

UKOPA Meeting  
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Ethylene Pipelines  
Societal Risk Assessments

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# Presentation Content

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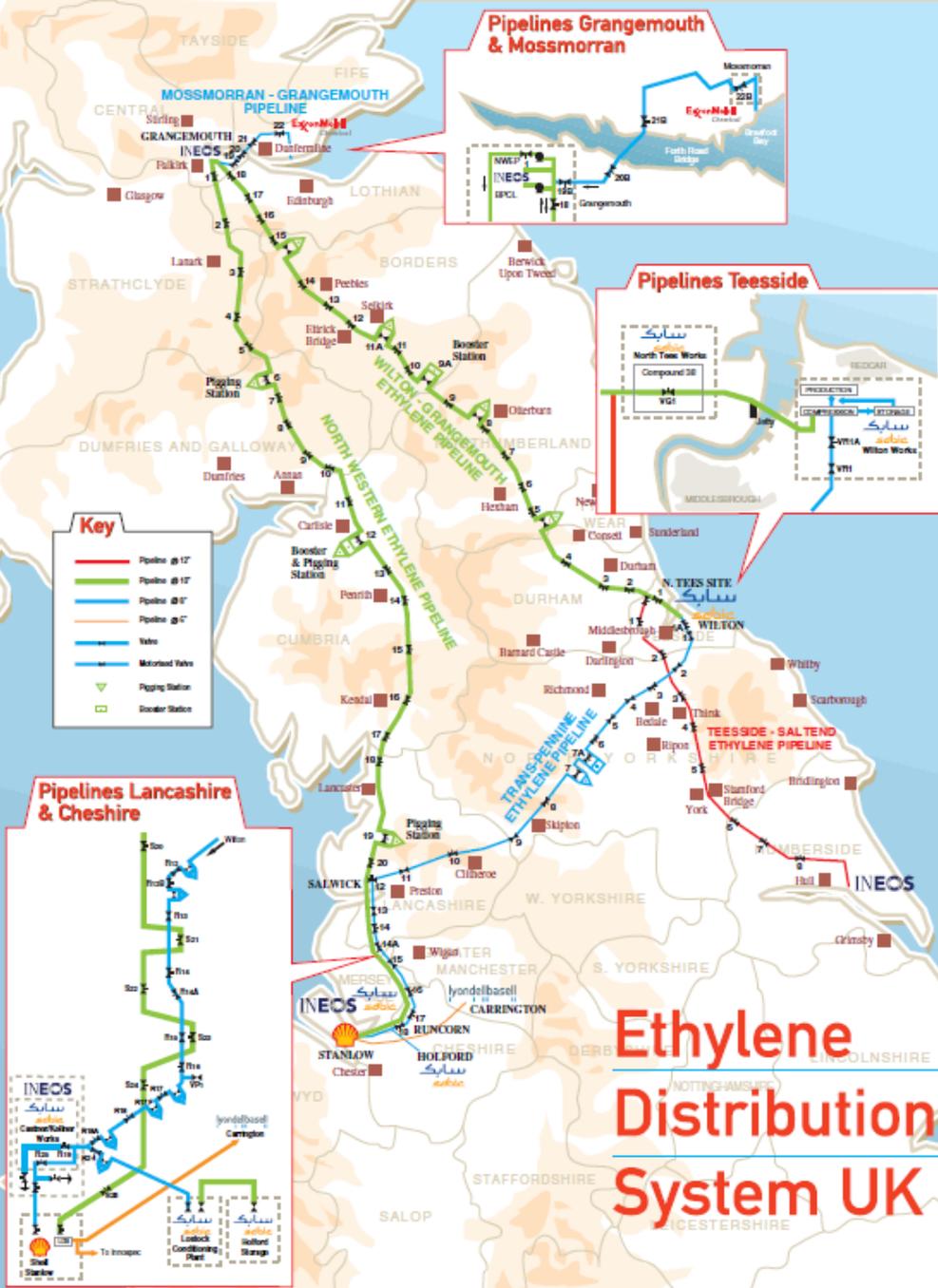
# Ethylene Cracker



# The UK Ethylene Pipeline Network

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- Ethylene –  $C_2H_4$  – building block of the chemical industry
- Shell gas pipelines Stanlow-Carrington (1960)
- Ethylene manufactured at ICI Wilton 1950s-60s - demand for ethylene at Runcorn, (chlorinated hydrocarbons for ICI Mond Division) resulted in the first dense-phase ethylene pipeline Wilton to Runcorn
  - 1968 Trans-Pennine Ethylene Pipeline TPEP
- For UKOPA presentation by Mark Harrison on the UK Ethylene network see:-
- <http://www.ukopa.co.uk/pdfs/UKOPA-09-0016.pdf>



## Timeline developments

TPEP – 1968  
 WGEP – 1979  
 RSEP - 1980  
 MGEP – 1985

1989  
Publication of BS 8010 Part 1  
This Code included routing requirements and thick wall pipe in Class 2 (suburban) areas

NWEP – 1992  
 TSEP - 2001

# The need for societal risk assessments

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- Pre-1989 pipelines located away from population (>50m) where possible, but did not have rigorous routing applied
- No change in wall thickness in higher population areas
- Individual risk generally low, but no further assessments of population density within potential hazard zone
- PD 8010 Part 3 published in 2009 contained a risk criterion line for assessing societal risk with the following advice:-

# The need for societal risk assessments

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“Societal risk is of particular significance to pipeline operators because the location of pipelines might be close to populated areas, so the impact of multiple fatality accidents on people and society in general should be taken into account.

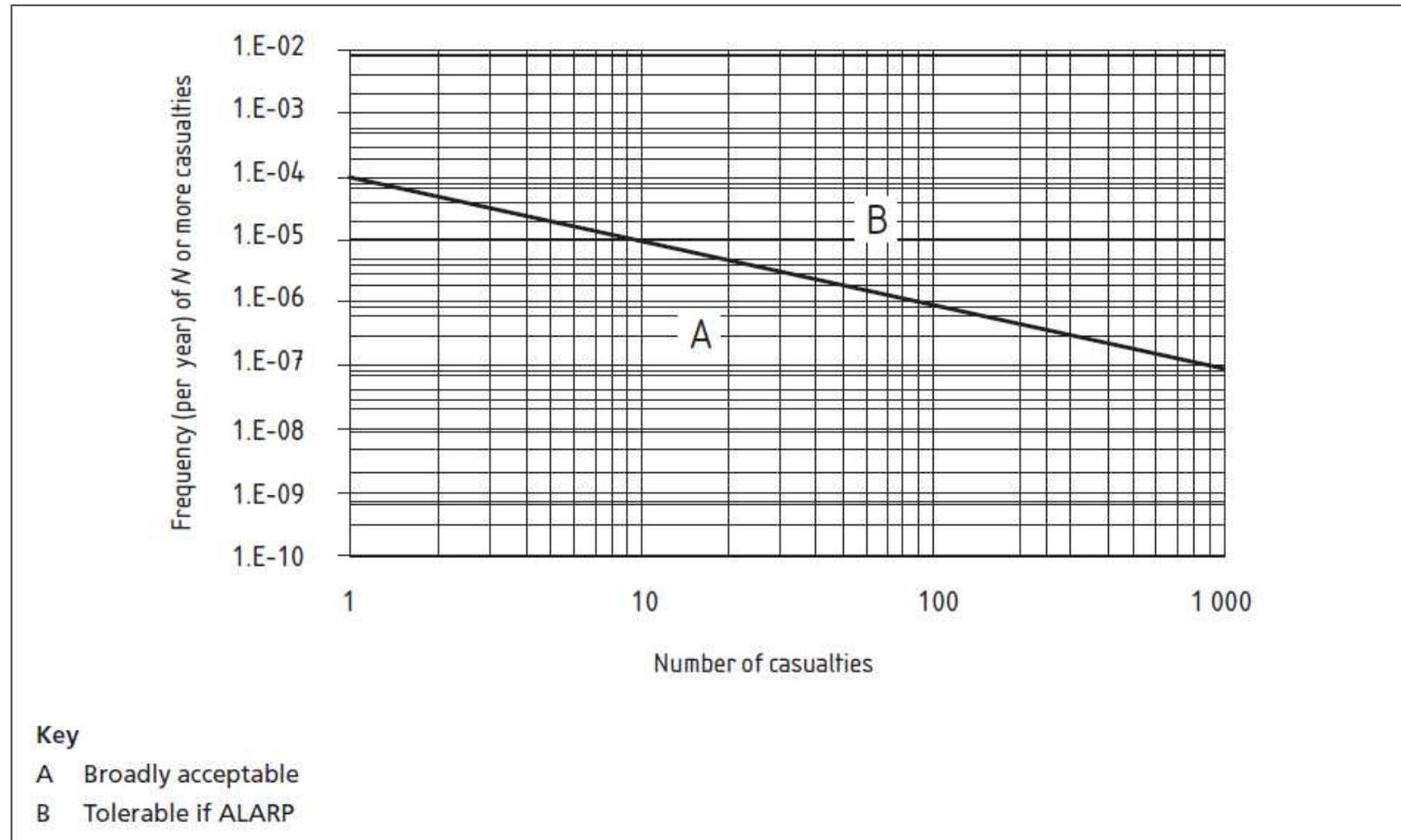
The original routing of the pipeline is expected to have taken into account the population along the route, but infill and incremental developments might increase the population in some sections of the route.

Societal risk assessment allows these developments to be assessed against the original routing criteria where a location class 1 area (i.e. rural) has a population density of up to 2.5 persons per hectare.

When the societal risk has increased significantly, the pipeline operator might then need to consider justifiable mitigation measures to reduce the risk.”

# The need for societal risk assessments

Figure 6 Societal risk *FN* criterion line applicable to 1 km of pipeline



# The need for societal risk assessments

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“Population density tends to vary along a pipeline route, with clusters of population at some locations.

Assessment of the societal risk in accordance with the FN criterion line might still allow such variations to be classified as an acceptable situation not requiring any upgrading of the pipeline to reduce the risk.

The FN criterion line given in Figure 6 represents broadly acceptable risk levels for 1 km of pipeline operation.

If the calculated site-specific FN curve falls below the FN criterion line, the risk levels to the adjacent population are considered broadly acceptable.

If the site-specific FN curve is close to or above the FN criterion line, then further mitigation might be required to reduce risks to acceptable/negligible levels if this is economically justifiable in terms of the requirement to demonstrate that the risks are ALARP.”

# Quantified Risk Assessment Methodology

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- HSE Methodology PRAM published by Carter in 1991
- HSE tried applying MISHAP to ethylene in 2002-3
- HSE found signification reduction in initial release rate using UCL' s PIPETECH in 2007-8 compared to original PRAM calculation
- HSE agreed that using UKOPA failure rates was valid for ethylene pipelines in 2012
- No further changes in HSE methodology
- Still have issues with HSE' s ignition probability (84% for ethylene,44% for natural gas) and event tree probabilities (impacted jet – late ignition)

# Quantified Risk Assessment Methodology

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- PIPERISK™ computer code developed for ethylene
- 4 page process calculates failure rates, consequence analysis, individual risk transect, and societal risk F-N curve
- Uses HSE methodology except for failure rates – uses UKOPA failure rates
- Shows that the limiting case for population density of 2.5 per hectare at design factor 0.72 is just underneath the PD 8010 Part 3 F-N criterion line – therefore meeting code requirement for population density also correlates with the F-N criterion line.
- Therefore allows cases for higher population at lower design factor which still meet the F-N criterion to be used for screening assessments:-



# Quantified Risk Assessment Methodology

Input Data | Calculated Data | Individual Risk Transect | Societal Risk F-N Curve

**Ethylene Pipeline QRA** PipeRisk™

**Pipeline Name**

**Nominal Diameter mm**

**Nominal Wall Thickness mm**

**Grade of Steel**

**Operating Pressure bar**

**Area Classification**

**Approximate Age**

**Societal Risk Effect Distance (usually 1000 m)**  *This is the interaction distance - the length of pipeline which could affect the developments - if less than 1000m*

**3rd Party Risk Reduction Factor (0.1 to 1)**  *This is the 3rd Party risk reduction/increase due to additional protection measures such as slabbing, extra markers, deeper or shallower cover, or extra surveillance - input a factor between 0.1 and 1.5*

**Press to Continue**

**Save as New Case**

# Quantified Risk Assessment Methodology

Input Data | Calculated Data | Individual Risk Transect | Societal Risk F-N Curve

**Failure Frequency Analysis from PD 8010 Part3 and PIE 3rd Party Predictive Model** PipeRisk™

Design Factor % SMYS:       3rd Party Extra Protection Risk Reduction Factor:

	Rupture	Large Hole	Small Hole	TOTAL	Rupture	Large Hole	Small Hole	TOTAL
3rd Party	0.0229	0.002	0.018	0.0429	18.8%	1.6%	14.7%	35.1%
Corrosion	0	0.0015	0.0135	0.015	0%	1.2%	11.1%	12.3%
Mechanical	0	0.0064	0.0576	0.064	0%	5.2%	47.2%	52.4%
Ground Movement	0.00021	0	0	0.00021	0.17%	0%	0%	0.17%
<b>TOTAL</b>	<b>0.02311</b>	<b>0.0099</b>	<b>0.0891</b>	<b>0.12211</b>	<b>18.9%</b>	<b>8.1%</b>	<b>73%</b>	<b>100%</b>

**Release Rate Analysis**

Ruptured Pipeline Open ends area -m2:       Initial Release Rate - kg/sec:       **Press to Continue**

Rupture Release Rate after 30 seconds - kg/sec:

Large Hole Release Rate - kg/sec:       Small Hole Release Rate - kg/sec:

**Consequence Analysis**

**Probability of Ignition**

Quantity in fireball kg:       Spontaneous Ignition Distance - m:

Fireball Radius m:       Fireball outdoor hazard distance m:

Fireball Duration secs:

Fireball:       Jet Fire:

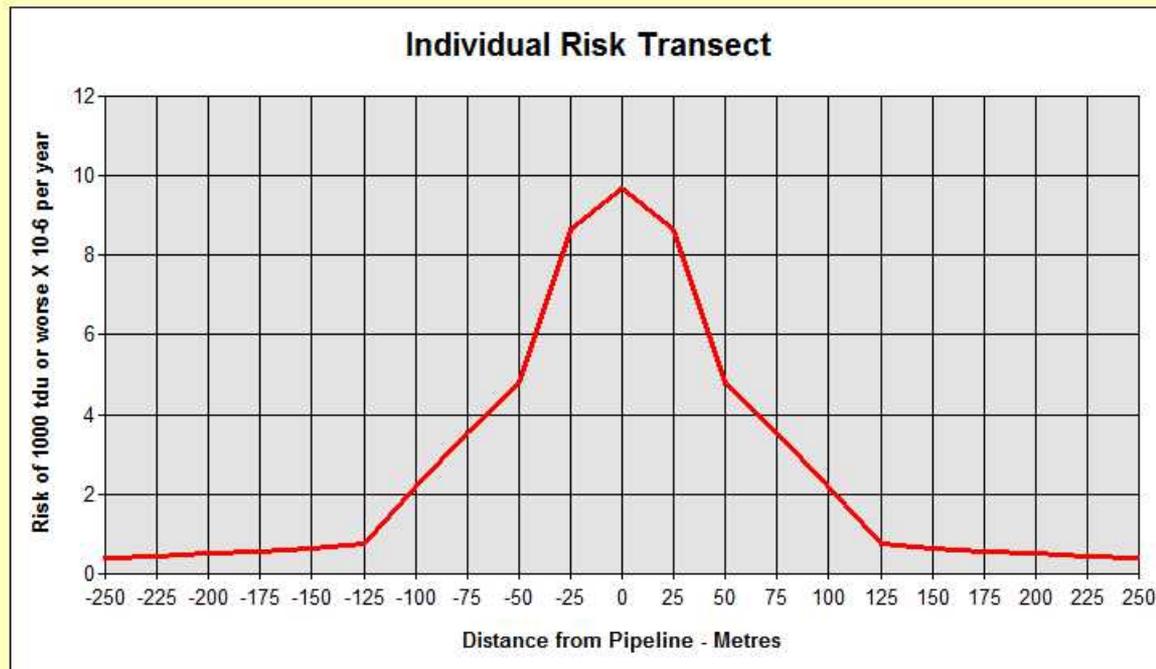
Daytime Flash Fire:       Nighttime Flash Fire:

	Jet Fire Dia m	Jet Fire Ht m	Jet Fire 1800 tdu m	Jet Fire 1000 tdu m	Daytime Flash Fire Length m	Daytime Flash Fire Width m	Nighttime Flash Fire Length m	Nighttime Flash Fire Width m
Rupture 30 sec release	36	298	72	115	469	208	984	468
Large Hole release	24	199	42	70	244	106	545	256
Small Hole release	17	138	26	44	113	48	283	131

# Quantified Risk Assessment Methodology

Input Data | Calculated Data | Individual Risk Transect | Societal Risk F-N Curve

PipeRisk™



PD8010 Minimum Distance to Occupied Buildings (Inner Zone)  metres

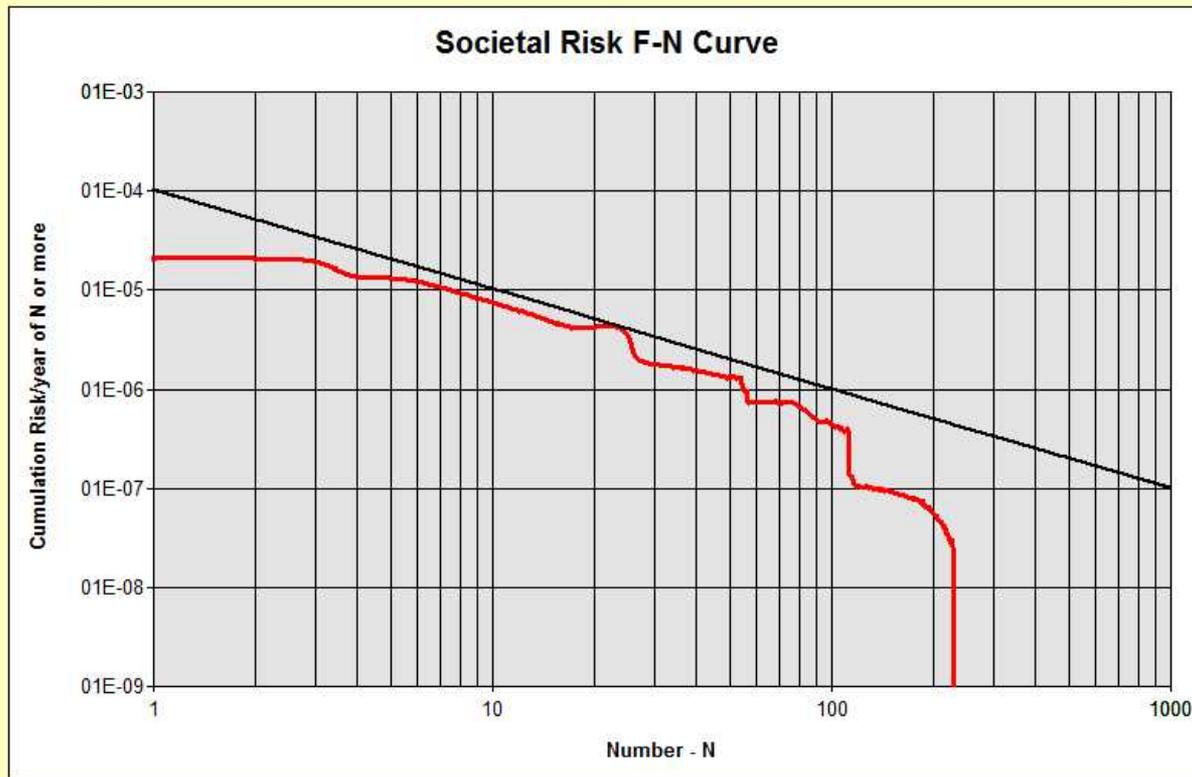
**Press to Continue**

10<sup>-6</sup> Risk (Middle Zone) Distance  metres

0.3 x 10<sup>-6</sup> Risk (Outer Zone) Distance  metres

# Quantified Risk Assessment Methodology

Input Data | Calculated Data | Individual Risk Transect | Societal Risk F-N Curve



PipeRisk™

2.71E-04 per year

- \*\* If the actual F-N curve (red line) is above the PD8010 Part 3 criterion line (black line), - this is the ALARP region requiring Cost-Benefit justification to not reduce the risk.
- \*\* If the F-N Curve is below the criteria line, risk is Negligible / Acceptable

# Pipeline Population & Site Specific Assessments

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- So this is a limiting case where there is a buffer zone of 50m between the pipeline and population
- Shows population limit of 4.8 per hectare = 24 in any 100m length
- Also able to calculate population densities for no buffer, 100m buffer, 200m and 300m buffer – due to higher risk closer to pipeline, larger population is permitted when there is a larger buffer between population and pipeline
- This then allows comparison with population surveys by RSK Orbital to assess where population density exceeds the limit
- Extended sections where limit is exceeded require *Site Specific Assessments*

# Pipeline Population & Site Specific Assessments



# Pipeline Population & Site Specific Assessments

Location	Pipeline Chainage	Pipeline Section	Population within				Buffer	Population Limit	RESULT
			50m	100m	200m	300m			
	22200	22200 to 22300	0	0	0	0	300m	54	OK
	22300	22300 to 22400	0	0	0	0	300m	54	OK
	22400	22400 to 22500	0	0	0	0	300m	54	OK
	22500	22500 to 22600	0	0	0	0	300m	54	OK
	22600	22600 to 22700	0	0	0	0	300m	54	OK
	22700	22700 to 22800	0	0	0	6	300m	54	OK
Village	22800	22800 to 22900	0	0	0	90	300m	54	EXCEEDED
Village	22900	22900 to 23000	0	0	21	183	200m	51	EXCEEDED
Village	23000	23000 to 23100	0	0	51	252	200m	51	EXCEEDED
Village	23100	23100 to 23200	0	0	42	318	200m	51	EXCEEDED
Village	23200	23200 to 23300	0	0	48	285	200m	51	EXCEEDED
Village	23300	23300 to 23400	0	0	60	237	200m	51	EXCEEDED
Village	23400	23400 to 23500	0	6	75	243	100m	24	EXCEEDED
Village	23500	23500 to 23600	0	6	63	204	100m	24	EXCEEDED
Village	23600	23600 to 23700	0	0	21	153	200m	51	EXCEEDED
	23700	23700 to 23800	0	0	0	24	300m	54	OK
	23800	23800 to 23900	0	0	0	0	300m	54	OK
	23900	23900 to 24000	0	0	0	0	300m	54	OK
	24000	24000 to 24100	0	0	0	0	300m	54	OK
	24100	24100 to 24200	0	0	0	0	300m	54	OK
	24200	24200 to 24300	0	0	0	0	300m	54	OK
	24300	24300 to 24400	0	0	0	0	300m	54	OK

# Pipeline Population & Site Specific Assessments

For site specific studies, identify populated area:-



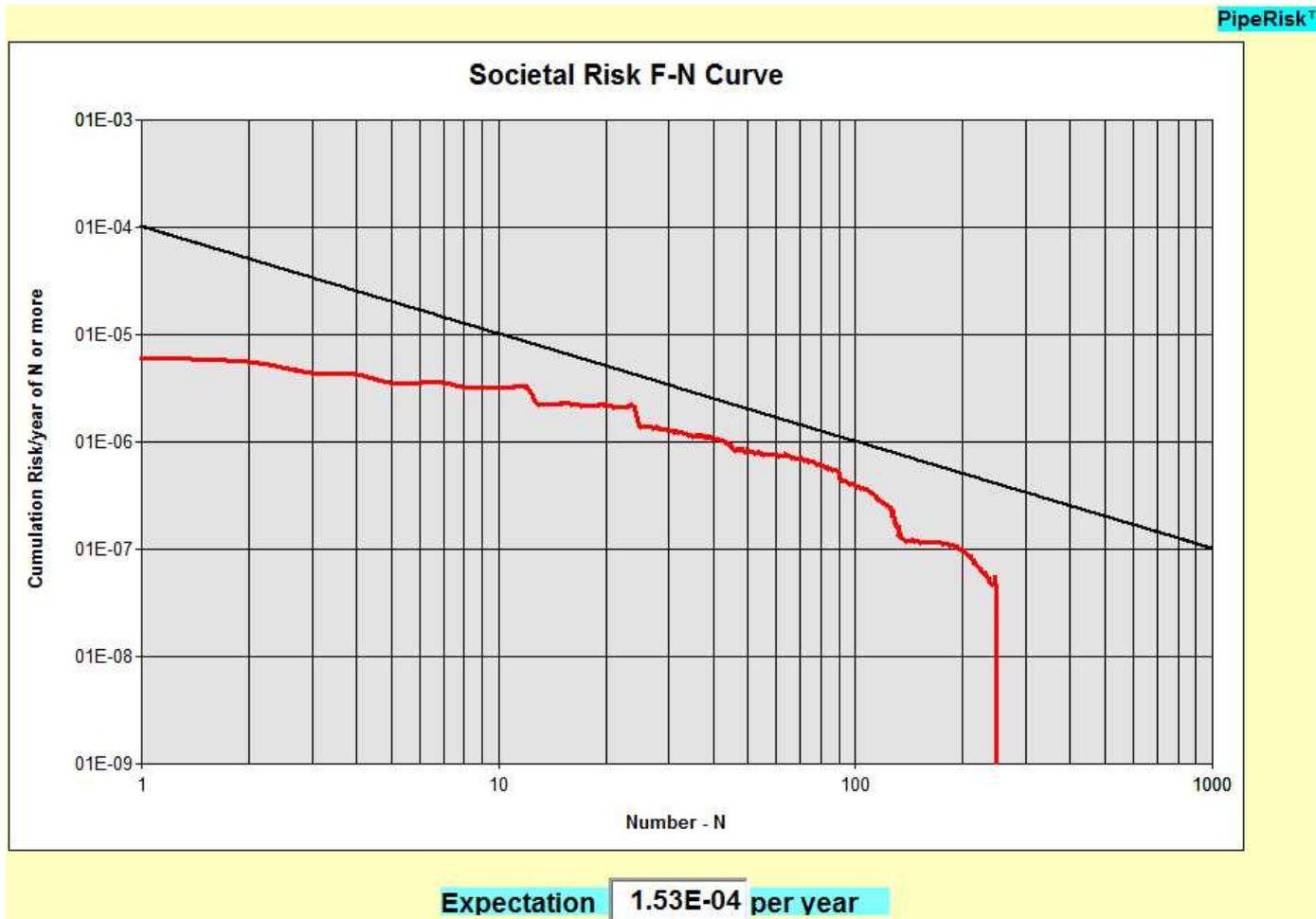
# Pipeline Population & Site Specific Assessments

Transfer population data to risk grid for daytime and nighttime population:-

300m	0m				100m				200m				300m				400m				500m				600m				700m				800m				900m				1
275m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	3	3	3	3	3	3	3	3
250m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	0	3	3	3	3	3	3
225m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3
200m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	15	15	15	0	0	4	3	3	3	3	3	3	3	3	3
175m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	12	0	0	0	0	0	0	0	0	0	0	0	0	3	3
150m	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0	0	0	0	3	3	3	3	3	3	3	3	3	3	3
125m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0
100m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0	0	0	0	0	0
75m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
50m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25m	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-25m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-50m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

# Pipeline Population & Site Specific Assessments

Run PIPERISK™ to obtain F-N Curve:-



# Results and Conclusions

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- 2 major pipelines completed, 6 others in progress.
- 33 site specific studies completed so far, 4 are above the risk criterion (ALARP demonstration required) 2 are on the limit, the rest below the criterion line.
- Able to demonstrate that population “creep” and infringements have been considered in line with code guidance for ethylene pipelines.
- Allows ongoing situation to be monitored using bespoke calculation model PIPERISK™ supplied for each specific location, based on detailed population surveys (e.g. RSK Orbital).