

LAND USE PLANNING AROUND LARGE SCALE PETROL STORAGE SITES

INITIAL REGULATORY IMPACT ASSESSMENT

Introduction

1. The explosion of a vapour cloud at the Buncefield oil depot, near Hemel Hempstead, on 11 December 2005 provided a new perspective on the nature of the hazard posed by large-scale petrol storage sites. This paper aims to analyse the costs and benefits of proposed revisions to land use planning controls around such sites.

Purpose and intended effect

2. The purpose of the proposed reform options is to mitigate through the land-use planning system the risks associated with building new developments close to major hazards where large quantities of petrol are stored.
3. The intended effect is to achieve the appropriate balance between limiting the risk that incidents at large scale petrol storage sites will affect people off-site and the benefits of developing land around such sites for residential, commercial or recreational use.

Background

4. The explosion and fire at Buncefield Oil Storage Depot in December 2005 challenged worldwide perception about the scale and nature of risks presented by sites storing large quantities of petrol. In the UK such sites have generally been designed and operated to goal-setting standards that were designed to cover a wide range of risks. However they did not consider a large vapour cloud explosion (VCE), as occurred at Buncefield, to be credible - a large petrol fire was considered the most likely 'worst-case scenario'.
5. On 12 January 2006 the Health and Safety Commission appointed a six-person Major Incident Investigation Board (MIIB) to oversee the formal investigation being carried out jointly by the HSE and the Environment Agency (see <http://www.buncefieldinvestigation.gov.uk>). In a statement to accompany the Board's third progress report on 9 May 2006 it said - 'In relation to land use planning the Board's statement of 21 February, on publishing the first progress report, emphasised the importance we attach to HSE reviewing the advice it gives to planning authorities in relation to

sites such as Buncefield, as information emerges from the investigation. While we still do not fully understand why the explosion was so violent, enough information has now emerged to enable HSE to undertake this review.’ The consultation document is a key element in formulating HSE’s response to the Board’s request.

Rationale for Government Intervention

6. The rationale for government intervention to control development around major hazard sites is based on the fact that it is not possible to reduce the risk posed by major hazards to zero, and hence there is residual risk to people living or working in the vicinity of such sites. Because the nature of the risk posed by major hazards is complex and difficult to understand it is unlikely that individuals will make appropriate decisions about such risks. More generally, individuals may benefit from the ‘reassurance value’ provided by government managing risks in this area, and land use planning restrictions are one way in which government does this.
7. There is also an issue about external costs that would not be captured by individuals and firms acting without regulation. The risk of death or injury posed by major hazards creates negative externalities in the form of costs to government (e.g. compensation, medical costs) and, in the case of large incidents, to wider society (e.g. damage to the economic infrastructure). Land use planning is a means by which the government can intervene in the market for land to ensure that the externalities are incorporated in decision-making and risks are addressed.
8. Buncefield proved that a VCE at a large petrol storage site is a credible event, whose extent and severity are greater than the previously assumed worst-case scenario of a large petrol fire. However, this new information may not affect individual decision-making about the risks posed by this particular type of site. Hence there may be a need to modify land use planning around large petrol storage sites to mitigate the off-site risk.

Assumptions

In the calculation of costs we have assumed the following:

- The opportunity cost of not being granted planning permission for a development is 10% of the increase in land value accompanying the granting of planning permission (i.e. 10% of the ‘development value’ of land). See Annex 1 for more information about this assumption.
- Planning applications surrounding the 6 petrol storage sites where data for planning applications was collected is representative of the national picture.
- If HSE advise against an application then the development does not proceed, i.e. no allowance is made for a local planning authority’s

discretion. However experience shows that in only a small minority of cases is HSE's advice ignored.

- There are 2.4 people per household and 40 households per hectare¹
 - The price of housing development land for small sites (less than 5 houses) is £2,870,000 per hectare², equivalent to £72,000 per plot.
 - The typical cost of industrial development land is £670,000 per hectare. There are 2.47 industrial developments per hectare.³ The values and size of plots for industrial development land have been applied to workplaces, schools and indoor public areas. There are assumed to be on average 20 people at a typical development.
 - The typical cost of farmland is £10,700 per hectare. The valuation of farmland used in the calculation of opportunity cost is the value of mixed use, unequipped farmland.
9. The calculation of costs and benefits in this analysis is largely based on research undertaken for National Air Traffic Services in relation to the Heathrow Terminal 5 planning application (see AW Evans *et al* "Third Party Risk Near Airports And Public Safety Zone Policy", NATS, 1997⁴). As in that analysis we assume that the value of reducing individual risk, through land use planning restrictions, can be measured using the Department for Transport's Value of Preventing a Fatality, which is based on the public's willingness to pay for the reduction in the risk of death, as well as the output losses and medical costs avoided by preventing a road accident fatality. These estimates are published yearly in the "Highways Economics Note No. 1"⁵. The values are updated annually by the Department for Transport (DfT) to reflect increases in GDP per capita and the most recent estimate (for 2004) was £1.4 million.
10. Following Evans *et al* we calculate the 'break-even' point where the benefit of reducing individual risk is equal to the opportunity cost of not developing land. It is important to realise that the 'break-even' point is a marginal concept: it provides a means for determining whether the benefit of not building a property in a particular location is equal to the opportunity cost of not developing that location. As the analysis is marginal it does not matter whether 1 or 100 developments are proposed for a particular location. In contrast, the analysis of costs is on an aggregate basis, and the number of potential developments in a location is an important determinant of overall costs.
11. Overall, the analysis of benefits should help to inform judgements about whether increased land use planning restrictions are justified, while the analysis of costs provides estimates of the scale of the issue, i.e. how large are the costs imposed on society by restricting land use given expected demand for new developments in these areas.

¹ <http://www.dclg.gov.uk/index.asp?id=1144325>

² Valuation Office Agency land values

³ 1 industrial development per acre

⁴ http://www.dft.gov.uk/stellent/groups/dft_aviation/documents/page/dft_aviation_041133.pdf

⁵ http://www.dft.gov.uk/stellent/groups/dft_rdsafety/documents/divisionhomepage/030763.hcsp

Options

The consultation document considers four options:

Option 1 – No Change to LUP advice

12. No change to HSE's LUP advice system - HSE would assume that improvements to on-site safety arrangements at petrol storage depots would reduce the risk of such an incident happening again to such an extent that the offsite risks could be considered acceptable without further planning restrictions.

Option 2 – Change size of CD and zones, based on hazard

13. Extend the current consultation distance and planning zones around petrol storage depots. The proposed consultation distance would be doubled and cover approximately four times the area of land covered by the current CD. All of the area covered by the current CD would fall within the new Inner Zone of 250 m. However the 'sensitivity levels' of developments HSE would advise to be permitted within the zones would not change, as shown in consultation document Figure 2.

Option 3 – Change size of CDs (as Option 2) and development sensitivity levels

14. Extend the consultation distance and zones around petrol storage depots and change the sensitivity levels for these sites (see consultation document Figure 3). This means that as well as the area of the CD and the zones being enlarged, the type of development within the inner zone would be more limited than at present. It would be restricted to buildings that are not normally occupied such as warehousing (no offices), outdoor storage, farm buildings and parking areas with no facilities. At present small factories and small offices (less than 100 people), a limited amount of housing and small retail use are permitted within the inner zone.

Option 4 – Change size of CD informed by risk, and adopt new Development Proximity Zone to give more restrictive advice

15. Extend the consultation distance and planning zones around petrol storage depots, as in Options 2 and 3, and introduce a new 'development proximity zone' with increased sensitivity levels. The new 'development proximity zone' (DPZ) would be at a radius of 150 m from the site. Within this zone HSE would 'advise against' new developments other than those involving 'not normally occupied' structures (analogous to the developments in the inner zone under Option 3 above). In this option the advice given about development in the revised Inner Zone, outside the new DPZ, would be identical to that given there at present (albeit over a greater area).

Sectors and groups affected

16. The proposed reforms have very well defined spatial effects, as it is only land around large petrol storage depots that will be affected. We do not believe that this will disproportionately affect particular industrial sectors or groups.

Methodology

Costs: sample data

17. The first step in calculating costs is to estimate numbers of planning applications advised against as a result of changes in policy. We have used analysis of likely changes in advice in a sample of 6 sites where data on planning applications was available dating back over a period of ten years. These are used as a representation of sites nationally and the estimate of costs has been scaled up appropriately. The sample sites were selected on the basis of data availability for the past 10 years. The data was taken from planning authority websites.

Table 1. Sample data for all planning applications during the period 1996-2006

Number of applications (individual buildings)	Percentage of total	
Workplace	24	39%
Indoor use by public	10	16%
Housing	25	41%
Education	1	2%
Parking	1	2%
Total	61	

18. The 6 sample sites are quite well spread out and are **assumed** to be a fair representation of land use planning applications surrounding each of the sites affected nationally. It is uncertain how accurately this data represents national trends and the results are unlikely to be statistically significant. However, there are no alternative sources of such data presently.
19. The sample data was divided by 10, to give an average number of applications for a single year over the past decade. Results were then scaled up in order to represent the full population of sites.

Table 2. Effect of proposed reforms: number and percentage of planning applications in the sample where HSE advice would change

Number where advice would change	OPTION 2	OPTION 3	OPTION 4
Workplace	0	15	7
Indoor use by public	0	5	3
Housing	12	13	12
Education	1	1	1
Parking	0	0	0
Total	13	34	23
Percentage of total where advice would change			
Workplace	0%	44%	30%
Indoor use by public	0%	15%	13%
Housing	92%	38%	52%
Education	8%	3%	4%
Parking	0%	0%	0%
Percentage of category where advice would change			
Workplace	0%	63%	29%
Indoor use by public	0%	50%	30%
Housing	48%	52%	48%
Education	100%	100%	100%
Parking	0%	0%	0%
Total	21%	56%	38%

20. **Table 2** shows the numbers and percentages of planning applications⁶, for individual properties (not developments), over the past ten years that would have been advised against under each of the options (and not advised against under existing policy). For options 2, 3 and 4 the percentages of applications in the sample where HSE advice would change, from ‘do not advise against’ to ‘advise against’, are estimated to be 21%, 56% and 38% respectively. Note, however, that the value of, e.g, a planning application for a workplace development is greater than the value of an application for a housing development; this effect is allowed for in the cost estimates below.

Costs: opportunity cost

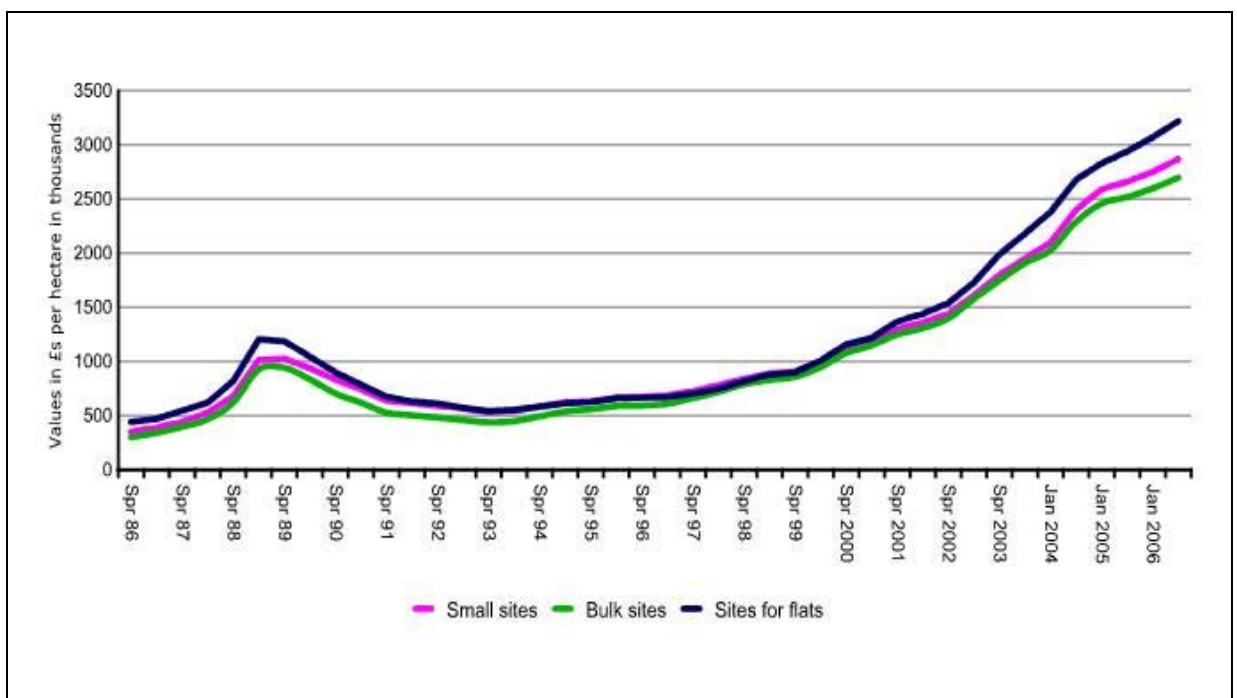
21. Where a development does not go ahead, because of HSE advice, the cost of reducing risk is effectively borne by developers and by local residents in the form of a loss of potential housing and/or commercial/recreational amenities. The relevant cost is therefore the ‘opportunity cost’ of not developing in a particular location. Following Evans *et al* (1997) this is

⁶ There are likely to be variations in types of applications and numbers of each type site to site depending on local geography and infrastructure. Each site is assumed to have average numbers of each type of application.

assumed to be 10% of the uplift in the value of land when it is granted planning permission. Note though that their analysis of opportunity costs is based on the average value of housing land, and to the extent that, currently, not all land around large scale petrol storage sites is classified as having the potential for housing this may over-estimate the opportunity cost of not developing. See Annex 1 for more discussion of the opportunity cost of not developing land.

22. Opportunity costs were calculated using the following method. Valuation Office Agency (VOA) figures⁷ on land values were used to identify the uplift in values of plots that were deemed to be development plots. Uplift was calculated by subtracting the value of mixed farmland from the value of housing development land for small sites (up to 5 houses), or where applicable typical land value for an industrial site in England and Wales.
23. Development land for housing in England and Wales (excluding London) has risen in value by over 600 percent in the past 13 years, from £438,000 per hectare in spring 1993 to £2,870,000 by July 2006⁸ (see Figure 1 below). The ‘per plot’ price has risen from £19,000 to £72,000 over the same period, despite a change in the housing density per hectare from 23.4 households to 40 households.

Figure 1: Time series of development land prices in England and Wales (excluding London)



Source: VOA property market report July 2006

⁷ VOA property market report July 2006, available at: http://www.voa.gov.uk/publications/property_market_report/pmr-jul-06/index.htm

⁸ Seasonal variations in prices have not been apparent and prices have risen fairly steadily over the period.

24. This opportunity cost has been extended over a period of 30 years (consistent with the methodology used by Evans *et al*) and is expressed in terms of the cumulative net present value (NPV). Future opportunity costs have been calculated by applying the standard Treasury discount rate of 3.5% during the first 30 years.

Table 3. Costs: net present values over 1 and 30 years, £ million

COSTS	Year							
	1				30			
	Option 1	Option 2	Option 3	Option 4	Option 1	Option 2	Option 3	Option 4
Workplace	0.0	0.0	0.4	0.4	0.0	0.0	7.1	7.1
Indoor use by public	0.0	0.0	0.1	0.1	0.0	0.0	1.4	1.4
Housing	0.0	0.1	0.1	0.1	0.0	1.5	1.7	1.5
Education	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5
Total	0.0	0.1	0.6	0.6	0.0	2.0	10.7	10.5

25. **Table 3** shows that:

- Option 1 (the do nothing option) has no impact upon costs
- Option 2 has a 30-year NPV of the opportunity cost of lost development of £2 million.
- Option 3 has a 30-year NPV of the opportunity cost of lost development of £10.7 million.
- Option 4 has a 30-year NPV of the opportunity cost of lost development of £10.5 million.

Costs to HSE

26. Other than for option 1 there will be some costs borne by HSE in the form of administration, communication and implementation of new land use planning regulations. These additional costs currently remain unquantified.

Costs to business

27. The costs to developers from restrictions on land use planning, in the form of opportunity costs from not being able to develop particular locations, are set out above. These opportunity costs to developers in turn reflect the lost utility of consumers and businesses who would have made use of the development had they been built. In effect a breakdown of the incidence of these costs is in Table 3, which describes the kinds of developments that are likely to be affected above. Under option 1 (the do nothing option) there would be no costs to businesses or consumers.

Environmental impacts

28. There are no environmental impacts from the reforms considered.

Small Firms Impact Test

29. There will be no disproportionate impact on small firms

Competition Assessment

30. There will be no effect upon competition as opportunity costs will be equal on a per plot basis.

Enforcement, Sanctions and Monitoring

31. All of the proposed options will be enforceable in practice through the land use planning regulations. Local authorities will be able to decline planning applications on the grounds of proximity to a petrol storage site.

Implementation and Delivery Plan

32. The reform will be implemented via changes to HSE's policy and practices relating to land use planning.

Post-implementation Review and Evaluation

33. The proposals discussed in this RIA will result in long-term changes to land use planning surrounding petrol storage sites. New building developments will be affected by changes under options 2, 3 and 4, although a small number of proposed developments will be affected under each option each year.

34. It is normal to review policy changes 3-5 years after implementation. Given the tentative nature of the risk and other estimates in this RIA it is sensible to review 3 years after implementation, i.e. during 2011. This will allow for the effect of changes on developments around affected sites to be evaluated, and for estimates of the risk posed by petrol storage sites to be updated.

Administration burden

35. There are perceived to be no additional administrative burdens external to HSE associated with changing the land use planning restrictions that surround petrol storage site.

Benefits

36. The benefit of restricting land use around hazardous sites is that the off-site consequences of an incident will be smaller because there will be

fewer people affected by an incident (because developments have been advised against). At the extreme, if there are no businesses or people in the vicinity of a hazardous site then the off-site consequences resulting from an incident will be zero (for the purposes of this analysis).

37. The safety benefits of not being exposed to risk are explored by Evans *et al*⁹. They calculate the benefit of reduced individual risk on the basis of the DfT's estimate for the value of a fatality saved (£744,000 in 1993; £1.4 million currently).
38. At the time of analysis Evans *et al* concluded that the level of risk at which safety benefits were equal to the opportunity cost of not developing land (i.e. the break even level of risk) was 3.7×10^{-5} per year. However, because of the large uncertainties involved in analysing the economics of land use planning and risk of fatality they also concluded that planning restrictions would be justified within the zone where risk (of an incident) is greater than 1×10^{-5}
39. However, land values and the estimate for the value of a fatality averted have both increased since the analysis by Evans *et al*, though at different rates. The 'break-even' level of risk, therefore, has also changed. Annex 2 provides an update of Evans *et al*'s analysis and applies their technique to land use planning around large-scale petrol storage sites. Annex 2 finds that an updated break-even level of risk (i.e. the level of risk where costs and benefits are equal) is where individual risk is 8.8×10^{-5} . The disproportionate increase in land values, relative to the value of a fatality saved, means that the break-even level of risk is higher now than in Evans *et al*'s analysis (3.7×10^{-5}).
40. It should be noted, however, that to remain consistent with the methodology used by Evans *et al* non-fatal injuries have not been considered in this analysis. If there were 7 major injuries averted per fatality then the level of benefit associated with averting a fatality would increase by a factor of two.
41. HSE has estimated the risks to people living, working or active within the four zones: DPZ, inner zone (IZ), middle zone (MZ) and outer zone (OZ). Cautious HSE calculations suggest that the risk for each zone is 8×10^{-5} , 1×10^{-5} , 4×10^{-6} and 1×10^{-7} respectively¹⁰. The break-even level of risk (8.8×10^{-5}) is therefore similar to the level of risk in the proposed DPZ but more than the level of risk in the IZ, MZ and OZ.
42. Because levels of individual risk vary within the zones it is not possible to monetise the benefits from restricting development, as proposed in Options 2, 3 and 4. Nevertheless, it is clear that under Options 2, 3 and 4 costs exceed benefits (at least under the methodology used here). We find that it is only when individual risk is relatively high, due to proximity to the

⁹ See Evans *et al*, paragraphs 11.16 – 11.37

¹⁰ See Consultation Document Annex 5

hazard, that the value of reducing risk is equal to the opportunity cost of not developing land. Broadly, therefore, the area where according to cost-benefit analysis development should be restricted is represented by the DPZ. As Options 2, 3 and 4 all propose additional restrictions on development beyond this area they all impose costs on society that exceed benefits.

Conclusion

43. Our analysis of the economic consequences of land use planning restrictions around large-scale petrol storage sites suggests that there is a relatively small opportunity cost associated with reducing development in these areas. Even in the most restrictive option the 30-year net present value of this opportunity cost is under £11 million. This relatively low cost is because, based on the limited data available in our sample, we would not expect there to be many planning applications in such areas in any event.
44. The benefit of restricting land use in the vicinity of petrol storage sites is that there will be fewer people potentially affected by an incident. Our comparison of the benefits from increased safety with the opportunity cost of not developing land suggests that the 'break-even' level of risk for housing land is 8.8×10^{-5} (88 chances per million). This is similar to the level of risk in the proposed DPZ but more than the level of risk in the Inner Zone.
45. According to this cost-benefit analysis, any decision to restrict development beyond the DPZ must be on the basis that the benefits of safety should be weighted more highly than the costs of not developing land. In relation to major hazards it is generally HSE's policy to apply such a weighting in the form of a "gross disproportion factor". The level of weighting reflects the degree of risk, and would tend to be higher as risk approaches 100 chances per million (the level considered to be intolerable). However, consideration of the appropriate level of disproportion between costs and benefits is outside the scope of this assessment.

ANNEX 1: OPPORTUNITY COST OF LAND USE PLANNING RESTRICTIONS

1. A key assumption in this impact assessment relates to the opportunity cost of not allowing land to be developed. As set out below, this assumption is subject to very wide margins of error and, as such, there is considerable uncertainty about the economic consequences of land use planning restrictions.
2. HSE's approach when considering the economic consequences of land use planning controls is set out in the document "Risk criteria for land use planning in the vicinity of major industrial hazards". It arrives at two principal conclusions:
 - a. The costs to be offset against the benefits of greater safety are, for the nation as a whole, considerably less than the apparent costs in lower land values borne by those owning property near the hazard.
 - b. In deciding whether or not to invest in the mitigation of a hazard, it is relevant to consider costs that would be saved for the nation in reducing the distortion of the otherwise desired pattern of development.
3. The document states:
4. *"The supply of land is virtually fixed. Any depression of the price of one site for whatever reason is likely to be reflected by an increase in the value of other sites. If the other sites are less suitable for development than the original site chosen, then the value will not rise to quite match the fall in value of the original site. There is thus a relatively small net overall loss in the price of land"*.
5. *The loss to the nation reflects the lower efficiency of placing the development on the less favoured site; it is a loss of development value... ...[which is] generally very much less than the loss to the owner of the original site"*.
6. It is clear therefore that it would not be appropriate to take the opportunity cost of not allowing land to be developed as the full development value of that land, i.e. the difference between the value of land for agricultural use and land with planning permission for, e.g., housing (a difference of some £2.8 million per hectare currently). Neither, however, would it be appropriate to assign no opportunity cost to land restrictions – being able to develop a chosen location must have benefits over an alternative location even if it is a very close substitute. The difficulty, however, is that there is little data that might help to determine where between these two extreme points the true opportunity cost of not developing lies.
7. Previous economic analyses of land use planning restrictions have used values for the opportunity cost of not developing of 10% and 5% of the development value of land. The analysis by Evans *et al* (1997) on public safety zones at airports used a value of 10%. However, an unpublished HSE analysis of land use planning restrictions around gasoline pipelines ("Extension of pipelines safety regulations RIA", 1996) used a value of 5%. The argument used was as follows:

8. *“When considering consultation distances around gasoline pipelines, there are very strong arguments that the social cost of any subsequent restriction is likely to be very marginal. This is because the area of land affected is relatively small. Public safety zone restrictions on new developments around airports are typically 2km long and 200m wide. It is very possible that such a zone could, for example, intersect with existing developments and service roads to such an extent that these could not be used for the new development, and new ones would have to be built. The social loss in this case could be quite significant.*
9. *However, the proposed restrictions surrounding gasoline pipelines are such that alternative land close to the proposal can be utilised, and so could any existing infrastructure. For example, if a restriction was imposed on a housing development, then this could be completely accommodated simply by extending the size of the developed area by 100m in one direction. The social value of this new land is likely to be very close to the social value of the original land, simply because it is in the same place.*
10. *For this reason, we consider that the marginal social costs of any land use restrictions imposed by these proposals are less than that assumed for airport safety zones, and we use a figure of 5% of the commercial value in the calculations detailed in the text.”*
11. On balance, the nature of land use planning restrictions around large petrol storage depots holds more similarities to public safety zones around airports than land use planning restrictions around gasoline pipelines. These similarities are due to basic attributes of the hazard, such as spatial magnitude of the risk posed. Hence the opportunity cost of not granting planning permission, when it would previously have been granted, is here taken as 10% of the development value of land (the value used by Evans *et al*). Nevertheless, it is clear that the opportunity cost of land use planning restrictions is difficult to estimate, and hence the cost estimates presented in this RIA should be treated with caution.

ANNEX 2: VALUATION OF RISK REDUCTION

1. Provided that the reduction in the risk of death enjoyed by any given individual is small, then regardless of the number of people affected, the monetary value of the benefit of n people each experiencing a small risk reduction, r , will be given by $n v r$, where v is the value of statistical life. Thus, if the average household contains n occupants, each of whom enjoys a small reduction r in the annual risk of death every year for m years, then the overall discounted present value of this risk reduction will be given by $n v r f(m, d)$ where $f(m, d)$ is the discount factor applicable to a constant sum arising each year for m years at a discount rate d per annum. Thus, for example, with $m = 30$ and a discount rate of 1.5% per annum we have $f(m, d) = 24.38$ so that the discounted present value of the average household risk reduction would be $24.38 n v r$. The algebraic form of this calculation is as follows:

$$nvr \times \left[\frac{\left(1 - \frac{1}{(1+d)^m}\right)}{\left(1 - \frac{1}{(1+d)}\right)} \right]$$

2. Following Evans et al (1997), it is useful to look at the benefit of risk reduction at the point where the chance of an incident is 1×10^{-4} per annum. This level of risk is taken as the point where it is deemed 'intolerable', and hence where cost-benefit analysis is constrained by ethical concerns. Assuming that the discount rate is 1.5% per annum¹¹, $m = 30$, $n = 2.4$, $r = 10^{-4}$ and $v = \text{£}1.4$ million, then the discounted present value of the benefit enjoyed by the average household as a result of the elimination of the risk would be $\text{£}8,200$.

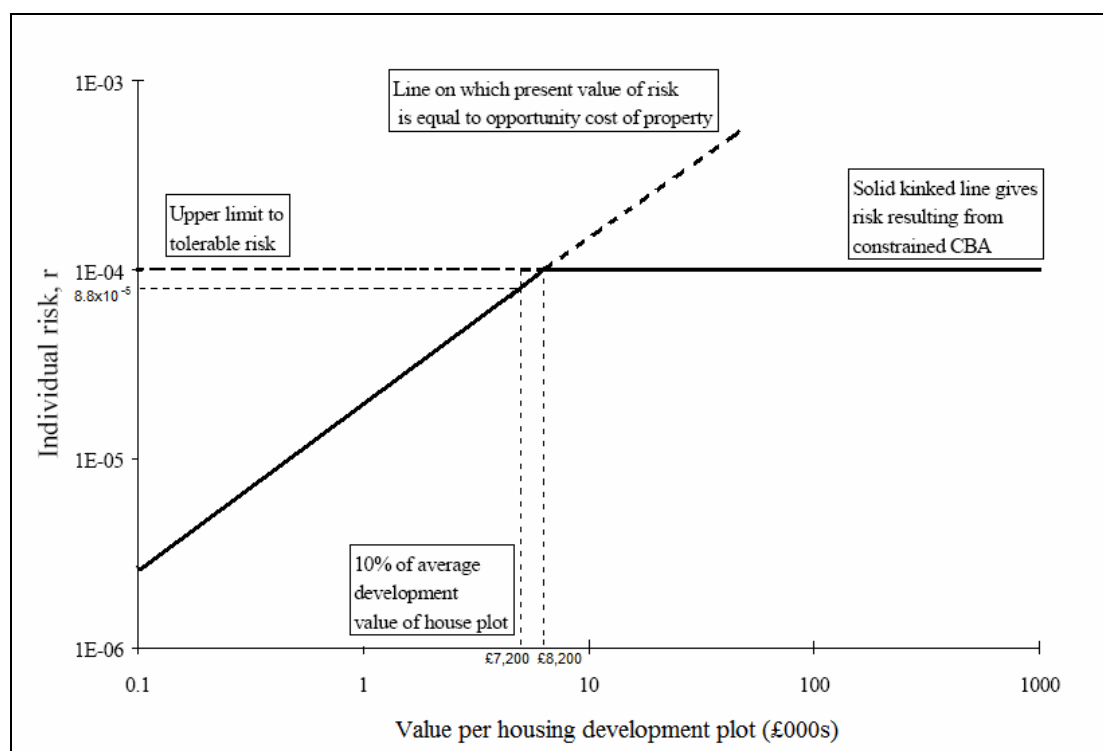
$$\begin{aligned} d &= 1.5\% \text{ }^{11} \\ m &= 30 \text{ years} \\ n &= 2.4 \\ v &= 1.4 \text{ million} \\ r &= 0.0001 (1 \times 10^{-4}) \end{aligned}$$

$$\begin{aligned} \text{NPV} &= (2.4 \times 1,400,000 \times 0.0001) \times \left[\frac{\left(1 - \frac{1}{(1+0.015)^{30}}\right)}{\left(1 - \frac{1}{(1+0.015)}\right)} \right] \\ &= \text{£}8,200 \text{ at } 10^{-4} \end{aligned}$$

¹¹ This is the standard discount rate for health related benefits taken from the Treasury green book.

3. The NPV of £8,200 at a level of risk of 1×10^{-4} updates the value of £3,750 that Evans *et al* arrived at, given some changes in assumptions. The increase is due to changes in the statistical value of a fatality saved, the discount rate used (now 1.5%), and the number of people per household (now 2.4). Note that not all casualties resulting from an incident may be in the form of fatalities, but as in Evans *et al*'s paper this has not been taken into account here.
4. The opportunity cost of not developing land was calculated by Evans *et al* to be £1,400 per plot at 1993 prices. Due to changes in data sources and land price inflation, our analysis based on Valuation Office Agency (VOA) figures produces a value in 1993 of £1,800 per plot and in 2006 of £7,200 per plot¹². This is less than the value of dis-benefit at a risk level of 1×10^{-4} , calculated above as £8,200 per plot. Therefore, cost-benefit analysis of restrictions on the development of housing land is not constrained by the tolerability limit of 1×10^{-4} .
5. Figure 2 is a diagrammatic representation of how the opportunity cost of not developing land and levels of individual risk compare. It is based upon the constrained analysis carried out by Evans *et al*.¹³ The vertical axis in Figure 2 is individual risk and the horizontal axis is the opportunity costs per house plot of a not being granted planning permission.

Figure 2 Constrained CBA for Land Use Planning.



Note: This diagram is a modification of the one used in Evans *et al*. It uses a logarithmic scale simply for the purposes of demonstrating a wide range of values.

¹² These figures exclude London.

¹³ See Evans *et al* paragraphs 11.21-11.25 and figure 11.1

6. Figure 2 shows that, given the estimated opportunity cost of not developing a housing plot of £7,200, the risk at which the economic costs and benefits of inhibiting development are in balance is 8.8×10^{-5} . At higher levels of risk than 8.8×10^{-5} the benefits of increased safety outweigh the opportunity cost of not developing land, although ethical criteria may be considered more important once risk levels rise to 1×10^{-4} .
7. For land where industrial developments would be permitted but housing would not the opportunity cost is lower than when all types of development are prohibited. This is because the opportunity cost reflects the uplift from industrial development land to housing development land, in contrast to the uplift from farmland to housing development land.
8. All other types of development, including workplaces, buildings for indoor public use and educational buildings, such as schools, are assumed to have an opportunity cost of 10% of the uplift in land value associated with movement from mixed-use unequipped agricultural land to industrial development land (in England and Wales).