at Buncefield) the review should be integrated between site operators to the appropriate extent. The Competent Authority should see that this is done.

103 Regulation should provide adequate public assurance that initially the safety integrity levels for key safety equipment on the site have been properly assessed and the site designed and provisioned accordingly. We see the COMAH safety report as the vehicle for this. The inspection, investigation and enforcement regime should include adequate verification of the arrangements for maintaining the safety integrity levels commensurate with the risks to vulnerable populations and to the environment.

Recommendation 11 We recommend that the regulatory regime for major hazard sites should ensure proper assessment of safety integrity levels (SILs) through the development of appropriate standards and guidance for determing SILs. Application of the methodology should be clearly demonstrated in the COMAH safety report submitted to the Competent Authority for each applicable site. Existing safety reports will need to be reviewed to ensure this methodology is applied.

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19 Leading from the top – avoiding major incidents conference organised by HSE on 29 April 2008. Over 200 industry leaders came together to share learning from incidents such as those at Texas City, Buncefield and the Thorp plant in Sellafield. Discussions served as a reminder to senior managers that the rates of conventional safety accidents and injuries in the past few years could not, in itself, be taken as positive assurance of an overall improvement in process safety across the major hazard industries.

20 These are so-called 'domino sites'. The COMAH Regulations provide for integrating the management of risks whereby one site can have an adverse impact on another. There were three major operators on the Buncefield site.

104 Taken together, Recommendations 10 and 11 align with our view that site operators should take a much more significant role in the revised system with the Competent Authority setting the standards and checking that the system is being operated effectively as we set out in paragraphs 47–51. These issues are being pursued by the Competent Authority as part of its response to our fifth report.[ref 4] We of course welcome this.

Consented quantities

105 As we have previously observed, the land use planning system around major hazard sites illustrates clearly the tension that can exist between strategic economic considerations prevailing at major hazard sites, and local economies. As reported in paragraph 36, HSE, as a matter of sensible technical policy, bases its planning advice on the maximum consented quantity, which can considerably exceed the quantities actually stored. Also where the consent is for a generic category of hazardous substances, the assessment is based on the most hazardous substance within that category even if that substance is not actually present. Both these situations can produce larger zones and consultation distances than circumstances require.

106 It would be relatively straightforward to conduct the risk assessments for any site based on the maximum hazardous capacity of the site under realistic operating conditions, both in terms of quantities and substances present. To avoid unwarranted restrictions on site owners, the inventory used in assessments could take into account consented plans for increasing the quantities on site, but not beyond the land capacity or the process capacity of the site (and not of course beyond the hazardous substance consented inventory).

Figure 8 Oil storage tanks at Falmouth docks, Cornwall, in south-west England. Note the occupied buildings adjacent to the storage tanks, and the estuary which leads into the English Channel

107 However, for reasons that we explain above, it is unusual to attach conditions to major hazardous substances consents (see paragraph 31) and consultation zones continue to exist where an operator in possession of major hazardous substances consent has ceased to operate, unless steps are taken by the minister responsible to revoke the consent.[21] We readily appreciate that retaining consent, or maintaining a far greater consent inventory than the site can actually handle, is in the commercial interest of the consentee. We do however challenge whether in every case it is in the overall public interest to restrict off-site development as a result of dormant consents or large spare capacities. At the same time we fully understand that HSE has no basis in the present circumstances for using anything other than maximum/most hazardous quantities in its assessment work.

108 The revised approach to planning around major hazard sites that we call for will apply risk assessment on a site-specific basis, and calls on the site operators to take on a much more significant role. It is therefore time to deal with this issue of consented quantities in a sensible and pragmatic way. To strike a balance between the genuine national interest in the strategic potential of major hazard sites and the regional or local economies we call on CLG, the devolved administrations, BERR and HSE to consider making changes to the management of major hazard substances consents. We ask, in Recommendation 12, for the necessary steps to be taken to limit or remove consents where the circumstances merit. We also call for a negotiated approach to the nature and quantities of hazardous substances that are to be taken into account in the revised system for planning consent around hazardous installations.

Recommendation 12 We recommend that CLG and the relevant ministers in the devolved administrations, HSE and BERR consider reforms to the major hazardous substances consent system, with the aims of:

- streamlining and simplifying the withdrawal of consents on sites that are 'dormant'; and
- allowing the size and nature of the hazardous inventories to be varied to enable realistic risk assessment for off-site planning purposes, including for revised development plans.

Existing and new developments

109 HSE is frequently asked to comment on proposals to develop or redevelop land where there may already be other land users who are closer to the major hazard site and where there is incompatibility with HSE's criteria. The policy is to 'accept' existing arrangements which are a legacy of our industrial heritage but not to increase those risks further. Therefore we have a system that for understandable reasons produces situations where businesses and residents are located within the inner zones of consultation and yet new developments that would bring welcome improvements to the prosperity or social amenity of the region are prevented.

110 It can be hard to communicate the message that HSE does not have a means for objecting to risks which already exist but has to rely on on-site safety measures

[21] This is illustrated at Hemel Hempstead where the consents are legitimately retained by the former operators of the Hertfordshire Oil Storage Limited and British Pipeline Agency Limited parts of the former Buncefield site. It is not known whether these sites will be reinstated.

and evacuation plans, yet can 'advise against' new development. HSE can be depicted on the one hand as being too cautious and restrictive in its advice on new development applications, and on the other hand of condoning unacceptable risk to the occupants of existing developments. Within the current system HSE will often struggle to secure acceptance for the advice it provides, notwithstanding the advice may be entirely inevitable.

111 We consider this situation would benefit from the joined-up approach to reaching land use planning decisions which we suggest in paragraphs 55–57 where the planning authority is supported in its decision-making role by key representatives for the regional interest, and if necessary for the national strategic interest. Technical information relating to the risks posed by the site would be provided by the COMAH operator under guidance developed by the Competent Authority, and aligned with the roles of regulator and operator under the COMAH Regulations. The planning authority will need to have the relevant expert advice available to it, and have sufficient expertise itself to process the information.

Recommendation 13 In moving to a fully risk-based system, and as part of the review called for in Recommendation 1, there should be a wider perspective given to the management of new planning applications where off-site development already exists. Consideration should include:

- the parties who should come together to give relevant and necessary advice and expert support to the planning authority;
- the size and nature of the existing population exposed to the risks on site;
- the safety integrity levels and environmental protection measures on the site relevant to the nature and intensity of operations;
- the mitigatory measures (ie means of reducing the consequences of a major incident) achievable for off-site buildings;
- the emergency preparedness and response arrangements;
- the needs of the regional economy as formally determined by the relevant authorities, and expressed in regional policies such as the Regional Spatial Strategy and Regional Economic Strategy;
- the strategic economic/national interest issues if relevant; and
- the further reductions that may be achieved in residual risk arising from the major hazard site.

CLG, the Welsh Assembly Government, the Scottish Government and HSE should give consideration to this issue and produce the necessary guidance to see the revised approach is implemented effectively.

Technical issues relating to societal risk

112 In addition the discussion of societal risk in Part 1, which focused on systemic issues, there are some important technical issues to resolve. HSE's summary of findings from consultation through CD212 lists a number of these. The most pressing issue at present is to achieve common agreement on how societal risk is measured and what the relevant criteria are.

113 Societal risk is a difficult concept to apply and further work is needed on how it can be used for ranking sites and prioritising mitigation measures. The relation between the likelihood of a serious incident, its severity and the consequences in terms of fatalities depends critically on the configuration of the population around the site, and it will increase with each new development around the site. The calculation of societal risk is usually expressed in the form of a graph showing the probability of events with greater than a certain number of casualties (F/N curves[22] – see Annexes 5 and 10), but it can also be more clearly displayed in the form of area-specific risk. HSE's publication R2P2(ref 13) proposed a societal risk criterion (a 1 in 5000 chance per annum of an event causing 50 fatalities). HSE has since proposed a more complex formulation and gone on to develop a ranking technique based on it, though there is not yet general agreement over how it can be applied to all hazardous sites. Clearly further research work is needed but we believe a rudimentary method of estimating societal risk agreed now between parties is more important than academic perfection. Refinement can come later. We understand that HSE intends to take this work forward as part of an agreement between ministers following the CD212 consultation. We believe that in going forward with the revisions to the planning system around major hazard sites, the boundaries of acceptability of societal risk need to come to public debate and a public consensus needs to be developed.

114 Another difficulty is that there is no clear basis in law for taking into account society's aversion to multiple fatality events (known as scale aversion) when conducting a numerical risk assessment or enforcing risk reduction measures, but HSE's policy is to reflect societal risk when making judgements about whether measures are grossly disproportionate in relation to what is reasonably practicable. While such aversion is not measurable in a literal sense, the debate about whether, and to what extent, scale aversion should be introduced has run for some time. Guidelines are needed on what weighting to give to more severe incidents to allow practical application of societal risk. HSE advises that this issue is being pursued as part of its ongoing work on societal risk, and we encourage HSE to conclude this work as soon as practicable.

Recommendation 14 We recommend that HSE should bring together key stakeholders and experts in the planning system (planning authorities, developers, operators, regulators, risk assessment specialists) with a view to reaching agreement as early as possible on:

- the way societal risk is measured and assessed;
- the data sources required for assessment purposes;
- the acceptability criteria for societal risk values around particular sites; and
- a suitable weighting factor for more serious, less frequent events (scale aversion).

22 FN curves are a means of plotting, normally on a logarithmic scale, the frequency (F) of a fatal incident against the numbers of people (N) who may be killed in such an incident.

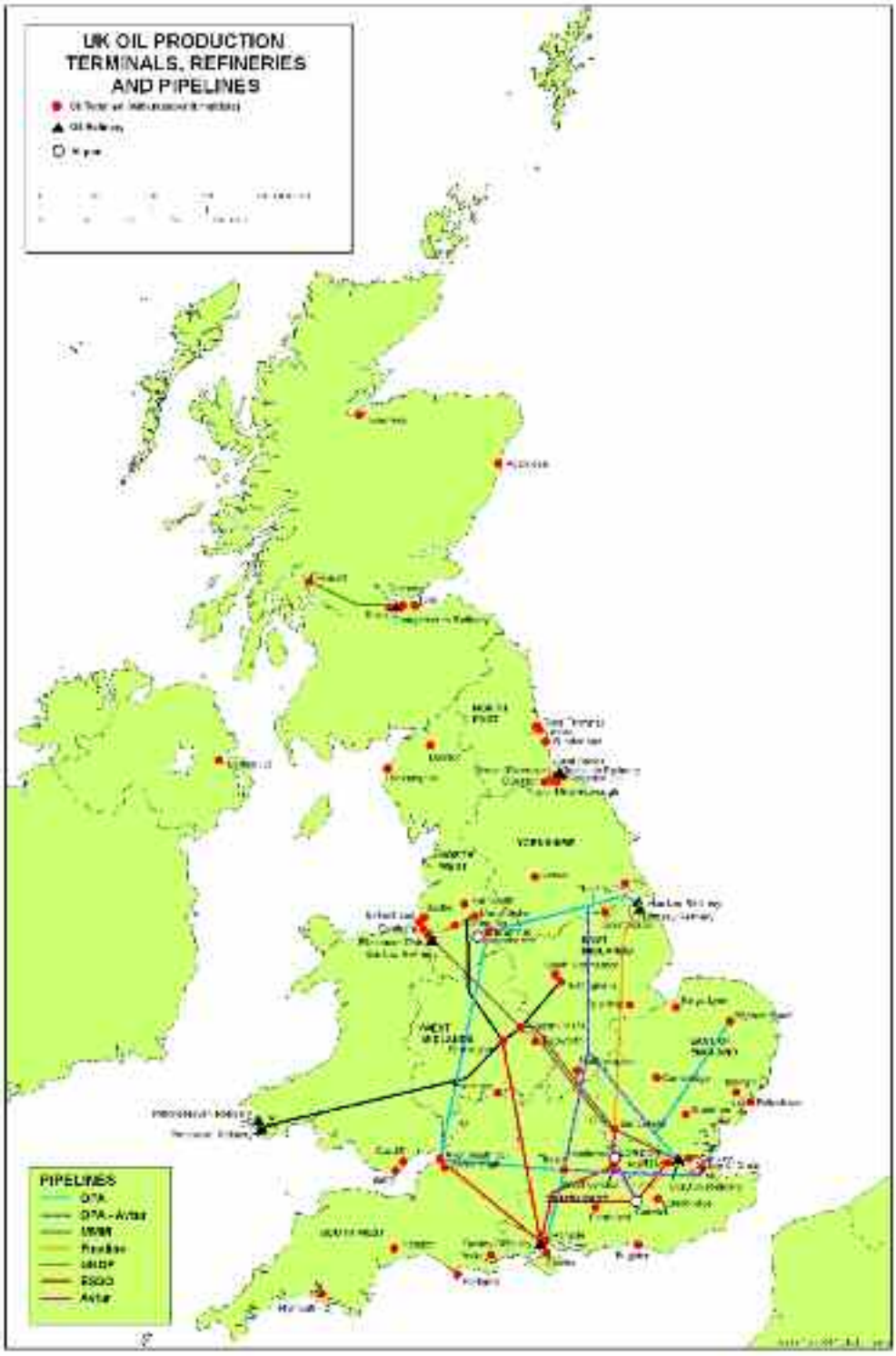

Figure 9 Privately operated refineries, pipelines and terminals in Britain. Note that some of the terminals are currently not operating (eg Buncefield)

Applying land use planning controls to gasoline pipelines

115 While there is no suggestion that the large gasoline pipelines which supplied the Buncefield site directly contributed to the major incident, there is an anomaly relating to regulation of such pipelines which we consider now needs rectifying. Under the Pipelines Safety Regulations 1996 (PSR) gasoline pipelines are subject to the same general duties as all other pipelines, covering design, construction and installation, operation, maintenance and decommissioning. However, they are excluded from the additional duties for pipelines conveying fluids with a major accident hazard potential. Consequentially, there are no requirements to produce an emergency plan for gasoline pipelines nor to set land use planning zones around them.

116 We understand that when PSR was enacted, HSE intended gasoline pipelines to be subject to the additional requirements but this has not happened. Subsequent research commissioned by HSE showed that although the levels of risk were low, the potential consequences of an accident were very serious and confirmed that gasoline pipelines should be treated as presenting a major accident hazard potential.

117 We conclude that PSR should be amended so that gasoline pipelines are subject to land use planning and emergency planning controls, ie the sorts of controls around other major hazard installations should apply in relation to development near pipelines. Recommendation 15 addresses this aspect. We understand that HSE is now taking this work forward and we welcome this initiative and encourage its completion.

Recommendation 15 HSE should take necessary steps to amend the Pipeline Safety Regulations with the aim of extending land use and emergency planning controls (and other suitable regulatory protections if necessary) to major pipelines carrying gasoline (petrol).

Public understanding

118 The basis on which HSE advises planning authorities was published in 1989 in a discussion document entitled *Risk criteria for land use planning in the vicinity of major industrial hazards*.[ref 9] There has since been a fundamental review in 1998 and consideration given to how to implement the conclusions of that review (see Annex 9). It was not until 2007 and the issue of CD211 that HSE first set out its policy objectives and principles on land use planning.

Figure 10 A large smoke clouds hangs over the north-eastern city of Enschede. A fireworks warehouse near the city centre exploded on 13 May 2000, killing 23 people.

119 For those ultimately affected, namely site operators and local communities, the basis on which land use planning decisions are reached can be difficult to understand. We therefore call on those responsible for revising the system in line with our recommendations to produce suitable technical guidance on how decisions should be reached by the planning community. Notwithstanding the technicalities that will inevitably have to be managed in determining planning applications, the technical guidance should be comprehensible to a lay audience.

Recommendation 16 We recommend that HSE should review, update and publish documentation on the process for handling land use planning risk assessments around major hazard sites by local authorities, and the main contributors to the decision-making process. The resulting publication should be capable of being understood by a lay audience.

Local planning authority resources

120 In moving to the revised system called for in this report the local planning authority will be required to take a much more transparent lead in the planning application decision-making process. Support from emergency responders and other key stakeholders is envisaged as being made available, and much more input from the site operator is also called for. The Competent Authority is also asked to provide expert guidance on the operation of the system and to see that it functions properly. Nonetheless we foresee that for many if not all planning authorities there will need to be a significant increase in resources and expertise available for it to manage the planning process effectively and consistently. In Recommendation 17 we ask for due consideration to be given to this vital aspect.

Recommendation 17 Local planning authorities and the administrations responsible for them should ensure the necessary expertise and other resources are available to implement the revised planning system around major hazard sites, as well as management systems to ensure maintenance of competencies, monitoring, audit and review of the planning systems in their authority.

Application to major hazard sites

121 We commissioned work to demonstrate what a feasible risk-based system might look like. An important aim of this commission was to present a model system to the lay reader who until now has had to manage with rather abstract descriptions. We also wanted to have some tangible indicators of the advantages and disadvantages of a QRA-based system that could be consistently applied to all major hazard sites compared to the status quo where a simplified risk approach is applied at flammable storage sites. The work included some preliminary risk analysis based on a part of the Buncefield site ('the model site'), primarily to gain a better understanding of the issues associated with the quantification of the risk posed by such a site. The scope of work is described in Annex 10, together with the detailed results. We asked to see a methodology that would enable a QRA to be carried out which would give predictions for both individual and societal risk, identifying the major uncertainties in the analysis.

122 Aware that other countries subject to the Seveso Directive, such as the Netherlands and Belgium, adopt a quantified approach to determine the risks from flammable storage sites we also asked for the methodology used for risk assessment and development control in the Netherlands to be applied to the model site. We also asked for a review of the predictions in order to consider whether a

methodology based on risk rather than a mixture of risk and hazard could potentially be used in the UK for future land use policy around all major hazard sites.

123 The key success criteria are whether the model system is responsive to changes in risk on and off site, whether it can incorporate societal risk in addition to risk-based land use planning zones (as are currently produced by the simplified risk approach), and whether the system would be affordable. The outcome of the work appears to meet the criteria and strengthens our call for work to begin without delay to develop a consistent risk-based system for use throughout the major hazard sector in Britain.

124 The work demonstrates that it is possible to carry out a QRA of a large petroleum storage facility and generate individual and societal risk predictions reasonably quickly and without significant expense despite the uncertainties. The current system for land use planning in Britain is based either upon the simplified risk approach or QRA. This hybrid approach has a number of disadvantages as we have pointed out. It would be possible to extend the QRA approach to all types of major hazard site and thereby develop a land use planning system which is consistently based on risk. A move to a universal QRA approach would be less straightforward than the simplified risk assessment approach but it would remove many of the undesirable features of the current system. It would also make the system consistent across Britain. Such systems, where the QRA methodology is defined by the regulator and the analysis is carried out by the site operator, are currently operated in the Netherlands and Belgium.

125 To consider societal risk, the population within the vicinity of the site that is exposed to the individual risk of fatality has to be considered. We are drawn to the approach in the Netherlands and Belgium where regional public authorities and

Figure 11 Smoke rises above Enschede. This picture was taken at 90° from the viewpoint in Figure 10. Both pictures illustrate the density of residential buildings around the fireworks warehouse

emergency services, operators and others consider new developments subject to some absolute guidelines set by the national regulator. Risk contours are developed by the site operators using actual site conditions processed in accordance with a methodology set by the national regulator. Off-site conditions and types of vulnerable populations are incorporated into the data provided for decision making.

126 The overall societal risk from a single installation can be broken down to show the main contributors to societal risk both in terms of the source of risk and the receptor of risk (the people and/or buildings that could be affected by the various hazard scenarios). Annex 10 shows the main societal risk contributors derived from the various hazard sources. The breakdown of the data in terms of receptors shows which measures to reduce the effect on the target feature would be most effective. There is obvious scope to calculate the most effective means, with due regard to cost, to reduce societal risk. Societal risks can also be added together, so the overall societal risk from all the major hazards within a local authority area could be determined and the local planning authority would be able to see the effect on the societal risk over a period of time due to changes in both the hazardous sites and even small changes in the population in the vicinity of these sites. This would enable better spatial planning than is possible on information available within the current system.

Implementation and priorities

127 In paragraph 88 we set out consistency of assessment of risk as our guiding principle. To achieve it we have identified a number of relevant issues and made recommendations. Overall it moves in the direction of a more individualised approach to sites to identify the risks they present in a way that is more closely related to actual circumstances.

128 We say above that we expect work to begin on revising the land use planning system without delay and in parallel with the wide review called for in Recommendation 1. We do recognise and commend the work done so far by HSE in responding to the land use planning issues raised at Buncefield though more needs to be done. We also recognise that the frequency data for vapour cloud formation and ignition and over-pressure propagation in open flammable clouds are uncertain. For the present, until the explosion mechanism work yields results, the uncertainties can be managed in the same way that they are currently managed, eg by using statistical outliers, sensitivity analyses and conservative assumptions in the event frequency data. Sensitivity analysis uses a range of failure event frequency data to test the assumptions behind the ones used in the risk calculations.

129 The explosion mechanism of the hazard of open flammable cloud explosions is only one new aspect to be incorporated in future revisions of the scenarios that feed the risk assesments. Revisions to all the scenarios that feed risk assessments need to be undertaken. In addition the new consultation distances applied by HSE to flammable storage sites are only applied to new developments. The impact of the Buncefield incident on the risks at and around existing sites needs to be viewed afresh. In the covering note to CD212[ref 3] HSE suggested there are already some sites to which HSE could give priority treatment as the current system is overhauled and agreed methodologies for new risk assessment approaches developed. The Competent Authority will need to agree with COMAH operators and planning authorities a programme of reviews of the sites of greatest concern, with clear timescales against which progress can be measured and reported.

130 Account should also be taken of the impact of the measures that we call on in our reports to the risks of a major incident as we believe the risks will reduce significantly as the improved controls are applied.

131 We also expect the ALARP[23](risks 'as low as reasonably practicable') risk threshold to change as a result of what we learn from Buncefield. In other words, measures that would perhaps have been deemed unreasonable in terms of the cost of achieving a risk reduction may come into the scope of the ALARP condition in the light of a revision to the worst-case scenarios after Buncefield, accounting for open flammable cloud explosions and multi-tank fires. This needs to be considered for the major hazards sector as a whole. It is not uncommon for operators with duties under safety and environmental legislation to see the risk threshold under the ALARP principle as a ceiling, the point at which they may safely stop seeking further improvements. In fact the ALARP threshold is the floor on which dutyholders need to stand, the starting point for best practice that is rightly expected by the public and those who might be affected by the major hazard risks created by the site.

Recommendation 18 The Competent Authority should agree a priority programme with site operators and planning authorities for assessing societal risk at sites of identified concern using the risk assessment methodologies developed in line with our recommendations. Account should also be taken whether the ALARP threshold has been raised due to considering previously unaccounted hazard scenarios.

132 Input to planning around major hazard sites under the system that we favour will be wider than from HSE alone. Quite apart from the critical new role for planning authorities and operators, guidance needs to be developed on how to use the criteria relating to risk contours, and societal risk indicative criteria when an acceptable approach and methodology for using societal risk have been devised. The Competent Authority will need to set the standard for what to do and for the criteria, while leaving the decisions to those affected. This is not a case of the regulator standing back from difficult situations. The Competent Authority will determine what needs to be provided – and by whom – to operate the system. The Competent Authority will also check that the system is operating as intended.

133 The Competent Authority will also have to decide how it will react, within its statutory role, to societal risk anomalies that come to light in the application of the revised system and there may well be lessons in how the French, Belgians and Dutch have adapted their systems to compensate for unacceptable societal and environmental risk at existing installations in the light of applying new knowledge or invention.

134 What are the potential downsides of our preferred system? A risk-based approach is unlikely to significantly reduce the planning contours without the improvements to the control measures we call for being carried out in practice. For example, under the method adopted for the analysis that produced a model of a risk-based planning system (see Annex 10) it was shown that the Northgate Building was a significant contributor to societal risk at Buncefield. Modelling the Northgate building so as to be further away from the site showed how the societal risk could be lowered. In reality, under a risk-based system, it might be practicable to reduce societal risk by improving the risk control measures (on- or off-site, or both).

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[23] The ALARP principle is further explained in Annex 5 (in the section 'QRA applications of relevance to land use planning around major hazard sites').

Figure 12 A view of the smoke plume at the height of the Buncefield fire as seen by police maintaining the cordon in the Leverstock Green area of Hemel Hempstead. Leverstock Green is one of the nearest residential areas to the Buncefield depot and many people were evacuated

135 A key disadvantage will be in the period of transition to a revised system which will have significant implications for central and regional government and industry. To illustrate the difficult questions to be faced, eg on retrospection and interim application (with, as yet, incomplete tools), one need only look at Recommendation 3, which calls for a broad economic case 'including costs to the industry and wider society' to be factored in. These will take some time and intellectual effort to determine, and the obvious question will be 'what do we do in the meantime, or do we wait?' On the subject of retrospection (which we have referred to, eg in paragraphs 29–30 and 126) we wish to make it clear that we are not calling for the bulldozing of swathes of perimeter developments or decommissioning of major hazard sites. We are looking for the Competent Authority, COMAH operators and planning authorities to agree what are the priorities for action when factoring in societal risk, and to make targeted and proportionate responses and maintain public confidence.

136 Recommendation 13, which calls for reforms to the management of the decision-making process, illustrates the same issue. Some two and a half years after Buncefield progress now lies in confronting the difficulties and not being deterred by them. While we have addressed the questions of the scope of application, the pace of progress and what to do during an interim phase of several years, we will greatly value the commitment now of CLG and relevant ministers of the devolved administrations, and HSE in particular to press ahead on a number of fronts in the interests of balancing the necessary pace of progress with technical and resourcing factors.

Annex 1

Terms of reference

This annex sets out the eight terms of reference for the Investigation and explains the progress that is being made towards accomplishment of each of them.

1 To ensure the thorough investigation of the incident, the factors leading up to it, its impact both on and off site, and to establish its causation including root causes

The Board has published three progress reports from the Investigation Manager between February and June 2006. These were followed by the Board's initial report on 13 July 2006, which summarised the investigation to date and set out the Board's main areas of concern. The reports have revealed the main facts of the incident, but have not speculated on why control of the fuel was lost.

The explosion mechanism, ie the means by which unexpectedly high over-pressures were generated, is subject to significant further investigation. An advisory group was appointed to make recommendations to the Board on whether and what further work could be undertaken in this regard – see term of reference 5.

The criminal investigation is pursuing all reasonable lines of inquiry into the facts and causes of the incident to enable the Competent Authority (HSE and the Environment Agency) to take a view on legal proceedings.

2 To identify and transmit without delay to dutyholders and other appropriate recipients any information requiring immediate action to further safety and/or environmental protection in relation to storage and distribution of hydrocarbon fuels

The Competent Authority issued a Safety Alert to around 1100 COMAH dutyholders on 21 February 2006. Special attention was paid to 108 fuel depot owners storing COMAH quantities of fuel in Great Britain, seeking a review of arrangements for detecting and dealing with conditions affecting containment of fuel. Most dutyholders responded to the alert by the Easter deadline. Meanwhile, the Competent Authority visited all 108 depots to follow up the alert. An interim report was published on 13 June 2006 and is available at www.hse.gov.uk/comah/alert.htm.

The Environment Agency issued further advice to its inspectors to investigate secondary (bunding) and tertiary (drains and barriers) containment at depots in England and Wales in response to the second progress report.

The Environment Agency continues to monitor the effects of Buncefield on the surrounding environment. Any changes picked up during monitoring will be reported on its website, www.environmentagency.gov.uk. The initiative is being handled separately for Scotland by the Scottish Environment Protection Agency, with joint inspections undertaken with HSE covering primary, secondary and tertiary containment, and management systems.

On 16 June 2006 investigators served two Improvement Notices on the manufacturers of the high level alarm switch installed on Tank 912, having identified a potential problem at other sites related to the setting of the switch for normal operations following testing. This was followed up by a Safety Alert from HSE on 4 July 2006 alerting operators relying on such switches of the potential problem.

The Chairman of the Buncefield Board wrote to the Chief Executive of the Health Protection Agency on 3 July 2006 enquiring into progress with informing regional resilience groups of early lessons learned from Buncefield, focusing on public health issues in the immediate aftermath of a major airborne incident, following up with a meeting December 2006.

The Buncefield Investigation Manager wrote to HSE on 30 August 2007 with observations on the reliability of servo level gauging systems. HSE subsequently held discussions with the Process Safety Leadership Group on this subject and provided an update report to MIIB on 31 October 2007.

3 To examine the Health and Safety Executive's and the Environment Agency's role in regulating the activities on this site under the COMAH Regulations, considering relevant policy guidance and intervention activity

Work is progressing steadily on both parts of the review, concerning respectively HSE's and the Environment Agency's prior regulatory activities at Buncefield. The full findings of the review will be incorporated into the Board's final report (see term of reference 8). Immediate important lessons from the examination of the Competent Authority's prior role have been incorporated as appropriate into the lessons learned programme under term of reference 5.

4 To work closely with all relevant stakeholders, both to keep them informed of progress with the Investigation and to contribute relevant expertise to other inquiries that may be established

The ongoing impact on residents and businesses of the Buncefield incident has been reported in the three progress reports and in the initial report in which, in Part 2, the Board set out its main areas of concern. The Board has maintained an active interest in releasing as much new information as possible to the community and its representatives, such as the local MP Mike Penning, to assist in understanding the events of 11 December 2005, and to maintain public confidence that progress is being made with the Investigation.

As has been reported previously, residents and businesses continue to show remarkable resilience in the difficult aftermath to the Buncefield incident. Dacorum Borough Council in particular, but also St Albans and Hertfordshire Councils, have performed extremely effectively in very difficult circumstances, and have supported the Board in its engagement with residents and businesses, as has Mike Penning MP.

The Board has also kept key Government stakeholders informed of the Investigation's progress, and has maintained its interest in developments that have taken place since Buncefield to help manage the aftermath and support a return to normality for residents and businesses.

The Board has engaged with all the public sector agencies involved in the emergency response to Buncefield and has met with a number of the key agencies, particularly the Category 1 (Gold) responders. This is not an issue in which the Board has primary responsibility, but has outlined its conclusions and recommendations within the contents of its sixth report *Recommendations on the emergency preparedness for, response to and recovery from incidents*.

The MIIB continues to meet from time to time with residents, businesses, agencies, government departments and public representatives to inform them of progress.

5 To make recommendations for future action to ensure the effective management and regulation of major accident risk at COMAH sites. This should include consideration of off-site as well as on-site risks and consider prevention of incidents, preparations for response to incidents, and mitigation of their effects

The Board's fifth report (March 2007), made recommendations for the design and operation of Buncefield-type sites. HSE convened an industry-chaired task group (the Buncefield Standards Task Group) which included the Environment Agency and the Scottish Environment Protection Agency, to also consider design and operation issues in parallel with the Board's work. This initiative was welcomed by the Board in its report.

The Board's sixth report (July 2007) made recommendations for the emergency preparedness for, response to and recovery from incidents. The work in producing the recommendations contained within the report was supported by an immense amount of work undertaken by other agencies such as Hertfordshire Resilience, Hertfordshire Fire and Rescue Service, and the Health Protection Agency. With these recommendations, the Board joined together the many strands of this subject, including issues concerning support to communities and businesses in the aftermath of an extreme incident.

An expert group was appointed in 2006 to give advice to the Board on possible explosion mechanisms of relevance to Buncefield. A report by the advisory group was published in August 2007 as the Board's seventh report. It recommended further investigations leading to a decision on whether full-scale research is required. The further investigations are currently ongoing.

HSE completed its initial work on changes to land use planning advice and issued a revised policy for large petrol storage sites in December 2007. The outcomes of consultation on societal risk around onshore non-nuclear major hazard installations was published in January 2008. The Board set out its own views to both consultation documents (see www.buncefieldinvestigation.gov.uk).

This report, the Board's eighth, sets out the Board's considered position for securing improvements to the system for land use planning around major hazard sites.

6 To produce an initial report for the Health and Safety Commission and the Environment Agency as soon as the main facts have been established. Subject to legal considerations, this report will be made public

The Board's initial report was published on 13 July 2006.

7 To ensure that the relevant notifications are made to the European Commission

A report from the Environment Agency and HSE was made to the European Commission on 10 March 2006. Subsequently, the Environment Agency declared Buncefield a major accident to the environment (MATTE), and the Competent Authority reported this to the European Commission in July 2006.

8 To make the final report public

The timing for the publication of the final report remains uncertain and is linked to progress on the main terms of reference and to any decision on any criminal proceedings that might be considered.

Annex 2

Members of the independent Board

The Rt Hon Lord Newton of Braintree has been a life peer since 1997 after spending 23 years as a Conservative Member of Parliament for Braintree, Essex. From 1982 to 1988 he held ministerial positions at the Department of Health and Social Security. In 1988 he joined the Cabinet as Chancellor of the Duchy of Lancaster and Minister at the Department for Trade and Industry. He then held the post of Secretary of State for Social Security from 1989 to 1992 when he was appointed Leader of the House of Commons, which he held until 1997. In 2002 he chaired the Committee that reviewed the operation of the Anti-terrorism, Crime and Security Act 2001.

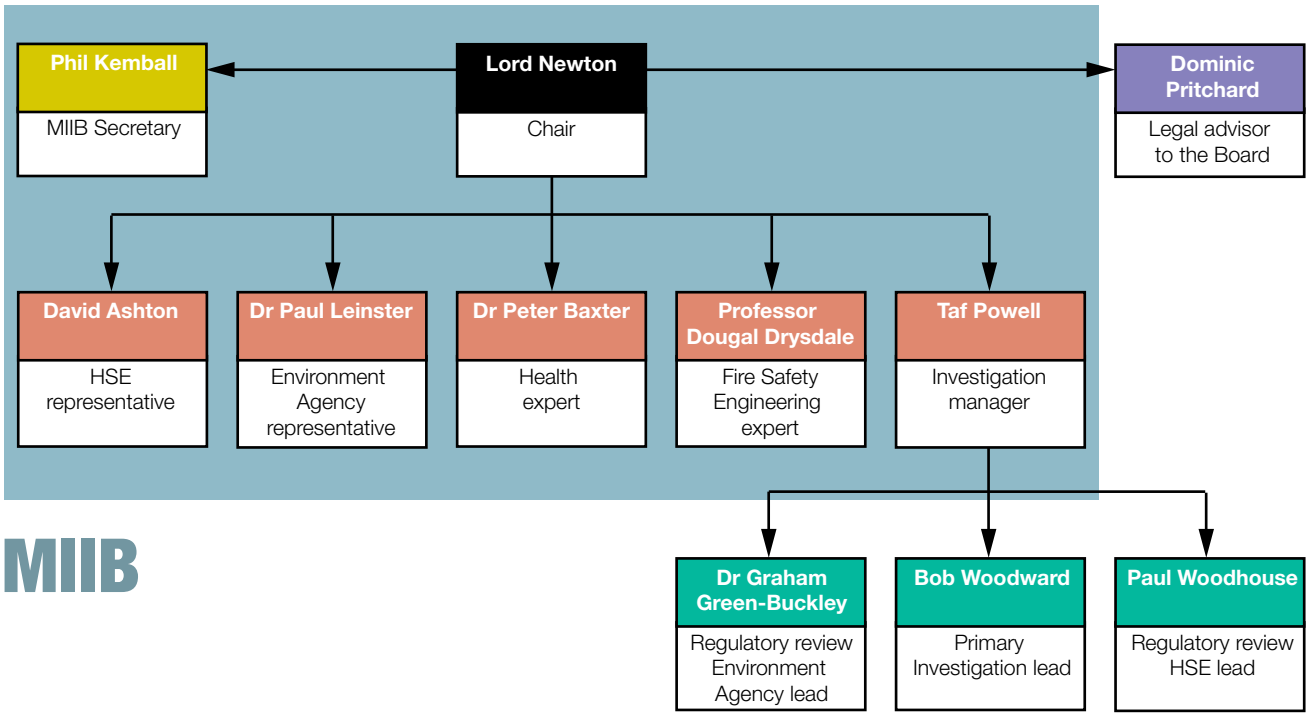
Professor Dougal Drysdale is one of the leading international authorities in fire safety engineering. He was the Chairman of the International Association of Fire Safety Science until September 2005 and is currently the editor of the leading scientific journal in the field, *Fire Safety Journal*. His wide range of research interests includes the ignition characteristics of combustible materials, flame spread and various aspects of fire dynamics. He is a Fellow of the Royal Society of Edinburgh and a Fellow of both the Institution of Fire Engineers and the Society of Fire Protection Engineers.

Dr Peter Baxter is a Consultant Physician in occupational and environmental medicine at Cambridge University and Addenbrooke's Hospital, Cambridge. In the past, he has advised the government on the impacts on public health relating to air quality standards, major chemical incidents, natural disasters and climate change.

Taf Powell is Director of HSE's Offshore Division. He graduated in Geology and Chemistry from Nottingham University. His oil field career has been split between working in the UK and abroad in offshore exploration and development and regulation of the sector in licensing, well operations, policy and safety regulation. In 1991 he joined HSE's Offshore Division from BP and started work to develop the new offshore regulatory framework, one of Lord Cullen's recommendations following his inquiry into the Piper Alpha disaster. As HSE's Operations Manager, based in Aberdeen, he then led inspection teams and well engineering specialists responsible for enforcing the new regulations until 2000 when he took up his current role.

Dr Paul Leinster is Director of Operations at the Environment Agency. Up until March 2004 he was the Director of Environmental Protection, having joined the Agency in 1998. Before this he was the Director of Environmental Services with SmithKline Beecham. Previous employers also include BP International, Schering Agrochemicals and the consultancy firm Thomson-MTS where he was Managing Director. Paul has a degree in Chemistry, a PhD in Environmental Engineering from Imperial College and an MBA from the Cranfield School of Management. He has worked in the health and safety and environmental field for 30 years.

David Ashton is Director of HSE's Field Operations North West and Headquarters Division. He joined HSE in 1977 as an inspector in the west of Scotland where he dealt with a wide range of manufacturing and service industries, including construction, engineering and the health services. In 1986 he joined Field Operations HQ to deal with machinery safety. He then held the post of Principal Inspector of manufacturing in Preston for two years, before being



appointed as a management systems auditor to examine offshore safety cases in the newly formed Offshore Division. In 1993 he became Head of HSE's Accident Prevention Advisory Unit, looking at the management of health and safety in organisations. Between 1998 and 2003 David was HSE's Director of Personnel, before being appointed to his current position.

Annex 3

The COMAH regulatory regime

Part 1: Regulatory framework for high-hazard sites
[reproduced from Initial Report Annex 8]

1 The regulatory framework for sites such as Buncefield, which present potential major accident hazards, comprises requirements imposed on the site operators under both health and safety and environmental legislation, complemented by the requirements of planning law. In particular, the Control of Major Accident Hazards Regulations 1999 (COMAH) apply.

Health and safety law

2 Operators in the process industries are subject to the requirements of the Health and Safety at Work etc Act 1974 (the HSW Act) and the Management of Health and Safety at Work Regulations 1999 which require, respectively, safety policies and risk assessments covering the whole range of health and safety risks.

Control of Major Accident Hazards Regulations 1999 (COMAH)

3 COMAH's main aim is to prevent and mitigate the effects of those major accidents involving dangerous substances, such as chlorine, liquefied petroleum gas and explosives which can cause serious damage/harm to people and/or the environment. The COMAH Regulations treat risks to the environment as seriously as those to people. They apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. There are two thresholds, known as 'lower-tier' and 'top-tier'. The requirements of COMAH are fully explained in *A guide to the Control of Major Accident Hazards Regulations 1999 (COMAH). Guidance on Regulations* L111.[ref 15]

4 The COMAH Regulations are enforced by a joint Competent Authority comprising HSE and the Environment Agency in England and Wales, and HSE and the Scottish Environment Protection Agency (SEPA) in Scotland. Operators will generally receive a single response from the Competent Authority on all matters to do with COMAH. The Competent Authority operates to a Memorandum of Understanding, which sets out arrangements for joint working.

5 The COMAH Regulations require operators of top-tier sites to submit written safety reports to the Competent Authority with the purpose, among others, of demonstrating that major accident hazards have been identified and that the necessary measures have been taken both to prevent such accidents and to limit any consequences. Operators of top-tier sites must also prepare adequate emergency plans to deal with the on-site consequences of possible major accidents, and to assist with off-site mitigation. Local authorities for areas containing top-tier sites must prepare adequate emergency plans to deal with the off-site consequences of possible major accidents, based on information supplied by site operators.

6 The COMAH Regulations place duties on the Competent Authority to have in place a system of inspections for establishments subject to the Regulations, and to prohibit the operation of an establishment if there is evidence that measures taken for prevention and mitigation of major accidents are seriously deficient. The Competent Authority also has to examine safety reports and inform operators about the conclusions of its examinations within a reasonable time period.

7 The inspection plan for a particular establishment is drawn up by inspectors from the Competent Authority based on previous interventions at the site and on information gained from the assessment of the safety report. The inspection programme requires input from a range of inspectors with specialist knowledge and identifies and prioritises issues. The focus of the programme is to ensure that the key risk control measures for preventing and mitigating major hazards are maintained.

8 The adequacy of this process and its application at Buncefield by HSE and Environment Agency inspectors is subject to a review under term of reference 3.

Environmental legislation

9 Some of the establishments regulated under the COMAH Regulations are also regulated by the Environment Agency and SEPA (the Agencies) under the Pollution Prevention and Control Act 1999 (PPC).

10 While the purpose of the COMAH Regulations (the prevention of major accidents) differs from that of PPC, the means to achieve them are almost identical. They require industry to have good management systems to control risk. PPC includes a specific duty to prevent and mitigate accidents to the environment which is complementary to the main COMAH duty. The Agencies manage this overlap between their different regimes following the principle that accident prevention work on COMAH sites is generally more significant because of the greater risks.

Supporting guidance and standards

11 The legal requirements are supported by a large body of guidance and standards that set out recognised good practice in the control of major accident hazards. This includes national and international standards, industry guidance and guidance published by the Competent Authority. Examples of the latter are *Reducing error and influencing behaviour* HSG48,[ref 16] *Successful health and safety management* HSG65 (Second edition)[ref 17] and *Containment of Bulk Hazardous Liquids at COMAH Establishments – Containment policy Supporting Guidance for Secondary and Tertiary Containment*.[ref 18]

Land use planning

12 The land use planning aspects of the Seveso II Directive are given effect in the UK by the Planning (Hazardous Substances) Regulations 1992, as amended in 1999. Under these Regulations the presence of hazardous chemicals above specified thresholds requires consent from the hazardous substances authority, usually the local planning authority. HSE is a statutory consultee on such occasions. The role of HSE is to consider the hazards and risks which would be presented by the hazardous substances to people in the vicinity, and on the basis of this advise the hazardous substances authority whether or not consent should be granted. HSE will also supply a consultation distance around the site. Any future developments in these zones require HSE to be consulted.

13 The aim of health and safety advice relating to land use planning is to mitigate the effects of a major accident on the population in the vicinity of hazardous installations, by following a consistent and systematic approach in providing advice on applications for planning permission around such sites.

14 Historically, HSE has based its land use planning advice on the presumption that site operators are in full compliance with the HSW Act. Section 2 of the Act places a duty on an employer to ensure, so far as is reasonably practicable, the health and safety of his employees. There is a corresponding duty in section 3 to ensure, so far as is reasonably practicable, that others (including the public) are not

exposed to risks to their health and safety. These duties are goal-setting and operators are expected to determine the most appropriate means to comply with them, without the need for detailed approval from HSE.

15 Under the General Development Procedure Order 1995, both HSE and the Environment Agency are statutory consultees for:

- the development of a new major accident hazard site; or
- developments on an existing site which could have significant repercussions on major accident hazards; or
- other developments in the vicinity of existing establishments, where the siting or development is such as to increase the risk or consequences of a major accident.

Part 2: Planning regulatory regime in Britain

Background

16 Regulation of major hazard sites under the Control of Major Accident Hazards Regulations (COMAH) and other health and safety law is complemented by the requirements of planning law.

17 Under the Planning (Hazardous Substances) Act 1990 and associated Regulations, the presence on, over or under land of a hazardous substance in excess of a specified amount (controlled quantity) requires consent from the hazardous substances authority, usually the local planning authority (LPA). The Act empowers the Secretary of State (for Communities and Local Government) to specify the hazardous substances and their controlled quantities. Flammable materials such as petroleum spirits and aviation fuels require consent in quantities above 5000 tonnes. The amounts present at Buncefield would significantly exceed this level.

18 HSE establishes a 'consultation distance', made up of three zones (to become four zones as a result of changes recently introduced by HSE for new planning applications), around hazardous sites based on the substances consent granted. LPAs are required to consult HSE (and others, including the Environment Agency or the Scottish Environment Agency (SEPA)) before future development takes place within consultation zones so that HSE can advise on appropriateness of a proposed development and minimise off-site risk to members of the public. LPA consultation is required by the Town and Country Planning (General Development Procedure) Order 1995 (as amended). Advice on planning applications is considered on a case-by-case basis.

19 The decision on whether the proposed development should go ahead is a matter for the LPA, not HSE. Where the LPA proposes to go against HSE's advice that permission should be refused, it is required to give HSE an opportunity to ask the relevant minister in England or Wales to call-in the application. Called-in applications are very rare. In Scotland a decision to go against is automatically advised to ministers who may decide to review the application.

20 Land use planning around major hazard installations in Britain has its origins in the reports[refs 19–21] of the Advisory Committee on Major Hazards (ACMH) which was set up following the explosion at Flixborough, the third report in particular. ACMH recognised the importance of providing planning authorities

with a source of safety advice prior to the establishment of new major hazard installations and, subsequently, on further development in the vicinity. Five years after the final ACMH report, HSE produced a separate document setting out its approach to land use planning.[ref 9] Various reports had been produced about HSE's approach to giving land use planning advice as a result of an internal 'Fundamental Review of Land Use Planning'; however, the 1989 document remains the key published document covering the policy on giving land use planning advice.

Legal basis for HSE's involvement in land use planning around major hazard sites

21 Over the years, the legal basis for giving the advice has been set out in acts, regulations and departmental guidance. These include:

- the Notification of Installations Handling Hazardous Substances Regulations 1982;
- the Planning (Hazardous Substances) Act 1990;
- the Planning (Hazardous Substances) Regulations 1992;
- the Town and Country Planning (General Development Procedure) Order 1995;
- the Planning (Control of Major-Accident Hazards) Regulations 1999;
- *Planning Control for Hazardous Substances* DETR Circular 04/2000; and
- *Hazardous Substances Consent – A Guide for Industry* DETR Sept 2000.

22 The current position is that the establishment of a new hazardous installation requires Hazardous Substance Consent (HS Consent). HS Consent is a planning matter and the responsibility of planning authorities, most usually local authorities at district level or unitary authorities.

23 The planning legislation relating directly to hazardous substances prescribes the controls on hazardous substances, their quantity and location, and the physical state in which they are kept and used. However, planning controls on subsequent development near to COMAH sites is general in nature and focused on other aspects of controlling development. It can prove difficult to control those aspects of development which might be significant when located near to COMAH sites.

Procedure for formulating planning advice

24 HSE must be consulted about HS Consent for new sites in accordance with the Town and Country Planning (General Development Procedure) Order 1995 (the 1995 Order). Once a hazardous installation is established, HSE must be consulted about development proposals nearby, also in accordance with the 1995 Order.

25 At the time of the Buncefield incident the procedure for giving advice relied on the definition of three zones around the hazardous installation (conventionally named inner, middle and outer). The zones are derived from a risk assessment process applied to the installation as specified in the HS Consent. The risk assessment may lead to risk-based zones where the likelihood (frequency) of a particular level of harm is predicted from a representative set of hazardous events and zones are set according to different likelihoods. This system is usually referred

to as quantitative risk assessment (QRA). In other cases the risk assessment may lead to zones based on three hazard ranges (that is, to different levels of harm) predicted from one or more hazardous events from the representative set considered. This system implements a philosophy that was described by ACMH as the 'protection concept'.

26 In either case, these zones are usually shown on a map of the area around the installation, which is produced by HSE and supplied to the planning authority (a three-zone map). All proposed developments that require consultation with HSE are allocated to one of four sensitivity levels, with 4 being the most sensitive and 1 the least sensitive. A 'go/no go' decision matrix is used to determine the advice according to the development sensitivity and the zone in which it is located.[24]

27 Following a consultation exercise in 2007, HSE published its plans to extend the outer consultation distance at large-scale petrol storage sites in Britain to 400 m. In addition, a new inner development proximity zone of 150 m radius is to be incorporated within which HSE's planning advice will be more restrictive. The revised interim policy will apply only to new planning applications and is intended to be introduced in the summer of 2008.

[24] PADHI – HSE's land use planning methodology. See Annex 9.

Annex 4

Planning history of Buncefield site and neighbouring developments

[Reproduced from Annex 3 of Initial Report]

1 Planning permission was granted in 1966 to Shell Mex and BP Limited, Regent Oil Co Limited, Mobil Oil Co Limited, and Petrofina (GB) Limited to develop 91 acres of land at Buncefield for the construction of a storage and distribution depot for petroleum products. St Albans Rural District Council initially refused the application on the grounds that it was an inappropriate development in the Green Belt and would have a detrimental effect on the amenity of the locality. On appeal, the Minister of Housing and Local Government granted permission subject to a number of conditions relating to design of the site, tree planting and restrictions on the size of office premises.

2 At the time that the terminal was built in 1968, the site was well screened by hedges and trees, but there were about nine dwellings on the periphery of the site to the north whose amenities were affected by the site, and a farm to the south. One of the nine dwellings to the north was converted in 2000 to create five separate properties. Since 1968 there has been general encroachment and development of adjacent land. This can be seen on the map in Figure 13. The majority of this building development took place during the period from the mid-1960s to the early 1980s, comprising the construction or redevelopment of residential properties and a number of schools and industrial premises to the west of the site, all of which fell within a 3 km radius as shown on the map. Between 1990 and 2006, a few additional industrial premises were built around the site.

3 Dacorum Borough Council is the principal planning authority for the site, but a small section to the north of Cherry Tree Lane falls to St Albans District Council.

4 The local planning authority decides whether developments can go ahead. But arrangements have existed since 1972 for local planning authorities to obtain consultee advice from HSE and its predecessors about the safety implications for developments from risks associated with major hazards. Between 1991 and 2005, 28 applications were passed to HSE for advice relating to a variety of commercial or residential developments around the Buncefield site. HSE advised against four of these proposals and advised that seven others could be allowed subject to certain conditions. As far as is known, the local authority followed HSE's advice in these cases.

5 In addition to these specific developments on which HSE was a statutory consultee, HSE is from time to time consulted on other matters. For example, HSE was consulted on four local structure plan revisions.

6 The complex began operations in 1968 after a pipeline was constructed to link two Shell refineries at Stanlow at Ellesmere Port in Cheshire and Shell Haven on the Thames Estuary at Stanford-le-Hope in Thurrock. The depot operated originally under licence given under the Petroleum (Consolidation) Acts 1928 and 1936. The Planning (Hazardous Substances) Act 1990 and subsequent statutory provisions, the Planning (Hazardous Substances) Regulations 1992 (PHS Regulations) and later the Planning (Control of Major Accident Hazards) Regulations 1999 introduced new procedures for consent to be sought from the hazardous substances authority to store hazardous substances.

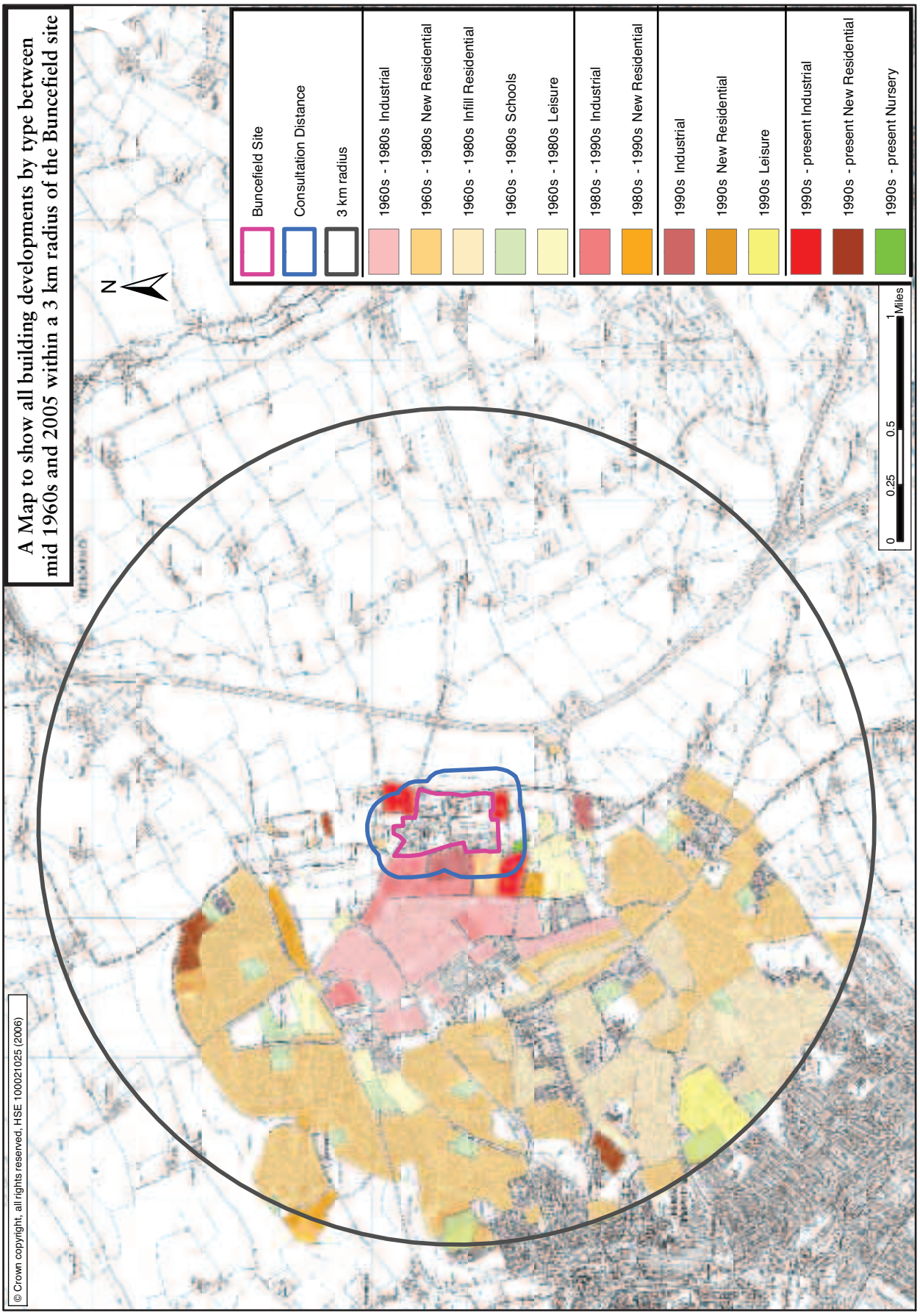


Figure 13 Developments within 3 km of the Buncefield site between 1966 and 2005

7 The consent identifies the hazardous substances and their location on site and defines certain conditions of use such as maximum size, temperature and pressure of storage vessels. Figure 16 contains some details of consents obtained for the Buncefield depot. The consents for Shell UK Oil Limited have been included in this table as they have not been revoked, although Shell no longer operates from this site.

HSE's role in land use planning

8 HSE's specific role in land use planning is twofold:

- Under the PHS Regulations, the presence of hazardous chemicals above specified threshold quantities requires consent from the local hazardous substances authority, which is usually also the local planning authority. HSE is a statutory consultee on all hazardous substances consent applications. Its role is to consider the hazards and risks which would be presented by the hazardous substance(s) to people in the vicinity, and on the basis of this to advise the hazardous substances authority whether or not consent should be granted. In advising on consent, HSE may specify conditions that should be imposed by the hazardous substances authority, over and above compliance with statutory health and safety requirements, to limit risks to the public (eg limiting which substances can be stored on site, or requiring tanker delivery rather than on-site storage). Hazardous substances authorities should notify HSE of the outcome of all applications for consent, and where consent has been granted should supply copies of the site plans and conditions.

- HSE uses the information contained in consent applications to establish a consultation distance around the installation. This usually comprises three zones or risk contour areas. The consultation distance is based on the maximum quantity of hazardous substance(s) that the site is entitled to have under its consent. HSE notifies the local planning authorities of all consultation distances in their areas. The General Development Procedure Order 1995 requires the local planning authority to consult HSE about certain proposed developments (essentially those that would result in an increase in population) within any consultation distance. HSE advises the local planning authority on the nature and severity of the risks presented by the installation to people in the surrounding area so that those risks are given due weight by the local planning authority when making its decision. Taking account of the risks, HSE will advise against the proposed development or simply note that it does not advise against it.

9 HSE's approach to land use planning is set out in more detail in Annex 2 of the first Progress Report.[ref 22] Some of this process is now being devolved to certain local planning authorities.

10 The consultation distance represents the furthest distance at which HSE wishes to be consulted about developments near hazardous installations/major accident hazard pipelines. This does not mean that there is no risk beyond the consultation distance, just that the predicted risks are sufficiently low that they need not be part of a planning decision.

11 Within the consultation distance, HSE undertakes an assessment of the hazards and risks from the installation and produces a map with three contours representing defined levels of harm or risk which any individual at that contour would be subject to, based on information relating to the hazardous substances consent. The harm or risk to an individual is greater the closer to the installation.

The contours form three zones, with the outer contour defining the consultation distance around major hazard sites. The local authority consults HSE on relevant proposed developments within this consultation distance

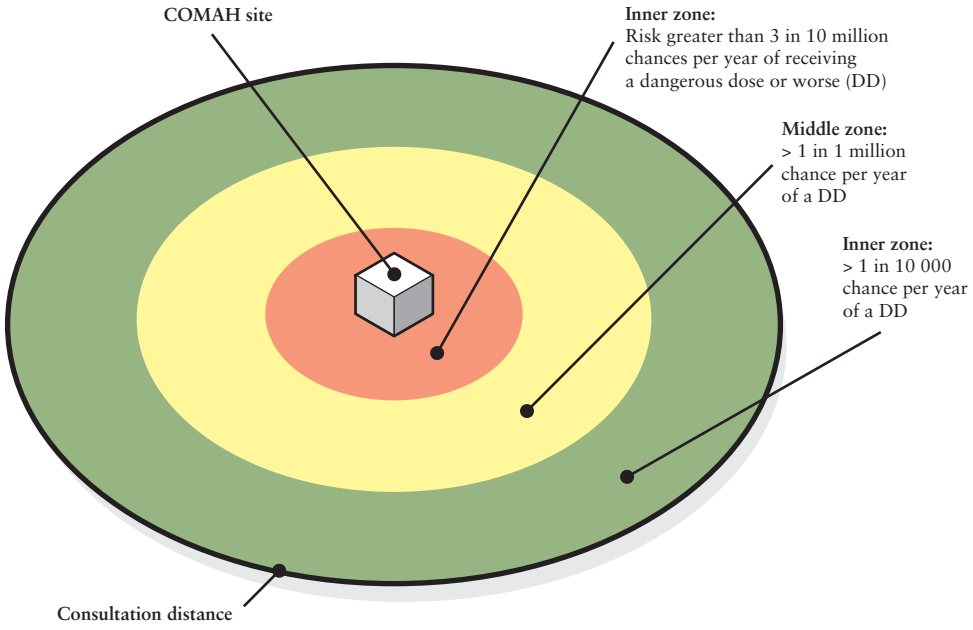


Figure 14 Consultation distance and zones

12 When a planning application is received, HSE or the local planning authority first identifies in which of the three zones the proposed development is located. Secondly, the proposed development is classified into one of four 'sensitivity levels'. The main factors that determine these levels are the number of people at the development, their sensitivity (vulnerable populations such as children, old people) and the intensity of the development. With these two factors known, a simple decision matrix is used to give a clear 'Advise Against' or 'Do not Advise Against' response to the local planning authority, as shown in Figure 15:

Level of sensitivity	Development in inner zone	Development in middle zone	Development in outer zone
1	DAA	DAA	DAA
2	AA	DAA	DAA
3	AA	AA	DAA
4	AA	AA	AA
Sensitivity level 1	*Example*	Factories	
Sensitivity level 2	*Example*	Houses	
Sensitivity level 3	*Example*	Vulnerable members of society eg primary schools, old people's homes	
Sensitivity level 4	*Example*	Football ground/large hospital	

DAA means Do not Advise Against the development
AA means Advise Against the development

Figure 15 Land use planning 'sensitivity levels' and decision matrix

13 More comprehensive guidance on the allocation of sensitivity levels is given on the Planning Advice for Developments near Hazardous Installations website (www.hse.gov.uk/landuseplanning/padhi.pdf).

History of the consultation distance around the Buncefield site

14 HSE has had arrangements with local planning authorities for consultation around developments in the vicinity of major hazards since the early 1970s, although it was not until the implementation of the Notification of Installations Handling Hazardous Substances Regulations 1982 (NIHHS Regulations) in 1983 that HSE first received notification from Shell Mex and BP of the terminal as a major hazard. A generic non-site-specific consultation distance of 250 m from the boundary of the site was set for consultation purposes and the relevant local planning authority was notified. At that time it was customary to issue a generic consultation distance without performing a site-specific assessment. This consultation distance was based upon the assumption that the main hazard was from thermal radiation following a major fire within the bund.

15 In 1992 the site expanded and Mobil and Shell sent another notification and application for consent to store certain amounts of flammable material. The existing consultation distance was maintained at a generic 250 m from the site boundary. There are no records of the technical assessments that were performed when the local planning authority sought advice on developments within the vicinity of the site, but early assessments were based then, as now, upon a pool fire following loss of containment of a substantial quantity of flammable liquid. However, for tanks that were bunded there was a continuing assumption that any subsequent fire would be within the confines of the bund.

16 In 1996 a site-specific reassessment was performed based upon consented amounts of flammable material, and the consultation distance was reduced from 250 m to 190 m. The original 250 m was set in the early days of HSE giving land use planning advice, to ensure that all developments that might be advised against would be subject to consultation. By 1996, technical policy and methodology had been reviewed. In addition, three-zone maps were now being produced so that development control advice could be given more quickly and efficiently. The new policy assumed that the bund would not be able to contain the full contents of a tank following a sudden, catastrophic failure. It was assumed that the bund would be overtopped and the resulting pool fire would extend beyond the confines of the bund.

17 In July 2001 another consultation distance was calculated due to an extensive reassessment of the hazards from the site following the submission of a batch of new consent applications from the oil companies. The regulations requiring consent to store flammable substances were changed in 1999 to include additional flammable materials. The consultation distance was reduced from 190 m to 185 m. This was unchanged following a further consent application on 8 July 2005 from BP. The presence of the additional material did not alter the main basis of the calculation which assumed the worst-case event was the catastrophic failure of the largest tank containing gasoline. The consultation distance was reduced slightly owing to a slight change to the inputs in the model used to perform the calculations. See Figure 17 for a representative plan of the site showing the consultation distance since July 2001.

Some details of hazardous substances consents issued for the Buncefield oil storage and transfer depot

Operator	Hazardous Substances Consent applications
Texaco Limited	19 September 1983:* 10 571 tonnes motor spirit
Mobil Oil Co Limited	8 November 1983:* 17 650 tonnes petrol
Hertfordshire Oil Storage Limited	30 November 1992: 34 020 tonnes motor spirit 18 October 1999: 15 314 tonnes kerosene
BP Oil UK Limited	18 November 1992: 17 650 tonnes gasoline in name of Mobil Oil Co Limited 26 October 1999: 15 080 tonnes automotive petrol and other petroleum spirits 21 October 2003: 15 200 tonnes automotive petrol and 10 522 tonnes petroleum products classified as dangerous for the environment (most likely to be gasoline or diesel) 3 May 2005: 26 900 tonnes automotive petrol and 10 522 tonnes petroleum products classified as dangerous for the environment (most likely to be gasoline or diesel)
British Pipeline Agency Limited	26 October 1999: 70 000 tonnes automotive petrol and other petroleum spirits
Shell UK Oil Limited	19 September 1983:* 37 397 tonnes HFLs Class 4 and 42 561 tonnes kerosene and white oils 30 November 1992: 34 013 tonnes petroleum spirit and 39 000 tonnes diesel, gas oil and kerosene 1999: 33 000 tonnes motor spirit and 17 000 tonnes kerosene

Figure 16 Hazardous substances consents issued

** **Note:** The first applications for 'consent' were in 1992, before then different arrangements were in place, ie these were notifications under NIHHS and consent was not required.*

Figure 17 Plan representing the hazardous substances consents and consultation area around the Buncefield depot since July 2001 (for illustration only)

Annex 5

Hazard and risk and the application of QRA and 'dangerous dose or worse' to land use planning around major hazard sites

1 The study of risk uses a number of terms with specific meanings which can vary to a degree from common usage. This annex provides a simple explanation of their meanings in this context. The current definitive text on the subject is HSE's *Risk criteria for land use planning in the vicinity of major industrial hazards* 1989.[ref 9]

Hazard and risk

2 The word **hazard** means a situation with the potential to cause harm (injury or death) but does not imply whether the likelihood of the harm being realised is high or small. The adverse consequences to people arising from the loss of containment from a tank of pressurised toxic gas or a large tank of flammable liquid are examples. In contrast **risk** means the frequency or likelihood (probability) of a harmful event such as injury or death from a major hazard incident.

Residual risk

3 The COMAH Regulations require the site operator to take all measures necessary to prevent major accidents and limit their consequences to persons and the environment. These measures can reduce the risk of an event occurring with off-site consequences but cannot entirely eliminate it. The irreducible minimum level of risk, having taken all necessary control measures, is known as residual risk. Land use planning decisions need to take residual risk into account. The intention is to control significant developments near to major hazard sites to avoid undesirable increases in the numbers of people exposed to the residual risk from the site.

Individual risk

4 This risk relates to the likelihood that a particular person might be harmed. Such a person may be a named individual with known habits, or a typical inhabitant of a house or a typical user of a leisure facility at a specified location. To provide general application, typical cases are the ones of interest, though this needs to be done with some care because of the wide variations in people's habits and vulnerability to harm.

5 Individual risk is expressed as the probability of a typical user of the development under consideration (eg a house, block of flats, factory, office, care home or sports facility) being harmed in the course of a year from the major hazard site.

Societal risk

6 Societal risk is a measure of the likelihood of a large-scale incident involving mass casualties, which depends upon integrating the risk of a major incident occurring with the number of people living or working in the vicinity of the site who could be exposed and suffer death or major injuries. The derivation of the

societal risk estimates requires, in addition to data on the integrity of the plant for deriving individual risk, an up to date knowledge of the size and distribution of the working and residential population around the site under review. Quantitative risk assessment is required to derive estimates of societal risk.

7 Societal risk is expressed as the relationship between frequency and the number of people sustaining a specified level of harm in a given population due to the realisation of specified hazards.

8 Societal concern is an expression of the public aversion to large-scale incidents. For example a rail accident with multiple fatalities will command huge public attention and calls for preventive action whereas most fatal car accidents attract little notice even though they are responsible for more deaths each year than rail travel. The Flixborough and the Piper Alpha disasters (between them resulting in 195 deaths) resulted in global interest – both incidents resulted in a loss of public confidence in the regulatory system and in the industrial sectors.

9 Societal risk can be subdivided in a number of ways. For example:

- national societal risk: the risk to the nation as a whole due to a particular type of activity, eg nuclear power generation or production of dangerous pathogens;

- local societal risk: the risk to a localised population from a particular type of activity, eg the risk of harm to the population of Canvey Island from the various petrochemical installations in the area; and

- case societal risk: the risk at a particular location or from a particular activity, eg people using a retail development in the vicinity of a hazardous installation.

10 In the context of land use planning at a major hazard site, societal risk is the likelihood of a disaster involving the off-site population in the vicinity of the site. For example an investigation was carried out into a proposal for additional petrochemical installations in the Canvey/Thurrock area (see Figures 1 and 6 in the main report) where there were existing sites of major accident potential. Each additional installation would have generated a 'case societal risk' but the overriding concern was with the cumulative risk to the local population from all the installations, existing and proposed, in that area, ie the extent of the 'local societal risk'.

11 The concept of societal risk is more difficult to express in terms of numbers than individual risk. There will be a range of events that can be postulated. These will be of different magnitudes, with different probabilities of occurrence, and different degrees of harm arising from them. Generally speaking in the UK, the more severe the event the less its likelihood but the greater its potential consequences in terms of human harm and environmental impact. Therefore societal risk is often expressed as a line on a graph which plots the relationship between the likelihood of an event and its estimated consequences in terms of the number of fatalities. Such lines, or curves, are called FN curves. The shape of this curve depends on how the population is distributed around the site, and is therefore very site specific. Obviously, the distribution of the population around a site changes as new developments take place, whereas the individual risk will not change if hazardous operations and their control measures on the site do not change. Therefore the societal risk around a site can change when the individual risk does not.

12 Measures of societal risk have been developed based on integrating the area under the FN curve. However, this simple 'risk integral' does not allow for distinguishing between one accident causing 100 fatalities and 100 accidents each

causing one fatality over the same time period. Therefore weighted risk integrals have been developed to account for society's aversion to multiple fatality events. FN criterion lines have also been drawn as standards for comparison. The calculated risk integral for a specific situation is then capable of comparison against the same integral calculated for a criterion FN curve.

QRA applications of relevance to land use planning around major hazard sites

13 The full scope quantified risk assessment (QRA) and the production and interpretation of FN curves[25] is the accepted best means for studying societal risk, but it is relatively costly, time-consuming and requires a high level of technical capability. Screening can be undertaken to determine at which sites the full scope technique is required because of increased concerns for societal risk, or where a more approximate (and therefore quicker and cheaper) means may be appropriate.

14 The fundamental principle of management of health and safety at work is the ALARP[26] principle. To demonstrate risks are ALARP site operators have to undertake a risk assessment, the depth of analysis of which should be proportionate to the major hazard risks taking account of the nature of the site operations and the size of the exposed off-site population. Where the risks relate to major hazards and the potential for killing or harming a number of people or creating a major accident to the environment, some form of QRA will be required. Even where the protection concept is currently used at flammable storage sites, QRA is deployed to determine the most significant individual risks arising from a site against which to assign consultation distances for land use planning purposes.

15 To integrate societal risk into land use planning around major hazard facilities, site-specific QRA will be needed. The key principles that illustrate the requirement for QRA are as follows:

Setting priorities and comparing risk values when adopting best practice or state-of-the-art technology at COMAH sites
See *A guide to the Control of Major Hazards Regulations 1999 (as amended). Guidance on Regulations*(ref 15)

16 This is of particular relevance at fuel storage sites following the Buncefield incident to ensure the highest integrity of containment measures to prevent the escape of fuel from storage tanks. A single model QRA would be applicable to a range of similar sites. Given the relatively uncomplicated nature of such sites compared to say a large refinery or a nuclear energy installation, the suitable methodology would be relatively straightforward.

Estimating the percentage contribution to individual and societal risk of single large buildings and proposed developments around the site, showing how the method is capable of measuring the impact on societal risk of incremental development
See Annex 10 to this report

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25 FN curves: see paragraph 113 and its footnote in the main report, and Annex 10 in general.

26 ALARP = as low as reasonably practicable. Risks are deemed ALARP where there is gross disproportion between the costs to the dutyholder of doing more, against the benefit gained (in terms of risk reduction) in doing it.

17 Prior to the Buncefield incident, the design event chosen for deriving the consultation distances using the protection-based system was a tank failure and pool fire, but post-Buncefield the unintentional release of fuel and the formation of a vapour cloud that can flow off site may lead to either a flash fire or a large explosion and both scenarios need to be included in risk assessment. What the QRA incorporating the three hazard types (pool fire, flash fire and vapour cloud explosion) would look like is shown in the example we commissioned in Annex 10. Individual risks of fatality at specific locations can be calculated along with the percentage of the individual risk due to tank events, as compared to overfill events and failure of feed pipelines.

Setting the interim consultation distance based on best practice in design and operations of an installation until the causes of the explosion at Buncefield are better understood
See *Recommendations on the design and operation of fuel storage sites*(ref 4) and HSE press release *HSE publishes land use planning consultation outcome* EO46.07 4 December 2007

18 HSE's interim solution to land use planning around fuel storage depots was to extend the consultation distances to the area of damage observed in the Buncefield explosion, with the proviso that it should remain in force until research provides more information on the mechanism of the vapour cloud explosion which took place at Buncefield. A precautionary approach can be justified when the level of uncertainty is high, but can be very restrictive on future economic development around sites, particularly, for example, where the means of preventing the initiating event (such as a petrol tank overfill) can be improved.

Providing a structured, objective and quantified approach to meeting ALARP can contribute to understanding the hazards and the measures needed to control them
See *A guide to the Control of Major Hazards Regulations 1999 (as amended). Guidance on Regulations* and *The Public Inquiry into the Piper Alpha Disaster*(ref 10)

19 Good practice applies 'defence in depth' by adopting accepted engineering principles, along with good operating and maintenance practices. Meeting these measures or going beyond them in seeking to further reduce individual and societal risk under the ALARP criterion can be demonstrated using QRA.

Annex 6

Development of risk criteria for use in land use planning

1 As early as 1967 Her Majesty's Factory Inspectorate (HMFI), one of the forerunner regulators to HSE, first drew attention to the disaster potential of major chemical installations. In time this led to the then Department of Environment issuing a circular (DOE 1/72) requiring planning authorities to consult HMFI on proposals to develop land in the vicinity of major hazard installations.

Flixborough

2 In 1974 a large amount of vapour escaped from one of the plants at the Flixborough chemical works, leading to a large unconfined vapour cloud explosion which killed 28 workers and caused considerable devastation on site. It also raised concerns about off-site consequences, though no members of the public were killed.

3 In response, the newly established Health and Safety Commission (HSC) set up the Advisory Committee on Major Hazards (ACMH). Its remit was to make recommendations for improving the understanding of accidents arising from major hazard sites, preventing such accidents occurring and mitigating their consequences where they did happen. In its three reports in 1976, 1979 and 1982,(refs 19–21) ACMH made a number of statements which were seminal in influencing HSE's approach to land use planning. For example it endorsed the consultation arrangements provided for under circular DOE 1/72 as being essential for preventing incompatible land uses. HSE, it said, had both the information and expertise needed to formulate advice on the safety implications of major hazard installations.

Canvey Island studies – 1978 and 1981 reports(ref 23)

4 Arising from a public inquiry to consider revoking planning permission, HSE was asked to carry out a study of the risks to people living in and around Canvey Island from the existing oil refinery in the area and a proposed additional one. The reports identified both the individual and societal risks to the public arising from ten major hazard installations. Following substantial public and Parliamentary debate, a societal risk value of 500 deaths at a frequency of 1 in 5000 years was accepted at that time as just tolerable and that the somewhat higher risk prior to safety improvements was not.

Piper Alpha Inquiry 1988–1990(ref 10)

5 The explosion and fire on the Piper Alpha oil production platform in the North Sea in 1988 caused the deaths of 165 platform workers and two rescuers. It led to a major inquiry conducted by Lord Cullen. This provided confirmation that the major events predicted by risk analyses were indeed realistic and that QRA could be a useful tool in trying to reduce the risks. The inquiry report in 1990 recommended a much more modern system of safety regulation for the offshore industry and this led to new regulations which explicitly required the use of QRA.

Study of major hazard aspects of transport of dangerous substances and ports 1991[ref 24]

6 This study by HSC's Advisory Committee on Dangerous Substances (ACDS), which took five years, examined those substances and transport aspects, including ports, most likely to give rise to significant risks. Societal risk criteria were used as one test of the tolerability of risk at some of the fixed sites (ports, parking areas, marshalling yards). The study endorsed the above Canvey post-improvement criteria, developed an approach for their use in decision making, and reported that not only did this reflect UK and worldwide experience of events involving major installations, but also society's decreasing willingness to tolerate increasing numbers of fatalities. However, it was noted that a community which derived significant economic benefit from the hazardous activity may well be more tolerant.

HSE publication *Reducing risks, protecting people* (R2P2), 1999 and 2001[ref 13]

7 In response to the Sizewell B inquiry, HSE published in 1988 (with an update in 1992) reports on the *Tolerability of risk from nuclear power stations*.[ref 11] These not only formulated and published guidelines on the tolerable levels of individual and societal risk to workers and the public, but outlined how they might be applied to inform regulatory judgements.

8 *Reducing risks, protecting people* articulated how statutory bodies responsible for administration of the Health and Safety at Work etc Act 1974 approached decisions about the management of risk. Following public consultation, R2P2 set down the criterion it had adopted for addressing societal concerns where there is a risk of multiple fatalities occurring from a single event at a major hazard installation. The criterion was that the risk of an accident causing the death of 50 people or more in a single event should be regarded as intolerable if the frequency is estimated to be more than 1 in 5000 years. This value was derived for a single installation using the levels of risk that society was prepared to tolerate at the multi-site industrial complex at Canvey Island and taking account of technological improvements since the Canvey study.

Annex 7

The Dutch land use planning system

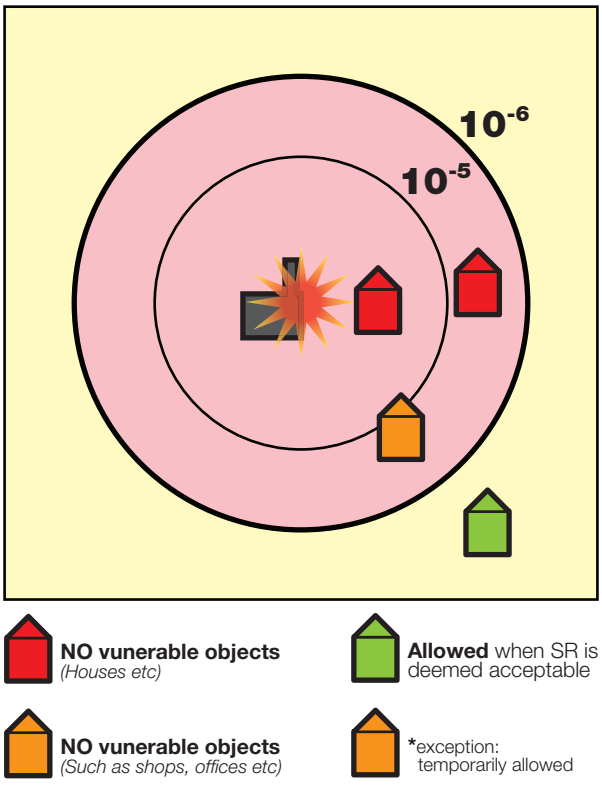
Summary of Dutch approach

1 The Dutch currently get site operating companies to prepare a QRA showing individual risk (location-specific risk) and societal risk. The inputs, such as failure frequencies, are set down in a common reference book. Some of these failure frequencies are reached by agreement between the various authorities.

2 Because of disagreement among experts, the Dutch have recently insisted that everyone uses the same computational methodology, which includes built-in methodologies such as dispersion codes. The Det Norske Veritas (DNV) code 'SAFETI' is used (called SAFETI–NL).

3 Once contours and FN curves are produced, they are compared against criteria. For individual risk, strict limits are applied to developments within the 10^{-5} and 10^{-6} contours. These are mandatory with time limits for implementation established by a decree operational from 1 November 2004. The decree imposes limit values for the location-based individual risk for vulnerable objects (red icons) and target values for 'less vulnerable' objects (orange icons). Vulnerable objects are residential properties and equivalent premises, such as schools and hospitals, less vulnerable objects are, for example, small offices and working places, playing fields etc. Compliance with the limit value of 10^{-5} per annum for the location-based risk must be reached within three years from the decree being operational and compliance with the limit value of 10^{-6} per annum for the location-based risk must be reached by 1 January 2010 for all vulnerable objects in the vicinity of establishments subject to the decree.

Figure 18 Risk criteria for new situations



4 From 2005 any 'vulnerable objects' – (red icon: houses, schools etc) will not be allowed within the 10^{-5} zone, then from 2010 none will be allowed within the 10^{-6} zone. The limit values are not so strict for 'less vulnerable objects' such as offices. They are targets but may be temporarily allowed. The orange icon represents these as targets, but may also be temporarily allowed.

5 For societal risk there is a criterion line, which had a slope of -2 and was a strict limit reflecting a large aversion to major accidents. The policy was that no part of the FN curve could cross it, but this caused problems so the limit was changed to an orientation line. Various parties (local authorities, public, fire brigades etc) now have to get together to agree development plans. The limit is there to inform any discussion; if it is exceeded then the reasons have to be recorded and justified.

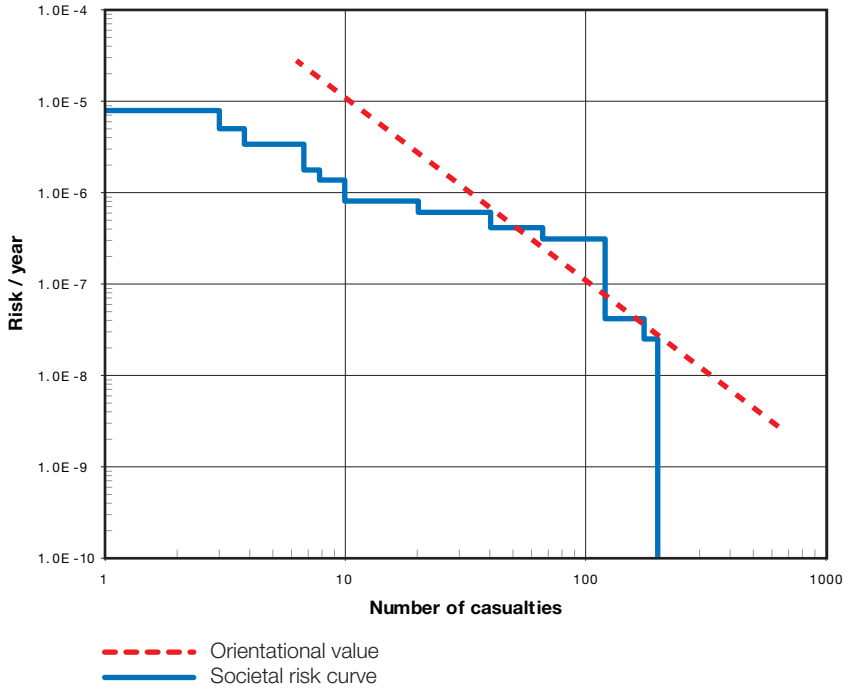


Figure 19 Societal risk plot (FN curve format) for determining maximum allowable population at risk from a major hazard incident on the site (see paragraph 113 in the main report and Annex 10 for further information on FN curves)

6 To help the various parties understand the implications of any change in societal risk, new methodologies have been developed which show the changes to societal risk on a colour coded map.

7 The concept of societal risk and associated criteria were found to be difficult to understand for many people and difficult to implement by the authorities. This was because societal risk is not a single figure that can be displayed as a contour on a map. At the request of the Dutch Government, consultants have developed a concept for an area-specific approach to societal risk. This approach considers the risks not from the perspective of the source causing the risk, but from those who are at risk. This area-specific approach shows societal risk displayed by coloured areas on maps. Orange indicates an area where societal risk is already high so development is limited, green means there is some room for more urban development and so on.

8 For further information, see *Area Specific Societal risk, societal risk on the map*,[ref 25] a paper by TNO (the Netherlands Organisation for Applied Scientific Research), which gives an account of the 'traffic light' approach with examples of colour-coded maps.

Annex 8

Harm criteria used in risk assessment

1 One of the key elements in conducting a risk assessment is setting the criterion for the harm that an event can cause. The seriousness of different potential events that can arise from major hazards can only be compared if there is a consistent criterion for the harm level, which is applicable across different types of hazard, especially 'toxics' and 'flammables'. This annex explains the two main harm criteria used.

Risk of fatality

2 This criterion relates to the probability of an individual receiving fatal injury. It is widely used and allows relatively consistent comparison of risks within and between sites, nationally and internationally. It does not accommodate serious injury, nonetheless many everyday risks are expressed in these terms. For instance, the road safety reports, and accident prevention initiatives, are based on annual fatality statistics. However, this criterion still needs to be used with care since there are different definitions, depending on whether the level of hazardous material presents, for example, a 1% or 50% risk of fatality.

Dangerous dose

2 HSE uses dangerous dose as its main harm criterion. This dose is defined as the level of toxic gas, or heat, or explosion over-pressure which gives all the following effects:[27]

- severe distress to almost everyone;
- a substantial fraction requiring medical attention;
- some people seriously injured, requiring prolonged treatment; and
- death in highly susceptible individuals.

3 The risk assessed in this way is the probability over the following year of an individual at a particular location being exposed to a dangerous dose or worse, depending upon the distance from source of the exposure.

4 Originally HSE advised on the basis of a concept of 'protection' of those exposed to a hazard so that the separation distance between development and hazard provided a high degree of protection against the more likely smaller events, while giving worthwhile protection against unlikely but foreseeable larger scale events. To apply the concept in practice required the identification of the worst events (of fire, explosion or toxic release) and then determination of a separation distance based on exposure to a defined level of harm, namely the dangerous dose.

[27] Note that damage to buildings is not taken into account except where such damage may cause harm to people. This approach does not account for damage to the environment.

5 Later HSE changed to advising LPAs on the basis of risk for some types of hazard. In these cases the risk was the probability per year of an individual at a particular location being exposed to a dangerous dose or worse. Based upon information supplied by the LPA, HSE produces a three-zone map, the outer boundaries of which represent either defined levels of risk or specified consequences from the identified event. This is further illustrated in Annex 4.

6 The choice of the dangerous dose criterion is to accommodate risks of serious injury as well as death and because there are technical difficulties in calculating risks of death from a hazard to which individual members of a population may have widely differing vulnerabilities. However, contained within the concept of 'dangerous dose or worse' is a range of outcomes with some types of event being more biased towards causing fatalities. Thus two different events assessed as having similar consequences in terms of dangerous dose may in fact cause very different results in terms of the number of fatalities. In practice, the use of dangerous dose makes it difficult to compare risks within sites between different types of hazard (toxics and flammables), and between sites.

7 The following is an extract from risk criteria document 1989,[ref 9] explaining the provenance of the concept of dangerous does or worse at that time. This extract puts into context the value of adopting dangerous dose or worse, although many of the considerations favouring this approach have been overcome.

Dangerous dose or worse

'48 It has often been assumed that risk criteria for major hazards should relate to the likelihood of death. This seems straightforward and easy to compare with risks from other hazards in life. However there are two important problems with a criterion based on the risk of death in the present context:

(a) society is concerned about risks of serious injury or other damage as well as death;
(b) there are technical difficulties in calculating the risks of death from a hazard to which individual members of a population may have widely differing vulnerabilities.

49 The second point may be appreciated by considering an example, such as the toxic gas chlorine. If a cross-section of the population were exposed to a dangerous cloud of chlorine, some people would be more seriously affected than others, and a proportion might die. Those who died could have had some pre-existing condition or weakness which made them more vulnerable, but there might also have been people who had simply been exposed to high-concentration pockets of gas in the cloud. It is not possible to identify in advance who these people would be, nor is it possible to predict a particular person's susceptibility to chlorine. Thus it is not possible to say with certainty what is the probability of a particular person being killed by a particular exposure to chlorine. This implies that it is not possible to calculate an individual risk of death for a particular person. However, there are techniques (eg probit transformations) which permit the calculation of proportions of populations affected by a given level of harm; these are also subject to uncertainties.

50 It is of course possible to take "average" or "typical" susceptibility and average concentration, and to use these to produce "average" individual risks. This "average" might conceal a very wide range of risks to particular people, and it is not clear whether it has any real meaning.

51 One approach to this sort of problem is to consider the case of the particular individual who is most at risk. This would give an indication of the maximum likely level of individual risk in situations where there is a variation about the average. The approach is questionable for the present purpose as there may be no obvious limit to susceptibility; people with severe breathing problems may be extremely sensitive. Thus it is not possible to draw the line and define the "worst case" individual.

52 It is possible to avoid some of these problems by using an injury criterion other than death. For example, it is possible to define a dose of toxic gas, or heat, or explosion overpressure which gives all the following effects: severe distress to almost everyone; a substantial fraction requires medical attention; some people are seriously injured, requiring prolonged treatment; any highly susceptible people might be killed. This might be described as a 'dangerous' dose, as it has the potential to cause death but it will not necessarily do so. Then the risk assessed is that an individual at a particular place will be exposed to such a dangerous dose or worse. The results of such an assessment may be described as:

"The risk that a typical user of the development will be exposed to a dangerous dose or worse of toxic gas, heat or explosion overpressure".

Annex 9

HSE's fundamental review of its role in land use planning

1 In 1998 HSE initiated a fundamental review which scrutinised its role in, and approach to land use planning. The review was wide ranging and covered issues such as:

- the criteria and methodology used for setting planning zones and for 'calling in' planning applications;
- codification so that HSE can provide transparent and accurate advice without detailed individual assessment of planning applications;
- devolving the codified advice so that local planning authorities (LPAs) can deal with the vast majority of planning applications themselves and developing a communication strategy to ensure buy-in to this devolution;
- reconsidering what to assess under the Consents legislation; and
- positioning HSE to influence any European developments.

2 The fundamental review reported back with a range of recommendations in 2001, and was followed up in 2002 by initiation of an implementation project. The Project Initiation Document identifies the following recommendations as within scope:

- the criteria and methodology used for setting planning zones and for 'calling in' planning applications should be reviewed and, if necessary, revised and then published;
- HSE's advice to LPAs on chemical major hazards and pipelines should be further codified so that transparent and accurate advice can be given without detailed individual assessment of planning applications;
- the codified generic advice should be devolved to LPAs so that they can deal with the vast majority of planning applications which are in the vicinity of chemical major hazards and pipelines.

3 Additionally, it was considered that the project:

- should consider the respective roles of COMAH and legislation relating to land use planning in ensuring that risks (both societal and individual) to members of the public are appropriately controlled and if necessary, develop policy and guidance;
- should reopen the debate on what to assess under the Consents legislation;
- should contribute to the work of European Commission Technical Group 5, re-established following the Toulouse ammonium nitrate explosion, so that HSE can be in a position to influence any European developments;
- should develop and implement a communication and engagement strategy to ensure optimum buy in by LPAs and other key stakeholders to the devolution proposals.

4 One product of this is devolution of a decision-making tool to LPAs – Planning Advice for Developments near Hazardous Installations (PADHI), which uses individual risk as the criterion. During 2006 and 2007, HSE gave all planning authorities in England, Scotland and Wales online access to PADHI+, which comprises a consultation zone library for all hazardous installations and pipelines together with a PADHI+ advice generator. The computer code in PADHI+ generates a decision to not advise against (DAA) or advise against (AA) based on HSE's experience of giving advice to LPAs. The decision matrix based on the 'sensitivity level' of the development is shown in paragraph 12 of Annex 4.

5 Another consequence of the implementation project was for HSE to commission two independent reviews, both of which reported in 2004. These were:

- review of HSE's risk analysis and protection-based analysis approaches for land use planning; and

- HSE land use planning models and methodologies review.

6 However, during the implementation of PADHI+, HSE began work with a cross-government task force exploring future policy on societal risk. The feasibility of delivering all the recommendations of the fundamental review was reconsidered in terms of interaction with societal risk policy. As a result a number of the recommendations of the fundamental review have yet to be implemented.

See www.hse.gov.uk/landuseplanning for more information.

Annex 10

Summary of work commissioned of DNV by MIIB to develop an illustrative risk based approach to land use planning around flammable storage sites

Introduction from the Buncefield Board (MIIB)

1 Det Norske Veritas (DNV) was commissioned to provide an independent illustration of what a risk-based model for land use planning at flammable storage sites might look like. We present a summarised version of their report below.

2 The work carried out by DNV shows how risks from a large petroleum facility can be estimated in the form of individual and societal risk and illustrates the advantages of adopting QRA in a new land use planning system in Britain. It demonstrates clear advantages in land use planning over the protection concept in use at the time of the Buncefield incident, but the events included here of vapour cloud formation, flash fire and explosion were not recognised hazards before the incident.

3 The assumptions and methodologies used in this report were the decision of DNV and have not been approved by the Buncefield Board or its advisors, nor subjected to external peer review. The frequency data used in computing the frequency curves in Figures 20–24 are based on internationally available data. The relevant sources of data for those figures are Lastfire, and Purple Book, and references are provided as footnotes to the text.

Summary report

Background to the report

4 At the time of the Buncefield incident neither the regulator nor the industry considered a large flammable cloud explosion to be a reasonably foreseeable event that needed to be taken into account in the design and operation of flammable storage sites, and in the emergency preparations and response planning at such sites. Since Buncefield the reliance on a protection-based approach to land use planning around flammable storage sites has been questioned. The Buncefield Major Incident Investigation Board (MIIB) that was appointed by Government to oversee the incident investigation has responded to two consultation documents issued by the Health and Safety Executive on land use planning (CD211) and on societal risk (CD212).

5 In its response to CD211 MIIB indicated that (a) advice on land use planning should be based more on a consideration of risk, (b) more attention should be paid to the population at risk and (c) it considered that land use planning should be responsive to the levels of risk presented by each particular site. In its response to CD212 it gave a view that land use planning and societal risk are inextricably linked. The MIIB commissioned Det Norske Veritas (DNV) to carry out an independent preliminary risk analysis using the Buncefield site as it was prior to the explosion to illustrate the QRA method and its uses by incorporating the now-recognised full range of hazards fuel storage sites may present.

Scope of and approach to the report

6 The scope of work defined by MIIB was as follows:

- provide an independent view on what a risk-based approach to land use planning in the vicinity of large petroleum storage facilities might involve and show how this might

be achieved in practical terms. This would include consideration of risk-based options in place elsewhere, particularly in Europe, including their perceived limitations. It would take into account HSE published material, and previous reports of MIIB and the hierarchy of control of major hazard risks;

- establish the nature of data that need to be determined or assigned in order to produce a risk-based model, and their source;

- show whether such a model can incorporate inherent risk reduction measures as called for in MIIB reports;

- show to what extent such a model could be used to determine societal risk and therefore provide an input into any decision making process.

7 DNV's approach to this work was as follows:

- develop a methodology that could be applied to a site similar to the Buncefield site that would enable a quantified risk analysis (QRA) to be carried out which would give predictions for both individual and societal risk, identifying the major uncertainties in the analysis;

- apply the methodology used for risk assessment/development control in the Netherlands to the same site;

- review the predictions and consider whether a methodology based on risk rather than a mixture of risk and hazard could be used in the UK for future land use policy around major hazard site.

Methodology and assumptions

8 The methodology used followed the classical approach to process QRA. Generally DNV considered the assumptions made to be reasonable, neither overly conservative nor optimistic so that the analysis gives a realistic estimate of the risk, although it is recognised that the error band will be quite wide, and this would need to be taken into consideration should the predictions be used for decision making. The system that was analysed comprised the west part of the Buncefield site, including the tanks in the vicinity of Tank 912 which was the source of leakage, the bunds, the feed pipelines and the export pipelines.

9 The hazard types analysed were:

- pool fires;

- flash fires;

- vapour cloud explosions.

10 Extrapolation from conventional dispersion codes was used to determine cloud sizes in low wind speed conditions to replicate the vapour/aerosol cloud that was produced at Buncefield (as the task was beyond the scope of CFD[28] was beyond the scope). Pool fires were modelled using a solid flame technique. Vapour cloud

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[28] Computational fluid dynamics (CFD) is a method that enables the study of the dynamics of things that flow. CFD is the numerical approximation to the solution of mathematical models of fluid flow and heat transfer. Computational fluid dynamics is one of the tools (in addition to experimental and theoretical methods) available to solve fluid-dynamic problems.

explosion modelling was based on the observed effects of the Buncefield explosion (RR511),[ref 26] by deriving decay curves from an assumed cylindrical cloud. A number of decay curves were used to represent the range of effects seen at Buncefield and larger and smaller clouds than ignited at Buncefield. The curves were derived for use in the Multi Energy framework, assuming a maximum overpressure of 350 mbar. Flash fires were represented by the same cloud that was used for the explosion predictions. The effect of the hazards on people in different building types was based on available vulnerabilities.

11 Frequency analysis used generic data from both HSE and Purple Book[ref 27] sources. The overfill frequencies were derived from data provided either by MIIB (termed MOC data) or by the Lastfire Group[29] (again via MIIB). Ignition probabilities were assigned based on an assumption that delayed ignition increases with cloud size and cloud duration. Explosion probabilities were also assigned and assumed increasing probability with cloud size.

12 A number of different analyses were carried out with the following assumptions:

- the overfill frequency was as per the MOC data, with tank failure data as per HSE;
- the overfill frequency was as per the Lastfire Group data, with tank failure data as per HSE;
- the overfill frequency was as per the Lastfire Group data, with tank failure data as per the Purple Book;
- the overfill frequency was as per the Lastfire Group data, with tank failure data as per the Purple Book with mitigation measures to ensure that the release duration did not exceed 600 seconds.

13 In the DNV analysis Northgate was the main contributor to societal risk in the area. A small sensitivity analysis was carried out to examine the effects on the overall or area societal risk[30] at Buncefield of moving the Northgate building 100 m and 200 m further away from the installation.

14 The predictions were given in terms of:

- hazard frequency and individual risk contour plots;
- individual risk at specified locations;
- societal risk.

15 The method of analysis used in the Netherlands for land use planning was also applied to the same site.

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29 Lastfire (Large Atmospheric Storage Tank Fires) is a consortium of international oil companies engaging in projects reviewing the risks associated with fires in storage tanks and developing suitable industry practise to mitigate the risks www.resprotint.co.uk/lastfire.htm.

30 Otherwise known as local societal risk – see Annex 5 for an explanations of national, local, and case area risk.

Results

16 The preliminary analyses using methods adopted for this project show where most of the potential risk lies and where control measures need to be focused:

- only the overfill events, the failure of the feed pipelines and the tank failures gave cloud formation rates that were sufficient to give a vapour cloud above the assumed threshold explosion volume (ie the other scenarios gave only flash fires and pool fires);
- the contribution to the offsite risk from explosions following the failure of the feed pipelines was insignificant compared with the overfill and tank events;
- the pool fires do not give levels that are considered to give fatal injuries at any of the buildings.

17 The explosions included in the analysis have the potential to cause significant knock on or 'domino' effects (failure of adjacent tanks and subsequent ignition of released liquids, as occurred during the incident). The effects of these secondary events were not included in the risks presented.

18 Examples of the outputs are shown below. The blue line marked CD on the plots is the consultation distance assigned by HSE for the Buncefield site following the implementation of Option 4 (CD211). The other contours show plots of the frequency of the overpressure generated should an explosion occur. The contours join up those points where the frequencies are the same.

19 Figure 20 shows the plots of where the frequency of an over-pressure exceeds the dangerous dose (in this case 70 mbars). The dangerous dose here represents that dose which would cause a few per cent deaths in a vulnerable population. Figure 21 shows similar plots, but where the frequency of an overpressure exceeds 140 mbar. This is the dangerous dose HSE uses for a normal population.

20 The frequencies are 1 chance in 10 million per year (1 x 10^{-7}/year) for the outer contours (dark blue), 1 chance in a million per year (1 x 10^{-6}/year) for the next one further in (green), 1 in 100 000 (pale blue), 1 in 10 000 (orange) and 1 chance in 1000 per year (red).

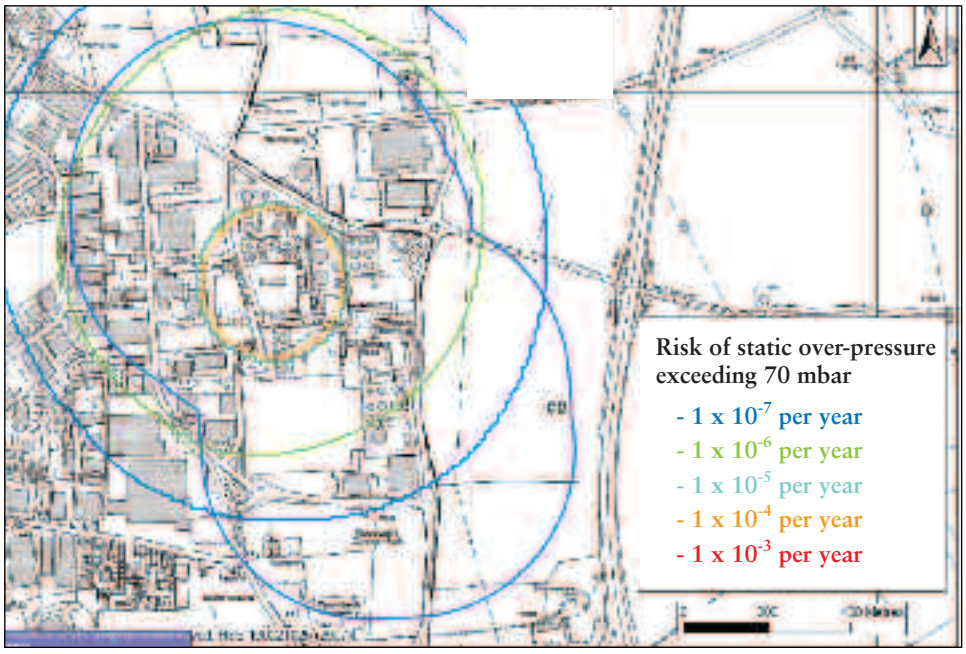

Figure 20 Frequency of over-pressure exceeding 70 mbar (HSE dangerous dose for vulnerable population)

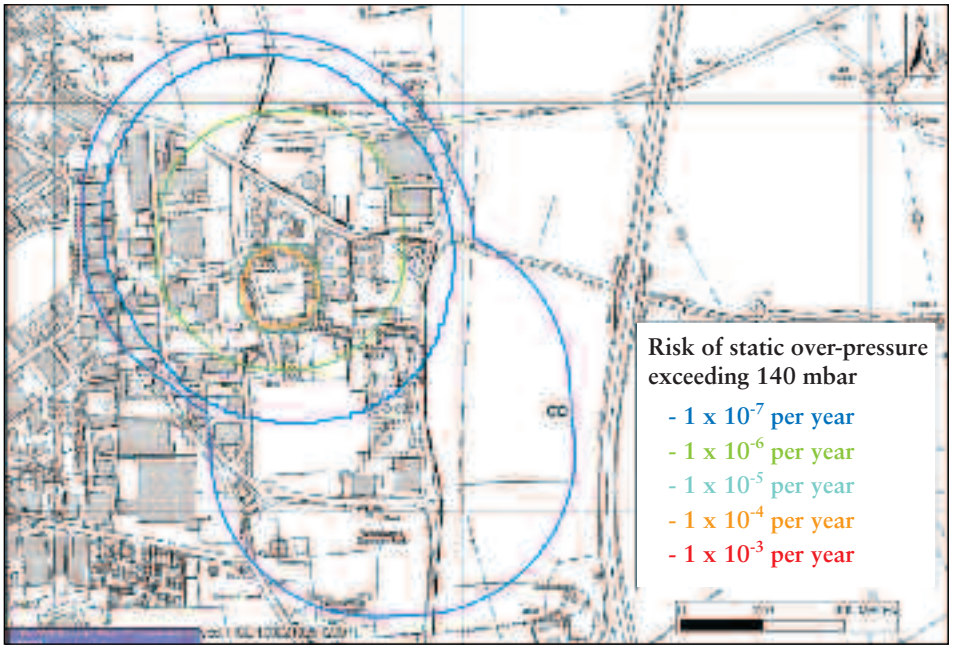

Figure 21 Frequency of over-pressure exceeding 140 mbar (HSE dangerous dose for a normal population)

21 These frequency plots could be used to delineate zones for land use planning purposes using the 1 in 100 000, 1 in a million and 1 in 10 million risk of dangerous dose or worse contours for a normal population. It can be seen that using the assumptions used in the calculations in this report this would lead to a smaller consultation distance. It might therefore be possible to utilise some of these frequency plots for land use planning purposes bearing in mind that these contours are for explosions only, but it would be advantageous and less confusing to use risk of death from all events rather than just the risk of over-pressure.

22 The contours in Figure 22 show risk of fatality gives rise to a 1 chance in 10 million per year of death that is comparable with the existing consultation distance. These are location specific risk contours. They are for people in typical brick buildings occupied for 365 days per year being affected by the process hazards on the site. They show the risks to people in the vicinity of the installation from the various hazardous events that might occur from loss of containment of the petrol. It is easier to compare the risks in these terms with other risks such as

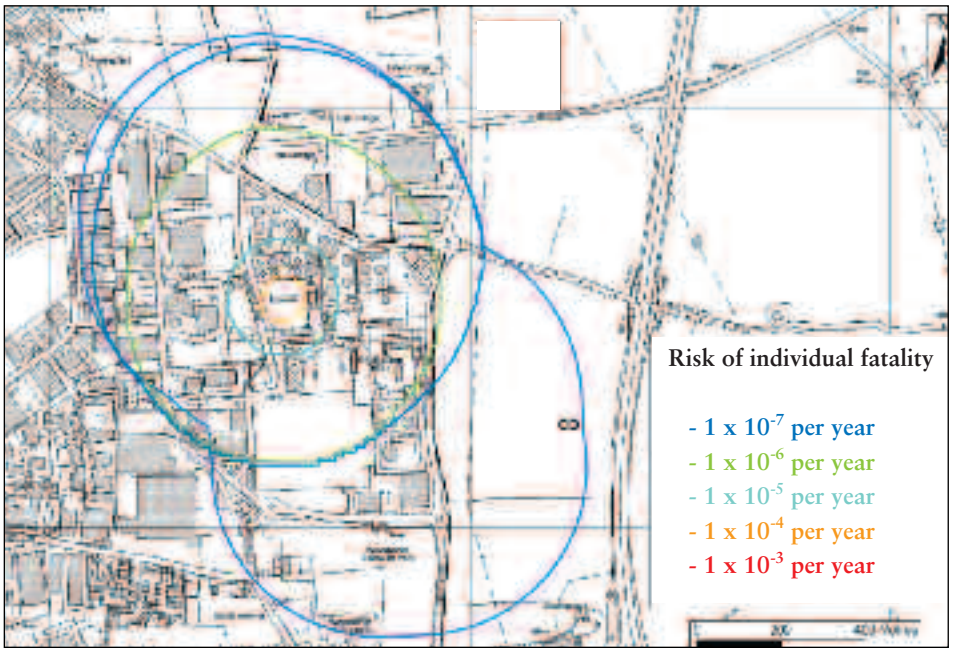

Figure 22 Individual risk of fatality

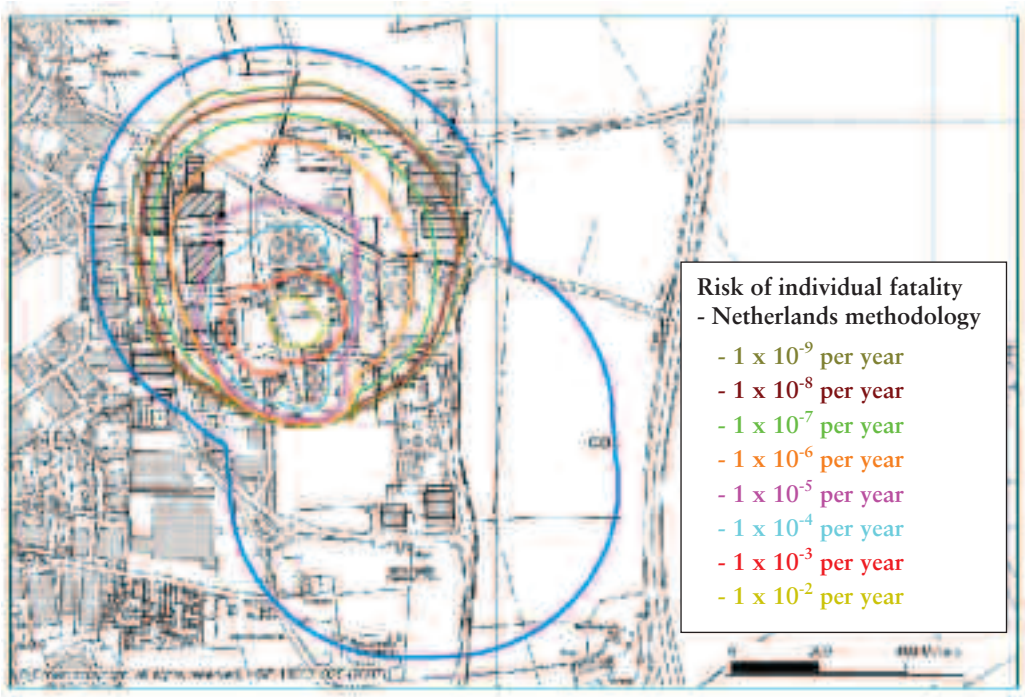

Figure 23 Individual risk of fatality (Netherlands methodology)

being struck by lightning since most other risks are similarly expressed as risks of death. They are also more readily comparable (with care) with HSE risk criteria as set down in R2P2.[ref 13] For example the tolerable risk to a member of the public from a work activity should be no worse than 1 in 10 000 per year (1×10^{-4}) represented by the orange contour.

23 In Figure 23 it can be seen that the risk contours generated using the Netherlands methodology are even smaller than those above and are well within the existing HSE defined consultation distance.

Societal risk (FN format)

24 FN curves are obtained by plotting the frequencies at which multiple fatality events might kill N or more people. The technique provides a useful means of comparing the impact profiles of man made accidents.

25 In Figure 24 the red line indicates the frequency of killing N or more people arising from overfilling events; the green line from tank failures, and the black line the societal risk from both events, adding the risks together. The plot is relatively flat showing a relative small change in frequency of event until you get to the really large accidents involving over 200 people. After this the frequency reduces rapidly until the limit of possible people killed is reached. The FN plot usefully shows that the overall societal risk can be broken down to show the various contributors to the overall FN risk curve. This can be used to target where you put your risk reduction measures.

Conclusions from the study

26 The QRA demonstrated that the risks associated with a large petroleum storage facility can be determined, despite the uncertainties and different assumptions representing different site conditions or different levels of safety give different risk predictions. The analyses show the effects of changing assumptions regarding:

- the frequency of overfilling a tank (which might be achieved by a more reliable overfill protection system);

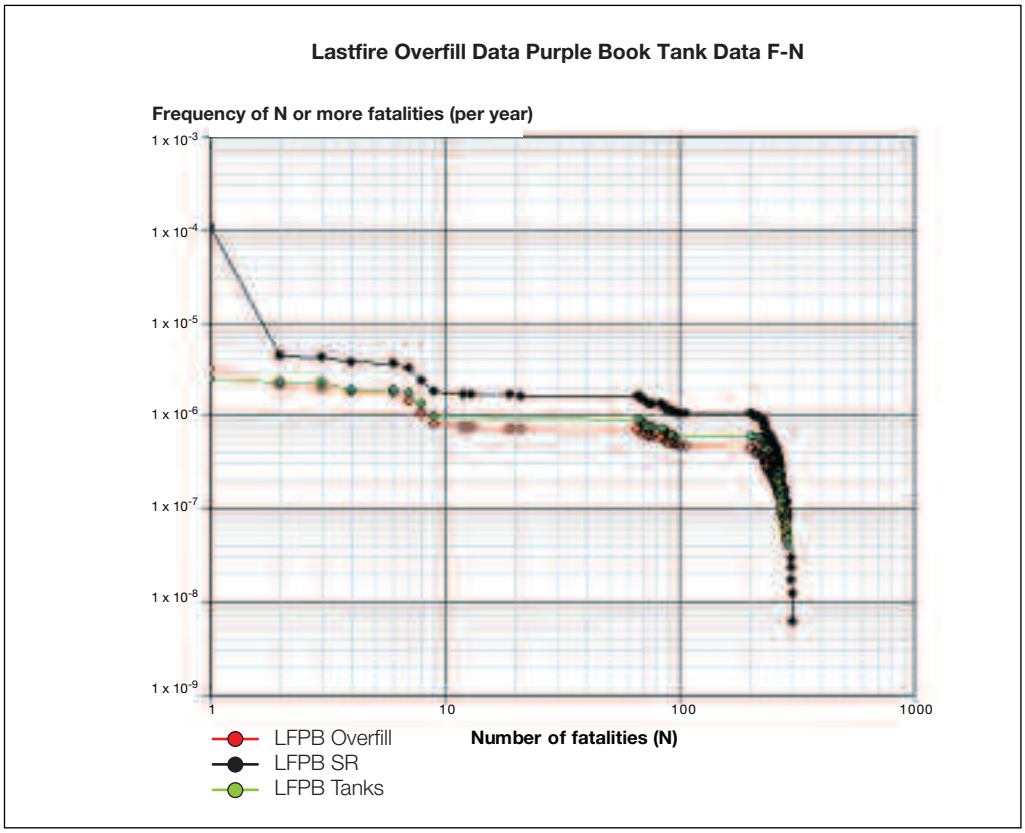

Figure 24 Societal risk arising from major hazards on the model site

- the reduction in the duration of the overfill (which might be achieved by gas detection and remotely or automatically operated valves); and
- the mitigation due to different building design as well as the effect of different base frequency data.

27 Other QRAs of this type of facility would likely follow the same approach, but, there is considerable scope for differences in the details in different QRA's, particularly the assumptions for frequencies and the analysis of consequences, and hence there would be differences in the numerical risk values predicted. Some of the more significant uncertainties in the analysis were:

28 The different properties of gasoline, including seasonal variations:

- the rate of formation of a vapour/aerosol cloud given a release of gasoline from piping or tank at different heights and with different potential mechanisms for the formation of both vapour and liquid droplets which remain airborne;
- the dispersion of the vapour/droplet cloud, particularly in low wind speed conditions;
- the size of the steady state cloud in different weather conditions;
- the magnitude of overpressure given ignition of the cloud both within and outside the cloud;
- the frequency of releases from piping and tanks;
- the probability and timing of ignition;
- the probability of an explosion given ignition for different weather conditions and sizes of cloud.

29 With further investigation the values used for some of the assumptions could become more robust (eg overfill frequency, tank failure frequency), but some will require considerably more time and analysis (eg likelihood of over-pressure generation) and for consequence information possibly even experiments (eg gasoline dispersion in low wind speed conditions, magnitude of an explosion and what conditions would/would not cause over-pressure). Work on the explosion mechanism that occurred at Buncefield has started, but detailed information for design purposes may take some time to produce. Data could be improved by the introduction of a formal system for collection, reporting and sharing of data across the onshore process sector. Such a system has been recommended by MIIB.[31] The system could be similar to the data sharing system developed for the offshore sector after the Piper Alpha accident. The COMAH Competent Authority could, either by regulation or agreement with the sector,[32] introduce a similar system for the onshore process sector, and if this was as successful as the offshore system, would produce a good quality database within a few years. If data already in the possession of companies (as provided to the Lastfire Group) were to be made available, this would put the frequency values on a far sounder footing and thereby improve the robustness of process QRAs.

30 The QRA estimates both the individual risk and societal risk of fatality that are needed for decision making. This type of analysis is currently used as a basis for onsite decisions (but with the inclusion of more scenarios) and its use could be extended to off-site land use planning decisions. Its use for such purposes would require some changes to be made to the current UK system. Possible changes are discussed below.

31 The current system of land use planning used in the UK derives essentially from a consultative document issued in 1989.(ref 9) HSE uses a combination of hazard (the protection concept) and the risk of a 'dangerous dose or more'[33] to define land use planning zones. In short the protection concept quantifies the consequences for a single scenario and determines the distance to a dangerous dose from that single scenario, whereas the risk-based approach quantifies both the consequences and the frequencies of a number of different scenarios and cumulates them. The use of dangerous dose is different from most QRAs (which use fatality), is different from the risk measure used in most other European countries for land use planning purposes, is different from the values assigned by HSE to the tolerability of risk framework and is different from data used to compare risk predictions with everyday risks. There would therefore be many advantages if the HSE changed to a land use planning system based on the risk of fatality.

32 Land use planning zone boundaries determined over the last few years would normally be based on the information in the hazardous substances consent (HS Consent). Although this information is specific in terms of the size of the largest vessel, it may not be specific in terms of the material (because of generic material classes). Consequently HSE bases its assessment on what could be stored

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31 See Recommendations 23, 24 and 25 in *Recommendations on the design and operation of fuel storage sites*.(ref 4)

32 Offshore hydrocarbon release reporting is voluntary, but universally supported by industry.

33 A dangerous dose of a toxic gas will give a range of effects because of different susceptibilities of different people, but will give all of the following – severe distress to almost everyone, with a substantial fraction requiring medical attention, serious injury with a requirement for prolonged treatment for some people and highly susceptible people might be killed.

under the terms of the HS Consent rather than what is actually stored on the site, so the risk at a zone boundary is based on a hypothetical risk. In determining the boundary HSE generally uses a material with properties at the most severe end of a class. There is very limited account taken in these assessments of measures that are in place at the site to mitigate the risks. The zone boundaries are therefore larger than if they took into account the actual material and the control and mitigation measures. Further, the current system does not lend itself to the cumulation of risks from different hazard types nor to the extension to societal risk.

33 The Netherlands and Belgium use both individual and societal risk (of fatality) as inputs and determinants for land use planning. The two approaches have some advantages and some disadvantages, such as:

- the methodology is set in the Netherlands so that two sites with the same design would pose the same individual risk. This may not be the case in Belgium;

- it is understood that the methodology in the Netherlands is fixed for a period of five years, and after this time changes can be made to update the methodology. This could impact on the location of the land use planning zones. In Belgium the methodology is more flexible and so changes to methodology and experience (such as the Buncefield incident) can take place more quickly. Again, however, these can impact on existing land use planning zones;

- the use of individual risk of fatality allows the effects of different types of hazards to be combined and also extended in a consistent way to societal risk.

34 As in the UK, the methodology for the analysis and the use of the risk predictions for land use planning are determined by the regulator. The actual analysis, however, is carried out by the operator of the site. A similar system if applied to the UK as control would still rest with the regulator, but the time and cost to carry out the analysis would fall on the occupier, and given that most occupiers of major hazard sites have carried out some QRA, the additional cost would be relatively small. Although QRAs were expensive when the methodology was being developed (some 30 years ago) since then there have been significant advances in the computer programs which aid the analysis, so that the cost of QRAs is now much less. Much of the cost of a QRA is associated with the time for the definition of input data and assumptions rather than the analysis itself and most sites will already have these input data.

35 As far as the cost of doing QRA is concerned, HSE has already invested considerable resources into the development of state of the art consequence models over the last 25 years and in 2004 there were approximately 80 models and over 20 methodologies in the HSE land use planning portfolio. HSE also has much data on most of the frequencies required for an analysis. Major companies have also developed QRA methods, using either commercially available or in-house developed consequence models, and either generic or company specific frequency data and use these for decision making. The development of a standard methodology, incorporating the experience that HSE has acquired in the determination of risk at major hazard installations, should therefore be reasonably straightforward. The methodology would, however, need to include sufficient detail so that all the information required by a planning authority to decide on the appropriateness of a new hazardous installation or development in the vicinity of an existing installation was made available. This would mean that the risk predictions would be based on the actual operations at an installation (eg as detailed in the COMAH safety report for top-tier sites) including the prevention measures, the extent and reliability of the control measures, and mitigation, eg through building design, and take account of emergency response. It would be expressed not only in terms of individual risk but also in terms of societal risk of fatality.

36 The issue of CD212 and feedback from the consultation indicated the level of interest in societal risk and the difference in both knowledge and expectations of stakeholders compared with that prevalent at the time the land use planning risk criteria document[ref 9] was issued in 1989. The feedback indicated:

- there was considerable support for using societal risk to aid decisions regarding both on site control measures and land use planning;

- it was considered important that the assessment of the site operations and the land use planning process could give acceptable levels of safety to people in the vicinity.

37 For most QRAs where the individual risk of fatality is determined, the extension to societal risk requires relatively minor effort. Methodologies typically in current use are straightforward to implement and transparent. Given the availability of aerial photographs and the existing knowledge about the external population (by the number of people who could be affected by the activities at a site and the distribution of information to those within a specified distance of an installation), the data required should be readily available and be sufficiently detailed to be a suitable input for long-term land use planning decisions and individual applications. The extension from individual risk to societal risk would therefore have benefits for improving site safety as well as providing more information for land use planning. Decisions about the safety of people in on-site buildings do not necessarily need to be based on a QRA, but the extent, severity and likelihood of harm do need to be considered and this would be, in most cases, be quantitative (as there is a numerical criterion for new buildings, an ALARP demonstration is required for existing buildings and HSE guidance contains a quantified methodology). Hence the use of risk for decisions for off-site development will bring land use planning in line with onsite decisions for safety of people in buildings.

38 The overall societal risk from a single installation can be broken down to show the main contributors both in terms of the source of risk and the receptor of risk. The PLL ('potential loss of life' – a single number that represents societal risk) can indicate the percentage reduction in risk that can be achieved, and, with a cost of life input, it can be determined whether risk reduction either at source or by mitigation is likely to be reasonably practicable. Societal risks can also be added, so the overall societal risk from all the major hazards within a local authority area could be determined for the LPA who would be able to see the effect on the societal risk over a period of time due to changes in both the hazardous installation and the population in the vicinity of the installation (for this to be effective the analysis would need to be 'live' and societal risk calculations would need regular updates in line with changes on the major hazard installation and in the population in the vicinity, probably as part of COMAH updates). This would enable better long-term spatial planning than is possible on currently available information.

39 A move in Britain to an approach that was totally based on risk (individual and societal risk of fatality) would retain some of the advantages inherent to the current system for land use planning around major hazard sites. It would at the same time remove many of the undesirable features of the current system discussed above, enable land use planning around major hazard sites to be more soundly and consistently based, and would be a close representation of the risks from an installation. In the development of such a system the main challenges would be technical with a consensus needed on the appropriate methodology, and in the management of the changes to some land use planning zones as well as the costs. It could not be expected that the predicted risk levels at an installation in Britain

would correspond with the predicted risk levels at the same facility in a different EU country (even though they may be the same), which would be the ideal situation, but a change to a common and defined system based on risk of fatality would mean that the risk measures are consistent. Further, it would enable a consistent methodology to be used for both on-site and off-site decisions, and could be devised to incorporate the best features of the current systems that have been developed for use in other EU countries (eg the Netherlands and Belgium) or by major companies and so would be a robust basis for decision making. A move to an approach based on the risk of fatality would also bring UK land use planning in line with advice on airports, the advice in R2P2 and remove much of the current confusion and inconsistencies.

References

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Glossary

ALARP acronym for the legal term 'as low as is reasonably practicable'. It requires the weighing up of the level of risk against the costs in the widest sense of averting that risk. Only where the dutyholder can show that the costs of averting the risk are grossly disproportionate to the benefits from further reducing the risk can it be said that the risk has been reduced ALARP.

COMAH the Control of Major Accident Hazards Regulations 1999 Regulations (COMAH).

COMAH sites sites to which the COMAH Regulations apply.

Competent Authority the COMAH Regulations are enforced by a joint Competent Authority comprising HSE and the Environment Agency in England and Wales, and HSE and the Scottish Environment Protection Agency (SEPA) in Scotland. The Competent Authority operates to a Memorandum of Understanding which sets out arrangements for joint working.

consultation distance the distance round major hazard sites set by HSE within which local planning authorities are required to consult HSE on all new planning applications.

containment barriers which, in the event of a spill, can prevent spilled materials from reaching the environment.

Control of Major Accident Hazards Regulations 1999 the main aim of these Regulations is to prevent and mitigate the effects of those major accidents involving dangerous substances, such as chlorine, liquefied petroleum gas, and explosives which can cause serious damage/harm to people and/or the environment. The Regulations treat risks to the environment as seriously as those to people. They apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. See also Seveso II.

dangerous dose a dose large enough to lead to: severe distress to all; a substantial number requiring medical attention; some requiring hospital treatment; and some (about 1%) fatalities.

dutyholder in the context of this report, any person or organisation holding a legal duty – in particular those placed by the Health and Safety at Work etc Act 1974, the Management of Health and Safety at Work Regulations 1999, and the COMAH Regulations 1999.

Environment Agency the Environment Agency is the lead regulator in England and Wales with responsibility for protecting and enhancing the environment. It was set up by the Environment Act 1995 and is a non-departmental public body, largely sponsored by the Department for Environment, Food and Rural Affairs and the National Assembly for Wales.

hazard anything with the potential to cause harm.

Health and Safety Commission the Health and Safety Commission was a statutory body, established under the Health and Safety at Work etc Act 1974, responsible for health and safety regulation in Great Britain. It merged with the Health and Safety Executive on 1 April 2008. The roles and functions of the Commission have now transferred the 'new' HSE.

Health and Safety Executive the Health and Safety Executive was a statutory body, established under the Health and Safety at Work etc Act 1974, and an enforcing authority working in support of the HSC. It has now merged with the Health and Safety Commission, taking over its roles and functions. Local authorities are also enforcing authorities under the Health and Safety at Work etc Act 1974.

HSC see Health and Safety Commission.

HSE see Health and Safety Executive.

Northgate a business located alongside the north-western perimeter of Buncefield whose premises was affected by the Buncefield incident.

on-site and off-site emergency plans operators of top-tier COMAH sites must prepare adequate emergency plans to deal with the on-site consequences of possible major accidents and to assist with off-site mitigation. Local authorities for areas containing top-tier COMAH sites must prepare adequate emergency plans to deal with the off-site consequences of possible major accidents, based on information supplied by site operators

over-pressure for a pressure pulse (or blast wave), the pressure developed above atmospheric pressure is called the over-pressure.

Planning Advice for Developments near Hazardous Installations (PADHI) software tool developed by HSE which in the vast majority of cases allows local planning authorities to obtain HSE's advice on an intended development within the consultation distance of a major hazard site.

pool fire a fire over a pool of fuel and/or water or other liquids.

primary containment the tanks, pipes and vessels that normally hold liquids, and the devices fitted to them to allow them to be safely operated.

quantified risk analysis/assessment (QRA) a systematic analytical technique for quantifying the risks associated with hazardous installations, based on assessing a range of foreseeable failure scenarios. The risk to an individual at a specific location is the summation of the risks arising from the different scenarios.

Regional Resilience Forum The Regional Resilience Forums are established by each Government Office to discuss civil protection issues from the regional perspective and to create a stronger link between local and central government on resilience issues. Similar arrangements are made in the devolved administrations.

responder under the Civil Contingencies Act 2004, the Environment Agency is a Category 1 responder, and HSE is a Category 2 responder. These categories define the roles played by each body in response to a major incident.

risk the likelihood that a hazard will cause a specified harm to someone or something.

safety integrity level (SIL) a safety integrity level (SIL) is a measure of safety system performance, in terms of the probability of failure on demand. There are four discreet integrity levels, SIL 1–4. The higher the SIL level, the higher the associated safety level and the lower the probability that a system will fail to perform properly.

safety reports the COMAH Regulations require operators of top-tier sites to submit written safety reports to the Competent Authority.

secondary containment Enclosed areas around storage vessels (often called bunds), created usually by concrete or earth walls. Their purpose is to hold any escaping liquids and any water or chemicals used in firefighting.

Seveso II In 1976, a major accident occurred in Seveso, Italy, where the accidental production and release of a dioxin as an unwanted by-product from a runaway chemical reaction led to widespread contamination. A number of such incidents, and the recognition of the differing standards of controls over industrial activities within the European Community, led the European Commission to propose a Directive on the control of major industrial accident hazards. The Directive on the Major Accident Hazards of Certain Industrial Activities (82/501/EEC) was adopted on 24 June 1982, and is generally known as the Seveso Directive. Following a complete review of the Directive by the European Commission a new one, now known as Seveso II, came into force on 3 February 1997 and was implemented in Great Britain on 1 April 1999 by the Control of Major Accident Hazards Regulations 1999, except for land use planning requirements, which were implemented by changes to planning legislation.

tertiary containment the site surface and associated drainage, boundary walls, roads, containment kerbs and any features such as road humps that can provide some retention of liquids. Proper design of drainage systems will limit loss of product out of the site and prevent lost product permeating into the ground with the potential risk that it can migrate to groundwater, or contaminate surface waters and land.

tier the COMAH Regulations apply where threshold quantities of dangerous substances identified in the Regulations are kept or used. There are two thresholds, known as 'lower-tier' and 'top tier'. Annex 1 gives a brief background to the origins of these Regulations.

top-tier see tier.

Further information

Useful links

Buncefield Major Incident Investigation
Marlowe Room, Rose Court 2 Southwark Bridge London, SE1 9HS
Tel: 020 7717 6909
Fax: 020 7717 6082
E¬-mail: buncefield.inforequest@hse.gsi.gov.uk
Web: www.buncefieldinvestigation.gov.uk

Community/business support

Dacorum Business Contact Centre
Tel: 01442 867 805
Business Link Helpline Tel: 01727 813 813

Hertfordshire Chamber of Commerce
Tel: 01727 813 680

Dacorum Borough Council
Tel: 01442 228 000
Web: www.dacorum.gov.uk

Dacorum Community Trust
Tel: 01442 231396
Web: www.dctrust.org.uk

Hemel Hempstead Citizens Advice Bureau
19 Hillfield Road, Hemel Hempstead HP2 4AA
Tel: 01442 213368

Local authorities and emergency services

Dacorum Borough Council
Tel: 01442 228 000
Web: www.dacorum.gov.uk

Dacorum Community Trust
Tel: 01442 231 396
Web: www.dctrust.org.uk

St Albans District Council
Tel: 01727 866 100
Web: www.stalbans.gov.uk

Hertfordshire County Council
Tel: 01483 737 555
Web: www.hertsdirect.org

Hertfordshire Fire and Rescue Service
Web: www.hertsdirect.org/yrccouncil/hcc/fire/buncefield

Hertfordshire Constabulary
Web: www.herts.police.uk/news/buncefield/main.htm

Hertfordshire Chamber of Commerce
Tel: 01727 813 680
Web: www.hertschamber.com

Government links

Cabinet Office
Web: www.cabinetoffice.gov.uk

Communities and Local Government
Fire and Resilience Directorate
Web: www.communities.gov.uk

Government Office for the East of England
Web: www.goeast.gov.uk

Environment Agency
Web: www.environment-agency.gov.uk

Department for Business, Enterprise and Regulatory Reform
Oil and Gas Directorate
Web: www.og.berr.gov.uk

Health and Safety Executive
Hazardous Installations Directorate
Web: www.hse.gov.uk/hid

Control of Major Accident Hazards
Web: www.hse.gov.uk/comah

Department for the Environment, Food and Rural Affairs
Web: www.defra.gov.uk

Health Protection Agency
Web: www.hpa.org.uk

Food Standards Agency
Web: www.food.gov.uk

Drinking Water Inspectorate
Web: www.dwi.gov.uk

Scottish Environment Protection Agency
Web: www.sepa.org.uk

UK Resilience
Web: www.ukresilience.info

Scottish Executive Justice Department – Civil Emergencies
Web: www.scotland.gov.uk/Topics/Justice/emergencies/guidance

Wales – Local Resilience
Web: http://new.wales.gov.uk/resilience/regional-local-resilience1/?lang=en

Northern Ireland Central Emergency Planning Unit
Web: http://cepu.nics.gov.uk

Process Safety Leadership Group (replaced the **Buncefield Standards Task Group**)
Contact: colette.fitzpatrick@hse.gsi.gov.uk

National Recovery Working Group
Contact: Rhiannon.harries@communities.gsi.gov.uk

Industry links

United Kingdom Petroleum Industry Association (UKPIA)
Tel: 020 7240 0289
Web: www.ukpia.com

Chemical Industries Association
Tel: 020 7834 3399
Web: www.cia.org.uk

Three Valleys Water
Tel: 0845 782 3333
Web: www.3valleys.co.uk

United Kingdom Onshore Pipeline Operators' Association (UKOPA) Tel: 01773 852003
Web: www.ukopa.co.uk

Tank Storage Association
Tel: 01244 335627
Web: www.tankstorage.org.uk

Investigation reports

Buncefield Major Incident Investigation:

- Progress Report published 21 February 2006
- Second Progress Report published 11 April 2006
- Third Progress Report published 9 May 2006
- Initial Report, published 13 July 2006
- Recommendations on the design and operation of fuel storage sites published 29 March 2007
- Recommendations on the emergency preparedness for, response to and recovery from incidents published 17 July 2007
- Explosion Mechanism Advisory Group report published 16 August 2007

Available from www.buncefieldinvestigation.gov.uk

DEFRA: Initial review of Air Quality aspects of the Buncefield Oil Depot Explosion
Main report: http://www.defra.gov.uk/environment/airquality/publications/buncefield/buncefield-report.pdf
Appendices: http://www.defra.gov.uk/environment/airquality/publications/buncefield/buncefield-append.pdf

Buncefield: Hertfordshire Fire and Rescue Service's review of the fire response Hertfordshire Fire and Rescue Service, November 2006 ISBN 978 0 11 703716 8

Angus Fire, Buncefield Oil Terminal Incident December 2005: Review of part played by Angus Fire and lessons learned
www.angusfire.co.uk

Other related reports/information

East of England Development Agency – report by SQW, Economic Developments Consultants on: *The Buncefield Oil Depot Incident: Economic and Business Confidence Impact Study*, June 2006
www.eeda.org.uk

Swiss Fire Service: *Quick Look Report – Buncefield Fire 11 December 2005*

Buncefield social impact report Dacorum Borough Council, January 2007
www.dacorum.gov.uk/default.aspx?page=4191

Contract research reports for HSE

WS Atkins Science and Technology: *Derivation of fatality probability functions for occupants of buildings subject to blast loads Phases 1, 2, & 3 147/1997 and Phase 4 151/1997*

Biomedical Sciences Chemical and Biological Defence Sector Defence Evaluation and Research Agency: *Review of blast injury data and models 192/1998*

Available from: www.hsebooks.com

Government Advisory Bodies

Committee on mutagenicity of chemicals in food, consumer products and the environment (COM)

Committee on carcinogenicity of chemicals in food, consumer products and the environment (COC)

Committee on toxicity of chemicals in food, consumer products and the environment (COT)

www.advisorybodies.doh.gov.uk/coc/

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