Attachment F Oil Spill Risk Calculations

Offshore Pipeline Spill Volume Estimate
Platform Irene to Beach

			Release at Shoreline		Release at Pipeline Midpoint	
	Description	**Units**	**Irene to Shore Current Operations**	**Irene to Shore Proposed Operations**	**Irene to Shore Current Operations**	**Irene to Shore Proposed Operations**
Q	Flow rate of shipping pump	B/D	57000	90000	57000	90000
t	Time to shut down pump and close valve	min	11	11	11	11
%	Oil cut (percent water)	%	87.7	60	87.7	60
V_{pump}	**Discharge volume from time to shut down**	**BBL**	382	413	382	413
P_D	Design pipeline pressure (PSV set point)	psi	1300	1300	1300	1300
D_{ID}	Nominal inside diameter	in	18.75	18.75	18.75	18.75
D_{OD}	Nominal outside diameter	in	20	20	20	20
D_{ID}	Nominal inside diameter	ft	1.563	1.563	1.563	1.563
D_{OD}	Nominal outside diameter	ft	1.667	1.667	1.667	1.667
s	Hoop stress	psi	40300	40300	40300	40300
E	Young's modulus		30000000	30000000	30000000	30000000
D_P	Inside diameter during pumping	ft	1.565	1.565	1.565	1.565
API	API gravity		16	16	16	16
SG	Specific Gravity		0.959	0.959	0.959	0.959
RO_s	Static density of oil	lb/ft^3	59.862	59.862	59.862	59.862
DRO	Difference in oil density due to compressibility from GPSA data book	lb/ft^3	0.1	0.1	0.1	0.1
RO_d	Dynamic density of oil	lb/ft^3	59.96	59.96	59.96	59.96
L	Pipeline length	ft	53328	53328	26664	26664
V_{RO}	**Discharge volume from density change**	**BBL**	27	18	13	9
V_D	**Discharge volume from diameter change**	**BBL**	43	29	21	15
L_1	Length above water line on inlet end	ft	395	395	395	395
L_2	Length above water line on discharge end	ft	315	315	315	315
V_H	**Discharge volume from hydrostatic head**	**BBL**	213	146	213	146
V_P	**Discharge volume from perculation due to density difference between oil and sea water**	**BBL**	**2248**	**7324**	**1124**	**3662**
V_2	**Volume of oil calculated to leak from a rupture of a subsea pipeline**	**BBL**	**2913**	**7929**	**1754**	**4244**

Notes: Assumes 100% of oil in pipeline volume lost due to hydrostatic pressure and buoyancy effects.
Worst case pipeline spill assumed to be located near shore (at highest elevation point of offshore pipeline)

Platform Irene Vessel and Pipeline Release Volumes Estimate

Variable	Description	Units	Current Operations	Proposed Project
Percent Oil			12.3	40
Vessel	V-140			
D	Diameter	ft	8.0	8.0
L	Length	ft	17.0	17.0
h_1	Top of oil layer	ft	8.0	8.0
h_2	Bottom of oil layer	ft	4.0	4.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**9.4**	**30.5**
Vessel	V-150			
D	Diameter	ft	8.0	8.0
L	Length	ft	17.0	17.0
h_1	Top of oil layer	ft	8.0	8.0
h_2	Bottom of oil layer	ft	4.0	4.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**9.4**	**30.5**
Vessel	V-100			
D	Diameter	ft	6.0	6.0
L	Length	ft	13.0	13.0
h_1	Top of oil layer	ft	6.0	6.0
h_2	Bottom of oil layer	ft	3.0	3.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**4.0**	**13.1**
Vessel	V-110			
D	Diameter	ft	6.0	6.0
L	Length	ft	13.0	13.0
h_1	Top of oil layer	ft	6.0	6.0
h_2	Bottom of oil layer	ft	3.0	3.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**4.0**	**13.1**
Vessel	V-120			
D	Diameter	ft	6.0	6.0
L	Length	ft	13.0	13.0
h_1	Top of oil layer	ft	6.0	6.0
h_2	Bottom of oil layer	ft	3.0	3.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**4.0**	**13.1**
Vessel	V-130			
D	Diameter	ft	6.0	6.0
L	Length	ft	13.0	13.0

Platform Irene Vessel and Pipeline Release Volumes Estimate

Variable	Description	Units	Current Operations	Proposed Project
h_1	Top of oil layer	ft	6.0	6.0
h_2	Bottom of oil layer	ft	3.0	3.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**4.0**	**13.1**
Vessel	V-910			
D	Diameter	ft	8.0	8.0
L	Length	ft	11.0	11.0
h_1	Top of oil layer	ft	4.0	4.0
h_2	Bottom of oil layer	ft	0.0	0.0
%	Oil cut	%	75.0	75.0
V	**Volume of oil**	**BBL**	**37.0**	**37.0**
Vessel	T-530/540			
D	Diameter	ft	10.0	10.0
L	Length	ft	10.0	10.0
h_1	Top of oil layer	ft	8.0	8.0
h_2	Bottom of oil layer	ft	0.0	0.0
%	Oil cut	%	75.0	75.0
V	**Volume of oil**	**BBL**	**84.0**	**84.0**
Vessel	V-160			
D	Diameter	ft	10.0	10.0
L	Length	ft	15.0	15.0
h_1	Top of oil layer	ft	9.0	9.0
h_2	Bottom of oil layer	ft	0.0	0.0
%	Oil cut	%	12.3	40.0
V	**Volume of oil**	**BBL**	**15.5**	**50.4**
Piping	**Volume of oil**	**BBL**	**17.1**	**28.5**
V_1	**Volume of oil discharged from vessels and piping**	**BBL**	**188.4**	**313.1**
Diesel Storage	**Volume of Diesel**	**BBL**	**238.0**	**238.0**
VT	**Volume of oil and Diesel discharged from vessels and piping**	**BBL**	**426.4**	**551.1**

Platform Irene Vessel and Pipeline Release Volumes Estimate

Variable	Description	Units	Current Operations	Proposed Project
V vessel	**Largest Vessel Release Volume**	**BBL**	**84.0**	**84.0**

Calculations and equipment based on Torch OSCP, October, 2000. Oil cut percentage correct for most recently available data (to 11.9% from 20%)

Tranquillon Ridge Project
Well Blowout Spill Volumes

Case	Platform Irene (bbls/day)	
	Current Operations[a]	Tranquillon Ridge[b]
Oil discharge rate of highest capacity flowing well	0	4,500

a. None of the current wells at Platform Irene are flowing without artifical lift.

b. Tranquillon Ridge wells are expected to flow without artifical lift for about five years.

MMS Oil Spill Risk Calculations: Current Operations
US OCS Spill Historical Spill Data

US OCS Spills	Number of Spills	Median Spill Size (bbls)	Spill Rate (spills per 10^9 bbls)
Spills Between 1 and 50 bbls			
Platforms	154	25	11.1
Pipelines	457	25	33.2
Spills Greater Than 50 bbls			
Platforms	27	159	1.9
Pipelines	80	159	5.8
Spills Greater Than or Equal to 1,000 bbls			
Platforms	11	7,000	0.45
Pipelines	12	5,600	1.35
Spills Greater Than or Equal to 10,000 bbls			
Platforms	4	41,500	0.16
Pipelines	4	17,700	0.44

Source: Comparative Occurrence Rate for Offshore Oil Spills, Anderson and La Belle, MMS.
Source: Delineation Drilling Activities in Federal Water Offshore Santa Barbara County, California, Draft Environemtnal Impact Statement, MMS, 2001-046.
Spills greater than 50 bbls estimated based on MMS, (2001) rate calculated from Table 5.1-1 Appendix 5.1 (50-999 bbls), rate of 0.15 spills/19 billion barrels
Assumed split between platforms and pipelines equal to 1 to 3 as per Anderson et al (25% platforms, 75% pipelines).
Spills between 1 and 50 bbls ratioed up from >50 bbl as per table 5.1.3.1-1 (for Pacific Region only) (47 total spills > 1 bbls, 40 in the 1-50 bbls range)
for a ratio of 40/7 small spills to larger spills
Mean spill size estimated from 159 bbls for 50 - 999 bbls range (as per MMS page 5-18) and mean size for 1 - 49 bbls range of assumed 25 bbls.
Source for >1,000 bbl spills: Comparative Occurrence Rate for Offshore Oil Spills, Anderson and La Belle, MMS.

MMS Calculation of Spill Probabilities for Platform Irene and Irene Pipeline with Pt. Pedernales Production Only

Location	Spill Rate (spills per 10^9 bbls)	Total Oil Production (10^9 bbls)	Duration of Total Oil Production (years)	Estimated Number of Spills During the Duration	Probability of Zero Spills Occurring (P(0))	Probability of One or More Spills Occurring	Rate/yr
Spills Between 1 and 50 bbls							
Platform Irene	11.1	0.0073	10	0.0808	92.2%	7.8%	8.1E-03
Irene Pipeline	33.2	0.0073	10	0.2425	78.5%	21.5%	2.4E-02
Total			10	0.3233	72.4%	27.6%	3.2E-02
Spills Greater Than 50 bbls							
Platform Irene	1.9	0.0073	10	0.0141	98.6%	1.4%	1.4E-03
Irene Pipeline	5.8	0.0073	10	0.0424	95.8%	4.2%	4.2E-03
Total			10	0.0566	94.5%	5.5%	5.7E-03
Spills Greater Than 1000 bbls							
Platform Irene	0.5	0.0073	10	0.0033	99.7%	0.3%	3.3E-04
Irene Pipeline	1.4	0.0073	10	0.0099	99.0%	1.0%	9.9E-04
Total			10	0.0131	98.7%	1.3%	1.3E-03

Notes:
Estimated average rate of oil production over remaining life. 2,000 bpd
Duration of production is for 10 years
Estimated number of spills during the duration=spill rate*total oil production.
Probability(P)=e^-number of spills during production duration.
The probability of one or more spills=1-P.

Calculation of Spill Probabilities for Platform Irene & Pipeline with Pt. Pedernales and Tranquillon Ridge Production

Location	Spill Rate (spills per 10^9 bbls)	Total Oil Production (10^9 bbls)	Duration of Total Oil Production (years)	Estimated Number of Spills During the Duration	Probability of Zero Spills Occurring (P(0))	Probability of One or More Spills Occurring	Rate/yr
Spills Between 1 and 50 bbls							
Platform Irene	11.1	0.1030	15	1.1404	32.0%	68.0%	7.60E-02
Irene Pipeline	33.2	0.1030	15	3.4211	3.3%	96.7%	2.28E-01
Total			15	4.5614	1.0%	99.0%	3.04E-01
Spills Greater Than 50 bbls							
Platform Irene	1.9	0.1030	15	0.1996	81.9%	18.1%	1.33E-02
Irene Pipeline	5.8	0.1030	15	0.5987	55.0%	45.0%	3.99E-02
Total			15	0.7983	45.0%	55.0%	5.32E-02
Spills Greater Than 1000 bbls							
Platform Irene	0.5	0.1030	15	0.0464	95.5%	4.5%	3.09E-03
Irene Pipeline	1.4	0.1030	15	0.1391	87.0%	13.0%	9.27E-03
Total			15	0.1854	83.1%	16.9%	1.24E-02

Notes:
Estimated average rate of oil production over remaining life. 18,840 bpd
Duration of production is for 15 years
Estimated number of spills during the duration=spill rate*total oil production.
Probability(P)=e^-number of spills during production duration.
The probability of one or more spills=1-P.

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

LOGP Facility

Scenario	Type	Units	Wind	Impact Distances: Fatality Distance, ft	Fatality Width, ft	Injury Distance, ft	Injury Width, ft	Base Frequency, /yr	Conditional Probabilities: Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Crude tank fire	Thermal	10 kw/m2 fat, 5 kw/m2 injury		650		885		4.00E-05	0.05	1.00	1.00	2.00E-06
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	318	32	740	115	2.00E-05	0.50	0.51	0.15	7.65E-07
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	318	32	740	115	2.00E-05	0.50	0.51	0.85	4.34E-06
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	705	71	1640	120	2.00E-05	0.50	0.49	0.15	7.35E-07
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	705	71	1640	120	2.00E-05	0.50	0.49	0.85	4.17E-06
LPG/NGL Vessel BLEVE	Thermal	80 kJ/m2 fat estimated, 40 kJ/m2 injury		1635		2240		8.00E-07	1.00	1.00	1.00	8.00E-07
LPG/NGL Vessel Explosion	Explosion	3 psi fatality estimated, 0.5 psi injury		470		1880		8.00E-07	0.25	1.00	1.00	2.00E-07
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	1032	103	2400	1900	2.00E-05	0.50	0.51	0.15	7.65E-07
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	1032	103	2400	1900	2.00E-05	0.50	0.51	0.85	4.34E-06
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	1075	108	2500	2000	2.00E-05	0.50	0.49	0.15	7.35E-07
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	1075	108	2500	2000	2.00E-05	0.50	0.49	0.85	4.17E-06
LPG/NGL tank truck rupture	Explosion	3 psi fatality, 0.5 psi injury		460		1800		4.04E-07	0.25	1.00	1.00	1.53E-05
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	593	59	1380	980	4.04E-07	0.50	0.51	0.15	2.35E-06
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	593	59	1380	980	4.04E-07	0.50	0.51	0.85	1.33E-05
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	538	54	1250	980	4.04E-07	0.50	0.49	0.15	2.26E-06
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	538	54	1250	980	4.04E-07	0.50	0.49	0.85	1.28E-05

IRENE/LOGP Pipeline Segment: Between Valve Station 9 and LOGP closest segments

Scenario	Type	Units	Wind	Impact Distances: Fatality Distance, ft	Fatality Width, ft	Injury Distance, ft	Injury Width, ft	Base Frequency, /mile-yr	Conditional Probabilities: Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Irene/LOGP 8" Pipeline												
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		49		289		4.34E-04	0.25	1.00	1.00	1.03E-04
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		75		92		4.34E-04	0.25	1.00	1.00	1.03E-04
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.27	2.83E-05
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.73	7.66E-05
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	112	34	246	58	4.34E-04	0.50	0.49	1.00	1.01E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	400	30	1060	49	4.34E-04	0.50	0.51	1.00	1.05E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	89	23	135	36	4.34E-04	0.50	0.49	1.00	1.01E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		125		751		2.13E-04	0.25	1.00	1.00	5.05E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		217		259		2.13E-04	0.25	1.00	1.00	5.05E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.27	1.39E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.73	3.76E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	448	137	974	236	2.13E-04	0.50	0.49	1.00	4.94E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	VCE	LFL, 1/2 LFL	F	1066	92	2477	128	2.13E-04	0.50	0.51	0.27	1.39E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	VCE	LFL, 1/2 LFL	F	1066	92	2477	128	2.13E-04	0.50	0.51	0.73	3.76E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	262	79	407	112	2.13E-04	0.50	0.49	1.00	4.94E-05
Segment length	5000 feet											

IRENE/LOGP Pipeline Segment: Between VS8 plus VS9 and LOGP farthest segments

Scenario	Type	Units	Wind	Impact Distances: Fatality Distance, ft	Fatality Width, ft	Injury Distance, ft	Injury Width, ft	Base Frequency, /mile-yr	Conditional Probabilities: Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Irene/LOGP 8" Pipeline												
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		49		289		4.34E-04	0.25	1.00	1.00	2.67E-04
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		75		92		4.34E-04	0.25	1.00	1.00	2.67E-04
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.33	9.00E-05
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.67	1.83E-04
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	112	34	246	58	4.34E-04	0.50	0.49	1.00	2.62E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	400	30	1060	49	4.34E-04	0.50	0.51	1.00	2.73E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	89	23	135	36	4.34E-04	0.50	0.49	1.00	2.62E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		125		751		2.13E-04	0.25	1.00	1.00	1.31E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		217		259		2.13E-04	0.25	1.00	1.00	1.31E-04
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.33	4.42E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.67	8.96E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	448	137	974	236	2.13E-04	0.50	0.49	1.00	1.29E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1066	92	2477	128	2.13E-04	0.50	0.51	1.00	1.34E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	262	79	407	112	2.13E-04	0.50	0.49	1.00	1.29E-04
Segment length	13000 feet											

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

IRENE/LOGP Pipeline Segment: Near Valve Station 7 and Valve Station 8

				Impact Distances					Conditional Probabilities			
				Fatality		Injury						
Scenario	Type	Units	Wind	Distance, ft	Width, ft	Distance, ft	Width, ft	Base Frequency, /mile-yr	Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Irene/LOGP 8" Pipeline												
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		49		289		4.34E-04	0.25	1.00	1.00	8.23E-05
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		75		92		4.34E-04	0.25	1.00	1.00	8.23E-05
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.33	2.77E-05
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	0.67	5.62E-05
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	112	34	246	58	4.34E-04	0.50	0.49	1.00	8.06E-05
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	400	30	1060	49	4.34E-04	0.50	0.51	1.00	8.39E-05
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	89	23	135	36	4.34E-04	0.50	0.49	1.00	8.06E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		125		751		2.13E-04	0.25	1.00	1.00	4.04E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		217		259		2.13E-04	0.25	1.00	1.00	4.04E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.33	1.36E-05
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	0.67	2.76E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	448	137	974	236	2.13E-04	0.50	0.49	1.00	3.96E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1066	92	2477	128	2.13E-04	0.50	0.51	1.00	4.12E-05
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	262	79	407	112	2.13E-04	0.50	0.49	1.00	3.96E-05
Segment length	4000 feet											

IRENE/LOGP Pipeline Segment: Remaining Segments

				Impact Distances					Conditional Probabilities			
				Fatality		Injury						
Scenario	Type	Units	Wind	Distance, ft	Width, ft	Distance, ft	Width, ft	Base Frequency, /mile-yr	Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Irene/LOGP 8" Pipeline												
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		49		289		4.34E-04	0.25	1.00	1.00	8.72E-04
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		75		92		4.34E-04	0.25	1.00	1.00	8.72E-04
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	172	88	461	159	4.34E-04	0.50	0.51	1.00	8.90E-04
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	112	34	246	58	4.34E-04	0.50	0.49	1.00	8.55E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	400	30	1060	49	4.34E-04	0.50	0.51	1.00	8.90E-04
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	89	23	135	36	4.34E-04	0.50	0.49	1.00	8.55E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		125		751		2.13E-04	0.25	1.00	1.00	4.28E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		217		259		2.13E-04	0.25	1.00	1.00	4.28E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	780	355	2033	660	2.13E-04	0.50	0.51	1.00	4.37E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	448	137	974	236	2.13E-04	0.50	0.49	1.00	4.19E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1066	92	2477	128	2.13E-04	0.50	0.51	1.00	4.37E-04
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	262	79	407	112	2.13E-04	0.50	0.49	1.00	4.19E-04
Segment length	42416 feet											

Torch Sales Gas Pipeline: rural areas

				Fatality		Injury			Conditional Probabilities			
Scenario	Type	Units	Wind	Distance, ft	Width, ft	Distance, ft	Width, ft	Base Frequency, /mile-yr	Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Torch Sales Gas 12" Pipeline												
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		126		138		1.51E-04	0.25	1.00	1.00	2.46E-04
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	335	52	600	85	1.51E-04	0.50	0.51	1.00	2.51E-04
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	167	16	259	23	1.51E-04	0.50	0.49	1.00	2.41E-04
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		771		791		7.43E-05	0.25	1.00	1.00	1.21E-04
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	1761	518	3050	758	7.43E-05	0.50	0.51	1.00	1.24E-04
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	928	154	1450	220	7.43E-05	0.50	0.49	1.00	1.19E-04
Segment length	34500 feet											

Torch Sales Gas Pipeline: along Highway 1/135

				Fatality		Injury			Conditional Probabilities			
Scenario	Type	Units	Wind	Distance, ft	Width, ft	Distance, ft	Width, ft	Base Frequency, /mile-yr	Event Cond. Prob.	Wind Stab Prob.	Wind Direction Prob.	Scenario Frequency
Torch Sales Gas 12" Pipeline												
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		126		138		1.51E-04	0.25	1.00	0.25	8.92E-06
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	335	52	600	85	1.51E-04	0.50	0.51	0.25	9.10E-06
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	167	16	259	23	1.51E-04	0.50	0.49	0.25	8.74E-06
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		771		791		7.43E-05	0.25	1.00	0.25	4.39E-06
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	1761	518	3050	758	7.43E-05	0.50	0.51	0.25	4.48E-06
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	928	154	1450	220	7.43E-05	0.50	0.49	0.25	4.31E-06
Segment length	5000 feet											

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

Conditional Prob based on CCPS, 50% of releases produce vapor cloud, 25% produce explosion, 25% immediate ignition. Toxic impacts assumed to conservatively be equal to vapor cloud effects.
Fatality Probabilities: 10% at 10 kw/m2 for thermal, 30% within LFL, explosion 50% at 3 psi (assumes 50% of persons indoors), 10% fatalities at ERPG-3 for toxic
Injury Probabilities: 10% at 5 kw/m2 for thermal, 50% within 1/2 LFL, 10% at 0.5 psi and 10% at ERPG-2
Wind Occurrence Based on 1993 SEIR: 50.5% D Stability, 49.5% F stability.
LOGP Harris Grade direction prob. based on 15% of time wind blowing from the NNE, NE, ENE, E, ESE, SE (HS&P met data 1988/89). Remaining 85% of time wind blows towards on rural areas.
Valve 9 to LOGP pipeline urban wind direction prob. based on fraction of time wind is blowing from the NW, NNW, N, NNE. Remaining time wind blows release towards rural only areas.
Valve 8 to Valve 9 pipeline urban wind direction prob. based on NW, WNW, W, WSW
Wind direction prob. for scenarios that do not reach urban areas assigned a value of 1.0 as all other areas are rural in all directions.
Zone rural and Harris Grade or urban fractions based on geometry of ellipses and circles with center area excluded (due to within facility boundaries for LOGP scenarios)
For vapor cloud explosions/fire (VCE) and Toxic impacts, width is equal to 1/2 width of ellipse with ellipse length equal to downwind distance from release point.
For thermal and explosion, downwind distance equal to circle radius with center at release point
For impact distances where numbers are not available, estimated impact distances assumed the following:
Assumed ratios of length to width for LFL = 0.1
Assumed ratio of 1/2 LFL to LFL = 0.43
Assumed thermal 10 kw/m2 to 5 kw/m2 ratio = 0.73
Assumed 0.5 psi to 3 psi ratio = 0.25

Distance from LOGP to Harris Grade Road (facility boundary), ft	700	feet
Distance between LOGP and Vandenberg Village, feet	4800	feet
Distance from Valve 9 - LOGP pipeline segment to Vandenberg Village =	1600	feet
Distance from Valve 8 - Valve 9 pipeline segment to Vandenberg Village =	2600	feet
Distance from Valve 7 - Valve 8 pipeline segment to Penitentiary Barracks =	2600	feet

Rural population =	1	persons/sq mile
Harris Grade population=	3.48	persons/sq mile (1.74 cars/mile, 2 persons per car)
Rte 1/135 population	24.24	persons/sq mile (12.12 cars/mile, 2 persons per car)
Urban population =	7000	persons/sq mile
Number of Irene-LOGP gas pigging operations per year	12	
Number of LGP trips per year	152	
Facility Life, years	22	
LOGP cumulative scenario frequency, per year	6.90E-05	
LOGP probability, percent	0.15	
Ignition probability per car	0.06	

Ignition sources of cars based on cars per mile with above probability. Ignition probability included in Event Conditional probability
Sales gas, due to being mostly methane, was assumed to not be able to create an explosion due to lack of confinement.

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

LOGP Facility

Scenario	Type	Units	Wind	Fatality Zone: Rural Fraction	Fatality Zone: Harris Grade Fraction	Injury Zone: Rural Fraction	Injury Zone: Harris Grade Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Crude tank fire	Thermal	10 kw/m2 fat, 5 kw/m2 injury		0.00	0.00	0.32	0.06	0.000	0.045	0.1	0.1	0.000	0.005
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	0.00	0.00	0.00	0.02	0.000	0.000	0.3	0.5	0.000	0.000
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	0.00	0.00	0.02	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	0.00	0.00	0.00	0.59	0.000	0.011	0.3	0.5	0.000	0.006
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	0.00	0.00	0.59	0.00	0.000	0.003	0.3	0.5	0.000	0.002
LPG/NGL Vessel BLEVE	Thermal	80 kJ/m2 fat estimated, 40 kJ/m2 injury		0.58	0.24	0.60	0.30	0.422	0.937	0.1	0.1	0.042	0.094
LPG/NGL Vessel Explosion	Explosion	3 psi fatality estimated, 0.5 psi injury		0.00	0.00	0.59	0.27	0.000	0.608	0.5	0.1	0.000	0.061
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	0.00	0.28	0.00	0.76	0.003	0.339	0.3	0.5	0.001	0.169
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	0.28	0.00	0.76	0.00	0.001	0.097	0.3	0.5	0.000	0.049
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	0.00	0.31	0.00	0.77	0.004	0.378	0.3	0.5	0.001	0.189
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	0.31	0.00	0.77	0.00	0.001	0.109	0.3	0.5	0.000	0.054
LPG/NGL tank truck rupture	Explosion	3 psi fatality, 0.5 psi injury		0.00	0.00	0.59	0.26	0.000	0.544	0.5	0.1	0.000	0.054
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	0.00	0.00	0.00	0.49	0.000	0.065	0.3	0.5	0.000	0.033
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	0.00	0.00	0.49	0.00	0.000	0.019	0.3	0.5	0.000	0.009
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	0.00	0.00	0.00	0.42	0.000	0.051	0.3	0.5	0.000	0.025
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	0.00	0.00	0.42	0.00	0.000	0.015	0.3	0.5	0.000	0.007

IRENE/LOGP Pipeline Segment: Between Valve Station 9 and LOGP closest segments

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Irene/LOGP 8" Pipeline													
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.000	0.009	0.5	0.1	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.001	0.001	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.0	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.000	0.000	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.000	0.001	0.3	0.5	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.002	0.064	0.5	0.1	0.001	0.006
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.005	0.008	0.1	0.1	0.001	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	0.94	0.06	0.008	16.9	0.1	0.1	0.001	1.69
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.038	0.1	0.1	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.002	0.006	0.1	0.1	0.000	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	VCE	LFL, 1/2 LFL	F	1.00	0.00	0.78	0.22	0.003	13.9	0.3	0.5	0.001	6.931
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.003	0.009	0.3	0.5	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.001	0.001	0.3	0.5	0.000	0.001

Segment length 5000 feet

IRENE/LOGP Pipeline Segment: Between VS8 plus VS9 and LOGP farthest segments

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Irene/LOGP 8" Pipeline													
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.000	0.009	0.5	0.1	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.001	0.001	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.000	0.000	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.000	0.001	0.3	0.5	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.002	0.064	0.5	0.1	0.001	0.006
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.005	0.008	0.1	0.1	0.001	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.0	0.1	0.1	0.001	0.00
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.038	0.1	0.1	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.002	0.006	0.1	0.1	0.000	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.003	0.009	0.3	0.5	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.001	0.001	0.3	0.5	0.000	0.001

Segment length 13000 feet

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

IRENE/LOGP Pipeline Segment: Near Valve Station 7 and Valve Station 8

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Irene/LOGP 8" Pipeline													
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.000	0.009	0.5	0.1	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.001	0.001	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.000	0.000	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.000	0.001	0.3	0.5	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.002	0.064	0.5	0.1	0.001	0.006
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.005	0.008	0.1	0.1	0.001	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.0	0.1	0.1	0.001	0.00
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.038	0.1	0.1	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.002	0.006	0.1	0.1	0.000	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.003	0.009	0.3	0.5	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.001	0.001	0.3	0.5	0.000	0.001
Segment length	4000 feet												

IRENE/LOGP Pipeline Segment: Remaining Segments

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Irene/LOGP 8" Pipeline													
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.000	0.009	0.5	0.1	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.001	0.001	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.000	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.000	0.000	0.1	0.1	0.000	0.000
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.000	0.001	0.3	0.5	0.000	0.001
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1.00	0.00	1.00	0.00	0.002	0.064	0.5	0.1	0.001	0.006
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.005	0.008	0.1	0.1	0.001	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	1.00	0.00	1.00	0.00	0.008	0.038	0.1	0.1	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1.00	0.00	1.00	0.00	0.002	0.006	0.1	0.1	0.000	0.001
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.003	0.009	0.3	0.5	0.001	0.004
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.001	0.001	0.3	0.5	0.000	0.001
Segment length	42418 feet												

Torch Sales Gas Pipeline: rural areas

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Torch Sales Gas 12" Pipeline													
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.002	0.002	0.1	0.1	0.000	0.000
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.000	0.001	0.3	0.5	0.000	0.001
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.000	0.000	0.3	0.5	0.000	0.000
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.067	0.071	0.1	0.1	0.007	0.007
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.028	0.065	0.3	0.5	0.008	0.033
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.004	0.009	0.3	0.5	0.001	0.004
Segment length	34500 feet												

Torch Sales Gas Pipeline: along Highway 1/135

Scenario	Type	Units	Wind	Fatality Rural Fraction	Fatality Urban Fraction	Injury Rural Fraction	Injury Urban Fraction	Fat. Zone Persons Affected	Inj. Zone Persons Affected	Fatality Prob.	Injury Prob.	Fatalities	Injuries
Torch Sales Gas 12" Pipeline													
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	0.043	0.002	0.1	0.1	0.004	0.000
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.012	0.001	0.3	0.5	0.004	0.001
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.002	0.000	0.3	0.5	0.001	0.000
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1.00	0.00	1.00	0.00	1.624	0.071	0.1	0.1	0.162	0.007
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	1.00	0.00	1.00	0.00	0.623	0.065	0.3	0.5	0.187	0.033
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	1.00	0.00	1.00	0.00	0.098	0.009	0.3	0.5	0.029	0.004
Segment length	5000 feet												

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

Conditional Prob based on CCPS, 50% of releases produce vapor cloud, 25% produce explosion, 25% immediate ignition. Toxic i
Fatality Probabilities: 10% at 10 kw/m2 for thermal, 30% within LFL, explosion 50% at 3 psi (assumes 50% of persons indoors), 1C
Injury Probabilities: 10% at 5 kw/m2 for thermal, 50% within 1/2 LFL, 10% at 0.5 psi and 10% at ERPG-2
Wind Occurrence Based on 1993 SEIR: 50.5% D Stability, 49.5% F stability.
LOGP Harris Grade direction prob. based on 15% of time wind blowing from the NNE, NE, ENE, E, ESE, SE (HS&P met data 198
Valve 9 to LOGP pipeline urban wind direction prob. based on fraction of time wind is blowing from the NW, NNW, N, NNE. Remai
Valve 8 to Valve 9 pipeline urban wind direction prob. based on NW, WNW, W, WSW
Wind direction prob. for scenarios that do not reach urban areas assigned a value of 1.0 as all other areas are rural in all directions
Zone rural and Harris Grade or urban fractions based on geometry of ellipses and circles with center area excluded (due to within
For vapor cloud explosions/fire (VCE) and Toxic impacts, width is equal to 1/2 width of ellipse with ellipse length equal to downwin
For thermal and explosion, downwind distance equal to circle radius with center at release point
For impact distances where numbers are not available, estimated impact distances assumed the following:

Assumed ratios of length to width for LFL = 0.1
Assumed ratio of 1/2 LFL to LFL = 0.43
Assumed thermal 10 kw/m2 to 5 kw/m2 ratio = 0.73
Assumed 0.5 psi to 3 psi ratio = 0.25

Distance from LOGP to Harris Grade Road (facility boundary), ft			700
Distance between LOGP and Vandenberg Village, feet			4600
Distance from Valve 9 - LOGP pipeline segment to Vandenberg Village =			1800
Distance from Valve 8 - Valve 9 pipeline segment to Vandenberg Village =			2600
Distance from Valve 7 - Valve 8 pipeline segment to Penitentiary Barracks =			2600
Rural population =	1	persons/sq mile	
Harris Grade population=	3.48	persons/sq mile (1.74 cars/mile, 2 persons per car)	
Rte 1/135 population	24.24	persons/sq mile (12.12 cars/mile, 2 persons per car)	
Urban population =	7000	persons/sq mile	
Number of Irene-LOGP gas pigging operations per year	12		
Number of LGP trips per year	152		
Facility Life, years	22		
LOGP cumulative scenario frequency, per year	6.90E-05		
LOGP probability, percent	0.15		
Ignition probability per car	0.06		

Ignition sources of cars based on cars per mile with above probability. Ignition probability included in Event Conditional probability
Sales gas, due to being mostly methane, was assumed to not be able to create an explosion due to lack of confinement.

Tranquillon Ridge Risk Analysis Spreadsheets
Scenarios with Potential to Impact Public Only

LOGP Facility

Scenario	Type	Units	Wind	Source
Crude tank fire	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1985 EIR, Table 4-13 tank rupture 66,000 barrel spill into dike, Fig 2-15 divided by 4 tanks. Event cond. Prob based on OPS spills at pump station with ignition
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-15, Fig 2-14
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-15, Fig 2-14
Gas/oil separator vessel rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-15, Fig 2-14
Gas/oil separator vessel rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-15, Fig 2-14
LPG/NGL Vessel BLEVE	Thermal	80 kJ/m2 fat estimated, 40 kJ/m2 injury		1996 Addendum
LPG/NGL Vessel Explosion	Explosion	3 psi fatality estimated, 0.5 psi injury		1996 Addendum
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-15, 525 bbl propane tank, Fig 2-14
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-15, 525 bbl propane tank, Fig 2-14
LPG/NGL Tank rupture/release, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-15, 525 bbl propane tank, Fig 2-14
LPG/NGL Tank rupture/release, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-15, 525 bbl propane tank, Fig 2-14
LPG/NGL tank truck rupture	Explosion	3 psi fatality, 0.5 psi injury		1985 EIR, Table 4-17 9,000 gallon rupture, Fig 2-24, base release rate per loading
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-18 propane release #4, Fig 2-24 base release rate per loading
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	D	1985 EIR, table 4-18 propane release #4, Fig 2-24 base release rate per loading
LPG/NGL tank truck rupture, towards Harris Grade	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-18 propane release #4, Fig 2-24 base release rate per loading
LPG/NGL tank truck rupture, towards rural areas	VCE	LFL estimated, 1/2 LFL	F	1985 EIR, table 4-18 propane release #4, Fig 2-24 base release rate per loading

IRENE/LOGP Pipeline Segment: Between Valve Station 9 and LOGP closest segments

Scenario	Type	Units	Wind	Source
Irene/LOGP 8" Pipeline				
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 2c, base freq. is per mile year
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 1c
Segment length	5000 feet			

IRENE/LOGP Pipeline Segment: Between VS8 plus VS9 and LOGP farthest segments

Scenario	Type	Units	Wind	Source
Irene/LOGP 8" Pipeline				
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 2c, base freq. is per mile year
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 1c
Segment length	13000 feet			

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

IRENE/LOGP Pipeline Segment: Near Valve Station 7 and Valve Station 8

Scenario	Type	Units	Wind	Source
Irene/LOGP 8" Pipeline				
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 2c, base freq. is per mile year
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig, urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig, non-urban	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 1c
Segment length	4000 feet			

IRENE/LOGP Pipeline Segment: Remaining Segments

Scenario	Type	Units	Wind	Source
Irene/LOGP 8" Pipeline				
Gas pipeline leak 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 2c, base freq. is per mile year
Gas pipeline leak 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 2c, updated to 8,000 ppm
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline leak 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 2c
Gas pipeline rupture, 6 mmscfd, 600 psig	Explosion	3 psi fatality, 0.5 psi injury		1993 SEIR, table 5.25, table 5.30 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		1993 SEIR, table 5.25, table 5.28 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	F	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	Toxic	ERPG-3, ERPG-2	D	1993 SEIR, table 5.25, table 5.26 scenario 1c, updated to 8,000 ppm
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	F	1993 SEIR, table 5.25 table 5.27 scenario 1c
Gas pipeline rupture, 6 mmscfd, 600 psig	VCE	LFL, 1/2 LFL	D	1993 SEIR, table 5.25 table 5.27 scenario 1c
Segment length	42416 feet			

Torch Sales Gas Pipeline: rural areas

Scenario	Type	Units	Wind	Source
Torch Sales Gas 12" Pipeline				
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	Adapted from PANGL Pipeline consequence modeling, 4/99
Segment length	34500 feet			

Torch Sales Gas Pipeline: along Highway 1/135

Scenario	Type	Units	Wind	Source
Torch Sales Gas 12" Pipeline				
Gas pipeline leak 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	F	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline leak 800 psig	VCE	LFL, 1/2 LFL	D	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	Thermal	10 kw/m2 fat, 5 kw/m2 injury		Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	F	Adapted from PANGL Pipeline consequence modeling, 4/99
Gas pipeline rupture, 800 psig	VCE	LFL, 1/2 LFL	D	Adapted from PANGL Pipeline consequence modeling, 4/99
Segment length	5000 feet			

Tranquillon Ridge Risk Analysis Spreadsheets

Scenarios with Potential to Impact Public Only

Conditional Prob based on CCPS, 50% of releases produce vapor cloud, 25% produce explosion, 25% immediate ignition. Toxic i
Fatality Probabilities: 10% at 10 kw/m2 for thermal, 30% within LFL, explosion 50% at 3 psi (assumes 50% of persons indoors), 1C
Injury Probabilities: 10% at 5 kw/m2 for thermal, 50% within 1/2 LFL, 10% at 0.5 psi and 10% at ERPG-2
Wind Occurrence Based on 1993 SEIR: 50.5% D Stability, 49.5% F stability.
LOGP Harris Grade direction prob. based on 15% of time wind blowing from the NNE, NE, ENE, E, ESE, SE (HS&P met data 198
Valve 9 to LOGP pipeline urban wind direction prob. based on fraction of time wind is blowing from the NW, NNW, N, NNE. Remai
Valve 8 to Valve 9 pipeline urban wind direction prob. based on NW, WNW, W, WSW
Wind direction prob. for scenarios that do not reach urban areas assigned a value of 1.0 as all other areas are rural in all directions
Zone rural and Harris Grade or urban fractions based on geometry of ellipses and circles with center area excluded (due to within
For vapor cloud explosions/fire (VCE) and Toxic impacts, width is equal to 1/2 width of ellipse with ellipse length equal to downwin
For thermal and explosion, downwind distance equal to circle radius with center at release point
For impact distances where numbers are not available, estimated impact distances assumed the following:

Assumed ratios of length to width for LFL = 0.1
Assumed ratio of 1/2 LFL to LFL = 0.43
Assumed thermal 10 kw/m2 to 5 kw/m2 ratio = 0.73
Assumed 0.5 psi to 3 psi ratio = 0.25

Distance from LOGP to Harris Grade Road (facility boundary), ft		700
Distance between LOGP and Vandenberg Village, feet		4600
Distance from Valve 9 - LOGP pipeline segment to Vandenberg Village =		1800
Distance from Valve 8 - Valve 9 pipeline segment to Vandenberg Village =		2600
Distance from Valve 7 - Valve 8 pipeline segment to Penitentiary Barracks =		2600
Rural population =	1	persons/sq mile
Harris Grade population=	3.48	persons/sq mile (1.74 cars/mile, 2 persons per car)
Rte 1/135 population	24.24	persons/sq mile (12.12 cars/mile, 2 persons per car)
Urban population =	7000	persons/sq mile
Number of Irene-LOGP gas pigging operations per year	12	
Number of LGP trips per year	152	
Facility Life, years	22	
LOGP cumulative scenario frequency, per year	6.90E-05	
LOGP probability, percent	0.15	
Ignition probability per car	0.06	

Ignition sources of cars based on cars per mile with above probability. Ignition probability included in Event Conditional probability
Sales gas, due to being mostly methane, was assumed to not be able to create an explosion due to lack of confinement.

Irene and Offshore Pipeline Failure Rate Calculations: Current Operations PL Pedemales Production Only

Summary of Frequency Results

Lifetime	10	years
Average oil production, bpd	2000	bpd over lifetime

Platform Irene Summary		
Scenario	Freq. per year	Lifetime Prob. %
Small Spills		
Irene - Wellhead Area Spill to Ocean - small	1.47E-08	0.0
Irene - Separator Failure Spill to Ocean - small	3.74E-06	0.0
Irene - Pumping and Shipping Spill to Ocean - small	2.38E-04	0.2
Irene - Diesel Fuel Loading - Small spill to Ocean	2.90E-04	0.3
Cumulative Small Spills	5.33E-04	0.5
Large Spills		
Irene - Blowouts	NA	NA
Irene - Wellhead Area Spill to Ocean - large	1.25E-08	0.0
Irene - Separator Failure Spill to Ocean - large	9.60E-05	0.1
Irene - Pumping and Shipping Spill to Ocean - large	2.80E-05	0.0
Irene - External impact	1.00E-05	0.0
Cumulative Large Spills	1.34E-04	0.1
Cumulative All Spills	6.67E-04	0.7

Offshore Emulsion Pipeline Summary		
Scenario	Freq. per year	Lifetime Prob. %
Leaks		
1985 EIR table 2-2, leaks	4.41E-03	4.3
CSFM for this pipeline, leak	3.11E-03	3.1
Ruptures		
1985 EIR table 2-2, ruptures	4.90E-04	0.5
CSFM for this pipeline, rupture	6.82E-04	0.7
OPS all crude lines, spills > 50 bbl	9.17E-03	8.8
MMS pipeline throughput method, 1,000 bbl spill, per year	9.86E-04	1.0

Offshore Emulsion Pipeline and Platform Summary		
Scenario	Freq. per year	Lifetime Prob. %
Leaks and Small Spills	4.94E-03	4.8
Ruptures and Large Spills	6.24E-04	0.6
Any Spill Size	5.57E-03	5.4

Detailed Calculations					
Platform Irene					
Description	***Base rate***	***Units***	***Multiplyer***	***Rate***	***Ref***
Irene - Blowouts				0.00E+00	
Blowout during drilling	3.90E-03	per well drilled	0	0.00E+00	1985 EIR, figure 2-2, 78% wellhead or drill floor (HLID, 1992), assumes wells drilled = 0, multiplyer units of wells/year
Blowout during drilling: below platform	1.10E-03	per well drilled	0	0.00E+00	1985 EIR, figure 2-2, 22% subsea (as per HLID, 1992), assumes wells drilled = 0, multiplyer units of wells/year
Blowout during well workover	5.20E-05	per well	0	0.00E+00	HLID, 1992, 93% wellhead or drill floor assumes workoverers every 7 years
Blowout during well workover: below platform	5.14E-06	per well	0	0.00E+00	HLID, 1992, 9% subsea, assumes workoverers every 7 years
Blowout during production	2.57E-04	per year	0	0.00E+00	1985 EIR, figure 2-2, 78% wellhead or drill floor (HLID, 1992), Assumes no production wells under reserviour pressure
Blowout during production: below platform	7.26E-05	per year	0	0.00E+00	1985 EIR, figure 2-2, 22% subsea (HLID, 1992), Assumes no production wells under reserviour pressure
Oil spill conditional probability	7.40E-02	per demand	1	7.40E-02	1985 EIR, figure 2-2, for blowouts on platform
Irene - Wellhead Area Spill to Ocean - small				1.47E-08	
Irene - Wellhead Area Spill to Ocean - large				1.25E-08	
Number of wellheads	22	number	1	2.20E+01	Current operation
Fittings per well	2	number	1	2.00E+00	1985 EIR, figure 2-3
Break of small fitting	3.00E-04	per year	1	3.00E-04	1985 EIR, figure 2-3
Failure to close sub surface valve	1.00E-02	per year	1	1.00E-02	1985 EIR, figure 2-3
Failure to close surface safety valve	1.00E-03	per year	1	1.00E-03	1985 EIR, figure 2-3
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Leak at 2" or 3" valve	7.88E-05	/valve.yr	5	3.94E-04	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6 *Assume 90% of leaks are significant but not catastrophic rupture*
Hole in well head	2.63E-06	/m.yr	2	5.26E-06	Treated as a hole in 8" pipe. Significant leak. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Full bore pipe rupture	2.60E-07	/m.yr	50	1.30E-05	Rupture of pipe. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Full bore 2" or 3" valve rupture	8.76E-06	/valve.yr	5	4.38E-05	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6 *Assume 10% of leaks are catastrophic rupture*
Well head rupture	9.00E-08	/m.yr	2	1.80E-07	*Treated as a 8" pipe rupture.* Rupture of pipe >150 mm diameter. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6

Irene and Offshore Pipeline Failure Rate Calculations: Current Operations Pt. Pedernales Production Only

Irene - Separator Failure Spill to Ocean - small				**3.74E-06**	
Irene - Separator Failure Spill to Ocean - large				**9.60E-05**	
Vessel Spontaneous Rupture	3.00E-05	per year	2	6.00E-05	1985 EIR, gross separators only
Vessel Maine impact	8.00E-06	per year	2	1.60E-05	1985 EIR, gross separators only
Vesel Seismic induced rupture	1.00E-05	per year	2	2.00E-05	1985 EIR, gross separators only
Break of small fitting	3.00E-04	per year	10	3.00E-03	See above, number estimated
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	See above, number estimated
Leak at 2" or 3" valve	7.88E-05	/valve.yr	6	4.73E-04	See above, number estimated
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Irene - Pumping and Shipping Spill to Ocean - small				**2.38E-04**	
Irene - Pumping and Shipping Spill to Ocean - large				**2.80E-05**	
Vessel Spontaneous Rupture	1.00E-05	per year	1	1.00E-05	1985 EIR, Shipping tank
Vessel Maine impact	8.00E-06	per year	1	8.00E-06	1985 EIR, Shipping tank
Vesel Seismic induced rupture	1.00E-05	per year	1	1.00E-05	1985 EIR, Shipping tank
Break of small fitting	3.00E-04	per year	10	3.00E-03	See above, number estimated
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	See above, number estimated
Leak at 2" or 3" valve	7.88E-05	/valve.yr	6	4.73E-04	See above, number estimated
Pump leak or ruture	1.70E-02	per year	2	3.40E-02	HLUD, 1992
Pig launcher improper action/mech defect	1.10E-03	per year	1	1.10E-03	1985 EIR, figure 2-7
Pigging operations per year	183	number	1	183	Project description
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Irene - Diesel Fuel Loading - Small spill to Ocean				**2.90E-04**	
Hose failure	1.10E-02	per year	1	1.10E-02	1985 EIR, figure 2-9
Loadings per year	1.20E+01	per year	1	1.20E+01	1985 EIR, figure 2-9
Check valve failure	2.20E-03	per demand	1	2.20E-03	CCPS, 1989, Failure to check
Irene - External impact				**1.00E-05**	**1985 EIR, Figure 2-10**
Total Large Spill Frequency				**1.34E-04**	
Years Between Spills				7462	
Platform Life, years				10	
Lifetime probability				1.34E-03	
Probability				0.1	
Total Small Spill Frequency				**5.33E-04**	
Years Between Spills				1877	
Platform Life, years				10	
Lifetime probability				5.33E-03	
Probability				0.5	
TOTAL SPILL TO OCEAN FREQUENCY				**6.67E-04**	
Years Between Spills				1500	
Platform Life, years				10	
Lifetime probability				6.67E-03	
Probability				0.7	
Combined Platform Irene and Pipeline					
Platform Life, years				10	
Small Spills				4.94E-03	
Small Spills Probability				4.8	
Large Spills				6.24E-04	
Large Spills Probability				0.6	

PIPELINE FAILURE RATES				**Freq/yr**	**Probability**
Offshore Emulsion Pipeline - Failure rates, utilize 1985 EIR leak rate				**4.41E-03**	4.3
1985 EIR table 2-2, leaks	4.28E-04	per mile-year	10.3	4.41E-03	4.3
CSFM for this pipeline, leak	3.02E-04	per mile-year	10.3	3.11E-03	3.1
1985 EIR table 2-2, ruptures	4.76E-05	per mile-year	10.3	4.90E-04	0.5
CSFM for this pipeline, rupture	6.62E-05	per mile-year	10.3	6.82E-04	0.7
OPS all crude lines, spills > 50 bbl	8.90E-04	per mile-year	10.3	9.17E-03	8.8
MMS pipeline throughput method, 1,000 bbl spill, per year				9.86E-04	1.0
Offshore Water Return Pipeline - Failure rates, utilize 1985 EIR leak rate				**3.60E-03**	3.5
1985 EIR table 2-2, leaks	3.50E-04	per mile-year	10.3	3.60E-03	3.5
CSFM for this pipeline, all products, leak	5.96E-04	per mile-year	10.3	6.14E-03	6.0
1985 EIR table 2-2, ruptures	3.88E-05	per mile-year	10.3	4.00E-04	0.4
CSFM for this pipeline, all products rupture	1.31E-04	per mile-year	10.3	1.35E-03	1.3
OPS all crude lines, spills > 50 bbl	8.90E-04	per mile-year	10.3	9.17E-03	8.8
MMS pipeline throughput method, 1,000 bbl spill, assumes 10,000 bpd water				4.93E-03	4.8
Onshore Emulsion Pipeline					
CSFM Failure rate - ruptures	6.62E-05	per mile-year	12.2	8.08E-04	
Seismic activity - rupture	4.15E-06	per mile-year	12.2	5.06E-05	
Onshore Emulsion Pipeline Ruptures				**8.59E-04**	0.9
Onshore Emulsion Pipeline Leaks	3.02E-04	per mile-year	12.2	**3.68E-03**	3.6
Onshore Gas Pipeline					
Leak rate, per pipeline mile-year	4.34E-04	per mile-year	12.2	**5.29E-03**	5.2
Rupture rate, per pipeline mile-year	2.13E-04	per mile-year	12.2	**2.60E-03**	2.6
Onshore Water Pipeline					
CSFM Failure rate - ruptures	1.31E-04	per mile-year	12.2	1.60E-03	
Seismic activity - rupture	4.15E-06	per mile-year	12.2	5.06E-05	
Onshore Water Pipeline Ruptures				**1.65E-03**	1.6
Onshore Water Pipeline Leaks	5.96E-04	per mile-year	12.2	**7.27E-03**	7.0
LOGP-Summit Pipeline					
Years Life	30	years			
CSFM Failure rate - ruptures	1.47E-03	per mile-year	27.65	4.07E-02	
Seismic activity - rupture	4.15E-06	per mile-year	27.65	1.15E-04	
Onshore Oil Pipeline Ruptures				**4.09E-02**	70.7
Onshore Oil Pipeline Leaks	6.71E-03	per mile-year	27.65	**1.86E-01**	99.6

Irene and Offshore Pipeline Failure Rate Calculations: Current Operations Pt. Pedernales Production Only

LOGP FACILITIES					
SCADA - failure				1.01E-01	Reference
Phone line failure	2.28E-04	demand	1	2.28E-04	Estimated 8 hours per year down time
Pump shutdown failure	1.00E-04	on demand	1	1.00E-04	Rijnonmd, failure to stop on demand
Actuated valve failure	1.00E-03	on demand	1	1.00E-03	Lees, failure to operate on demand
Pressure Switch	1.00E-04	on demand	1	1.00E-04	Rijnonmd, failure on demand
Operator Restarts system, override SCADA	1.00E-01	on demand	1	1.00E-01	Reliability and Maintainability in Perspective, 3rd Edition, D.J. Smith, 1988, *Fail to recognise incorrect status on inspection*
Other LOGP Freqeuncies taken directly from the 1985 EIR					

Irene and Offshore Pipeline Failure Rate Calculations: Proposed Operations, Pt. Ped and tranquillon Ridge Production

updated to 15 year lifetime

Summary of Frequency Results

Lifetime	15	years
Average oil production, bpd	18,840	bpd over lifetime

Platform Irene Summary		
Scenario	Freq, per year	Lifetime Prob, %
Small Spills		
Irene - Wellhead Area Spill to Ocean - small	1.47E-08	0.0
Irene - Separator Failure Spill to Ocean - small	3.74E-06	0.0
Irene - Pumping and Shipping Spill to Ocean - small	2.38E-04	0.4
Irene - Diesel Fuel Loading - Small spill to Ocean	2.90E-04	0.4
Cumulative Small Spills	5.33E-04	0.8
Large Spills		
Irene - Blowouts	2.78E-03	4.1
Irene - Wellhead Area Spill to Ocean - large	1.25E-08	0.0
Irene - Separator Failure Spill to Ocean - large	9.60E-05	0.1
Irene - Pumping and Shipping Spill to Ocean - large	2.80E-05	0.0
Irene - External impact	1.00E-05	0.0
Cumulative Large Spills	2.91E-03	4.3
Cumulative All Spills	3.44E-03	5.0

Offshore Emulsion Pipeline Summary		
Scenario	Freq, per year	Lifetime Prob, %
Leaks		
1985 EIR table 2-2, leaks	4.41E-03	6.4
CSFM for this pipeline, leak	3.11E-03	4.6
Ruptures		
1985 EIR table 2-2, ruptures	4.90E-04	0.7
CSFM for this pipeline, rupture	6.82E-04	1.0
OPS all crude lines, spills > 50 bbl	9.17E-03	12.8
MMS pipeline throughput method, 1,000 bbl spill, per year	9.28E-03	13.0

Offshore Emulsion Pipeline and Platform		
Scenario	Freq, per year	Lifetime Prob, %
Leaks and Small Spills	4.94E-03	7.1
Ruptures and Large Spills	3.40E-03	5.0
Any Spill Size	8.34E-03	11.8

Detailed Calculations					
Platform Irene					
DESCRIPTION	**BASE RATE**	**UNITS**	**Multiplyer**	**RATE**	**REFERENCE**
Irene - Blowouts				**2.78E-03**	
Blowout during drilling	3.90E-03	per well drilled	2	7.80E-03	1985 EIR, figure 2-2, 78% wellhead or drill floor (HLID, 1992), assumes wells drilled = 0, multiplyer units of wells/year
Blowout during drilling: below platform	1.10E-03	per well drilled	2	2.20E-03	1985 EIR, figure 2-2, 22% subsea (as per HLID, 1992), assumes wells drilled = 0, multiplyer units of wells/year
Blowout during well workover	5.20E-05	per well	0	0.00E+00	HLID, 1992, 93% wellhead or drill floor assumes workoverers every 7 years
Blowout during well workover: below platform	5.14E-06	per well	0	0.00E+00	HLID, 1992, 9% subsea, assumes workoverers every 7 years
Blowout during production	2.57E-04	per year	0	0.00E+00	1985 EIR, figure 2-2, 78% wellhead or drill floor (HLID, 1992), Assumes no production wells under reserviour pressure
Blowout during production: below platform	7.26E-05	per year	0	0.00E+00	1985 EIR, figure 2-2, 22% subsea (HLID, 1992), Assumes no production wells under reserviour pressure
Oil spill conditional probability	7.40E-02	per demand	1	7.40E-02	1985 EIR, figure 2-2, for blowouts on platform
Irene - Wellhead Area Spill to Ocean - small				**1.47E-08**	
Irene - Wellhead Area Spill to Ocean - large				**1.25E-08**	
Number of wellheads	22	number	1	2.20E+01	Current operation
Fittings per well	2	number	1	2.00E+00	1985 EIR, figure 2-3
Break of small fitting	3.00E-04	per year	1	3.00E-04	1985 EIR, figure 2-3
Failure to close sub surface valve	1.00E-02	per year	1	1.00E-02	1985 EIR, figure 2-3
Failure to close surface safety valve	1.00E-03	per year	1	1.00E-03	1985 EIR, figure 2-3
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Leak at 2" or 3" valve	7.88E-05	/valve.yr	5	3.94E-04	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6. *Assume 90% of leaks are significant but not catastrophic rupture.*
Hole in well head	2.63E-06	/m.yr	2	5.26E-06	Treated as a hole in 8" pipe. Significant leak. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Full bore pipe rupture	2.60E-07	/m.yr	50	1.30E-05	Rupture of pipe. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Full bore 2" or 3" valve rupture	8.76E-06	/valve.yr	5	4.38E-05	Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6. *Assume 10% of leaks are catastrophic rupture*
Well head rupture	9.00E-08	/m.yr	2	1.80E-07	*Treated as a 8" pipe rupture.* Rupture of pipe >150 mm diameter. Risk Analysis Report to the Rijnmond Public Authority, D.Reidel Publishing Co., 1981 ISBN 90-277-1393-6
Irene - Separator Failure Spill to Ocean - small				**3.74E-06**	
Irene - Separator Failure Spill to Ocean - large				**9.60E-05**	
Vessel Spontaneous Rupture	3.00E-05	per year	2	6.00E-05	1985 EIR, gross separators only
Vessel Maine impact	8.00E-06	per year	2	1.60E-05	1985 EIR, gross separators only
Vesel Seismic induced rupture	1.00E-05	per year	2	2.00E-05	1985 EIR, gross separators only
Break of small fitting	3.00E-04	per year	10	3.00E-03	See above, number estimated
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	See above, number estimated
Leak at 2" or 3" valve	7.88E-05	/valve.yr	6	4.73E-04	See above, number estimated
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Irene - Pumping and Shipping Spill to Ocean - small				**2.38E-04**	
Irene - Pumping and Shipping Spill to Ocean - large				**2.80E-05**	
Vessel Spontaneous Rupture	1.00E-05	per year	1	1.00E-05	1985 EIR, Shipping tank
Vessel Maine impact	8.00E-06	per year	1	8.00E-06	1985 EIR, Shipping tank

Irene and Offshore Pipeline Failure Rate Calculations: Proposed Operations, Pt. Ped and tranquillon Ridge Production

updated to 15 year lifetime

Vesel Seismic induced rupture	1.00E-05	per year	1	1.00E-05	1985 EIR, Shipping tank
Break of small fitting	3.00E-04	per year	10	3.00E-03	See above, number estimated
Hole in 3" diameter pipe	5.26E-06	/m.yr	50	2.63E-04	See above, number estimated
Leak at 2" or 3" valve	7.88E-05	/valve.yr	6	4.73E-04	See above, number estimated
Pump leak or ruture	1.70E-02	per year	2	3.40E-02	HLUD, 1992
Pig launcher improper action/mech defect	1.10E-03	per year	1	1.10E-03	1985 EIR, figure 2-7
Pigging operations per year	183	number	1	183	Project description
Failure of drainage system	1.00E-03	on demand	1	1.00E-03	Estimated, Lees, failure to operate on demand
Irene - Diesel Fuel Loading - Small spill to Ocean				**2.90E-04**	
Hose failure	1.10E-02	per year	1	1.10E-02	1985 EIR, figure 2-9
Loadings per year	1.20E+01	per year	1	1.20E+01	1985 EIR, figure 2-9
Check valve failure	2.20E-03	per demand	1	2.20E-03	CCPS, 1989, Failure to check
Irene - External impact				**1.00E-05**	**1985 EIR, Figure 2-10**
Total Large Spill Frequency				**2.91E-03**	
Years Between Spills				343	
Platform Life, years				15	
Lifetime probability				4.37E-02	
Probability				4.3	
Total Small Spill Frequency				**5.33E-04**	
Years Between Spills				1877	
Platform Life, years				15	
Lifetime probability				7.99E-03	
Probability				0.8	
TOTAL SPILL TO OCEAN FREQUENCY				**3.44E-03**	
Years Between Spills				290	
Platform Life, years				15	
Lifetime probability				5.17E-02	
Probability				5.0	
Combined Platform Irene and Pipeline					
Platform Life, years				15	
Small Spills				4.94E-03	7.1
Large Spills				3.40E-03	5.0

PIPELINE FAILURE RATES				**Freq/yr**	**Probability**
Offshore Emulsion Pipeline - Failure rates, utilize 1985 EIR leak rate				**4.41E-03**	6.4
1985 EIR table 2-2, leaks	4.28E-04	per mile-year	10.3	4.41E-03	6.4
CSFM for this pipeline, leak	3.02E-04	per mile-year	10.3	3.11E-03	4.6
1985 EIR table 2-2, ruptures	4.76E-05	per mile-year	10.3	4.90E-04	0.7
CSFM for this pipeline, rupture	6.62E-05	per mile-year	10.3	6.82E-04	1.0
OPS all crude lines, spills > 50 bbl	8.90E-04	per mile-year	10.3	9.17E-03	12.8
MMS pipeline throughput method, 1,000 bbl spill, per year				9.28E-03	13.0
Offshore Water Return Pipeline - Failure rates, utilize 1985 EIR leak rate				**3.60E-03**	5.3
1985 EIR table 2-2, leaks	3.50E-04	per mile-year	10.3	3.60E-03	5.3
CSFM for this pipeline, all products, leak	3.36E-04	per mile-year	10.3	3.46E-03	5.1
1985 EIR table 2-2, ruptures	3.88E-05	per mile-year	10.3	4.00E-04	0.6
CSFM for this pipeline, all products rupture	7.38E-05	per mile-year	10.3	7.60E-04	1.1
OPS all crude lines, spills > 50 bbl	8.90E-04	per mile-year	10.3	9.17E-03	12.8
MMS pipeline throughput method, 1,000 bbl spill, assumes 10,000 bpd water				4.93E-03	7.1
Onshore Emulsion Pipeline					
CSFM Failure rate - ruptures	6.62E-05	per mile-year	12.2	8.08E-04	1.2
Seismic activity - rupture	4.15E-06	per mile-year	12.2	5.06E-05	0.1
Valve Station 2 Pump Failure - leak	3.10E-01	per year			99.0
Valve Station 2 Pump Failure - rupture	3.10E-03	per year			4.5
CSFM failure rate - Leaks	3.02E-04	per mile-year	12.2	3.68E-03	5.4
Onshore Emulsion Pipeline Ruptures				**3.96E-03**	5.8
Onshore Emulsion Pipeline Leaks				**3.14E-01**	99.1
Onshore Gas Pipeline					
Leak rate, per pipeline mile-year	4.34E-04	per mile-year	12.2	5.29E-03	7.6
Rupture rate, per pipeline mile-year	2.13E-04	per mile-year	12.2	2.60E-03	3.8
Onshore Water Pipeline					
CSFM Failure rate - ruptures	7.38E-05	per mile-year	12.2	9.00E-04	
Seismic activity - rupture	4.15E-06	per mile-year	12.2	5.06E-05	
Onshore Water Pipeline Ruptures				9.51E-04	1.4
Onshore Water Pipeline Leaks	**3.36E-04**	**per mile-year**	**12.2**	**4.10E-03**	6.0
LOGP-Summit Pipeline					
Years Life	30	years			
CSFM Failure rate - ruptures	1.28E-03	per mile-year	26	3.33E-02	
Seismic activity - rupture	4.15E-06	per mile-year	26	1.08E-04	
Onshore Water Pipeline Ruptures				3.34E-02	63.3
Onshore Water Pipeline Leaks	5.83E-03	per mile-year	26	1.52E-01	98.9

LOGP FACILITIES					
SCADA - failure				**1.01E-01**	
Phone line failure	2.28E-04	demand	1	2.28E-04	Estimated 8 hours per year down time
Pump shutdown failure	1.00E-04	on demand	1	1.00E-04	Rijnonmd, failure to stop on demand
Actuated valve failure	1.00E-03	on demand	1	1.00E-03	Lees, failure to operate on demand
Pressure Switch	1.00E-04	on demand	1	1.00E-04	Rijnonmd, failure on demand
Operator Restarts system, override SCADA	1.00E-01	on demand	1	1.00E-01	Reliability and Maintainability in Perspective, 3rd Edition, D.J. Smith, 1988, Fail to recognise incorrect status on inspection