PROPOSED CORRIB ONSHORE PIPELINE.

QUANTIFIED RISK ASSESSMENT.

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ABP Ref No PL16.GA0004

QUALIFICATIONS AND EXPERIENCE

1. My name is Philip Crossthwaite. I am a Chief Specialist in DNV (Det Norske Veritas Limited). DNV is a leading professional service provider and our areas of expertise cover risk management of assets and IT, safety, health and environmental risk management, technology qualification and offshore classification and verification. I am in the health, safety and environmental group and based in the UK; worldwide this group comprises some 350 people.

2. I have a B. Sc. and a Ph. D. in Fuel Engineering. I am a Chartered Engineer and a Member of the Energy Institute (UK). I have been working in the field of health and safety for the past thirty four years following a few years working in combustion engineering. I worked for the UK Health and Safety Executive (UKHSE), the UK safety regulator for 13 years, where I held the position of Principal Inspector, and for the remaining 21 years I have been a consultant (including 17 years with DNV). My experience includes auditing, inspection and risk assessment of various types of facilities. During the last 27 years I have carried out many quantified risk assessments (QRAs) of facilities that have fire, explosion and toxic hazards. During my time at the UKHSE I carried out QRAs on hazardous facilities including onshore gas and liquid pipelines and assisted in the development of the land use planning policies for the UK. During my time as a consultant I have carried out QRAs of onshore gas and liquid pipelines for many clients in many locations e.g. UK, various EU countries and China including export pipelines from LNG terminals and high pressure gas pipelines which form part of a country's gas transmission system.

3. I have worked on the Corrib project since 2003 preparing the QRA for the terminal. My evidence today covers the revised QRA of the proposed onshore pipeline which is detailed in Appendix Q6.4 in the EIS.

4. In this statement I will describe some of the work that has been carried out for this QRA following the 2009 Oral Hearing and two letters from An Bord Pleanála dated 2nd November 2009 and 29th January 2010.

5. The update of the 2009 QRA has taken into account the following matters as requested by An Bord Pleanála:

- Changes in the pipeline route (which is now within a tunnel for 4.9 km of its length) and a reduction in the maximum pressures (Maximum Allowable Operating Pressures (M.A.O.P.) in the offshore and onshore pipeline sections have been established as 150 barg and 100 barg respectively).
- More detailed consideration of potential failure modes and the associated specific failure frequency, especially due to internal corrosion of the pipeline, landslip and hydrate formation.
- Quantification of potential third party intentional damage to the pipeline and landfall valve installation.
- Prediction of individual risks from specified levels of 'dangerous dose' or more which An Bord Pleanála have set out as a standard against which the proposed development will be assessed.
- Prediction of the inner, middle and outer zone risk contours for the pipeline and landfall valve installation.
- Prediction of the societal risk at Glengad and along the revised route.

I have included in this 2010 QRA an overview of the methodology that has been adopted. Consideration has also been given to a large number of potential (although as can be seen, extremely remote) failures from the qualitative risk assessment (Appendix Q6.3). The selection of failure frequencies which are processed in the QRA are supported by specialist reports contained in other Appendix Q documents and also fully explained derivations from pipeline databases.

6. I begin this statement by providing a summary of the outcome of the QRA. I then give an overview of the QRA process, followed by details of some of the key aspects that influence this outcome with particular focus on those aspects raised by An Bord Pleanála in their letters of 2nd November 2009 and 29th January 2010. Certain technical terms used in the statement are defined in a glossary at the end of the statement.

SUMMARY

7. The predictions contained in the QRA give the absolute level of residual risk to the people in dwellings in the vicinity of the proposed pipeline and landfall valve installation. Two measures of risk have been determined, individual risk and societal risk.

8. The individual risk, which is the chance per year of a house resident receiving a dangerous dose or greater of radiated heat, was calculated at varying distances from the pipeline and landfall valve installation. The calculation followed the method given in PD 8010 Part 3 which contains 'rule-sets', or specified assumptions, that should be used in this type of analysis in order that the risk calculation is consistent and can therefore be compared with set numerical criteria. The risk is presented as a 'risk transect' and also on an aerial photograph as a 'risk contour'.

9. The predicted levels of individual risk are as follows:

- At the landfall valve installation the individual risk is below $1x10^{-5}$ per year (which is one chance in one hundred thousand per year) of receiving a dangerous dose or more for a person who is at that location continuously.
- At the pipeline the individual risk is $3x10^{-9}$ per year (which is one chance in 320 million per year) of receiving a dangerous dose or more.
- A person at the nearest existing occupied dwelling to the onshore pipeline would have an individual risk of $2x10^{-11}$ per year (which is one chance in 50 thousand million per year or 0.00000000002 per year, which is an infinitesimally small number) of receiving a dangerous dose or more.

10. An Bord Pleanála have specified that if the individual risk level was one in one million per year or higher, then SEPIL would need to demonstrate that the risks were as low as reasonably practicable (ALARP), and if the individual risk level was below one in one million per year the risk would be broadly acceptable. As shown above the level of risk at the pipeline is well below one in one million per year and so meets the Board's criteria. In the vicinity of the landfall valve installation the broadly acceptable risk level is reached at a distance of 63m, and the nearest dwelling is some 280m away, where the risk level is well below the Board's criteria. The risks from the

proposed development meet the Board's criteria because they are either broadly acceptable or, where the risk is slightly higher than one in one million, which only occurs within 63m of the landfall valve installation, the risks are considered to be ALARP.

11. The societal risk, which shows the risk from one kilometre of pipeline to people in the vicinity of that stretch of pipeline is also presented. This measure of risk takes into account the actual number of people in dwellings that may be affected in the Glengad area. The societal risk levels are extremely low, in fact one million times lower than the broadly acceptable threshold stated in PD 8010 Part 3, a code designated by the Technical Advisory Group for the pipeline.

THE 2010 QRA

12. This QRA takes account of the new route of the pipeline between the landfall valve installation and the Bellanaboy Bridge gas terminal. The rerouting of the pipeline increases the minimum distance between the pipeline and an occupied dwelling from 140m (in the 2009 route) to 234m (in the 2010 route), more than three times the distance to an occupied dwelling in the original pipeline route. The pipeline M.A.O.P.s have been set. These are 150 barg for the landfall valve installation and the pipeline upstream of the landfall valve installation and 100 barg for the pipeline downstream of the landfall valve installation. Normally a QRA would be carried out on the operating conditions (as was done in 2009). The operating pressure is lower than the M.A.O.P s, and so the assumptions in the QRA are conservative. Both the change in route and the reduction in the maximum pressure reduce the maximum predicted risk levels associated with the pipeline and landfall valve installation to people in the housing along the pipeline route. However, it is important to note that the risks predicted for the 2009 route were already considered to be broadly acceptable or negligible. The new route is shown in Volume 1, Section A, Chapter 1 of the EIS, and the explanation regarding the maximum allowable operating pressures is given in Appendix Q4. This QRA (Appendix Q6.4) shows, in a complete and transparent way, that the predicted risks do not pose an unacceptable risk to the public.

AN OVERVIEW OF THE QRA METHOD

13. The technique of quantified risk assessment has been used for many years to assist in decisions associated with technological systems (for example nuclear power

stations, aircraft, hazardous installations). It is a well recognised technique which is used to determine numerically the 'residual risk' which is the risk that remains after all reasonably practicable risk reduction measures have been taken, and in most cases is used to determine the risk level associated with hazards that could give serious consequences to people (such as a release of radiation from a nuclear power station, or the crash of an aircraft). The method embodies the following steps:

- Definition of the system (which in this case is the proposed pipeline and landfall valve installation) and the criteria by which the predicted risks will be judged (which have been defined by An Bord Pleanála).
- Identification of the hazard (which is flammable gas in the pipeline) and development of a set of scenarios which, when analysed together, will give an appropriate representation of the risks from the whole system. In this case all equipment at the landfall valve installation was included together with the entire length of pipeline from 50m offshore to the terminal.
- Calculation of the consequences (from an ignited release of gas) and the effect of the ignited release on members of the public (a dangerous dose of thermal radiation).
- Determination of the likelihood that the pipeline or landfall valve installation will fail and give a release of gas and possibly ignition.
- Combination of the consequences and frequencies to give the likelihood of receiving a dangerous dose or more at all locations along the pipeline route.

The method used is basically that used for the 2009 QRA and as specified in PD 8010 Part 3 and further details are given in Appendix Q6.4 in the EIS. This recommended method to assess the safety of a pipeline to members of the public combines several elements of probability, or likelihood, with consequences to determine the overall risk.

POTENTIAL CAUSES OF PIPELINE FAILURE

14. The qualitative risk assessment (see Appendix Q6.3 in the EIS) identified 32 different threats that might potentially cause a loss of containment from the pipeline. In accordance with the methodology in PD 8010 Part 1, 16 of these were screened out from further analysis because the threat was assessed as either non credible,

meaning it could not realistically occur, or the frequency of occurrence was so low that its omission would have negligible impact on the risk predictions. Examples of potential failure modes screened out and not carried forward to the QRA included internal dynamic loads, methanol fire and internal erosion. The screening exercise was carried out in conjunction with information on previous incidents that had caused loss of containment from pipelines in the past and with information associated with the specific properties and design of this pipeline.

15. The remaining 16 threats were failure modes which have historically given pipeline failures as indicated by the various pipeline databases. They can be grouped as follows:

- Internal corrosion
- External corrosion
- Construction or material defects
- Accidental external interference
- Intentional or malicious third party damage
- Ground movement
- Other failures (which in this case was caused by lightning).

16. The likelihood of loss of containment was then determined for each of these potential failure mode groups, based on existing databases of pipeline experience, which contain data on failures from pipelines throughout Europe, supplemented by specific studies either in the open literature or carried out for this EIS. While a request had been made by An Bord Pleanála to identify relevant data specifically on failures of hazardous pipelines in tunnels no such data could be located. The risks associated with the tunnelled section of the pipeline are, however, considered to be slightly less than those associated with the buried section. The derivation of each specific frequency is given in Appendix Q6.4 in the EIS. In this statement I will concentrate on the derivation for internal corrosion, ground movement, intentional third party damage and hydrates.

17. **INTERNAL CORROSION**

A detailed review of all the relevant corrosion mechanisms has been carried out; this is documented in Appendix Q4.7. Data which are specific to Shell's experience with transporting unprocessed gas in pipelines is given in Attachment Q4.9a in Appendix Q4.9 in the EIS. The total Shell experience with wet gas pipelines in Europe is over 40,000 km years without a loss of containment incident. As a result it would only be possible to use these data to derive a failure frequency by making a number of assumptions and a statistical calculation. Such a calculation was not considered appropriate to give a robust estimation of a failure frequency for use in this analysis, so it was necessary to use a more extensive but less specific database.

18. Untreated gas is transported from offshore platforms to onshore processing facilities and data on these pipelines, including failures caused by internal corrosion, are contained in the Pipeline and Riser Loss of Containment (PARLOC) reports. Unfortunately it is not possible to isolate failures for pipelines transporting unprocessed gas from pipelines transporting other fluids such as gas, oil, condensate, methanol etc, so specific failure frequencies due to internal corrosion of pipelines transporting unprocessed gas could not be derived.

19. The calculated inhibited corrosion rate for the Corrib pipeline is slightly higher than the rate that might be expected for a dry gas line but is significantly less than might be expected for a pipeline transporting oil, where additional threats such as under deposit corrosion and microbial induced corrosion might occur (see Appendix Q4.7). The Conservation of Clean Air and Water in Europe reports (CONCAWE) cover pipelines transporting liquids in Europe, and these data include failures due to internal corrosion for different groups of pipeline fluid (crude oil, white oil or heated fluid). Consequently specific failure frequencies for each fluid type due to internal corrosion can be calculated. As a result it was considered appropriate to use the internal corrosion rate experience for crude oil pipelines in the CONCAWE database as a conservative estimate of the frequency of loss of containment due to internal corrosion of the Corrib pipeline.

20. A recent paper to a conference of the American Institute of Chemical Engineers, which was co authored by Dr Acton, who was also one of the principal authors of the Independent Safety Review carried out by Advantica in 2006, gives an analysis of pipeline data that can be used to modify generic frequencies to account for specific pipeline conditions and safeguards. Using modification factors from this paper to account for the 27.1mm pipeline wall thickness and for the pipeline in line inspection, gives a specific base frequency of 3.1×10^{-8} per km per year (one chance in 30 million per year for a failure in a length of one kilometre of pipeline) for loss of

containment from the Corrib pipeline due to internal corrosion. This frequency was further partitioned to give frequencies of 1 x 10^{-8} per km per year for 'holes' (one chance in 100 million per km per year) and 2.2 x 10^{-9} per km per year for ruptures (which is one chance in 500 million per year per kilometre of pipeline).

GROUND MOVEMENT

21. The potential for ground movement along the length of the pipeline has been assessed (see Appendix M2). The ground stability as a result of a landslide in peat was assessed for the pipeline route and for the use of a stone road in peat. It was found that (a) the natural peat slopes along the pipeline route have an acceptable and relatively high factor of safety (which is a measure of the stability) and (b) the stone road has an acceptable and high factor of safety; indeed the stone road increases the stability of the natural peat slope and was adjudged to provide a robust and stable platform for long term stability.

22. PD 8010 Part 3 Appendix B contains ranges of rupture frequencies for high pressure gas pipelines due to natural landsliding in the UK. The background frequency (one chance in 5 million per km per year) has been separated into three different frequency ranges which are dependent on the local instability. The lowest frequency range is from 0 to one chance in 11 million per km per year, and the description of this range is 'slope instability is negligible or unlikely to occur, but might be affected by slope movement on adjacent areas'. The conclusion of the stability assessment was that the rupture rate of the Corrib pipeline, including the tunnelled section, due to ground movement should be considered to be less than one chance in 11 million per km per year (that is the lowest frequency range specified in PD 8010 Part 3).

23. Settlement in the stone road was also considered. Three cases were examined and it was concluded that with the worst case settlement profile the pipeline would not be subject to failure.

24. Based on these analyses, and the analysis by J P Kenny that the pipeline could be unsupported over a length of more than 40m without failure, it was concluded that none of the potential ground movement scenarios posed a credible threat to the integrity of the pipeline and accordingly a zero frequency was allocated in the QRA for rupture due to ground movement or natural landsliding. However, given the findings of the stability analysis and the request from An Bord Pleanála to examine uncertainties in failure frequencies (letter dated 2nd November 2009), a sensitivity

analysis was carried out which used the upper value in the range given above (one chance in 11 million per km per year) for pipeline rupture from ground movement or natural landsliding.

INTENTIONAL THIRD PARTY DAMAGE

25. This failure mode is not normally included in QRAs, and data to support a frequency for loss of containment from this cause are limited. Worldwide the reason for third party intentional damage incidents can be grouped as follows:

- Terrorism or sabotage;
- Vandalism;
- Theft

The first group is associated with the use of bombs and explosives and often gives pipeline ruptures. The other two involve more limited pipeline damage characterised by holes. Most of the incidents are associated with above ground pipelines; the threat to buried pipelines is generally negligible. CONCAWE (which only gives details for European pipelines) reports 23 spillages caused by third party intentional activities; two from terrorist activities, five from vandalism and 16 from attempted or successful product theft. The Corrib pipeline is either buried to a depth of at least 1.2m, and at certain locations concrete slabs are located above the pipeline, or it is buried in a concrete tunnel backfilled with grout. The landfall valve installation is also buried and specifically incorporates the following features; security fence, cages over the above ground valve actuators, CCTV monitoring, intruder alarms and lighting.

26. The expert analysis referenced above has derived frequencies for third party intentional damage for pipelines which are above ground for at least part of their length (and it is stated that these frequencies are likely to be very conservative for pipelines which are totally buried). The frequencies are grouped into high, medium or low probability of threat. The lowest frequency range (a chance of one in one hundred thousand per km per year for a puncture or hole), is described as 'history of terrorist attacks in the region or risk of pilferage or illegal tapping' and this frequency range has been used in a sensitivity analysis. There are no data for third party intentional damage of equipment items (such as valves or flanges) either above or below ground, thus an adjustment which increased the frequency of 25mm and 75mm holes at the landfall valve installation by an order of magnitude was included in the sensitivity analysis. That is the modified frequency to take into account third

party intentional damage at the landfall valve installation was assumed to be ten times greater than all the other failure modes added together.

HYDRATES

27. The strategy to avoid hydrate formation is given in Appendix Q4.5. The study concludes that the formation of a hydrate plug which could cause a full bore impermeable blockage in the pipeline is not sufficient to lead to a failure of the pipeline. This mechanism can therefore be considered as not credible, so a frequency for pipeline failure due to hydrate formation has therefore not been included in the QRA.

28. Overall, when the frequencies for all the failure modes were added together, for the Base Case, the likelihood of a rupture was one in four hundred and fifty million per km per year. This frequency is so low that normally the risks would not be quantified further.

PREDICTIONS OF THE RISK OF DANGEROUS DOSE

29. Risk predictions are presented in two forms: individual risk and societal risk (see Appendix Q6.4). The individual risk has been determined at various locations with respect to the pipeline. The individual risk predictions are in terms of receiving a dangerous dose or more which is different from the 2009 QRA where the individual risk was presented in terms of the risk of being fatally injured. A dangerous dose is a 1% chance of being fatally injured. The individual risk of receiving a dangerous dose or more from a failure of the pipeline at the nearest existing occupied dwelling to the buried section of pipeline is 2×10^{-11} per year (a chance of one in 50 thousand million per year). The individual risk at the nearest existing occupied dwelling to the tunnelled section of pipeline is also a chance of one in 50 thousand million per year. The nearest existing occupied dwelling to the landfall valve installation is beyond the largest range for a dangerous dose to be experienced, and consequently is assigned a zero risk of receiving a dangerous dose.

30. An Bord Pleanála has stated in its letter of November 2009 that it considers it appropriate to adopt the UKHSE risk thresholds for the assessment of the Corrib gas pipeline. These are:

- Individual risk level above one chance in one hundred thousand per year is intolerable.

- Individual risk level between one chance in one hundred thousand per year and one chance in one million per year is tolerable if the risks are demonstrated as being as low as reasonably practicable (ALARP).

- Individual risk level below one chance in one million per year is broadly acceptable.

They are shown in SLIDE 1, which is a traditional way of presenting risks, and has been shown previously as part of the statement on the qualitative risk assessment. High risks are shown at the top of the risk triangle, in the red area, and as one goes down the triangle to the green zone at the bottom of the triangle the risks are reduced to broadly acceptable risks. The predicted levels of individual risk at the nearest occupied dwelling from the proposed pipeline and landfall valve installation are many orders of magnitude less than the threshold of the 'broadly acceptable' level (they are in fact less than one ten thousandth of the broadly acceptable level) and well below the level that risks would normally be quantified.

31. Risks from everyday activities or occupational risks are often used to put technological risks into perspective, although it should be noted that the documented values of these risks are in terms of the likelihood of being fatally injured. One of the highest occupational risks is that from agriculture, forestry and hunting (which is a category used by the Health and Safety Authority). Risk from these activities is approximately a chance of one in ten thousand per year of being fatally injured. The risks from construction are similar, but most other occupational risks are well below this level. The predicted risk from the pipeline to a person in the housing closest to the pipeline is similar to the range of values calculated for the risk of a person being killed by a meteorite and approximately one thousand times less than the likelihood of an aircraft crash onto an acre of land in this location. The average risk to a person in the home is one in five hundred thousand, so the addition of the risk at the nearest dwelling to the pipeline represents an increase in the risk of being at home which is less than one thousandth of a percent.

RISK CONTOUR LINES

32. In their letter of 2nd November 2009, An Bord Pleanála requested that SEPIL plot inner, middle and outer contour zones for the Corrib pipeline, and that these should represent the distance from the pipeline at which risk levels of one in one hundred thousand, one in one million and one in three and one third million per year exist. The risk levels along the pipeline are much lower than these levels, so the inner,

middle and outer zone contours cannot be plotted for the pipeline. At the landfall valve installation, the middle and outer zone contours can be plotted (see Appendix Q6.4). The distance from the landfall valve installation to these zone boundaries is 63m and 91m respectively. The nearest occupied dwelling to the landfall valve installation is 280m away, which is well beyond the outer zone boundary.

SOCIETAL RISK

33. Societal risk is a measure of the risk due to accidents which may cause varying numbers of casualties. The predicted level of societal risk from the proposed pipeline in the vicinity of Glengad to the occupants of existing dwelling houses was found to be extremely low (negligible) as it was almost one million times below the broadly acceptable criterion level in PD 8010 Part 3.

34. As requested by An Bord Pleanála sensitivity analyses have been carried out on a number of the assumptions. The sensitivity predictions for the nearest occupied dwelling to the buried section of the pipeline are given in SLIDE 2. For the Base Case the predicted risk of receiving a dangerous dose or more at the nearest housing to the pipeline is one in 50 thousand million per year. There is no significant change in the predicted risk level if the assumption about the speed of a person subject to heat from an ignited release from the pipeline attempting to move to a place of shelter is decreased from 2.5 m/s to 1 m/s, or if third party intentional damage is included. If the upper frequency for natural hazards from PD 8010 Part 3 (mentioned previously) is included, then the predicted individual risk of receiving a dangerous dose or more is increased to one in two thousand million per year. This is still well below the Board's adopted criterion for a 'broadly acceptable' risk.

35. DNV would therefore interpret the predictions from the QRA that the level of individual and societal risk from the proposed pipeline and landfall valve installation are negligible and so the proposed development does not pose an unacceptable risk to the public.

36. To summarize the following key points should be noted:
- Risk is a function of likelihood and consequence; in order to make a balanced decision on the tolerability of a potentially hazardous facility the two components should be considered together and not in isolation.
- The calculation of the residual risk of the Corrib pipeline has followed a methodology specified in a code that has been designated for the pipeline by the Technical

Advisory Group. Some of the key assumptions have been shown, by sensitivity analysis, to have only a marginal effect on the risk predictions. The analysis also contains a number of deliberately conservative assumptions (for example the use of failure frequencies for internal corrosion based on oil pipelines, and ignition immediately following a pipeline rupture). Consequently the prediction of the very low risk levels is robust.

- At the pipeline itself the level of risk is so low as to be 350 times less than the risk level considered 'broadly acceptable' and stated by An Bord Pleanála in its letter of 2nd November 2009 as the standard against which the proposed development would be assessed. The increase in risk at the nearest occupied dwelling represents an increase of one thousandth of one percent of the average risk to a person at home.
- The residual risk from a typical gas pipeline that is designed, constructed and operated in accordance with the codes of practice designated by the Technical Advisory Group is low. The residual risk from the Corrib pipeline is extremely low, because:
  - The pipeline wall thickness which, together with special design features like the stone road, virtually eliminates the possibility of failure. The predicted likelihood of a rupture, which is the only failure that could affect people in existing dwellings, is one in four hundred and fifty million per km per year.
  - The separation of the pipeline from occupied dwellings (at least 234m) gives an extremely low (negligible) risk to the occupants of all dwellings along the pipeline route - the predicted risk of receiving a dangerous dose or more at the nearest existing occupied dwelling to the pipeline is one in 50 thousand million per year.

That completes my statement.

GLOSSARY

Individual risk

Individual risk is the risk of harm to an individual person, i.e. the frequency with which an individual could be exposed to potentially harmful effects, which in this case is a dangerous dose of thermal radiation or more.

Societal risk

Societal risk is a measure of the possibility of a single outcome simultaneously affecting more than one person and requires an estimate of the location and number of people at risk. It is a term used to describe the chances that a major accident could result in harm to a significant number of people.

Dangerous dose

A dangerous dose is considered to cause all of the following effects to an exposed population:

- severe distress to almost everyone;
- a substantial proportion requires medical attention;
- some people are seriously injured, requiring prolonged treatment;
- any highly susceptible people might be killed.

A dangerous dose corresponds to approximately 1% fatalities for a typical, exposed population. For short duration thermal radiation events, a dangerous dose is 1000 tdu (1000 $(kW/m^2)^{4/3}$ s). The dangerous dose takes into account both the level of heat and the time for which a person might be exposed to the heat.

Risk Transect

A presentation of the individual risk; the transect shows in cross-section the variation in risk with distance from the pipeline or landfall valve installation.

Risk Contour

A presentation of the individual risk; the lines overlaid onto a map join together points where the individual risk is the same.

ALARP

As Low As Reasonably Practicable.

Factor of safety

Stability expressed as the ratio $R_d/E_{d.}$ where R_d is the design value of the effect of actions (or imposed loads) and E_d is the design value of the resistance to an action or imposed load. If the ratio is one or greater, the ground is stable. Further details are given in the EIS (Appendix Q M2).

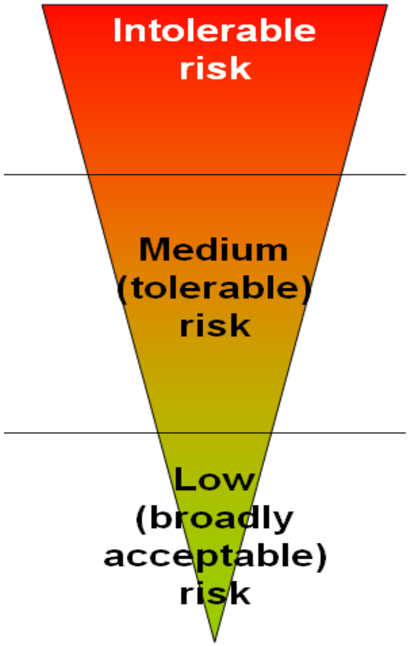
Corrib Onshore Pipeline

QRA

By Phil Crossthwaite

(An Bord Pleanála Application Reference No.: 16.GA0004)

Corrib natural gas



- One in one hundred thousand (Board's upper limit)
- One in one million (Board's lower limit)
- Normal lower limit for risk quantification
- Risk from pipeline and landfall valve installation

Sensitivity Predictions

Description	Individual risk of receiving a dangerous dose at 240 metres (per year)	Chance of receiving a dangerous dose at 240 metres (per year)
Base Case	2×10^{-11}	1 in 50 thousand million
Moving away from the incident at a speed of 1 m/s	2×10^{-11}	1 in 50 thousand million
Incorporating the frequency from PD 8010-3:2009 for landslip	7×10^{-10}	1 in 1.5 thousand million
Incorporating a factor to account for third party intentional damage	2×10^{-11}	1 in 50 thousand million