

Summary: Intervention & Options		
Department /Agency: HSE	Title: Impact Assessment of making gasoline a dangerous fluid under the Pipelines Safety Regulations (PSR) 1996)	
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Related Publications:		

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What is the problem under consideration? Why is government intervention necessary?

Gasoline pipelines are not classified as major accident hazard pipelines and are therefore not within the scope of the additional duties as set out in Part III of the Pipeline Safety Regulations (PSR) 1996. Research demonstrates that gasoline pipelines have major accident hazard potential. Following the Buncefield incident the Major Incident Investigation Board have expressed concern at the anomaly that gasoline pipelines are still not within the scope of the additional duties of PSR.

What are the policy objectives and the intended effects?

The policy objectives are to apply:

- 1) the more prescriptive, major accident hazard requirements of PSR to gasoline pipelines including notification, major accident prevention documents and local authority emergency plans;
- 2) land use planning (LUP) controls around gasoline pipelines to manage the residual risks.

What policy options have been considered? Please justify any preferred option.

The following regulatory options are being considered:

- i) no change
- ii) define a new dangerous fluid, referred to as ‘flammable liquids’ and categorised by reference to flashpoint. This will mean that gasoline pipelines will attract the full PSR duties as major accident hazard pipelines
- iii) same as option ii) but also extending land use planning controls to qualifying pipelines

When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects?

The policy will be reviewed within five years of implementation.

Ministerial Sign-off For SELECT STAGE Impact Assessments:

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister:

.....Date:

[Use this space (with a recommended maximum of 30 pages) to set out the evidence, analysis and detailed narrative from which you have generated your policy options or proposal. Ensure that the information is organised in such a way as to explain clearly the summary information on the preceding pages of this form.]

Extension of pipeline safety regulations (1996) to include gasoline pipelines as a dangerous fluid

1. This Impact Assessment considers proposed changes to the regulations that apply to gasoline pipelines under the Pipeline Safety Regulations (PSR) 1996.

Purpose and intended effects

Issue

2. Gasoline is not a prescribed dangerous fluid for the purposes of the Pipeline Safety Regulations 1996 and therefore a number of specific additional duties currently do not apply to gasoline pipelines.

Objectives

3. The objective of this extension of the PSR regulations is to reduce the risks of gasoline pipeline accidents, and to reduce the impact of accidents that may arise from gasoline pipelines. The intended effect is to achieve the appropriate balance between limiting the risk of an accident affecting people in the vicinity of the gasoline pipeline, the benefits provided by gasoline pipelines, and the benefits of developing land around such sites.

Background

4. The Health and Safety Executive is considering taking forward amendments to the Pipeline Safety Regulations (PSR) 1996. The aim is that amended regulations can be ready for implementation in April 2009.
5. The Pipelines Safety Regulations 1996 (PSR), which came into force on 11 April 1996, impose 2 levels of duties;
 - The lower level (general duties) applies to all pipelines as defined in the regulations. These cover design, construction/installation, operation, maintenance and decommissioning of the pipeline.
 - The higher level (additional duties) imposes additional duties for notification, major accident prevention documents, emergency procedures and emergency planning – these apply to pipelines carrying prescribed dangerous fluids.
6. Gasoline pipelines are included under general duties and are excluded from the additional duties for pipelines conveying fluids with a major accident hazard potential. Under general duties there are no requirements to produce an emergency plan or land use planning zones around gasoline pipelines.
7. At the time of implementation of the Pipeline Safety Regulations, the HSE initially proposed to include gasoline among the list of substances which would require notification under the new regulations, but decided that gasoline should be removed from this list until further research into the risks of gasoline pipelines had been conducted.

8. Two research projects¹ were carried out to assess the risks associated with different pipelines and have concluded that the risks associated with pipelines conveying gasoline justify the additional duties under PSR. The report into this work was accepted by the Advisory Committee on Dangerous Substances (ACDS) in February 2001, and a consensus was reached recommending the inclusions of gasoline as a dangerous fluid in PSR with the application of the land use planning provisions. It was concluded that non-topographical quantified risk assessment should be used to calculate consultation distances.
9. A number of options for amending PSR were considered including regulating gasoline pipelines without the application of land-use planning controls. The preferred option identified by ACDS was to include gasoline as a dangerous fluid in PSR with the application of the land use planning provisions. This is represented by option 3 described below.
10. By 2003 a draft consultation document, including a Regulatory Impact Assessment, had been prepared by HSE for the amendment of PSR, , but the project was cancelled in July 2004 following the outcome of the 2002 spending review and HSE's subsequent sun setting project. At the time, the justification for this decision was that the work should be suspended until the European Commission produced a pipeline directive.
11. Following the Buncefield Incident in December 2005 the regulation of gasoline pipelines has again become a matter of debate. The Buncefield Major Incident Investigation Board indicated in its ['Recommendations on the design and operation of fuel storage sites'](#) report that gasoline pipelines should be subject to the requirements of major hazard legislation. In their response to HSE consultation document 211 on land use planning, they noted the anomaly that major pipelines carrying gasoline are excluded from the additional duties of PSR. Therefore there are no requirements to produce an off site emergency plan or for land use planning zones around gasoline pipelines.

Rationale for Government Intervention

12. The rationale for extending additional duties under PSR to pipelines carrying gasoline is that, because risks of a pipeline accident cannot be reduced to zero, there is residual risk to people in the vicinity of such pipelines. Because information regarding pipelines and the level of risk associated with them is complex and difficult to understand, it is unlikely that individuals can fully access or interpret all relevant information and hence make informed decisions about such risks. Therefore there is a role for government intervention in managing and reducing the residual risks from gasoline pipelines.
13. A further rationale for government intervention in this area relates to the possibility that individuals and firms only consider private costs and benefits relating to gasoline pipelines. External costs arising from risks from gasoline pipelines (for example, those costs that are incurred by the general public and not by the pipeline operator) may not be fully captured in the decision making process regarding management of these risks. The risk of death or injury from gasoline pipeline accidents creates a negative externality in the form of costs to the wider society. Including gasoline pipelines in the additional duties is a means by which regulators can ensure the externalities generated by the risks associated with gasoline pipelines are appropriately controlled.

Options

¹ Arther D Little "Risks from gasoline pipelines in the United Kingdom" report to the UK HSE, June 1996 and WS Atkins Safety and Reliability " Assessing the risk from gasoline pipelines in the UK based on a review of historical experience" HSE report 210/1999, HSE Books.

Option one – No change to PSR

14. Option 1 would involve the following.
 - No change to PSR so that gasoline would continue to not be included as a dangerous fluid.
 - Gasoline pipelines remain under general duties where there are no requirements to produce an emergency plan or land use planning zones around gasoline pipelines.
15. This option, which would involve leaving the current Pipeline Safety Regulations in place with no amendments, is the baseline against which other options can be compared. This option therefore has no additional cost or benefit implications.

Option two – Amend PSR to include gasoline as a dangerous fluid

16. This option would involve extending current the PSR to include gasoline as a dangerous fluid. Under this option additional duties under Regulations 18 – 25 of the Regulations would apply to gasoline pipelines. This would involve application of more prescriptive requirements to gasoline pipelines including notification, major incident prevention documents, emergency procedures and local authority emergency plans.

Option three - Amend PSR to include gasoline as a dangerous fluid and implement Land Use Planning restrictions

17. Option three is a combination of option two and additional land use planning restrictions, which would consist of the following:
 - Land use planning controls around gasoline pipelines to manage residual risks from gasoline pipelines.
 - Arrangements for notifications for new major hazard pipelines:
 - A requirement to ensure that information provided is sufficient to set consultation zones and maintain an adequate data base for LUP purposes

COSTS and BENEFITS

Data sources and assumptions

Technical assumptions

18. This section presents an assessment of the costs and benefits of the options that are outlined above.
19. Some of the costs to organisations of carrying out new duties are opportunity costs. It is assumed that the loss of output is equal to the cost of employees' time allocated to these additional duties, based on the number of hours allocated to the duty and average earnings for the employees that would undertake the duty.
20. We allow a full economic cost of £207 per day for middle managers and safety engineers, based on an average of the gross earnings as reported to the Annual Survey of Hours and Earnings (2008) for the occupational groups "Engineering professionals" and "production works and maintenance managers". This includes an allowance of one-third of earnings for the non-wage costs associated with employing the personnel. Similarly, we allow a full economic cost of £150 per day for 'front-line' personnel, and £509 per day for senior managers.
21. Costs have been discounted over a period of forty years and expressed in present value terms. This period of time has been used because pipelines are usually designed to last

approximately forty years. No new gasoline pipelines are being planned at present and it is assumed that no new pipelines will be constructed in the over the appraisal period considered in this Impact Assessment. It is also assumed that owners keep their pipelines in good repair and will upgrade them regularly to compensate for any deterioration and decline in capacity that would otherwise occur. The stock of pipelines is therefore taken to be constant throughout the period.

22. A discount rate of 3.5% is applied for costs and benefits, with the exception of health and safety costs and benefits to which a 1.5% discount rate is applied, in line with HM Treasury guidelines.

Methods of calculating risk

23. Risk calculations are discussed in further detail in **APPENDIX 1**.
24. There are generally two methods of calculating risk: historical record and quantitative risk assessment (QRA). Historical data can be used to inform QRA so that a combination of the two methods is used.
25. Risk calculation methodology for this paper is based on research provided by W.S. Atkins, on the individual level of risk. This data has been used together with data provided by the Health and Safety Laboratory on population estimates around gasoline pipelines, and updated estimates of pipeline failure rates based on Europe wide failure rate analysis.

Historical risk

26. Based on historical record of fatal injuries, WS Atkins calculated that the Probabilistic Loss of Life (PLL) associated with gasoline pipeline failures as 0.031 per year, if the figure for Western Europe is applied to the UK adjusting for length of pipeline in each case. The average loss of life based on the QRA exercise is 0.013 fatalities per year.
27. Historical risk can be approximately converted into individual risk using the assumption that one tenth of gasoline pipeline is in heavily populated areas. The individual unadjusted fatality risk is calculated to be 1.1×10^{-7} per year.

Modelled risk

28. HSE's proposed land use planning zones are based on an inner zone (50m radius) and an outer zone (the consultation distance of 60m). The outer zone is based on the maximum risk of 0.3 chances per million (cpm) each year of receiving a "dangerous dose or worse". Beyond the consultation distance risk falls below 0.3 cpm and is no longer considered intolerable.
29. The calculated risk given average soil but maximum operating pressure is estimated to be around 3×10^{-8} over the pipeline system.

Corrections to calculated risk estimates

30. The WS Atkins report concluded that the appropriate risk for the UK is one that reflects historical rather than modelled risk. This is due to historical risk including all people that could be within the vicinity of the gasoline pipeline and not simply those that live there.
31. The difference between the modelled risk and historical risk in WS Atkins report is 2.4. The report suggests adding a factor of 2.4 to the average modelled risk.

32. Historical record also shows that each fatality from a gasoline pipeline leak ignition can be associated with four significant injuries. Given weighting factors common to this type of analysis we assume each fatality is equivalent to 1.4 “equivalent fatalities”.

Comparison of historical and calculated risk

33. The HSE and WS Atkins estimates of risk in average soil, multiplied by 2.4, and the WS Atkins estimates based on historical risk suggest an average annual value for individual risk in the order of 10^{-7} (ie 0.1 cpm). This is below the generally accepted risk requiring minimisation to a level “as low as reasonably practical”.²
34. Historical data suggests that modelled risk to residents is likely to significantly underestimate total individual risk, so the following equivalent fatality preventable risks per year are used in this assessment:
35. HSL calculates the following estimates of individual risk:
- Overall Urban Average Individual Risk 2×10^{-6}
 - Overall rural average individual risk 3×10^{-7}
36. Multiplying the calculated individual risk by the population within proximity of gasoline pipelines for both rural and urban areas gives an estimation of the expected number of fatalities per year. Population estimates include both resident and transient populations provided by HSL scientists. The expected number of injuries is obtained by multiplying the expected number of fatalities by 4 following paragraph 35 of the technical assumptions. The calculated estimates are given in the table below.

	Total Population in zone	Expected No. of fatalities	Expected No. of injuries	Expected fatalities over 40 yr period	Expected injuries over 40 yr period
Urban	50593	0.1019	0.405	4.05	16.19
Rural	9206	0.0026	0.011	0.11	0.43

37. The risk of pipeline failure estimated from HSL research is 0.000767 per 1000k-yr for an urban pipeline and 0.000207 per 1000km-yr for a rural pipeline. This gives a combined value of 0.000097 per 1000km-yr.
38. Ignition probabilities are taken as 3% (rural) and 5% (Urban). This gives a calculated probability of 0.045 for ignited gasoline pipeline incidents per annum.
39. Research on previous evidence on the scale of loss incurred following high cost chemical/petrochemical accidents finds a lack of reliable data in the public domain. Published costs tend not to include unobserved cost. An analysis of 119 events at petrochemical, chemical and refinery sites were on average 2.7 times the commercial property damages. There is no reason to believe that this proportion would be different for a major incident involving gasoline pipelines.

Benefits

²As most recently described in HSE’s draft Discussion Document “Reducing Risks, Protecting People”, HSE Books, DDE11, c150, 5/99.

40. Benefits from intervention under option 2 are the costs saved from a reduction in risk of a gasoline pipeline accident. Option 3 encompasses the benefits of option 2, and also the benefits of reducing the residual risks of an accident via land use planning restrictions.
41. The benefits of intervention under option 2 and option 3 are the reduction in human costs and other economic costs associated with fatalities, non-fatal injuries, and property and infrastructure damage that would be generated by a gasoline pipeline failure. As an illustration of the potential benefits of reduction in property damage, if it assumed that between 10-20 residential properties would be destroyed in an urban area as a consequence of a gas pipeline accident, the property damage can be valued at around $10-20 \times \text{£}150,000 = \text{up to } \text{£}3 \text{ million}$. It is assumed that business interruption, clean-up and other infrastructure damage could increase this figure to $\text{£}4 \text{ million}$. Further research would be required in order to obtain more robust estimates of these costs. However, as the WS Atkins report notes, there is insufficient data from the research to build up a consequence model for ignition events from the historical data. From the data that is available, property damage of $\text{£}4 \text{ million}$ would not be a worse case scenario.

Estimation of costs of fatalities

42. The monetised costs of fatalities and injuries calculated using the estimates in paragraph 36 above, are presented in the table below using HSE appraisal values of $\text{£}1.5 \text{ million}$ as the value of prevention of a fatality (VPF) and $\text{£}40,500$ as the value of prevention of serious injury. All costs have been discounted according to HM Treasury guidelines using a discount rate of 1.5%. In order to reflect the lack of certainty about accurately estimating costs of this nature we provide a sensitivity analysis showing the costs associated with 3 scenarios of varying severity.

	100% Fatalities and Injuries	50% Fatalities and Injuries	20% Fatalities and Injuries
Urban	£5,106,446	£2,553,223	£1,021,289
Rural	£139,376	£69,688	£27,875

43. The estimates in the table above present the results of these calculations, and show that the potential reduction in fatalities and injuries, arising from the additional duties imposed under the PSR, could generate benefits of approximately $\text{£}5.2 \text{ million}$ in present value terms over a forty year period.

Non-catastrophic risks

44. Although proposals introducing land use planning will not prevent direct losses to gasoline pipeline operators, land use planning can be expected to reduce human costs and property damage from ignited gasoline, and also reduce accident recovery and clean up costs. We also consider the costs of losses from an event which does not result in an ignition. These will result in environmental damage, business loss and require mitigation.
45. There is little information from the historical record about the costs of damage and mitigation of gasoline pipeline releases, since these tend to focus on technical descriptions of the incidents. However, 'clean-up' operations in rural areas are typically stated to take between one and two weeks and involve many personnel. Although there is very limited data, anecdotal evidence of a cost of $\text{\$}25,000$ (approximately $\text{£}17,000$) was reported by one US operator. These costs would remain unchanged by the proposals. However if the clean up operations involved property adjacent to the pipeline, we would expect clean-up costs to be much greater. Further research would be required in order to obtain more robust estimates of these costs.

46. Reports of un-ignited gasoline have estimated costs of property damage of several hundred thousand dollars; land use planning zones would reduce this. Other significant costs of leakages in urban (or `semi-urban') areas would be in evacuation and local business interruption. This would be mitigated (but not prevented) to some extent by LUP controls.
47. Clearly, the scale of such costs prevented by an event subject to LUP is significant. We assume, on the basis of available evidence reviewed for this that land use planning restrictions implemented under option 3 would result in a reduction of costs of around £100,000 - £200,000 per incident. However this estimate is only illustrative as the cost can be expected to vary considerably for specific incidents depending on the industrial, commercial, and residential structure of the area surrounding the pipeline.
48. Risk assessment indicates that we would expect a non-ignition event involving a gasoline pipeline approximately once every 1.3 years per thousand kilometres. At a cost of £99,710 each year, this would be a present value of £3.02 million over 40 years.

Total Benefits (Cost saving)

49. The combination of pipeline failure costs and clean up costs gives a potential for cost-savings of approximately £5.2 million plus £3 million = £8.2 million in present terms over the appraisal period.

Costs

Business sectors affected

50. There are estimated to be just over 3,600 km of pipelines in the UK which could carry low flash point material. Of these a quarter run through urban or built up areas and the remaining three quarters run through rural areas. They are owned and operated by a small number of operators. OPA is responsible for the 2,000 km of the Government system; Esso has an extensive system of 966 km; BPA has 358 km to its UKOP system; and Fina has 231 km of pipeline from Humberside to Buncefield. The remaining six operators have approximately 51 km of local pipelines between them. The pipeline systems of the major operators consist of a range of different diameter pipelines, from 6" to 16", each of different length, except for the Fina pipeline which is 10" throughout.
51. Costing methodology has been taken from previous impact assessment and updated using the GDP deflator. Using the HM Treasury GDP deflator series, 2007/08 prices are calculated to be higher than 1999/00 prices by a ratio of 1.22.

Option 1 – do nothing

52. Option 1 is the baseline for the analysis presented in this Impact Assessment, and there are no additional cost implications associated with this option

Option 2 - Amend PSR to include gasoline as a dangerous fluid

53. There would be no cost implications from general regulations (5 – 17) as these already apply to gasoline pipelines.
54. The additional costs of this option apply under additional duties in Regulations 20- 25. This is considered below.

Regulation 20 – Notification before construction

55. This applies to new pipelines only. It is considered to be unlikely that any new gasoline pipelines will be constructed over the next 40 years so no additional costs should be incurred.

Regulation 21 – Notification before use

56. HSE must be notified and have 14 days to act before fluids can be conveyed in pipelines that have not been in regular use. It is assumed that there will on average be one notification a year and that this will take about 30 minutes of the time of a safety engineer. Total cost of this notification is therefore negligible.

Regulation 22 – Notification in other cases

57. HSE must be notified about any changes in the operator within fourteen days. The operator will already be notifying customers and other of the change and therefore this is assumed a marginal cost and has been excluded.
58. Notification is also required when there are major modifications or changes in the operating limits or fluid being transported in the pipeline (all gasoline pipelines in the country are operated as multi-product pipelines conveying gasoline approximately 40% of the time) it has been assumed that this will occur about twice a year and that each notification will cost about £24 (£48 in total per year). The present value of regulations 21 and 22 over forty years is about £1100.

Regulation 23 – Major Accident Prevention Document

59. A new “Major Hazard Prevention Document” (MHPD) will have to be prepared and revised as often as necessary. The document has to include details of the operator’s health and safety policy for persons who may be affected by the pipeline. It must also detail all hazards with the potential to cause a major accident, the appropriate risk assessments, details of steps taken to reduce risks to the lowest practicable level, details of the safety management system and audit procedures for the safety management system.
60. The MAPD is not dissimilar to documents required under other regulations. Much of the preparatory work for these documents will have already been done. The major task will be assembling the information together. Experience with MAPD documents already prepared under the regulation suggests a typical cost of preparation in the order of £6,000. The total cost of preparing a major accident prevention policy (MAPP) is assumed to be in the range of £30,000 - £100,000, depending on the size and classification of the site. One large pipeline operator has reported that pipeline failure is just one of 35 scenarios already identified under the regulations preceding COMAH and carried forward under the new regime. This would suggest that the additional costs of including a new scenario concerning gasoline pipelines should require work costing a total of no more than £6,000 per MAPD document.
61. The total one off cost of preparing MAPD’s will be £60,000 to the ten operators. It is assumed there will be no net addition to the number of operators and that, if there are any changes in ownership, it is possible to transfer the MAPD at minimal cost.
62. MAPDs will need to be periodically reviewed; it is assumed they will be reviewed every five years at a cost of one fifth of the initial cost. This amounts to £12,000 each time the MAPD’S are reviewed. A combined present value for the costs of initial preparation and five yearly reviews is about £110,000 over forty years.

63. Regulation 23 also requires adequate arrangements for audit and for making reports on the audit. It is assumed an audit is undertaken each year and that it takes one person one week for the four major gasoline pipeline companies at a resource cost of £1,500 per audit. (Allowing for the possible appointment of external management auditors in some cases) The remaining six companies are assumed to incur audit costs between them equal to those of one major operator. In present value terms, total costs of safety management audits are £67,000.

Regulation 24 – Emergency Procedures

64. Emergency arrangements must be in place before the pipeline is in use. These should be revised as often as appropriate. All operators already have extensive procedures in place; this requirement should not result in significant additional cost.

Regulation 25 – Preparation for Emergency Plans in case of major accidents and possibility of future charging by a local authority for testing a plan

65. Every local authority (LA) which has a pipe line passing through it, must be notified that a major hazard pipe line is to be constructed – they must be provided with information about the pipe line carrying a dangerous fluid.
66. The local authority is required to prepare an Emergency Plan setting out how it proposes to deal with the possibility of major accidents. This must be revised at least once every three years. It is expected that every LA will build upon plans it (or other LA's) already have in place. It is not expected that this cost will be as great as the costs of drawing up the MAPD. There is no information on actual costs, but an allowance of £6,100 initially – representing twenty days of middle management time at full economic cost might be a reasonable estimate. In present value terms over 40 years this is approximately £22,000.
67. The above includes plans being revised at least once every three years, this is assumed to cost £2000 (approximately 20 hours middle management time at full economic cost). In present value terms over the forty year period this is £15,000.
68. In addition, a regime is under discussion in which the PSR regulations would be further amended so that there would be a new legal requirement to test the plan. These potential amendments to PSR are still under development and will be considered in a separate Impact Assessment.

Option three – Implement Land Use Planning (LUP) Restrictions

69. HSE is a statutory consultee on the route of major accident hazard pipelines and, under option 3, would provide advice on the routing of any new gasoline pipeline. HSE would also be required to set LUP consultation distances (CD) around gasoline pipelines and would in future advise local planning authorities on developments in the vicinity of gasoline pipelines.
70. Currently no new gasoline pipelines are under construction, neither is any new gasoline pipelines being planned for construction.
71. The land use planning restrictions will impose additional costs for future development proposals near existing pipelines through restrictions on development. HSE will not apply advice retrospectively, so there will be no alterations where developments previously existed. Compensation clauses covering restrictions in land development that are normally incorporated in contracts drawn up between pipeline operators and land owners would affect both applications for development where there are existing buildings and where there are no existing buildings.

72. The value of land affected depends on the uses to which it has or can be put – it depends on buildings already on the land and what buildings would otherwise be permitted. Land for residential or industrial development typically has a value several times greater than agricultural land. The difference between its value with permission for a specified use of development and its value without that permission is its development value

Number and nature of land use applications

73. Using previous HSE records of application of land use planning controls to existing major hazard pipelines as a guide, the likely action on the 30 cases referred to HSE can be determined. In a trawl of 6625 decisions, 14% are shown as “advised against” the remainder being shown as “not advised against” (56%) or “special reply” (30%). It should be noted that following the implementation of the PADHI+ system after 2002, consultations are dealt with at HSE local offices.
74. The HSE’s approach to land use planning around major hazard sites is based on the designation of three zones (inner, middle, and outer) which are designated as the Consultation Distance policy. The boundary of each zone of the Consultation Distance is designated by HSE based on an assessment of the specific risk of harm based on the nature of the population that would be exposed. Whether a development is advised against depends on the location of the development and the characteristics of the development. For example, a development such as housing would generally be advised against in the inner zone but may not be advised against in the outer zone. A non-sensitive commercial development may not be advised against in the inner zone.
75. Since gasoline pipelines have not in the past been classified as major accident hazards, the “inner zone” or restriction was only three metres wide on either side of the pipeline and it was assumed that no future development applications will be made along this narrow zone. In practice, there will be no change for commercial development which will continue to be considered low risk. Since 1996 (when PSR repealed controls under the Pipelines Act 1962) there is no longer formal control for housing and sensitive developments near non-PSR pipelines (the previous control related to developments within 10 feet (3 metres) of a pipeline - which in the past would almost certainly not be put forward this near to the pipeline). The issue is whether any submissions will be made for the category where the public is present in significant numbers for only part of the day and where emergency action may be difficult to co-ordinate (e.g. large scale retail developments).
76. In the case of sensitive developments, commercial developments are unlikely to be advised against in either zone. The differences from current practice will arise over housing and large scale retail, community and leisure developments, which might be advised against in the middle zone but not the outer zone. Given the application of the PSR regulations to date, HSE inspectors advise that we might expect around one-quarter of applications to be advised against, and become subject to land use planning. However, as a result of the extensive research on the risks from gasoline pipelines detailed above, we might expect fewer developments to be advised against. We therefore assume that between 10% and 20% of referred applications are advised against on safety grounds. Changes to the location or design of the development would then be required before the development is assessed again against the PADHI+ system.

Action taken for applications that are “Advised Against” by HSE

77. Compensation clauses covering restrictions in land development are normally incorporated in contracts drawn up between pipeline operators and landowners. An extract from a

Pipeline Deed of Grant, for example, states that “the Grantor shall give written notice to the Company stating whether or not he requires the diversion of the pipeline (for the development to occur) and the Company will pay to the Grantor compensation for the loss of value of any of the land of the Grantor by reason of the restriction of development of the pipelines”.

78. Compensation will only be a relevant consideration if planning permission is refused, or withdrawn where there are existing permitted development rights. However, HSE has no record of compensation ever having actually been paid with respect to pipelines already under PSR. In practice, a range of other measures can be (and have been) adopted.
79. Firstly, and most commonly, the development can be modified so that the features giving rise to concern are sufficiently changed. It cannot be assumed that no development will take place on land where a proposal has been rejected by the LPA on the basis of HSE advice. Other less sensitive schemes may be devised, and the actual loss in development potential will be the difference between the value of the original development if it had been allowed to proceed, and the next best use to which the land could have been put. If there are no other alternative uses, the loss of development value will be the full value of the development foregone; if the next best use of the land has a similar value to the development foregone, there will be no loss of development value.
80. With no previous record of land use planning decisions in this area, it is uncertain whether developers will change the type of planning application to reflect the changed circumstances and, if their application is rejected, whether they will then resubmit with the next best alternative likely to be acceptable to HSE. The developments will vary in size and value depending on type and location and on any existing buildings.
81. Secondly, action can be taken to minimise the risk so that the original development can go ahead as planned. There are several ways of minimising the risk from pipelines carrying hazardous substances, including:
 - Ensure (or increase) pipeline integrity. This reduces risk by reducing the failure rate.
 - Mitigate the consequences of failure, for example, by diverting the pipeline.
 - Mitigate consequences of failure by land use planning.
82. Which option (if any) is adopted depends on the nature of the particular development. With respect to consequence mitigation by moving the pipeline, this has been done in the past with respect to large scale developments, and may well be done in the future. Occasional large scale developments where parties agree to mitigate the consequence in this way would be unlikely to require further action by HSE.
83. There are various methods of mitigation, including using concrete slabbing over the pipeline, sleeving the pipeline, or lowering the pipeline in a deeper trench. If any of these options are considered feasible, then the operator would be expected to put them into place only after carrying out a detailed risk assessment (supplemented by cost benefit analysis) to show that the additional mitigation measures are not disproportionate for the achieved reduction in risk. If they are disproportionate, then the remaining alternative is the use of land use planning, which is discussed below.
84. It should be noted that all of these mitigation measures could cost more to implement than the social cost of land use planning. It might be expected that they would be undertaken if the commercial return made the action worthwhile (including the commercial benefit of avoiding land use planning restrictions). The social costs of LUP therefore represent the additional cost to society of these proposals.

Resource costs to society

85. The cost of land use restrictions has been examined in published research commissioned for the former Department of Transport on public safety zones around domestic airports
86. If developers are denied planning permission near gasoline pipelines, they will almost certainly look elsewhere. Development is assumed to take place at the next best alternative site. Since land is practically fixed in supply, the depression in the price of sites near the gasoline pipeline is likely to be offset by an increase in the value of other alternative sites. We assume that the alternative sites are not quite as suitable as the rejected sites, (otherwise they would have been chosen initially), so there is some overall loss in development value.
87. It is assumed, in line with the Department for Transport research on public safety zones around domestic airports, that the opportunity cost of inhibiting land development is a portion of the land development potential (10%). However, limitations to this assumption are recognised, which takes a narrow view of the costs of land use planning restrictions. Further research is currently being planned by HSE to examine in more detail the economic costs of land use planning restrictions.
88. This opportunity cost is applied to the difference in the price of land. This is because any LUP restriction reduces the supply of land useable for one purpose (eg a housing development), but increases the supply of land useable for another (eg an industrial premises). The effect of applying LUP would be to cause a marginal fall in the price of land suitable only for this secondary use, which would act to offset the social cost of the restriction.
89. Because of the relatively smaller size of the areas affected by pipeline restrictions compared to public safety zones in any given area, there is more likely to be alternative land in the immediate vicinity that could be used for development. We therefore assume that the net loss in development value is 5% of the fall in development value of the rejected proposals, and this is reflected fully in land prices.
90. The average price of housing development land for small sites and farm land is £2,870,000 per hectare and £10,700 per hectare respectively³, or £287 and £1.07 per m².
91. Assuming that if development is advised against, the land will be used for its second best use, the *maximum* fall in land development value will be approximately £286 per m². 5% (the assumed net loss in development value) is approximately £14 per m².
92. We can estimate a rough cost of Land use planning restrictions. If each planning application affects 100 m² around gasoline pipelines then each application advised against and subject to land use planning restrictions costs society £1400. Assuming half of the applications advised against each year are subject to land use planning restrictions (i.e. a maximum of 3), then there is an annual cost of £4200. In present value terms over a period of 40 years this is £100,000. The actual cost will depend specifically on the percentage of applications advised against, which may differ from the assumptions in this calculation.

Costs to HSE

93. There will be some additional costs to HSE. Pipeline inspectors will have to process notifications, notify local authorities and consult on emergency plans, inspect operating

³Per Hectare prices taken from "Land Use Planning around Large Scale Petrol Storage Sites" Regulatory Impact Assessment (HSE 2007).

pipelines including MAPDs, etc. We cannot estimate the scale of these additional costs at present.

Consultation and familiarisation

94. There will be a need for managers to familiarise themselves with the proposed regulations once they are introduced. It is assumed that 100 managers will spend one hour each on this task, giving rise to one-off costs of around £3,000. The total one off consultation and familiarisation exercise will cost approximately £83,000.

Impact on small and medium sized businesses

95. No SMEs are expected to be affected by these proposals.

Balance of resource costs and benefits

96. The balance of costs and benefits can be compared with the value of risk reduction, which is *equivalent to* a “value of preventing a fatality” (VPF) of £1,500,000⁴ from the HSE economic analysis unit (EAU) appraisal values. The EAU appraisal values can be used to estimate the benefits of proposed measures which aim to improve safety, and to compare such benefits with the cost of government intervention. The prevention and mitigation of an accident leads to a reduction in costs to society, the EAU appraisal values are used to inform estimates of the size of such reductions in cost.

97. The actual value of the benefits of these amendments is subject to significant uncertainty. A review of the historical evidence suggests that preventing all fatality risk is unfeasible. For example, there are examples of gas and gasoline pipeline ruptures from ground disturbance during isolated construction work that have resulted in immediate ignition and death to the worker concerned. On the other hand, there are many multiple fatality events which could have been almost entirely mitigated by adequate emergency response. Preventing ignition or mitigating a spreading fire early could also realise significant loss prevention. We would also expect the frequency of unignited releases to fall.

98. If all the 200 developments each year were that we assume to be advised against occupied 100m² of land (fully intersecting the pipeline), then the total length of pipeline affected by development over forty years would be 8000km (100m* 200 * 40 years). This is greater than the length of urban pipeline at present. In practice, both costs and benefits are likely to be lower than the assumptions indicate, since some land will be redeveloped over this time, whilst other developments will remain in place.

99. The analysis undertaken for this Impact Assessment suggests that a significant proportion of the total risk would be mitigated by imposing LUP on the riskiest developments.

100. The actual costs of land use planning restrictions will depend on the specific development proposals that become subject to LUP. Land use planning can only be considered on a case by case basis. This suggests that the requirement to refer all developments for consideration of LUP is sensible. Detailed consideration would be required to estimate the cost of restricting any specific development, although it could be expected, based on records of land use planning restrictions around major hazard sites, that a proportion of developments could be excluded from LUP after the referral process.

Competition assessment

101. No significant economic impact on competition

⁴ <http://www.hse.gov.uk/economics/eauappraisal.htm>

Small firms Impact test

102. No significant economic impact on SMEs.

Other tests

103. No Significant or economic impact on legal aid, sustainable development, carbon assessment, Health impact assessment, race equality, disability equality, gender equality, , Human rights or rural proofing.

Uncertainties

104. There are uncertainties with regard to cost and risk in the analysis. These are detailed through the text. There has been discussion with industry representatives on the assumptions underlying these calculations.

105. HSE will be monitoring the number and type of land-use planning cases received, which involve gasoline pipelines and this will be recorded in the database. Then this can be reviewed after a sufficient number have been received, to ensure the system is working correctly.

106. This Impact Assessment is carried out on an individual risk based approach. It is noted however that a societal risk based approach may be more appropriate. This would require further research to identify how societal risk should be applied to this analysis.

Summary of Costs and Benefits under option 4:

Costs		Benefits	
One off costs		One Off	
Annual Costs		Annual	
Present Value Total		Present Value Total	5.2 million (fatalities and injuries)

Specific Impact Tests: Checklist

Use the table below to demonstrate how broadly you have considered the potential impacts of your policy options.

Ensure that the results of any tests that impact on the cost-benefit analysis are contained within the main evidence base; other results may be annexed.

Type of testing undertaken	<i>Results in Evidence Base?</i>	<i>Results annexed?</i>
Competition Assessment	Yes	Yes/No
Small Firms Impact Test	Yes	Yes/No
Legal Aid	Yes	Yes/No
Sustainable Development	Yes	Yes/No
Carbon Assessment	Yes	Yes/No
Other Environment	Yes	Yes/No
Health Impact Assessment	Yes	Yes/No
Race Equality	Yes	Yes/No
Disability Equality	Yes	Yes/No
Gender Equality	Yes	Yes/No
Human Rights	Yes	Yes/No
Rural Proofing	Yes	Yes/No

Annex 1

Methods of calculating risk

1. There are generally two ways of calculating the risk of an accident at a hazard. The historical record can provide a good indication of risk, providing there are enough actual incidents to provide a statistically sound estimate, and conditions have not changed significantly.
2. Another method is a quantitative risk assessment (QRA) which attaches a probability to the necessary chain of events leading to an incident. In practice, historical data can be used to inform QRA when undertaking risk assessment, so that a combination of the two methods can be used.
3. The use of QRA ('modelled risk') requires assumptions about prevailing conditions. It is HSE's methodology when considering land use planning contours for referral to assume impermeable, frozen or saturated ground and maximum safe pipeline operating pressures. This is because the LUP zones are designed to provide an indication of when a development should be referred for further consideration. The decision to actually apply LUP restrictions or not is separate, and will depend on the details of the particular case. Permeable ground (for example) would be a mitigating factor which might mean that LUP restrictions are not suggested by HSE. A range of conditions, reflecting the variation in actual risk, is considered for LUP application in this analysis.

Historical risk

4. Based on the historical record of fatal incidents, WS Atkins calculate the Probabilistic Loss of Life (PLL) associated with gasoline pipeline failures on a worldwide basis, and separately for the USA and Western Europe. In addition, they calculate a PLL for the UK based on QRA, and concerning a typical residential population in the vicinity of a gasoline pipeline. The average loss of life based on the QRA exercise is 0.013 fatalities per year. This compares with a figure of 0.031 per year quoted by WS Atkins if the historical figure for Western Europe is applied to the UK, adjusting for the length of pipeline in each case. This latter figure may be inaccurate. Since the total length of gasoline pipelines in the UK is 3606 km, use of the West European figure of 0.012 fatalities/1000 km leads to 0.043, not 0.031.
5. The historical risk (using WS Atkins estimates) can be approximately converted into individual risk (using figures below) on the following basis. This risk estimate can only be considered approximate because it draws a sharp distinction between urban and rural population, when in fact population density will vary between the figures show (a different population density, for example encompassing 'semi-urban' areas, would also provide a different split between urban/semi-urban and rural populations). Having said this, an estimated one tenth of the pipeline length is in heavily populated areas, and this accounts for the vast majority of the risk.
6. Total area around pipeline subject to risk = $(60\text{m} + 60\text{m}) * 3,600 \text{ km} = 430 \text{ km}^2$, of which 10% is urban area and 90% is rural area.
7. Assume urban population density of $5,000/\text{km}^2$ and rural density of $2.5/\text{km}^2$.
8. Population at risk = $0.1 * 500 * 5000 + 0.9 * 500 * 2.5 = 250,000$ (approx).
9. Individual unadjusted fatality risk = $0.031/250,000 = 1.2 \times 10^{-7}$ per year.

Modelled risk

10. HSE's proposed land use planning zones are based on an inner zone related to spillage pool radius (of 50m) and an outer zone (the consultation distance) related to risk (60m). This outer zone is based on the maximum risk of 0.3 chances per million (cpm) each year of receiving a dangerous dose or worse (beyond the consultation distance risk falls below 0.3 cpm).

11. The exact scale of the risk has been modelled in detail both by HSE and in the published reports noted above. Some of the underlying calculations are subject to dispute, however, the majority of evidence shows that the higher bands of individual risk in urban areas are between 1×10^{-6} and 6×10^{-6} per year at 10m from the pipeline falling to between zero and 1×10^{-6} at around 50m and, by definition, a maximum of 3×10^{-7} at 60m. This spread of risk is related to pipeline diameter. For simplicity, this can be taken to average 2×10^{-6} over the whole consultation distance.
12. Similarly, for rural areas, HSE now estimate the higher bands of individual risk to be between 2.5×10^{-7} and 1×10^{-6} at 10m, falling to between zero and 6×10^{-7} at around 50m, and zero to 3×10^{-7} at 60m. This can be taken to be equivalent to 3×10^{-7} over the consultation distance.
13. Given that 10% of pipeline length is in urban areas and 90% in rural, this would suggest an overall average individual risk of around:
 - $2 \times 10^{-6} * 0.1 + 3 \times 10^{-7} * 0.9 = 5 \times 10^{-7}$
14. The calculated risk given average soil, but maximum operating pressure is estimated to be on average around 2×10^{-7} in urban areas and around 1×10^{-8} in rural areas, giving around 3×10^{-8} over the pipeline system.
15. These calculations are taken from the most recent HSE analysis of gasoline pipeline risk. This analysis took account of the findings of both published reports and involved a re-interpretation and development of the data in the WS Atkins report. WS Atkins estimates were corrected for a number of apparent errors, and also to allow for HSE's preferred choice of assumptions. Future research will be needed before full consultation to ensure calculations are fully informed and up to date.

Corrections to calculated risk estimates

16. The WS Atkins report concluded the appropriate risk for the UK is one that reflects historical risk rather than modelled risk. This is because historical risk accounts for fatalities not included in modelled risk, and an examination of the historical incidents would suggest that this is significant, even with respect to developed countries.
17. The authors note that the modelled (QRA) figure only related to those living in the vicinity of gasoline pipelines. The historical figure included all those injured in the event, including bystanders and members of the emergency services. The authors conclude that the historical figure is therefore the most appropriate to use in assessing risk. This conclusion has been questioned by industry, who contends that a figure relating to Western Europe is not appropriate to the UK. Nevertheless, this work suggests that there is a significant increase in risk once other persons are included. From reviewing historical incidents, it is clear that work-related activity (for example excavating near the pipeline) is a significant cause of inadvertent pipeline rupture and sometimes ignition. In many cases, this automatically places non-residents near the event. These risks are not captured in risk modelling.
18. Risk to non-resident persons can be minimised by adequate emergency response and evacuation. The difference between the modelled risk and historical risk in the WS Atkins report is 2.4. As the Author's suggest, we apply the factor of 2.4 to average modelled risk. The historical record also suggests that each fatality from a gasoline pipeline leak ignition would be associated with on average four significant injuries of varying severity. Given weighting factors common to this type of analysis, we assume that each fatality is equivalent to 1.4 'equivalent fatalities'.

Comparison of historical and calculated risk.

19. The HSE and WS Atkins estimates of risk in average soil, multiplied by 2.4, and the WS Atkins estimates based on historical risk suggest an average annual value for individual risk in the order of 10^{-7} (ie 0.1 chance per million, cpm). This is below the generally accepted risk requiring minimisation to a level “as low as reasonably practical”.⁵
20. HSE’s modelling suggests that individual risk to residents could be at least 50 times higher than the overall average in urban areas with paved or impermeable soil (2×10^{-6} compared to 3×10^{-8}). Conversely, risk will be considerably lower than 10^{-7} in rural areas in soil with good drainage.
21. Bearing in mind the historical data, which suggests that modelled risk to the residential population is likely to significantly underestimate the total individual risk, we use the following equivalent fatality preventable (efp) risks per year in this assessment:
- Average risk : 1×10^{-7}
 - Urban areas, impermeable soil: $(1 \times 10^{-7}) * 50 = 5 \times 10^{-6}$
 - Rural areas, average soil: $(1 \times 10^{-8}) * 2.4 * 1.4 = 3 \times 10^{-8}$
22. These estimates give the total extremes of individual risk likely to be encountered on a generic basis. Individual developments may well have individual risk levels either higher or lower than these extremes (for example due to favourable or unfavourable topography).
23. We can use the research by WS Atkins - and published research on previous evidence on the scale of losses incurred following high cost chemical/petrochemical accidents undertaken by HSE in conjunction with WS Atkins⁵⁶ - to assess the risk of loss from gasoline pipelines leaks that result in ignition and consequent major losses.
24. WS Atkins have calculated the risk of a pipeline failure fatality using event trees constructed from pipeline failure data, and ignition data using the historical record. The risk of pipeline failure can be calculated from WS Atkins data⁶⁷ as 0.66 /1000 km-yr for an urban pipeline, and 0.25 /1000 km-yr for a rural pipeline.
25. Using the author’s split between urban and rural pipelines of 10% / 90% gives a combined value of:
- $0.9(0.25) + (0.1)0.66 = 0.291$.
26. This agrees with data later in the report, although the weighting of the failure rates according to length of pipeline adds further uncertainty.
27. The ignition probabilities⁷⁸, based on European data, were 2.5% (rural) and 4.3% (urban), although HSE would argue that these should be 3% (rural) and 5% (urban), when taking into account wider evidence. This gives new calculation for ignited gasoline pipeline incidents each year of:
28. Urban: $10\% \times 3606/1000 \times 0.66 \times 5\%$ = 0.012pa
29. Rural: $90\% \times 3606/1000 \times 0.25 \times 3\%$ = 0.025pa
30. Total incidents = 0.038pa

⁵As most recently described in HSE’s draft Discussion Document “Reducing Risks, Protecting People”, HSE Books, DDE11, c150, 5/99.

⁶P Fewtrell (WS Atkins) and I Hirst (HSE, CHID) “A review of high-cost chemical/petrochemical accidents since Flixborough (1974)”, Loss Prevention Bulletin, 140, (1998).

⁷WSA Report, page 5, Table 3.2

⁸WSA Report, page 12, sectn 3.8.1

31. This suggests one ignition event every 25 years, comprising one urban ignition every 80 years and one rural ignition every forty years.
32. Industry analysts contend that historical ignitions in the UK have not necessarily been of the type under scope of these proposals. However, the analysis also included ignition events (of gasoline, kerosene and jet fuel) from the United States. This provided a much larger dataset, including many incidents clearly under scope of the proposals. WS Atkins concluded that no significant differences in ignition probability could be determined between either the US or UK data, or the type of product. Hence a total probability is calculated across all the data, further increasing the size of the dataset.
33. It should also be noted that the frequency of urban ignition events (one in twenty years) is such that the historical data for the UK might, by chance, show no observed event over a 27 year period. The data does show one event that can reasonably be described as a near miss, and one event that involved an ignition of another product in a mixed product pipeline (although this latter pipeline was not a 'cross-county' pipeline, it may well be in the class affected by these proposals). Although an urban ignition involving a gasoline pipeline has not been observed in the UK, failure probabilities are calculated to be higher in urban areas because of the higher risk of disturbance due to both ground movement and ground working. Adding to this, the majority of US ignitions occurred in urban areas.
34. The consequences of an urban ignition of gasoline can be severe, as the following descriptions from the WS Atkins report show:
35. **[On 16th June 1976 in Los Angeles, California]** "An 8 inch gasoline pipeline was struck and ruptured by excavation equipment. Gasoline sprayed from the rupture drenching nearby buildings. Ignition occurred 90 seconds later. The subsequent fire killed 9 people and injured 14 and caused extensive property damage in a busy town thoroughfare. An entire block of buildings was involved in the fire".
36. **[On 30 January 1980 in Puerto Rico]** "An 8 inch products pipeline was struck and ruptured by a bulldozer... ..Gasoline from the rupture sprayed downhill and ran off into a small creek, and then a populated area some 2 km away... ..The subsequent fire killed one person and extensively damaged 25 houses".
37. **[On 22 April 1992 in Guadalajara, Mexico]** "The slow and continued leak of gasoline from a transmission pipeline resulted in a migration of gasoline vapours into the sewage system under a congested area in Guadalajara. An external source ignited these vapours and consequently a series of explosions occurred along the path of the sewer system through a twenty block area. These explosions resulted in the decimation of a twenty block area and some 252 deaths".
38. We do not have any further information about the scale of economic loss in these events. WS Atkins list several examples worldwide where gasoline has sprayed on to surrounding buildings (see section 4.2, WS Atkins), which have then been engulfed by fire, however the authors find insufficient historical data to develop an appropriate consequence model for the overall risk in the UK - although they note that the risk could be 'significant'.
39. It should also be noted that we are considering proposals which would impose land use planning restrictions on what will be in practice a minority of proposed developments - ie those which would propose a particular high risk should an incident occur. The proposals are expected to affect large scale housing and retail developments, particularly where the location could increase the risk. The losses

we have estimated could clearly be incurred with respect to these types of developments, but not 'lower risk' developments.

40. Furthermore, the full economic loss can be far higher than is immediately apparent. Research on previous evidence on the scale of losses incurred following high cost chemical/petrochemical accidents has been undertaken by HSE in conjunction with WS Atkins⁹. The report found a lack of reliable data in the public domain, and conflict between reported values in cases where data was available. These differences are ascribed to the wide scope of costs involved, commercial sensitivity, changes in monetary values over time and simple clerical error.
41. The report found that published costs would tend not to include unobserved cost. The published report of one accident quoted company representatives as saying that the unobserved cost of business interruption could have been many times the initial cost. This is consistent with published research from many sources¹⁰ in the field of health and safety economics. An analysis of 119 events at petrochemical, chemical and refinery sites concluded that the business interruption losses were on average 2.7 times the commercial property damage losses (with wide variation between the individual cases¹¹). We have no reason to believe that this proportion would be different for a major incident involving gasoline pipelines.

⁹P Fewtrell (WS Atkins) and I Hirst (HSE, CHID) "A review of high-cost chemical/petrochemical accidents since Flixborough (1974)", IChemE Loss Prevention Bulletin, 140, 1998.

¹⁰ See for example: "The Costs of Accidents at Work", HSE books, 1997 (2nd ed).

¹¹Loss Control Newsletter, January 1997.