UKOPA

United Kingdom Onshore Pipeline Operators' Association

Good Practice Guide – Application of Cost Benefit Analysis to Demonstrate ALARP

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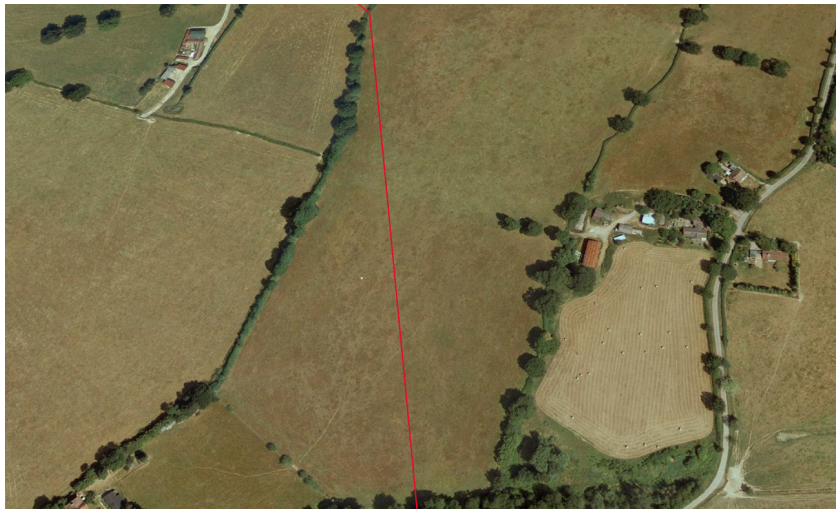
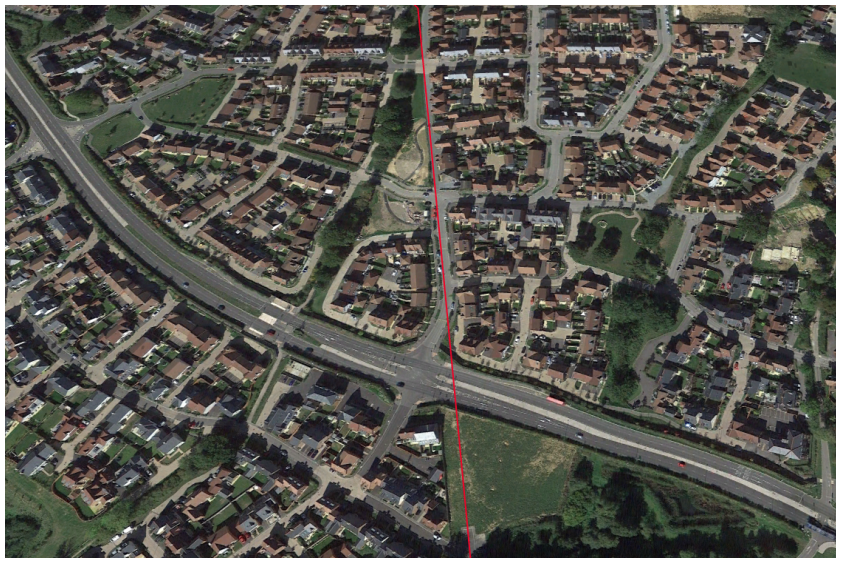
Operators Predicament

- The risk to people from pipelines are a constant and continuing threat
  - Towns expand closer to once rural pipelines.
  - Developers and landowners try to maximise the land for buildings.





Operators Perspective

- Pipeline operators operating Major Accident Hazard Pipelines (MAHPs) are required to demonstrate that risks from their pipelines are 'As Low As Reasonably Practicable' (ALARP).
- Demonstration of this generally requires compliance with recognised industry good practice, supported where necessary by risk analysis.
- If the risk analysis exceeds broadly acceptable then risk reductions need to be considered.

- This can present problems to operators…

Operators Perspective

- Cost Benefit Analysis is commonly used for making decisions on funding for all types of pipeline inspection & maintenance
  - e.g. Intervals…
- All of us use (informal) CBA in life to make decisions
  - Health
  - Travel
  - Maintenance to our properties
  - Even an evening out…
- Where there are significant safety hazards, we have to be more formal

Societal Risk TBN Suite

- A suite of technical bulletin notes to provide operators support on managing societal risk.
  - Published
    - Managing Societal Risk in the Vicinity of High Pressure Natural Gas Pipelines
    - Managing Encroaching Development and Societal Risk Around Ethylene Pipelines - Published
  - (Still) being written
    - Managing Encroaching Development and Societal Risk Around Oil Pipelines

Societal Risk TBN Suite

- Overview
  - Guidance on societal risk
    - Including historical data for review
  - How these risks can be ALARP
  - Basic steps in a QRA
  - Risk Assessment Process
  - Assessing Societal Risk

- All refer to IGEM/TD/2 and PD 8010-3 for technical details on QRA methodology

GPG Scope

- Concept of ALARP as implemented by pipeline operators
- How CBA is applied by operators to demonstrate that risks are ALARP

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Legislative Requirements (1/2)

- Health & Safety at Work etc. Act 1974 (HASWA)
  - "It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his/her employees"

- Management of Health & Safety at Work Regulations 1999
  - "Every employer shall make a suitable and sufficient assessment of-

    (a) the risks to the health and safety of his employees to which they are exposed whilst they are at work; and

    (b) the risks to the health and safety of persons not in his employment arising out of or in connection with the conduct by him of his undertaking"

Legislative Requirements (2/2)

- Pipelines Safety Regulations (PSR) 1996
  - Goal-setting
  - Design, construction and safety systems
    - Limited by reasonable practicability clauses
  - MAPD (MAHPs only)
    - All hazards identified and risks arising from those hazards evaluated
    - Adequate Safety Management System for ensuring risk of major accident is ALARP

Code Requirements (UK)

- IGEM/TD/1 Edition 5
  - Affirmation of MOP including infrastructure survey – every 4 years
    - 'TD/1 Survey'
  - QRA allowed to justify proximity & population density infringements as part of a safety evaluation
  - Cost benefit analysis to demonstrate ALARP required when
    - Individual Risk is in the tolerable region, or
    - Societal Risk is outside the broadly acceptable region

- PD 8010-1:2015
  - Currently lighter on O&M details but does now require Affirmation of MAOP in accordance with requirements of IGEM/TD/1
    - UK HSE does expect operators of pipelines designed to earlier versions of PD 8010 to complete MAOP Affirmation

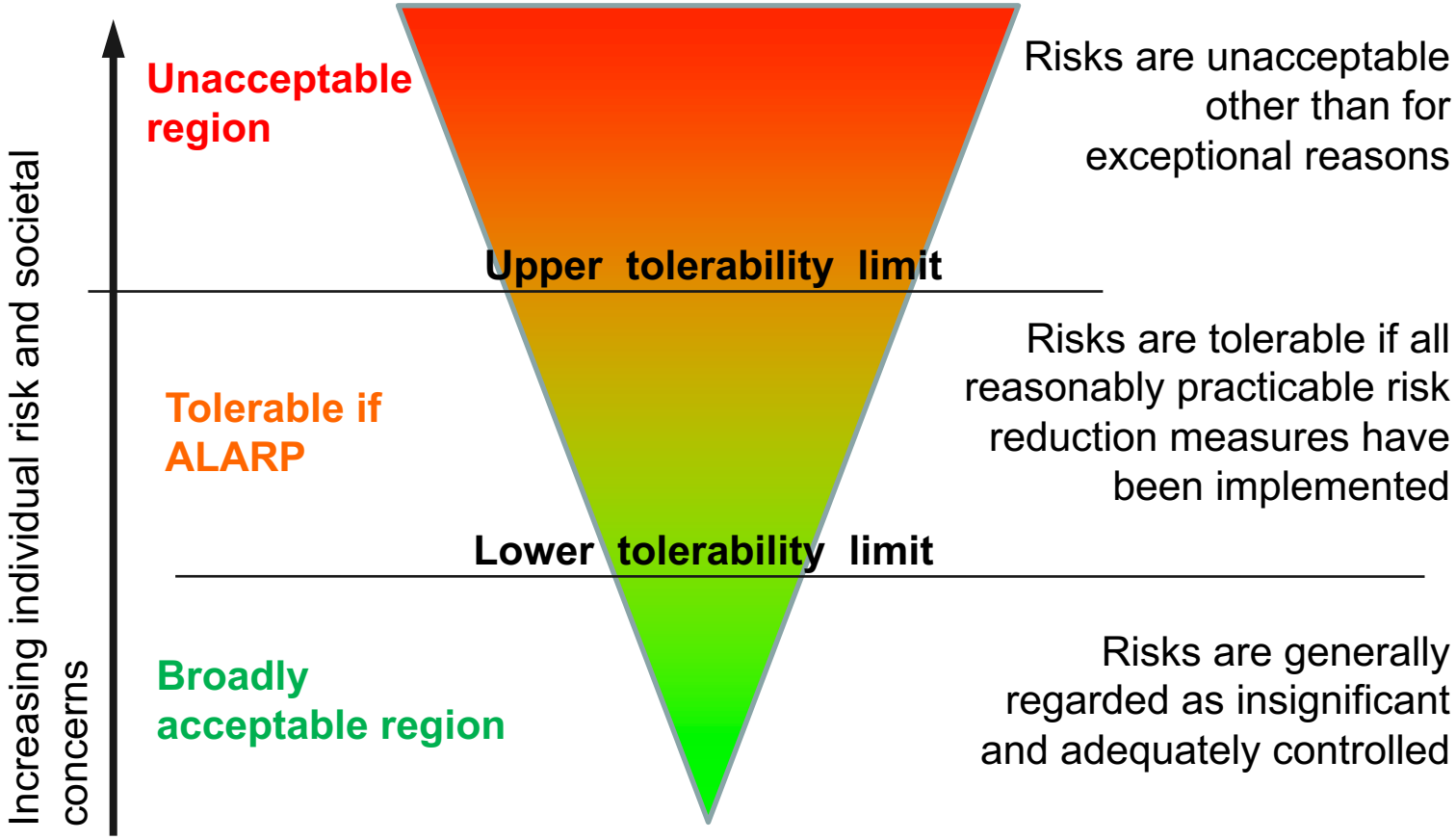
Background – ALARP Principle

- Concept of ALARP introduced in Appeal Court judgement from Edwards vs National Coal Board [1949] 1 All ER 743

"…in every case, it is the risk that has to be weighed against the measures necessary to eliminate the risk. The greater the risk, no doubt, the less will be the weight to be given to the factor of cost"

"'Reasonably practicable' is a narrower term than 'physically possible' … a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that, if it be shown that there is a gross disproportion between them – the risk being insignificant in relation to the sacrifice – the defendants discharge the onus on them."

ALARP Principle – UK HSE



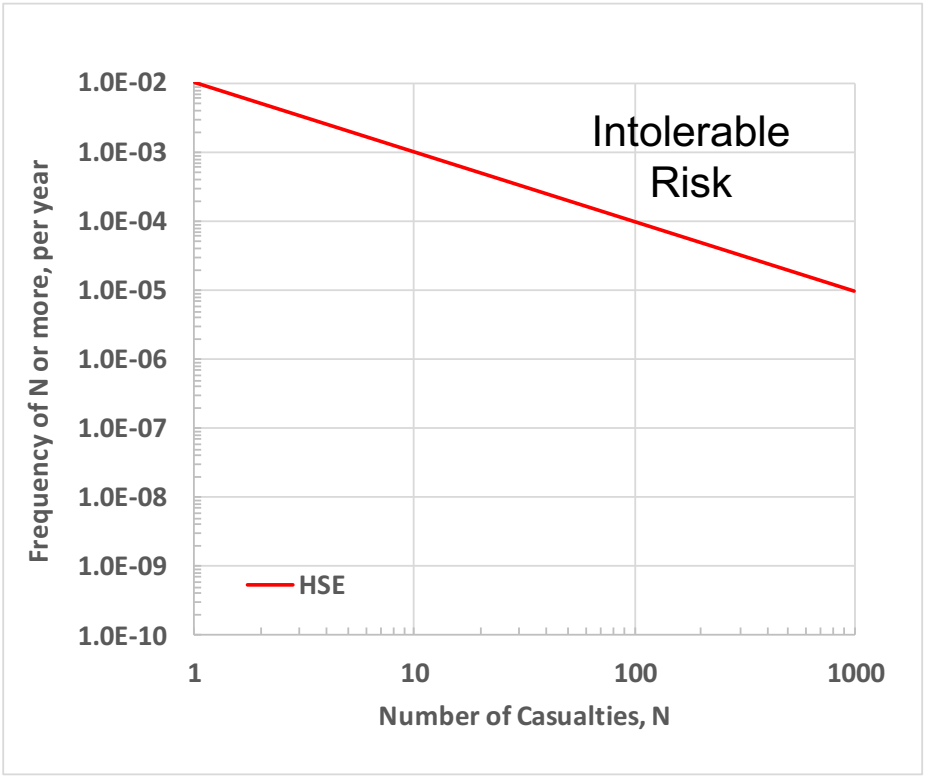
Tolerability Limits – Individual Risk

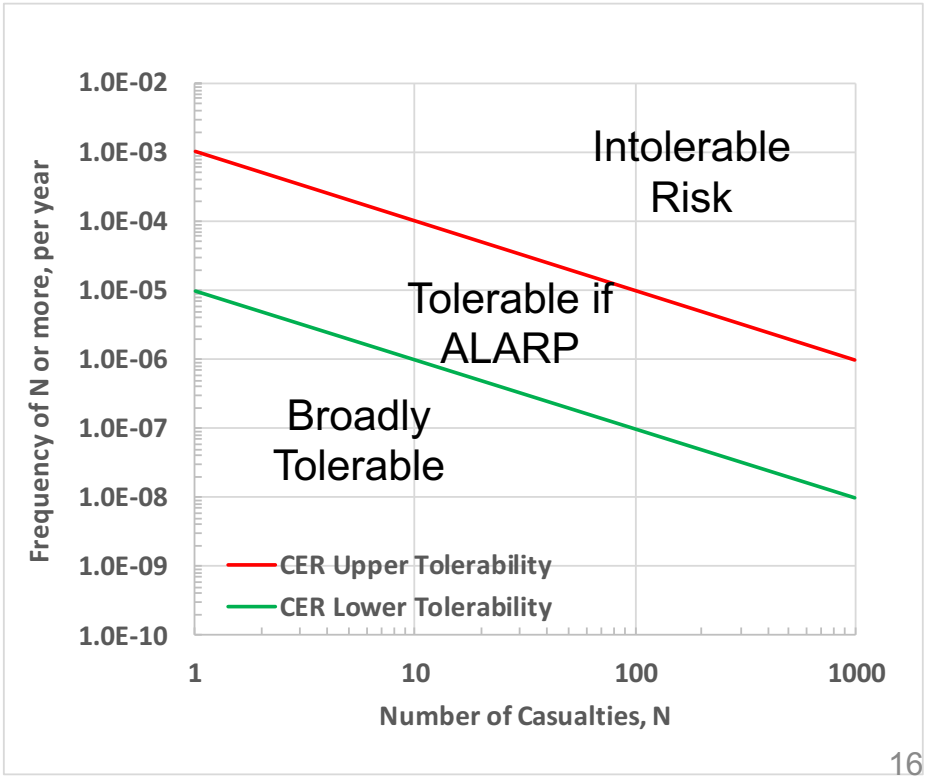
- UK HSE
  - Upper Tolerability Limit (Worker) – 1×10^{-3} per year
  - Upper Tolerability Limit (Public) – 1×10^{-4} per year
  - Lower Tolerability Limit – 1×10^{-6} per year

- Average risk of death from all causes is approximately 1×10^{-2} per year
  - i.e. Risks at lower tolerability limit add 0.01% to overall individual risk for average person

Tolerability Limits – Societal Risk

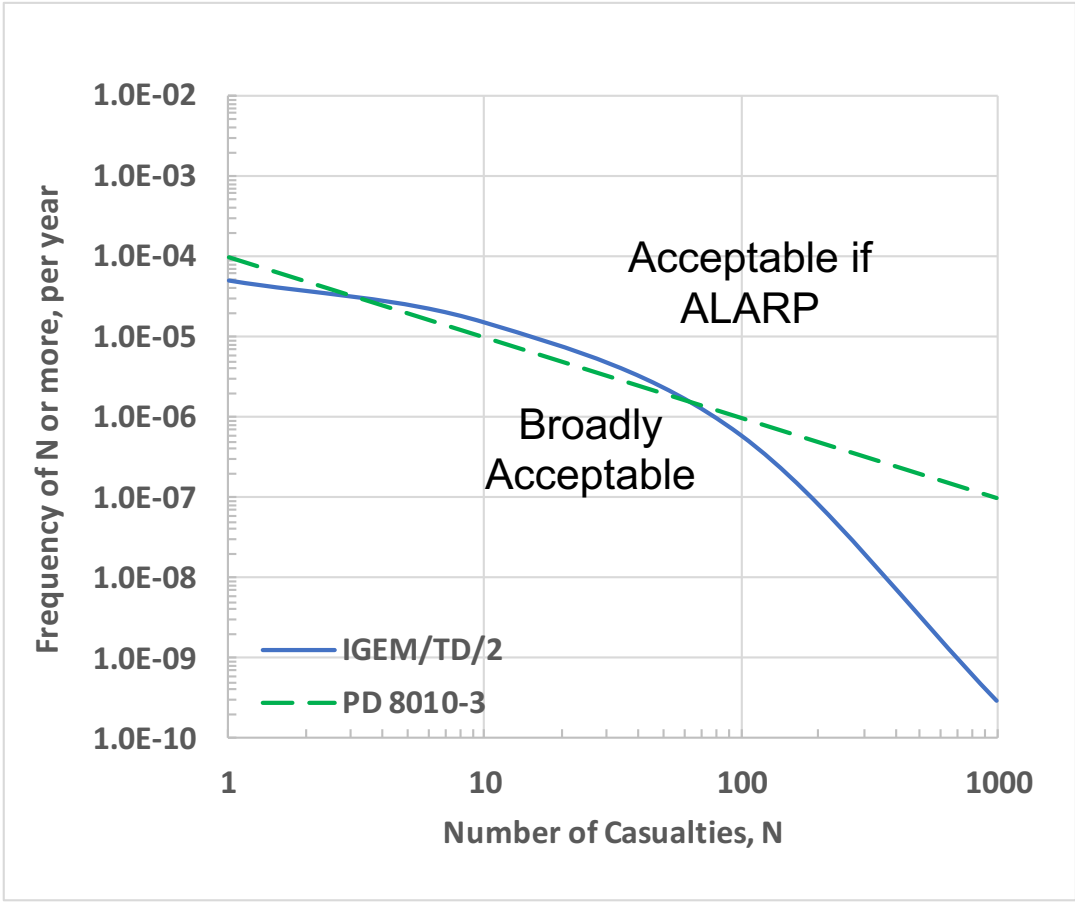
- UK HSE
  - Intolerable region defined as 50 people at more than 2 x 10^{-4} per year
  - Slope of -1 (no aversion)
- ROI CRU
  - One order lower & Tolerable if ALARP Region defined





Tolerability Limits – Societal Risk

- IGEM/TD/1 & IGEM/TD/2
  - 1.6 km of pipeline
- PD8010-3
  - 1 km of pipeline



Risk Management Process

1. Identify all (major accident) hazards associated with the activity
2. Good practice (or its equivalent) must be implemented
3. Undertake Quantitative Risk Assessment of all Major Accident Hazards
4. If risk is between upper and lower tolerability limits
   a) Identify appropriate risk reduction measures
   b) Implement each measure unless it is not reasonably practicable to do so

ALARP Demonstration

- 3 key aspects:
  1. Demonstrating that relevant industry standards, codes and good practice have been / are being followed in the design, construction, operation and maintenance of the pipeline.
  2. Highlighting where additional measures have been implemented to reduce risk.
  3. Identifying additional risk reduction measures that could be considered and performing a cost benefit analysis to determine whether the cost of implementing a measure is commensurate with the safety benefit experienced.

Good Practice & ALARP Demonstration

- 1st step in an ALARP assessment is to determine if relevant good practice risk reduction measures have been adopted
  - Defined by recognised codes / standards / ACOPs / etc.
- Design, construction, operation and maintenance to IGEM/TD/1 or PD 8010-1 considered to be good practice by UK HSE
  - Implicit assumption that risk levels of pipelines to code are ALARP
    - QRA of the residual risk used where code is infringed
  - Be careful with cherry-picking!

Cost Benefit Analysis Process

- Calculate the Cost of Preventing a Fatality (CPF)
  - Sometimes called Cost per Life Saved (CPLS) or Cost per Casualty Averted (CPCA)
- Compare with Value of Preventing a Fatality (VPF)
  - £1,000,000 in 2001
  - Approximately £1.6 million (2018 - adjusted for inflation)
- Determine the Disproportion Factor (DF)
  - UK guidance not totally clear on what is gross disproportion but robust justification required, e.g. if DF less than 10
    - i.e. CPF or should be greater than ≈£16 million (2018 figures)
    - QRAs typically use a larger value to account for uncertainty in frequency and consequence predictions

Cost of Preventing a Fatality

$$CPF = \frac{Cost\ of\ Risk\ Reduction\ Measure}{Reduction\ in\ Potential\ Loss\ of\ Life}$$

$$= \frac{Annualised\ Cost}{\Delta EV} = \frac{Cost}{\Delta EV \times Remaining\ Life}$$

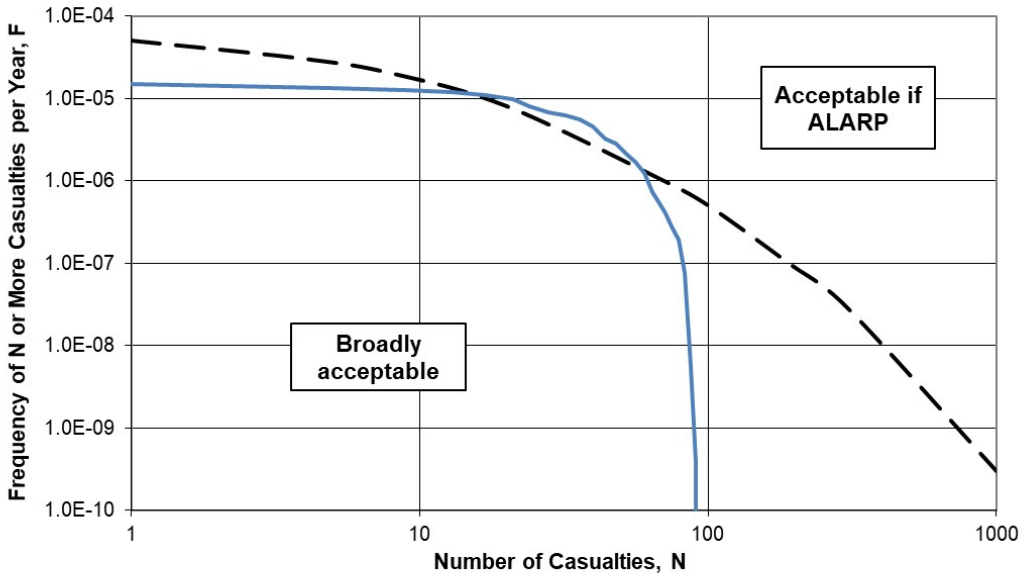
- EV = Expectation Value
  - Statistical expression for average number of casualties per year
  - Also known as Potential Loss of Life (PLL)

$$EV = \sum f.n$$

  - Equivalent to area under FN curve

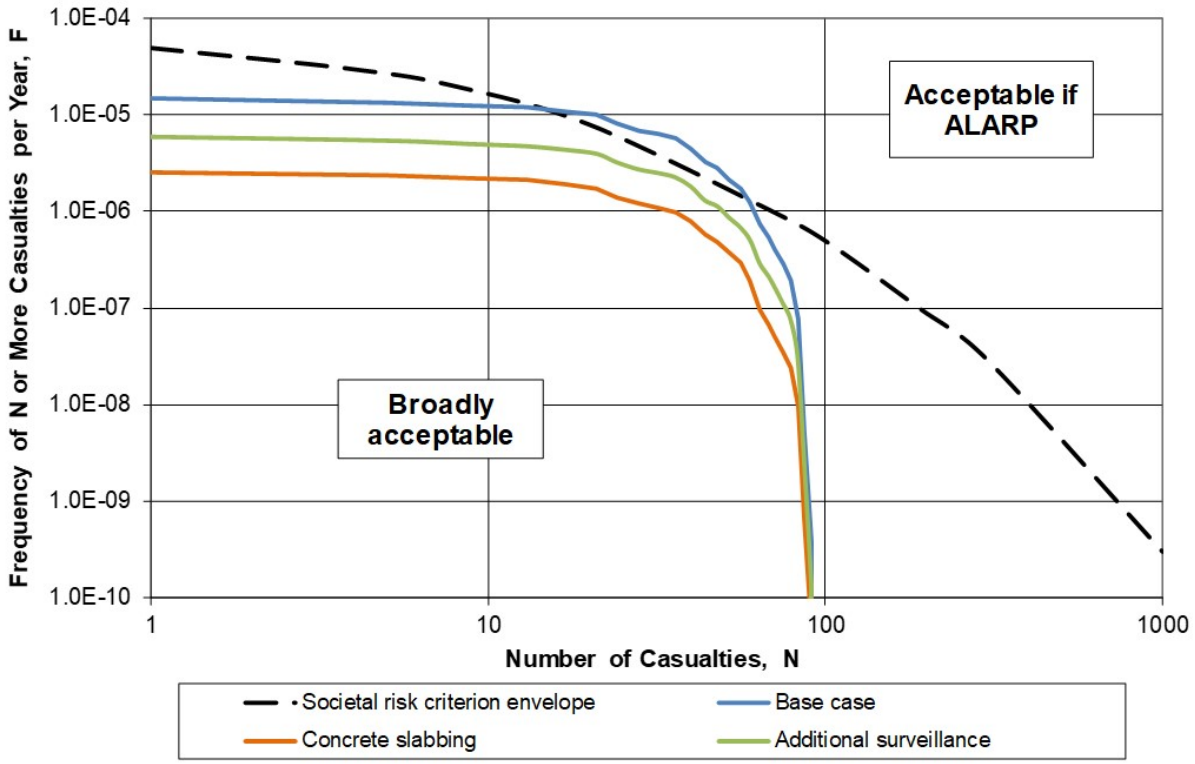
CBA Example 1

- Suburban Area
  - Current societal risk levels just greater than IGEM/TD/1 criterion
- Consider
  - Additional surveillance
  - 100 m concrete slabbing



CBA Example 1 – QRA Results

- Both bring risk level below criterion
  - Risk reductions due to slabbing greater than additional surveillance



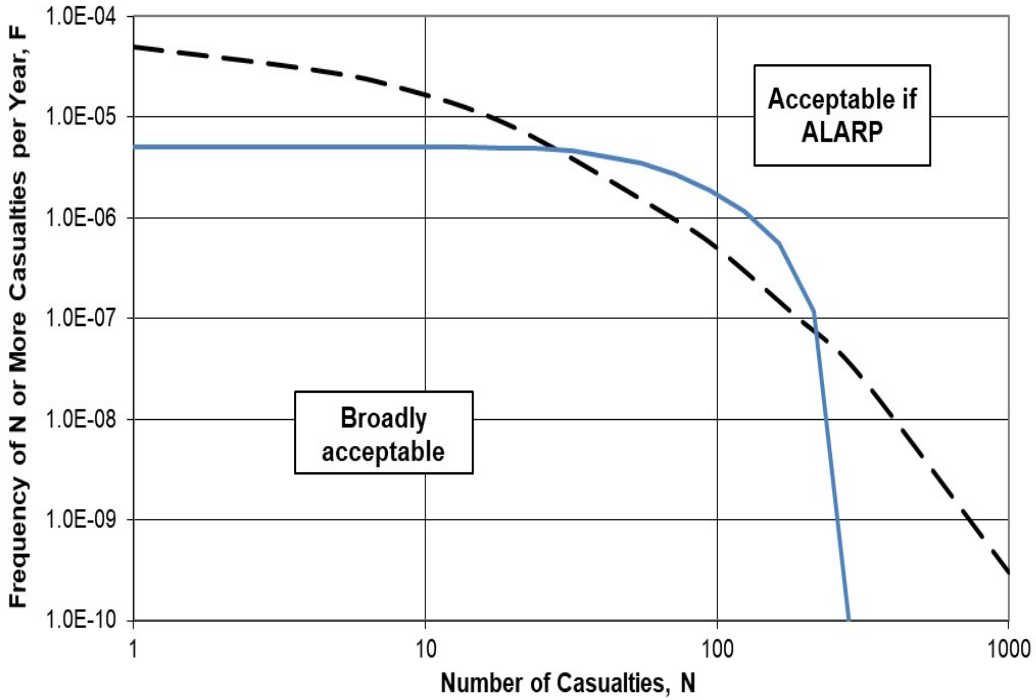
CBA Example 1 – Results

Risk Reduction Measure	Original Expectation Value	Reduced Expectation Value	Annualised Cost	VPF	DF
Surveillance	4.41×10^{-4}	2.64×10^{-4}	£1,620	£6.14 million	3.8
Slabbing		7.68×10^{-5}	£2,500	£6.86 million	4.3

- Both considered ‘reasonably practicable’
  - i.e. not ‘grossly disproportionate’
- HSE typically prefers physical not procedural protection measures
  - May assume surveillance budget likely to be cut at a future RIIO…

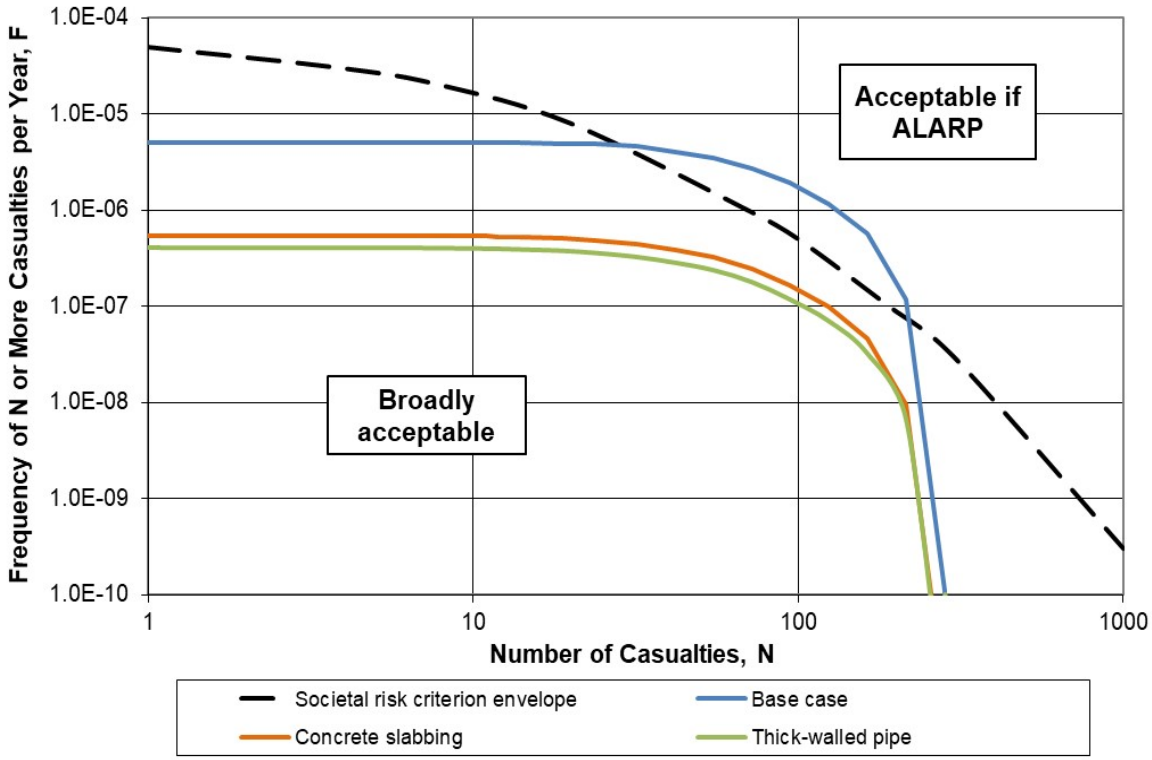
CBA Example 2

- Rural Area
  - Current risk levels greater than IGEM/TD/1 criterion
- Consider
  - 100 m concrete slabbing
  - 250 m thick wall



CBA Example 2 – QRA Results

- Both bring risk level below criterion
  - Risk reductions due to slabbing and thick-wall are broadly similar



CBA Example 2 – Results

Risk Reduction Measure	Original Expectation Value	Reduced Expectation Value	Annualised Cost	VPF	DF
Slabbing	4.31×10^{-4}	4.42×10^{-5}	£6,250	£16.2 million	10.1
Relaying		2.95×10^{-5}	£17,500	£43.6 million	27.2

- Relaying in thick-wall considered ‘grossly disproportionate’
- Slabbing is borderline
  - Most operators would probably install the slabs
    - Especially if you can get the developer to lay them for construction protection!

Conclusions

- Legislation requires operators to demonstrate ALARP
  - Good Practice
    - Follow IGEM/TD/1 or PD 8010-1 & UKOPA GPGs
  - Identify additional risk mitigation
  - Assess using QRA and CBA
- TBNs provide advice on use of QRA for different fluids
- GPG for Cost Benefit Analysis

Questions?