Communities and Local Government

Guide to risk assessment tools, techniques and data

Fire Research Series 5/2009

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Fire Research Series 5/2009

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The views expressed in this document are those of the authors and its contractors and not necessarily represent those of the Communities and Local Government.

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TABLE OF ACRONYMS

BERR	The Department for Business Enterprise and Regulatory Reform
BGS	British Geological Survey
CCA	Civil Aviation Authority
CCS	Civil Contingencies Secretariat
CLG	Department for Communities and Local Government
CNI	Critical National Infrastructure
COMAH	Control of Major Accident Hazards
DEFRA	Department for Environment Food and Rural Affairs
DfT	Department for Transport
DOH	Department of Health
EPC	Emergency Planning College
ERA	Extreme Rainfall Alert
ESPON	European Spatial Planning Observation Network
FRS	Fire and Rescue Service
FSA	Formal Safety Assessment
FSEC	Fire Service Emergency Cover
GB	Great Britain
GIS	Geographic Information Systems
HPA	Health Protection Agency
IPCC	Intergovernmental Panel on Climate Change
IRMP	Integrated Risk Management Plan
LRAG	Local Risk Assessment Guide

LRF	Local Resilience Forum
MAHB	Major Accident Hazards Bureau
MAIB	Marine Accident Investigation Board
MARS	European Union Major Accident Reporting System
MCA	Maritime and Coastguard Agency
MEHRA	Marine Environmental High Risk Areas
NaFRA	National Flood Risk Assessment
Ofwat	Office of Water Services
OPRA	Environment Agency's Operational Risk Appraisal
PHRTAs	Potentially High Risk Train Accidents
QRA	Quantitative Risk Analysis
RSSB	Rail Safety and Standards Board
RTCs	Road Traffic Collisions
SEPA	Scottish Environment Protection Agency
SFRA	Strategic Flood Risk Assessment
SMIS	Safety Management Information System
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
SPZ	Source Protection Zones
SRM	Safety Risk Model
UK	United Kingdom
WHO	World Health Organisation

1 Introduction

1.1 Background

The Civil Contingencies Act 2004 was introduced to provide a framework for civil protection in the UK. The Act divides local responders into two categories: in Category 1 are those organisations at the core of the response to most emergencies (eg emergency services, local authorities, NHS bodies) and in Category 2 are 'co-operating bodies' such as the Health and Safety Executive (HSE), transport and utility companies. Category 1 responders 'assess the risk of emergencies occurring and use this to inform contingency planning'. Local Resilience Forums (LRFs) were created to bring together all the Category 1 and 2 organisations that have a duty to co-operate under the Civil Contingencies Act. LRFs risk assessments are led by the Category 1 responders with input and support from Category 2 responders.

Integrated Risk Management Plans (IRMPs) were introduced in 2004-05 for every Fire and Rescue Service (FRS) as part of the FRS modernisation process. All FRSs produce an IRMP. The IRMPs are local to the area served by each FRS. IRMPs reflect local needs and set out plans to tackle effectively both existing and potential risks to communities, in partnership with neighbouring authorities and other agencies. Communities and Local Government (CLG) has provided extensive guidance on data needs for IRMPs[1], assessment processes and approaches. At the same time the Fire Service Emergency Cover (FSEC) Toolkit has been provided to enable integrated risk assessment.

The UK Resilience website, developed by the Cabinet Office's Civil Contingencies Secretariat (CCS), provides a standard approach to Local Responder risk assessment, as carried out by Category 1 responders within LRFs. The Local Risk Assessment Guide (LRAG[2], 2006), as developed by the CCS, provides guidance to LRFs on likelihoods and impacts of national and regional scale emergencies, and of some localised events.

The LRFs and IRMPs are both focused on integrated emergency management, which require effective risk analysis.

This document provides concise information on risk assessment tools, techniques and data for use by FRSs and LRFs. It is intended to compliment the support provided in LRAG and previous Communities and Local Government support to FRSs in respect of IRMPs.

[1] www.communities.gov.uk/fire/developingfuture/integratedriskmanagement/
[2] As a restricted document the LRAG is not publicly available.

1.2 Aims

This guide aims to support the conduct of risk assessments by LRFs in the context of civil contingency planning and by FRS in the context of IRMP. It provides:

- an overview of the form of risk assessment that is possible for each risk category
- identifies specific tools, techniques and data where they exist and summarises these
- notes the limitations of current tools, techniques and data
- provides references and sources for use by LRFs and FRSs.

This guide focuses on strategic risk assessment, particularly the frequency of major events and their severity, rather than real time or dynamic risk assessment.

This guide focuses on those tools, techniques and data that are thought to be of potential value to LRFs and FRSs. As such, it does not provide a comprehensive listing or review of all risk assessment techniques. It is limited to those judged to be of relevance to LRFs and IRMPs.

This guide can be used in conjunction with the LRAG. The LRAG guide focuses on events that may require a regional or centrally planned response. This guide aims to support the assessment of 'localised' major incidents by LRFs. These are major events that can be handled by the resources of emergency services within that LRF area, typically a number of local authorities. With regard to IRMPs, this guide, whilst addressing risk assessment of 'normal' fire and rescue risks, particularly aims to address major incident risks attended by FRSs.

1.3 Scope

This guide is limited to the use of risk assessment in the context of LRFs and FRS IRMPs. It covers all of the risk categories listed in Cabinet Office guidance[3] and the main risks covered within IRMPs. The focus is on tools and data that support civil contingency risk assessment and related planning, particularly:

- assessment of the likelihood and consequence of incidents
- profiling the scale and nature of incidents – for the sake of developing contingency plans
- the interaction of incidents and knock-on effects.

[3] www.cabinetoffice.gov.uk/media/131921/ep_ann_04b.pdf

The guide does not aim to replace or duplicate the guidelines in LRAG for reviewing regional and national scale events. It instead aims to support assessment by LRF of 'localised' major incidents in particular, and so should be used in conjunction with any guidance from the CCS, particularly where this relates to national and regional scale events.

It does not explore or consider the use of tools, techniques and data in the context of:

- regulatory decision making, safety cases or licensing processes
- land use planning
- environmental, health and safety risk assessments within businesses
- corporate risk assessment
- insurance risk assessment.

In some cases we have identified tools, techniques and data that have been developed to support these latter processes. In these cases we have identified how they could be drawn on to support LRFs and IRMPs, whilst also highlighting the limitations of these tools and data in the context of LRF and IRMP related risk assessment. These limitations are cited in the context of applying these tools outside of their original area of application and should not in any way be interpreted as implying anything about the application of these tools and data in their original settings.

1.4 Structure of the guide

The guide has main sections for each risk category, and one section for modelling domino effects. These risk categories would cover all of those in the LRAG and others addressed by FRS in IRMPs, particularly road traffic collisions (RTCs), dwelling and other building fires and outdoor fires.

The guide is structured by risk categories. The main risk categories match those in the LRAG (2006). Sub-sections deal with each sub-category of risk, such as aviation and railways. Each sub-section provides:

- an overview of the form of risk assessment possible
- suggested tools and techniques
- suggested data sources.

The sections are presented in an approximate order of those risks that can be assessed quantitatively presented first, then presenting those risk categories that are less amenable to quantitative risk assessment.

In some cases, national risk assessments are cited for use at a local level. Where the national risk assessment does not express a likelihood in the same terms as the LRAG used by LRFs, we have aligned the results to the LRAG criteria.

The LRAG likelihood criteria are given below.

Table 1: Civil contingencies likelihood scale

CCA Term	Proposed term	CCA Probabilistic definition
1: Negligible	Very Low	<0.005 per cent per year >1 in 20,000 chance in 5 years >1 in 100,000 per year
2: Rare	Low	>0.05 per cent to 0.5 per cent per year 1 in 2,000 to 1 in 200 chance per 5 years 1 in 10,000 to 1 in 1,000 per year
3: Unlikely	Medium	>0.5 per cent to 50 per cent per year 1 in 200 to 1 in 20 chance per 5 years 1 in 1,000 to 1 in 100 per year
4: Possible	High	5 per cent to 50 per cent per year 1 in 20 to 1 in 2 per 5 years 1 in 100 to 1 in 10 per year
5: Probable	Very High	>50 per cent per year > 1 in 2 chance over 5 years > 1 in 10 per year

The guidance on scaling Impact is less prescriptive. The scale is stated below with the Health descriptors given. It should be noted that, in the context of civil contingencies that a moderate number of fatalities is graded as a Moderate Impact, which is commonly graded as a High Impact in occupational health and safety risk assessment.

Table 2: Civil contingencies impact scale

Impact	Descriptor for health
Insignificant	Insignificant number of injuries or impact on health
Minor	Small number of people affected, no fatalities, and small number of minor injuries with first aid treatment
Moderate	Moderate number of fatalities with some casualties requiring hospitalisation and medical treatment and activation of MAJAX, the automated intelligent alert notification system, procedures in one or more hospitals
Significant	Significant number of people in affected area impacted with multiple fatalities, multiple serious or extensive injuries, significant hospitalisation and activation of MAJAX procedures across a number of hospitals
Catastrophic	Very large numbers of people in affected area(s) impacted with significant numbers of fatalities, large number of people requiring hospitalisation with serious injuries with longer-term effects

2 Transport

2.1 Overview

This section of the guide covers the four main forms of transport-related civil contingencies, namely:

- aviation
- railways
- major vehicle accidents, and
- maritime.

This section also provides guidance on the assessment of 'standard' road traffic collision, particular for the sake of emergency service response planning.

In all cases the identification of transport risks can be achieved by scrutiny of local infrastructure and operations, ie does the pertinent type of infrastructure or operation occur in the area? In particular:

- is there an airport, harbour, navigable waterway, motorway or A road, shipping route or flight path in the area?

In the case of aviation, shipping and railways, the frequency of these categories of incidents and the application of risk assessment provides a basis for probabilistic risk assessment. Major vehicle incidents, whilst relatively frequent, are not systematically recorded or been subject to risk assessment. Therefore, there is less data on which to base the assessment of major vehicle accidents.

'Standard' road traffic accidents are relatively frequent. The use of local data provides a basis for risk assessment of 'standard' traffic accidents.

The data and methods are elaborated as follows.

2.2 Aviation

2.2.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

Whilst there have been few major aviation incidents in the UK, or any other single country, the high frequency of aircraft movements and reporting of accidents provides a reasonably robust basis for providing incident rates. A number of authoritative studies have been completed that provide measures of the rate of accidents per aircraft movement. These can and are used to give an indication of the likelihood of aircraft incidents, particularly at or around airports. They also enable the likelihood of incidents along flight paths and elsewhere to be assessed. These methods have been used to produce both complex and simple tools for use in risk assessment.

There is no known source of information or analysis tools that directly and specifically supports assessing the scale (in terms suitable for contingency planning) and nature of aircraft incidents. The consequence of incidents can, generically, be considered qualitatively by reference to past incidents, with judgements about specific scenarios expressed quantitatively. Tools have been developed to assess the magnitude of incidents in any one location, but these tools tend to require specialist expertise and software. Their results could be drawn on for the sake of contingency planning though, such as by defining the physical size of incidents and area affected for example.

Accordingly, aviation risk is amenable to quantitative risk assessment with a reasonable level of certainty.

It is recommended that the frequency of incidents is not based on local incident, such as the historical rate of incidents at an airport. The local rate of major incidents renders such local data an unreliable guide to the likelihood of major incidents.

REQUIREMENT FOR SPECIALIST EXPERTISE

Whilst the specialist risk assessment methods require particular expertise, the simplified inputs and outputs of these methods can be drawn on by non-experts.

AUTHORS' GUIDANCE

The authors of this guide suggest, for the sake of LRFs and IRMPs, that:

- The generic incident rates provided by the 1987 and 1997 HSE studies are used in combination with Civil Aviation Authority (CAA) data on aircraft movement to give an indication of likelihood of crashes in the vicinity of airports
- The US data on the location of crashes relative to the runway is used as an indication of likelihood of striking runway versus surrounding structures/areas

- The RAND table of impact areas is used in combination with CAA data on the predominant type of aircraft at an airport to gauge the size of the impact area and the possible scale of the incident
- The DfT Public Safety Zone maps can be used to get an indication of the likely crash area.

The more advanced mathematical models require advanced skills and produce, in the opinion of the authors of this guide, more specific and complex results than needed by LRFs and IRMPs.

As the rate of incidents is very low, it is advised that any local incident data is unlikely to provide a valid measure of risk.

2.2.2 Tools and techniques

AIRPORT VICINITY CRASH LIKELIHOOD
The HSE and other organisations have produced estimates of the rate of aircraft crashes per aircraft movement at airports. These can be used in combination with CAA data on the number of aircraft movements at airports to produce predicted incident rates per airport. The CAA data includes the number of aircraft movements (landings and take offs) per airport.

The studies are:

- Criteria for the rapid assessment of aircraft crash rate onto major hazards installations according to their location. D.W. Phillips, SRD/HSE/R435, HMSO 1987 (no longer published)
- *External risk around airports: A model update,* A.J. Pikaar, M.A. Piers and B. Ale, NLR Technical Publication, NLR-TP-2000-400, August 2000
- *R&D Report 0007 A Methodology for Calculating Individual Risk due to Aircraft Accidents near Airports,* National Air Traffic Services, 2000
- Cowell P et al: *A Crash Model for Use in the Vicinity of Airports: NATS R and D Report 007:* 2000
- *The calculation of aircraft crash risk in the UK.* HSE contract research report 150/1997
  www.hse.gov.uk/research/crr_pdf/1997/crr97150.pdf
- *A method for estimating the risk posed to UK sites by civil aircraft accidents* Chief Scientist's Division Report 9345, CAA, October 1993. Slater, K.;
- *RAND, Airport Growth & Safety, A study of the External Risks of Schiphol Airport and possible Safety-Enhancement Measures,* 1993.
  www.rand.org/pubs/monograph_reports/2006/MR288.pdf

These studies provide incident rates in the vicinity of airports and methods for estimating the probability of a crash at any one location in or around an airport. The former values can be applied in a simple manner by combining them with CAA aircraft movement data to give an airport incident rate. The latter methods require the use of a mathematical formula which demands advanced mathematical skills and models.

The studies quote a range of rates. For example:

- The 1987 HSE funded study (Philips, 1987) gave a rate of crash in or near an airport of 2.4×10^{-7} per movement (this is 0.00000024 per airplane movement)
- The 1997 HSE study quotes a rate of 3.3×10^{-7} per movement (this is 0.00000033 per airplane movement); derived by Slater (1993[4]) and 5.9×10^{-7} (this is 0.00000059 per airplane movement); for large transport derived by Bryne and Jackson 1992.

The 1987 HSE study split the incidents into on and off airport incidents. The off airport rate was 1×10^{-7} per movement, with an on airport rate of 1.4×10^{-7} per movement.

A movement is a take off or a landing of an aircraft.

As noted above these incident rates per movement can be multiplied by the number of aircraft movements per airport to give a rate of incident per year per airport. For example, the CAA airport statistics indicate 242,629 air transport movements for Gatwick airport for 2004. Thus the incident rates would be:

$2.4 \times 10^{-7} \times 242{,}629 = 5.8 \times 10^{-2}$ per year (one in every 17 years).

[4] A method for estimating the risk posed to UK sites by civil aircraft accidents. Chief Scientist's Division Report 9345, CAA, October 1993. Slater, K.

A Dutch study (Pikaar et al 2000) indicated that 3rd generation aircraft have a crash rate half that of the generic rate quoted here, whilst 1st generation aircraft have a ten times higher rate. Accordingly the risk of crashes at any one airport will depend on the mixture of aircraft and airport risk controls and features such as hills and navigational aids. The simple application of the latter generic incident rates would be only an approximation.

CONSEQUENCE OF AIRPORT VICINITY CRASHES

The consequence of crashes depends on:

- location of crash (nature of structure/area struck)
- size and weight of the aircraft
- level of fuel on board
- angle and speed of descent.

A simple method or tool for assessing these factors was not identified. The 1997 HSE study provides formula for calculating the strike area. These require advanced mathematical skills.

The RAND study (www.rand.org/pubs/monograph_reports/2006/MR288.pdf) provides a simple table of (p181) of impact areas of large and small aircraft and of different angles of descent. These could be used as an indication of the size of the area of impact, such as 0.020 square miles for large aircraft on a steep takeoff.

Some studies have examined the location of aircraft crashes in the vicinity of airports, as an input to considering their consequences. An Australian study[5] cites US work (Ashford, N., and Wright, P.H., Airport Engineering, 3rd edition, 1992. New York: Wiley. pp 268 and 269), which indicates, that the majority (75 to 80 per cent) of incidents occurred on or close to runways (typically within 250 m of either side of the runway and 1,000m of either end of the runway). This can be used as a first approximation of the possible spread of crash locations, and therefore their possible consequences. For example, would the crash involve only the plane or impact onto commercial or residential buildings?

The CAA aircraft movement data is sub-divided by type of aircraft. To some extent, this allows the magnitude of events to be considered. For example:

- Airports that are predominantly private aircraft, tend to have smaller aircraft and therefore relatively smaller scale incidents
- Airports with commercial airliners tend to have larger aircraft and therefore relatively larger scale incidents.

[5] www.newparallelrunway.com.au/files/pdf/D8.pdf

CAA INDIVIDUAL RISK (PUBLIC SAFETY ZONES) MAPS

The CAA has produced Individual Risk (of death) maps for approximately 20 of the UK major airports, termed Public Safety Zones[6]. These have been developed to support land use planning decisions around airports, rather than for contingency planning. They indicate the area where the risk of death of any one person is up to 1 in 10,000 per year. It should be noted that Individual Risk is a very different measure to the frequency of incidents. An airport could have a frequency of major incidents of (for example) 1 in 50 years but the likelihood of death in any one location (such as a house next to the airport) could be (for example) 1 in 500,000 per year. This is because the measure of individual risk includes the likelihood of the aircraft striking that particular house and the resident being in at the time of the incident. The Civil Contingencies Act risk assessment guidance and IRMPs require the use of incident frequencies rather than measures of Individual Risk.

The maps show the area around an airport where the Individual Risk of death from an aircraft accident is 1 in 10,000 per person per year. These maps do not directly indicate the magnitude of potential incidents, for example they do not indicate how many people may be injured in any one incident. However, they do show whether residential and neighbouring industrial areas are at risk of being struck and so whether 'third parties' should be included in the review of consequences.

It should be noted that the risk of death of 1 in 10,000 is calculated very differently to the likelihood of an incident occurring *somewhere* on or around an airport. An airport may have a crash likelihood of 1 in 17 years but the likelihood of striking a specific location such as a specific street could be 1 in 10,000. Thus, the incident likelihood for an airport should be calculated as a frequency for the airport and its environs as a whole, such as 1 in 17 years, and the Individual Risk contours should only be used (in the context of LRFs) to identify the area at risk.

Printed copies of maps[7] showing the Public Safety Zones and, where applicable, the 1 in 10,000 individual risk contours, are sent to the local planning authorities whose areas are affected by them. Additional copies are available for sale from the Department for Transport. The boundaries of the Public Safety Zones and any 1 in 10,000 individual risk contours are available from the Department (cad4@dft.gsi.gov.uk), free of charge, in digital format.

An example of a public safety zone map can be found for Farnborough at: www.tripos.org.uk/docs/tag/psz%20extents.pdf

[6] www.dft.gov.uk/consultations/archive/2006/pepszca/annexdairportsthatalreadyhav1823

[7] Requests for additional paper copies of Public Safety Zone maps or requests for the Public Safety Zones and, where applicable, the individual risk contours in digital format should be addressed to Civil Aviation Division, Department for Transport or to cad4@dft.gsi.gov.uk.

ASSESSING OTHER CONSEQUENCES

The majority of aircraft risk assessment has focused on the risk of crashes onto residential off-airport areas and major hazard sites.

The method developed by the HSE (1987 and 1997) can be used to predict the likelihood of impact onto any one location. This method can therefore be used to assess possibility of impact onto, for example, power plants and other infrastructure. As previously stated, this requires expertise in modelling and is resource intensive.

A simpler alternative is to use the Public Safety Zone maps to identify areas and structures that may be struck by aircraft around an airport.

BACKGROUND CRASH RATE (AWAY FROM AIRPORTS)

The 1997 HSE-funded study produced two ways of assessing in-flight crash risk. The first involved a simple estimate of a background crash rate (excluding incidents related to take off and landing) for the UK of 0.20 x 10^{-5} per km^2 per yr for large transport (this is 0.000002 per km^2 per year). The report also provides crash rates for other classes of aircraft. These can be applied by non-experts calculating the area (in km^2) under review and multiplying the background rate by the generic rate.

The second approach, as noted in the 1997 HSE report, requires advanced expertise and data. It entails modelling flight altitude, number of aircraft movements and distance from the centre line of the flight path. This approach can provide an incident likelihood for any one location, thereby enabling assessment of probability of a specific structure being hit.

UNCERTAINTIES

There are a number of key uncertainties in assessing the likelihood of aircraft incidents using historical data. These include:

- Different studies give somewhat different incident rates, depending on the period reviewed for example
- To what extent do historical incident rates apply to the current mix of aircraft? On the one hand, modern aircraft have superior safety systems, whilst on the other hand the growth of new airlines introduces uncertainty about their safety performance. A study[8] can be drawn on to indicate the trend in aircraft crash rates
- The effect of variations in airport safety systems
- The effect of traffic density at and around airports.

8 www.math.uio.no/eprint/stat_report/2005/07-05.pdf

Accordingly, these methods give an indication of likelihood rather than an exact prediction of probability.

Moreover, they do not distinguish between crash scenarios, such as between single aircraft impacts onto runways versus aircraft collision over residential areas.

2.2.3 Data sources

CAA AIRCRAFT MOVEMENT DATA
The CAA publicly report the number of aircraft movements (landings and take offs) per airport:

- www.caa.co.uk/docs/80/airport_data/2004Annual/Table_02_2_Summary_of_Activity_at_UK_Airports.csv
- www.caa.co.uk/default.aspx?catid=80&pagetype=88&sglid=3&fld=200709

This data can be used in combination with the generic incident rate per aircraft movement to give a predicted rate of incidents at or around an airport, for civil aircraft.

NATURE AND SCALE OF INCIDENTS
Some information on the nature of major aircraft incidents can be acquired from public sources, including:

- The list of incidents published by the Emergency Planning College (EPC).

The National Transportation Safety Board (www.ntsb.gov/) provide a downloadable database for all US aircraft accidents from 1982 – 2002, which are available on the Internet.

There is no known source of documentary information specific to the needs of emergency planners with respect to the nature and consequences of aircraft incidents.

FREQUENCIES
Boeing, Statistical Summary of Commercial Jet Airplane Accidents Worldwide Operations 1959 - 2003, May 2004.

Information on the frequency and causes of incidents can be found at:

- CAA Safety Regulation Group, CAP 681 Global Fatal Accident Review 1980 - 1996. Civil Aviation Authority, Gatwick (1998). (www.caa.co.uk/docs/33/CAP681.PDF)

The following site provides an update on incident rates – www.caa.co.uk/default.aspx?catid=978&pagetype=90&pageid=6277

2.3 Railways

2.3.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

Historical data is available on the frequency of railway incidents. In addition, the main cause of incidents are 'technical factors' such as mechanical defects and human error, which means that the probability of incidents is amenable to prediction using historical data and risk analysis methods.

The frequency of major railway incidents on the overland railway network has been assessed at a national level by Rail Safety and Standards Board (RSSB). Indeed, they provide an annual update on the predicted frequency of incidents, their magnitude and causes. These predictions are based on an extensive database that is systematically collated by RSSB. The RSSB risk analyses are commonly accepted as authoritative. However, the national level risk analysis needs to be interpreted for application at a local level.

All train operators are required to complete risk analysis of their networks, including underground networks. Therefore, predictions of major incidents should be available from train operating companies for underground systems.

LEVEL OF EXPERTISE NEEDED

The risk analysis completed by RSSB and train operators use methods that demand specialist expertise. Therefore, it is not recommended that LRFs or FRSs attempt to apply these risk analysis methods. However, it is recommended that the results of these risk analyses are drawn on to provide 'generic' incident rates that can be applied at a local level by LRFs and FRSs.

AUTHORS' GUIDANCE

It is suggested that:

- LRFs and FRSs use the rate of railway incidents (as quoted by RSSB) with five or more deaths, or the rate for incidents with ten or more deaths, as a generic rate to be applied to the size of local overland (Network Rail) railways. These generic incidents could be modified by LRFs judgement of local factors, such as the rate train movements and railway features
- LRFs and FRSs request the results of quantitative risk analysis completed by train operators for underground networks.

It is recommended that LRFs do not use local data, such as the number of major railway incidents in a county, as a basis of railway risk analysis, as the low frequency of major railway incidents usually renders local data unreliable with respect to predicting incident frequencies.

2.3.2 Tools and techniques

Tools and data have been used to produce predicted frequencies and severities of major train incidents, excluding terrorist incidents, ie ‘conventional’ incidents. These are summarised below.

NETWORK RAIL SYSTEM

The likelihood of high risk train accidents can be derived from work completed by the RSSB for the system operated by Network Rail. The assessments give results for incidents with severity defined in terms of number of potential deaths, namely five or more, or ten or more. Results for incidents with larger numbers of deaths are not necessarily publicly available.

RSSB SAFETY RISK MODEL

RSSB have developed and maintain the Safety Risk Model (SRM), as summarised at: www.rssb.co.uk/safety/spr/srmodel.asp

As noted, ‘The SRM is a quantitative representation of the potential accidents resulting from the operation and maintenance of the UK rail network. It comprises a total of 125 individual computer based models, each representing a type of hazardous event. A hazardous event is defined as an event or an incident that has the potential to result in injuries or fatalities.’

The results of the SRM are published within the ‘Profile of Safety Risk on the UK Mainline Railway’, which can be accessed at the above noted website. The summaries of results do not necessarily indicate the frequency of major railway incidents.

However, as noted below, RSSB publish detailed Safety Performance Reports which do provide the predicted frequency of incident by severity (as derived from the Safety Risk Model). For example, the 2007 report stated in table 12 (p.110) that, for the Network Rail system as a whole that the incident frequencies were predicted as shown in the table below.

Table 3: Predicted frequency of incident by severity for the Network Rail system

	>+ 5 deaths (workers, public, passengers)	+>10 deaths (workers, public, passengers)
Years between incidents (using SRM v5.5 / SRM v5)	5.3	9.1

This can be used by LRFs and FRSs. The predicted frequency is for the Network System as a whole. The national rate can be divided by the length of track (or route) to give a rate per kilometre. The rate can then be multiplied by the amount of track or route in an area to give an approximation of the local incident rate. A further option is to modify this rate by applying a traffic level factor and considering local features, such as absence of level crossings.

The latter approach was applied to the development of incident rates in the FSEC Toolkit[9]. The RSSB estimate (by personal communication) that there is 31,800 km of track in Great Britain. Table 4 indicates the annual rate of incidents per track kilometre. An option is to double these rates by two, to give a crude rate per kilometre of route. This could be applied where the track length is unknown but where the route length can be derived from, for example, Ordnance Survey's Mastermap[10]. The frequencies are quoted using scientific notation and as a decimal.

Table 4: Estimated rate of incidents per km of overland track

Number of fatalities (passengers, staff and MOPs)	Km of track	Years between events	Frequency per year across entire network	Frequency per km of track per year	Frequency per km of track per year
≥5	31,800	5.3	0.1887	5.93×10^{-6}	0.00000593
≥10	31,800	9.1	0.1099	3.46×10^{-6}	0.00000346

Thus, if there was 1,500km of track in a county the rate of incidents with ten or more deaths would be 5.2×10^{-3} (once in 192 years). If there was 500 km of route, the rate of incidents with ten or more deaths would be 3.46×10^{-3} (once in 289 years), ie 500 x (2 x 3.46 x 10-6).

Whilst the results are approximate, they can be developed by LRFs and FRSs without requiring input from train operators and would give a reasonable approximation of incident rates.

[9] www.communities.gov.uk/fire/researchandstatistics/fireresearch/operationalandsocial/fsectoolkit

[10] www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/applications/asset.html

The generic rate can be modified to give a more localised measure. For example, it could be modified up or down according to the relative traffic level on a local route compared to routes as a whole. Traffic level data would need to be acquired from train operating companies or Network Rail, unless the assessment was based on judgement of relative traffic levels. In addition, collisions with road vehicles at level crossing are the single greatest cause of high risk train accidents, at about 50 per cent of all major railway incidents. Therefore, incident rates for routes without level crossings can be reduced by about half.

LONDON UNDERGROUND

Quantitative Risk Analysis (QRA) has been completed of the London Underground network. The QRA used specialist methods such as fault and event trees and historical data. The specialist QRA method is beyond the remit of LRFs and FRSs. A publicly available copy of the results (as of 2001) can be found at: www.yellowbook-rail.org.uk/site/resources/models/yellowbookR1.pdf

The results include a predicted frequency (as of 2001) of incidents for the entire network with various numbers of deaths, as specifically shown in the table below.

Table 5: London Underground's predicted frequency of incidents (2001)

Estimated number of deaths (ten or more)	Approximate predicted frequency
10 deaths	1 in 10 years
100 deaths	1 in 1,000 years
1,000 deaths	1 in 50,000 years
10,000 deaths	1 in 1,000,000 years

The cause of these incidents are given, thereby allowing the type of incident to be understood, such as derailments and collisions. This publicly available report is from 2001. A more recent edition may be available directly from Transport for London who, reportedly, continue to develop and update the LUL major accident QRA. This includes railway line (ie tube lines) specific QRAs, that can provide more localised results.

These results can be used directly by LRFs and FRSs, for the London network.

2.3.3 Data sources

The main publicly available source of data is from the RSSB, which covers the railway system operated by Network Rail.

RSSB SAFETY MANAGEMENT INFORMATION SYSTEM
RSSB operate the Safety Management Information System (SMIS). SMIS is a national IT system used by all Railway Group members to record all safety related events that occur on Network Rail controlled infrastructure. Legislation mandates its use so that all data is accessible to Railway Group Members, in order that they can use the information to analyse risk, predict trends and focus activities on major areas of safety concern.

Further information can be found at: www.rssb.co.uk/safety/spr/smis.asp

This system covers the overland railway network as operated by Network Rail, but not underground systems. As noted above, access is possible for Railway Group Members only. Therefore, it is of use to LRFs and FRS only if a request for information is accepted on a discretionary basis, although Category 2 responders who belong to the Railway Group could access information from SMIS.

RSSB SAFETY PERFORMANCE REPORTS
RSSB provides summary and detailed safety performance reports, for all operations on the Network Rail system. These can be found at:
www.rssb.co.uk/safety/spr/spreports.asp

The overview reports provide long-term trend data on train accidents, such as collisions, for the system as a whole. These are termed Potentially High Risk Train Accidents (PHRTAs), a group which includes derailments, trains striking road vehicles, buffer stop collisions and collisions between trains (excluding roll backs and open doors). However, only a minority of these entail an actual major incident. Therefore, whilst they give a measure of trends and types of accidents, they do not provide a direct measure of major incident rates.

The detailed safety review reports provide a breakdown of the causes of PHRTAs, such as level crossings, derailments, train collisions, striking buffers and striking vehicles on the track (not level crossings). This can assist local risk assessment. The potential for each cause can, to some extent, be assessed by ascertaining if these features (level crossings and buffers particularly) exist on the local network, and, if not, reducing the probability of incidents accordingly. They also cite examples of recent incidents.

2.4 Vehicle (major accidents)

2.4.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

The ability to assess the frequency and consequence of major vehicle accidents is limited by the absence of an authoritative database of major vehicle accidents and absence of prior quantitative risk assessment. Department for Transport (DfT) data indicates the number of accidents and casualties, but does not indicate the frequency of road traffic accidents with (for example) more than five casualties. Also, the low frequency of major vehicle incidents means that the use of data from any one LRF is unlikely to be reliable. On the other hand, there have been a number of major vehicle incidents in the UK, which may be used to provide an approximation of the frequency of incidents.

As most major vehicle incidents are limited in scale, it is suggested that they can be treated (for the sake of LRF risk analysis) generically as Moderate (as per the CCA guidance).

LEVEL OF EXPERTISE NEEDED

As no actual tools or techniques have been identified, beyond the use of generic incident rates, the level of expertise needed to apply these is low.

AUTHOR'S GUIDANCE

Thus, it is recommended that, for the sake of LRF and FRS analysis, that the generic rates derived for the FSEC Toolkit are used for major vehicle risk analysis.

As the rate of incidents is very low, it is advised that any local incident data, such as the number of incidents in a county, is unlikely to provide a valid measure of risk.

2.4.2 Tools and techniques

No previous quantitative risk assessment could be identified for major vehicle incidents in the UK other than some work for the FSEC Toolkit that has not yet been published. This work produced a generic incident rate per kilometre of road using a one-off search of publicly available data. The review of incidents from public sources (namely an internet search of newspaper reports) indicated about one major incident (where it involved five or more deaths or people whose survival depended on emergency service action) per year in the UK between 1995 and 2005. The DfT report that there was 2,199 miles (3,519 km) of motorway in 2006[11]. This gave the following rate of incidents per km yr of motorway:

- 1 ÷ 2,199 = 0.00045 per mile of motorway per annum, ie 0.0007 per km yr of motorway

[11] www.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/edition2006.pdf – Chapter 7 Roads and Traffic, Table: 7.6: 7.6 Roads lengths: Great Britain: 1914-2005

There is also 46,000 miles of A road in the UK, again based on DfT data, and about one A road major incident per year according to the FSEC review. This gave a rate of 0.00004 (4×10^{-5}) incidents per km of A road per annum.

The latter rates can be adjusted to reflect the local traffic level by dividing the traffic throughput (vehicles per day travelling along the A road or motorway) by the average throughput for A roads and Motorways. The average throughput was quoted by the DfT in 2005 (source DfT National Road Traffic Survey) as 84,000 per day for Motorways, 11,100 for rural A roads and 20,300 for urban A roads. For example, if the local flow on a Motorway is 100,000, this would be divided by 84,000 to give a multiplier of 1.2 for the generic rate of 0.0007 per km yr of motorway, ie 0.00084. If there was 100km of Motorway this would give a predicted rate of 0.084 per year, ie one every 12 years.

It is also possible to adjust the generic rate by reference to research on the impact of road safety features such as lighting and speed restrictions. For example, DfT research on the relationship between speed and traffic accidents[12] indicates that a decrease in speed of 1mph, compared to a benchmark, reduces the accident rate by 5 per cent, whilst an increase of 1mph above the benchmark can increase accident rates by 20 per cent. The benchmarks (taken from the referenced DfT report) are:

- Motorway = 70
- Dual carriageway = 68
- Single carriage way A road not built up areas = 48
- Built up A road with 40 mph limit = 36.

Other research can suggest how other features such as lighting can influence accident rates.

2.4.3 Data sources

As noted above, no identifiable source of incident data or risk analysis could be identified.

The length of Motorway and A road in an area can be identified from sources such as Ordnance Survey's Mastermap[13]. The length of Motorway and A road can then be multiplied by the generic incident rates to give local risk measures.

12 www.dft.gov.uk/pgr/roadsafety/speedmanagement/newdirectionsinspeedmanageme4802?page=3#a1005

13 www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/applications/asset.html

2.5 Maritime

2.5.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

Historical data is available on the frequency of maritime incidents including fires, collisions, foundering, groundings and other causes of sinking, drawing on international data sources. In addition, the main cause of incidents are 'technical factors' such as engine failures and navigational error, which means that the probability of incidents is amenable to prediction using historical data and risk analysis methods.

The frequency of major shipping incidents has been assessed at a national level by the Maritime and Coastguard Agency (MCA) for some types of shipping, such as ferries. Indeed, they have estimated annual probabilities of major passenger ferry incidents. These predictions are based on an extensive database. The Formal Safety Assessment (FSA) risk analyses are commonly accepted as authoritative. However, the national level risk analysis needs to be interpreted for application at a local level. Also, the publicly available analysis does not necessarily cover all modes of shipping.

There is also an assortment of publicly available reports on maritime incidents. These can be collated to provide a count of incidents around parts of the UK coastline. This count provides a very approximate estimate of the frequency and severity of incidents, particularly in areas with high level of maritime traffic. However, as the frequency of major shipping incidents is relatively low, such a count may not provide an accurate likelihood estimate for areas with lower levels of maritime traffic or the potential for more severe incidents.

LEVEL OF EXPERTISE NEEDED

The risk analysis completed by the MCA use methods that demand specialist expertise. Therefore, it is not recommended that LRFs or FRSs attempt to apply these risk analysis methods. However, it is recommended that the results of these risk analyses are drawn on to provide 'generic' incident rates that can be applied at a local level.

AUTHORS' GUIDANCE

It is recommended that LRFs use a combination of data on the local history of major incident and generic incident rates. Assorted data sources provide an indication of the frequency of what are mostly minor maritime incidents. This provides an indication of frequency around parts of the UK coastline. However, as the frequency of major maritime incidents is low, local data may not provide a full basis on which to predict incident frequencies. Therefore, it is suggested that the generic incident rate per vessel derived from the MCA's FSA is also applied to local data on the number of vessel movements.

2.5.2 Tools and techniques

The MCA have completed FSAs of local passenger ships (ferries) operating in UK waters[14]. This provides an estimated frequency of major incident per vessel operating year, namely 4.32 x 10^{-04} per vessel operating year for ferries. So a route with ten ferries operating on it would have an incident rate in the region of 4.32 x 10^{-3}, ie once every 231 years. This may be combined with vessel movement data from the DfT to give an estimate of likelihood. The FSA requires specialist expertise to complete, but the results can be drawn on by non-specialists.

2.5.3 Data sources

The DfT provide data on maritime transport (Transport Statistics Report, maritime Transport Statistics report 2006)[15]. The DfT do not provide the number of ferry journeys. They do provide the total number of ship arrivals at UK ports (p.112) and the number of international Ro-Ro ferry passenger movements per year (p.96).

The annual reports of the Marine Accident Investigation Board (MAIB) provide a list and summary of incidents each year at this address: www.maib.gov.uk/publications/index.cfm. They also provide a list of investigation reports at:

- www.maib.gov.uk/publications/investigation_reports.cfm

The MAIB reports need to be examined to identify those that constitute a civil contingency as many are minor incidents. For example, of the 39 reports published between 2008 and 2005, about 14 involved what might be defined as Minor or Moderate incidents, about half in the eastern part of the Channel and a third off the north east coast.

The Emergency Planning College Major Incident database lists some marine incidents at:

- www.cabinetoffice.gov.uk/epcollege/library_and_information_centre/major_incidents_dbase.aspx

The latter lists of reports and incidents can be used to identify incidents that were or had the potential to comprise a civil contingency.

14 www.mcga.gov.uk Formal safety assessment of local passenger ships – risk assessment. Report by Det Norske Veritas June 2005.

15 www.dft.gov.uk/162259/162469/221412/221658/223721/287109/Maritimestatistics2006

In addition, Lloyds List (www.lloydsmiu.com/lmiu/index.htm) provide a subscription service that provides lists of marine incidents.

The compilation of the latter sources and public reporting of incidents can be drawn together to give a count of incidents around the UK, typically about three to four minor incidents a year and about one with the potential to be a moderate or more severe incident each year. However, these sources may not provide a complete count of incidents. The MAIB reports only cover those incidents that have been investigated and for which a report has been published.

The next section of this document provides guidance on assessment of spills from vessels.

3 Fire and explosion

3.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE
The frequency of major incidents at COMAH sites has been subject to extensive quantitative risk assessment by the HSE. Their analysis provides a basis for authoritative LRF and FRS assessment of major events at COMAH sites. Similar analysis is available for major accident hazard pipelines.

No publicly available analysis or data was found on which to assess the risk of biological releases.

LEVEL OF EXPERTISE NEEDED
The quantitative risk assessment completed by HSE and others requires specialist expertise. However, the condensed results of their analysis can be applied without specialist expertise.

AUTHORS' GUIDANCE
It is suggested that the results of HSE's risk analysis is used as a basis for authoritative LRF and FRS assessment of major events at COMAH sites. Similar analysis is available for major accident hazard pipelines.

It is also suggested that:

- The frequency of dwelling and other building fires can be assessed using the Communities and Local Government supplied FSEC Toolkit
- In the case of wildfire, FRSs can use FDR1 and FDR3 data to assess historical frequency and location of fires, including large fires.

The assessment of fires in dwellings, other buildings and outdoor can be achieved using data and tools already held by FRSs, specifically the FSEC Toolkit.

3.2 Industrial fire and explosion

3.2.1 Tools

COMAH SITES
The LRAG guide focuses on incidents requiring a regional or national response.

HSE do hold site-specific assessments, including:

- Risk contours for use in land use planning (also held by local authorities)
- Societal risk results for COMAH sites.

HSE's societal risk analyses of specific sites are restricted. However, a published HSE funded study produced assessments of a series of 'typical' sites[16]. Another HSE funded study estimated the societal risk for a hypothetical large scale petroleum storage site[17]. Based on a review of these assessments, the following values are to be used in the FSEC Toolkit (see reference 60):

- A default value of 1×10^{-4} is used per COMAH site for events with ten or more deaths
- A default of 1×10^{-5} is used per COMAH site for events with 100 or more deaths.

It is also possible that the potential likelihood and impact of events would already be available from COMAH safety reports and that emergency plans would already be developed through the standard COMAH processes.

Each local authority should hold a copy of the Risk contour maps (showing land use planning zones) per site and Major Accident Pipeline that are used to inform land use planning decisions. These show the area at risk of accidents from the site, and so the extent of populated area at risk.

It should be noted that the HSE risk analyses focus on the likelihood of events that cause multiple deaths. 'Lesser' incidents that may cause disruption are not necessarily captured by these frequencies. The historical frequency of events large enough to be reported under the European Union Major Accident Reporting System (MARS) has been examined (Andrew Franks, ERM September 2004, report for the HSE[18]). It was estimated that there was a rate of one incident per 240 site years (4.2 x 10-3) in the UK in the period 1985 to 2000 (74 incidents amongst 1200 major hazard sites). This could be taken as a measure of events with the potential to cause economic and infrastructure disruption at COMAH sites.

In addition, fire services record all fires and explosion that they attend. This will include all incidents at COMAH sites. Examination of local records can provide a measure of the frequency of major 'local' incidents (such as a count of Cloud Burst incidents) in the local area.

16 Development of an intermediate societal risk methodology. An investigation of FN curve representation. Prepared by ERM Risk Ltd for the Health and Safety Executive. Research Report 283, 2004.

17 Review of significance of societal risk for proposed revision to land use planning arrangements for large scale petroleum storage sites. Prepared by Atkins Consultants Ltd for the Health and Safety Executive,RR512, 2007

18 *A Review of HSE's Risk Analysis and Protection – Based Analysis Approaches for Land-Use Planning.* 2004. A. Franks. www.hse.gov.uk/landuseplanning/ifrlup/images/independentreviewreport.pdf

PIPELINES: UKOPA RATES

The UKOPA pipeline fault database[19] gives:

- Full bore failure rate of 0.011 per 1,000 km per yr
- Ignition probability of 0.05

This gives an incident rate per 1,000 km yr of 0.00055. This can be multiplied by length of Major Accident Hazard pipeline in the review area to give an indicative incident rate. This would be a broad estimate as it ignores local risk factors such as proximity to urban areas. However, it may be sufficient for the purposes of LRFs and FRSs, particularly as the incident rate is low.

3.2.2 Biological releases

No publicly available risk analysis was identified with respect to releases from laboratories. Risk assessment relies on expert judgement.

Centres that are licensed for genetic modified organism work are licensed with the Health and Safety Executive. In 2005 the HSE quoted 522 centres. These have been regulated since 1992 by the HSE. There have been no recorded releases in this period, giving a historic release rate of less than one per circa 9,000 years per site.

3.2.3 Data sources

MARS was established to handle the information on 'major accidents' submitted by Member States of the European Union to the European Commission in accordance with the provisions of the 'Seveso Directive'. It is operated by the Major Accident Hazards Bureau (MAHB) (www.mahbsrv.jrc.it/).

A list of COMAH sites is available from the HSE and/or FRSs.

The HSE also publicly report UK incidents that qualify for notifications to the European Union at:

- www.hse.gov.uk/comah/accidents.htm

19 UKOPA pipeline fault database. Pipeline product loss incidents. 4th Report of the UKOPA fault database management group. Advantica Report Reference R 8099, April 2005.

4 Weather

4.1 Flood

4.1.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

To some extent it is possible to draw on quantitative risk assessments to review the risk from flooding. Current models focus on fluvial and coastal flooding, with other work on dam failure. Existing flood models do not consider causes of flooding from other sources, such as rising groundwater, surface permeability and local drainage networks. Work is ongoing[20] to develop models to assess surface runoff flood modelling.

LEVEL OF EXPERTISE NEEDED

The flood risk analysis models require specialist expertise. However, the results of these assessments can be drawn on by LRFs and FRSs.

AUTHORS' GUIDANCE

It is recommended that the Environment Agency flood risk maps and National Flood Risk Assessment (NaFRA) results are used in combination with dam failure risk analysis results (from dam operators) or the generic dam failure rates quoted here. The latter flood frequencies need to be combined with estimates of the impact of flood warning, type of housing and flood depth/speed in order to provide an estimate of a flood causing risk to life and property. Additional information may be sought from local councils and the Environment Agency's Area Offices, which may provide data on the estimated depth of floods.

4.1.2 Tools and techniques: fluvial and coastal flooding

ENVIRONMENT AGENCY FLOOD RISK MAP

The Environment Agency publicly provides a flood risk map for England and Wales at:

- www.environment-agency.gov.uk/homeandleisure/floods/31656.aspx

The maps show the area that could be affected by flooding:

- From the sea by a flood that has a 0.5 per cent (1 in 200) or greater chance of happening each year
- Or from a river by a flood that has a 1 per cent (1 in 100) or greater chance of happening each year.

It also shows the additional extent of an extreme flood from rivers or the sea, with a 0.1 per cent (1 in 1,000) or greater chance of occurring each year.

[20] For example see: www.geoconnexion.com/geouk_online_article/Strategic-Flooding/223

The maps show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements. Therefore, the maps do not necessarily represent a true 'flood' extent. However, they do indicate the likelihood of flooding, taking account of flood defences as:

- Low – the chance of flooding each year is 0.5 per cent (1 in 200) or less
- Moderate – the chance of flooding in any year is 1.3 per cent (1 in 75) or less but greater than 0.5 per cent (1 in 200)
- Significant – the chance of flooding is greater than 1.3 per cent per year (1 in 75).

These likelihoods are provided in NaFRA (a separate model), referred to previously. The method for flood risk assessment uses a risk-based approach to factor in the location, type, condition and effects of flood defences, and works by calculating the actual likelihood of flooding to areas of land within the floodplain of an extreme flood (0.1 per cent or 1 in 1,000 chance in any year).[21]

These models do not provide an indication of the depth of flooding or whether it could threaten people or buildings. However, visual examination of a map can indicate the extent of occupied areas at risk of flooding and so may provide an indication of severity to a sufficient level of accuracy for LRFs contingency planning.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels. These indicative flood maps do not provide information on flood depth, speed or volume of flow; nor do they show flooding from other sources, such as groundwater, direct runoff from fields, or overflowing sewers. Therefore, the predicted flood frequencies may be low, due to omission of sewer overflow etc. However, the local Environment Agency office may have more specific information on these, and would need to be contacted directly.

Importantly, both the Environment Agency indicative flood maps, and NaFRA, cover all of England and Wales. Separate flood maps have been produced for Scotland and Northern Ireland.

SCOTTISH ENVIRONMENT PROTECTION AGENCY (SEPA) FLOOD RISK MAP

The Indicative River and Coastal Flood Map (Scotland)[22] has been developed to provide a strategic national overview of flood risk in Scotland. They do indicate the areas at risk of flooding. They do not display the frequency of flooding.

Importantly, the flood map only shows flooding from rivers or the sea and does not account for flooding from other sources such as surface water runoff, surcharged culverts (where rivers which have been channelled underground flood) or drainage systems.

21 www.halcrow.com/nafra/default.html

22 www.sepa.org.uk/flooding/flood_map.aspx

RIVERS AGENCY NORTHERN IRELAND FLOOD RISK MAP

The Rivers Agency is an Executive Agency within the Department of Agriculture and Rural Development, and is the statutory drainage and flood defence authority for Northern Ireland. They too have produced an indicative flood risk map[23]. It has similar constraints to those identified previously, eg in that it only identifies areas prone to flooding from rivers and the sea, and not from any other sources. The flood map contains a number of layers that capture information relating to previous flood events, estimated extents of the river and coastal floodplains under current climatic conditions, those areas benefiting from existing flood defences, and takes account of predicted changes to climatic conditions and sea-levels for the year 2030.

Rivers Agency is currently developing a map to illustrate the areas throughout Northern Ireland that may be prone to flooding from fluvial flows[24], which will be uploaded to the Strategic Flood Map some time in the future (date unspecified).

IMPACT OF FLOOD WARNINGS AND TYPE OF HOUSING

The Environment Agency flood maps provide an indication of the frequency of flooding rather than the frequency of people being threatened or property damage. The probability of having to mount an evacuation and/or rescue operation is also influenced by:

- The speed and depth of flooding
- The adequacy of flood warning systems
- The type of property in the area – low rise versus high rise
- The existence of critical infrastructure in the area.

No publicly available tool or method was identified at the time of reporting to enable assessment of these factors by LRFs or FRSs. However, some paper based methods have been developed which can be drawn on, as discussed below.

The risk assessment of Thames Coast (in New Zealand[25]) provided some values as per Table 6. Values such as these could be applied as multiplication factors to the NaFRA flood frequencies, such as assuming warnings will be adequate on 0.45 of occasions (an average of the day and night values).

23 www.riversagencyni.gov.uk/index/stategic-flood-maps.htm?Submit=View+the+Strategic+Flood+Map+(NI)+-+Rivers+%26+Sea

24 Fluvial flow (also known as surface water or overland flow) can occur as a result of an intense rainfall event and this can cause flooding in low lying areas and hollows before reaching a watercourse or sewer.

25 www.ew.govt.nz/Projects/Peninsula-Project/Thames-Coast-Project/

Table 6: Probability of level of flood warning available		
Level of warning	**Day**	**Night**
Adequate warning	0.5	0.4
Little warning	0.4	0.4
No warning	0.1	0.2

Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) commissioned a scoping study to develop a method for assessing the benefits of flood warning[26]. The study provides a series of values to assess the outcome of floods, specifically for:

- A flood Hazard Rating (HR)
- Area Vulnerability – composed of speed of onset, nature of the area and flood warning
- People Vulnerability (percentage of residents suffering long-term illness and percentage of residents 75 or over).

The number of people injured is given by number of people in zone at ground or basement level (Nz) x HR x Area Vulnerability x People Vulnerability

The Hazard Rating is derived from the estimated depth of flooding, velocity of water and debris factor. Flood hazard is graded as follows:

Table 7: Hazard rating for flood events		
HR	**Degree of flood hazard**	**Description**
<0.75	Low	Flood zone with shallow water or deep standing water
0.75 – 1.25	Moderate	Flood zone with deep or fast flowing water
1.25 – 2.5	Significant	Flood zone with deep fast flowing water
>2.5	Extreme	Food zone with deep fast flowing water

[26] *Assessing the benefits of flood warning: A scoping study.* Sniffer, August 2006. Project UKCC10.

Area vulnerability is given by the sum of the scores for speed of onset, nature of area and flood warning from Table 8 below.

Table 8: Area vulnerability for flood events

Parameter	1. Low risk area	2. Medium risk area	3. High risk area
Speed of onset	Onset of flooding is very gradual (many hours)	Onset of water is gradual (an hour or so)	Rapid flooding
Nature of area	Multi-storey apartments	Typical residential area (two storey homes, commercial premises and industrial premises)	Bungalows, mobile homes, busy roads, parks, single storey schools, campsites etc
Flood warning	Score for flood warning = 3 – (P1 x (P2 + P3)) P1 = percentage of warning coverage target met P2 = percentage of warning time target met P3 = percentage of effective action time met		

People vulnerability is the percentage of people with either long-term limiting illness or over 75.

The report does not indicate whether the approach has been validated or applied.

These approaches have been drawn on in the development of the FSEC major incident module. In particular, they have been used to suggest the following risk factors (see Table 9 below). The flood likelihood (from the Environment Agency) is multiplied by each factor to give a likelihood of people in the affected area needing rescue. This module is under-development by Communities and Local Government at the time of reporting, and is due for release to FRSs in 2009.

Table 9: Possible flood risk factors

Factor	Default value(s)			Comments
Hazardous flood (deep and rapid)	Default = 0.1			
Rapid onset of flooding	Default = 0.5			
Nature of area (predominant building type)	Multi storey apartments = 0	Typical residential area = 0.5	Bungalows etc = 1	This factor can be applied by examination of local area
Inadequate flood warning	Default = 0.45			

STRATEGIC FLOOD RISK ASSESSMENTS

Strategic Flood Risk Assessments (SFRAs) are completed by Councils to fulfil the guidance set out within Planning Policy Guidance Note 25 'Development and Flood Risk': July 2001 (PPG 25). SFRAs illustrate the extent of flooding and how it may impact upon future development proposals with the inclusion of climate change effects taken into account. Maps are produced that seek to illustrate the extent of flooding for the critical 1 per cent annual probability including climate change (assessed as a 20 per cent increase in flood flows over the next 50 years).

These SFRAs are usually publicly available on local council websites.

They offer information on:

- Sources of flooding
- Flood defences
- Potential depth of flooding.

However, they focus on areas of potential future development rather than existing developed areas.

INTERNAL DRAINAGE BOARDS

Internal Drainage Boards (IDBs) are independent bodies responsible for land drainage in areas of special drainage need that extends to 1.2 million hectares of lowland England. They may also undertake flood defence works on ordinary watercourses within their district (that is, watercourses other than 'main river'). Much of their work involves the improvement and maintenance of rivers, drainage channels and pumping stations. There are approximately 170 in England and Wales[27], concentrated in East Anglia, Yorkshire, Somerset and Lincolnshire.

CRITICAL INFRASTRUCTURE

Utility operators should have identified any critical infrastructure within flood risk areas.

In addition, the OSMasterMap[28] can be used locally to identify critical infrastructure and whether it is located in a flood zone. OSMasterMap also notes elevation of property. Ordnance Survey also provide:

- Land-Form PROFILE® Plus – a high-specification digital terrain model designed to underpin modelling applications and prediction analysis in a GIS environment. It supports sophisticated environmental risk assessments, including flooding at: www.ordnancesurvey.co.uk/oswebsite/products/landformprofileplus/
- Points of Interest – a digital database of facilities and resources (including transport and utilities). It can be used within a GIS to display each feature's geographic location as a point in combination with a topographic map. This is available from: www.ordnancesurvey.co.uk/oswebsite/products/pointsofinterest/

These sources can be combined with Environment Agency flood maps to identify infrastructure in flood zone and the elevation of the area, ie is it on low or high ground?

An ongoing project (Atlantis Initiative) aims to pull together flood, geology and infrastructure datasets to better support assessment of flood risk to infrastructure.

27 List of IDBs can be found at www.defra.gov.uk/environ/fcd/policy/oaidblist.html

28 www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/applications/asset.html

WATER AND SEWERAGE COMPANIES: SEWER FLOODING

In 2007-08, nearly 7,650 properties were flooded internally from sewers, and almost four times as many flooded externally (excluding river and surface water flooding)[29]. Properties at risk of flooding from sewers due to hydraulic overload are recorded on a Water and Sewerage Company's (WaSC) DG5 register. This is a record of flooding events that have actually occurred. This approach does not identify the total risk as demonstrated by the fact that new properties come on to the register each year or that a property may be potentially at a greater risk of flooding than currently indicated on the DG5 registers. These registers are not comprehensive or consistent in the reporting of flooding and related data and information.

Some WaSCs appear to be taking a more active approach of mapping of flood risk by funding predictive sewer modelling work, rather than relying on historical sewer flood events[30]. This might also be in relation to changes in legislation in the sale of property that requires it to identify if it has been previously flooded.

4.1.3 Data sources

LOCAL ENVIRONMENT AGENCY AREA OFFICES

There does not appear to be a single 'database' of historical flood events (maps) or a record of their outcomes, as ascertained from a search of published research and personal communication with the Environment Agency. However, Environment Agency Area Offices may hold some flood risk information in the form of historical flood maps and details of any flood modelling studies undertaken.

LOCAL COUNCILS

PPS25 requires all local councils to undertake a Strategic Flood Risk Assessment which may also hold valuable flood risk information. Some local councils, particularly in coastal areas, will be responsible for the management of coastal flood defences.

INTERNAL DRAINAGE BOARDS (IDBS)

IDBs hold information on managed assets, such as pumping stations and drainage channels, particularly in lowland areas.

29 www.environment-agency.gov.uk/research/library/consultations/101283.aspx

30 Such as the Flood Risk Mapper (FRM), whose functionality uses the flood characteristics, DTM and OS MasterMap data to generate flood paths and identify properties at risk of sewer flooding www.wallingfordsoftware.com/news/fullarticle.asp?ID=871

UTILITIES DATASETS
A map of power stations (as of 2006) is available at:

- www.news.bbc.co.uk/1/shared/bsp/hi/pdfs/14_06_06_powerstations.pdf

Water and Sewerage Companies (WaSCs) produce DG5 sewer flooding (historical) risk registers. This is produced for Ofwat to assess annual performance.

Other data sources are:

FLOOD ESTIMATION HANDBOOK (CENTRE FOR ECOLOGY AND HYDROLOGY)
A paper and software based product that gives guidance on rainfall and river flood frequency estimation in the UK.

- www.nerc-wallingford.ac.uk/ih/feh/

GROUNDWATER LEVELS (BGS AND ENVIRONMENT AGENCY)
Historical and spatial records of groundwater levels are held by the British Geological Survey (BGS) and the Environment Agency.

- www.bgs.ac.uk/
- www.environment-agency.gov.uk

GROUNDWATER FLOOD SUSCEPTIBILITY (BGS)
Maps showing zones likely to include areas prone to groundwater flooding.

- www.bgs.ac.uk/
- Experian's Groundwater Flood Model www.experian.com/

BUILT ENVIRONMENT (ORDNANCE SURVEY)
OSMasterMap data shows detailed topography and the footprints of the built environment.

- www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/index.html

FLASH FLOODING MAPS (JBA CONSULTING AND ENVIRONMENT AGENCY)
Under development, JBA Consulting are producing 2-D models of the national flash flood risk.

- www.jbaconsulting.co.uk/pdf/flashflood.pdf

4.1.4 Dams

DEFRA have published an Interim Guide to quantitative risk assessment for reservoirs[31]. It provides a comprehensive approach to assessing individual dams, providing an estimated frequency of events and their severity. This approach requires specialist expertise. However, it is expected that dam operators may have completed quantitative risk assessments of high hazard reservoirs to inform periodic safety reviews. Therefore, they may be able to provide results in the form of F-N curves (frequency versus number of incidents) to LRFs and FRSs, along with the expected flood area for each dam.

Otherwise, a simple generic incident rate of 1 in 10,000 per dam per year has been suggested for use in the Communities and Local Government FSEC Toolkit, which can be used as a broad catastrophic likelihood measure. Aforementioned OS maps may be used to assess possible impact areas, by identifying whether there is housing or other infrastructure downstream of the dam.

The Pitt Review into the 2007 summer floods recommended that the Government should produce inundation maps for all large raised reservoirs, which would show the effects on the downstream catchment of a dam breach. Mapping of all large raised reservoirs in England and Wales is due to be completed at the end of 2009. LRFs will use the information to draw up a list of sites which pose a significant risk to life, property and critical infrastructure, and subsequently more detailed inundation mapping can be carried out and emergency plans prepared for these identified sites[32].

NATIONAL DAM DATABASE

This provides data on location and type of each dam in the UK, as well as dam failures and incidents. It was developed as part of the Government's Reservoir Safety Research Programme and is held by the Environment Agency Reservoir Safety Group. The database is explained at:

- www.publications.environment-agency.gov.uk/pdf/GEHO0408BNSH-e-e.pdf
- www.publications.environment-agency.gov.uk/pdf/GESW0407BMGM-e-e.pdf

31 Available from: www.thomastelford.com/books/bookshop_main.asp?ISBN=0727732676

32 www.environment-agency.gov.uk/business/sectors/100596.aspx

4.2 Severe storms and gales, low temperatures, heat waves, snow and drought

4.2.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

The majority of meteorological models focus on real time assessments of weather over the forthcoming days, and so are of limited use to long-term style of risk assessment needed by LRFs and FRSs.

The assessment of the likely probability of incidents over forthcoming years is achieved primarily by reference to past experience at a national and local level.

However, there are a number of ongoing trends and changes in risk management that make past trends an imperfect guide to the future, including:

- The UK Heat Health Watch System which is accredited with reducing deaths in the July 2006 hot weather (although 680 were still reported)
- Climate change is thought to being leading to more droughts, fewer cases of low temperature/heavy snow, more heat waves and more storms/gales.

Thus, the assessment of likelihood and severity is principally an informed judgement, drawing on past events, but taking account of 'difficult to quantify' trends and ongoing research into the consequences of climate change on extreme weather events.

LEVEL OF EXPERTISE NEEDED

All dynamic modelling requires specialist expertise, as do the research stage models developed to model extreme weather events. The use of historical data and the results of research studies does not require specialist expertise.

AUTHORS' GUIDANCE

In the context of civil contingency planning, it is probably sufficient to apply a historical rate of incidents from national and local data, as precise estimates of frequency are not required.

The likely scale of incidents may also be based on past events. However, recent developments need to be taken into account (by judgement) as they may reduce the scale of future events, particularly the Heat Health Watch System.

4.2.2 Tools and techniques

No specific tool could be identified that provides long-term estimates of the severe weather events. There are a number of research studies and guides that provide information on the trends in the likelihood of events and their consequences.

RESEARCH STUDIES

A number of scientific models exist that explore events such as heat waves. These models require specialist expertise and often make projections for periods such as 2050 or 2100 (beyond the planning horizons of LRFs and FRSs). However, the results of the models can be used to inform risk assessments. Some examples are cited below.

- Intergovernmental Panel on Climate Change (IPCC) – The panel provides a considered view of the likely trends in climate and trends in extreme weather events. For example, see the Fourth IPCC Assessment on Climate Change (IPCC, 2007)[33]
- The Met Office provided an analysis of trends in extreme weather for each UK region[34]. This includes duration of cold and heat waves by region (figures 8 and 9), snow cover (figure 13), thereby allowing some consideration of regional variations by LRFs
- Since the floods of summer 2007, the Environment Agency, together with the Met Office, has launched a successful Extreme Rainfall Alert (ERA) pilot service to forecast and warn emergency responders about extreme events
- The final report of the European Spatial Planning Observation Network (ESPON) Hazards project shows the spatial patterns of natural and technological hazards in Europe, as an overview on all NUTS3 areas and identifies possible impacts of climate change on selected natural hazards.[35] This report provides a hazard map for Europe, down to country level in the UK, for the full range of natural hazards.

[33] www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

[34] A spatial analysis of trends in the UK climate since 1914 using gridded datasets. Climate Memorandum No 21 www.metoffice.gov.uk/climate/uk/about/UK_climate_trends.pdf

[35] The Spatial Effects and Management of Natural and Technological Hazards in Europe. European Spatial Planning Observation Network. 2006. www.preventionweb.net/files/3621_Finalreport.pdf

HEAT AND COLD WAVES

The Environment Agency report on the Social Impacts of Heat Waves, referenced below, summarises research into the relationship between heat levels and mortality. This provides points (see Table 4.1) such as indicating that mortality increases 1.30 per cent and decreases by 1.43 per cent per 1°C temperature rise/fall above/below 18°C. A range of such estimates are provided, such as 3.34 per cent per 1°C over 21.5°C, and indicates that mortality 'jumps' at temperatures over 27°C. It also provides:

- (see figure 4.4) a relationship between temperature and mortality rate for temperatures from circa -5°C to circa 35°C
- An explanation of the wider social impacts of heat waves, such as public disorder and overload of infrastructure and public services.

Thus, this work can be drawn on to assess severity and impact of heat waves, and characterise the spectrum of outcomes of heat waves (eg overload power supplies on underground networks, outdoor fires etc).

As noted below, other public sources also provide reports on the impacts of heat waves on infrastructure and other social features.

In addition, the Department of Health Heatwave Plan for 2008[36] provides background information that may inform local risk assessment, including discussions of likelihood, how heat levels vary by area. Similarly a study by the World Health Organisation (WHO)[37] provides models for assessing how heat waves risk may vary between rural and urban areas.

4.2.3 Data sources

WeatherWise[38] appears to be one source of data that identifies and briefly describes some of the key weather events and extreme conditions that have been experienced across the UK in recent years in relation to month, date, region and nature of event for the period 2004-09[39]. A number of other publicly available sources are noted below. These are in addition to the National Resilience Planning Assumptions (restricted) produced by the Cabinet Office.

NATIONAL/REGIONAL EVENTS

The National Risk Register[40] published by the Cabinet Office makes brief reference to some recent events which may be used to inform assessments of the likelihood of regional or national scale events, and makes brief reference to their severity.

36 www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_084670

37 Health and Global Environmental Change, Series No 2. Heat waves: Risk and response. www.euro.who.int/document/E82629.pdf

38 www.wiseweather.co.uk/id43.html

39 Pages on extreme weather events pre-2004 are currently under construction.

40 www.cabinetoffice.gov.uk/reports/national_risk_register.aspx

Table 10: Record of recent events as taken from the National Risk Register (Cabinet Office)			
Storms and gales	**Low temperatures and heavy snow**	**Heat waves (>32°C)**	**Drought**
October 1987	1947	1911	Cited as regular
January 1990	1962-63	1976	2004-06
January 2007 (nine deaths plus power disruption)	February 2001	August 1990	
	February 1991	2003	
	February 2007	2006	
	February 2009		

It is also noted that Emergency Drought Orders have been used only three times in England and Wales since 1945, ie about once every 20 years.

An Environment Agency report[41] cites three major UK heat waves in 1976, 1995 and 2003, each associated with drought. Thus, there is about one heat wave and one extreme cold event every eight years in the UK.

EMERGENCY PLANNING COLLEGE – MAJOR INCIDENTS DATABASE

The EPC Major Incident Database notes seven events (six storms in 1986, 1987, 1990, 1990, 1995 and 2007, and two blizzards in 1984 and 1990), causing deaths and damage, with four limited to parts of the UK. This is about one major storm every five years, although they tend to effect only a few regions each time This is available at:

- www.epcollege.gov.uk/library_and_information_centre/major_incidents_dbase.aspx

It also notes the 2005 flood (the Carlisle floods) as also involving storms with storm related damage.

41 The Social Impact of Heat Waves, Science Report – SC20061/SR6. 2007. www.publications.environment-agency.gov.uk/pdf/SCHO0807BNCW-e-e.pdf

The database quotes number of deaths and a short description of damage, with an excerpt shown in the table below.

Table 11: Excerpt from the Emergency Planning College Major Incident Database

Date	Place	Country	Type	Fatalities	Injured	Notes
1984	Britain	UK	Severe weather	22	-	12-16 January: Blizzards caused 22 deaths.
1986	UK	UK	Severe weather	11	-	25 August: Hurricane Charlie – at least 11 deaths attributed to the storm.
1987	Southern England	UK	Severe weather	19	-	15 October: Storm force winds caused havoc, millions of trees blown down.
1990	Wales & West Country	UK	Severe weather	45	?	25 January: Hurricane force storms kill 45, mainly Wales and the West Country.
1990	UK	UK	Severe weather	10	?	19 December: Abnormal blizzards cause ten deaths.
1990	Southern England	UK	Severe weather	45	-	25 January: Hurricane force storm.
1995	Scotland	UK	Severe weather	-	-	24 December-1 January: Severe weather damages Scottish homes to tune of £30m. 120,000 Scots affected.

Table 11: Excerpt from the Emergency Planning College Major Incident Database *continued*

Date	Place	Country	Type	Fatalities	Injured	Notes
2005	England/ Scotland/ Wales	UK	Storms/ floods	?	?	January: Severe storms caused widespread flooding, especially in Carlisle and with hurricane force winds causing much damage including sweeping away a family of five into the sea in Scotland as they tried to get away from their home.
2007	United Kingdom	UK	Weather	14	N/K	January: Worst storms since 1990 battered the UK resulting in death, severe disruption and damage.

UK MET OFFICE

The Met Office holds meteorological data for all UK districts. In principal they can provide historical and trend data on the frequency of extreme weather in each part of the UK, on request.

PUBLIC SOURCES

There are assorted publicly available reports on specific events.

- Eurosurveillance: this is an open-access peer-reviewed journal about infectious diseases surveillance prevention and control in Europe. It includes reports on the extent of outbreaks across the world. www.eurosurveillance.org/Default.aspx

Whilst Eurosurveillance focuses on infectious disease, some articles cover the affects of severe weather including the 2003 heat wave which it is reported to have caused over 2,045 excess deaths in the UK, for example:

- The impact of the 2003 heat wave on daily mortality in England and Wales and the use of rapid weekly mortality estimates. MedLine: Eurosurveillance 2005;10(7):168-171 - www.eurosurveillance.org/ViewArticle.aspx?ArticleId=558

- Wikipedia: this unverified source provides summaries of the nature and consequences of UK heat waves, cold waves, storms and droughts based on a mixture of Government and media reports
- London School of Hygiene and Tropical Medicine: provides reference to research into heatwaves and their impacts. www.lshtm.ac.uk/pehru/mrcheat/hwmain.htm

LOCAL AUTHORITY EMERGENCY PLANNING OFFICER DATA
Local authorities are likely to hold data on the past occurrence of extreme weather events that may be drawn on to compliment national data.

5 Pollution

5.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE
Pollution incidents include:

- Pollution of inland waterways and coastal waters
- Land contamination
- Air quality incidents.

Whilst the possibility of pollution incidents are in theory amenable to probabilistic risk assessment, environmental risk assessments have not expressed results in a form that can be directly related to an absolute frequency or impact scale, ie they do not quote incident rates in a way that can be placed on the LRAG likelihood scale. The exception is spills from seafaring vessels for which some data is available to give an indication of incident likelihood.

LEVEL OF EXPERTISE NEEDED
All of the environmental risk assessment methods require specialist expertise. As a LRF style risk assessment of pollution requires interpretation of specialist data, it is also suggested that these risks are assessed by appropriate Category 2 responders.

AUTHORS' GUIDANCE
It is advised that the generic likelihoods suggested in the (restricted) LRAG are used as a starting point in local risk assessment for onshore incidents along with expert judgement. These could be adjusted, by judgement, based on consideration of information on the existence of sites, shipping and protection zones. Generic incident rates may be used for marine incidents.

5.2 Tools, techniques and data

As noted above, no specific tool or technique could be identified for direct application to a LRF or FRS IRMP form of risk assessment. An assortment of data is cited below.

ENVIRONMENT AGENCY

The Environment Agency can provide a variety of information including:

- Operational Risk Appraisal (OPRA)[42] – The Environment Agency risk rate sites from A to E, where A is least risk. In addition to the standard of site management it includes proximity to drinking water sources, process complexity and emissions
- Source Protection Zones (SPZs)[43]. SPZs have been defined for 2,000 groundwater sources such as wells, boreholes and springs used for public drinking water supply. These zones show the risk of contamination from any activities that might cause pollution in the area
- Sites licensed under Integrated Pollution Control and their risk rating
- Pollution incidents in England and Wales[44]
- An online interactive map which identifies sites that pose a risk of pollution and location of Major/Significant pollution incidents at: maps.environment-agency.gov.uk/wiyby/wiybyController?topic=pollution&layerGroups=default&lang=_e&ep=map&scale=1&x=357683&y=355134.

The Scottish Pollutant Release Inventory (SPRI) is a database of annual mass releases of specified pollutant to air, water and land from SEPA regulated industrial sites. It also provides information on off-site transfers of waste from these sites. SPRI provides emission values and waste transfers when they are over the reporting thresholds and indicate if a site releases a pollutant below the threshold. SPRI emissions data from 2002 to 2007 (except 2003) are available and reported annually[45].

None of the latter sources provide an indication of the likelihood of incidents.

42 www.environment-agency.gov.uk/business/regulation/31827.aspx

43 www.environment-agency.gov.uk/homeandleisure/37833.aspx

44 www.environment-agency.gov.uk/research/library/data/34363.aspx

45 www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

DEPARTMENT FOR ENVIRONMENT FOOD AND RURAL AFFAIRS (DEFRA)
DEFRA publicly provide data on pollution incidents by region as part of their e-Digest Statistics on inland water quality and use.

EMERGENCY PLANNING COLLEGE (EPC) – MAJOR INCIDENTS DATABASE
The EPC Major Incident Database notes three shipping incidents (1990, 1993, 1996), two incidents of polluting waterways (1994 and 1990), and one air quality incident (1991). This database is available at:

- www.epcollege.gov.uk/library_and_information_centre/major_incidents_dbase.aspx

SHIPPING DATA
A study has provided a map of the quantities of oil passing through UK waters and to and from UK ports, which may inform local assessments of pollution risk. The paper also notes that the MCA hold maps of the vulnerability of oil pollution at sea.

- Page 50 of www.belspo.be/belspo/Northsea/publ/Report%20MIMAC.pdf

The MCA also hold data on ship movements through UK water which include data on ship type and size. For example, it quotes 36 per cent of movements through Dover strait and 32 per cent through the southern North Sea area.

The MCA completed as a research exercise a predictive study of chemical tanker releases in UK waters.[46] This gives the frequency and magnitude of releases, and their most likely location in the UK. For example, it indicates about four chemical tanker and 1.5 gas carrier incidents per year around the UK, with about one every two years resulting in a spill (mostly due to foundering or grounding).

By combining the estimated incident rates with the ship movement data it is possible to develop a crude estimate of the incident likelihood per ship movement through a shipping area. For example, with 36 per cent of chemical ship movements going through the Dover Strait (about 5,229 vessels) and 0.42 spills in the UK, this equates to 0.15 spills per year in the Dover Strait or 0.00026 per chemical tanker vessel passing through the Dover Strait.

The DfT have established 32 Marine Environmental High Risk Areas (MEHRAs). The areas are mapped, described and ranked from highest to lowest risk, thereby supporting an element of local risk assessment.

- www.dft.gov.uk/pgr/shippingports/shipping/elc/secmehras/pdfmehras.pdf

[46] Chemical spill risk assessment. Research report 447. www.mcga.gov.uk/c4mca/mcga-research_report_447.pdf

The report also shows on Map 10 the risk ranking of the entire UK coastline, which allows a relative risk assessment to be completed. The DfT also provide detailed vulnerability maps for each part of the UK coastline at the above site.

The map is also available on the MCA website at:

- www.mcga.gov.uk/c4mca/mcga-05_annex_c-mehras_map.pdf

Since 1974, the International Tanker Owner Pollution Federation has maintained a database of accidental oil spills from tankers, combined carriers and barges. A summary[47] of some key points has been reported, including the long-term downward trend in spills in UK waters, about 35 per cent to 45 per cent reduction every ten years. This may be used to guide judgement of future incident rates in the UK. They also publicly report and list all major oil spills (worldwide).

47 Trends in oil spills from tanker ships 1995-2004. International tanker owner federation. by Keisha Huijer. Paper presented at the 28th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, 7-9 June 2005, Calgary, Canada www.itopf.com/_assets/documents/amop05.pdf

6 Industrial infrastructure

FORM OF RISK ASSESSMENT POSSIBLE

The restricted National Resilience Planning Assumptions, which cover the nature and scale of incidents, provide:

- Expected likelihood of a local, as well as a national electricity loss of supply, along with the expected durations
- Expected likelihood of a significant strain on national gas supplies causing restrictions on supply
- Expected likelihood of a local loss of the public service telephone network and its duration, and for a regional loss of network
- Expected likelihood of a local loss of water supply, as well as for regional supplies, along with the expected duration of disruption
- The loss of transport is based on low temperatures and heavy snow or loss of power, with an expected likelihood and duration given. This could be added to loss of transport due to flooding.

No superior source of risk assessment values could be identified, or indeed, would be necessary. Therefore, it is suggested that assessment of local industrial infrastructure failure can be achieved by use of the National Resilience Planning Assumptions.

7 Human and animal health

7.1 Overview

Human and animal health, are presented together here as they are both subject to the same type of risk assessment. That is, the possibility of animal or human health incidents is reported to be subject to international events and the emergence of new conditions. These risks are dynamic. Over the past 25 years, the Cabinet Office report that more than 30 new, or newly-recognised, infectious diseases have been identified around the world. Therefore, the risk assessment involves surveillance of real time events in the UK and overseas. The risk assessment may change in response to changing events.

The assessment of these risks requires specialist expertise. In addition, given the international nature of these risks, the likelihood of events is assessed for the UK as a whole, although the consequences may vary locally.

Therefore, it is recommended that the national animal and human health risk assessments are drawn on at a local level. It may be noted that, at this time, the national risk assessments generically assess the likelihood as probable. This likelihood would apply nationally.

7.2 Human health

7.2.1 Tools and techniques

A number of assessments indicate that there is a significant risk of a human influenza pandemic occurring at some point, whether in the short-term or further into the future, starting anywhere in the UK. As stated by the Global Outbreak Alert and Response Network of the World Health Organisation (WHO)[48] 'Experts at WHO and elsewhere believe that the world is now closer to another influenza pandemic than at any time since 1968, when the last of the previous century's three pandemics occurred.' The NHS is reported to assume a 3 per cent chance per year of a flu pandemic, based on three occurring in the past 100 years (this likelihood level is termed 'Possible' using LRAG criteria). It is stated in the Department of Health's (DOH) National Framework[49] that:

> "A future influenza pandemic could occur at any time (intervals between the most recent pandemics have varied from about 10 to 40 years with no recognisable pattern, the last being in 1968-69)." (p24)

[48] A national framework for responding to an influenza pandemic www.who.int/csr/disease/avian_influenza/phase/en/

[49] www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_073168

A national risk assessment has been completed by the Health Protection Agency (HPA), giving the possible severities of a flu pandemic in the UK. The UK national modelling indicates a number of scenarios, including:

- Twenty five per cent of the population suffering from influenza over one or more 'waves', each of around 15 weeks duration, and potentially weeks or months apart, with a case fatality rate of around 0.37 per cent (about 53,000 excess deaths across the UK). A second wave could occur and be more severe
- The 'worst-case scenario' is that 50 per cent of the population will suffer from influenza with a case fatality rate of 2.5 per cent (over 700,000 excess deaths across the UK).

These scenarios are based on past pandemics, of which there have been three (1918, 1957 and 1968) to which a future pandemic may not conform. They are elaborated in the aforementioned DoH National Framework.

Other researchers have developed flu pandemic models, such as the Indiana University School of Informatics[50], however, they all require specialist expertise and provide similar results to those of the HPA/DOH.

The WHO has defined six phases in the evolution of an influenza pandemic which define a staged approach to preparedness planning and response, leading up to the declaration of the onset of a pandemic. The Government has identified four additional UK alert levels (within WHO phase 6) to define the extent of the pandemic within the UK.

The WHO phases and UK alert levels are as noted below.

1) Inter-pandemic period

- Phase 1 – Low risk of human cases: No new influenza virus subtypes have been detected in humans. An influenza virus subtype that has caused human infection may be present in animals. If present in animals, the risk of human infection or disease is considered to be low
- Phase 2 – Higher risk of human cases: No new influenza virus subtypes have been detected in humans. However, a circulated animal influenza virus subtype poses a substantial risk of human disease.

[50] www.newsinfo.iu.edu/news/page/normal/4684.html

2) Pandemic Alert Period

- Phase 3 – No or very limited human-to-human transmission: Human infection(s) with a new subtype, but no new human-to-human spread, or at most rare instances have spread to a close contact
- Phase 4 – Evidence of increased risk of human-to-human transmission: Small cluster(s) with limited human-to-human transmission but spread is highly localised, suggesting that the virus is not well adapted to humans
- Phase 5 – Evidence of significant human-to-human transmission: Large cluster(s) but human-to-human spread still localised, suggesting that the virus is becoming increasingly better adapted to humans, but may not yet be fully transmissible (substantial pandemic risk).

3) Pandemic Period: efficient and sustained human-to-human transmission

- Phase 6 – Pandemic phase: increased and sustained transmission in the general population
  - UK Alert level 1 – Virus/cases only outside the UK
  - UK Alert level 2 – Virus isolated in the UK
  - UK Alert level 3 – Outbreaks(s) in the UK
  - UK Alert level 4 – Widespread activity across the UK.

4) Post-Pandemic Period

- End of pandemic – return to inter-pandemic period.

For UK planning purposes, the Government is working on the basis that, from Alert level 2, it may take two to four weeks for the virus to become established in the UK and seven to nine weeks for activity to reach a peak. Once Alert level 3 has been reached, there is likely to be intense pressure on healthcare and all other services for at least six to eight weeks.

This alert system essentially forms the real time risk assessment process, along side the generic conclusion that a pandemic could occur in the near future and range in severity as noted.

BUILDING ON THE NATIONAL RISK ASSESSMENT

Whilst it is difficult to see how a LRF or FRS can add to the national risk assessment, it is possible to examine the local impact, in a number of respects particularly:

- The impact on local services – such as how the availability of local emergency services may be impacted. A standard, if undocumented, process is to assess what level of service may be maintained with reduced availability of staff, and how diminished resources may best be distributed
- The impact of loss of utilities on local services, such as how the loss of power (due to staff absences), impact provision of medical services.

Thus, at a local level, a risk assessment can be completed of the ability of local services to respond to a pandemic and manage its impact on their service provision. This generally takes the form of a 'what if' assessment, ie what if 25 per cent of staff were absent from work. The assessments tend to include examining peak demands and variable level of staff absence.

7.2.2 Data sources

Some useful sources include:

- The current WHO phase of pandemic alert - www.who.int/csr/disease/avian_influenza/phase/en/
- UK DOH's Influenza Pandemic Contingency Plan - www.dh.gov.uk/PolicyAndGuidance/EmergencyPlanning/PandemicFlu/fs/en
- Eurosurveillance, which is an open-access peer-reviewed journal about infectious diseases surveillance, prevention and control in Europe. It includes reports on the extent of outbreaks across the world. www.eurosurveillance.org/Default.aspx
- UK DOH information on potential scale and impact on care services at: www.dh.gov.uk/en/Publichealth/Flu/PandemicFlu/index.htm
- DEFRA's revised Contingency Plan for Exotic Animal Diseases, supplementing Defra's Framework Response Plan for Exotic Animal Diseases (covers avian flu) - www.defra.gov.uk/animalh/diseases/control/contingency/exotic.htm
- WHO Avian Influenza website - www.who.int/csr/disease/avian_influenza/en/

7.3 Animal health

7.3.1 Form of risk assessment possible

There have been a number of cases of significant animal disease in the UK. These include:

- Bluetongue – 2007 ongoing at time of reporting (February 2009) in Great Britain (GB)
- A limited case of foot and mouth in Guildford due to a release from a laboratory, 1997
- Avian influenza outbreak June 2008
- A major 2001 foot and mouth outbreak; across GB
- 1967 foot and mouth outbreak confined to small part of England.

In addition, there have been a number of avian 'flu' outbreaks in recent years including a highly-pathogenic H5 avian flu in a dead swan in Scotland 2006, H7 at an English chicken farm and H5NI infection at a Suffolk turkey farm in 2007, although they were all contained by emergency procedures. Thus, historical data would suggest that some form of animal health outbreak is Probable (using the LRAG guidelines, ie once every ten years or more often) somewhere in the UK, although the scale is uncertain.

However, it is difficult to base predictive risk assessment on past history because:

- The risk controls have changed
- Agricultural and transport practices change
- It is not possible to fully know the risk of disease introduction through illegal imports or other human activities from the affected countries where the disease is endemic, or because of uncontrollable natural phenomena
- The risk is subject to overseas events, including importation of contaminated stock and migratory birds.

As with flu pandemics, animal health risks can arise from overseas, as well as originating in the UK, particularly foot and mouth disease, Swine Fever, Bluetongue and Newcastle Disease and avian influenza. Therefore, animal health risk assessment involves monitoring of disease outbreaks around the world, reporting on latest developments and risks.

DEFRA do not carry out a detailed consequence assessment because it is assumed that an animal disease will have a high impact on the UK animal health and that the consequences of an outbreak will be unacceptable because of potential damage to the UK's rural economy, export industry and costs of implementing control measures.

An LRF may wish to consider the vulnerability of the local economy to damage due to movement restrictions and/or loss of trade. For example, it may assess what proportion of employment or trade is dependent on agriculture or leisure access to the countryside.

7.3.2 Tools and techniques

DEFRA REAL TIME RISK SURVEILLANCE

DEFRA carry out a qualitative risk assessment when notified of a new disease incident in an EU state. The qualitative risk assessment is outlined at:
www.defra.gov.uk/animalh/diseases/monitoring/pdf/riskplan.pdf

This is a real time risk assessment. As part of these they do provide an indication of the current likelihood of introduction to the UK. Risk is graded as follows:

- Negligible – not worth considering; insignificant
- Low – more than negligible. Comparable to the background level of risk through illegal imports or uncontrollable routes
- High – Introduction of disease is probable. Comparable to the risk due to importation of live animals which have been exposed to infection. UK livestock likely to be exposed through contact with imported animals or germplasm.

LOCAL VULNERABILITY ASSESSMENT

Local risk assessment can take the form of assessing the vulnerability of the local economy to restrictions on agriculture and movement of people. At the time of reporting no specific method was identified to aid this assessment. It tends to be a 'what if' form of assessment that explores what if there were restrictions on movement of people, vehicles and livestock, considering by judgement the impact on the economy and local services.

SPECIALIST MODELLING

The University of Liverpool (www.liv.ac.uk) developed a computer model for avian flu. They state that:

> "We have also classified 12,000 farms in the UK according to the species they raise and the purpose of the farm; for example, is it a chicken meat farm, chicken egg farm or duck meat? The team modelled each farm detailing who their contacts were – feed mills, slaughter houses and other farms for example. This level of detail helps us predict areas and industry sectors at greatest risk."

The model also provides analysis of government policy, such as the implementation of control zones. This strategy aims to limit the movement of birds, as well as trace potential contacts where transmission of the disease is more likely. The team found that this strategy was beneficial in reducing the chance of very large outbreaks to almost zero.

This is a specialist model. However, its results may be drawn on by LRFs to develop local plans based on local risk assessments.

7.3.3 Data sources

DEFRA provides a variety of information that can be drawn on in local risk assessments. These include:

DEFRA SURVEILLANCE REPORTS
Clinical scanning surveillance information derived from diagnostic samples and carcasses is collected and analysed to determine baseline disease levels in the animal population. The aim is to provide a targeted assessment of the current animal disease status of Great Britain (GB) and to warn of potential risks from changing disease trends or new diseases, and of zoonotic diseases of human health significance.

These are available at: www.defra.gov.uk/vla/reports/rep_surv.htm

The reports cover:

- Avian
- Cattle
- Pigs
- Small ruminants (goats and sheep)
- Wildlife
- Miscellaneous captive exotic and farmed species

The reports include real time Endemic Disease Surveillance. They do require an understanding of clinical results.

DEFRA MAPS SHOWING THE DENSITY OF ANIMALS
Cattle, pig and poultry farms are registered with DEFRA who publish maps of the density of farms and animals, including:

- **Pig maps**[51]
- **Sheep maps**[52]
- **GB Poultry Register** – This contains location and size of all registered poultry farms (with 50 or more birds) in the UK and is held by DEFRA. Publicly available information[53] includes maps of the density of each type of bird and farm per county. These may assist with assessing potential scale of incidents in a county
- **RADAR Cattle handbook** – All cattle farms are registered with DEFRA who publish a handbook[54] giving maps of the density of cattle and cattle farms. These may assist with assessing potential scale of incidents in a county.

[51] Pig maps can be found at www.defra.gov.uk/animalh/diseases/vetsurveillance/reports/pdf/dist-pigs-uk030604.pdf

[52] Sheep maps can be found at www.defra.gov.uk/animalh/diseases/vetsurveillance/reports/pdf/sheep-totnum010603.pdf

[53] www.defra.gov.uk/animalh/diseases/vetsurveillance/reports/pdf/poultry-registered140706.pdf

[54] www.defra.gov.uk/animalh/diseases/vetsurveillance/pdf/radar-cattlebook06.pdf

Maps for other types of farm animals are available on DEFRA's Veterinary Surveillance pages (www.defra.gov.uk/animalh/diseases/vetsurveillance/index.htm).

WORLD ORGANISATION FOR ANIMAL HEALTH

The World Organisation for Animal Health (OIE[55]), as referenced by DEFRA, provides:

- Official Country Disease status[56]
- Disease outbreak maps, a summary of all immediate notifications and follow-up reports for any unusual disease events submitted by reporting Member Countries, by week.[57]
- A publicly searchable database of notified animal disease incidence for all countries, including the UK[58] but not the scale of the outbreak.

55 www.oie.int/eng/en_index.htm

56 www.oie.int/wahis/public.php?page=disease_status_map&disease_type=Terrestrial&disease_id=1&empty=999999&sta_method=semesterly&selected_start_year=2008&selected_report_period=1&selected_start_month=1&page=disease_status_map

57 www.oie.int/wahis/public.php?page=disease

58 www.oie.int/wahis/public.php?page=disease&WAHIDPHPSESSID=6dbf6e841fbb5381beb740e7005a22c1

8 Structural collapse

8.1 Overview

This section is limited to accidental structural collapse and excludes collapse due to terrorist attacks.

FORM OF RISK ASSESSMENT POSSIBLE
The very low frequency of accidental structural collapse of structures in the UK means that there is a limited basis on which to assess structural collapse risk for the sake of LRFs or IRMPs. In addition, no comprehensive source of data could be identified covering structural collapses in the UK, or elsewhere. Therefore, risk assessment is limited to the use of publicly available information of incidents.

LEVEL OF EXPERTISE NEEDED
A minimum of expertise is needed to use the only identified risk analysis tool for structural collapse, namely Communities and Local Government's FSEC Toolkit.

AUTHORS' GUIDANCE
Accidental structural collapse is a rare event in the UK and has historically resulted in relatively few casualties, classed as Moderate severity using the LRAG scale. It is suggested that, for the sake of IRMPs and LRF purposes, that a simple generic incident rate per million buildings is used along with a generic rate for miscellaneous structures such as temporary arenas. As the rate of incidents is very low, it is advised that any local incident data is unlikely to provide a valid measure of risk.

8.2 Tools and techniques

No currently available specific tools or techniques were identified to assist LRFs or FRSs in assessing structural collapse risk in the context of IRMPs or local civil contingency planning. Some analysis has been completed on incidents in support of the FSEC Toolkit. The analysis used publicly available reports of cases of structural collapse and data on the number of buildings in the UK to provide generic incident rates, measured as a rate one per 16.5 million buildings. It also provided a generic incident rate to reflect risk associated with miscellaneous structures such as walkways and temporary arenas. The results were being used at the time of producing this guide to further develop a major incident module in the FSEC Toolkit. Once released the major incident module of the FSEC Tool will provide a measure of the frequency of structural collapse incidents and their severity. The FSEC Toolkit is available to all GB FRSs.

8.3 Data sources

No specific data sources were identified to assist LRFs or FRSs in assessing structural collapse risk in the context of IRMPs or local civil contingency planning. Sources such as Valuation Office and Land and Property Gazetteer can be used to indicate the number of buildings in an area. This can then be multiplied by the generic incident rate to give an indicative likelihood of incidents.

9 Terrorist and protest

9.1 Overview

FORM OF RISK ASSESSMENT POSSIBLE

Civil protest (such as riots and major strikes) and terrorist risks are grouped together here as being 'dynamic' types of risk. That is, the likelihood and severity will change over time. Therefore, unlike accidents, the future likelihood of terrorist and civil protest risks cannot reliably be indicated on the basis of past experience. Instead, the form of risk assessment is closer to a real time monitoring of events and emergence of threats. The nature and likelihood of such threats can change.

There is some scope to assess the risk of public protest using judgement or predictions based on some, limited, previous research. However, as factors such as unemployment change over time, so would the risk of public protest.

LEVEL OF EXPERTISE NEEDED

The threat assessments tend to require specialist security expertise and tend to require confidential information not available at a local level. However, the national threat levels can be applied at a local level by applying guidance on the identification of local 'targets', to give an indication of relative likelihood at a local level.

The assessment of public protest risk may be achieved, to some extent, by use of 'guidelines' drawn from past experience and research.

AUTHORS' GUIDANCE

It is recommended that, in the case of terrorist risk, national threat assessments are drawn on at a local level along with guidance on identifying local 'targets' to give an indication of relative likelihood and severity of local risks. Some specific guidance is available to elaborate local risk assessments, as noted below.

In the case of public protest, the guidelines outlined below are recommended for application by LRFs.

As the rate of incidents is very low, it is advised that any local incident data is unlikely to provide a valid measure of risk.

9.2 Public protest (riots)

9.2.1 Tools and techniques

No specific risk assessment technique was identified beyond the work for the FSEC Toolkit (not yet published). A process has been improvised to give an indication of the likelihood of riots. The process is based on a minimum of research into the characteristics of areas that have experienced riots and violent disturbances in GB. In particular it draws on work by the Joseph Rowntree Foundation (1997[59]) which identified the features of communities experiencing riots, namely areas where unemployment and lone parents are three or more times than national average (namely >12 per cent are lone parents and >12 per cent are unemployed) and people aged under 24's are about 10 per cent more than on average (namely >45 per cent are young people). These features were used to produce an algorithm that indicates areas at risk of riots, which relates the likelihood of public disorder to how many of these conditions exist.

The FSEC Toolkit will also provide[60] some very simple guidelines on the frequency of riots in different types of areas, such as deprived cities versus rural areas, based on the rate of riots in previous decades. The toolkit is available to all FRSs.

The latter work is limited to giving an indication of 'community' riots, usually of a local scale. It does not cover 'political' or 'industrial' protests akin to the 1984 miners' strike or the 1990 'poll tax' riots.

In addition, the likelihood of riots is dynamic and responsive to changing social and economic events. Therefore, whilst past events may provide a broad indication of frequency, the future likelihood is subject to judgement based on a review of current events.

9.2.2 Data sources

No specific data sources were identified other than searches of public sources. A search of sources[61], such as newspapers and research studies, identified 17 major disturbances between 1980 and 2006, mostly in the 1980's. This data can be used in developing crude historic frequencies. As the riots occurred in six major cities, there was a one in ten rate per year per city over the quoted period, ie probable in LRAG terms. Obviously judgement must be applied to the question of whether the past rate of riots would occur in future years.

[59] Riots and violent disturbances in thirteen areas of Britain. Social Policy Research 116 – June 1997. www.jrf.org.uk/knowledge/findings/socialpolicy/sp116.asp

[60] Major Incident module currently under development

[61] FSEC major incident module. Report to Communities and Local Government by Greenstreet Berman Ltd, 2008, unplublished.

9.3 Industrial protest

9.3.1 Tools and techniques

No specific risk analysis technique or data could be identified to support assessment of industrial protest risks. It is generically rated within the LRAG (Restricted) based on judgement. As noted before, this is a dynamic risk whose likelihood can change depending on industrial and economic developments, and Government preventive measures adopted since previous protests.

It may be noted that there have been a number of major industrial protests including:

- Fuel protests of 2000 – the financial impact of the week-long fuel drought was estimated at close to £1 billion[62]
- UK Fire Service strike of 2002-03.

If these events are accepted as major incidents, they suggest a Probable or Possible likelihood using the LRAG guidance at both a national and local level. It may be noted that there have been other local public service strikes and threats of strikes in the period 2000 to date of reporting, suggesting a higher likelihood of localised major industrial protest. Clearly the low frequency and dynamic nature of industrial protests renders any risk assessment unlikely.

In previous decades there was the coal miners' strike of 1972, 1974 and 1984, and the assorted strikes in 1978-79. Clearly though, industrial law and developments mean that the frequency of past events may not be a guide to the future.

Notwithstanding the uncertainty around industrial protest possibilities, it is suggested that the historical frequency of such events indicates that, for the sake of LRF planning purposes, basing likelihoods on past experience is a reasonable approach. Obviously judgement must be applied to the question of whether past rates of incidents may re-occur. Whilst the specific disputes may not re-occur, a view must be taken of whether a dispute of similar scale and type could occur.

In addition, systems may have been developed in response to past events that may reduce the likelihood or severity of repetition, such as the National Emergency plan for responding to fuel protests and shortages.

BUSINESS CONTINUITY RISK ASSESSMENT
At a local level, the main form of risk assessment comprises a form of contingency planning for a degraded service due to loss of staff, fuel or utilities. The assessment focuses on whether there is a risk of local services being unable to maintain operations in the event of loss of supplies etc.

[62] www.iwar.org.uk/cip/resources/PSEPC/fuel-price-protests.htm

Guidance is available from The Department for Business Enterprise and Regulatory Reform (BERR) on business continuity risk analysis at:

- www.berr.gov.uk/whatwedo/sectors/infosec/infosecadvice/continuitymanagement/process/page33406.html

This includes an impact analysis to identify critical business processes that may be affected and vulnerability analysis.

Guidance is also available at:

- www.preparingforemergencies.gov.uk/bcadvice/index.shtm

This includes a Business Continuity Management Toolkit, which also contains some guidance on risk assessment.

9.3.2 Data sources

No specific data sources were identified other than searching publicly available sources.

9.4 Terrorist

9.4.1 Tools and techniques

THREAT LEVEL ANALYSIS
The Joint Terrorism Analysis Centre provides assessments of the threat level from international terrorism with the Security Service covering domestic terrorism, as outlined at www.mi5.gov.uk/output/the-uks-threat-level-system.html. There are five threat levels which inform decisions about the levels of security needed to protect Critical National Infrastructure (CNI), namely:

- Low – an attack is unlikely
- Moderate – an attack is possible, but not likely
- Substantial – an attack is a strong possibility
- Severe – an attack is highly likely
- Critical – an attack is expected imminently.

The current threat level is published by M15 on its website (www.mi5.gov.uk/output/the-threats.html).

This threat assessment is national rather than local to any part of the UK.

It can be noted that the National Risk Register, which is in the public domain, gives the likelihood of Attacks on Public places as the same as flu pandemics (which are stated as probable), whilst non-conventional attacks are on par with inland flooding (which is unlikely). These are national likelihood judgements. In the case of terrorist attacks, a judgement must be made as to whether the likelihood in any one LRFs is less than the likelihood for the UK as a whole, and whether it is proportionately less or not. With a 'Probable' (about one in ten years, or more frequent) likelihood, and dozens of major UK cities, the local likelihood could be pro rated down. However, areas with more targets are obviously more likely to be attacked.

NATIONAL NEW DIMENSIONS PROJECT
Whilst there is no known local risk assessment method, the UK Fire Service did develop and apply a method for risk rating individual buildings from one to eight (eight being the greatest risk). The risk rating included likelihood and severity. The methodology is restricted but can be obtained by persons with Basic Clearance from Communities and Local Government's Fire and Resilience Directorate.

The method can be drawn on to provide a view of the local likelihood and severity of a terrorist incident. For example, the existence of sites classed as eight combining with a 'Severe' threat level could be interpreted as indicating a high risk (Probable in LRAG terms).

RESILIENCE PLANNING ASSUMPTIONS
The restricted Cabinet Office guide on National Resilience Planning Assumptions provides information on the presumed scale and severity of incidents that can be drawn on for local risk assessments.

9.4.2 Data sources

No specific data sources were identified beyond the:

- UK Resilience website (www.ukresilience.gov.uk/emergencies/terrorism.aspx) and;
- The EPC Major Incidents database www.epcollege.gov.uk/library_and_information_centre/major_incidents_dbase.aspx

CENTRE FOR THE PROTECTION OF NATIONAL INFRASTRUCTURE
The Centre for the Protection of National Infrastructure[63] provides security advice on protection of national critical infrastructure.

63 (www.cpni.gov.uk/aboutcpni188.aspx)

10 Domino effects

10.1 Introduction

An event such as a flood or industrial explosion can have multiple effects, including loss of infrastructure. Some examples include:

- A flood disabling a power plant or water treatment works, causing loss of utilities
- An industrial fire causing closure of a major road or railway
- Heat waves causing excessive demand on power supplies
- A flood causing loss of emergency services.

This leads to the issue of modelling the 'knock-on' effects of incidents.

10.2 Generic tools

No tool was identified that has been developed to specifically address this need.

As a matter of principal, the assessment of knock-on effects is achieved, in practice, by:

- Review of past events, for example reviewing the impact of a past heat wave on power demand, transport systems, public disturbances, etc, as well as public health
- Judgement by scrutiny of the event, including identifying interdependencies between services (such as power supply loss impacting railway services)
- Using process flow diagrams to map out interdependencies.

Some tools that can assist include:

- The use of Geographic Information Systems – such as to identify critical infrastructure in the area impacted by floods, explosions, storms etc
- The use of flow charts (sometimes called LifeLine charts) to map out domino effects – this is akin to a process flow diagram where one activity or service links to another, so that the impact of interruption of one part of the process on downstream parts can be identified

  Process flow charts are a simple and common practice and can be found in common sources such as www.en.wikipedia.org/wiki/Business_process_modeling

- The use of key words such as 'what if' 'x' is lost?

  'What if' hazard analysis is a standard form of risk assessment that asks 'What if' certain failures happened, such as equipment failure? It relies on 'brainstorming'. Guidance is publicly available on its application to safety issues[64].

The field of business continuity planning has developed and applied a variety of approaches to assessing interruption of operations. Whilst they often focus on financial outcomes, they do offer some concepts and measures that can be applied more widely. Some examples[65], which can be paraphrased, include:

- *Determine Criticality* – Identifying critical function and the impact of a disruption. While non-critical functions and processes may have a lower priority, consideration should be given to the impact of interdependencies between various functions before ultimately determining their criticality and priority. For example, loss of power supply may cause loss of water supply
- *Estimate Maximum Downtime* – Estimate the maximum downtime that can be tolerated – that is the duration that a service is unavailable without having an adverse impact (such as loss of water supply can be tolerated for 'n' hours)
- *Evaluate Resource Requirements* – Estimate realistic recovery efforts required to resume critical operations.

The field of major accident hazard analysis includes the application of probabilities to the modelling of knock-on effects. This can be expressed on the form of an event tree, where the initiating event may lead to a variety of secondary impacts, each with a certain probability. The probabilities are derived from historical experience, computational modelling or judgement. Guidance on event tree analysis is commonly available (such as at www.event-tree.com/ and www.fault-tree.net/papers/clemens-event-tree.pdf) along with commercially available software. In many cases a simple event tree can be produced using Microsoft Excel or other charting packages.

Thus, at the time of reporting, it is necessary to draw together good practice and apply it using expert judgement for the sake of assessing inter – dependencies and domino effects.

64 www.web.mit.edu/course/10/10.27/www/1027CourseManual/1027CourseManual-AppVI.html

65 www.ffiec.gov/ffiecinfobase/booklets/bcp/bcp_14.html

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