RECENT DEVELOPMENTS IN THE USE OF SOCIETAL RISK ASSESSMENT FOR LAND USE PLANNING FOR UK NON-NUCLEAR, ON-SHORE MAJOR HAZARD INSTALLATIONS†

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This paper presents an overview of a programme of work the Health and Safety Executive is conducting following the UK government public consultation on societal risk in 2007. The work programme is examining techniques for the assessment of societal risk in the vicinity of selected COMAH sites, and how societal risk could be used to supplement existing controls of development around such sites. The programme includes an examination of approaches used elsewhere, testing of risk assessment techniques and presentation of results from model sites. The paper will briefly examine how these techniques could operate within the UK's regulatory framework including possible criteria for Land Use Planning (LUP) decision making.

INTRODUCTION

Risk assessment has been used for many years to analyse and assess risks from hazardous activities in the UK. The existing planning system for development in the vicinity of hazardous installations involves HSE determining a Consultation Distance (CD) and hazard zones for the installation, based on individual risk calculation.

Local Planning Authorities use HSE's advice, PADHI (1), to judge the advisability of developments within the consultation distance. HSE's risk assessments to calculate consultation distances are based on the concept of 'individual risk'. The number of people present at a new development and their vulnerability is taken into account within the PADHI assessment process. But advice for a new development does not take account of the number of people already present in the vicinity, and the rest of the area surrounding the hazardous installation.

The introduction of the Control of Major Accidents Hazards (COMAH) Regulations in 1999 required operators of Top Tier COMAH installations to provide, as part of their safety report, information about the potential effects of major accidents. This included information about the likelihood of the event, how far the effects might be experienced off-site and the number of people that could be affected. In some cases, although the likelihood of such events may be very low, a significant number of people could be harmed if such an event occurred.

HSE subsequently used this information to produce estimates of societal risk levels around all COMAH top and lower tier major hazard sites. For this work societal risk is defined as the relationship between frequency and the number of people suffering from a specified level of harm in a given population from specified hazards, and does not include societal concern, which is discussed later. The societal risk estimates indicated that there are a number of sites (about 50) where the criterion of an accident that could harm 50 or more people once in 5000 years (2) was exceeded. It should be noted that this is out of a total of about 1400 COMAH installations in the UK.

A consultation exercise (3) confirmed that societal risk techniques should be looked at in the context of development proposals around COMAH installations. The Buncefield incident added impetus to this work and the Major Incident Investigation Board land use planning report's (4) recommendations endorsed and supported HSE's on-going work on societal risk.

This paper is a summary of some of the key areas of work in this project, illustrating some of the complex considerations, and details of some aspects of the approaches being considered.

PROJECT DEVELOPMENT

Any changes in policy for land use planning that take societal risk into account will have a consequential effect on other Government policies in areas such as industry, housing and planning. Changes to advice provided by HSE and decisions made by planning authorities could result in further constraints on new development around major hazard installations. An Inter Governmental Task Group has been set up with the following key objectives:

- Ensuring the health and safety of workers and those living around major hazard installations;
- Enabling available land to be put to the most efficient and productive use for housing, economic development, public services and amenities;
- Establishing a regulatory environment in which business and industry can invest and flourish not only producing employment and wealth, but also meeting the UK's strategic needs and delivering sustainable economic development.

Two stakeholder groups have been created to assist HSE in examining methodologies, criteria and decision frameworks:

- Technical Advisory Group (TAG) – this is a group with representatives from academia and industry, the Depart-

ment for Communities and Local Government, the Department for Business, Innovation and Skills, the Scottish Government, the Welsh Assembly and HSE.
- Local Planning Authority (LPA) Focus Group who represent local authorities likely to be affected by any new policies.

The TAG is considering issues relating to how societal risk can be integrated into land use planning decisions and COMAH assessments. This includes the nature of risk assessment, scale aversion and the role of criteria in decision making.

The LPA Focus Group is reviewing and commenting on the output from societal risk trials. The trials are using three volunteer local planning authority areas encompassing seven major hazard sites. The purpose of the trials is to test the package of risk assessment methodology, criteria and decision-making for taking account of societal risk in planning decisions, primarily in the preparation of development plans, but also to inform decisions for individual planning applications.

The trials aim to produce societal risk estimates around the identified major hazard sites, both as the local population exists now and as it will do when local development plans are implemented.

Currently HSE advises planning authorities (PAs) whether any particular proposed development is suitable given the risks from a major accident at the installation and takes into account the location, size and type of the proposed development. This is based on a risk assessment carried out by HSE. The risk assessment currently leads to the production of a consultation distance for a hazardous installation, within which local authorities must seek HSE advice regarding proposed developments. Local authorities can then weigh this advice against other factors when deciding whether to grant planning permission.

SOCIETAL RISK – SOME IMPORTANT ISSUES BEING CONSIDERED

Societal risk is a reasonably straightforward concept but when it comes to undertaking an assessment of societal risk estimates, a host of issues arise.

A risk assessment is often carried out by an operator to better understand the risks associated with a process, for instance the proportion of risk that different hazards contribute, so that they can be reduced or controlled more effectively by targeted risk reducing measures. The regulator uses risk assessment of hazardous installations to set a framework for LUP control around a site. These are two different objectives and affect how a risk assessment is approached.

A site operator should use site specific data as far as practicable, and may aim for a best estimate of the risk. The assessment for land use planning purposes will generally use industry representative data and take a cautious best estimate approach, because it is seeking to establish a control framework that will be in place for some time.

Among the issues that have to be considered during the course of a societal risk assessment, some of the more significant ones are;

- Hazardous installation consented quantities;
- Scale aversion;
- Measures of societal risk;
- Societal risk criteria;
- Socio-economic benefits;
- Assessment of results for advice and action.

These issues are being considered by the HSE Project team through consultation and discussion with the technical advisory group and the local planning authority focus group.

HAZARDOUS SUBSTANCES CONSENT

Consented quantities of hazardous substances are legally granted rights for hazardous installations. They are granted under planning law by the hazardous substances authority (usually the local planning authority) and HSE has to be consulted for advice on the health and safety risks. Once a 'consent' is granted, an operator is entitled to hold the defined quantities of hazardous substances on an installation. HSE have to assume these quantities could be handled at any time with no reference to the planning authority (PA) or HSE, and HSE must use these consented quantities in societal risk calculations. This could lead to hazard ranges that may constrain development in the vicinity of these installations.

As consented quantities of hazardous substances allow flexibility for a company's operations, it is understandable that companies may not want to reduce these quantities without careful consideration.

SCALE AVERSION

An analysis of the literature (5) concluded that there is little evidence that society is averse to multiple fatality events, but there is evidence that society is more affected by some types of accident due to the nature and dread of certain types of events. There is also evidence that the 'informativeness' of events as indicators of future dangers, causes society to place a greater emphasis on the prevention of these events.

The issue of blame also appears important – society believes greater preventative measures should be taken where government or businesses may be to blame. Therefore the societal impact of an accident cannot be modelled solely as a function of the number of people affected, and other factors such as the benefits provided by a hazard should be taken into account.

Scale aversion has been examined in more detail in a specific report for this project (6). This has concluded that there is some qualitative support for scale aversion in the decision making process overall, but the balance of opinion is that scale aversion should not be included in the numerical estimation of risk.

SOCIO ECONOMIC BENEFITS

It must also be recognised that a hazardous installation is likely to bring benefits to the surrounding area, and the local and wider economy, which could in some way be offset against the unwanted effects from its location. These benefits could include local employment and benefits to surrounding businesses, and income to the local council. There may also be national strategic benefits associated with some hazardous installations which may be necessary to take into account.

The project view is that these, and other benefits should be taken into account in the decision making process. But it is considered that this task is not within the scope of HSE whose remits covers 'risks to people'. The inter departmental task group has asked the department of communities and local government to provide guidance to LPA decision makers on those factors that can be considered with safety and risk advice.

MEASURES OF SOCIETAL RISK

Table 1 (7) lists some measures for representing societal risk that have been considered in the project. These measures must be capable of being compared with criteria or guidelines so that any decision based on them is sound. The measures and associated guidelines must also be understandable by all those involved in the process from risk assessors to planners.

Table 1. Some advantages and disadvantages of various societal risk measures

Measure	Advantages	Disadvantages
fN points (f is the frequency of an event that leads to N casualties.)	Contains the greatest amount of information.	Difficult to apply sensible criteria.
fN histogram	Simple.	Less information than an FN curve.
FN curves (F is the cumulative frequency of events that lead to N or more casualties.)	Generally accepted as the best way of presenting societal risk. Various reasonably well established criteria (compared with any other societal risk measures). Can be used for a wide range of types of risk.	No significant disadvantages. Some concern over validity (7) that FN curves are poor decision tools as they are not a 'disutility function', but this has been considered by Hirst (10).
EV/PLL (EV – Expectation Value is the sum of all the fN pairs for a defined situation. Also referred to as PLL – potential loss of life.)	Single value – easy to understand.	Less informative than an FN curve.
Other risk integrals (e.g. RI – Risk Integral, ARI – Approximate Risk Integral, SRI – Scaled Risk Integral, ESRI – Establishment SRI). These integrals generally apply a scale aversion factor to weight the contribution of N.	Single value.	Not easy to interpret. If $\alpha > 1$ (where α is the numerical scale aversion factor applied to the risk calculation) could lead to inconsistency in decisions if 'salami slicing' tactics are adopted. Accuracy degrades due to increased uncertainty for high N events. Not technically robust.
N_{max}Maximum number of casualties from one event for a specified installation.	Single value – easy to understand.	Fails to take account of likelihood.
Risk indices (e.g. Modified SRI, $(FN)_{max}$)	Single value. Useful screen for case decisions.	Less easy to understand than EV. MSRI based on dangerous dose. Hard to define robust criteria. Doesn't deal with transport route populations.
Area specific societal risk (ASSR)	Societal risk on a map may be useful for planners. Concept of 'severity' of FN curves may be useful.	Not technically a very useful/robust approach for a variety of reasons. Doesn't provide planners with what they need to know.
Location specific societal risk (LSSR) (i.e. hotspot map or EV Density map)	Societal risk on a map may be useful for planners. (NB EVD is similar to MSRI but based on fatality)	Hard to define robust criteria. Doesn't deal with transport route populations.

SOCIETAL RISK CRITERIA OR GUIDELINES

An Individual Risk criteria framework is well established in the UK (2) and is widely followed by industry and regulators. Societal Risk considerations are implicit to some degree in existing LUP advice, but although Societal Risk is used in risk assessment there are, as yet, no widely agreed societal risk criteria. An indicative point is presented in (2) (50 deaths at 200 chances per million (cpm) per year). This was proposed by HSE as a basic criterion for the limit of tolerability, particularly for accidents where there is some choice whether to accept the hazard or not, eg the risk of such an event happening from a major chemical site or complex continuing to operate next to a housing estate.

There is a developing industry framework for Societal Risk criteria summarised in (8) and a possible approach could be based on the guidelines shown in Figure 1. It can be seen that these guidelines do not explicitly include scale aversion. This scheme is based on established

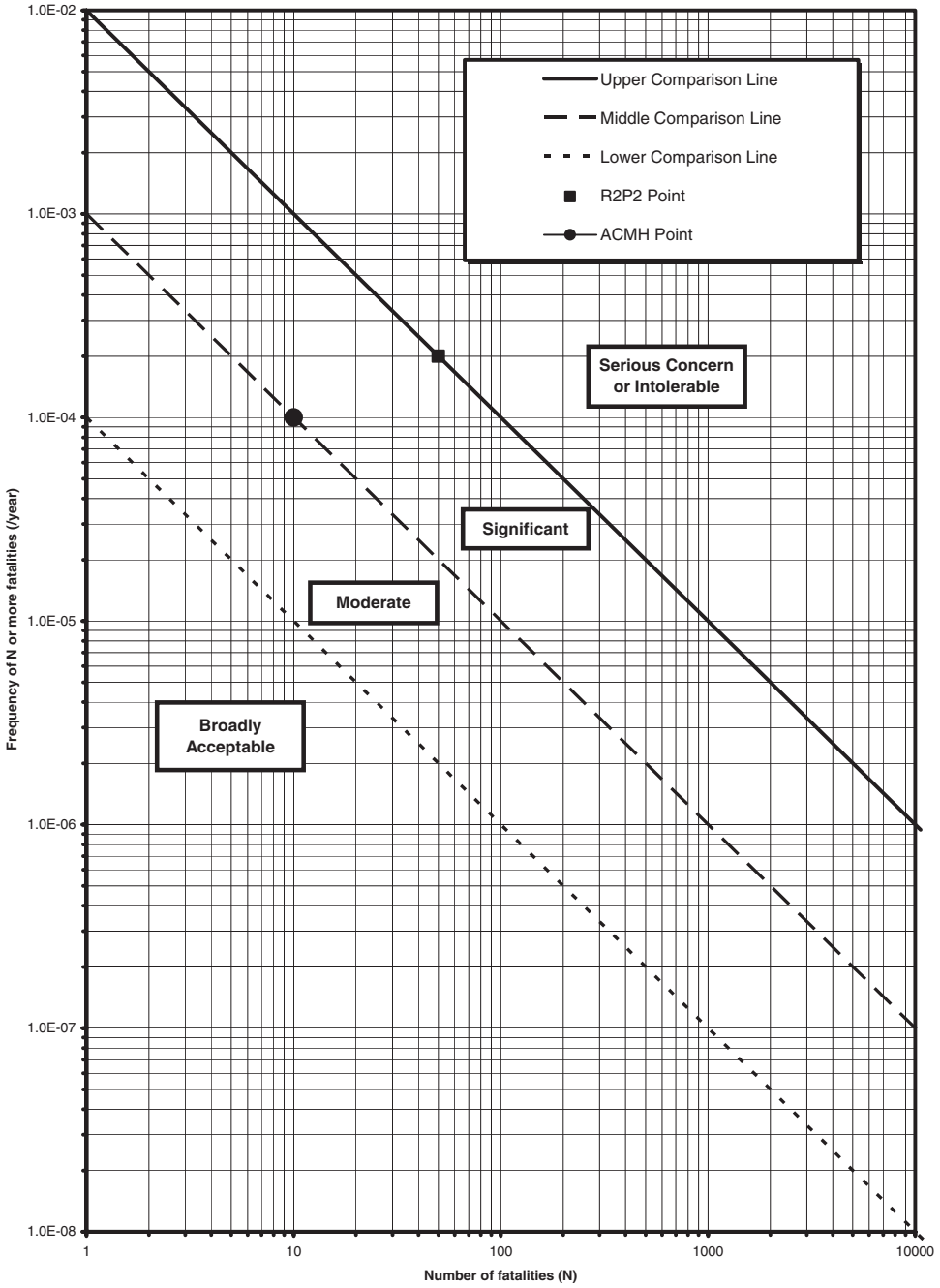

Figure 1. Sample societal risk comparison FN lines

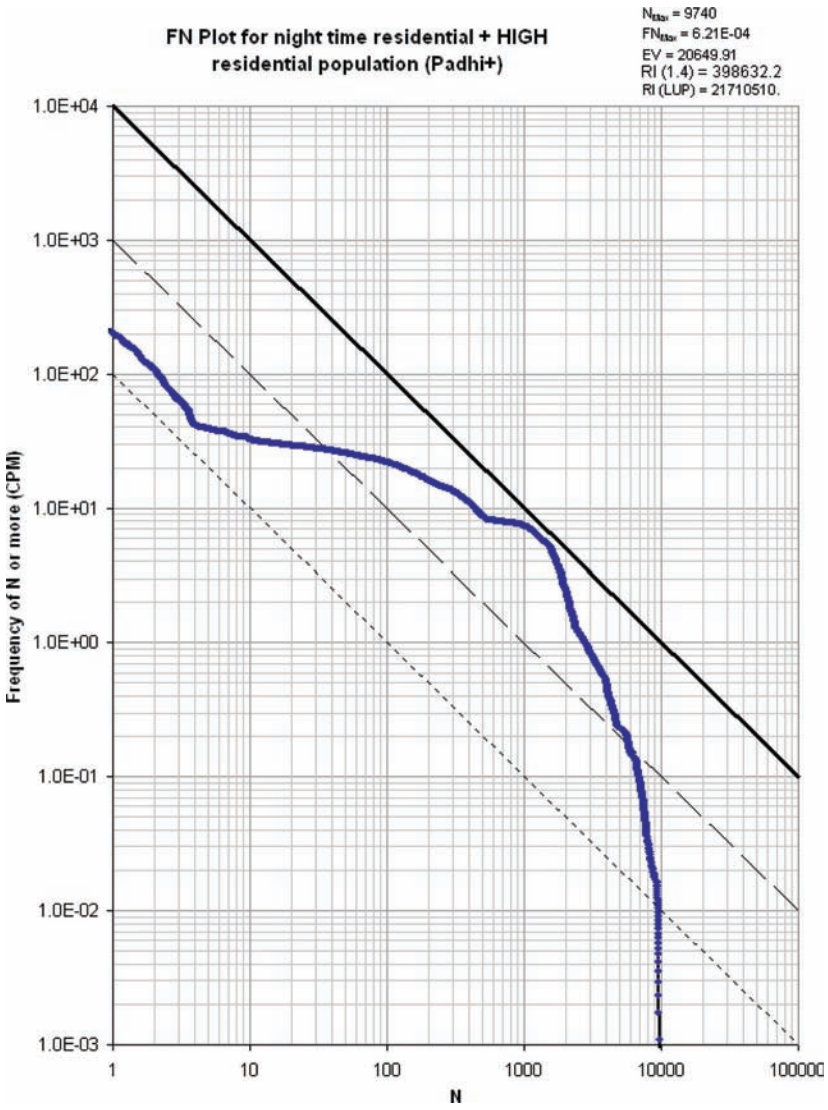

Figure 2. FN curve for sample major hazard installation

reference criteria or anchor points, and proposes four guideline bands to use to initially assess the results of societal risk calculations.

Figure 2 illustrates an FN curve for a sample hazardous installation plotted over the guidelines from Figure 1. Land use planning advice may initially be guided by the position of the FN curve in relation to the comparison lines. If the FN curve was substantially above the upper comparison line this would indicate significant societal risk and a high expectation value (EV), and attract firm negative advice.

An FN curve also shows the more dominant contributors to the EV, in terms of whether they are high or low frequency or high/low N, or a combination of the two. This could form the basis to review development plan proposals to reduce potential risks.

Figure 3 shows the individual risk contours for an installation, at 10, 1, 0.3 chances per million (cpm) of dangerous dose. These contours form the basis for existing land use planning advice, defining the inner, middle and outer zones. The outer contour defines the existing consultation distance for hazardous installations.

Figure 3 also shows a blue line that is plotted at a distance of twice the consultation distance. This is expected to be the outer boundary for most societal risk planning advice. The basis for this is that outside this distance individual risks are low and the EV from most developments is likely to be a very small proportion of the existing EV. Extremely large developments, located outside the blue line, where very large numbers of people may accumulate cannot be completely ignored, and may have to be included in a screening process.

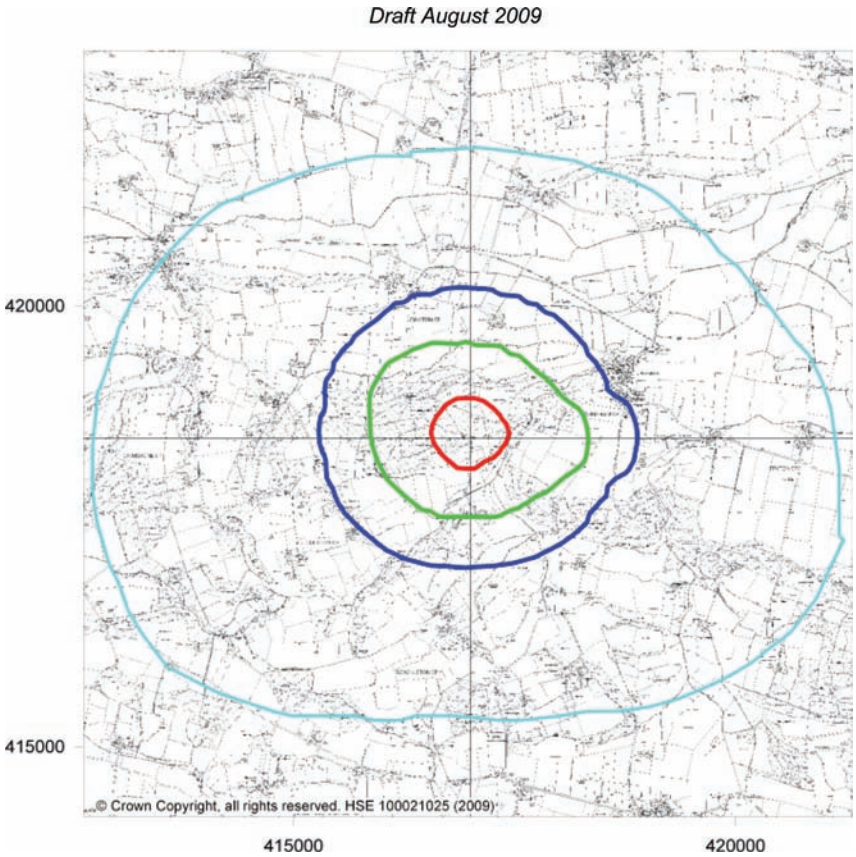

Figure 3. Individual risk (total risk of death) map

Map based representations of risk assessment results could be more informative and useful to planners giving an indication of areas more suitable for development. For example map based representations of risk could help illustrate to planners preferred locations for new developments.

An example of a map based approach is shown in Figure 4, named an EV hotspots map. This shows the EV at each grid square used in the calculation process. A grid square is 100 m × 100 m (one hectare) and the EV for a grid location is a function of the population assigned to that grid square and the events that affect that location. Areas shown in red indicate an EV greater than 0.01 fatalities per year and would indicate further development is inadvisable.

The project is looking at how these measures, and others, could be used to provide advice to local planning authorities.

LUP AND ENFORCEMENT OF HEALTH & SAFETY LEGISLATION

HSE's land-use planning risk assessments assume that, at least for individual risk management, all measures necessary to control the risk are in place, that is to say all reasonably practicable risk reducing measures are in place, and that the operator is achieving the historical level of success in managing the risk, including maintaining those measures.

Land use planning is an additional measure to limit the consequences of what should be infrequent events. HSE's advice to planners, if against any particular development, does not imply that proceeding with that development would imply a failure of the operator of the hazardous installation to have in place all measures necessary.

CONCLUSIONS

This is a summary of the process that HSE is following to test methods, criteria and decision-making for applying societal risk to planning decisions, primarily in the preparation of development plans, but also for individual planning applications.

The trials work is calculating societal risks for COMAH major hazard sites, both for the local population now and as it will be when local development plans are implemented. The results are being discussed with the local authorities involved and further refinement of how

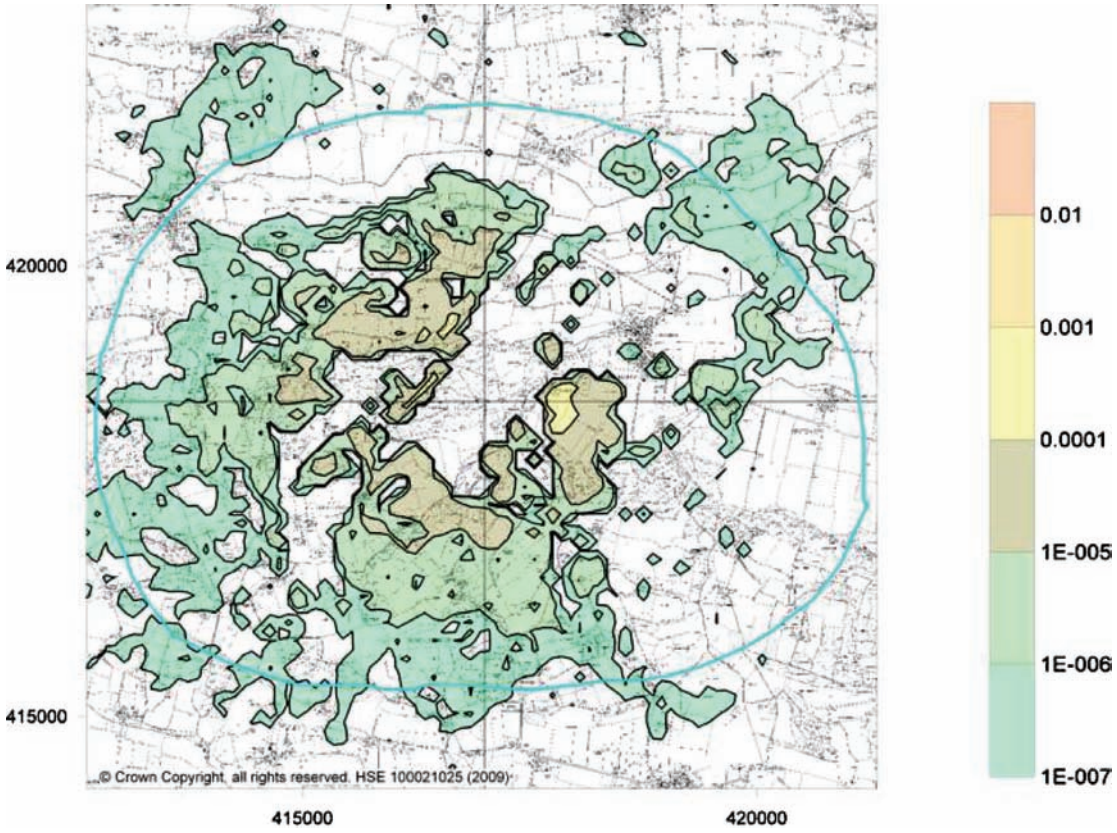

Figure 4. EV density (hot spots) map (night time residential population), colour scale numbers in fatalities per year per hectare

HSE estimates and presents data on societal risk is in progress.

A technical seminar was hosted by HSE on 30 April 2009 at the Health and Safety Laboratory (Buxton). The event was an opportunity for those industry and other stakeholders, with a direct interest in the development of the technical aspects of the societal risk methodology to be brought up to date with progress. The presentations given and a report of the event are now available on the HSE website at: *http://www.hse.gov.uk/societalrisk/seminar0409/index.htm*.

A further stakeholder event is planned for March 2010 for representatives of industry and local planning authorities, to discuss the proposed methodologies, criteria and decision frameworks.

The trial and development phase of the work is due for completion by autumn 2009. Implementation is planned for 2010/11 for both major accident prevention and land use planning, subject to other Government Departments agreement.

HSE will publish research reports explaining the technical rationale for the selected methodology for the assessment of societal risk from on-shore major hazards for both land use planning and COMAH compliance. The reports will cover how HSE will carry out societal risk assessments and provide advice to planners. Some of these documents are currently available on the HSE website, at http://www.hse.gov.uk/societalrisk/index.htm.

In 2010 HSE plan to re-issue the Risk Criteria Document for decisions in land use planning. This will bring up to date the basis upon which HSE's land use planning advice is given to local planning authorities.

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