



**Assessing the risk from
gasoline pipelines in the
United Kingdom based on a
review of historical experience**

Prepared by
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for the Health and Safety Executive

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Assessing the risk from gasoline pipelines in the United Kingdom based on a review of historical experience

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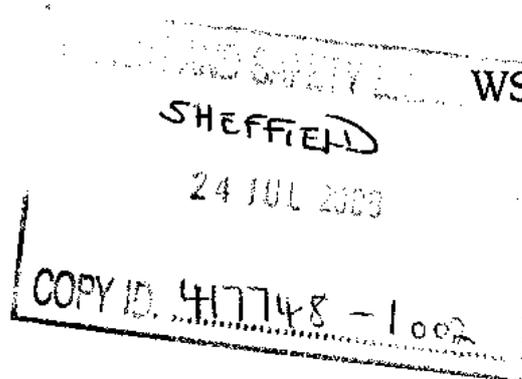
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In order to address these issues, HSE invited WS Atkins to undertake this study to assess the risks from gasoline pipelines in the United Kingdom (UK), based on a review of the historical experience. The study began by identifying and collating the evidence from all the events worldwide involving gasoline leaks from cross country pipelines. This historical evidence was used to determine the likelihood of events such as leaks and fires, and also to generate consequence models based on the available data. The levels of individual risk associated with typical UK gasoline pipelines were calculated, and some assessments of societal risks were undertaken for typical pipeline examples. The predicted levels of risk were compared with historical data.

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EXECUTIVE SUMMARY

Gasoline pipelines have been included in the general duties applicable to all pipelines under the new Pipeline Safety Regulations (SI 825), but have been excluded from the additional duties applicable to pipelines conveying fluids with major accident hazard potential.

The Health and Safety Executive (HSE) commissioned an external research project to ascertain the degree of risk posed by gasoline pipelines in the UK. The objective of this work was to enable the Advisory Committee on Dangerous Substances (ACDS) to make a recommendation as to whether or not gasoline pipelines should be incorporated within the regulations. The ACDS committee decided that there was a need for further study before a final decision could be taken. In particular, it was felt that the risk assessment for gasoline pipelines needed to take full account of the historical experience accumulated around the world in order to provide a realistic estimate of the levels of consequence and risk.

In order to address these issues, HSE invited WS Atkins to undertake this study to assess the risks from gasoline pipelines in the United Kingdom (UK), based on a review of the historical experience. The study began by identifying and collating the evidence from all the events worldwide involving gasoline leaks from cross country pipelines. This historical evidence was used to determine the likelihood of events such as leaks and fires, and also to generate consequence models based on the available data. The levels of individual risk associated with typical UK gasoline pipelines were calculated, and some assessments of societal risks were undertaken for typical pipeline examples. The predicted levels of risk were compared with historical data.

The maximum calculated levels of individual risk of fatality to a typical residential population close to a gasoline pipeline were 1.4×10^{-7} /year in urban areas and 3.2×10^{-8} /year in rural areas on the pipeline centreline. These risks decrease with increasing distance from the pipeline, less than 1×10^{-9} /year at about 150 m. The majority of this risk arises from ignited sprays of gasoline or from flash fires above gasoline pools or gasoline soaked ground. Beyond 150 m, there is still a low level of risk associated with running pool fires, which may cause injuries/fatalities at considerable distance from the pipeline.

There have been no fatalities in the UK associated with accidents from cross country gasoline pipelines. Calculations suggest that the societal risk to residential populations corresponds to an average of 1 fatality in the UK every 77 years. Extrapolation of the actual Western European historical experience suggests a higher rate of 1 fatality in the UK every 32 years, but this figure covers all population types including pipeline workers, contractors, farmers, emergency services, etc.

It should be emphasised that the figures given above have been derived from a relatively small number of relevant events, and so should be treated with caution.

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ABBREVIATIONS AND ACRONYMS

ACDS	Advisory Committee on Dangerous Substances
API	American Petroleum Institute
bbl	Barrel
BWI	Baltimore Washington International Airport
CDT	Central Daylight Time
CDST	Central Daylight Savings Time
CFR	Code of Federal Regulations
CONCAWE	Oil Companies' European Organization for Environment, Health and Safety
CST	Central Standard Time
DEQ	Department of Environmental Quality (United States)
DER	Department of Environmental Resources (United States)
DOT	Department of Transportation (United States)
EDT	Eastern Daylight Time
EPA	Environmental Protection Agency (United States)
EPC	Exxon Pipeline Company
ERW	Electric Resistance Welding
HAZMAT	Hazardous Material
HSC	Health and Safety Commission
HSE	Health and Safety Executive
JFA	Commercial jet fuel
KDHE	Kansas Department of Health and Safety
LEL	Lower Explosive Limit
MDNR	Missouri Department of Natural Resources
MDT	Mountain Daylight Time
MIC	Microbiological influenced corrosion
MMF	Montello maintenance foreman
MOP	Maximum operating pressure
MOV	Motor operated valve
MP	Milepost
MPL	Marathon Pipeline Company
NCRA	National Coop Refinery Association
NDEC	Nebraska Department of Environmental Control
NRC	National Response Center (United States)
NTSB	National Transportation Safety Board
OD	Outside diameter
OPS	Office of Pipeline Safety (United States)
PDT	Pacific Daylight Time
PLL	Probable Loss of Life
ppm	Parts per million
psi	Pounds per square inch
rpm	Revolutions per minute
SCADA	Supervisory Control and Data Acquisition
SCBA	Self-contained breathing apparatus
SFPP	Santa Fe Pacific Pipeline Company
SI	Statutory Instrument
SPL	Sun Pipeline Company
TCC	Tulsa Control Center
TEPPCO	Texas Eastern Products Pipeline Company
TNRCC	Texas Natural Resource Conservation Commission

TWC	Texas Water Commission
UK	United Kingdom
US	United States
VOC	Volatile Organic Compounds
VSD	Variable Speed Drive
WPL	Williams Pipeline Company

UNIT CONVERSIONS

In general, metric units are used in this report, but conversion factors for other units are given below.

Length

1 mile	=	1.609 km
1 foot	=	0.3048 m
1 inch	=	0.0254 m

Area

1 square mile	=	2.59 km ² (= 259 hectares)
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Volume

1 gallon (UK)	=	4.546 litres
1 gallon (US)	=	3.785 litres
1 barrel (bbl)	=	0.1590 m ³

Mass

1 ton	=	1.016 tonnes
1 pound	=	0.4536 kg

Pressure

1 psi	=	6895 N/m ² (Pa)
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Flow Rate

1 barrel per hour (bph)	=	0.0442 litres/second
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1. INTRODUCTION

1.1 BACKGROUND

Gasoline pipelines have been included in the general duties applicable to all pipelines under the new Pipeline Safety Regulations (SI 825), but have been excluded from the additional duties applicable to pipelines conveying fluids with major accident hazard potential.

The Health and Safety Executive (HSE) commissioned an external research project to ascertain the degree of risk posed by gasoline pipelines in the UK. The results were used to assist HSE in deciding whether or not such pipelines should be included in the regulations. A steering group from the Advisory Committee on Dangerous Substances (ACDS) monitored this work.

Conclusions drawn by the ACDS steering group were such that a final decision could not be made until the risks associated with gasoline pipelines were further examined. It was suggested by the ACDS committee that this re-assessment needed to take full account of the historical experience accumulated around the world and the information available in previous technical reports/journals.

In order to address these issues, HSE invited WS Atkins to undertake a study to re-assess the risks from gasoline pipelines in the United Kingdom (UK), based on a review of the historical experience.

1.2 SCOPE OF STUDY

The primary objectives of this project were to carry out a quantified risk assessment of gasoline pipelines taking account of known historical incidents. Available data was used to develop a pipeline model that realistically portrays the working environment.

The objectives were achieved through the following scope of work:

- Identification of pipeline data sources;
- Collection of detailed information on worldwide gasoline pipeline incidents;
- Review of the information obtained in conjunction with the ACDS Steering Group members;
- Determination of a range of representative accident scenarios (based upon the historical data);
- Development of a methodology to determine the risks associated with pipelines using a first principles approach;
- Identification of petroleum pipelines for inclusion in the study;
- Assessing the risks from the selected pipelines using the risk methodology developed;
- Recommendation of possible improvements to current pipeline risk models;
- Report the findings in a technical report.

As the project developed, the requirement to include a risk assessment of actual UK pipelines was abandoned in favour of providing an assessment of individual and societal risks for urban and rural pipelines, based entirely upon the historical data collected.

2. IDENTIFICATION OF RELEVANT DATA SOURCES

2.1 INTRODUCTION

An extensive range of data sources was scrutinised to ensure best possible accuracy in the derivation of historically based failure rates, ignition probabilities and accident event scenarios. The route taken in collating an accident data set is depicted in Figure 2.1. These data sources are described in the sub-sections below. To summarise, the key features of the identification of relevant data sources were:

- Failure rates were derived from European CONCAWE data for clean products relating to line pipe only. It was decided that CONCAWE was the best available source for deriving failure rates because of its inclusion of UK failures and general applicability to the UK in terms of pipeline system age.
- Ignition probabilities were derived from below ground cross country pipelines from USA DOT data, after screening for incidents which did not involve line pipe. The DOT data was selected because the USA database is based on legally required reports of incidents, including those involving fires.
- Accident event scenarios were derived from all data sources in order that an accurate representation of events could be made.

2.2 CONCAWE

The Oil Companies' European Organization for Environment, Health and Safety (CONCAWE) annual reports on the 'Performance of Cross-Country Oil Pipelines in Western Europe' were examined for relevant information on incidents involving white oils. Particular emphasis was placed on incidents relating to fires and casualties involving line pipe and these are presented in the case studies information. In addition, some database information was directly supplied by CONCAWE and this is analysed in Section 3. Descriptions of particularly relevant incidents reported to CONCAWE are detailed in Appendix 1.

2.3 DOT AND NTSB

The United States Department of Transport (DOT) and the National Transportation Safety Board (NTSB) were both contacted for information. The DOT were able to provide information summarising incidents between 1985-1997 from their records. This data was broken down into incidents involving 3 types of fuel i.e. gasoline, jet fuel and kerosene. A complete set of this information is given Appendix 2. Incidents involving deaths and serious injuries are presented in Section 4. The NTSB were able to provide some detailed reports on major accidents involving casualties and these are also outlined in Section 4.

2.4 LIBRARIES

A literature search conducted by WS Atkins to identify and gather further details on accidents previously identified by other sources such as previous WS Atkins work, HSE, IChemE, DOT, NTSB and some oil and pipeline operators. The library utilised an on-line database (FT Profile) to search English Language Newspapers world-wide and in the UK to gain further information on worldwide accidents. Relevant papers relating to the consequences of gasoline release, such as fires and release migration etc., were also collected.

2.5 HSE AND ACDS STEERING GROUP

The HSE were able to provide some information on incidents involving multi-product pipelines in the UK from their records. Information was also provided by some oil companies via members of the ACDS Steering Group. This information is presented in Appendix 3. In addition some brief details of incidents were obtained from the HSE-MHIDAS database which are described in Appendix 4. Those accidents where the consequences included casualties and fire are presented in Section 4.

2.6 INSTITUTION OF CHEMICAL ENGINEERS

The Institution of Chemical Engineers Accident Database was searched for accidents relating to gasoline and kerosene transmission lines. The results of this search are included in Appendix 4 and in Section 4.

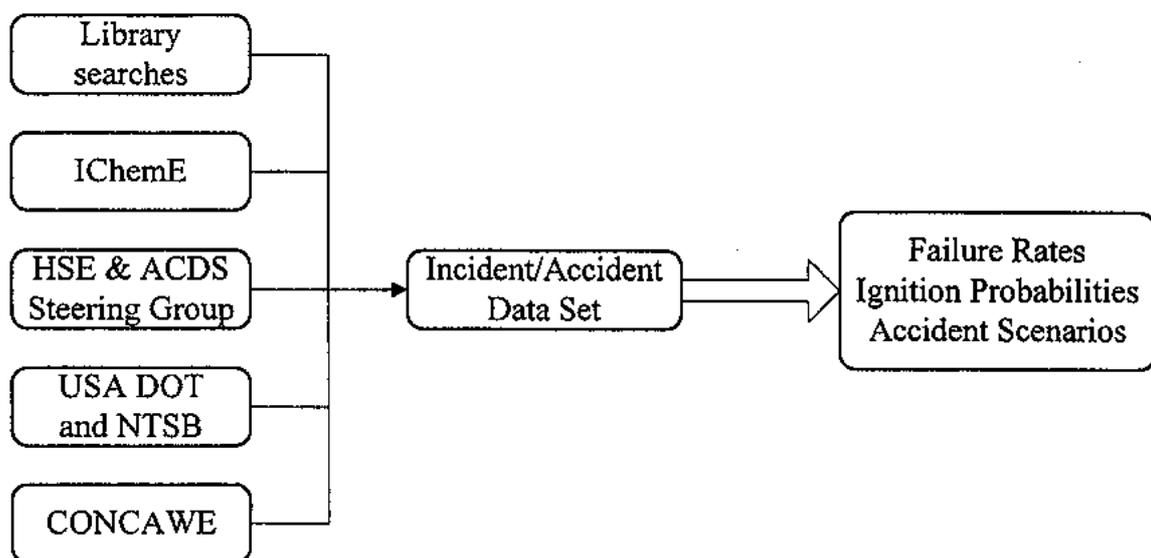


Figure 2.1
Information search

3. STATISTICAL ANALYSIS

3.1 INTRODUCTION

A statistical review was undertaken using the data sources described in Section 3.2 to examine:

- General failure frequencies
- Locations of incidents
- Causes of releases
- Release volumes
- Pipeline characteristics
- Release effects

3.2 DATA SOURCES

The Oil Companies' European Organization for Environment, Health and Safety (CONCAWE) provided WS Atkins with information from their database for clean products incidents excluding fuel oil. Data for fuel oil was discounted because fuel oil lines have a disproportionately high failure rate due to corrosion due to pipeline design defects. More importantly fuel oil does not exhibit similar flammability properties to gasoline. The USA DOT data was used to supplement CONCAWE data where this was necessary.

3.3 GENERAL FAILURE FREQUENCY

The failure set for UK CONCAWE incidents is too small for credible results to be obtained and therefore it was decided to use all clean product line pipe CONCAWE data.

A failure rate of 0.29 per 1000 km-yr was obtained from this data. This figure was derived from CONCAWE data from 1971-1996.

3.4 LOCATIONS OF INCIDENTS

Table 3.1
Locations of incidents

Area/Locality	Data supplied by CONCAWE (%)
Rural	77
Industrial	17
Residential	5
Commercial	1

Table 3.1 shows the locality where incidents took place as detailed by the CONCAWE data. The proportions of areas/locality categories described in 86% of incidents were applied to the 14% with no listed area category. The percentages derived from this apportionment are shown in Table 3.1. It should be noted that the population based definition included in BS 8010 would classify Industrial, Residential and Commercial areas as 'Urban'. It is clear from Table 3.1 that most clean product releases occur in rural areas which is to be expected, since most lines

traverse mostly rural areas. A significant proportion of incidents occurred in industrial areas, but it was not possible from CONCAWE data to estimate the relative lengths of pipelines traversing residential, commercial or industrial areas. The consequences of the ignition of a release in an industrial area can be more severe because of escalation in facilities/areas near the pipeline. The potential for the ignition of releases in these areas may be greater because of the proximity of hot work, spark producing processes and general increased levels of activity.

3.4.1 Failure Frequency and Incident Location

The frequency of incident occurrence is linked to the geographic area. Table 3.2 was constructed to show this link. The table was derived using UK government figures for land use to establish the areas of land in urban, residential, commercial or industrial use (approximately 10%) and areas of land in rural-agricultural use (approximately 90%) (DETR, 1997a & 1997b). The total number of failures were apportioned between rural and urban categories.

Table 3.2
Failure frequencies per 1000 km-yr by locality

Locality	Failure frequency 1000 km-yr
Urban	0.66
Rural	0.25

(Based on CONCAWE data 1971-1996)

It is apparent from Table 3.2 that the increased levels of human activity in urban areas gives rise to higher failure rates.

3.4.2 Relationship between Location and Release Volumes

Table 3.3 shows the relationship between release volumes and locations. Approximately one third of these all release incidents with release volumes in excess of 100 m³ involved Third Party Activity (TPA). It is evident that large releases dominate incidents in industrial areas which is too be expected in areas where high activity gives rise to higher rates of third party damage. Industrial and Residential pipeline failure events are both classified as 'urban' in calculating failure rates.

Table 3.3
Release volumes by location

Release volume (m ³)	Residential % of total releases	Industrial % of total releases	Rural % of total releases
50 or more	2	13	38
>100	-	8	26
>500	-	7	1
>1000	-	5	-

(These percentages are derived from data where locality was specified - in some 86% of cases)

3.5 THE CAUSES OF RELEASES

Table 3.4 shows the causes of failure found in CONCAWE data.

Table 3.4
Failure by cause

Cause	Data supplied by CONCAWE (%)
Third Party Activity	64
Corrosion	16
Mechanical Failure	14
Natural Hazard	4
Operational Error	2

DOT (USA) data also shows that:

- TPA is the predominant cause by far
- Corrosion is the second biggest cause and this can be largely attributed to external corrosion
- Mechanical failure is the third most important cause.

3.5.1 Third Party Activity (TPA)

TPA is the largest cause of clean product incidents. Damage to pipelines could arise from equipment used by the pipeline company or by an outside party. Typical types of operations preceding TPA include:

- farming
- trenching
- road construction

The specific activities which lead to pipeline penetration or rupture include:

- drilling
- blasting
- bulldozing
- ditching

Table 3.5
Third party activity by type

Type	Percentage (%)
Accidental	83
Incidental	12
Deliberate Damage	5

Table 3.5 shows that accidental damage is the predominant mechanism for pipelines releases to occur. Incidental damage incidents not causing immediate failure may be detected by pigging as should corrosion and mechanical damage (Ref CONCAWE).

3.5.2 Corrosion

There are two basic forms of corrosion, external and internal. The former may be reduced by cathodic protection and coating protection. The latter can be reduced by usage of corrosion inhibitors, inspection and cleaning pigs. About 81% of all failures in the CONCAWE data involved external corrosion. The remainder were caused by internal corrosion. Table 3.6 gives a breakdown of these corrosion failure modes found in the data.

Table 3.6
Corrosion failures by type

Type	Percentage (%)
External	81
Internal	19

3.5.3 Mechanical Failure

Mechanical failure may be broken down into two basic modes, construction and fabrication. Construction defects pertain to the welding and pipeline geometry. Fabrication failures relate to defects in the steel used for the particular pipeline. Table 3.7 gives a breakdown of the mechanical failure modes found in the data.

Table 3.7
Mechanical failures by type

Type	Percentage (%)
Material Failure	64
Construction Fault	36

3.5.4 Natural Hazard

Many of the natural hazards accidents described in the CONCAWE data occurred in Italy where the mountainous terrain traversed by many of the pipelines is responsible for failures due to landslides and flash flooding of rivers. Only a small number of incidents occurred due to natural hazards.

Natural hazards include:

- landslide
- earth movements (e.g. mining, old mine etc.)
- storm/heavy rain (these are especially important near to or at river crossings)
- frost
- land subsidence

3.5.5 Operational Error

This category relates to errors in operation and it is evident that only a small proportion of incidents were caused by this failure mode.

3.6 RELEASE VOLUMES

The volume of releases will depend upon a number of factors including hole size, line pressure and time to detect and isolate. Historical data shows that 47% of all incidents recorded involved releases of 100 m³ or more. Table 3.8 shows that the greatest number of releases in excess of 100 m³ are caused by TPA. Releases of 1000 m³ or more are uncommon, accounting for just 4% of all incidents.

Table 3.8
Volume released by cause

Cause	Number of release volumes of 100 m ³ or more	Number of release volumes of 1000 m ³ or more
Mechanical Failure	5	2
Corrosion	6	1
Third party activity	28	1
Operational	1	-
Natural Disaster	2	-

Table 3.9 shows data from CONCAWE for clean product pipelines incident release volumes for various pipe diameter ranges. Higher volume releases would clearly be expected from the larger pipelines but the data is not conclusive.

Table 3.9
Volume of releases

Pipe diameter (inches)	No. of incidents	Volume(m ³)		
		Maximum	Minimum	Mean
<8	18	115	0.6	26.64
8-12	55	1000	3	199.19
12-16	15	292	112	171.80
16-24	11	3050	3	508.45
>24	3	125	10	61.33
ALL	101	3050	0.6	190.02

(Based on CONCAWE data)

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>24	3	125	10	61.33
ALL	101	3050	0.6	190.02

(Based on CONCAWE data)

3.7 PIPELINE CHARACTERISTICS

3.7.1 Introduction

The characteristics of failed pipelines are discussed in this section and include:

- pipeline diameter
- wall thickness
- hole size
- depth of cover
- pipeline age
- detection and shut down times

3.7.2 Diameter Analysis

Data shows that smaller pipelines have a higher failure rate than larger pipelines. This is probably because smaller pipelines have less wall thickness and are therefore less robust and more susceptible to failure from third party interference and corrosion. Table 3.10 shows a breakdown of CONCAWE data for clean products pipelines 1977-1996. Similar trends are shown in DOT (USA) data. It should be noted that there are few pipelines in the >24 inch category in Europe and thus the failure rate calculated must be treated with caution. UK pipelines are mainly 8-16 inch.

Table 3.10
Failure rate by diameter

Diameter range (inches)	Percentage of all failures %	Failure rate (all areas) per 1000km-yr
< 8	18	0.79
8-<12	54	0.44
12-<16	15	0.15
16-<24	11	0.12
> 24	3	0.66
All	100	0.29

3.7.3 Hole Size Analysis

Table 3.11 shows a summary of CONCAWE data for hole sizes for reported incidents.

Table 3.11
Hole size as a percentage of diameter for reported incidents

Hole size as percentage of diameter	Percentage (%) of total incidents
Pin hole < 10%	70
Smaller size hole 10-30%	24
Intermediate hole 30-50%	4.5
Rupture > 50%	1.5

It clearly evident from this data that pin hole and smaller size holes are dominant and that the ruptures of pipelines are infrequent.

3.7.4 Depth of Cover

The depth of cover of pipelines has an impact on the number pipeline failures. The greatest exposure to potential damage exists where the pipeline has the least amount of cover. In the UK, the vast majority of cross country transmission lines are buried to a depth of a least 0.9-1m and at greater depths at road and rail crossings.

Table 3.12
Reduction of third party activity incidence with depth of cover

Depth of cover (m)	Reduction % in failure frequency due to third party activity
1.5	25
2	50
3	99

(Based on HSE figures quoted in 'Risks from gasoline pipelines in United Kingdom', ADL, 1996)

Extra protective measures may be deployed in areas that are deemed to have high activity levels. Research by British Gas (Corder, 1995) has found that a combination of slabbing and warning tapes is the most effective mechanism for preventing third party damage.

3.7.5 Effect of Pipeline Age on Failure Rates

CONCAWE data indicates that as would be expected failure rates increase with pipeline age. Table 3.13 shows the age of pipelines that failed in recent years (1994-1996) against the approximate % of pipeline length in service. Further analysis, outside the scope of this report would be required to determine a more precise relationship. It can be further noted that mechanical failures are more likely to occur in the early life of a pipeline. 1971-1996 data shows that almost 40% of mechanical failures occurred after less than 10 years service. This can be partly attributed to construction faults causing failures in the early years of service.

Table 3.13
Failures by pipeline age

Age (years)	No of failures 1994-1996	Approximate Percentage (%) of Pipeline Length in Age Group
<10	1	10
10 - 20	1	10
20 - 30	1	35
30 - 40	6	30
>40	4	15

3.7.6 Detection and Shutdown Times

Details on the detection time for releases are given in Table 3.14. The times involved in shutting block valves and pumps are also included. These figures are similar to those provided by industry (ADL, 1996.).

However, as expected slow leaks involving pinholes have a much longer duration and detection time. This is because leak rates may be below the threshold of some leak detection systems. Data shows that pinhole leaks are discovered primarily by third parties who report odours and/or a rainbow colour or oily sheen on water or land. Flow may continue for some time after shutdown due to pressure and gravity effects.

**Table 3.14
Detection and shut down times by flow type**

	Detection time (minutes)	Time shut block valve/ pump (minutes)
Strong Flow Releases		
Average	5	10
Maximum	20	38
Minimum	1	1
Slow flow Leaks		
Average	3652	4412
Maximum	33120	33120
Minimum	1440	1590

3.7.7 Rights of Way

USA DOT data shows that some 9% of incidents occur at rights of way. This can be explained by a number of possible factors:

- Higher levels of construction activities in their vicinity leading to greater likelihood of accidental and incidental third party damage being sustained.
- Defective sleeving design leading to a higher incidence of external corrosion failure.
- Insufficient design factors for vibration from traffic.
- Subsidence in area due to road design/construction defects

3.8 CONSEQUENCES OF RELEASES

The consequences of releases are examined in this section. Consequences may include:

- ignition;
- pool formation;
- spray releases;
- migration into watercourses;
- migration into sewers.

3.8.1 Ignition

Ignition probabilities were calculated using 1985-1997 USA DOT data and CONCAWE 1971-1996 data. The data was filtered for incidents that did not relate to line pipe. Table 3.15 shows the calculated ignition probabilities. US data were broken down into gasoline, jet fuel and kerosene categories to determine if a difference could be seen between the 3 categories (all designated 'oil products' by CONCAWE), as might be expected based upon volatility. From the small data set it is concluded that no significant differences can be determined.

Table 3.15
Ignition probability of fuel by type

Fuel	No. of incidents	No. of fires	Probability of ignition (%)
USA DOT Data			
Gasoline	284	10	3.5
Jet Fuel	35	2	5.7
Kerosene	9	0	0
All	328	12	3.7
CONCAWE Data			
All	101	3	3.0

Of the 3 CONCAWE reported incidents, 2 occurred in rural areas (2.5% of incidents) and 1 in an urban area (4.3% of incidents). Where location can be determined from USA DOT reported incidents, only 1 occurred in a rural area and 6 in urban areas. Ignition sources have been identified as vehicle engines (most often the vehicle damaging the pipe), bystanders smoking and on one occasion an acetylene torch being used to cut into the pipe erroneously.

3.8.2 Areas Affected by Releases and Pool Formation

About 50 % of releases in the CONCAWE data had a figure recorded for land pollution. Table 3.17 details these incidents. The average pollution affected area was 5000 m². The most polluting clean product incident resulted in an area of 55,000 m² being polluted.

Table 3.17
Areas affected by releases as cumulative % of all release incidents

Areas affected by releases (m ²)	Cumulative percentage (%) of all release incidents
>0	100
>100	62
> 1000	35
>10000	14

However, it must be emphasised that this data is based on surface area covered by releases. It therefore does not differentiate between incidents with a thin layer of product on top soil and those incidents where top soil is drenched with product or where small pools or puddles of product are formed. Hence the area affected by pollution is only a crude measure of the extent of a release, but it is apparent from Tables 3.17, 3.18 and 3.19 that large pools of product with very large radii are rarely formed.

Table 3.18 shows the variation of effective radius of release (calculated from the areas recorded) with pipe diameter. Smaller pipes as expected appear to give smaller releases with less land area affected, but there is probably insufficient data for a definite correlation, particularly in the >24 inch diameter category. Most UK pipes are in the 8 to 16 inch diameter region.

Table 3.18
Effective area of releases

Pipe diameter (inches)	No. of incidents	Radius (m)		
		Maximum	Minimum	Mean
<8	14	25.23	0	12.39
8-12	24	132.31	0	37.24
12-16	6	43.70	0	23.93
16-24	4	66.75	0	34.18
>24	1	112.83	0	112.83
ALL	49	132.31	0	33.89

(Based on CONCAWE data)

Table 3.19 shows that large radius releases are not a common occurrence. Historical data often mentions gasoline sodden soil, rainbow coloured interfaces, small puddles and small surface deposits of gasoline. Significant size pools of gasoline do not appear to form in the vast majority of cases. This may only be possible in areas of impermeable ground. Where incidents have occurred in which buried pipelines have been exposed the release is often contained in the trench dug-out.

Table 3.19
Detailed breakdown of spillage radii

Radius of release (m)	Percentage (%) of releases
< 5	35
5-10	14
10-20	21.5
20-30	17.5
30-50	4
> 50	8

(Based on CONCAWE data)

Incidents giving a radius of more than 50 m are mainly releases into watercourses and on river banks, creeks etc. and are therefore not particularly relevant to a consideration of a release spread on ground. Table 3.19 amplifies the point that the vast majority of releases result in only a small ground spread.

3.8.3 Spray Releases

The mechanism of product release distribution is sometimes sprays. The magnitude of area affected will be dependent on the flow rate, pressure and size of rupture. Sprays have generally occurred when the pipe is exposed but there are one or two exceptions, where upward flow from buried pipes has made its way to the surface. The position of the breach on the pipe is clearly an important factor in determining the type of release. A hole at the bottom or the side of the pipe would not result in an upward jet.

From the data collected, it is evident that larger releases are more likely to have involved jets forming sprays above ground. Slow underground releases, which often affect soil in the vicinity of the pipeline breach, normally have magnitudes of up to 50 m³. However, for releases of 100m³ sprays are often mentioned in accident descriptions.

From USA DOT data, where sprays were deemed to have occurred, 93% were caused by third party activity. The average release volume for these incidents was 233 m³. It is estimated by examination of incident reports, that 16% of incidents recorded have involved spray release for some period. However, only 3.5% of incident reports included a definite reference to sprays. Of 101 CONCAWE incident reports for clean products pipelines only 1 spray incident is confirmed. It is considered that sprays occurring in remote areas may often not be seen before the pipe is shut down, or may not be reported due to a lack of detail in the incident reports, therefore the 16% figure should be used, as a conservative estimate, in risk assessments.

3.8.4 Migration into Watercourses and Discharge into Potable Water

Releases of gasoline into watercourses and potable water have the potential to migrate to areas of high population, where high concentrations of ignition sources are present. Approximately 8% of all clean product incidents given in CONCAWE data for 1977-1996 involved discharge into potable water. It is interesting to note that this occurred for releases averaging 317 m³ in magnitude. It is possible that smaller releases migrating into water are not detected, thus distorting the figures. CONCAWE data shows no ignitions of such releases having occurred.

USA DOT data shows that 12 % of releases migrate into water courses, floating as combustible interfaces, and that 1 such release ignited causing injuries. In other countries, the paths of rivers often traverse the boundaries and centres of town and a number of incidents have been recorded where ignition of releases into watercourses has occurred.

3.8.5 Migration into Sewers

All data sets mention migration into sewers systems. Incidents where vented deflagrations and fires have occurred are evident in the data, especially in urban areas, often where the initial release is onto a roadway. CONCAWE shows 2 of 101 incidents (2%) have resulted in releases into sewers, but neither ignited. USA DOT data indicates that 3% of incidents migrated into sewer systems and 0.4% of incidents involved deflagrations in sewers.

4. RELEVANT ACCIDENT EVENTS

4.1 INTRODUCTION

The following section gives details of the incidents identified as most relevant to this study and the development of the event trees based upon these incidents and the analysis of the historical data undertaken in Section 3.

Appendices 1 to 4 contain detailed descriptions of all incidents identified.

- Detailed reports of incidents in Europe from CONCAWE are presented in Table A1.1 in Appendix 1.
- USA DOT data is presented in Table A2.1 in Appendix 2.
- UK incident details are presented in Table A3.1 in Appendix 3.
- Significant worldwide incidents identified are presented in Table A4.1 in Appendix 4.

4.2 CASE STUDIES

Detailed case histories are available for a small number of the most incidents involving gasoline pipelines. These have been used, where appropriate, in consideration of the consequences of incidents for the risk assessment presented in Section 6. The case studies are:

- 1) Calnev Petroleum Pipeline, San Bernardino, California, USA, 25 May 1989
- 2) Mounds View, Minnesota, USA, 8 July 1986
- 3) Bayamon, Puerto Rico, USA, 30 January 1980
- 4) Los Angeles, California, USA, 16 June 1976
- 5) Jacksonville, Maryland, USA, 3 September 1970
- 6) Cubatão, Brazil, 25 February 1984
- 7) Uong Bi, Quang Ninh Province, Vietnam, 2 November 1993
- 8) Kaycee, Wyoming, USA, 23 July 1985
- 9) Near Houston, Harris County, Texas, USA, 20 October 1994
- 10) Guadalajara, Mexico, 22 April 1992

These 10 incidents are described below in more detail, but some common traits discovered amongst the incidents were:

- poor emergency response and accident scene control
- isolation failures and deficiencies, resulting in the consequences of releases being more severe
- proximity of people to releases

4.2.1 Case 1 - Calnev Petroleum Pipeline, San Bernardino, California, USA, 25 May 1989

Summary

A high pressure pipeline ruptured and led to a fireball as a result of a train wreck several days earlier when heavy equipment, deployed to remove the wreck, inflicted third party damage. The 14 inch pipeline was operating at 1700 psig at the time of the incident. Ineffective pipeline isolation through the failure of check valves to operate exacerbated the incident and a large volume was released, i.e. about 300,000 US gallons of gasoline in total. Two people died from burns and 31 were injured as gasoline sprayed onto nearby housing and was ignited.

Incident Description

On May 12, 1989, a Southern Pacific Transportation freight train derailed in San Bernardino, California. Two children died as the derailed trains demolished nearby housing. Local officials evacuated homes in the surrounding areas because of a concern that a 14 inch diameter pipeline owned by the Calnev Pipeline Company, which was transporting gasoline, may have posed a hazard. They feared that the pipeline, which was located under wreckage, might have been damaged during the derailment or might be susceptible to being damaged during wreckage clearing operations. However, residents were allowed to return to their homes within 24 hours.

Pipeline operations were restarted on May 16 following inspections for external damage to the pipeline. Inspections were carried out at intervals of 1 foot which allowed visual inspections from the 10 to 2 o'clock position. The whole pipeline segment in the original train crash area was not exposed for inspection.

On May 25, 1989, 13 days after the derailment, the pipeline ruptured at the site of the derailment at about 8 am. According to eye witnesses' statements a jet or 'geyser' of gasoline sprayed out of the ground at an angle of about 60 degrees and landed on nearby housing. Eye witnesses said they heard a rumble and described 'white rain' falling out of the sky. This spray was ignited a few moments later and witnesses reported that they heard a loud explosion that was followed by black smoke. Two residents in the nearby housing died from burns, one at 2327 Duffy Street and one at 2315 Duffy Street. Three other residents were seriously injured, receiving second and third degree burns, while escaping from their burning homes. Sixteen other residents reported minor injuries from smoke inhalation. About 31 people in total sustained injuries from the incident.

Eleven homes in the nearby neighbourhood were destroyed and 6 others sustained smoke and fire damage. In addition, 21 vehicles were destroyed. Residents within a 4 block area of the rupture were evacuated by local officials. Figures 4.1 and 4.2 show the area of the incident. Post accident reports revealed that the rupture had occurred in front of lot 76. This rupture was at a 1:30 o'clock position, 29 inches long and 4.2 inches wide at its widest point. At the time of the incident the weather was 57 degrees F with clear skies.

The fire brigade en route to the accident scene noticed flames and black smoke rising straight up into the air with no apparent wind. Once at the scene, the fire brigade saw seven houses fully engulfed in flames and two houses partially on fire. Calnev personnel in a police helicopter noticed:

- a flaming jet of gasoline at 60 degrees from the horizontal in an eastward direction;
- substantial fire damage in the direction of the jet;

- a small pool of liquid burning around the rupture and a small grass fire burning south of Highland Avenue.

It was determined by post accident investigations that the Calnev pipeline was most likely damaged during the train wreckage removal operations. These operations resulted in the pipeline sustaining a micro-fissure, which propagated resulting in the rupture of the line on May 25. A manual block valve was closed some 55 minutes after the initial release by Calnev personnel at the Cajon Pass Station (see Figure 4.3). The fire burnt out by 3:30 pm on May 25. A total of 300,000 US gallons of gasoline was released in this incident. Some people were not allowed to return to their homes until early August 1989 because of concerns over residual gasoline in the soil.

Lessons Learned

- Surveillance during the initial wreckage removal operation was insufficient because the pipeline was mechanically dented and gouged at several locations by earth moving equipment.
- The pipeline returned to service after the rail crash without adequate testing. Untested check valves failed to operate during the incident allowing more gasoline to be released at. A total of 4 check valves downstream of the rupture on an elevated ground level failed to close properly (MP 6.9, 14.9, 19.2 and 25.7)(see Figure 4.3). These valves would normally have closed on detecting a reversal of flow direction. If the four valves had closed properly then the release would have been limited to 4000 gallons or 100 barrels. Investigations revealed that these check valves had not been inspected and functionally tested in 19 years since they were installed. Moreover, USA regulations did not require that these valves be tested and inspected.
- USA Federal requirements for liquid pipelines were inadequate because there was no requirements for rapid detection and shutdown, and no provision for safety enhancements for populations at risk.
- Recommendations were made for testing all mainline check valves on an annual basis.
- Recommendations were made to install facilities to enable the use of in-line inspection equipment.
- Recommendations were also made for the installation of remotely operated valves on pipelines that transport hazardous liquids, and that the spacing of these remote operated valves should be based on the population at risk.

4.2.2 Case 2 - Mounds View, Minnesota, USA, 8 July 1986

Summary

Unleaded gasoline under 1434 psig spewed from a 7½ foot long opening along the longitudinal seam of a pipeline. Vaporised gasoline combined with air and liquid gasoline and flowed along neighbourhood streets and was subsequently ignited by a passing car 20 minutes later. The car caught fire and the driver was injured. The initial rupture awakened residents. One family of two, thinking that they were in danger, ran out into the vapour cloud and were engulfed by a fireball and died from third degree burns. Contributing to the extent of the incident was the non-availability of remotely operated valves or automatic shutdown capability on the pipeline. The cause of the incident was deficiencies in cathodic protection which led to corrosion and the subsequent rupture. 493 barrels flowed downhill into sewers, drains and streets.

Incident Description

At about 4:40 am, a resident of 5114 Long Lake Road (see Figure 4.4), Mounds View, Minnesota, was awakened by a smell which he believed to be natural gas. Consequently, he checked his appliances and determined that the source of the smell was not within his home. He subsequently went outside his house and found the smell to be stronger. After examining his cars and finding no leaks, the resident looked into the street and saw a pool of liquid covering the west side of the road. Moments later a car turned left from Ridge Lane, onto Long Lake Road and stopped at number 5200. The resident stated he saw a fireball in front of the car, heard a loud noise, saw liquid in the street ignite and then saw a person run from the car into number 5200 Long Lake Road. The flames travelled south on Long Lake Road and east on Woodcrest Drive. Two residents suffered fatal burns while escaping from their home on Woodcrest Drive after hearing a loud noise. The driver of the car suffered second degree burns on her arms and legs.

By the time the fire brigade had arrived at 4:50 am, flames covered two blocks of Long Lake Road and one block of Woodcrest Drive. It took pipeline personnel one hour and forty minutes to close a manual block valve some distance away. After this, the intensity of the fire was noted to have decreased. One house sustained moderate damage, its exterior was charred and the fire had burned through the front door. A garage attached to one house sustained structural damage. Five vehicles were damaged.

At about 6:10 am, the fire brigade ordered an expansion of the evacuation area to the south-east as a result of concerns over explosions from gasoline in sewers. Gasoline had entered the storm sewer system and sewer covers were occasionally being blown into the air by explosions in the sewer system.

By 6:00 am only the area near the rupture in front of 5064 Long Lake Road was on fire and by 6:35 am the fire had been extinguished.

Lessons Learned

- Inadequate company procedures and training for personnel to respond to emergencies involving failed sections of pipeline exacerbated the incident.
- The non-availability of automatic shutdown or remotely operated valves contributed to the extent of the incident.
- The company had an ineffective programme for detecting corrosion faults.

4.2.3 Case 3 - Bayamon, Puerto Rico, USA, 30 January 1980

Summary

The pipeline was struck by a bulldozer during maintenance work on a nearby water pipe. Gasoline sprayed downhill and ran off into a small creek. About 1½ hours later, gasoline vapours were ignited by an undetermined source and exploded. The subsequent fire killed 1 person and extensively damaged 25 houses. A contributory factor in the accident was the lack of temporary markers, indicating the exact location where the pipeline crossed under the water pipe. Gasoline vapour was ignited at 11:20 am in a populated area and flames travelled back to the accident scene some ten minutes later. Approximately 77,700 US gallons of petrol leaked in total, most of which burned. People were not evacuated until after the fires had first occurred.

Incident Description

Gasoline at approximately 300 psig pressure gushed from the triangular 10 by 8 by 6 inch hole in the pipeline and sprayed down a 45 degree slope about 300 feet into Pajaro Puertorriqueno Creek (see Figure 4.5) at 9:50 am. At the time of the incident, the temperature was about 90 degrees F and the weather was cloudy skies and a moderate wind.

Having reached the creek, the gasoline then flowed under the residences and the commercial district of Urbanization Rexville via an underground canal and beyond to the open canal which divides the residential district of Urbanization Bayamon Gardens and Urbanization Royal Gardens. Approximately 77,700 gallons of petrol leaked in total. At 10.08 am the pipeline was shutdown and a maintenance inspector drove a mile from the leak site to close the nearest block valve. At 11:20 am gasoline was ignited in Bayamon Gardens. On its 2-mile path, the fire traversed ½ mile of open canal, approximately 1 mile of underground canal and 1½ miles of the creek's curved natural course up to the point of rupture after 10 minutes. The flames destroyed property 20 feet on each side of the canal and creek. People were not evacuated until after fires had first occurred.

At 10:35 am engineers tried to contain the release by building a small earth dam but this proved to be inadequate. The fire brigade returned to the scene at 11:45 am, having been on the scene of the incident at 10:30 am when they decided to leave because gasoline was not leaking onto a nearby highway.

The fire brigade reported that the fire was extinguished at 2:00 pm. They failed to evacuate people fully from the accident scene in which individuals were collecting petrol for their own personal use. One youth who was approximately 150 feet down the slope from the rupture perished due to burns. He had been collecting petrol from the leaking line (see Figure 4.5), when he was exposed to the fire.

Lessons Learned

Post accident investigations recommended:

- The setting up a one-call system.
- Training emergency personnel in responding to incidents involving pipeline failures.
- Marking pipelines accurately when undertaking excavation or building activities in the vicinity.

4.2.4 Case 4 - Los Angeles, California, USA, 16 June 1976

Summary

At 10.32 am on June 16, an 8 inch pipeline owned by the Standard Oil Company of California was struck and ruptured by excavation equipment that was being used on a road widening project. Petrol sprayed from this line drenching nearby buildings. Ignition occurred 90 seconds later. The subsequent fire and explosions killed 9 people, injured 14 and caused extensive property damage.

The accident investigations determined that the probable cause of the accident was the rupture of the pipeline by excavation equipment, due to the operator being unaware of the pipeline's precise depth and location.

The Incident Description

The operator of a mechanical digger was excavating on a central reservation separating the east and west bound lanes in block 94000 on Venice Boulevard, a heavily utilised thoroughfare (see Figure 4.6). This block comprises seven two and three story commercial buildings. At the time of the incident people were inside the buildings and pedestrians were passing on the pavement. Some cars were parked on the pavement whilst others were travelling down Venice Boulevard.

At 10:32 am a mechanical digger punctured the 8 inch products pipeline. The gasoline, which was under an initial pressure of 550 psig, gushed from an 2½ by 5 inch hole in the pipeline and sprayed over the pavement and onto surrounding buildings. The workmen realised gasoline had escaped and ran away. Other people in the area on foot, in cars and in the buildings did not have time to escape as the rapidly vaporising gasoline created a fog-like atmosphere over the area. After ninety seconds the gasoline ignited; one witness later stated that the fire started beneath a truck. A deflagration followed the ignition and a thunder clap sound was heard. A ball of fire rolled skywards followed by dense black smoke. Flames then engulfed the gasoline drenched buildings and flashed back to the gasoline pool at the rupture site.

Flame engulfed the block, people were trapped in vehicles, pedestrians' gasoline drenched clothing ignited - some people with clothing on fire ran from buildings into the street. Emergency services were initially hampered in responding to the fire because of the intense heat but were latter able to assist. No automatic/remotely operated valves were installed on the segment where the rupture occurred, and it took 38 minutes for personnel to close a manual isolation valve.

The fire brigade arrived at 10:39 am and sprayed buildings with water and pumped foam onto the rupture. Fires were under control by 2 pm.

8 persons died from burns, 1 from a heart attack, and 14 were injured. 16 buildings were destroyed (see Figure 4.6). In addition, fifteen mostly parked vehicles were destroyed. The weather at 10:30 am was both foggy and hazy with a visibility of 3 miles. The temperature was 65 F and the wind was 9 knots blowing from the west-south-west.

Lessons Learned

- High pressure pipelines require more frequent and closer monitoring in congested areas than in rural areas to guard against excavation damage.
- Accurate information should be available on the depth and the location of pipelines.
- Pipeline operators should consider participation in a one-call system; USA experience shows that this reduces excavation damage.

4.2.5 Case 5 - Jacksonville, Maryland, USA, 3 September 1970

Summary

Contractors were attempting to locate a leak by excavating near a section of pipeline when gasoline vapours were ignited by the engine of a backhoe. Five workers were burned in the ensuing flash fire. Approximately 30,156 gallons of kerosene and gasoline were released in the incident.

Incident Description

On September 2, 1970, a pipeline leak occurred in the Colonial Pipeline system near Jacksonville, Maryland. Residents living near the Colonial pipeline called and complained about the smell of gasoline at 6.19 pm. The pipeline was shutdown at 6:34 pm. Contractors worked continuously for 20 hours to find the leak, and on the next day at 5.50 pm an explosion occurred, followed by a flash fire. There were no fatalities but five men were burned; of these two were considered to have non serious injuries whilst the other three had serious injuries (one was placed on the critical list).

The probable cause of the incident was a flaw of undetermined origin in the pipe wall which failed after a period of fluctuating pumping pressures. The probable cause of the explosion and fire was the ingestion of the gasoline rich vapour into the diesel engine of a backhoe which resulted in the speeding up and backfiring of the engine, igniting the gasoline rich atmosphere. The backhoe was working downhill and downwind of a ditch partially filled with gasoline (see Figure 4.7).

Contributing to the accident were the lack of planning and precautions in the operation and positioning of the backhoe, the inadequate training of the workmen in safe working procedures, and the failure to use vapour detection devices.

Factors affecting the magnitude of the incident included:

- A dry period had dehydrated the soil at the leak site and as a result the petroleum products did not come to the surface of the ground near the leak site, as might be expected. Had the soil been moist, the petroleum products, being lighter than water, would have tended to gravitate to the surface riding on soil moisture and surfacing as either a pool of gasoline, a damp aromatic spot or a rainbow. These would normally have enough identifiable odour to be detected.
- The sloping terrain around the leak site and the still weather conditions allowed petroleum vapours to accumulate at the bottom of slope near where the maintenance crew were working. The large underground column of entrapped gasoline was released suddenly by digging operations, which deluged the area where the maintenance crew was working.
- The leak was not detected by metering, which was accurate to 0.5 percent of volume throughput. The hole itself was crater-like in appearance on the surface. It was about 1.5 inches long and 1 inch wide, and coning down to 3/16 inch hole through the pipe wall.

Lessons Learned

- Examine existing state-of-the-art technology for detecting small pin hole type leaks with particular regard to large diameter pipelines operating at high volumes.
- Operators should hold periodic pipeline safety meetings with fire departments and other interested agencies to familiarise them with pipeline operations and emergencies.
- Operators should develop in-depth manuals for handling petroleum product spills and fires and this information should be provided to contractors.

4.2.6 Case 6 - Cubatão, Brazil, 25 February 1984

Summary

Gasoline leaked from a Petrobras owned pipeline and spread over a wide area. On ignition, fire destroyed 500 shanty homes making 2500 people homeless and killing between 89 and 508 people. The cause of the incident was unknown but was later found to be corrosion or operational error.

Description

A 2 foot diameter petroleum products transmission line owned by the Brazilian State Oil Company Petrobras passed within 50 metres of illegally constructed shanty huts. These huts were constructed of wood and cardboard and were mounted on stilts over a creek. The line ruptured after midnight on February 25 according to company officials. However, residents reported that the break had occurred several hours earlier and had complained of smells of gasoline. The company had apparently sent an inspection team to the area some hours before the ignition. The line was carrying gasoline at the time, which flowed out of the ruptured pipeline into the small river running down the middle of a narrow 2 km expanse of shacks built over water. The spillage stretched to 30 metres in width and a mile in length. Fire fighters reported that within approximately five minutes of a spark igniting the release, about 2500 shanty huts were engulfed in a flash fire.

The fire killed between 89 and 508 people, most of whom perished due to burns. A total of 700 tonnes of high octane gasoline had been released from the pipeline rupture. Witnesses stated that on February 28 after the accident, as workmen cut away the ruptured section of pipeline, they noticed that it showed visible signs of rust and decay. However, Petrobras claimed that the incident was caused by operational human error.

Lessons Learned

The emergency response in investigating complaints of gasoline odours was inadequate. Obviously this incident might have been avoided had a proper investigation been undertaken.

4.2.7 Case 7 - Uong Bi, Quang Ninh Province, Vietnam, 2 November 1993

Summary

An explosion and fire followed repairs to a damaged pipeline passing through a village. A leak was ignited following the repairs. Many people gathering petrol from the leaking lines were killed and injured in the ensuing fires and explosions.

Description

A crowd were trying to steal gasoline from a pipeline that had previously leaked and been plugged. The spillage had occurred in a paddy field. The crowd trying to steal the leaked gasoline were digging holes to collect the gasoline when it was ignited by an unidentified source. The subsequent fire amidst the crowd resulted in 47 fatalities and numerous injuries from burns. Emergency personnel evacuated people from a nearby village. The fire burnt itself out within a few minutes. It was later suspected that people gathering the gasoline might have inadvertently caused ignition by smoking.

Lessons Learned

Improper control of the release area exposed people to the hazard of being very close to a highly flammable substance.

4.2.8 Case 8 - Kaycee, Wyoming, USA, 23 July 1985

Summary

At about 10:30 am on July 23, 1985, in a rural area about 8 miles south of Kaycee, Wyoming, a girth weld failure allowed a release and the atomisation of aircraft turbine fuel under 430 pounds pressure. This release was ignited and the subsequent fire killed one person and burned six other workers.

The cause of the rupture was a failure by the operating company to identify a sub-standard girth weld when the pipeline was constructed in 1963 and again when the girth weld was exposed during a re-coating project in 1985. Contributing to the accident was the failure by the company to develop written instructions and guidance for re-coating projects and to brief contractors and company personnel on the hazards associated with re-coating projects.

Description

At 10:30 am, the workers in the immediate area of a sideboom (tractors used to lift the pipeline during maintenance work) heard a sharp crack and observed a spray and then a shower of kerosene. The pipeline had cracked at a girth weld. Ignition followed almost immediately from the acetylene torch on a wrapping machine. The foreman was saturated by a shower of kerosene, and his clothing was on fire while he was still in the tractor seat of the sideboom. A company inspector who was standing near the sideboom and one of the company contractors, were also saturated with kerosene and were critically burned. A total 6 of the personnel were injured (burned) and one killed in the fire. Figure 4.8 shows the location of personnel at the time of the incident.

Pipeline control staff were alerted and the pipeline was shut down by 11:05 am and was isolated within an 11 mile section. The fire, which was contained almost entirely within the 400 foot long kerosene filled ditch at the accident site, was allowed to burn out under controlled conditions: it burned until about 23:00 that night.

Inspection of the area after the fire had burned out revealed that the 8 inch pipeline had been picked up by the sideboom tractor close to a girth weld. The girth weld had cracked along the top and down the side from about the 11 o'clock to 2:30 o'clock positions looking northwards.

Lessons Learned

Following the accident it was recommended that:

- Inspections of pipelines should be carried out prior to raising them.
- Guidance on lowering in service pipelines should be followed for raising in-service lines.
- The training and qualifications of personnel undertaking pipeline re-coating work are important in ensuring safety.

4.2.9 Case 9 - Near Houston, Harris County, Texas, USA, 20 October 1994

Summary

Massive flooding caused a series of pipelines to fail at river crossings. Releases from gasoline and petroleum product pipelines were ignited and a number of fires and explosions occurred on the San Jacinto River and the adjoining flood plains. 547 people suffered (mostly minor) burn and inhalation injuries. Two elderly residents sustained serious burn injuries while returning to their homes.

Description

Due to massive flooding (up to 2.9 times the 100-year-flood) in the San Jacinto River near Houston, Texas, 8 pipelines ruptured and 29 were undermined at river crossings and new channels were created in the flood plain. More than 35,000 US barrels of petroleum and petroleum products were released into the river. Ignition of the released products within flooded residential areas resulted in 547 people receiving (mostly minor) burns and inhalation injuries.

Amongst these 8 ruptures was that of a 40 inch gasoline line, which ruptured on October 20 at around 9 am. Gasoline pooled in slow moving sections of the river and flood waters. Residents evacuating a residential area mentioned that gasoline fumes had entered house boats. At about 9.51 am explosions and fires erupted on the river and began moving down the river. After the first explosion fire and smoke rose about 300-440 feet into the air. A series of explosions followed the first. Witnesses described fires flashing above the floating product. They added that the initial fire originated from the river's eastern bank. Two elderly residents of a street adjacent to the river suffered serious burns. Due the absence of remote isolation on the 40 inch pipeline, isolation was effected after 1 hour thirteen minutes, when both manual isolation valves had been shut.

At 1 pm the emergency services incident commander extended the evacuation zone to all persons within a 9 mile distance of the failed 40 inch pipeline. At 2 pm a 36 inch pipeline carrying petroleum products also failed. Personnel were directed to close isolation valves on the river crossing for this pipeline. In addition a main isolation valve was closed.

Lessons Learned

Post accident investigations revealed:

- The design of pipelines did not consider the threat of rupture due to flooding.
- Pipeline operators continued operations without evaluating the capability of pipelines to withstand the threat of flooding.
- Failed lines continued to release excessive volumes of petroleum and liquid products because of there being no legislative requirement for the rapid detection and shutdown of failed sections of pipeline and moreover because the industry had not incorporated any means of rapidly detecting, locating and shutting down failed sections of pipe.

4.2.10 Case 10 - Guadalajara, Mexico, 22 April 1992

Summary

The slow and continued leakage of gasoline from a transmission pipeline resulted in a migration of gasoline vapours into the sewage system under a congested area in Guadalajara.

An external source ignited these vapours and consequently a series of explosions occurred along the path of the sewer system through a 20 block area. These explosions resulted in the decimation of a 20 block area and some 252 deaths.

Description

A gasoline transmission pipeline owned by PEMEX, the Mexican State oil company, slowly leaked gasoline from a hole formed due to corrosion. This leakage occurred over an extensive period of several weeks. The gasoline migrated into the sewer system under a twenty block congested section of the town of Guadalajara. On April 22, 1992, an unidentified external source caused the ignition of these vapours. A series of explosions followed, which led to the demolition of 20 blocks along the sewer's path. These twenty blocks were completely flattened by the explosions and about 252 people perished in the blasts. Apparently, residents had complained about the smell of gasoline odours for some days previously and PEMEX had known about the leakage some eight days before the blast. Yet PEMEX, Local Government officials, and the fire brigade failed to evacuate people from the area affected by the release.

Lessons Learned

Inadequate emergency response was the key factor in this accident. If complaints of gasoline odours had been properly investigated then this incident could have been avoided.

4.3 DEVELOPMENT OF EVENT TREES BASED UPON HISTORICAL DATA

Events trees, Figures 4.9 and 4.10 have been derived from an examination of all relevant historical evidence considered in this study. Events occurring in urban areas are considered in Figure 4.9 and rural events in Figure 4.10. The event trees are identical except for the frequency and probability values assigned to the events.

The events which have been identified as causing major threats to life are fires resulting from ignition of spray releases, pools and discharges to sewers and watercourses. If no ignition occurs the major problem is the damage to the environment.

Spray releases have drenched buildings and formed pools before ignition. The resulting fires may be flash fires, pool fires and/or simply burning buildings or vehicles. Event descriptions do not always clearly define the type of fire and therefore the event trees have not been developed further for these incidents. In section 3.8.3 it was estimated that conservatively 16% of incidents result in sprays. No fires were reported from sprays in CONCAWE data but 2 (0.8%) of USA incidents considered involved fire. This figure has been used in the event tree for both urban and rural areas. In the large majority of cases, ignition has not occurred and released gasoline has run away into sewers or watercourses or soaked into the ground. Section 6 discusses how the determination of the consequences of these events have been dealt with in estimating risks.

Pool fires and flash fires associated with pools of gasoline are the other main cause of deaths or injuries. In most reports studied it is clear that releases rarely form large pools. CONCAWE and DOT reports include data on areas of land contaminated but this is often largely below the surface with only oil patches seen above ground. As reported in Section 3.8.2 about 50% of incidents included in the CONCAWE data sets had a figure recorded for land pollution thus it is assumed pools were formed in these cases. The potential for significant pool fires is, in these circumstances, very small. Significant pool fires have generally occurred in urban areas, where pools are formed on roadways and pavements, and, in both urban and rural areas, within trenches dug deliberately to access the pipeline or in error not knowing it was there. Ignition sources have been vehicle engines, often of the vehicle digging the trench, or from other human

activities. 2 (2.5%) of the 77 rural incidents and 1 (4.3%) of the urban incidents reported by CONCAWE were pool fires. The US DOT data set gives similar overall results (2.8% of all incidents) but incidents were not classified into areas. Examination of the data indicates that 6 incidents of pool fires occurred in urban areas of our estimated total of 40 urban incidents (15%). For the event trees it has been assumed that 2.5% of rural incidents and 5% of urban incidents result in pool fires. Whether ignited or not the pools formed may run-off into sewers or watercourses and cause environmental pollution.

Some difficulty was encountered in constructing the event trees, to distinguish between releases to sewers and watercourses. Examples are culverted watercourses running through towns and the lack of distinction between sewers and watercourses running through shanty towns in developing countries. Gasoline within sewers is generally a greater hazard than gasoline within watercourses because sewers are within populated areas and vapours are confined and thus may potentially result in explosions. Urban releases have resulted in gasoline reaching sewers via roadway drains. In the UK these drains mostly feed the sewerage systems but some may run-off into watercourses. Releases could also reach watercourses running through urban areas via running pools or migration through the ground. In rural areas of the UK releases may result in gasoline finding its way into drainage systems, which can be regarded as watercourses rather than sewers. If these drainage systems do lead to sewers then the likelihood of ignition in the rural area resulting in injuries or deaths is considered insignificant.

Within Europe there have been two incidents for which it is recorded that gasoline reached a sewer, but a number where potable water has been affected. This may be due to under-reporting. USA DOT data included a number of such incidents. There are no incidents in CONCAWE 1971-1996, or DOT 1986-1997 reports where discharges to sewers or watercourses resulted in a death.

Section 3.8.4 shows that 8% of CONCAWE reported incidents and 12% of USA DOT reported incidents resulted in a discharge to a watercourse. Of these only 1 USA incident (0.4%) resulted in a fire. However other incidents have been reported in worldwide data. For the 'rural' event tree, 8% of incidents are assumed to involve discharge into a watercourse and 10% of these to give a running watercourse fire.

2 (8%) of CONCAWE reported urban incidents and 7 (3%) of USA DOT all reported incidents involve discharge into a sewer. No ignitions occurred in the CONCAWE incidents but 1 (0.4%) of USA DOT incidents gave a deflagration in a sewer. For the urban event tree, 8% of incidents are assumed to involve discharge into a sewer and 10% of these to give a fire or deflagration.

Evaluation of the event trees has been carried out using the values discussed above and the failure rates derived in Section 3. Probability values used for each event are shown on the diagram. Intermediate values have been calculated to give final values consistent with the those discussed above. The far right hand column shows the probability of the final event given that the pipe fails. The frequency of the event can be calculated by multiplying this probability by the pipe failure rate shown in the far left hand column.

5. CONSEQUENCE ASSESSMENT

Consequence assessment is the methodology by which the effects of potential major accidents are quantified in order to determine the range and severity of the accident's impact. The consequences of the various potential events may then be combined with their frequencies in order to calculate the overall levels of risk.

One of the major objectives of this particular study is to develop consequence models that are based on historical grounds. Therefore, the overall approach that has been adopted is to develop consequence models for gasoline pipeline accidents that are based on the results from the detailed accident review described in Sections 2 to 4.

The fundamental requirement of the consequence model is that, for any particular situation, it should be able to predict the risk of fatality (or the risk of exceeding a dangerous thermal load) as a function of distance from the pipeline for any particular type of exposed population. This information is essential in order to quantify the risks in terms of risk transects or FN curves.

If there were sufficient relevant accident data for a particular type of accident, such as gasoline spray releases, then would be possible to develop a fully statistically based consequence model. Such a model might, for example, predict that a typical residential population at 50 m from a 10" pipeline operating at 80 bar has a 10% risk of fatality in the event of a spray release, based on the fact that this is the relevant historical evidence for such populations at this distance for this type of incident with this type of pipeline. Clearly, a statistically significant number of relevant events (i.e. ignited spray releases from 80 bar, 10" pipelines with residential population at 50 m) would have to be examined in order for this type of fully statistical consequence model to have any validity. Even a couple of relevant accidents where no one had been killed would not be sufficient to demonstrate a zero level of risk.

In general, there has not been a sufficient number of relevant accident events to justify the development of this type of fully statistical consequence model that is capable of taking into account all the factors which are important (such as distance to population, pipeline pressure, etc.). Therefore, the most appropriate approach is to develop a semi-statistical or empirical model, which is based on a consideration of both of the following:

- a) All of the limited information available from accidents that have occurred.
- b) A physical understanding of the accident consequences, using the most appropriate methods and data.

Therefore, although this empirical model will not be fully statistically based, it will be fully consistent with all the statistical evidence currently available. The importance of this empirical model is that it can be used to predict the levels of risk associated with any combination of circumstances, even if there is no relevant historical evidence available.

Section 5.1 presents a summary of the most relevant methods and data which are currently available for the physical prediction of the consequences of gasoline pipeline accidents. This includes a brief review of some of the approaches that have been used in previous studies. It is emphasised that these physical models are only described here in order to provide a more complete understanding of the relevant physical processes, and to help ensure that any empirical models that have been developed are physically realistic, they have not been used directly in the risk assessment.

Section 5.2 describes the empirical consequence models that have been developed for the purposes of this particular study. The relevant historical evidence for each type of consequence model is summarised, and the extent to which this statistical evidence can be used in the development of the empirical consequence model is discussed.

5.1 REVIEW OF EXISTING PHYSICAL MODELS AND DATA

In this section, a brief overview is given of the most important physical models that are typically used for the assessment of releases of flammable liquids such as gasoline.

In many cases, there are well established methods which are either based on many years experience or are based on the fundamental physics of the situation. The data for gasoline, such as the burning rate for example, are based on numerous tests and can generally be regarded as reasonably well determined.

The most important point to note concerning all the methods and consequence models described in the remainder of Section 5.1 is that they often represent idealised situations, and it is vital that the analysis considers the extent to which any particular model is suitable for the purposes to which it is being applied. These matters are discussed in Section 5.2 which describes the development of empirical consequence models appropriate for this study of gasoline pipelines.

5.1.1 Calculation of Release Rates

The mass release rate of non-flashing liquid through an orifice may be calculated using Bernoulli's equation.

$$m_r = C_D A \rho \left(\frac{2(P - P_{atm})}{\rho} + 2gh \right)^{0.5} \quad 5.1$$

- where
- m_r = Mass release rate (kg/s)
 - C_D = Discharge coefficient (taken as 0.62)
 - A = Area of orifice (m²)
 - ρ = Density of liquid (taken as 740 kg/m³ for gasoline)
 - P = Absolute pressure of liquid (N/m²)
 - P_{atm} = Atmospheric pressure (N/m²)
 - g = Acceleration due to gravity (taken as 9.81 m/s²)
 - h = Head of liquid (m)

In general, for gasoline releases of the type being considered in this report, the head of liquid can be ignored as it is much less significant than the pressure. The head of liquid only becomes important in the later stages of releases when the pressure in the line has fallen.

However, it should be noted that the release rates calculated using this equation may be much greater than the normal pumping rate, and so Bernoulli's equation is generally only used for small gasoline leaks.

For large ruptures, it is appropriate to limit the release rate to the normal pumping rate.

For intermediate holes, the release rate will be less than the normal pumping rate, depending on the size, orientation and nature of the orifice. Calculations, based upon Bernoulli's equation, have shown that intermediate holes, normally taken as 30-50% of diameter, could be taken to have a release rate equivalent to a fraction of about 75% of the normal pumping rate.

The results of applying this type of approach for various typical pipeline diameters are summarised in the table below.

Table 5.1
Gasoline pipeline release rates

Pipeline diameter	Hole size	Release rate (kg/s)	Comment
16" (406 mm)	Rupture	205	Normal pumping rate
	Intermediate	154	75% of normal pumping rate
12¾" (324 mm)	Rupture	164	Normal pumping rate
	Intermediate	123	75% of normal pumping rate
8⅝" (219 mm)	Rupture	100	Normal pumping rate
	Intermediate	75	75% of normal pumping rate
6⅝" (168 mm)	Rupture	30	Normal pumping rate
	Intermediate	23	75% of normal pumping rate
All	10 mm Leak	5.3	Calculated discharge rate

5.1.2 Sprays and Jets

If a loss of containment event occurs on a pressurised pipeline, then the gasoline may be ejected at a considerable speed. If this jet of liquid is not impeded, by the ground or nearby obstructions, then the gasoline jet may spray over a large area.

If complex effects such as air resistance and jet disintegration are neglected, then the following formulae may be applied for a liquid jet:

$$h_t = \frac{(u \sin \alpha)^2}{2g} \tag{5.2}$$

$$x_t = \frac{u^2 \sin 2\alpha}{g}$$

- where
- h_t = Theoretical maximum height reached by jet (m)
 - u = Velocity of exit flow (m/s)
 - α = Angle of release to vertical
 - g = Acceleration due to gravity (9.81 m/s²)
 - x_t = Theoretical range of jet (m)

The maximum range occurs for $\alpha = 45^\circ$.

Cox, Lees and Ang (1993) appear to have made a minor error in that they quote a different result for x_t (p 49), but they do state that there is a rule of thumb that the actual range of the jet is 50% of the theoretical distance. Cox, Lees and Ang (1993) also give a formula which may be used to define the range of a non-flashing liquid jet with air resistance taken into account:

$$x = \frac{u \cos \alpha}{k} [1 - \exp(-kt)]$$

with

5.3

$$t = \left(\frac{ku \sin \alpha}{kg} + g \right) [1 - \exp(-kt)]$$

where x = Range of jet (m)
 k = A constant representing air resistance
 t = Time (seconds)

The equation for t must be solved iteratively to find the value of t required in the equation for x .

The equation for t given above by Cox, Lees and Ang (1993) also appears to be incorrect. The correct equation should be:

$$t = \left(\frac{u \sin \alpha}{g} + \frac{1}{k} \right) [1 - \exp(-kt)]$$

5.4

It should be noted that the value of the constant k is of great importance, and that there is little available data. Values of around $k = 0.3$ have been suggested, but this a significant assumption and has a major effect on the range of the spray.

It should also be emphasised that in the equations above, the air resistance is taken to be directly proportional to the velocity of the liquid. However, it is well known that air resistance is a much more complex function of the velocity (e.g. it may depend on the square or cube of the velocity, particularly at high speeds) and so it is not surprising that the above formulae including air resistance still tend to overpredict the range of gasoline jets. Conversely, it should be noted that as the jet breaks up and forms small droplets, the wind may blow the falling spray a considerable distance.

All of the above discussion shows that simple theoretical models need to be treated with extreme caution, and that it is probably simpler (and just as valid) to develop an empirical model based on the limited historical data available. This is considered further in Section 5.2.1.

5.1.3 Mass Burning Rate

The mass burning rate of gasoline in a pool fire may be expressed using the correlation derived by Babrauskas (1983).

$$m_f = m_\infty (1 - e^{-k\beta D})$$

5.5

where m_f = Mass burning rate of finite pool (kg/s/m^2)
 m_∞ = Mass burning rate of infinite pool (kg/s/m^2)
 $k\beta$ = Mean beam length corrector extinction coefficient product (m^{-1})
 D = Pool fire diameter (m)

This correlation is the method used in standard pool fire models such as POOLFIRE6, which takes the following values for the burning rate parameters.

$$m_\infty = 0.067 \text{ kg/s/m}^2$$

$$k\beta = 1.48 \text{ m}^{-1}$$

This leads to the following mass burning rates for various gasoline pool fire diameters.

Table 5.2
Gasoline pool fire burning rates

Pool diameter (m)	Burning rate		
	(kg/s/m ²)	(kg/s)	(mm/minute)
1	0.052	0.0406	4.20
3	0.066	0.468	5.37
10	0.067	5.26	5.43
20	0.067	21.0	5.43
30	0.067	47.4	5.43
50	0.067	132	5.43
100	0.067	526	5.43

It is noted that some previous work (ADL, 1996) appears to have taken $m_f = 0.055 \text{ kg/s/m}^2$.

Lees (1996) gives data (after Babrauskas, 1983) which gives m_∞ as 0.055 kg/s/m^2 and $k\beta = 2.1$.

5.1.4 Pool Spreading

Previous studies (ADL, 1996) have placed great emphasis on the importance of the formation and risks associated with gasoline pools. Two specific cases were considered:

- a) immediate ignition
- b) delayed ignition

In the case of immediate ignition, the pool of gasoline is assumed to grow until the mass burning rate over the entire pool is equal to the release rate. The maximum pool diameter is then given by:

$$D_{\max} = 2 \sqrt{\frac{m_r}{\pi m_f}} \quad 5.6$$

where m_r = release rate of gasoline into pool (kg/s)
 m_f = mass burning rate of gasoline per unit area (kg/s/m²)

In the case of delayed ignition, the pool of gasoline is assumed to grow until it reaches 100 m diameter.

These simple assumptions leads to the following pool diameters.

Table 5.3
Gasoline pool fire diameters on impermeable ground

Pipeline diameter	Hole size	Release rate (kg/s)	Pool diameter (m)	
			Immediate	Delayed
16" (406 mm)	Rupture	205	62.7	100
12¾" (324 mm)	Rupture	164	55.8	100
8⅝" (219 mm)	Rupture	100	43.6	100
6⅝" (168 mm)	Rupture	30	23.9	100
All	10 mm Leak	5.3	10.0	100

It is noted that the results above do not include the effect of soil permeability, which is discussed below, and hence the values given in the table above should be regarded as upper bounds.

5.1.5 Effect of Soil Permeability on Pool Spreading

The size of the pool formed by a gasoline spillage will depend on the extent to which it seeps into the ground. The faster the gasoline seeps into the ground, the smaller the pool is likely to be. If the gasoline spill occurs on permeable ground then, based on Darcy's Law, it will seep into the soil at a rate given by:

$$m_s = \rho k \tag{5.7}$$

- where
- m_s = Mass seepage rate into ground per unit area (kg/s/m²)
 - ρ = Liquid density (kg/m³)
 - k = Coefficient of soil permeability for permeating fluid (m/s)

Soil permeabilities may also be expressed in terms of the 'absolute' or 'specific' permeability, which is expressed as an area and is independent of the nature of the permeating fluid.

$$K = \frac{k \eta}{\rho_w g} \tag{5.8}$$

- where
- K = Absolute or specific permeability (m²)
 - η = Dynamic viscosity of permeating fluid (water = 0.001 Ns/m²)
 - ρ_w = Density of water (taken as 1000 kg/m³)

Previous studies have used absolute permeabilities of 10⁻¹² m² and 10⁻¹⁶ m² to characterise average and clay soil respectively. This corresponds to coefficients of permeability of 10⁻⁵ m/s and 10⁻⁹ m/s for water. It should be noted that the dynamic viscosity of gasoline is approximately 4 times less than that of water, and so the coefficient of permeability for gasoline will be a factor of about 4 times greater than that of water. It should also be noted that various soil types may have an extremely wide range of permeability values, as indicated in the tables below.

Table 5.4
Classification of soil according to permeability

Degree of permeability	Range of coefficient of water permeability k (m/s)
High	Greater than 10^{-3}
Medium	$10^{-3} - 10^{-5}$
Low	$10^{-5} - 10^{-7}$
Very low	$10^{-7} - 10^{-9}$
Practically impermeable	Less than 10^{-9}

Table 5.5
Permeability and drainage characteristics of main soil types

	Coefficient of water permeability (m/s)												
	k = 1	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}
Drainage characteristics	Good						Poor			Practically impervious			
Permeability classification	High		Medium		Low		Very low		Practically impermeable				
General soil type	Gravels	Clean sands		Fissured & weathered clays			Very fine or silty sands		Intact clays				

When both seepage and pool burning are taken into account, the maximum pool diameter for immediate ignition is then given by:

$$D_{\max} = 2 \sqrt{\frac{m_f}{\pi(m_f + m_s)}} \quad 5.9$$

and for delayed ignition by

$$D_{\max} = 2 \sqrt{\frac{m_f}{\pi m_s}} \quad 5.10$$

but the maximum pool size is still limited to 100 m.

This leads to the following pool diameters for average ($k = 10^{-4}$ m/s) and clay ($k = 10^{-8}$ m/s) soils (note that these permeabilities are an order of magnitude greater than those used in previous studies (ADL, 1996)).

Table 5.6
Gasoline pool fire diameters on permeable ground

Pipeline diameter	Hole size	Release rate (kg/s)	Soil type	Pool diameter (m)	
				Immediate	Delayed
16" (406 mm)	Rupture	205	Average	43.0	59.4
			Clay	62.4	100
12¾" (324 mm)	Rupture	164	Average	38.5	53.1
			Clay	55.8	100
8⅝" (219 mm)	Rupture	100	Average	30.1	41.5
			Clay	43.6	100
6⅝" (168 mm)	Rupture	30	Average	16.5	22.7
			Clay	23.9	100
All	10 mm Leak	5.3	Average	6.9	9.5
			Clay	10.0	100

It should be emphasised that the pool diameter on permeable soils is very sensitive to the precise value of the coefficient of permeability (k). For example, on a very permeable soil (with k = 0.01 m/s) the maximum pool diameter for delayed ignition of a 205 kg/s gasoline release is only 5.9 m.

It should also be noted that very impermeable clay soils are relatively uncommon in the UK although in areas of North West England, the Midlands and London there are considerable regions of boulder clay. Also the permeability of soils will be affected when saturated with water or frozen and of course urban releases may be onto areas of concrete or similar surfaces.

5.1.6 Time Dependent Pool Spreading

Previous studies have made been based on the assumption that gasoline leaks from pipelines will lead to large diameter pools and that anybody within that maximum pool diameter will suffer fatality.

However, pools take a finite time to spread, and so it is important to consider the time dependent nature of the pool growth in order to determine whether escape would be practicable.

Various suitable time dependent pool spreading models do exist (e.g. LPOOL, LSM90 or GASP), which are capable of taking into account time dependent spreading and factors such as evaporation, viscous forces, etc. However, simple one line equations may also be used, such as that given by Carter (1995):

$$r(t) = 1.03 \left(\frac{g m_r}{\rho} \right)^{1/4} t^{3/4} \quad 5.11$$

where $r(t)$ = Time dependent radius of spreading pool (m)
 t = Time elapsed since start of release (seconds)

so for a release of 100 kg/s of gasoline, the radius is 14 m after 30 seconds.

Carter's equation is an approximate solution to the following system of equations.

$$\begin{aligned}
 V &= \pi r^2 h \\
 \frac{dr}{dt} &= (2gh)^{1/2} \\
 \frac{dV}{dt} &= \frac{m}{\rho}
 \end{aligned}
 \tag{5.12}$$

where V = Volume of spreading pool (m^3)
 h = Depth of spreading pool (m)

Which has an exact analytic solution given by:

$$\begin{aligned}
 r &= \left(\frac{32 g m_r}{9 \pi \rho} \right)^{1/4} t^{3/4} \\
 h &= \left(\frac{9 m_r}{32 \pi \rho g} \right)^{1/2} t^{1/2}
 \end{aligned}
 \tag{5.13}$$

These equations demonstrate that the pool spreading rate, even for a 205 kg/s gasoline release, is less than 1 m/s (2 mph). Figures 5.1 and 5.2 show the pool radius and rate of growth for a 205 kg/s gasoline release. These results imply that it may be possible to walk away from a large gasoline release, even if the exposed individual starts very close to the leak location.

The system of equations describing the spreading pool may be modified to include a minimum pool depth (δ), seepage into the ground and pool burning:

$$\begin{aligned}
 V &= \pi r^2 h \\
 \frac{dr}{dt} &= (2g(h - \delta))^{1/2} \quad (\text{for } h > \delta) \\
 \frac{dV}{dt} &= \frac{m_r}{\rho} - \pi r^2 \left(k + \frac{m_f}{\rho} \right)
 \end{aligned}
 \tag{5.14}$$

where δ = Minimum pool depth (m)

The TNO Yellow Book (1979) describes a similar approach for the spreading of liquids on land. It is stated that they know of no data in the literature on the value of the minimum layer thickness (δ) linked to a specific surface roughness, and that for that reason a lower limit of 0.005 m is recommended for very smooth surfaces, whilst this value can be increased to several centimetres for less smooth terrains.

Griffiths (1996) states that the value used for the minimum pool depth used in the code RASP (for oleum spillages) depends on the nature of the surface over which the pool is assumed to spread. For a smooth concrete surface a value of 0.005 m is appropriate, whereas with a typical rougher surface a value of 0.02 m should be used. This choice dictates at what rate and how far the pool will spread.

Griffiths (1996) also states that a limit of 50 m radius is usually applied for an unrestricted pool. This value is a pragmatic assumption, bearing in mind the likely presence of various irregularities in the ground surface.

Figure 5.3 shows the time dependent properties of a 205 kg/s gasoline spillage on average soil. It can be seen that the pool grows in size to a radius of 26 m, whilst the rate of spreading decreases from an initial value of about 1 m/s to zero after about 95 seconds (i.e. the pool reaches its equilibrium diameter). At equilibrium, the combined rate of burning and rate of seepage into the ground exactly balance the rate of release.

5.1.7 Calculation of Thermal Radiation Levels

The thermal radiation from gasoline pool fires can be calculated using standard pool fire models, such as POOLFIRE6, which was developed by WS Atkins for the Major Hazards Assessment Unit of the HSE. The model and its validation are described in full by Rew and Hulbert (1996).

It is noted that models such as POOLFIRE6 are not able to model the thermal radiation from a growing pool fire, but it does include the following features:

- a) Thermal radiation is based on a 2 zone solid flame surface emitter model.
- b) The flame is taken to be a sheared elliptical cylinder.
- c) Flame drag and tilt in the wind direction are included, dependent on wind speed.
- d) View factors are integrated numerically.
- e) Obscuration ratios for gasoline are based on the data by Pritchard and Binding (1992), who give a value of 0.02 for gasoline, for all pool diameters.
- f) Thermal radiation levels may be calculated at any (x, y, z) location for any target orientation.
- g) Integrated thermal loads may be calculated for people escaping from the pool fire at any specified speed.
- h) Distances to piloted and spontaneous ignition of wood may be calculated.

It is interesting to note that, for the zero wind speed case, POOLFIRE6 tends to predict significantly lower radiation intensities than those calculated by ADL (1996). This is probably because POOLFIRE6 uses lower values for the obscuration ratio for the upper obscured layer. However, with a typical wind speed of 5 m/s, the radiation intensities in the downwind direction increase significantly, and are comparable with those quoted by ADL (1996).

5.1.8 Thermal Radiation Impact Model

Previous studies have made relatively simple assumptions concerning the impact of pool fires on people. For example, Morgan et al (1996) assumed that:

- within a pool of any diameter there is a 100% chance of dangerous dose, and that there is a 100% chance of fatality in pools of diameter greater than 5 m;
- the fatality rate falls linearly to 0% at 10 kW/m². This level of heat flux equates to a threshold fatality based on an exposure of 40 seconds, assuming that the individual is stationary. The probability of receiving a dangerous dose is taken to be 1% at 10 kW/m².

This approach, although having the great benefit of simplicity, has some major shortcomings as there are a number of other factors which may be important in determining the risks associated with a pool fire. The most significant shortcomings are:

- a) The time dependent growth of the pool is not considered. There may be sufficient time for people very close to the release to escape simply by walking away.
- b) The exposed individual is taken to be stationary. Normal practice is to assume escape at a speed of typically 2.5 m/s.
- c) Protection by buildings is not included. It is normal in risk assessments to consider both indoor and outdoor populations.
- d) Potential escalation of the fire is ignored.
- e) The distinction between risk of fatality and risk of receiving a dangerous thermal load (DTL) is much more significant than has been assumed by Morgan et al (1996). The risk of exceeding a DTL for a person outdoors will be significantly greater than the risk of fatality.
- f) All the risks quoted beyond the pool are not based on radiation intensity or thermal load, as is standard practice, but rather on an arbitrary interpolation down to 1% risk of fatality at 10 kW/m². Morgan et al (1996) do not state what type of interpolation they have used, but it appears that simple linear interpolation has been used. It is probable that this is unsatisfactory. In general, it is found that logarithmic interpolation would be more suitable. By using linear interpolation, Morgan et al (1996) may have overestimated the risks at some distances by up to a factor of 8.

It would be possible to develop a more sophisticated thermal radiation impact model, to address the factors identified above, but the approach that will be adopted in this study is to base the probability of fatality on the limited historical data. This also involves considerable uncertainties and is discussed further in Section 5.2.

5.1.9 Atmospheric Transmissivity and the Effect of Relative Humidity

Thermal radiation from fires is absorbed by the atmosphere as it passes from the flame to the target. The degree of absorption is characterised by the transmissivity (τ), which is largely dependent on the humidity and the path length. Various authors have provided analytic expressions for the transmissivity.

Brzustowski et al (1984) give:

$$\tau = 0.79 \left[\frac{100}{R_H} \right]^{\frac{1}{16}} \left[\frac{30.5}{d} \right]^{\frac{1}{16}} \quad 5.15$$

where τ = Atmospheric transmissivity
 R_H = Relative humidity (%)
 d = Distance from flame to receiver (m)

Cook et al (1990) give the transmissivity as

$$\tau = 1.389 - 0.135 \log_{10}(P_w d) \quad 5.16$$

where P_{wv} = Ambient partial water vapour pressure (N/m²)

The partial pressure of water vapour can be calculated using

$$P_{wv} = 101325 \frac{R_H}{100} \exp\left(14.4114 - \frac{5328}{T_a}\right) \quad 5.17$$

where T_a = Ambient temperature (K)

POOLFIRE6 uses the methodology of Wayne (1991) to calculate the atmospheric transmissivity, in which

$$\begin{aligned} \tau = & 1.006 - 0.01171[\log_{10} X(\text{H}_2\text{O})] - 0.02368[\log_{10} X(\text{H}_2\text{O})]^2 \\ & - 0.03188[\log_{10} X(\text{CO}_2)] + 0.001164[\log_{10} X(\text{CO}_2)]^2 \end{aligned} \quad 5.18$$

$$X(\text{H}_2\text{O}) = \frac{\frac{R_H}{100} d \frac{P_{wv}}{13332237} 288.651}{T_a}$$

$$X(\text{CO}_2) = \frac{273 d}{T_a}$$

At the distances of interest for gasoline fires (up to about 150 m), the differences between the various models for atmospheric transmissivity are not likely to be significant.

5.1.10 Shielding by Obstructions

It is well known that shielding by intervening structures, such as a fence or row of houses, can significantly reduce the radiation intensities received from pool fires (Considine, 1984). Such effects cannot be dealt with generically, but may have an important role to play when considering societal risks or the individual risks at a particular location.

5.2 DEVELOPMENT OF CONSEQUENCE MODELS

The major objective of this study is the development of consequence models based on the historical data from accidents which have occurred. The relevant events have been identified in Section 4 above. The major conclusion from Section 4 is that there are various types of gasoline event which may lead to injury or fatality, namely:

- Spray releases
- Pool fires/flash fires
- Running pool fires/flash fires

For each of these main types of event, we shall develop an appropriate empirical consequence model based on the historical data. Ideally, the model should be entirely statistical, with no need for any detailed consequence assessment calculations. However, in general there have not been a sufficient number of relevant accidents in order to develop a statistically significant model based purely on the historical data, and therefore it has been necessary to develop various empirical models, based on both the limited historical data and taking account of the physical understanding provided by the consequence models from Section 5.1. These empirical models are still fully consistent with the limited data available from all those relevant events which have occurred.

The development of the appropriate empirical consequence model for each type of event is described in Sections 5.2.1 to 5.2.3.

5.2.1 Spray Releases

The case histories for gasoline accidents include several examples where gasoline has sprayed onto occupied buildings, which have then been engulfed by fire. Examples of spray incidents include:

Table 5.9
Incidents involving sprays

Date	Location	Spray details
16 June 1976	Los Angeles California	Gasoline sprayed from the rupture drenching nearby buildings.
30 January 1980	Bayamon Puerto Rico	Gasoline from the rupture sprayed downhill.
23 July 1985	Kaycee Wyoming	Workers observed a spray and then a shower of kerosene.
16 June 1986	Valencia County New Mexico	Product was spraying 20 feet into air.
1 December 1986	Whitwell Marion County Tennessee	Kerosene had sprayed from the pipe onto trees and rocks.
11 June 1987	Centreville Fairfax County Virginia	At least 15,000 gallons of gasoline was released, some went 100 ft into the air. Gasoline, under an initial pressure of 190 psig, sprayed over 6 townhouses and a wooded area. The spraying of gasoline lasted for approximately 10 minutes.
17 June 1988	Crawford County Kansas	Gasoline sprayed the dozer and the operator.

Date	Location	Spray details
25 May 1989	San Bernardino California	2 died and 31 were injured, as petrol sprayed onto nearby housing and was ignited.
3 August 1989	Great Haywood Staffordshire	Corrosion led to a leak from this 10 inch pipeline involving a fine spray.
23 November 1990	Wilton North Tees	About 14 m ³ of gasoline was observed as a fine spray.
29 April 1991	Shoemakersville Berks Pennsylvania	Product shot 25-30 feet into the air.
4 March 1992	Edgmont Delaware Pennsylvania	Control centre received a call from a resident that oil was spraying over the road.
27 October 1993	City of Allentown Pennsylvania	The unleaded gasoline vaporised causing the population around the release site to be evacuated.
13 June 1994	Throop Cayuga New York	Product sprayed into the excavated ditch and was contained.
24 November 1994	Spain	Product sprayed onto nearby fruit trees from the 60 x 80 mm hole (pressure 50 kg/cm ²).
29 July 1996	Clark Nevada	Maintenance man saw "a geyser". Product was spraying out of the line.
16 April 1997	Wyandotte Kansas	Line was spraying gasoline.

Further details of these incidents are given in Appendices 1 to 4.

The most significant of the above incidents are those that occurred at Los Angeles, Centreville and San Bernardino. Detailed information on the spray size/height/area affected is rarely available, but even from the limited data that does exist, it is clear that there is a wide variation in the size of spray that may be formed. This can be partially explained in terms of the physical modelling described in Section 5.1.2. Pipelines at higher pressure have the potential to lead to larger sprays, but if the hole size is large then the outflow rate may be limited by the available flow in the pipeline, resulting in a lower exit velocity and hence a smaller spray. This suggests that there is probably a critical hole size (depending on pipeline pressure and flow rate) which leads to the maximum possible spray size. If the hole is smaller or larger than this critical size then the dimensions of the spray are reduced.

The consequence model for sprays, based on a review of all the accidents that have occurred, is that the spray is assumed to cover an approximately elliptical area. The best evidence for this assumption comes from a detailed examination of the photographs and diagrams in the detailed accident reports for incidents such as those at San Bernardino and Los Angeles. The analysis described in Section 5.1.2 shows that the maximum range of the jet/spray is theoretically proportional to the pressure, and so we propose the following empirical formula which gives reasonably good agreement with the limited historical evidence for gasoline accidents (based on the photos, diagrams and eye witness statements in detailed incident reports).

$$\text{Range of spray} = 2 \times \text{Pressure} \quad 5.19$$

Where the range is in metres and the pressure in bars.

Sprays do not always have this maximum range, and so 4 cases corresponding to 25%, 50%, 75% and 100% of the maximum range are considered (with equal probability as the data does

not permit any more detailed distribution to be derived). In each case, the maximum width of the ellipse is taken to be 80% of the range (again based on an examination of the photos, diagrams and eye witness statements in detailed incident reports).

If the spray is not ignited, then it is assumed that there are no fatalities. If the spray is ignited, forming jet, pool and/or flash fires, then it is assumed that, for a typical residential population, 10% of those within the elliptical footprint of the spray would suffer fatality. This is based on the limited historical evidence from incidents such as those at San Bernardino and Los Angeles, where the fraction of people within the footprint who suffered fatality was of this order. It is noted that the historical evidence is not very detailed and so the figure of 10% should be treated with some caution.

5.2.2 Pool Fires/Flash Fires

These types of event generally involve the formation of a gasoline pool or gasoline soaked ground in the immediate vicinity of a pipeline failure, which is then ignited resulting in a flash fire involving the vapour above the spillage.

The historical data shows that pool fires themselves are rarely responsible for fatalities, except in the following two cases:

- a) when people are attempting to collect gasoline from the leak/rupture
- b) when there is a running pool fire

It is assumed that, in the UK, the likelihood of people attempting to collect gasoline from a leaking pipeline, or behaving in other similarly irrational and dangerous ways, is sufficiently low as to be discounted. The historical evidence shows that this assumption would not be appropriate for other countries, particularly those in the developing world. It should also be noted that when people behave in this type of irrational manner, they may not live anywhere near the pipeline, but have moved closer to it in order to collect petrol etc. Therefore, it would be misleading to include this type of incident in an individual risk transect or contour plot. However, such incidents should still be included in societal risk assessments.

Running pool fire/flash fires (i.e. not local to the release site) are considered in Section 5.2.3.

The evidence shows that, for pools formed local to the release site, it is the flash fire above the pool which can take people unawares and result in fatality. Even so, the only major accident of this kind in Western Europe or the USA which resulted in fatalities to a residential population is the Mounds View incident which resulted in 2 fatalities.

The incident in Spain in 1996 resulted in 3 fatalities from this type of event, but the people involved had come to view the incident and were standing too close. They were therefore not part of a local residential population and it should be noted that the individual risk transects that will be calculated would not cover this situation.

The analysis in Sections 5.1.4 to 5.1.6 has shown that, on flat ground, the rate of pool spreading is so low that it should pose very little risk to anybody outdoors unless they are right on top of the leak site (i.e. people able to detect from even a short distance away that the release had occurred, would generally be able to walk away). This implies that the standard pool fire models, which assume the instantaneous formation of a large fixed diameter pool, have little practical relevance in terms of calculating a risk of fatality.

However, if people are indoors, and the building becomes involved in a fire or flash fire from a spreading pool of gasoline, then there is a probability of fatality.

The area affected by the flash fire is essentially determined by the area of the vapour cloud above the LFL. This will depend on the ambient temperature, the wind speed and other meteorological conditions which influence the rate of evaporation and dispersion of the vapour. In general, however, the historical evidence indicates that flash fires are limited to the area immediately above the gasoline pool (or gasoline soaked ground).

For the purposes of this study, the area that may be affected by this type of pool fire/flash fire event is based on the distribution of spillage radii given in Table 3.19. This is a reasonable assumption as the historical evidence shows that the flash fires tend to be restricted to the immediate vicinity of the spillage. However it should be noted that the spillage radii are based upon a measurement of contaminated ground, often involving small pools of gasoline or simply drenched topsoil rather than surface pools. Therefore this is a conservative assumption. It is also assumed that the area affected is circular as there is insufficient historical information for any other assumption. Although the fire at Mounds View affected quite a large residential area, there were only 2 fatalities, and so it is assumed that the fraction of people who suffer fatality within the affected area is about 10%. Again, this is subject to a considerable degree of uncertainty due to the paucity of relevant historical data.

5.2.3 Running Pool Fires/Flash Fires

These events are similar to those described in Section 5.2.2, except that the pool and fire are not restricted to the immediate vicinity of the pipeline failure. Such events typically occur for spillages on hillsides, or when the gasoline travels some distance in watercourses, drains or sewers. Examples of such events include:

- Bayamon, Puerto Rico, USA
- Guadalajara, Mexico

It should be noted that although such events could occur in the UK, they are much less likely to affect large numbers of people. This is because the leak is likely to be detected and isolated relatively quickly, and also because people in the UK tend not to live in close proximity to open drains or sewers.

Furthermore, it is important to note that, because these events are not necessarily local to the pipeline (the Bayamon fires were up to 2 km away), the risk may be spread amongst a large population. The level of individual risk associated with such events in the UK is therefore considered to be negligible, and therefore there is no requirement to develop a consequence model to calculate the risk transects associated with such events.

Nevertheless, it should be noted that the societal risk may still be significant, as a large number of people could be involved in a fire at some distance from the pipeline. There is insufficient historical data to develop an appropriate consequence model or to provide a reasonable estimate of this societal risk for gasoline pipelines in the UK.

5.3 POPULATION CHARACTERISTICS

Previous studies have not always explicitly considered the different risks to the various different population types who may be exposed to the risk from gasoline pipelines. Different population types (e.g. pipeline workers, contractors, farmers, residential population, etc.) may have very different characteristics in terms of:

- Proportion of time that they are present
- Probability that they themselves are responsible for the pipeline failure
- Probability of being outdoors
- Probability of being sheltered by a building (or being trapped inside a burning building)

Such factors are well known to have a significant effect on the results of a risk assessment for toxic or flammable releases. Therefore, for the purposes of this study, it has been assumed that the population whose risk is being assessed is a typical residential population defined as follows:

- They are always present (100% occupancy)
- Spend 10% of their time outdoors, and 90% of their time indoors
- They occupy typical housing

It should be emphasised that all the risks calculated later in this study will refer to this typical residential population group. The levels of individual risk for other groups, such as workers at a factory, contractors, farmers, school children, occupants of a prison, hospital, old people's home, etc., would all have to be calculated separately.

6. RISK ASSESSMENT

6.1 EVALUATION OF INDIVIDUAL RISKS FOR TYPICAL UK PIPELINES

The consequence models described in Section 5.2 have been applied to the events described in the event trees in Section 4, using the event frequencies and probabilities derived in Section 4. The results are shown in terms of risk transects in Figure 6.1, which shows the individual risk to a member of a typical residential population in the UK as a function of the perpendicular distance from a typical gasoline pipeline operating at 80 bar.

Figure 6.1 gives two risk transects to reflect the historical evidence for the different frequencies of pipeline failures in urban and rural locations. Each risk transect is a summation of the risks from a variety of spray and pool fire/flash fire events.

Figure 6.2 shows the contributions to the overall total risk transect (for an urban pipeline) from the spray and pool fire/flash fire events. It can be seen that within 30 m of the pipeline, most of the risk comes from the pool fire/flash fire events, but at greater distances the risk is dominated by the spray events.

It should be noted that there is almost no historical evidence which relates directly to the risk of fatality for residential populations within about 25 m of the pipeline and so the results presented here should be treated with caution.

Similarly, although the risk transects show the risk falling towards zero at about 160 m, this will depend on the actual pressure in the pipeline. In most cases, 80 bar or less is the maximum pressure at the pump and this falls off along an operating pipeline. It is possible that points further along the pipeline can approach the pump head pressure if a valve is closed and the pump left running. However the assumption of 80 bar at the release point is considered conservative. It should also be noted that there will still be a very small level of risk at distances above 160 m, due to events such as running pool fires/flash fires etc. which are not local to the pipeline failure location.

These transects are based upon the average pipeline. The curves obtained can be adjusted using the frequency levels in Table 3.10 for various pipe diameters. Using these values, the curve would remain the same shape but be moved upwards or downwards on the y-axis.

6.2 SOCIETAL RISK PREDICTIONS FOR UK GASOLINE PIPELINES

One way of calculating the societal risk associated with a pipeline is to assume a uniform population density over various sections of the pipeline, and hence calculate the number of people likely to be affected by each event. These results can then be summed to arrive at the overall societal risk. However, this uniform population density approach does not necessarily provide a complete understanding of the societal risk. For example, in a rural area with an average population density of 250 people per km², a gasoline spray affecting 200 m² would only cover $250 \times 200 \times 10^{-6} = 0.05$ people. In practice, if there were 50 homes with 5 inhabitants each in each kilometre square, then in most cases the spray would affect nobody, but in a small number of cases it could potentially affect 5, 10 or more people (a fraction of whom could suffer fatality). Therefore, although the use of uniform population distributions may be adequate for the determination of average Probable Loss of Life (PLL) values, they should not be used for the calculation of FN curves.

If this approach is used with the individual risk transects given in Figure 6.1, then the PLL for all gasoline pipelines in the UK is calculated to be 0.013 fatalities per year (i.e. an average of one fatality every 77 years). This is based on 2500 km of gasoline pipeline in the UK, 90% of which is in rural areas (population density 250/km²) and 10% of which is in urban areas (population density 5000/km²).

It should be noted that population distributions are not uniform, and this introduces some additional uncertainty in the above result. For example, it is likely that the population density within 20 m of the pipeline is somewhat lower than average, which implies that there may be very few people exposed to the highest levels of risk. The incorporation of such effects would result in a reduction in the calculated PLL value.

It is also emphasised that the PLL value calculated above does not include the risks to workers or to the wider population who may come and view incidents or be exposed to running pool fire/flash fire events which occur in locations at some distance from the pipeline.

6.3 SUMMARY OF SOCIETAL RISK BASED UPON HISTORICAL DATA

The table below lists all the gasoline pipeline accidents identified worldwide which have resulted in one or more fatalities. It is emphasised that although this list is probably complete for Western Europe and the USA, it is likely that there have been a significant number of further fatality accidents in other parts of the world which have not been identified in this study.

Table 6.1
Worldwide gasoline pipeline accidents since 1975 that have involved fatalities

Date	Location	Number of fatalities
5 September 1975	Rosendaal, Netherlands	2
16 June 1976	Los Angeles, California, USA	9
30 January 1980	Bayamon, Puerto Rico, USA	1
16 April 1981	Chonan, South Korea	1
20 January 1982	La Venta, Mexico	5
25 February 1984	Cubatão, Brazil	89 ^a
23 July 1985	Kaycee, Wyoming, USA	1
8 July 1986	Mounds View, Minnesota	2
25 May 1989	San Bernardino, California, USA	2
28 July 1989	France	3
22 April 1992	Guadalajara, Mexico	252
2 November 1993	Uong Bi, Quang Ninh, Vietnam	47
14 April 1994	Monterrey, Mexico	1
17 February 1995	Villahermosa, Tabasco, Mexico	3
4 December 1996	Spain	1

Note ^a One source gives the unofficial death toll as > 508, but this is not confirmed.

This data is shown in the form of FN curves in Figure 6.3. Each curve shows the frequency per year of events involving N or more fatalities. For example, the worldwide data curve shows that the frequency of events involving 10 or more fatalities is about 0.17 per year, or one such event every 6 years.

The two curves for Western Europe and the USA are considered to be reasonably representative, but the upper worldwide FN curve is probably a significant underestimate. The

lower curve does not represent actual data but is a best estimate for the UK, based upon a scaling of Western European data.

The FN curves all show a reasonably steady decrease in the frequency of increasing N events. The apparent dip in the worldwide data curve in the N = 1 to 10 region could well be related to the under-reporting of these low N events, whereas the high N events (N > 10) may be reasonably complete.

The area under these FN curves corresponds to the PLL, also known as the expectation value, which is the average number of fatalities per year. The table below presents the PLL values for the available data. The PLL values may also be expressed as the average number of fatalities per year per km of pipeline (based on the assumption of 21,000 km of gasoline pipeline in Western Europe, 175,000 km in the USA, and approximately 400,000 km worldwide).

Table 6.2
Probabilistic Loss of Life (PLL) associated with gasoline pipeline failures

Region	PLL (fatalities per year)	PLL (fatalities per 1000 km-year)
Worldwide	18	0.046
USA	0.65	0.0037
Western Europe	0.26	0.012

This data implies that although one would expect an average of 18 fatalities worldwide every year, one would only expect an average of one fatality every 4 years in Western Europe. Again, it should be noted that the PLL values for the worldwide data are probably significant underestimates.

It is interesting to note that although the average number of fatalities per year in the USA is significantly higher than in Western Europe, the rate of fatalities per km of pipeline is lower in the USA than in Western Europe. This is probably due to the fact that the USA has a significant length of gasoline pipeline, much of which runs in relatively unpopulated areas.

There are many reasons why the worldwide PLL values per km are significantly higher than those in Western Europe and the USA:

- The worldwide frequency of accidents is probably greater than that in the USA or Western Europe for a wide variety of reasons (quality of manufacture, installation, testing, security, vulnerability, etc.).
- The speed of detection and isolation of spillages is better in the USA and Western Europe.
- The emergency response (including evacuation) tends to function more effectively in Western Europe and the USA, particularly in terms of ensuring that people are not left exposed in hazardous areas.
- The worldwide data includes events which involve high population densities of vulnerable people in buildings which provide little or no protection.
- The worldwide data includes several events where many of the people involved were not behaving in a sensible manner (e.g. people collecting petrol from spillages). Such behaviour is less likely in Western Europe or the USA.

It is reasonable to assume that the corresponding figures for the UK (with about 2500 km of gasoline pipelines) would be about 12% (or less) of those for all of Western Europe. This implies an average PLL of approximately 0.031 (i.e. one fatality in the UK every 32 years). Figure 6.3 shows the corresponding best estimate FN curve for the UK based upon this 12% figure.

There have been no fatal accidents in the UK, which is still consistent with the calculated figure of one fatality per 32 years based on scaling the Western European average figure.

It is emphasised that all these historically based figures are derived from a relatively small number of accidents, and are therefore subject to a considerable degree of uncertainty. Even just one more accident involving a few fatalities would alter the results significantly.

6.4 COMPARISON OF CALCULATED AND HISTORICAL SOCIETAL RISKS

The PLL for the UK was calculated in Section 6.1 as 0.013 fatalities per year. This related to the overall risk to typical residential populations in the vicinity of gasoline pipelines.

The actual worldwide historical societal risk data described in Section 6.3 covers a number of different population types, and includes events which are not appropriate to the UK, and whose frequency has not been determined (because such events are irrelevant to the risks in the UK). Therefore, it is not appropriate to compare any predicted risks calculated using the UK type events (and frequencies) with the actual worldwide data.

However, one would expect that a full societal risk analysis for the entire UK would predict an average PLL that was consistent with the value derived from the historical data for Western Europe (i.e. 0.031 /year). The complication is that the historical data relates to all population types (i.e. it includes pipeline workers, contractors, farmers, emergency services, general public, etc.) whereas the predicted risks (i.e. 0.013 /year) refer specifically to members of a typical residential population living near gasoline pipelines.

It is not surprising that this difference exists, and it simply suggests that a significant fraction of the risk associated with gasoline pipelines is not to residential populations, but rather to pipeline workers, contractors, farmers, emergency services, etc., or to residential populations who do not live in the immediate vicinity of pipelines.

7. CONCLUSIONS

This report presents the results of an assessment of the risk from gasoline pipelines in the UK based on a review of historical experience.

The major conclusions arising from the study can be summarised as follows:

Historical Data

- There are no records of any fatalities in the UK associated with failures of cross country gasoline pipelines.
- There have been at least 15 accidents worldwide since 1975 involving a total of at least 419 fatalities. It is likely that these figures are significant underestimates as data is not available/complete for many countries.
- The major sources of historical data in this study are those from CONCAWE and the USA DOT. This is because these sources are most comprehensive since the organisations keep detailed records of all incidents no matter how minor. They are also the most relevant to the UK situation.
- The historical data provides no direct information for individual risk, but scaling of the limited Western European data suggests that the UK PLL is about 0.031 fatalities per year (covering all population types).

Frequency of Gasoline Pipeline Failures

- The frequency of various types of gasoline pipeline failure have been determined from the available historical data.
- The probability of various accident outcomes has been quantified using event trees with probabilities derived from the historical data.

Consequence Models for Gasoline Pipeline Failures

- The historical data has been used to develop simple consequence models for gasoline sprays and pool/flash fires which may be used for the prediction of individual and societal risk.
- The development of the models is based on very little relevant quantitative data, and so there are undoubtedly considerable uncertainties associated with their use. There are many factors which may be relevant, but the lack of suitable data means that it is not possible to justify the development of more sophisticated empirical models.
- The models could be developed further by the incorporation of more theoretical modelling, but this was not the object of this study.

Predicted Levels of Individual Risk Near Gasoline Pipelines in the UK

- Risk transects have been calculated to show the individual risk to members of a typical UK residential population from gasoline pipeline accidents. The individual risks are higher in urban areas than in rural areas, reaching values of 1.4×10^{-7} and 3.2×10^{-8} /year on the pipeline centreline for typical urban and rural pipelines respectively.
- Data has been presented which could be used to prepare risk transects for any particular pipeline (i.e. diameter, pressure, etc.).

Predicted Levels of Societal Risk Near Gasoline Pipelines in the UK

- The calculated PLL for UK gasoline pipelines is 0.013 fatalities per year, but this only relates to typical residential populations living near gasoline pipelines. The fact that it does not include other population groups (e.g. pipeline workers, contractors, farmers, emergency services, etc.) may explain why this calculated value is less than the historical overall PLL of 0.031 fatalities per year that was derived by scaling the Western European data.

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FIGURES

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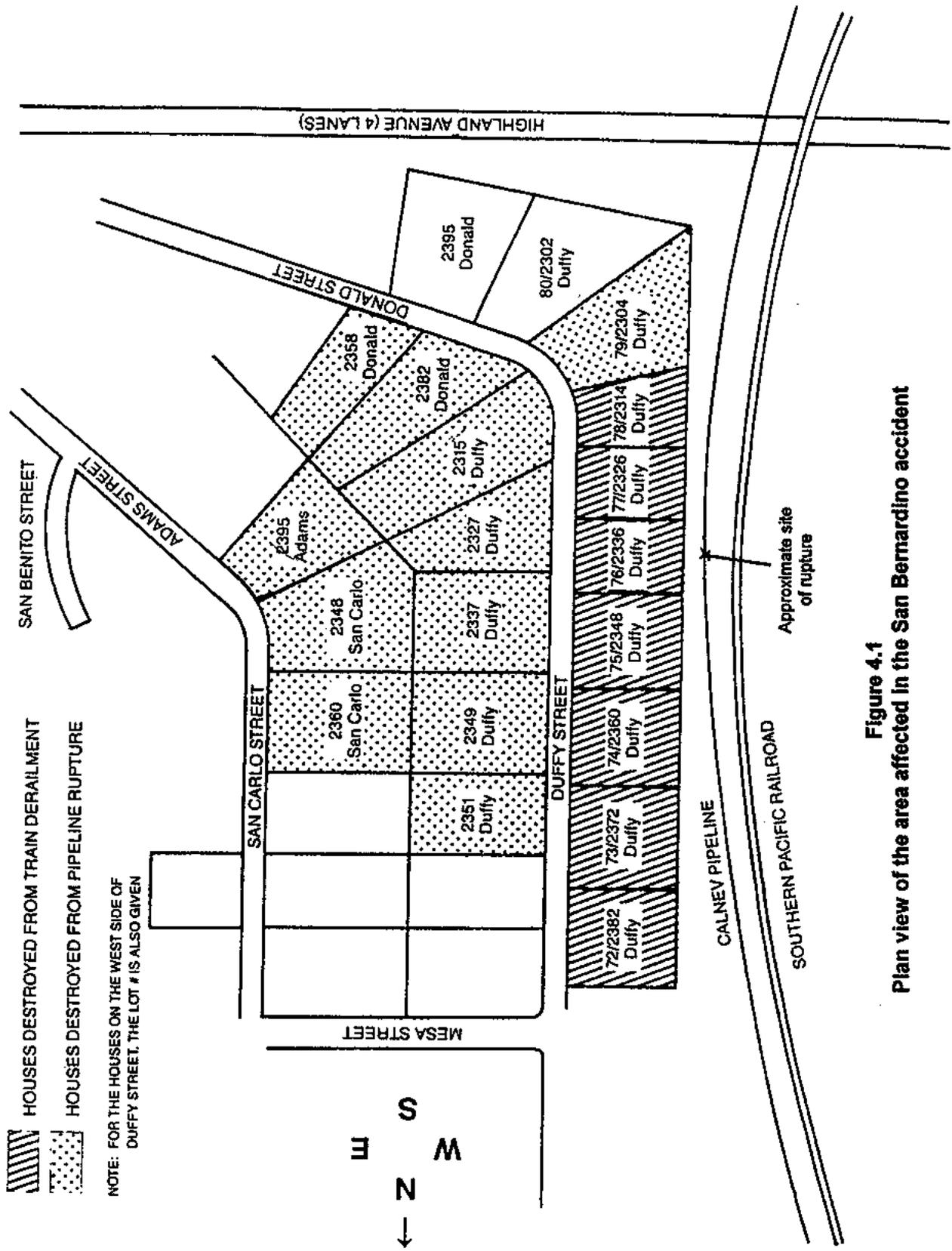


Figure 4.1
Plan view of the area affected in the San Bernardino accident

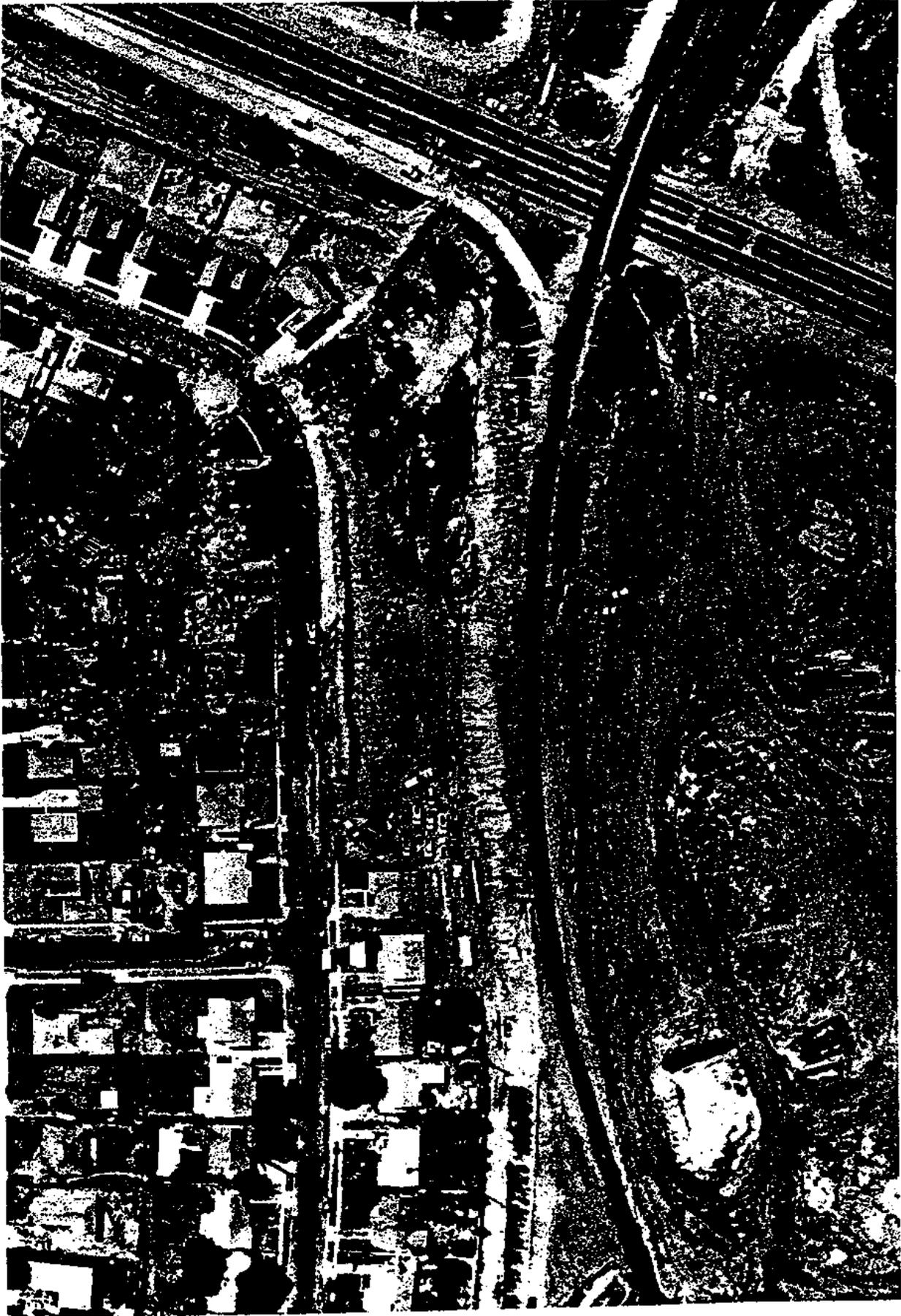


Figure 4.2
Aerial photo of the area affected in the San Bernardino accident

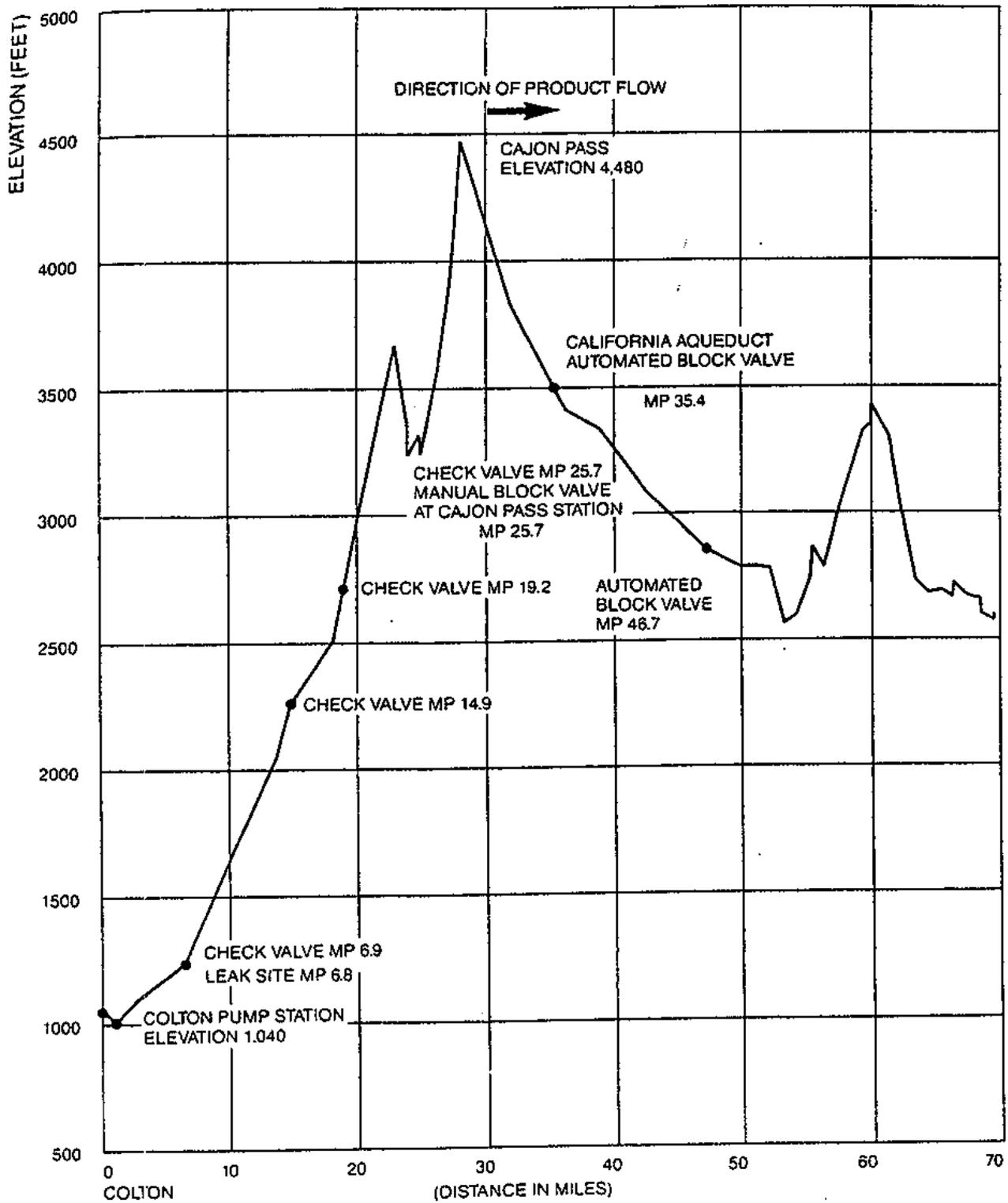


Figure 4.3
Elevation of the Calnev pipeline in the San Bernardino accident

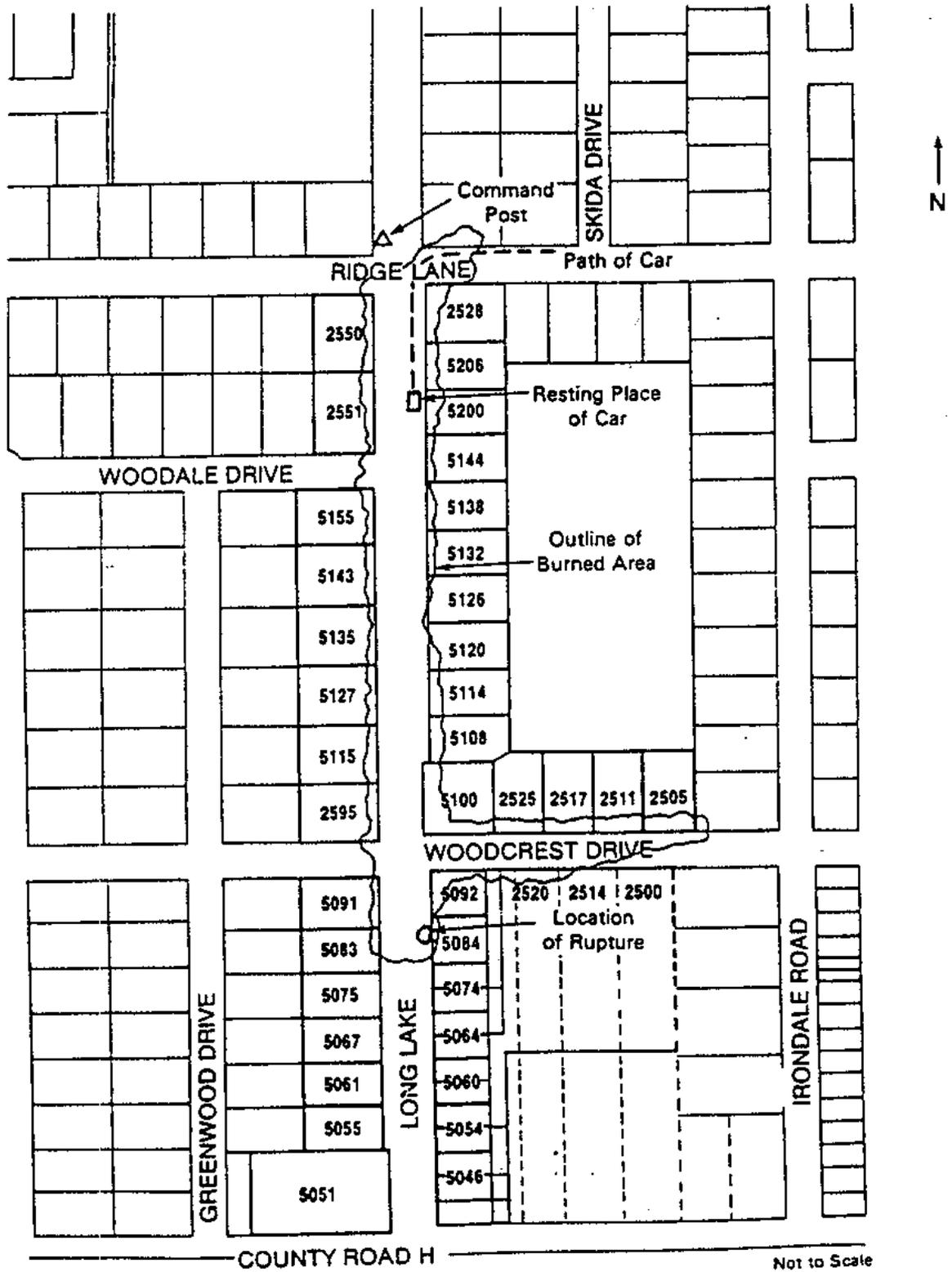


Figure 4.4
Plan view of the Mounds View accident site

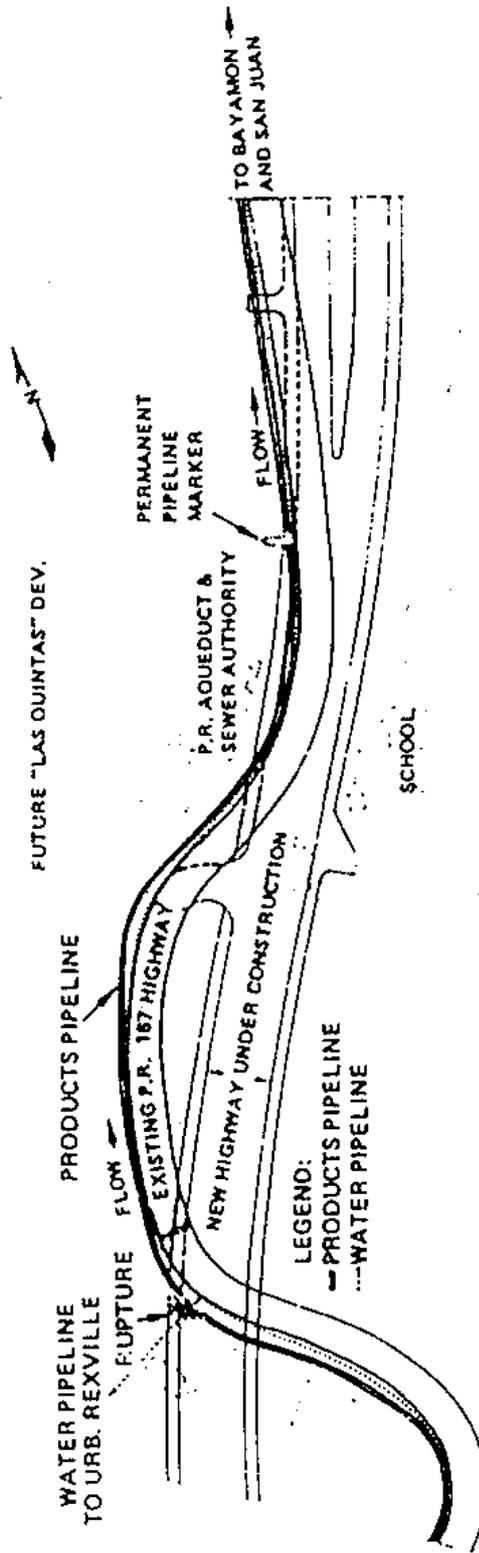


Figure 4.5
Plan view of the Bayamon accident site

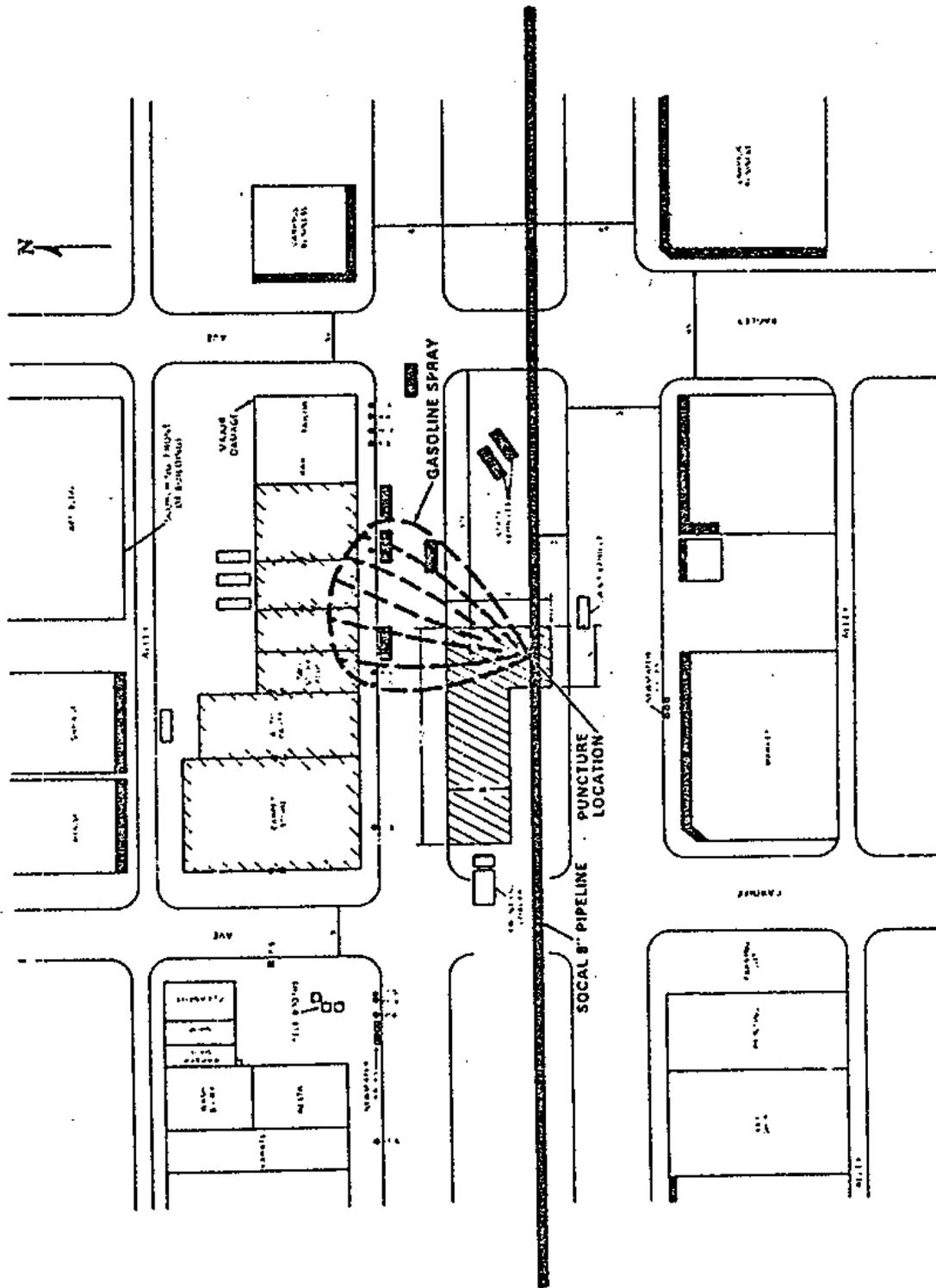


Figure 4.6
Plan view of the Los Angeles accident site

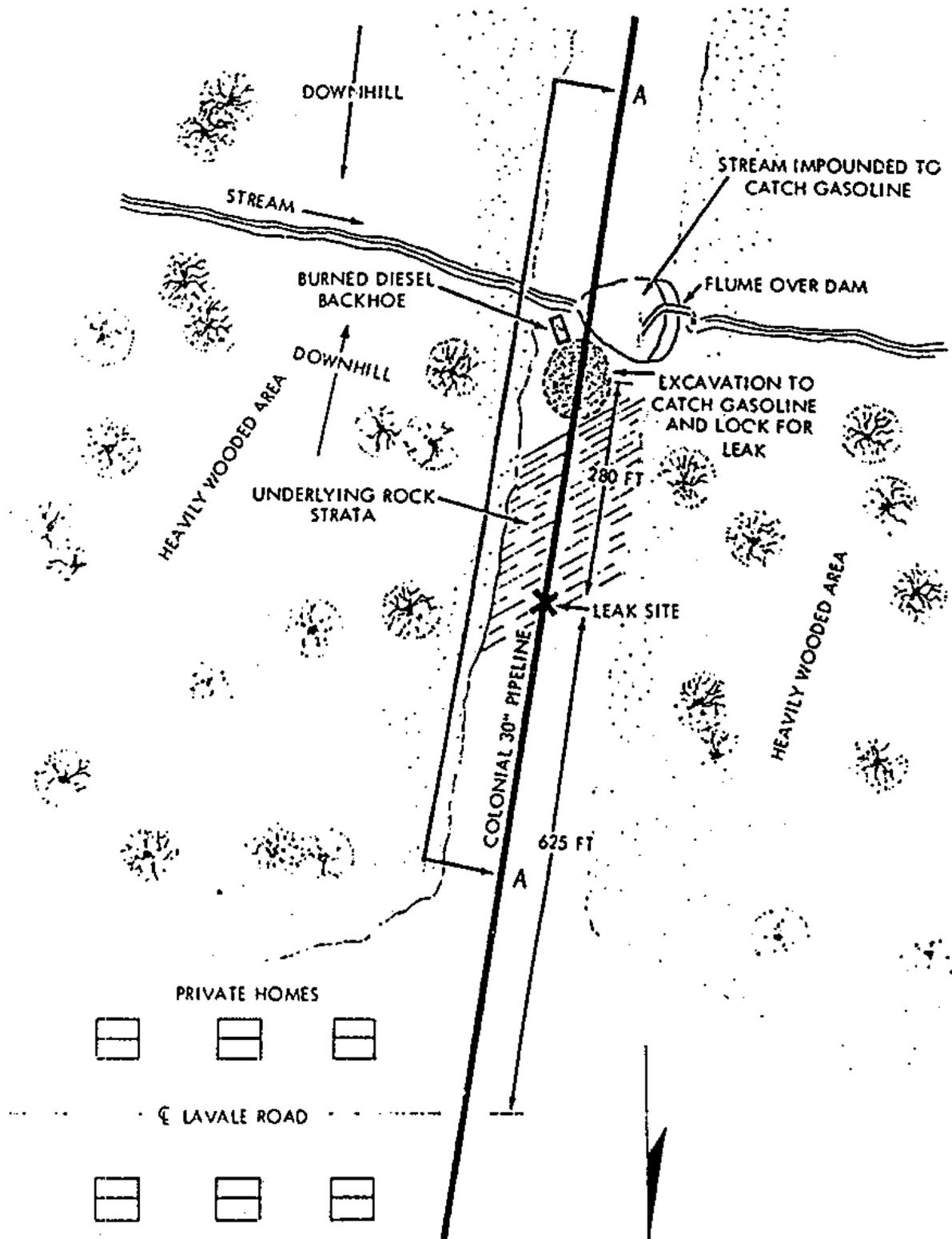
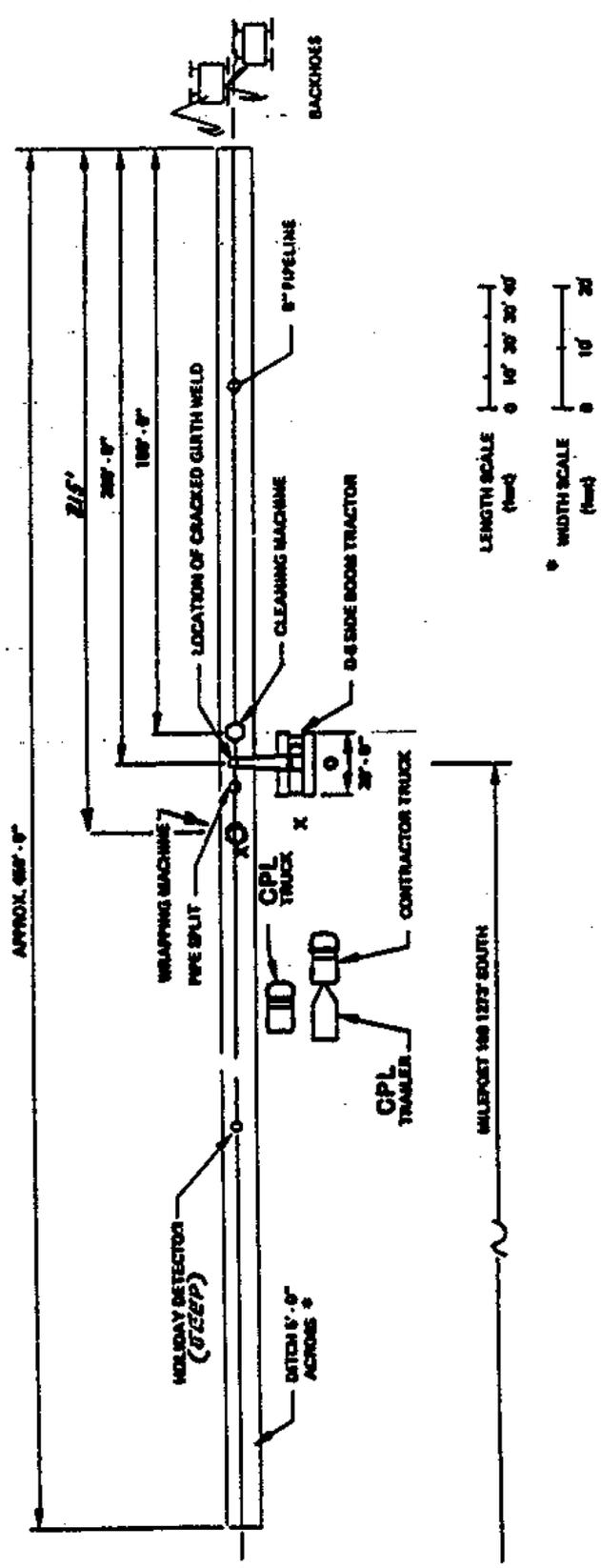


Figure 4.7
Plan view of the Jacksonville accident site



○ FATALITY
x CRITICALLY INJURED

Figure 4.8
Plan view of the Kaycee accident site

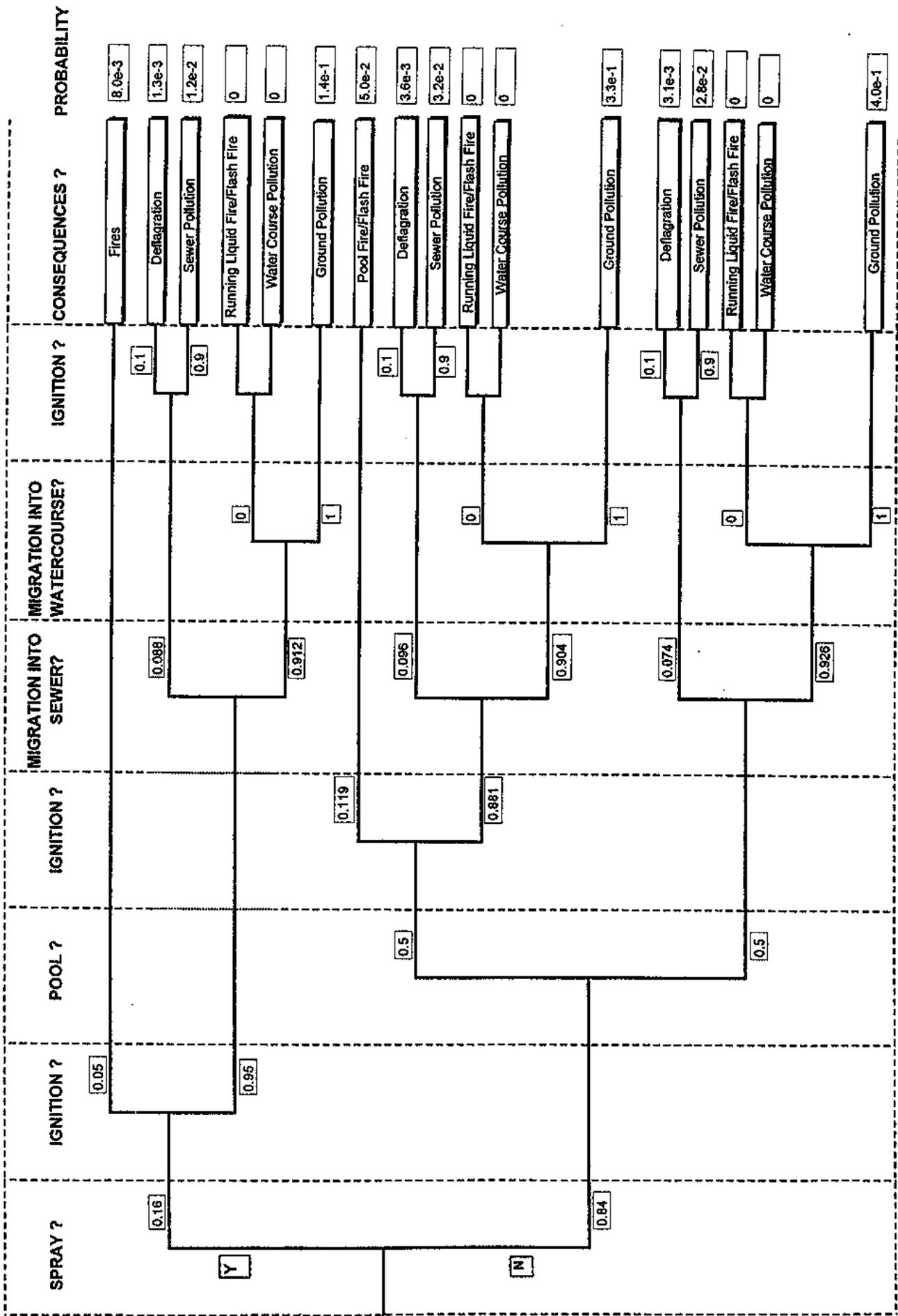


Figure 4.9 Event Tree: Destination of Releases in Urban Areas

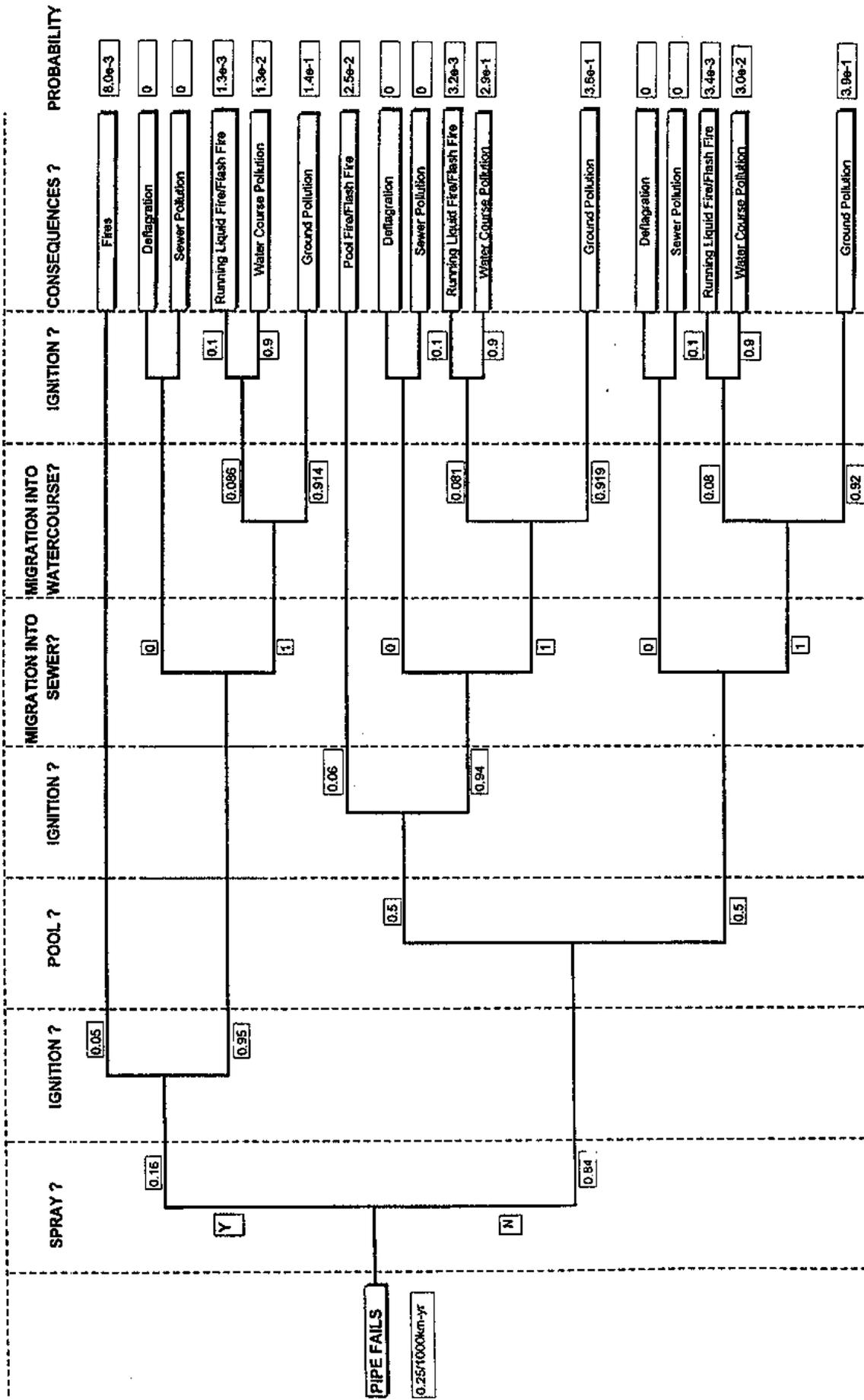


Figure 4.10 Event Tree: Destination of Releases in Rural Areas

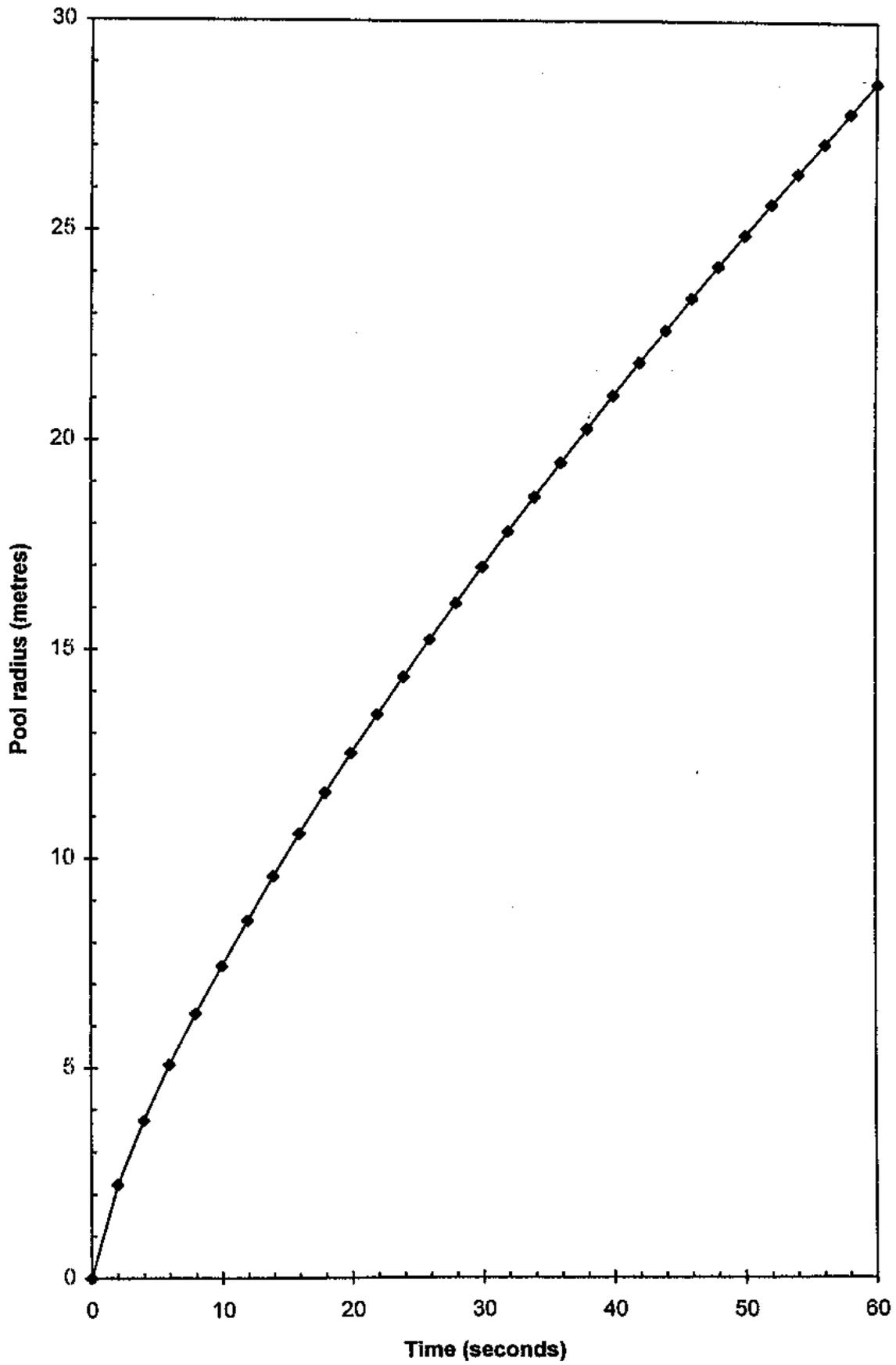


Figure 5.1
Growth in pool radius for a 205 kg/s gasoline release on impermeable ground

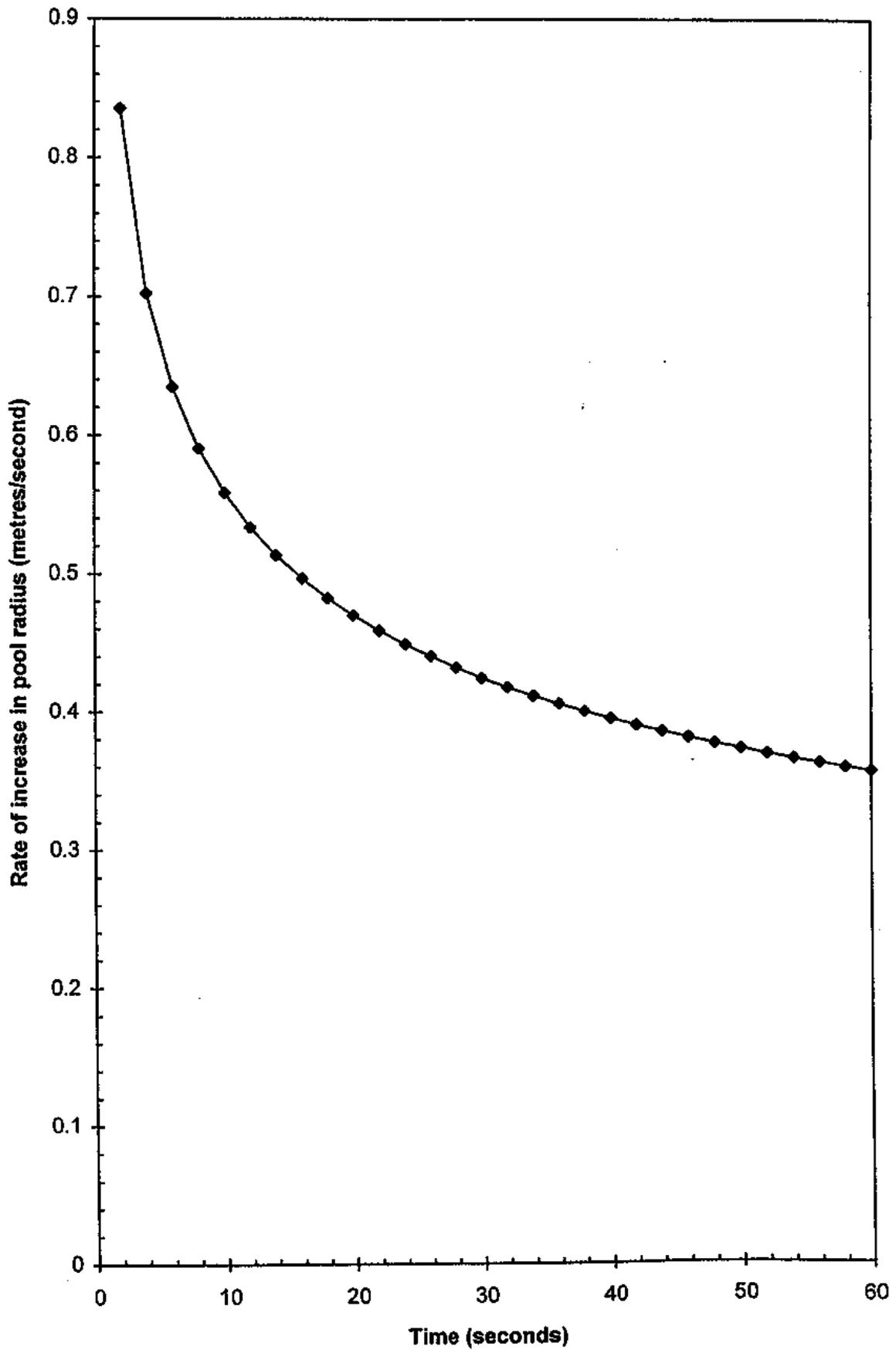


Figure 5.2
Rate of growth in pool radius for a 205 kg/s gasoline release on impermeable ground

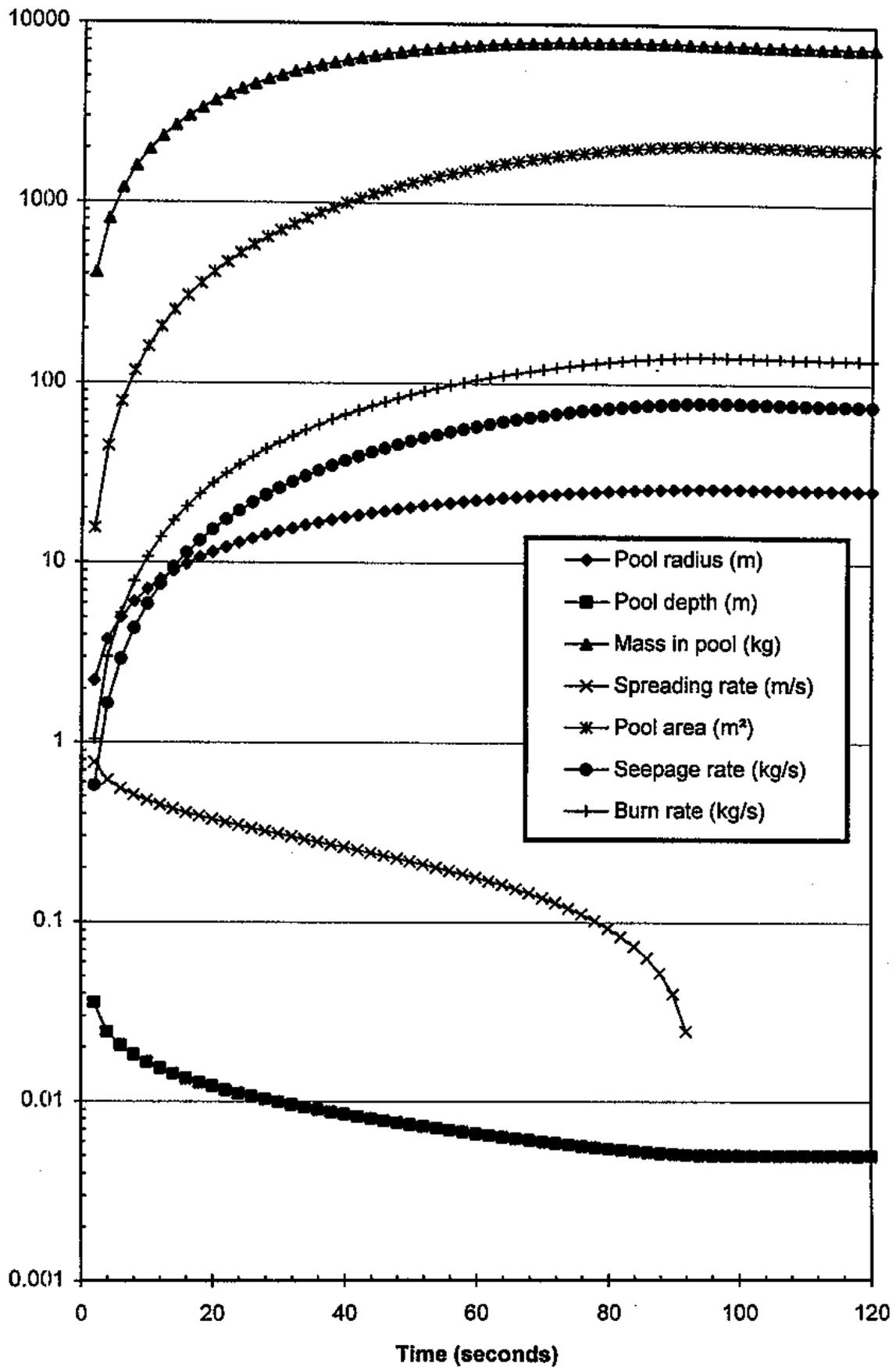


Figure 5.3

Time dependent parameters for the burning spreading pool from a 205 kg/s gasoline release on average soil

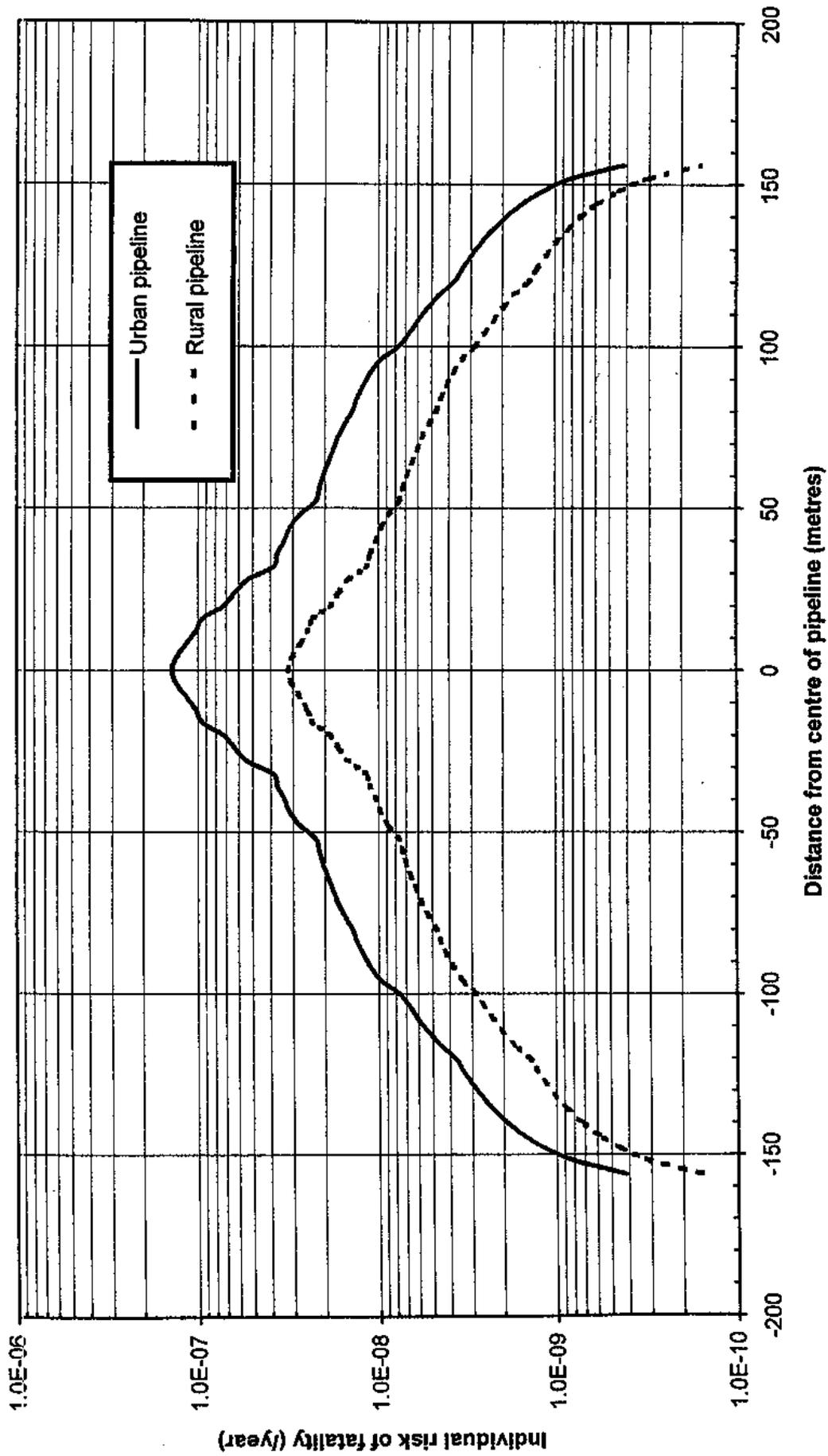


Figure 6.1
Individual risk transects for typical rural and urban gasoline pipelines in the UK

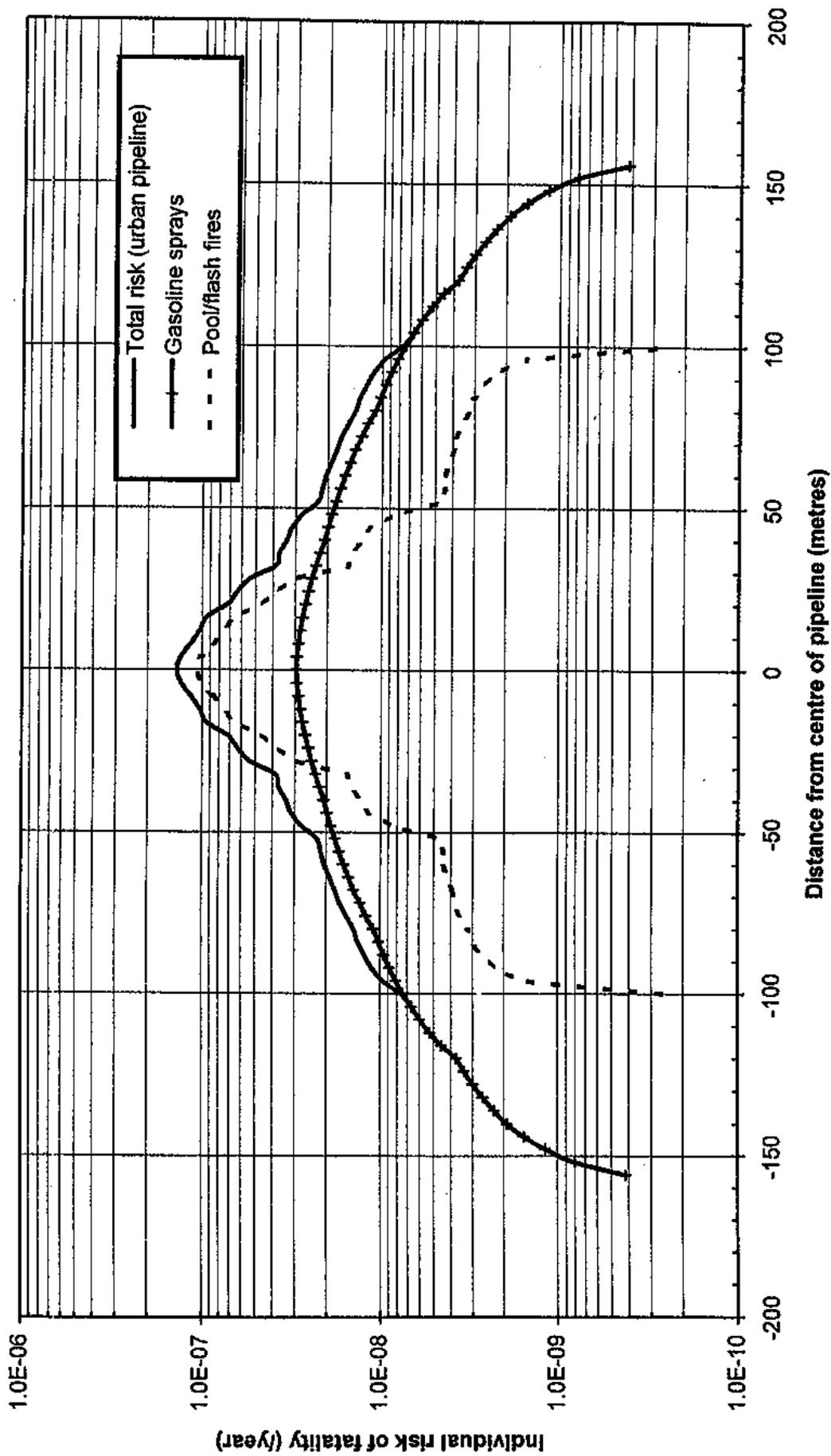


Figure 6.2

Individual risk transect for typical urban gasoline pipeline in the UK showing contribution to overall risk from sprays and pool/flash fires

APPENDIX 1 - EUROPEAN DATA (CONCAWE)

Table A1.1
CONCAWE incident descriptions

Date & Location	Description	Further details
29 September 1976 Europe (see also Table 4.2)	An 8 inch pipeline was ruptured due to agricultural works being undertaken without prior notice to the operating company. A tractor ruptured the line and was itself burnt out in the subsequent fire. All of the 153 m ³ of gasoline product released was burnt due to ignition from an unknown source, probably the tractor itself. The operating company were notified about the release by a third party.	Diameter: 8 inches. Wall thickness: 5.16 mm. Rural area.
6 May 1977 France	A pipeline split at a river crossing after a period of severe flooding. However, the cause of the incident was primarily third party activity as large quantities of material had been extracted from the river bed, thereby weakening the foundations of the river crossing. Bending moments arising from the flood resulted in the pipeline rupturing at a weld. A total of 2530 m ³ of naphtha were released. Isolation valves either side of the river crossing were shut after forty minutes.	Diameter: 20 inches. Wall thickness: 11.91 mm. Rural.
10 July 1979 Spain	The pipeline failed under to pressure after it had been weakened due to scratches caused by machinery. About 90 m ³ of JP4 aviation fuel spewed out of the rupture. The machinery was being used for earth movement in the area for a construction project.	Diameter: 8-12 inches. Wall thickness: 0.25-0.375 inches. Pressure at incident: 100 kg/cm ² .
17 December 1979 France	A leak was caused by an illegal tap made with improper equipment only suitable for water pipes (limited to 10 bar max.). The point which was chosen had a pressure of 40 bar and started to leak progressively jet fuel and domestic fuel. About 950 m ³ of product leaked in total.	Diameter: 10 inches. Wall thickness: 7.8 mm. Normal flow rate: 2000 m ³ /hr. Normal pressure: 40 bar. Incident flow rate: 1500 m ³ /hr. Industrial area.
1980 Italy	The cause of this incident was a fracture due to external corrosion. The pipeline was carrying heavy product when it ruptured. In total, about 325 m ³ of product were involved in the incident. The pipeline had no leak detection system. The product flowed beneath a road's base via storm water drains into a river. This river was contaminated over a 3 km stretch, over a width of 10 metres.	Diameter: 10¼ inches. Wall thickness: 6.35 mm. Flow rate at incident time: 300 m ³ /hr. Industrial area.

Date & Location	Description	Further details
1981 Italy	At 9:20 pm a dispatcher on duty received a third party telephone call advising him that a strong smell of hydrocarbon was present in an area about 15 km north east of Genoa Harbour in a hilly region. The pipeline was shut down immediately and all valves were closed. Emergency teams and the fire brigade discovered that 125 m ³ of gasoil had spilled from a crack on a welding joint on a section of pipeline which had been badly stressed by a landslide. The automatic leak detection system that was installed, based on input-output flow rate balancing, could not detect any leak because the pipeline was not completely filled up. The product found its way into a stream leading into a river (which was a torrent) leading into Genoa harbour. The gasoil was then recovered by a skimming vessel.	Diameter: 26 inches. Wall thickness: 9.52 mm. Normal flow rate: 2400 m ³ /hr Normal operating pressure: 72 bar. Pressure at incident: 24 bar. Incident flow rate: 1750 m ³ /hr. Leak rate: 260 m ³ . Hole size: 800 mm x 3 mm. Rural area.
18 February 1984 UK (see also: Table 4.2 Appendix 3)	An 8.62 inch pipeline failed due to internal corrosion caused by small amounts of HF acid in product (alkylate). The line failed at the lowest point of the overland section where water had collected and had formed an interface. The cause was verified by metallurgical examination. Fire occurred when a mechanical digger, excavating in marshland to expose the leak, severed a live electrical cable, igniting the 236 m ³ of alkylate.	Diameter: 219.1 mm. Wall thickness: 6.35 mm. Pressure at incident: 2 kg/cm ² . Hole size: 6 mm diameter. Flow rate at incident: 44.3 m ³ /hr. Estimated leak rate: 0.77 m ³ /hr Area affected: 200 m ² . Rural area.
19 August 1985 Italy	A spillage occurred during the packing phase of pumping. A sudden pressure drop was recorded in the control room and pumping was immediately stopped. At about the same time, the product spillage location, some 90 km from a refinery, was given via an external telephone call. A company emergency plan was activated. Emergency services were mobilised into the incident area, which was 2.5 km from a village. The product was partially flowing onto the ground and flowing into a stream which was a tributary of a major river. Although block valves were manually closed, the release continued for a further two hours because of the static head remaining in the pipeline. Meanwhile, emergency crews set about the task of isolating the incident area, minimising the risk of fire and explosion. The excavated pipe showed signs of damage sustained during third party activities. A land owner nearby reported that some work to remove tree stubs had been carried out earlier, and that it was possible that the bulldozer teeth caused the damage. Approximately 211 m ³ of product were involved in this incident.	Diameter: 8 inches Wall thickness: 5.56 mm. Flow rate at incident: 100 m ³ /hr. Pressure at time of incident: 70 bar. Leak rate: 100 m ³ /hr. Area affected by leak: 1000 m ² . Manual isolation valves closed after 80 minutes - stopping the leak.

Date & Location	Description	Further details
16 June 1986 Holland	A mechanic, performing maintenance work detected the leak on June 17, at 7.00 am. The automatic leak detection system did not detect the leak. The leak had occurred for less than 1 day, so it was not discovered helicopter surveillance (one every 10 days) or by pipeliners (inspections by car/foot every 3 months). It was discovered that a flange on the pipeline near a river crossing was leaking. Apparently some unknown third party activity had damaged the pipeline. A total of some 288 m ³ of oil products had leaked.	Diameter: 24 inches. Wall thickness: 12.7 mm. Flow rate at incident: 1000 m ³ /hr. Pressure at time of incident: 30 bar. Area affected by leak: 3000 m ² .
8 October 1986 UK	The pipeline was breached by the teeth of a chain excavator on the front of a large trenching machine which was laying land drains. A data logger at the central control centre detected a change in the line balance, which was immediately confirmed by a telephone call from the contractor who caused the damage. The pipeline was shut down. Approximately 280 m ³ of kerosene were spilled. The affected section of line was isolated to minimise the spillage and the emergency crew was able to uplift the product at a greater rate than the leakage. Some of the product passed through a new sewage pipe into a nearby sewage works. This product was collected and safely disposed of without any environmental effect upon the sewage works. Controlled drain down took place for a further four hours after the initial leak before the release stopped.	Diameter: 14 inches. Wall thickness: 0.281 inches. Flow rate at incident: 760 m ³ /hr. Pressure: 730 psi. Area affected by leakage: 100 m ² . Leak rate: 44 m ³ /hr. Hole size: 38 x 12 mm. Depth of cover: 0.96 m. Surveillance was conducted by helicopter on a 2 weekly basis. Rural area.
5 September 1988 Italy	Heavy rainfall and landslides caused a pipeline to fail near a river crossing. The pipeline failed due to being over-stressed by the heavy rainfall and landslides. Product migrated in a tributary of a major river and a large scale clean up operation was initiated.	Diameter: 10 inches. Wall thickness: 5.56 mm Flow rate at incident: 210 m ³ /hr. Pressure at incident: 56 kg/cm ² .
4 January 1989 France	A leak occurred when a municipal digger crashed into the line. The crash produced a hole 45 mm long and 12 mm wide. The pipeline had been scratched in several places. Repair operations involved performing 2 injections upstream and downstream of the rupture point in order to empty the line and recover product. The placement of floating barrages at the confluence of a stream with a river prevented the further spread of pollution. A total volume of some 660 m ³ of gasoline was released.	Diameter: 406.4 mm. Wall thickness: 8.74 mm. Leak rate: 44 m ³ /hr. Rural area.
28 July 1989 France	In order to build a path a bulldozer driver 'borrowed' earth from along the path of a pipeline and in doing so perforated the pipe during a loading manoeuvre. The release ignited sometime later and three bystanders were killed in the fire. 253 m ³ of naphtha of spewed out from the rupture at 36 m ³ /h. The pipeline was de-pressurised after fifty minutes. Clearly, in this incident there was inadequate emergency service control over the incident site, allowing the bystanders to be exposed to the fire.	Diameter: 16 inches. Wall thickness: 7.14 mm. Max. allowed pressure: 69 bar. Pressure at rupture time: 8 bar. Hole dimensions: 30 x 50 mm. Detection: immediate. Pipeline de-pressurisation: 50 min. Surveillance details: aerial 2 times per month, on foot 2 times per month. Rural area.

Date & Location	Description	Further details
16 September 1989 Italy	During the morning the automatic leak detection system pointed out something irregular in the line. The pipeline was shutdown immediately and all valves were closed. Emergency teams and the fire brigade were sent to inspect the line but it took a very long time to find the location of leak; it was only the next day, after a thorough survey, that the leak was discovered in a maize field. A strong smell of product (gasoline and gasoil) revealed the presence of a spillage. It was found that the spillage originated from a small hole. A total volume of 400 m ³ had been released.	Diameter: 10 inches. Wall thickness: 5.56 mm. Max. operating pressure: 112 bar. Max. normal operating pressure: 48 bar. Pressure at incident: 45 bar. Hole dimensions: 30 x 1 mm. Area affected: 2000 m ² . Rural area.
5 January 1990 France	From 10:50 hours, a sharp fall in pressure was detected. At 11 o'clock a telephone call from the person who caused the accident gave the exact leak location. The pipeline was shut down by 11:50. A farmer had damaged the pipeline with the blade of his bulldozer whilst doing unauthorised work. The product leaked into the farmer's field and entered a small river. In total, 189 m ³ of white oil product had leaked. Fortunately, few fish were killed by the release and the damage to the environment was considered to be minimal. Floating barrages were deployed on the river for the recovery of product. The recovery operations included placement of floating barrages and recovery of product by pumping, placement of drains and de-oilers, cleaning of stream, and site surveillance for over 6 months.	Diameter: 10¼ inches. Wall thickness: 7.09 mm. Max. operating pressure: 84 bar. Pressure at incident: 40 bar. Flow rate at incident: weak. Hole dimensions: 40x10 mm. Rural area.
3 April 1991 Italy	In the afternoon of April 3, 1991, a land-farmer informed a pipeline control room that a strong smell of gasoline came from one of his fields traversed by a pipeline. The pipeline apparently was not in operation. A micro crack was discovered which had been induced by a chemical reaction between water in the surrounding area. The spillage was not serious, but had occurred over a long period of time (62 hours) and involved about 80 m ³ of gasoline.	Diameter: 10 inches. Wall thickness: 5.56 mm. Max. allowed pressure: 112 bar. Max. normal operating pressure: 48 bar. Pressure at rupture time: 11 bar. Flow-rate at rupture time: 0 m ³ /hr. Hole dimensions: <1 mm. Rural area.

Date & Location	Description	Further details
5 May 1991 Germany	At 7:20 am a 20 inch pipeline, traversing an old mining area where excavation had ceased ten years earlier, failed and started to leak gasoline. The leak was discovered by the pipeline operations control centre. The duty shift engineer immediately initiated pipeline isolation which was completed within 6 minutes from the start of the incident i.e. pumps were switched off and all dampers closed. The pipeline ran parallel to a motorway from Germany to Holland, and was at a distance of only some 40 m from it. 275 m ³ of gasoline were released. Product was discharged down the embankment of the motorway into the motorway sewage system and from there into streams. As a result, product entered waterways 1 km away and travelled through some residential areas. The motorway was closed on both sides and the emergency services monitored petrol concentrations in air. Respiratory protection had to be worn because of the high concentration of gasoline in air. Product recovery work was hampered because of the high risk of ignition of the explosive gasoline atmosphere surrounding the incident area.	Diameter: 20 inches. Wall thickness: 14.2 mm. Flow rate at incident: 1800 m ³ /hr. Pressure at incident: 55 bar. Rural area.
1994 Country unknown	A 285 m ³ gross spillage of gasoline occurred after a pipeline was punctured at a river crossing when hit by an excavating machine digging along the side of the river. The leak was discovered by a third party. No product was recovered due the product lightness and evaporation. The river was affected by pollution.	Diameter: 10 inches. Wall thickness: 6.35 mm.
24 November 1994 Spain	The damage was caused by a digger that was ploughing. The leak was detected by a fall in pressure and confirmed by a telephone conversation with the person responsible for the damage and the police. The leak was discovered within ten minutes of the rupture occurring. Product sprayed onto nearby fruit trees and continued by soaking and drenching the earth. Later it began to filter slowly through to a nearby stream, where it was restricted by measures such as small ditches. The product was separated from the streams by means of an absorbent blanket and skimmer. Cleaning lasted during all of 1995. A total of 195 m ³ of gasoline sprayed from the 60 x 80 mm hole.	Diameter: 8 5/8 inches. Wall thickness: 6.35 mm. Flow rate at incident: 127 m ³ /hr. Pressure at rupture time: 50 kg/cm ² . Leak rate: 30 m ³ /hr. Area affected: 8000 m ² . Rural area.
26 December 1994 Italy	The loss of 90 m ³ of product was detected by a third party. As a result the emergency procedure was activated to control the pollution. The failure was caused by external corrosion along a bend and close to a dent. An intelligent pig was able to detect the metal loss, but gave an incorrect evaluation due to the dent. The pipeline was repaired in three days. The cold weather conditions limited the impact of pollution. The contaminated earth was removed and deposited in an authorised dump.	Diameter: 12 inches. Wall thickness: 6.35 mm. Max. allowed pressure: 95 bar. Pressure at rupture time: 10 bar. Flow-rate at rupture time: 240 m ³ /hr. Leak rate: 80 m ³ /hr. Hole dimensions: 20 x 20 mm. Rural area.

Date & Location	Description	Further details
4 December 1996 Spain (see also Table 4.1)	During the clearing of land, an excavator scoop struck a pipeline. This impact caused a rupture and subsequent fire. A lorry driver who was near the excavator was badly burned and died. All of the product flowing through the hole was allowed to burn to avoid the contamination of nearby aquifers.	Diameter: 8 5/8 inches. Wall thickness: 6.35 mm. Flow rate at incident: 0 m ³ /h. Pressure at incident: 35 kg/cm ² . Industrial area.

APPENDIX 2 - USA DATA (1985-1997)

Table A2.1
Incident descriptions based on DOT database

Date, location and report ID	Incident description provided by pipeline operator
11 October 1985 Town of Winnie Jefferson Texas 850142	<p>On October 11, 1985, an 8" natural gasoline pipeline was struck by a bulldozer operated by an employee of the Lower Neches Valley Authority. This resulted in a six-inch (6") break in the pipeline. There was no fire, explosion, or injury associated with this incident. Approximately 200 bbls of natural gasoline were spilled, 187 bbls recovered, with a net loss of 13 bbls. The incident occurred at a canal crossing where the pipeline rises out of the ground to make an overhead crossing of the canal. The pipeline was struck approximately 4" below ground level resulting in a six-inch (6") hole in the pipeline. The pipeline was well marked, with a pipeline warning sign located approximately two feet (2') from the break location. The bulldozer operator moved his machine back some twenty feet (20'), turned off the engine, and ran for safety. He then notified his supervisor, who contacted the Chevron Houston Controller Center. This centre notified the Chevron Pipeline Company Beaumont Division office. Emergency response and cleanup operations were immediately initiated. A small quantity of liquid gasoline seeped into the canal at the canal crossing. The gasoline was contained with a containment boom and recovered with absorbent pads. All gasoline on the water was recovered.</p>
21 October 1985 Sioux Woodbury Iowa 850163	<p>Contractor removing earth from over pipeline and struck line with highloader which punctured pipe. The pipeline was 48" deep prior to earth removal. Incident occurred about 100 yards from road where line markers were visible.</p>
13 November 1985 Douglas Minnesota 850148	<p>Pit leak occurred which caused a very small amount of gasoline to escape at the edge of a marsh. Pit would only leak at high pressure (approximately 700 psi).</p>
4 December 1985 Lake Alfred Polk Florida 850143	<p>Valve malfunction at the Taft Terminal in Orlando Florida created a high pressure condition to exist on our 10" pipeline. Tampa Pump Station shut down immediately when high pressure was evident. Taft Terminal corrected valve problem and we began pressure line but noted problem when line did not pressure up in normal manner. Began to pressure line segments to locate suspected leak site and two employees riding right-of-way to locate obvious leak. Leak located in Lake Alfred at 18:30 on December 4, 1985. Due to the swampy conditions at the leak site, fill dirt was hauled in to access the leak site and the line was exposed on Saturday December 7, 1985. Pipe coating had been scraped from the top of the line and creases were evident in the pipe from some previous construction around our pipeline. Recovery of lost product was initiated at time of leak location and by early morning of December 5, 1985, three recovery teams were cleaning up leak site. EPA and DER representatives were present during our repair and cleanup operations. We are presently monitoring skirt and absorbent booms now in place to protect any further contamination from small amounts of hydrocarbons leaching from surrounding vegetation.</p>

Date, location and report ID	Incident description provided by pipeline operator
22 February 1986 Muskegon Michigan 860047	<p>At 13:10 hours CST on February 22, 1986, Marathon Pipeline Company's operations centre was notified of a potential leak on our 8" line delivering to Amoco's Muskegon Terminal. The line was shut down at 13:12 hours and Marathon personnel were dispatched to the site. The line failed as result of a weld failure. Two absorbent booms were installed across Rudiman Creek by the coastguard. Marathon called in contractors to effect product recovery, cleanup and line repair. The gasoline leaked into the Muskegon sanitary sewer system and five minor basement fires were reported on the evening of February 22. The line was exposed and drained up on February 24. On February 25 the line was repaired with a factory bend and returned to service. A siphon dam has been installed downstream of our line crossing and approximately one barrel of product per day is being recovered. Throughout the entire leak response, Marathon received excellent co-operation from the Michigan Department of Natural Resources and the Muskegon Police, Fire and Public Works Department. 977 US barrels of gasoline leaked in total.</p>
3 March 1986 Zionsville Boone Indiana 860042	<p>At 20:30 hours CST, Marathon Pipeline Company received a call from a landowner along the right-of-way on Marathon's #2-10" products line. The landowner stated he smelled gasoline in the area. MPL personnel immediately proceeded to the site where they verified that the smell was due to a pipeline leak. At 20:47 hours, Marathon's control centre was notified and the line was shut down. Additional personnel were dispatched from Martinsville and Indianapolis to secure the area the evening of March 3. On March 4, Marathon personnel excavated the line, discovered a pinhole corrosion leak, clamped the leak and began recovery operations. The line was repaired on March 5 with a full encirclement sleeve and the recovery operation was completed.</p>
26 March 1986 McKenzie North Dakota 860051	<p>At approximately 9:00 am on March 26, 1986, station operators at Glendive, Montana, and Minot, North Dakota, reported low flow into terminals and loss of pressure on pipeline. Glendive Pump Station was immediately shut down and people were sent from Glendive and Minot to begin closing block valves. We received a report 35 minutes later that Northwind Construction Company, doing work for Williston Gas Company, had hit our pipeline near Keene, North Dakota. They were instructed on the location of the block valves for this area. Also vacuum trucks were dispatched to the site to recover product isolated in the trench for the 4" pipeline they were working on. They had not notified us of their intention to lay this line, although there was an air marker approximately one half mile to the east of the site, and line marker at the highway crossing approximately three fourths of a mile west of the site. Our maintenance crew proceeded to the site and repaired the puncture by installing 13" of new pipe.</p>
25 April 1986 Kern California 860071	<p>Contractor, operating a heavy equipment loader, struck the pipeline and caused a rupture.</p>
7 May 1986 Hardin Texas 860076	<p>Pipeline leak due to external corrosion. Leak discovered by routine aerial patrol. Leak occurred in an sparsely populated and wooded area. The pipeline was repaired using Plidco sleeves.</p>
14 May 1986 Elmhurst Du Page Illinois 860101	<p>On the evening of May 13, 1986, a car being towed by a tow truck came loose and struck a temporary power pole installed during highway reconstruction on Illinois Route 83. The power lines became tangled with a traffic signal controller and the resulting arc was grounded through a grounding rod which had been driven to the top of the pipeline. The grounding of the 4100 volt line resulted in a hole being burned through the pipeline. The leak was discovered on Wednesday May 14, 1986, by Elmhurst sewer treatment plant employees when gasoline started showing up in the plant through collection sewer lines.</p>

Date, location and report ID	Incident description provided by pipeline operator
3 June 1986 Toledo Lucas Ohio 860104	<p>Equipment operator was moving top soil from Sun Pipeline Company row to cover concrete and swamp area in an adjacent landfill site. Front end loader penetrated 8" steel line causing hole approximately 4"x6". No lead gasoline was released from the hole in the line and accumulated in a nearby depression. A small amount of the product was blown by the wind into a nearby swamp area. Equipment operator temporarily patched line with a water line clamp. Sun Pipeline Company responded to the leak immediately. Visible spilled product was recovered to the satisfaction of Ohio EPA representative on scene. Line repairs were made in approximately 2½ days and line was returned to service.</p>
7 June 1986 Wortham Freestone Texas 860118	<p>Landowner notified the station attendant about the leak at 7:45 pm. Repair crew arrived at the leak site at 8:30 pm. and started looking for the exact location of the leak. The pipeline leak was temporarily repaired with saddles, 3-10" with plate and #3 rubber plug. Station was notified and system was back to normal operation at 10:45 pm. Electric inspection is being run in this section for evaluation of the line pipe's integrity. Railroad Commission of Texas ordered and so contaminated soil is being hauled by chemical waste management to a dump site at Carlyss, Louisiana. Hauling operation is still going on. Slowdown is caused by the recent heavy rains in the area.</p>
13 June 1986 Anne Arundel Co. Maryland 860113	<p>At 10:30 hours on June 13, 1986, a telephone call was received at Colonial's Dorsey Junction, Maryland, facility from a contractor advising that he had just ruptured a Colonial pipeline in a new development near the Baltimore Washington International Airport (BWI). Construction activities at the site have been in progress for more than six months and the pipelines have been located and marked by Colonial. A contractor was removing spoil from the right-of-way with a front-end loader without giving notice to Colonial and misjudged the depth of the pipeline causing the accident. Three pipelines are located in the right-of-way. The 6" diameter BWI delivery pipeline was idle at the time and the other two operating pipelines were shut down and isolated because the contractor reported a gasoline spill. It was found that the 6" BWI had been struck by aviation kerosene. The contractor used his machine to construct an earthen dike around the leak site to contain the oil. Colonial emergency personnel recovered 87 bbls of the spilled oil leaving a net loss of 19 bbl. The Anne Arundel County Fire and Police Department were notified by Colonial and responded to the scene. The federal EPA and Maryland Department of water resources were notified and responded to the site. A repair clamp was bolted around the damaged pipe to prevent additional product leakage until the area was made safe for welding. The repair clamp was then welded to the pipe to serve as a temporary repair until the damaged section of pipe can be removed and replaced.</p>
16 June 1986 Valencia County New Mexico 860108	<p>A Valencia County road maintainer (grader) was deepening the bar ditch alongside a gravelled road maintained by the county. The maintainers blade struck Chevron Pipeline's 6" products line, resulting in a release of unleaded gasoline from the line. The maintainer operator (Andrew Sair) immediately backed away from the site and proceeded to a nearby house to call the sheriff's department. The sheriff and fire department responded immediately to the scene and Don Pittman (Chevron Pipeline supervisor) was contacted at 9:30 am by the Public Service Commission of New Mexico. The El Paso pipeline dispatcher was notified at 9:31 am to shut down the line. The line was shut down by 9:35 am. The Valencia County Sheriff's and Fire Department had closed off the road and diverted traffic. At 9:35 am Chevron Pipeline personnel were on their way to the scene, and to close MP 220 block valve. Don Pittman and Rick Fillingner arrived on the scene at 10:10 am. Product was spraying 20 feet into air. Fire department was damming bar ditch to contain product, situation was under control. MP 220 block valve closed at 10:15 am. Don Pittman called Assistant Manager Valencia County (Mrs Barbara Beattie). Don Pittman showed all parties present (county sheriff, fire and highway patrol) the in place marker signs at road crossing. With contract and company crews line was repaired and back in service by 8:00 pm on June 16, 1986. The amount of product spilled was 1140 bbls. No product was recovered from the ground.</p>

Date, location and report ID	Incident description provided by pipeline operator
8 July 1986 Mounds View Ramsey County Minnesota 860129	<p>On July 7, unleaded gasoline was being pumped through the #2-8" pipeline from Minneapolis, Minnesota to the Duluth/Superior area. At 04:00 hours on July 8 a product switch from unleaded gasoline to #2 fuel oil was made. At about 04:20 hours the Minneapolis Station operator noticed relays dropping in the unit control cabinet and proceeded to inspect the pump unit and piping. At 04:21 hours, the Tulsa dispatcher received an alarm that indicated a pressure drop on the station discharge. He contacted the station operator to confirm readings and at 04:24 hours, executed an emergency stop of the pump unit, then proceeded to close the mainline gate valves. Emergency response personnel were called to look for a suspected leak. At 05:00 hours, Ramsey County Sheriff's Department called and reported a fire on Long Lake Road in Mounds View.</p>
14 July 1986 Brooklyn Kings County New York 860130	<p>On Monday, July 14, 1986, at 11:20 hours, a model 983 caterpillar front-end loader ruptured the pipeline by striking it with a tooth of the bucket causing a 4-inch long opening in our 12-inch pipeline which originates in Linden, New Jersey, and terminates in Long Island City, New York. This occurred in Brooklyn, Kings County, New York. At the time of the rupture, the pipeline was not operating but was under normal closed in pressure. This allowed gasoline to escape and vaporise. No ignition of vapours occurred. Approximately 159 barrels were released and to date we have recovered 60 barrels. A scavenger-type initial rupture, many barrels were vaporised, and, therefore, there will not be a total recovery.</p>
24 July 1986 Little Rock Pulaski Arkansas 860125	<p>On July 24, 1986, at approximately 11:38 hours, a road gang at the Department of Corrections facility at Wrightsville, Arkansas, punctured Texas Eastern Pipeline Company's 20-inch P-2 pipeline with a road grader. Personnel at the facility immediately notified Texas Eastern and the line was shut down within a few minutes. The upstream valve was closed at approximately 12:00 hours and the downstream valve at approximately 13:32 hours. Approximately 100 barrels were spilled, but was totally contained in drainage ditches and returned to Texas Eastern tankage. In accordance with the Arkansas EPA officials, the earth on which the product spilled was picked up and spread out to aerate. The line was repaired by welding a full encirclement sleeve over the damaged area. The pipeline was placed back in service at 00:23 hours on July 25, 1986.</p>
26 July 1986 Taylor Texas 860124	<p>BE & K Communications was trenching in a communication cable. The trenching plough penetrated a 12" casing and cut into the 8" product line.</p>
28 July 1986 Kansas City Clay Missouri 860131	<p>On Monday, July 28, 1986, at 09:40 hours, Damon Pursell Construction Company, notified the division office that a dozer operator struck Williams Pipeline Company's #6-12" pipeline. The dozer was removing soil in preparation for an 8' x 9' box culvert at the south-east corner of Barry Road and Highway 169 intersection in Kansas City, Missouri. The dozer blade left an 8" gouge in the line, resulting in a leak of approximately 1749 barrels of unleaded gasoline. The line was shut down and the gate valve at MP 12+18 was closed immediately. A check valve is in place at MP 2+52 which isolates on the south side of the leak. Three (3) maintenance crews and one (1) environmental contractor were dispatched to the site for leak containment, cleanup and line repairs. A 200' section of line was spooled in so that repairs could be made in a gasoline vapour-free environment. The Kansas City Fire Department, Sanitation Department, federal EPA, and the Missouri Department of Natural Resources were co-operative and were complimentary of our response and cleanup efforts. The regional office of the federal EPA was notified of the accident at 10:47 hours, the Missouri Department of Natural Resources at 10:54 hours, and the National Response Center at 16:15 hours. The damaged pipe has been removed and will be kept on hand for 60 days at the Kansas City warehouse. The line was repaired and returned to service at 04:45 hours on July 29, 1986. Cleanup should be completed by August 4, 1986.</p>

Date, location and report ID	Incident description provided by pipeline operator
3 September 1986 Sanders County Montana 860143	Continental Pipeline Company (operator of Yellowstone pipeline) was notified at approximately 11:30 am on Wednesday, September 3, 1986 by the Sanders County sheriff that oil had been sighted in the Flathead River near a Yellowstone pipeline overhead crossing. The pipeline was shut in at the time of this notification. Company personnel located the leak and closed the adjacent block valves. The leak, which occurred in a pipe overbend, was repaired by company and contract personnel, and cleanup efforts were begun immediately.
4 September 1986 Lockwood Yellowstone Montana 860142	At approximately 12:00 hours (24 hour clock) on September 4, 1986, operator at Laurel Station started up station to pack the line following a routine shutdown to pass a pig at Billings Station. Start-up was normal. Approximately 3 minutes after start-up, Billings Station lost suction pressure from Laurel - system immediately was shut down and Billings Station was notified to block in line. Maintenance gang working at tank farm upstream closed block valve shortly thereafter. Personnel were dispatched from three sources to locate leak. No outside sources reported an observed leak. At 12:15 hours leak was located by our forces, containment procedures and emergency procedures were invoked immediately. The leak occurred in the bottom of an irrigation ditch, consequently all of the gasoline was discharged into the ditch, and ran nearly one mile downstream before it was stopped. Nearby businesses and residences were evacuated by the sheriff's department for 24 hours. Proper authorities were notified, and cleanup began 15:00 hours of the same day. No gasoline was discharged to the Yellowstone River, no gasoline has been allowed into nearby water wells. Spill site cleanup continues as of this date (September 15, 1986) and will continue to satisfaction of all authorities.
21 September 1986 Liberty Clay County Missouri 860166	'One-call' is just starting in Missouri. Flair, Inc. of Sikeston, Missouri was installing a fibre optic cable for Southwestern Bell across a pasture owned by Lewis Tapps. A dozer pulling a large ripper bar mistook the pipeline for an underground rock structure and punched a 4"x6" elliptical hole into the side of the 12-inch line. The work was being done on a Sunday and apparently the construction drawings made no reference to Amoco's buried line. Amoco had not been notified. The pipeline's location was prominently marked with the appropriate warning signs and brightly coloured posts at the points it crossed the property owners' fence lines. The pipeline control centre identified the leak almost immediately with a confirming phone call received from the contractor at 16:27 CDT, 7 minutes after the incident occurred. The line was shut down, the Clay County Sheriff's Office was notified, and a pipeline employee was dispatched to close manually operated block valves on each side of the leak site. The valve 3 miles north (upstream) of the leak was closed at 17:10 CDT with the valve 6 miles south of the leak closed 45 minutes later. A vacuum truck was dispatched to the leak site, but the bulk of the gasoline had either soaked into the ground or evaporated (90 degrees ambient temperatures). Containment structures were placed in an adjoining dry creek bed. Two weeks of extensive rainfall in the area have brought small amounts of hydrocarbons to the surface and recovery operations are continuing. A subsurface drilling program is planned to determine the lateral and vertical extent of residual hydrocarbons in the soil with remedial action to be taken as appropriate.
26 September 1986 Wright Minnesota 860170	Pipeline was ruptured by a landscape contractor who was in the process of removing a tree with a hydraulic tree spade. The machine punctured the line allowing approximately 583 bbls of unleaded gasoline to escape. The product was contained in an area 30' x 200', and did not get on any water. The contractor was aware the pipeline was in the area, but did not bother to call to have it located. No injuries or damages were sustained. Cleanup operations are in progress.

Date, location and report ID	Incident description provided by pipeline operator
<p>7 October 1986 King of Prussia Montgomery Pennsylvania</p> <p>860172</p>	<p>At approximately 9:55 am on October 7, 1986, a pressure drop was observed at SPL's Twin Oaks Station. At approximately 10:00 am Twin Oaks operator advised Glenhardie and by 10:04 Glenhardie dispatcher advised Twin Oaks to shut down the line after checking line balances. At approximately 10:40 am Philadelphia Gear called SPL and reported product coming out of the ground at their plant. Concurrently, SPL personnel were dispatched to shut down the main line block valves. The National Response Center was immediately notified and company and contract personnel were called to the scene. Appropriate federal, state and local agencies advised. Requests for additional SPL and contractual personnel. Police and fire personnel directed security and evacuation efforts. Earthen dams constructed across Abrams Creek to prevent migration of free product into the Schuylkill River and to assist in cleanup of product. Throughout the night, state, federal and local officials worked along with SPL to monitor the situation and continued cleanup and water flushing operations. This pipeline was relocated in 1965 and 66, and our engineering department states that the pipe was tested; however, the pressure test charts are not available.</p>
<p>20 October 1986 Ardmore Carter Oklahoma</p> <p>860175</p>	<p>An outside contractor hit line with ditching machine causing a gouge in the pipe.</p>
<p>27 October 1986 Dallas Texas</p> <p>860188</p>	<p>A contractor employed by a major local developer was cleaning out a drainage ditch with a backhoe. The contractor also had dug a hole adjacent to the drainage ditch to dispose of silt and soil from the ditch. While enlarging the disposal pit, the contractor hit Explorer's 12" diameter petroleum products pipeline with the backhoe bucket. The pipeline was approx. 9 feet deep at the location of the disposal pit. The teeth on the backhoe bucket ripped an 8" long, 2" wide hole in the side of the pipeline at approximately 5:00 o'clock position. The pipeline was shutdown at the time with 71 psig pressure. Nolead gas spilled from the pipeline and was contained in the disposal pit. The contractor called Explorer's dispatcher in Tulsa, Oklahoma, seven minutes after hitting. Maintenance contractor and vacuum trucks, local fire and police departments were also contacted. Drain-up was almost immediate, repairs were made with a new section of pipe connected with weld plus ends. Permanent welding was delayed until gas vapours were completely eliminated. The nearest pipeline marker was approximately 150 feet from the leak. However, the contractor had to drive by several pipeline markers located in the field while gaining access to the drainage ditch. Explorer had not been previously contacted about the nature or date of the contractor's work.</p>
<p>21 November 1986 Dale Oklahoma</p> <p>860194</p>	<p>Okemah Pipeline Construction Company was working on removing an old Sun Oil pipeline that ran perpendicular to our eight inch line. In the process of digging, their backhoe hit our line that crosses the Crutcho Creek. Our line was buried some +24" below the bottom of creek. They hit our line in the south bank of the creek. The line was hit around 10:45 am and we were notified immediately by contractor. Booms were deployed on each side of leak and two earthen dams were installed about 400 yards downstream of the downstream boom. Product is being picked up. After inspection of leak area, the pipe will be replaced.</p>
<p>22 November 1986 Tustin Orange County California</p> <p>870007</p>	<p>At approximately 12:50 on November 22, 1986, Orange Station personnel advised our products movement section of abnormal line pressure and flow rates. Approximately 13:05 on November 22, 1986, products movement received a call from Shell Oil Company via the Los Angeles Basin Leak Wheel of a pipeline leak south of Red Hill Avenue, on Santa Fe railroad right-of-way paralleling Moulton Parkway in Tustin, California. Line was shut down at 13:11 on November 22, 1986, and field forces notified. Block valves were closed on both sides of ruptured section of pipe. The Orange County Fire Department was the first emergency response personnel at the leak site and arranged to construct an earthen dam in a flood control channel where most of the escaping gasoline was flowing. Vacuum trucks recovered some of the gasoline at the leak site and dam site. The ruptured pipeline section was removed and new section installed.</p>

Date, location and report ID	Incident description provided by pipeline operator
1 December 1986 Whitwell Marion County Tennessee 870017	<p>On December 1, 1986, at 03:00 hours, the Chattanooga to Nashville, Tennessee, 8" diameter pipeline was shut down by automatic safety devices due to a pump bearing failure at the Murfreesboro, Tennessee, Pump Station. The unit was repaired, and at 04:00 hours an attempt was made to restart the pipeline, but the pump station upstream of Murfreesboro would not start due to low suction pressure. The pipeline was secured, and emergency personnel were alerted to a possible leak in the pipeline. The Marion County, Tennessee, Sheriff's Office was notified at 08:00 hours that a possible kerosene spill existed from the pipeline in the vicinity of Whitwell, Tennessee. At 10:00 hours the leak site was located on a steep slope of the south side of Whitwell mountain. A 15 foot long split in the pipe longitudinal seam was the source of the failure. Several dents in the pipe were observed along the longitudinal seam which was located near the 12 o'clock position. It is believed that the pipe was possibly damaged by contractor equipment engaged in constructing an adjacent parallel Colonial 10" diameter pipeline in 1972. Approximately 600 bbls of kerosene had sprayed from the pipe onto trees and rocks and was appearing on the surface of the mountain slope below the leak site. All of the 60 foot long joint of pipe containing the split was removed from the pipeline and replaced.</p>
21 December 1986 Colleyville Tarrant Texas 870068	<p>The cause of the accident was a broken girth weld. This particular weld showed to have no welding penetration on the inside of the pipe. This was not a recent weld, but looked to have been done in the last 25 years.</p>
30 December 1986 Martinez Contra Costa California 870020	<p>The rupture was at a point where line had been damaged sometime in the past and damage was never reported.</p>
7 January 1987 Jim Wells Texas 870057	<p>Isolated external corrosion pitting penetrated the pipe wall resulting in the natural gasoline spill. A temporary leak clamp was installed to stop the leak, the damaged section of pipe will be replaced with new pipe.</p>
22 January 1987 Nueces Texas 870050	<p>Isolated external corrosion pitting penetrated the pipe wall resulting in the natural gasoline spill. A temporary leak clamp was installed to stop the leak, the damaged section of pipe will be replaced with new pipe.</p>
2 February 1987 Freeman Cass Missouri 870054	<p>On February 2, 1987, at 09:00 hours CST a scraper was launched from Freeman Station which is approximately 1.4 miles south of the leak site. Prior to this, the last scraper was run on February 4, 1986. At about the time the scraper reached what turned out to be the leak site, our instrumentation indicated a drop in pressure at Sugar Creek Terminal which is 34 miles downstream (north) of the leak site. Simultaneously, an increase in flow rate occurred at Mayview Station, the nearest upstream pumping station. The operator on duty immediately began shutting down the line down at 10:14 hours CST. About 5 minutes later a call was received from Mr Gary Richardson indicating a leak was occurring on his property. After our initial response, subsequent inspection of the break showed a telephone cable parallel to and directly above our pipeline. Conclusive signs of external mechanical damage were apparent on the pipeline. Further investigation revealed that in July of 1986 a contractor for the local telephone company ploughed in a direct burial cable to provide service to the Richardson home which was then under construction. The split which was 21 inches long and ran directly along a 10 foot track of overlapping dents or peen marks on the pipeline. A cross sectional view through the split showed a flattening of the line. Our records indicate that we did not receive a line location request from the telephone company.</p>

Date, location and report ID	Incident description provided by pipeline operator
<p>28 February 1987 Palo Pinto Texas 870051</p>	<p>At approximately 6 pm Friday, February 27, 1987, Chevron Pipeline Company shut down the section of its pipeline that delivers motor gasoline to Eastland, located approximately 100 miles west of Fort Worth. The company's metering system had shown a shortage of product delivery indicating a problem, which later was discovered to be a leak. Inspection of the pipeline began immediately, but was hindered by heavy rain and resulting high water. Response crews were alerted. Spill containment equipment was deployed, and appropriate governmental agencies notified. At daylight Saturday morning, crews continued inspecting the pipeline by walking the right-of-way and by aerial surveillance. At 10 am Saturday, February 28, 1987, the leak was confirmed and located some 20 miles south-west of Mineral Wells, Texas, 35 miles west of Fort Worth. The leak was stopped and visible surface gasoline was contained and recovered using vacuum trucks, it is estimated at least 400 barrels of leaded gasoline was spilled. The pipeline leak occurred in a flooded creek that flowed into other tributaries. Cleanup efforts were initiated using the spill containment equipment and vacuum trucks. As late as 9 pm Saturday, inspections by Chevron with the EPA and city water department showed no gasoline beyond the spill location. At 6 am Sunday, March 1, 1987, the water treatment plant of the city of Mineral Wells detected the odour of gasoline. Around 10 am, three individuals in one of the outlying communities reported a gasoline odour in their water. As a precautionary measure, local citizens were advised to not drink the water. This information was communicated by local television and radio stations. Chevron arranged the delivery of bottled water to Mineral Wells and assisted the city in dispensing it to area citizens. Special arrangements were made for deliveries to nursing homes and to people confined to their homes. Water was also set aside for the delivery to local school districts. Chevron will continue to provide bottled water until Chevron and the city of Mineral Wells with the state department of health are assured the water supply is safe to drink. Chevron sent water samples collected Sunday to a Fort Worth laboratory for chromatographic analysis. The results of these analyses showed less than 1 ppm gasoline. Additional testing will be conducted to confirm these results. Chevron continues around-the-clock monitoring for the presence of gasoline at the city's water treatment plant and the leak site. Chevron is also providing personnel with radio-equipped trucks to assist the Mineral Wells water department. Chevron is also continuing to work with the city in a co-operative effort to resolve the problem. The city of Mineral Wells last night, March 2, 1987, started an extensive treatment process on advice of their newly hired consultant, Aid Consulting Engineers, Inc. of Dallas, Texas. The process will establish a base line evaluation of the total water system by comprehensive sampling. Activated carbon (charcoal) was added at the wet well which takes suction from Palo Pinto Creek, the major source of the city's water supply. Charcoal was also added at the weirs in the main water treatment plant. The charcoal removes impurities from the water, aromatics in particular. The consultant also advised that the water system be flushed, after the charcoal is in place, by opening fire hydrants at the most distant points from the main treatment plant. Progress will be measured by additional sampling. At midnight Sunday, March 2, 1987, the city put into operation its auxiliary water treatment facility which utilises water from Mineral Wells Lake nearby. This system, however, is only capable of supplying about one third of the total city water usage. Tolerance limits obtained by the city from the Texas department of health and the EPA are: toluene, less than 2.0 ppm; benzene, less than 0.05 ppm; xylene, less than 1.0 ppm; and lead, less than 0.05 ppm. Water analyses on samples sent by Chevron to Talem laboratory in Fort Worth showed toluene and xylene levels within tolerance. Initial results obtained Sunday ranged from 0.006 ppm as the highest level found. While encouraging, these results are not conclusive and further testing will be required. Most of the tests for lead content showed less than the 0.05 ppm maximum. The number of telephone calls to city hall from residents is increasing with questions including the effects of the water on nursery plant stock, fish and household pets. To assist in resolving these and similar questions, a toxicologist and an insurance representative are en route from Chevron headquarters in San Francisco. Chevron continues supplying bottled water to area residents, schools, nursing homes, etc. The excellent working relationships between Chevron and city personnel continues. Over 30 company and contact employees continue working around the clock on the final cleanup of the spill location and creek. Planning is underway to make permanent repairs to the pipeline.</p>

Date, location and report ID	Incident description provided by pipeline operator
5 March 1987 Ewa Beach Honolulu Hawaii 870078	The pipeline was shut down due to discrepancy on a product transfer. Line was pressured up to 450 psig (which is below design pressure) and blocked in. Pressure dropped off. The pipeline was displaced with water then pressured up to 950 psig. The leak was then discovered and repaired on March 5. The National Response Center, coastguard and the state department of health were notified of the leak.
20 March 1987 Harris Texas 870093	While repairing the leak described in Report ID 870095, we elected to inspect other adjacent pipelines. We found an extremely small 'seep' coming from the weld of stopple fitting on the Baytown-Irving product line. The stopple fitting was cut out and replaced with new pipe. The Baytown-Irving products line resumed service at 17:41 hours on March 26. Cleanup operations were complete on March 27, 1987.
20 March 1987 Harris Texas 870095	The US Coastguard called Jesse Shead (Exxon USA) to report a 20' x 20' sheen on the west bank of the San Jacinto River, north of the I-10 crossing. Mr. Shead called Exxon Pipeline Company's (EPC) oil traffic control centre at 10:55 hours. The Satsuma-Baytown 20" crude line, the Baytown-Irving 10" products line, and the Baytown-Aldine 8" products line were immediately shut down. EPC field personnel arrived on the scene at 11:15 hours and the sheen was located at 12:00 hours. Booms were immediately put out to contain the leak. It was not apparent that the sheen was caused by a pipeline leak, so the Baytown-Irving products line and the Satsuma-Baytown 20" crude line resumed operations at 14:30 hours. The cause of the sheen was confirmed to be a pipeline leak at 16:30 hours. The leak was found to be a failed asbestos-type gasket in a stopple fitting on the Baytown-Aldine products line. The gasket was replaced with a metal, spiral wound gasket to prevent a recurrent leak. The line was placed back into service at 18:25 hours on March 21. Cleanup operations were completed on March 27, 1987.
26 March 1987 Caroline County Virginia 870104	The accident occurred in a rural area of Caroline County Virginia at 7:30 pm EST on March 26, 1987. A contractor was burying debris after having performed a controlled burning of a house approximately 75 feet from Plantation's 12 inch, .203" wall thickness, X-52 grade petroleum products pipeline. The contractor had dug a 30' x 3.5' hole. A 3.5" x 2" hole was torn in the pipeline at the 9 o'clock position looking downstream. The JP-5 fuel in the line immediately caught fire. The source of ignition was the remains of the burned structure when the product (JP-5) under pressure reached it. Two persons required hospital treatment. The owner of the loader who was standing behind it suffered minor burns to his arm. The operator who had ingested fuel was retained at the hospital for observation. The applicable 'one-call' centre had not been notified of the excavation. The closest line marker was 75 feet from the point of damage and three other line markers were within line of sight. 952 US barrels of jet fuel leaked in total.
31 March 1987 Natrona County Wyoming 870130	At 17:11 on March 31, 1987, a 400 pound decrease in discharge pressure, along with an increase in flow rate, was noted at Casper Station. The pipeline was shut down at 17:12 by Houston Oil Movements. Air search of pipeline right-of-way started at 18:00 and continued until dark, then employees drove to all locations along pipeline accessible by vehicle but could not detect any product or product odour. On April 1, at 05:30, two employees were dispatched on ATVs to MP 278 to close the block valve and look for the leak on the south side of Casper Mountain. At the same time, two other employees on snowmobiles were dispatched to look for the leak on Casper Mountain. At 10:10, the Natrona County Sheriff's Department confirmed a leak with product in Bolton Creek. Product had followed Bolton Creek and entered the North Platte River at a point near where the North Platte River crossed Wyoming Highway 220. Numerous containment booms were placed across Bolton Creek and the North Platte River. Siphon dams were also constructed on Bolton Creek. Product pick up with absorbent pads and vacuum trucks was started on a twenty-four-per-day schedule. Ninety-six feet of pipe was replaced at leak site with 8", .188" wall thickness, X-52, ERW pipe which had been pre-tested. Approximately 20' of pipe, which included the section of pipe that was ruptured, was sent to Conoco's research and development laboratory in Ponca City, Oklahoma to determine the exact cause of failure.

Date, location and report ID	Incident description provided by pipeline operator
8 April 1987 Paimyra Nebraska 870165	<p>A leak was discovered on April 8, 1987, at milepost 24+19 by a local farmer. The line was shut down and gate valves were closed to isolate the leak. Previous third party damage was identified as the cause of the failure. Permanent repairs were completed, and the line resumed operation on April 10, 1987. Officials from the Nebraska Department of Environmental Control (NDEC) inspected the leak site and required that a site assessment be completed and a written report submitted to their department for review. The NDEC approved our proposal for assessment on June 5, 1987. Based on this approved plan, the total cleanup is estimated to be \$25,000. Until the time of the state's approval, it was not fully clear what the extent or cost of the cleanup measures would be.</p>
9 April 1987 Miami Kansas 870112	<p>A back hoe operator employed by Killough Inc. Ottawa Kansas struck the #3-8" line puncturing it. The line had been marked by Williams Pipeline Company prior to the contractor beginning work.</p>
21 April 1987 Sugar Creek Jackson Missouri 870125	<p>A heavy rainstorm which occurred early the morning of April 21, 1987, triggered a series of slope failures resulting in the fracture of Amoco's 8 inch pipeline within the city limits of Sugar Creek, Missouri. Instrumentation at the Sugar Creek Control Center detected the possibility of a leak and the valves and the system were shut down. Personnel were dispatched to close gate valves and to physically walk the pipeline in the suspect area because of unusual geological conditions. The leak was not located until 09:30 hours CDT. The pipe was uncovered and the fracture was confirmed at 11:45 CDT. The highly unstable nature of the soil conditions necessitated a 427 foot pipeline relocation. The line was returned to operation on April 25, 1987.</p>
1 May 1987 Chesterfield Co. Virginia 870113	<p>The accident occurred in Chesterfield County Virginia at 8:07 am EDT on May 1, 1987. Plantation's 12-inch, .203" wall thickness, X-52 grade petroleum products pipeline runs north, parallel to a Virginia Power high voltage transmission line between the power line and a heavily wooded area. The leak occurred just south of the construction area for Virginia Highway 76. The pipeline ruptured at the 10 o'clock position looking north. The split was 32 inches long and 3 inches wide at its broadest point. The ERW pipe seam was at the 12 o'clock position. There were no operational upsets and the pipeline was operating within design criteria. The failed section of pipe revealed evidence of lamination. The entire joint of pipe was replaced. 1647 barrels of unleaded regular gasoline escaped into the wooded area. A portion of the product traversed approximately one half mile along a creek and was contained on Evergreen Lake. There were no injuries. As requested by Dr Douglas Chisholm, Chief, Research Unit of the Office of Pipeline Safety, a laboratory analysis of the failed section of 12 inch pipe will be forwarded under separate cover as soon as it is received.</p>
8 May 1987 Casper Natrona 870139	<p>Pipeline was hit by a John Deere 544 front end loader. Hole in pipeline was 1½" wide by 3" long.</p>
11 June 1987 Constantine St Joseph Michigan 880117	<p>In June of 1987, a local landowner complained of a dead oak tree and some stunted crops. Upon investigation, it was discovered that a mainline block valve flange was leaking. Based on the area of stunted crops, it was decided that an investigation was warranted. A series of observation wells revealed a considerable volume of product on the water table. From that point to present, we have been working with the Michigan Department of Natural Resources to recover the product and remediate the site.</p>

Date, location and report ID	Incident description provided by pipeline operator
11 June 1987 Centreville Fairfax County Virginia 870147	A contractor was operating a D-9 bulldozer to pull a rock ripper (plough) to facilitate grading for a side walk to be constructed across the Colonial pipeline right-of-way in the Singleton's Grove subdivision. The ripper struck and punctured the 32" diameter Greensboro, North Carolina to Dorsey Junction, Maryland pipeline at 09:47 hours EDT on June 11, 1987. Prior to the start of construction in the development the pipeline had 38" of cover over the pipe, but grading activity before the accident occurred had left approximately 30" of cover over the pipe at the time of the puncture. A line marker was in place and plainly visible 25.5 feet from this point. The pipeline was transporting unleaded gasoline at a pressure of 190 psi and flow rate of approximately 14,300 bph when the incident occurred. Gasoline spewed from the pipe for about three minutes and was blown by the wind away from the tractor, over the construction office about 100 feet from the rupture and dispersed into a wooded area of about three acres. A Colonial Pipeline Company employee had just arrived at the construction office to inquire about the location of another construction project when the accident happened. The employee immediately ran to equipment being operated in the general area warning the operators to shut down their machines and vacate the area. The employee then obtained a ride to the fire station a few blocks away to notify Fairfax County.
16 June 1987 Wayland Massachusetts 870135	On the morning of June 16, 1987, E.B. Rotondi and Sons, Inc. were operating their rotary drill at the intersection of Mainstone Road and Coltsway in Wayland, Massachusetts, for the purpose of trenching a cable for continental cablevision. They were aware our line was there and the road had been marked with yellow reflective paint and regular pipeline marker poles were adjacent. They failed to call Shell for the location or depth and were not hand digging in a safety zone as prescribed by Massachusetts one call system (Dig Safe). No shell representative was on hand to witness the crossing.
9 July 1987 Tyler Texas 870151	Nearby landowner reported the leak to the Houston dispatching office at 5:55 pm, and system was shutdown at 6:00 pm. Incident was confirmed at 8:30 pm. All concerned federal and state agencies were informed of the incident by 9:30 pm. External corrosion caused the incident and part of it seeped into a nearby creek branch. Product was recovered by vacuum trucks and absorbent pads and was returned for storage. Plidco sleeve was welded to the pipe for permanent repairs.
16 July 1987 Corpus Christi Nueces Texas 870190	The Corpus Christi to San Antonio refined products pipeline was showing a shortage which could not be resolved. While the system was shut down for other work, the south section of the pipeline was pressure tested. It was determined from this test that there was a leak. By walking the pipeline, a small amount of regular gasoline was found on Heldenfels Ditch. This gasoline was contained with a boom and picked up with a vacuum truck, absorbent pads were used to clean up that portion of the gasoline that remained. Three small pinholes were found in the pipe which were caused by external corrosion. The damaged section of pipe has been replaced with new coated line pipe.
23 July 1987 Kootenai Idaho 870188	Conoco Pipeline (operator of Yellowstone pipeline), was notified at 9:37 am PDT on Thursday, July 23, 1987, that product was leaking from the pipeline at Fourth of July Pass. The pipeline was immediately shut down by operating personnel in Houston, Texas and local personnel were dispatched to the leak site. The leak was repaired by company and contract personnel and cleanup operations began immediately. The leak was caused by the pipe being struck by a road grader during road construction by a private contractor doing work for the state of Idaho.

Date, location and report ID	Incident description provided by pipeline operator
27 July 1987 Hennepin Minnesota 870186	At 08:30 hours Friday, July 24, 1987, Williams Pipeline Company was notified by the local police department that a 90" sewer main in Eden Prairie had ruptured and had washed out a large area beneath our pipeline. The line was immediately shut down and maintenance personnel were dispatched to investigate. The sewer effluent had washed out the side of a bluff just north of the Minnesota River creating a hole approximately 100' deep. Valves were closed on either side of the washout to isolate the segment. Due to the steep gradient, maintenance crews were able to tap the line and drain off much of the line fill. Work continued through the weekend to set up a purge operation so as to displace the remaining line fill with nitrogen. At 20:05 hours on July 27, 1987, while the line was being purged, the pipe cracked (as result of flexing and bending that occurred during the washout) and spilled an estimated 24 barrels of product. A 1250 foot temporary re-route was installed and the line resumed operation on August 14, 1987.
29 July 1987 Richmond Contra Costa California 870183	Our field personnel found a small stain on ground approximately .57 miles from our Richmond Station. Line was on a scheduled shutdown. Pressure immediately bled off line and block valves closed. Leak was caused by a seam failure (approximate 1½ inch crack). Approximately 60 feet of pipe replaced.
7 August 1987 Sedgwick Kansas 870176	Chase Transportation Company operates two petroleum products pipelines in the area of this reported leak. The lines are parallel to each other in the same right-of-way. One line is a 10.75" OD, .344" wall thickness, grade B pipe. The other is a 8.625", .322" wall thickness, grade B pipe. Both lines carry motor gasolines and diesel. The 10" line also carries jet fuel.
21 August 1987 Wylie Collin Texas 870227	Pipeline punctured Friday afternoon with backhoe during excavation for sewer line installation. Conoco operations coordinator in Houston noted reduction in pressure and shut the line down. Local company personnel began shutting block valves and searching for leak site. Contractor telephoned company and reported accident location. Cleanup and repairs were initiated the same day and all work was completed by early Sunday morning.
28 September 1987 Cook Illinois 870206	An operator for an excavating company struck the Arco Pipeline Company pipeline with a dozer.
29 September 1987 Rosebud County Montana 870221	The Rosebud County road department had two motor graders grading soil from the borrow ditches along the road up and into the road crown to raise the roadway elevation prior to new surface gravel application. One of the graders hooked the pipeline with the grader blade, tearing a gash approximately 6" long by three-fourths wide in the pipe. Pipeline markers are located on each side of the right-of-way at the fence line stating "danger-high pressure petroleum pipeline, etc., etc.". One sign was within 10 feet of the graders. No location or depth was requested by the road department. The grader operators were allegedly told by their foreman that the line was "at least 6 feet deep".
2 October 1987 Commerce Adams Colorado 870216	Contractor did not notify Conoco prior to digging at leak site although line markers were visible on both sides of leak site.

Date, location and report ID	Incident description provided by pipeline operator
26 October 1987 Natrona Wyoming 870211	Pipeline had been shut down from October 21 to October 26 for scheduled maintenance. It was restarted at 18:12 hours on October 26. Line conditions had stabilised by 18:45 hours with a flow rate of 800 bph, Casper discharge pressure was 1620 psi and Sinclair backpressure was 220 psi. At 20:53 hours, the Sinclair pump was shut down in preparation to receive a scraper. Pipeline was stabilised by 21:48 hours with Casper discharge pressure 1806 psi and Sinclair backpressure 600 psi. At 21:50 hours, the Casper variable speed drive (VSD) unit went into sequence and the rpm decreased from 3592 to 1988 indicating that the unit had controlled back. The Casper (VSD) continued to control back and would not respond to setpoint commands from Houston. Casper Station was shut down at 22:37 hours and the Casper supervisor was called out. He went to milepost 262 block valve to take pressure readings. At 02:30 hours, Houston said a leak had been found near milepost 268. Block valves at milepost 262 and 278 were then closed. Replaced 237.5 feet of 0.188" wall pipe.
26 October 1987 Navarro Texas 870228	Daily over/short meter readings reflected shortage on Sunday morning, October 25, 1987. The pipeline was shut down and gate valves were blocked, pressure readings on the segment between Dawson (MP 22) and Grandview (MP 55) gradually dropped and maintenance crews were called in to walk the pipeline (unable to fly right-of-way due to fog). The pipeline could not be completely walked due to nightfall. On Monday, at approximately 2:00 pm, the leak was located at MP 311 and temporary repairs made by 5:00 pm.
29 October 1987 Swisher County Texas 870250	At 15:25 (central time) October 29, 1987, a road grader operated by a Swisher County employee, struck and ruptured our 6 5/8" Abernathy products pipeline while cleaning ditches adjacent to a county dirt road. 663 barrels of premium unleaded gasoline escaped of which 206 barrels were subsequently recovered resulting in a net loss of 457 barrels. A pipeline warning sign was in place and located 8 feet north of the rupture site. Additionally, our aerial mile marker No. 116 and another warning sign were in place 45 feet to the south and across the road from the damage site. The product did not ignite and no injuries were sustained. The pipeline was repaired without incident and returned to service.
5 November 1987 Brown Kansas 870255	At approximately 17:20 hours on November 5, 1987, a backhoe operator contracted by Williams Pipeline Company struck and punctured the Kansas City - Irvington #3-8". The equipment operator was digging a bell-hole in preparation for a tie-in of a new spool at a stream crossing. While lifting the bucket out of the hole, it struck the 8" line, creating a small puncture. The line was immediately shut down and valves at MP 73+21 and MP 82+47 were closed. Equipment already on site was used to create an earthen dam to contain all product (regular gasoline) and keep it from entering the creek. At no time did any gasoline reach the water. After a majority of the gasoline was removed from the ditch, an attempt was made to plug and saddle the line. The saddle attempt was not successful, and the line was then tapped and completely drained up between the two (2) valves. Since a new spool had already been placed beneath the stream bed, this new bed, this new spool was tied in and the line was placed into service at approximately 18:10 hours on November 6, 1987.
11 November 1987 Chester County Pennsylvania 870260	The incident came to our attention on November 9, 1987, at approximately 12:10 pm when we were notified that a home owner in West Whiteland, Chester County, Pennsylvania, smelled gasoline fumes in his basement. Our 12" pipeline was shut down and we immediately went to the area to investigate the possibility of a leak. We walked our line throughout the day without finding any evidence of a leak on the surface. A pressure check on the segment of line in this area revealed a pressure loss. The following day a pipeline leak consultant was hired to assist us in the search. Bore holes were dug along the pipeline so that a vapour analyser could detect for gases. On November 11, 1987, we began excavating our pipeline in Ship Road 250 feet south of the intersection with Hillcrest where the greatest indication of vapours was found. At 13:02 the leak was discovered at the five o'clock position of the pipe. By 13:30 the hole was clamped.
12 November 1987 Hidalgo Texas 880017	Pipeline was hit by J.Y. Chapa Construction Company who were laying a flow line for Shell Oil Company.

Date, location and report ID	Incident description provided by pipeline operator
23 November 1987 Sulphur Spring Hopkins Texas 870263	Pipeline ruptured by contractor during excavation for telephone cable installation. Conoco operations coordinator in Houston noted reduction in pressure and shut the line down. Cleanup and repairs were initiated the same day and all work was complete by early the following morning.
25 November 1987 Davis Utah 870238	Incident involved a failure of the Chevron pipeline.
30 November 1987 Newton County Missouri 880028	Newton County road grader was deepening channel in bar ditch when he struck the Conoco pipeline.
1 December 1987 McLennan Texas 880001	At 12:05 hours on December 1, 1987, a products leak was reported by Texaco Pipeline to Exxon Pipeline Company (EPC) headquarters in Longview, Texas. The Waco, Texas, gauging supervisor was immediately notified and EPC personnel were dispatched to the leak site to investigate the report. At 13:10 hours the gauging supervisor arrived and requested a backhoe to excavate the site. Products were seeping out of the ground and had run into a nearby rock quarry, where it was contained. After excavation, at 14:05 hours, it was confirmed that the leak belonged to EPC, so the line was shut down and block valves closed to isolate the leak site. Additional EPC personnel along with contracted equipment and vacuum trucks were dispatched to the leak site at about 16:10 hours. The product was found to be coming from a stopple fitting which was placed on the line in 1978 to install a creek crossing. The line had to be drained down and permanent repairs made by installing a new O-ring, along with a new blind flange and flextaulic gaskets. The line was restored to service at 13:30 hours on December 3, 1987. Cleanup operations have been coordinated along with the TWC and have consisted of vacuuming up the excess products and digging several pits to allow the products to seep out of the ground. Cleanup is still in progress while soil and water samples have been taken to determine the extent of contamination.
11 February 1988 Hanover Virginia 880043	At approximately 3:30 pm EST on February 11, 1988, a leak was located on Plantation's 12-inch, .203" wall thickness, grade X-52, ERW petroleum products pipeline which operates between Greensboro, North Carolina and Washington, DC. The leak occurred on R.F.&P. Railroad right-of-way near Doswell, Virginia wherein the pipeline lays by permit. The pipeline was resting on two rocks which had broken the coating and created an area of galvanic corrosion. Product escaped through a pinhole located in a one-inch diameter corrosion pit located in an area of various smaller non-leaking pits at the six o'clock position on the pipe. There were no operational upsets and the pipeline was operating within design criteria. The pipeline was repaired with a two-foot-long full encirclement sleeve.
16 February 1988 Dallas Texas 880034	On February 16, 1988, at approximately 10:10, a contractor installing a fibre optics cable for US Sprint struck Explorer's 12" pipeline at MP 36.7, resulting in a puncture and escape of 819 barrels of unleaded gasoline. The pipeline was shut down at 10:12 and the upstream block valve at MP 35.6 was confirmed closed at 10:35. The downstream block valve at MP 39.5 was closed at 11:34, after allowing as much product as possible to gravity drain from the leak site. Earthen dams were built to contain the small amount of product not contained in the ditch opened by the Sprint contractor. No product escaped into the nearby creek. Approximately 538 barrels of gasoline was recovered from the site with vacuum trucks and hauled to Explorer's tank farm at Greenville, Texas. At the request of the Texas Water Quality Board, approximately 200 cubic yards of soil was hauled to a sanitary landfill after laboratory soil analysis and approval of environmental authorities. The damaged section of pipe was removed and replaced with a 12 foot pre-hydrostatically tested piece of 12" pipe using weld plus ends. Repairs were completed and the line put back into operation at 05:36 on February 17, 1988.

Date, location and report ID	Incident description provided by pipeline operator
19 February 1988 Hardin Texas 880064	External pit on pipeline, release discovered by aerial patrol plane. All necessary agencies were notified. Cleanup was nominal. Two visits by the Big Thicket National Preserve rangers and our response and cleanup was adequate and timely. Plidco repair sleeve to be welded February 22, 1988, sorbent pads were disposed of at authorised disposal site. Plidco sleeve was welded, doped, wrapped, anodes installed and backfilled.
12 March 1988 Wilson Texas 880069	A section of the 4" Corpus Christi to San Antonio refined products pipeline was isolated and pressurised with water to determine the location of a leak. The leak was the result of external corrosion penetrating the wall of the pipe. The joint of 4" pipe was removed and replaced with new pre-tested 4" pipe.
17 March 1988 Monee Will Illinois 880070	On the morning of March 17, 1988, a pipeline maintenance crew broke some field tiles while excavating an adjacent pipeline. The field tiles contained unleaded gasoline. Further investigation revealed that a flanged spool piece was leaking on the 14" pipeline. It appears that the fibre gaskets on the flanged spool piece had deteriorated with age and allowed the gasoline to leak from the pipeline.
12 April 1988 Orchard Farm St Charles Missouri 880118	A 1½ inch, capped air vent projecting 8-9 inches above a 12-inch pipeline was struck by Mr Herbert Boerding while ploughing his field. Though the pipeline was adequately below normal plough depth, the upward projecting fitting was struck and damaged by Mr Boerding's plough causing product to be released through a hairline crack in the circumference of the branch weld. Much of the product was vaporised as it passed under pressure through the narrow crack. The most heavily saturated soil was moved to a state approved landfill for further treatment. The balance of the affected soil is being aerated to permit release of any residual hydrocarbon vapours. Four domestic water wells in the general vicinity are being tested on a regular basis. Seven ground water observation wells have been drilled and an environmental consultant has been engaged to oversee the monitoring and remediation efforts.
14 June 1988 San Bernardino California 880133	Contractor was installing conduit for fibre optic cable in roadway of Baldy Mesa Road and struck 8" pipeline with trenching machine causing about ¾" hole. The pipeline was not operating at the time. The contractor notified San Bernardino office immediately and an intermediate booster station downstream was started up and the line was drained down thereby minimising product loss.
15 June 1988 Guadalupe Texas 880119	Maintainer working for tenant hit pipeline while making terraces in field.
17 June 1988 Crawford County Kansas 880139	On June 17, 1988, an employee of Crawford County struck our 8" Humboldt-Springfield pipeline with a D-7 dozer while grading in an abandoned landfill area. The line was actually struck twice without puncture, however, thinking he had hit a large rock, the dozer operator struck the line a third time, and punctured it. Gasoline sprayed the dozer and the operator but no ignition occurred. The operator reported the incident to the Crawford County Highway Department. The responding ambulance crew washed the dozer operator down with water and sent him to a local hospital where he received a check-up and was then released. Conversations with the operator indicated that he was aware of the pipeline's location (line marker was present), but he did not realise that he was grading deep enough to hit the line. Cleanup efforts are being coordinated with appropriate state agencies.
23 June 1988 Falls Texas 880125	Downstream booster station went down due to electric power outage. Upstream booster shuts down on pressure build-up to 1100 psig. Seam split at 1080 psig. Operator shut system down. Split pipe location between these two booster stations, about 4 miles downstream of upstream booster.

Date, location and report ID	Incident description provided by pipeline operator
28 July 1988 Sauk Village Cook Illinois 880154	The two hour system balances started to trend higher than normal. The pipeline was shut down and pressure tested to determine if there was a leak present. A ten mile section of pipeline was isolated and segmented until the leak was located. The line was then repaired and re-tested and returned to service.
4 August 1988 Aurora Adams Colorado 880195	Contractor working with front end loader over the pipeline without permission. The line had been marked and contractor was told not to remove dirt over line. A few days later he went ahead with dirt removal and hit the line.
17 August 1988 Tarrant Texas 880171	Line was struck by a contractor operating a motor grader. Total of 1455 barrels were out - 34 recovered.
23 August 1988 Hennepin Minnesota 880177	On August 23, a leak was discovered on our #7-8" Rosemount to Minneapolis Airport pipeline. The leak occurred at MP 12+33 near Fort Snelling State Park. Further investigation revealed that the line, which was 12-15' deep, had been dented and creased by a large piece of concrete rubble. It is thought that the airport had dumped miscellaneous fill material in the area back in the 1970's. The exact cause and time of the leak is still unknown as of this date. Since the area is relatively marshy, it is speculated that soil movement from repetitive frost action could have pushed the pipeline against the concrete rubble, thereby causing the damage. Conversations with other local utilities (water, sewer) who have line in the area lend support to this theory. Approximately 20' of new line was installed and backfilled with sand. Cleanup operations are being coordinated with state officials.
28 August 1988 Yellowstone Montana 880163	Approximately two days before the incident, a backhoe being used by a Conoco contractor to dig around the pipe, unintentionally hit the line. The line was dented and scraped. A half-sole with pipe clamp was installed for support so that the line could be put back into service replacement the following week. At 1:20 am on August 28, 1988, the line was shut down due to low discharge pressure at the Billings Station. The leak site was discovered at 2:40 am by Conoco field personnel. 390 barrels of leaded gasoline were spilled into the construction ditch surrounding the pipe. All product was contained in the trench. 380 barrels were recovered. Temporary repairs were made on August 28, 1988, with a pre-tested 6 foot section of X-52, 0.219" wall line pipe and weld plus ends. The line was put back in service at 4:30 pm the same day at reduced pressure. The pipeline was shut down on August 30, 1988 at which time permanent repairs were made.
3 September 1988 Nueces Texas 880179	The leak developed from an isolated corrosion pit which penetrated the wall of the pipe. The pit was in a place where the coating had been damaged during installation of a 2" flow line crossing our pipeline from a nearby well. Mobil Pipeline Company was not notified that the crossing was being made. The leak was repaired by welding two full encirclement wraps to the pipeline.
21 September 1988 Riverside California 880208	A contractor working for our company hit the Colton to Phoenix pipeline. The input station was immediately shut down, the upstream block valve was closed, and booster stations downstream were kept on line until pipe at leak site was drained. Approximately 23 feet of pipe replaced.

Date, location and report ID	Incident description provided by pipeline operator
27 September 1988 Powell Montana 880197	<p>On the day the incident occurred, Yellowstone Pipeline Company's (YPL) 10-inch products pipeline was struck by equipment being used by a contractor for AT&T to install fibre optic telephone cable. At 13:41 MDT Conoco's oil movements group noticed a sudden pressure drop at the Drummond Pump Station which was being bypassed. The pipeline was immediately shut down. The equipment operators for AT&T noticed liquid leaking from the pipeline and notified YPL by telephone. The equipment operators were instructed to close a block valve which was near the leak site. YPL personnel arrived at the leak site approximately one hour later and began cleanup efforts. Two sections of the pipeline were damaged by the AT&T equipment. A 14-foot section and a 39-foot section of the pipeline were removed and replaced with pre-tested sections of 0.279" wall, X-46 line pipe. The pipeline was put back into service at approximately 20:00 MDT on September 28, 1988. YPL is continuing cleanup efforts in close co-operation with state authorities.</p>
5 October 1988 Cotton County Oklahoma 880185	<p>Cotton County road grader was deepening the channel in the bar ditch when he struck and ruptured our pipeline.</p>
9 October 1988 Powell Montana 880196	<p>Approximately 2 weeks prior to the leak, Yellowstone Pipeline Company's (YPL) 10-inch products pipeline was struck by a contractor who was installing a fibre optics cable. The pipeline apparently did not rupture at that time. YPL was not notified of the incident. At 18:48 MDT on Sunday, October 9, 1988, Conoco's oil movements control centre was notified of the leak by the property owner. The line was shut down at 18:53 MDT. The Missoula pump unit was left in operation to pull product from the leak site. Field personnel arrived at the leak site approximately 40 minutes later, closed the nearest block valve and began cleanup efforts. Several sections of the pipeline were damaged by the contractor. A total of 244 feet of pipe were removed and replaced with pre-tested sections of 0.322" wall X-46, 0.365" wall X-52, and 0.307" wall X-52 line pipe. All welds were 100% X-rated. The line was put back into service at 6:30 MDT on October 13. YPL is continuing cleanup efforts with the assistance of an outside consulting firm and in close co-operation with state authorities. A review of pressure logs indicates that the leak probably occurred at 16:11 MDT. The line was experiencing pressure fluctuations due to a planned unit shutdown at Thompson Falls. Therefore, the pressure drop that occurred at 16:11 MDT at Drummond Station was not interpreted at the time as a potential leak.</p>
8 November 1988 Limestone Kankakee Illinois 880200	<p>Leak occurred in localised corrosion pit when pipeline was inadvertently blocked in during a valve switch. Pressures did not exceed 110% of MOP during the abnormal condition. Leak was discovered at 22:45 hours on November 9, 1988. Supplemental Report April 12, 1994, indicates a correction in Part G, #3: barrels spilled from 2431 to 380, filed by J.W. Holden, Manager Health, Safety and Environment on December 5, 1988. Reports continues: during recent investigation into this spill, we discovered a discrepancy in the volume amount which was reported to the Illinois EPA versus that which was originally reported to DOT-OPS. We filed the original DOT-7000-1 report on December 5, 1988, showing an estimated spill amount of 2431 bbls. During remediation work conducted following the spill, we conducted subsequent analysis of the release volume and submitted a volume range of 300-500 bbls to the Illinois EPA on February 13, 1989. (This volume range was later simplified to 380 bbls for discussion and reporting purposes). The more current volume amount is based on hydraulic and geometric calculations using an 'orifice' model. Following this correction in our originally estimated volume, we failed to submit a timely revised DOT-7000-1 which included the new spill volume.</p>
25 November 1988 Phelps Ontario New York 880204	<p>The spill was caused by a small pinhole leak in a weld. The leak was temporarily repaired by installing a Plidco clamp. Permanent repair was made by replacing a section of pipe including the weld with 6 feet of new pipe. The spilled gasoline was picked up with a vacuum truck and absorbent pads. Trenches were cut to trap and to recover any product migrating in the soil.</p>

Date, location and report ID	Incident description provided by pipeline operator
1 December 1988 Forrest View Cook Illinois 880212	A front-end loader, operated by others, struck and ruptured the 14" pipeline while loading crushed concrete from a pile near the pipeline. A section of pipe was replaced with pre-tested pipe, and the area was cleaned up.
6 December 1988 Johnson Kansas 890002	Equity Construction was hired by Jones Intercable to lay TV cable. Equity contacted Kansas one-call November 16, 1988, regarding the project. However, in the one-call report, Equity stated that they would deliver prints to the utilities regarding the exact location of the work so that lines could be appropriately marked. That follow-up contact to the utilities was never made. Williams Pipeline Company (WPL) personnel attempted to contact Equity Construction to inquire about the anticipated prints, however, they were unable to reach them because the listed phone number on the one-call report was a non working number. Leonard Brown, with Equity Construction, proceeded to plough a trench for TV cable, at which time he struck and punctured the 8" WPL Barnsdall to Kansas City pipeline. Cleanup efforts have been coordinated with the state.
20 December 1988 Montclair San Bernardino California 890009	Pipeline was shut down at approximately 09:40 on December 20, 1988, and block valves on both sides of derailment were closed on completion of bleed-in process at approximately 10:19 on December 20, 1988. At 14:45 on December 20, 1988, field personnel reported that in the process of moving derailed railroad car over the pipeline they had punctured the pipeline at 11 o'clock facing downstream, opening a hole of approximately ¼" x ½", letting approximately 224 bbls of unleaded premium gasoline escape, 124 barrels were recovered. A 22-foot section of pipeline was cut out and replaced. Pipeline returned to normal operations at 03:50 on December 23, 1988.
22 December 1988 Adams Pennsylvania 890015	On December 22, 1988, at approximately 10:30 hours, third party surveyors were working in a field which is traversed by Sun Pipeline Company's 6-inch high pressure petroleum products pipeline facility. When the surveyors were in close proximity to the pipeline right-of-way they detected a petroleum type odour and reported it to Sun Pipeline Company. Upon excavating our facility that same day, a 'sweat' type leak was discovered at pipeline station number 692+65 at 17:30 hours. The 'sweat' was temporarily repaired with a split sleeve and permanent repairs, which consisted of replacing a 20 foot long section with new line pipe, were completed on January 4, 1989. The date that the pipe started to 'sweat' is unknown, however, the length of damaged coating and the degree of saturation of the surrounding soil are physical observations which support Sun Pipeline's theory that the 'sweat' type condition hadn't been occurring for a long period of time and only a small volume of product had been discharged during the life of the 'sweat'.
3 January 1989 Cumberland Co. North Carolina 890023	At approximately 10:25 am on Tuesday, January 3, 1989, Colonial personnel at Greensboro were notified by army post engineers at Fort Bragg, that its 6" pipeline from Apex to Fayetteville, North Carolina, had been punctured by an army motor grader performing maintenance on a firebreak on the Fort Bragg army reservation. The pipeline was immediately shut down and the Cumberland County Fire and Police Departments were notified. The pipeline was blocked at Apex and Lillington stations, and the segment between Lillington and Fayetteville was allowed to drain into tankage at Texaco's Fayetteville Terminal. Prior to the arrival of Colonial's response and maintenance crew, military maintenance personnel constructed earthen pits and dams to contain the gasoline. In addition, they installed a temporary water service clamp on the 6" line to halt the escape of product. Colonial's maintenance personnel arrived at approximately 1:00 pm and found that the clamp had been successfully installed. Later they learned that one of the civilian maintenance employees working for the army had been overcome by fumes. This incident was reported to the National Response Center in Washington at approximately 5:30 pm when it was determined that the contract employee had been hospitalised. Cleanup and recovery efforts were continued by Colonial and the Fort Bragg environmental personnel.

Date, location and report ID	Incident description provided by pipeline operator
28 January 1989 Huntley Yellowstone Montana 890018	The pipeline leak occurred approximately 15 feet from the edge of a ploughed field. The line marked with a yellow marking stake at the edge of the field. The line was 10-12 inches underground at point of leak. We have strong evidence that the line was damaged by a plough or some other type of farm equipment. This possibly occurred some months ago. We have had no request for line location or depth in this area.
7 March 1989 Kansas City Wyandotte Kansas 890048	At 9:10 am on March 7, 1989 a call was received from Don Jones of the Kansas City Fire Department to report gasoline leaking from a vent pipe near the intersection of Stanley Road and Chrysler Road. All pipelines were shut down immediately. The cause of the leak was determined to be an external corrosion pit which failed. The pit was located on the carrier pipe inside the casing where the #3-8" Kansas City - Omaha line crossed the Union Pacific railroad at MP 1+00. The pipeline was repaired by replacing the 56' of carrier pipe through the casing with new pipe. The line was restored to operation on March 9, 1989. Cleanup and recovery efforts have been coordinated with state environmental officials.
10 March 1989 Cleveland Ohio 890043	The Cuyahoga County sewer district called our terminal at Bradley Road in Cleveland to report a gasoline leak on the Cuyahoga River. This was at 12:00, and the pipeline was not in operation at the time. After three hours of investigation we determined that the gasoline was coming from our line. The leak was located directly beneath the river. We immediately initiated the leak response procedure and began proper cleanup and notification activities.
17 April 1989 Boone Missouri 890062	Farmer struck line with chisel plough while preparing field for spring planting.
24 April 1989 Dubuque Iowa 890061	Tiling contractor hit line with tiling machine causing a 2" rip in pipe wall. Contractor did not contact the state one-call, or pipeline operator, prior to excavating.
28 April 1989 Grant Oklahoma 890065	A small leak was discovered on April 25, 1989, and corrective action was taken to replace the affected section of pipe. Repairs were made and subsequent to the purging of the line, the temporary repair failed resulting in the reported product loss.
25 May 1989 San Bernardino California 890074 (see also Section 4.3.1)	A Southern Pacific railroad train derailed on May 12, 1989, at the site of the subsequent pipeline rupture. The pipeline was shut down during the cleanup operations. Cleanup was monitored by pipeline personnel and the pipeline excavated and inspected at several locations. The line was restarted on May 16. On May 25, 1989, during stable pipeline operations, the pipeline ruptured spilling gasoline and causing a fire.
16 June 1989 El Dorado Union Arkansas 890070	Excavator called and the 20" line was marked at the time the 6" water line crossing was originally installed during August, 1980.
17 June 1989 Knox Illinois 890072	Twelve inch products pipeline was being started up to establish flow in the pipeline so a stopple fitting could be welded to the pipeline. As the pressure came up the longitudinal seam on a joint of ERW pipe ruptured due to a manufacturer's defect in the weld and resulted in a spill of unleaded gasoline.

Date, location and report ID	Incident description provided by pipeline operator
26 June 1989 Talladega Alabama 890086	<p>Following a tuboscope magnetic flux inspection run of this pipeline, Plantation began investigating locations shown by the linalog chart as having the most severe anomalies. Excavation at this site exposed the pipe resting on a four-foot diameter rock and gasoline odours indicating leaking product, although there was no evidence of liquid product in the ditch. The line was shut down and block valves on either side of the site were closed. After the rock was removed the line began to leak. The gasoline was caught in a large container and pumped into waiting tanker trucks. The line was repaired by removing a six-foot section of pipe and installing a new pre-tested section. The Office of Pipeline Safety was notified at 11:26 am CDST on June 26, 1989 (Report #10331). (See Report ID 890085 and 890087). The Environmental Protection Agency, region IV office was notified at 12:20 pm CDST on June 26, 1989. The Alabama Department of Environmental Management was notified at 10:50 am CDST on June 26, 1989.</p>
29 June 1989 Talladega Alabama 890085	<p>Following a tuboscope magnetic flux inspection run of this pipeline, Plantation began investigating locations shown by the linalog chart as having the most severe anomalies. Although there was no evidence on the ground surface, excavation exposed the pipe resting on a large rock and gasoline odours indicating leaking product. The upstream block valve was closed and the pumps downstream pulled product away from the site. A hairline crack was observed in the dented pipe when the rock was removed, but there was no liquid product. The pipe was repaired by the installation of a full encirclement pressure vessel sleeve over an epoxy filler in the dent. The Office of Pipeline Safety was notified at 3:10 pm CDST on June 29, 1989 (Report #10566). The Environmental Protection Agency, region IV office was notified at 3:05 pm CDST on June 29, 1989. The Alabama Department of Environmental Management was notified at 3:00 am CDST on June 29, 1989. (See Report ID 890086 and 890087).</p>
30 June 1989 Talladega Alabama 890087	<p>Following a tuboscope magnetic flux inspection run of the pipeline, Plantation began investigating locations shown by the linalog chart as having the most severe anomalies. Although there was no evidence on the ground surface, excavation exposed the pipe resting on a large rock and gasoline odours indicating leaking product. The upstream block valve was closed and the pumps downstream pulled product away from the site. A hairline crack was observed in the dented pipe when the rock was removed, but there was no liquid product. The pipe was repaired by the installation of a full encirclement pressure vessel sleeve over an epoxy filler in the dent. (See Report ID 890085 and 890086). The Office of Pipeline Safety was notified at 2:55 CDST on June 30, 1989 (Report #10646). The Environmental Protection Agency, region IV office was notified at 2:48 pm CDST on June 30, 1989. The Alabama Department of Environmental Management was notified at 2:39 CDST on June 30, 1989.</p>
5 July 1989 Los Angeles California 890088	<p>Tri-state utilities company made an initial notification to the one-call system approximately one month prior to the accident. A Shell Pipeline Corporation representative met with a tri-state representative, showed the tri-state representative the location of Shell's pipeline and determined that the initial phase of the excavation would not expose Shell's pipeline. The Shell Pipeline representative gave the tri-state representative a card and with specific instructions to call Shell Pipeline before excavating in the vicinity of the Shell pipeline. Tri-state failed to call Shell pipeline and, on July 5, 1989, exposed Shell's pipeline. Tri-state thought it was an abandoned gas company pipeline and drilled a small diameter hole in the pipe to determine its contents. The pipeline was temporarily shutdown with approximately 60 psi of pressure. After drilling the hole, tri-state clamped the pipe and called Shell Pipeline.</p>
5 July 1989 Augusta Butler Kansas 890090	<p>The LA Knebler Construction Company of Augusta, Kansas gave notice to the Kansas one call system to remove trees from an empty lot in the city of Augusta, which Kaneb Pipeline Company did respond to by telephone stating that we were clear because we did not cross the area involved. After they had removed the trees, they evidently were levelling the site by removing the top soil and had built two long narrow parallel stock piles outside their work and notification area, inside a wide drainage ditch area, and both piles crossed our pipeline. Earth moving scoops were used to build the stock piles and one of the scoops slid off the top of one stock pile in between the two and in its movement around trying to get out from between the parallel stock piles it had gouged into the ground and pierced a hole about the size of a man's thumb in our pipeline with the corner of its hydraulic operated blade.</p>

Date, location and report ID	Incident description provided by pipeline operator
13 July 1989 Martinez Contra Costa California 890092	The leak was at a point where the line had been damaged sometime in the past and damage was never reported. Pipe developed a stress crack over a period of time resulting in small leak. Estimated 20 barrels in marshy area 30' x 100'.
1 August 1989 Union County Arkansas 890108	On August 1, 1989, at 08:40 hours CDT, a leak was reported to Texas Eastern personnel by the Union County Sheriff's Department. The booster stations south of the leak site were shut down immediately, and the affected line section was isolated by closing valves on each side of the accident site. Recovery of spilled gasoline was initiated by Texas Eastern maintenance crews within one hour of notification of Texas Eastern. A sump was excavated at the spill site, allowing pickup of gasoline on the ground by vacuum trucks. Spill booms were strategically placed to control any potential releases of product to surface water. Floating gasoline was then recovered from surface water using skimmer pumps or by using sorbent pads. The initial site cleanup was completed at 12:00 hours on August 4, 1989. Spill booms were left in place, and the site is presently being monitored daily. Final site cleanup will take place after permanent repairs to the 20" pipe have been completed, and all contaminated soil will be removed from the site and transported to Texas Eastern's property, where it will undergo biological remediation. After uncovering the 20" line, Texas Eastern maintenance personnel discovered that the leak had been caused by the failure of a rubber gasket used with a leak clamp that was installed on June 16, 1989, as a temporary repair. Improved temporary repairs to the line were completed on August 1, 1989. Permanent repairs to the 20" pipe are scheduled for September 12, 1989.
5 August 1989 East Baton Rouge Louisiana 890102	Plantation owns and operates 4 parallel 12" diameter pipelines which run between its dock station and its Baton Rouge tank farm, a distance of 6.2 miles. On August 4, 1989, while performing weekly on-foot inspections, it was discovered that a contractor working in an old deactivated bauxite plant had spilled a mixture of oil and gasoline on the pipeline right-of-way inside the plant. On August 5, 1989, while excavating the pipeline to determine if this mixture had damaged the pipe coating, gasoline was found to be dripping from a casing on the No. 1 dock line. The casing and the pipe inside the casing were removed and a new section of pipe was installed on August 10, 1989. A pinhole was discovered at the 6 o'clock position in a pitted area of the pipe which was inside the casing. The Environmental Protection Agency, Region VI Office, was notified at 19:25 CDST on August 5, 1989. The Louisiana DEQ was notified at 19:40 CDST on August 5, 1989. An on-site visit was made by a representative of the Louisiana DEQ at 20:30 CDST on August 5, 1989. The office of pipeline safety was notified at 11:25 CDST on August 7, 1989 (Report #13551).
5 September 1989 Linn Oregon 890118	A ditching contractor was digging a ditch for the installation of a drainage system for the farm when he hit the mainline pipeline at MP 99.6.
13 September 1989 Salem Marion Oregon 890124	The pipeline was damaged by a contractor running over the line causing a leak in Mill Creek approximately half a mile upstream of our Salem booster station. The pipeline was immediately shut down and product drained into Albany, downstream of leak site, until main line block valves were closed to minimise product loss.

Date, location and report ID	Incident description provided by pipeline operator
7 October 1989 Johnson Missouri 890142	On October 7, 1989 the #7-8" Olathe to Columbia line (MP 47+18) was struck by a front end loader which was levelling a site in preparation for setting a mobile home when he struck the line. The line was not operating at the time of the puncture, however, it was pressured to approximately 200 psi. He ran to the nearest line marker to obtain our emergency number, then called our dispatching centre. Maintenance crews were dispatched to the site to initiate cleanup and repair operations. Approximately 85 bbls of free product was recovered. The remaining soils were hauled to a nearby landfill. Cleanup efforts were coordinated with the EPA and the Missouri Department of Natural Resources. The operator of the loader claims that he did not notice the line markers when he began to excavate (markers were located 50' west and 600' east of the site). Williams Pipeline is a member of the Missouri one-call system, however, the operator of the loader did not bother to call.
17 October 1989 El Paso Texas 900035	At approximately 9:45 pm on October 17, 1989, product foreman and an electrical engineering consultant were in the process of completing final electrical changes to the pipeline supervisory control system. These changes were being made to enhance the ability of the control system. At some point during these final electrical tie-ins the back pressure control valve, which monitors and controls mainline pressure shut, blocking the flow in the pipeline. Within minutes of the valve closing, the pipeline operator in Artesia, New Mexico noticed the decrease in flow. Before the Artesia pipeline operator could call the El Paso Terminal the El Paso city police notified the product foreman at the El Paso Terminal of a leak on Zaragosa road. The product foreman in El Paso notified the Artesia pipeline operator and the line was immediately shut down. Product foreman went to valve approximately ¼ mile upstream of leak and shut valve which stopped the flow of the escaping gasoline. Navajo employees and equipment as well as contractor employees and equipment were immediately dispatched to repair pipeline and clean spill area. Pipeline was repaired and resumed operations at approximately 3:00 am on October 18, 1989. Cleanup of spill area was completed on November 2, 1989. The normal operating pressure at this point on the pipeline is less than 200 psig when flowing. For that reason we normally leak test this portion of the pipeline at approximately 750 to 800 psig. However, with the control valve closing we have calculated that the pressure may have reached 1370 psig before failing. Telephone notice was given on October 18, 1989 (control #18444-Bradshaw).
20 October 1989 Albuquerque Bernalillo New Mexico 890129	Equipment operator for Universal Constructors Company was grading and removing dirt with a front-end loader and struck pipeline. Company control centre noted pressure drop and initiated shutdown procedures. A representative of Universal Constructors located a pipeline marker in the area and phoned the control centre to report the incident. The area was diked off to contain the spill. Standing product was removed by vacuum trucks. Contaminated dirt was removed from site to landfill designated by county health department representative who responded. The local fire department had been notified and responded as a precautionary measure as well as the state police. Temporary repairs made; line back in service 17:12 hours.
22 October 1989 Ricardo Kleberg Texas 900045	Pipeline was struck by a plough on an earlier date which is unknown. There was about an 18" gash on top of pipeline. The line ruptured at this point.
1 November 1989 Sapulpa Creek County Oklahoma 890156	On November 1, 1989, Conoco Pipeline Company's 8 inch petroleum products pipeline experienced a corrosion leak in SE/4 of Section 23, township 18N, range 11E, Creek County, Oklahoma.

Date, location and report ID	Incident description provided by pipeline operator
18 December 1989 Unionville Orange Virginia 900008	On December 18, 1989, Colonial's line 4 dispatcher was completing a delivery to Mitchell Junction and beginning a delivery at Chantilly Station. While completing this operation, at 10:32 am, he observed that Louisa Station's discharge pressure was abnormally low, and he shut the pipeline down and notified his supervisor. The Richmond area manager was notified of the possibility of a leak, and advised to arrange for aerial surveillance and for maintenance crews to be mobilised. The regular aerial patrol had just completed Mitchell Junction to Fairfax and was redirected south toward Louisa Station. The Richmond area manager also joined the surveillance in a helicopter. At 1:03 pm, the leak site was located one mile north of Locust Grove Station. Kerosene was observed in mine run, which empties into the Rapidan River. Maintenance crews deployed booms, built dams, and conducted recovery operations at various locations between the leak site and the Rapidan River. The split on the pipe, 5'2" long with a gap of 6" at the widest point, occurred adjacent to the longitudinal seam in the base metal at the toe of the weld. The pipeline was repaired by removing 34'2" of pipe containing the fracture and replacing it with pre-tested line pipe and a 7-degree fitting. All girth welds passed a radiographic inspection. The pipe specimen has been sent to a metallurgical laboratory for analysis. A total of 4,759 barrels of the 5,043 barrels lost from the pipeline have been recovered. Cleanup efforts are still in progress. Notice by telephone was given to the National Response Center. A subsequent review of the pipeline operating data revealed that the leak occurred at approximately 10:27 am.
4 January 1990 Quay New Mexico 900025	At approximately 11:00 hours on January 3, 1990, during the construction of a new 10" pipeline parallel to our existing 6" pipeline, product was found in the dry bed of Pajarito Creek. Crews began excavating immediately to find the source. At 11:00 hours on January 4, 1990, a pinhole leak was discovered in our 6" Albuquerque refined products pipeline which allowed 1000 barrels of unleaded gasoline to escape, of which 722 barrels have been subsequently recovered. The product did not ignite and no injuries were sustained. The cause of the external corrosion was investigated by a third party chemist and attributed to MIC (microbiological influenced corrosion). The pipeline was repaired without incident by replacing 793 feet of pipe, hydrostatically tested, and the line returned to service.
21 January 1990 Brazoria Texas 900043	Line was running in normal operating procedure and blew out, dispatcher saw pressure drop and shut line down, and notified appropriate personnel. Part G - 376 barrels recovered (includes 50 bbl of water).
25 January 1990 Palo Pinto Texas 900034	At approximately 16:27 on January 25, 1990, the Carswell pipeline was punctured by a scraper operator hired by E.W. Carte Cattle Company. This was noticed by a sudden loss of pressure at our Brock Pump Station suction pressure. The Abilene pipeline control operator immediately began reducing pipeline flow and contacted the shift foreman on duty. 16:40 - the pipeline system was shut down. 16:50 - the scraper operator called reporting the pipeline leak and its location. 16:55 - Aledo Terminal personnel dispatched to site. Sneed Contractor, Inc., Eastland, contacted to respond to leak site. 17:30 - Abilene spill response team left Pride Refining's Abilene refinery. 17:40 - the damaged pipeline section was isolated by pipeline block valves. Damming of spill began to contain spill. 18:45 - Abilene spill response team reached leak site. Cleanup began. 18:55 - pipeline clamp installed around puncture. 19:00 - the railroad commission and DOT were notified to the spill. Spill cleanup continued through the night and for five days. The TWC representative from Duncanville coordinated the requirements of the cleanup. The pipeline was repaired by removing approximately 20 feet of pipe and replacing with new tested pipe of the same diameter. The pipeline was started up at 15:35 on January 26, 1990.

Date, location and report ID	Incident description provided by pipeline operator
19 February 1990 Carthage Panola Texas 900053	<p>At approximately 9:00 am Monday, February 19, 1990, Dallas dispatching supervisor, notified Longview area that following a routine shutdown of the Hebert Waskom products line at approximately 4:00 am, a pressure drop had been detected. After further investigation, Dallas dispatching personnel determined the pressure drop had occurred between Center and Waskom terminals. At approximately 9:20 am, Dallas controllers called the patrol pilot to fly the line. At 11:00 am, Longview construction personnel were dispatched to walk the line after the patrol plane reported nothing unusual on the Waskom-Center flight. At approximately 5:00 pm a site at MP 152.9 was found where gasoline was coming to the surface. Personnel found an illegal tap had been installed on the line. The gaskets used in the installation failed and gasoline was leaking from the connection. Gasoline had flowed into a drainage ditch. This ditch allows water to flow into an unnamed tributary of Socagee Creek, which is approximately 2 miles from the leak site. Immediately upon discovering the leak, spill control booms were placed in the tributary to Socagee Creek to contain any gasoline that might reach the creek. Repair was made to the pipeline on February 19, 1990, by welding a steel patch on the affected area of pipeline.</p>
20 April 1990 Pima Arizona 900073	<p>At approximately 00:17 on April 20, 1990, operator at Tucson Terminal noticed a sharp drop in pressure and reported it to scheduler and the pipeline was shut down. Marana police department reported to Tucson Terminal at 01:17 on April 20, 1990, the sighting of the leak. Field personnel and contract personnel were dispatched to the scene immediately. The leak was caused by unknown persons scraping the pipeline and not reporting it.</p>
21 April 1990 Sacramento Yolo California 900074	<p>While trenching for the laying of a fibre optic communication cable, trenching machine scraped the pipeline for several hundred feet and then gouged it.</p>
15 May 1990 Oak Brook Du Page Illinois 900090	<p>A contractor working in the general vicinity of the leak called and notified us of product on the ground at 12:49. The pipeline was immediately shut down. Upon excavation of the pipeline, it was found that a guard-rail post had been augered into the ground and the auger had dented our pipeline in 2 places about 6 inches apart. A crack had developed between the 2 dents. Indications are that the guard-rail was installed during Highway 83 reconstruction work sometime in the fall of 1989.</p>
20 May 1990 Marion County/ Grundy County Tennessee 900098	<p>Colonial's Atlanta controller received a call from the Coalmont Tennessee police department at 2130 EST on May 20, 1990. A bulldozer working in the area known as Clifty Cove at Clifty Creek on the Marion County - Grundy County line had hit a pipeline and caused a leak. This occurred where Clifty Creek flows into the Little Sequatchie River. Colonial has two pipelines in this area and both were immediately shut down by the controller. Contract and Colonial personnel were dispatched from Chattanooga and Nashville. At 02:30 on May 21, 1990, the leak was located at the bottom of a 1,200 foot slope accessible only on foot or by tracked vehicle. Gasoline was leaking from the pipeline through a gouged hole. Hand excavation of the line began at about 03:30 and a full encirclement repair sleeve was installed by 09:00. Other personnel began installation of containment booms on the Little Sequatchie River at Camp Glancz, one mile west of Highway 28, 5 miles north of Jasper, Tennessee in Marion County, 7 to 8 miles downstream from the leak site. A helicopter survey revealed that product had travelled about two miles downstream. Local government officials were notified at approximately 02:30 EST and the National Response Center was notified at approximately 14:40. The Department of Transportation, Office of Pipeline Safety, the Environmental Protection Agency, Tennessee Emergency Management Agency and the Tennessee Water Quality Department responded to the leak. An examination of the leak site revealed that the dozer operator was grading and lowering a remote road when he hit the pipeline. An estimated 134 barrels of product escaped from the pipeline and only about one barrel was recovered. The rest of the product either evaporated or was trapped in rock formations.</p>

Date, location and report ID	Incident description provided by pipeline operator
6 July 1990 Brentwood Contra Costa 900152	Pinhole leak developed along seam, pipe was wet but no liquid in soil. Pipe failure probable cause.
25 July 1990 Mad River Montgomery Ohio 900127	BP Oil Pipeline Company's Vandalia Ohio dispatching centre became aware of a gasoline spill and evacuation through local radio news broadcasts at about 13:30 on July 25, 1990. A check with the Mad River township fire department attributed the problem to a leaking truck. A meter-in-meter-out line balance system showed no abnormal variation and operating pressures were also normal, but the pipeline route was right through the affected area and the product in the line (red dyed gasoline) matched the description of the spilled product. Two pipeline supervisors were sent out to assess the situation at 16:00 and before they arrived the line was shut down (16:20). A field assessment was completed by about 17:30. The most likely cause was thought to be a pipeline leak into a storm sewer which crosses the pipeline. Block valves were closed and pressure was bled off into tankage located at BP Oil's Dayton, Ohio Terminal. Product stopped leaking into the sewer, but the pipeline leak could not be located. The fire department officially allowed residents to return to their homes at 01:00 on July 26, 1990. The storm sewer/pipeline crossing was dug out the morning of July 26 and a heretofore unknown sewer junction box was discovered to have been constructed around the pipeline. The pipeline coating was damaged and atmospheric corrosion was present on all of the uncoated pipe. A leak clamp was installed and the line was tapped to admit air and allow a gravity draindown into Dayton tankage. On July 27 an 8' 11.5" section of pipe was replaced with new pipe and the pipeline was restarted. The new pipe was protected with epoxy coating; hand applied wrap and rock shield. The sewer junction box was rebuilt with a manhole to allow inspection of the pipe.
1 August 1990 Kankakee Illinois 900131	Explorer's 24" mainline was punctured at milepost 606.1 on August 1, 1990, near Bourbonnais, Illinois by a third party contractor's trenching machine. The contractor notified Explorer's operations coordinator in Tulsa, Oklahoma at 13:15 on August 1, 1990, that he had hit the line and fuel was spilling. The operations coordinator confirmed an abnormal pressure loss on the damaged line segment simultaneous with the call and closed remote block valves at mileposts 563.5 and 642.3. The line was not operating at the time of damage and had a static pressure of 171 psi at the accident site. Explorer's emergency response team was activated immediately. The trenching contractor (Basailon Excavating Company) constructed earthen dams in the open trench to contain escaping jet fuel. The contractor, along with local fire and police officials were requested to close adjacent block valves at mileposts 605.3 and 606.8. Both valves were closed by 14:30. All product was contained by the ditch in a 30 ft x 300 ft area. Explorer personnel were flown by helicopter from our Wood River, Illinois and Hammond, Indiana offices. Spill response equipment was dispatched from Hammond. The Hammond area supervisor arrived on the site at 14:55. Vacuum trucks began arriving at the site at 17:30. By 24:00 on August 1, 1990, product from the ditch had been recovered and a controlled draindown of the pipeline segment into trucks was started. Draindown and repairs to the line were completed at 12:00 on August 3, 1990. The Illinois EPA requested removal and disposal of approximately 1500 cubic yards of contaminated soil. The contaminated soil has been removed and replacement with clean soil is in progress.
13 August 1990 Portage County Wisconsin 900130	The leak was confirmed at 12:55 pm on August 13, 1990. Koch personnel were on the scene at this time from our junction city terminal. The contractor, Minnesota Limited, arrived at the leak site at 6:30 pm. Site cleanup began at 12:30 am on Tuesday August 14, 1990, with the leak on the pipeline exposed at 8:00 am that morning. Cleanup and repair continued throughout the day. On Wednesday August 15, 1990, welding on the pipeline started at 9:50 am, with the repairs being completed at 3:20 pm. Portage County emergency response personnel and the Wisconsin Department of Natural Resources people were on the scene to coordinate the cleanup procedures.

Date, location and report ID	Incident description provided by pipeline operator
16 August 1990 Aurora Arapahoe Colorado 900140	Contractor working for the city of Aurora, Colorado punctured the pipeline with a front-end loader while excavating a temporary driveway.
9 September 1990 Racine Wisconsin 900136	A contractor was installing 4" drain tile in a field for a landowner. The drain tile was being installed at a depth of approximately 4.5 feet by a ripping-type tiling machine. The tiling machine hit the pipeline (which was at a depth of approximately 4.0 feet) at about a 90 degree angle and put a hole in the pipeline approximately 14" by 12".
11 October 1990 Fillmore Nebraska 900158	The rupture occurred approximately 2 miles west of Kaneb's Shickley Junction and affected the line that goes to Phillipsburg, Kansas. Shickley Junction is the facility that Kaneb built after the Champlin pipeline acquisition. We pump product from Geneva Terminal to Shickley Junction, where the flow can be diverted north or south into the former Champlin line or west into the Phillipsburg line. Our investigation revealed that the rupture occurred in a section of line pipe that had been hit several times by a sub soil chisel farm implement. Further investigation confirmed that the ground had been worked with a sub soil chisel only 2 or 3 days before the rupture. Prior to the rupture, our operation was splitting the stream between the Phillipsburg line and the north leg of the Champlin line at Shickley Junction. The Phillipsburg line during the operation withheld the pressure of the split stream, but when the flow was diverted into only the Phillipsburg line, the weakened area struck by the chisel ruptured.
7 November 1990 Vernon Missouri 900167	At approximately 20:31 hours on November 7, 1990, the Williams Pipeline Company dispatching department observed a pressure drop at Sheldon Station. The unit at Sheldon automatically shut down. The dispatcher immediately shut down the operation and drained into the Columbia Terminal tank farm. The dispatcher contacted field personnel and apprised them of the situation. Emergency response crews were dispatched immediately to shut mainline valves and the search for the site of the leak. At approximately 22:45 hours on November 7, 1990, the leak was found and emergency response crews were directed to the area. The cause of the spill was determined to be a corroded area in the pipe where the top of the pipe was exposed in the bottom of a dry creek bed. The pipeline was repaired by replacing the corroded area of pipe. Approximately 3,000 barrels of premium unleaded gasoline were spilled with 500 barrels recovered. All cleanup efforts were coordinated with the Missouri Department of Natural Resources (MDNR). Approval was obtained from the MDNR to burn the remnant product to aid in site remediation.
10 November 1990 Seneca Erie New York 900164	Leak was discovered at 06:15 hours and the line was completely shut down by 06:17 hours. Mobil Pipeline Company maintenance crews were immediately dispatched and recovery and cleanup procedures were initiated. Refined petroleum product entered a storm sewer that drained into the Buffalo River. Spill containment booms were installed in the Buffalo River. Cleanup and recovery of free product has been successfully completed. A site assessment and site remediation plan is being developed for the soil and groundwater with the approval of DEC for the final site restoration. Leak was caused by external corrosion resulting from direct contact with a 4 inch unprotected water line. This water line was installed in the 1950's by an unknown contractor and our records reflect 12 inches of clearance. Activities since the 1950's, which resulted in the direct contact, are being researched. Permanent repair was made by replacing damaged section of pipe.
2 February 1991 Wichita Sedgwick Kansas 910044	At approximately 22:37 CST on February 2, 1991, Conoco Pipeline Company's 6" Wichita, Kansas petroleum products pipeline experienced a leak. The incident occurred when an acetylene weld on the line cracked due to being subjected to a hydraulic shock. Conoco Pipeline Company is replacing the 1920 vintage 6" pipeline with 87 miles of new 10" and 8" pipe.

Date, location and report ID	Incident description provided by pipeline operator
4 February 1991 Cowley Kansas 910051	Jomax Construction Company of Great Bend, Kansas, gave notice to the Kansas one-call system approximately one month before this accident occurred. Approximately two weeks before the accident, Jomax had a pre-construction meeting. Kaneb attended this meeting, and requested that a representative from Jomax accompany a Kaneb employee to the crossing locations to ensure that they would be properly marked. Kaneb was advised that Jomax would contact Kaneb prior to ditching activity commencing in the Arkansas City, Kansas area, and that it was not necessary to mark the pipeline at that time since all construction activity was out of the affected area. Kaneb has a policy that requires the line to be located and marked just prior to any activity. In addition, Kaneb requires that an employee be present during any activity in close proximity to the pipeline. Unfortunately, Kaneb was not contacted by Jomax, and as a result, the pipeline was ruptured by their ditching machine.
15 February 1991 Berks County Pennsylvania 910075	At approximately 14:30 hours on Friday February 15, 1991, the Pennsylvania Department of Environmental Resources contacted Sun Pipeline about a possible leak near Mountain Road in North Berks County. Upon investigation at 15:00, we found an area of soil about 140' x 60' saturated with gasoline on our right-of-way. Hassler Run Creek also had a sheen of product on it. The line was already shut down; the area was then excavated and a pinhole leak was found at approximately 4 o'clock on the bottom of the pipe. A temporary leak clamp was installed, contaminated soils removed, booms and pads used to remove contaminants from the water. Permanent repairs are scheduled to occur on March 20, 1991.
26 March 1991 Mulbuery Grove Bond Illinois 910081	The pipe was deactivated on January 28, 1991. The pipeline had been shut down with valves closed in preparation for displacement of the product and deactivation. Ground temperature increases caused the pressure in the section of the pipeline to increase to 837 psi causing a pinhole leak in a corrosion pit.

Date, location and report ID	Incident description provided by pipeline operator
<p>29 March 1991 Shoemakersville Berks Pennsylvania 910086</p>	<p>On Good Friday, March 29, 1991, at approximately 10:30, a farmer's son was operating a rental tracked front-end loader to widen swale in farm field. A tooth on the loader bucket punctured Sun Pipeline Company's (SPL) 6" north line. This line is in the SPL eastern region II, Montello area. Unleaded gasoline was being pumped through the line at approximately 1020 psig. The farm owner called 911 at 10:42; the Shoemakersville fire department was dispatched. The farm owner contacted the eastern area control centre at 10:45. The control centre contacted the Montello area supervisor; he ordered the pumps down. All three line pumps on lines through the general area of the leak were shut down at 10:47. The Montello area supervisor telephoned the farm owner and learned the line was ruptured (later determined the line had been slightly dented and penetrated with a 2" x 1/2" hole), that product was shooting 25-30 feet into the air and the 'one-call' had been made. The supervisor called the eastern region II superintendent to arrange for additional assistance. The Shoemakersville firemen, after reaching the site, called out the Berks County HAZMAT team at 10:55. HAZMAT set up a level III controlled hazardous materials site with restricted access and checkpoints and began evacuation of a one-half mile radius (20-25 homes). They also set up a hay-bale dam to block the flow of gasoline in the drainage swale toward the farm pond east of the leak. NRC/EPA was contacted at 11:30 (# 65762). The area supervisor arrived at the site at 11:50. He was informed by the HAZMAT leader that no one could enter the hot zone without self-contained breathing apparatus (SCBA). The hot zone was being monitored with flammable vapour detectors. The Pennsylvania DER was notified at about 12:30 (Kerry Leib). DER was already aware of the incident. SPL supervision, crew and equipment arrived on site at various times after 13:00, and valves at Berks Pump Station and Berne Junction (nearest mainline valves above and below the leak) were closed at that time. A Pennsylvania DER response team, EPA and fish and game commission personnel also responded to the scene at various times thereafter. The leak was excavated and temporarily repaired with a 6" Plidco sleeve at approximately 17:30. The line valves were reopened at 18:00. At 18:40 the line was re-pressured to 1140 psig and held pressure.</p> <p>Supplemental June 3, 1993: owner experienced chest pains and was taken by ambulance to a hospital. He was in the hospital for 4 days. It was learned that 3 blood vessels were 50% blocked, and were surgically cleared.</p>
<p>10 April 1991 Tulsa Oklahoma 910092</p>	<p>At approximately 13:00 on April 10, 1991, Conoco Pipeline Company's 4 inch commercial jet fuel (JFA) pipeline that services the Tulsa, Oklahoma International Airport was severed by a backhoe operated by McGuire Brother Construction Company. The 4 inch pipeline was properly marked for the construction and McGuires was instructed to contact Conoco prior to doing any excavation near the line. McGuires failed to contact Conoco and did not yield to our line location markers. McGuires has admitted guilt to not contacting Conoco and not yielding to the line markers.</p>

Date, location and report ID	Incident description provided by pipeline operator
29 April 1991 Luzerne County Pennsylvania 910098	<p>Pipeline control centre at Wayne, Pennsylvania (Chester County) received a telephone call from a resident (James Bach) near 6" north line, Luzerne County, Salem township, who had smelled petroleum odour near right-of-way above Saw Mill Road, approximately 2 miles west of Shickshinny, Pennsylvania and observed a small stained area. The Montello Maintenance (Berks County, Spring township) Foreman (MMF) was notified and ordered the line shut down. He also sent a pipeliner to the scene to investigate. The line was under pressure (668 psig) and was blocked in at operating pressure. The product was unleaded gas. The line is not coated in this area. The pipeliner walked the area and hand-excavated three test pits on the right-of-way. One of the pits did have an odour but it did not appear to have a petroleum odour. The line pressure had held steady for nearly 4 hours. The Montello district supervisor released the line for start-up and instructed the MMF to follow-up the next day with a crew and heavy equipment for a more thorough investigation. 6" north line was shut down at end of gasoline cycle. The MMF and a crew with equipment left for the site to follow up with additional test pits. MMF reported possible evidence of a leak, and continued with excavations. Notification of suspected leak to NRC; #70023. Notification of suspected leak to Pennsylvania DER (answering service - representative to call back). Call back from Pennsylvania DER representative, Kevin Augustine. Stated DER would not respond immediately, but asked to be notified if leak proved to be a major leak. Leak found; was an isolated corrosion pit about ¼" in diameter located at approximately the five-thirty position on the pipe when facing north. Bellhole excavated around pipeline. Emergency leak clamp installed over hole in pipe to stop escape of product while line was drained downhill as much as possible. Little product was seen; it was believed that very little had escaped. About 15 gallons of product were collected from the hole in the pipe before clamp was installed. Product was also collected in absorbent materials. Temporary repair sleeve (Plidco) installed. Line will not be re-pressured until May 2, 1991, at 01:15. Pipeliners will be on-site to monitor temporary repair during start up. Notified Pennsylvania DER of situation. Robert Gadinski, hydrogeologist, responded to site, inspected area and discussed future actions.</p>
25 June 1991 Sedgwick Kansas 910127	<p>This is the supplemental report required by CFR title 49 part 195.54(2). Telephonic notice of this incident was given to the National Response Center at 05:00 June 25, 1991. Even though this incident did not meet any of the criteria listed in 195.50 or 195.52, it was determined that notification was in order because of the close proximity to the city of Wichita. Although propane was in this line section initially, it was displaced with gasoline shortly after the leak was discovered. The location of the leak was approximately ¼ mile from the Phillips pumping manifold, where the propane was shut off and the gasoline diverted to the line section. Our investigation has determined that less than 5 barrels of propane or 5 barrels of gasoline escaped through the leak. Immediately after the propane was displaced, excavation of the leak site began and less than 5 gallons of gasoline were recovered due to the small amount of contamination. A small localised corrosion pit was discovered as the cause of the leak. One other localised pit was also found and repaired. There were a number of discarded welding rod butts in the immediate area of the pits and they are suspected as the cause of the corrosion. The line was exposed and checked 25 feet minimum either side of the leak and it was still in "like new" condition as personnel were able to read the original mill stencils. The line was repaired and placed back into operation.</p>
26 August 1991 Trumbull Ohio 910158	<p>A bulldozer operator excavating a pit for use fracturing a natural gas well struck the pipeline with the dozer blade just as the pit (approximately 10' x 50' x 4') was nearly completed. The line was struck somewhat prior to 11:00. The BP dispatch centre was notified of the strike shortly after 11:00 and the pipeline was shut down at 11:07. The field foreman had not notified the one-call system, but was able to readily obtain the emergency notification number from a sign at our nearby road crossing.</p>

Date, location and report ID	Incident description provided by pipeline operator
7 September 1991 West Cocalico Lancaster Pennsylvania 910169	<p>Sun Pipeline control centre was contacted on September 7, 1991, at 07:30 hours by property owner, Mr Walters, who stated there appeared to be gasoline entering an unnamed creek on his property from a tile drain that crossed our pipelines. The APL 6" and 8" west lines were immediately shut down. Control centre then contacted field supervisors who met sorbent booms and pads, and constructing sorbent fencing in the stream. Once the leak was contained, a series of excavations in the area determined the source of the leak to be in a corrosion pit in the 6" west line, located in the road crossing at Swamp Church Road. A temporary repair sleeve was installed and leak was stopped. Permanent repairs are currently being planned, and remediation of contamination in and around the site is continuing.</p>
8 September 1991 Sulphur Calcasieu Louisiana 910168	<p>Citgo dug up their 8" hydrogen line for repairs and found hydrocarbons coming out of the end of the common casing with our 6" kerosene line. Trident sampled the hydrocarbon and it was found to be heavier gravity and analysis, different than kerosene. Notified adjoining pipeline owners of possible leak. At that time, 16:15 hours on September 9, 1991, Trident filed a possible pipeline leak Report #87557. On September 12 through September 13 Trident pressured up the pipeline and did a 26 hour shut-in test to verify pipeline integrity. At the same time monitored casing for any type of hydrocarbon loss. Pipeline held pressure and no sign of any product loss or leak. Trident is filing this report to follow up on initial possible leak report #87557. As reported earlier - Trident NGL Inc., has no leak on this line.</p>
19 September 1991 Brooks Texas 910176	<p>Leak was caused by external corrosion. Access to the leak site was very difficult due to heavy rains prior to the leak occurring.</p>
2 October 1991 Lane Oregon 910201	<p>There is a 2" bypass line around the Tualatin check valve and because of faulty pipe pinhole leaks developed.</p>
20 October 1991 Montgomery Kansas 910196	<p>Land owner damaged pipeline with farm implement. A company crew was immediately dispatched to repair leak and begin spill cleanup. NOTE: Telephonic notice to the National Response Center was made prior to accurately determining the quantity of spilled product. After further investigation, it was found that the incident didn't require DOT reporting. However, this report is being submitted as a follow-up to the telephone notice.</p>
5 November 1991 Dallas Texas 910219	<p>At 13:55, Manhattan Construction reported a leak on Exxon Pipeline Company's (EPC) Waco to Irving Products Pipeline. Contractor (Manhattan Construction) is constructing a parking lot adjacent to EPC and a bulldozer punctured EPC's line causing unleaded gasoline to spill. System was shutdown a 13:59 hours. By 14:30 hours, local fire departments had constructed a containment dam. EPC had personnel on-site by 15:00 hours to begin cleanup and repair operations. Permanent repairs were completed by 08:30 hours on November 6, 1991. Cleanup operations are presently continuing. System on-line by 11:00 hours on same day of completed repair.</p>

Date, location and report ID	Incident description provided by pipeline operator
13 November 1991 Eutaw Greene County Alabama 910213	<p>On November 13, 1991, a contractor was removing a section of the pipeline casing at Alabama County Road 231 to inspect a possible pipeline dent in the 36" segment of Colonial's, Houston, Texas to Greensboro, North Carolina gasoline pipeline. At 18:22 EST, while cutting away the casing with a torch, gasoline vapours escaping from the pipeline ignited, causing a small fire. This flame was immediately extinguished. The pipeline was shut down, and the Greene County Sheriff's Department and the Eutaw Fire Department were notified at 18:32 EST. The National Response Center was notified (Report #96173) of the incident at 20:18 EST on November 13, 1991. After securing the area, a pipe saw was then employed to complete the removal of the casing and expose the pipeline. An inspection of the exposed pipeline revealed the source of the leak to be a 1¼" x ½" hole. Although the hole had not completely penetrated the pipe wall, the remaining segment had apparently cracked allowing the product to escape. Twenty-one gallons of gasoline was lost from the pipeline, of which 20 were recovered. The inspection also revealed a nearby 1¼" deep buckle in the pipeline. Both of these defects were repaired by the instalment of one, 5 foot, full encirclement sleeve to the pipeline. The exact cause of the hole could not be determined by the investigation of on-site personnel. The sleeve prevented a more thorough investigation.</p>
20 November 1991 Odessa Ector Texas 910224	<p>130 barrels of product evaporated and 40 barrels soaked into the soil. Pipe was damaged by third party, possibly during landowner business activities.</p>
10 January 1992 Wilson Texas 920045	<p>External corrosion pit apparently caused by cathodic interference from another pipeline company's rectifier and grounded in the general area of the leak. Repairs were made on January 11.</p>
11 February 1992 Augusta St Charles 920061	<p>On February 11, 1992, at 12:15 hours, a trackhoe operated by Murphy Brothers Construction Company, struck and ruptured Conoco Pipeline's No. 1 Wood River line. The contractor was moving earth in preparation of backfilling a 16" gas pipeline being laid parallel to Conoco's two 10" lines by Missouri Pipeline Company. Conoco's lines had been previously marked via the one-call system operating in Missouri. Additionally, Conoco had instructed Murphy Brothers Construction not to excavate or move heavy equipment over the marked lines. Having not complied with Conoco's request, the line was ruptured. The line was immediately isolated with automated block valves, and repair crew dispatched, by our oil movements group in Houston, who monitor the lines 24 hours a day. Once on site, containment dams were constructed to limit product migration away from the ruptured line. Cleanup was initiated and the line was repaired as soon as conditions would allow the repairs to be conducted safely.</p>
29 February 1992 Beatrice Gage Nebraska 920079	<p>Pipe failed at pressure below operating pressure. The pipe failed in the base metal, five inches from the ERW seam. The failure occurred at a spot affected by localised external corrosion.</p>
4 March 1992 Edgmont Delaware Pennsylvania 920074	<p>Sun Pipeline control centre received a call from a resident that oil was spraying over the road at Meadow and Shepherd Lane. Upon excavation and examination, a 9" split was observed on the pipe. In close proximity to the split there were indicators of mechanical damage to the pipe.</p>

Date, location and report ID	Incident description provided by pipeline operator
12 March 1992 Pacheco Contra Costa California 920144	Line rider found 30 feet of loose and soft coating plus an odour in soil at site - no free product - caused by a bad weld on a weld plus end. Forty-two feet of pipe were cut out and replaced. Note: initial estimates of the total property damage caused by this occurrence were less than \$5,000 and therefore no formal report was filed. However, subsequent investigation has raised those estimates to exceed \$5,000 and we now submit this report to comply with the intent of the regulation.
30 March 1992 San Leandro Alameda California 920130	A small drip was discovered oozing from a 1" pipe thread. The pipe was removed and the opening plugged. Note: initial estimated of the total property damage caused by this occurrence were less than \$5,000 and therefore no formal report was filed. However, subsequent investigation has raised those estimates to exceed \$5,000 and we now submit this report to comply with the intent of the regulation.
23 April 1992 Malheur Oregon 920095	The main line crew was verifying data from British Gas smart pig. They found contaminated soil, they exposed 60' of main line and uncovered two weld plus ends which were weeping. Pressure at that time was 700 psi. The weld plus ends were cut out and new pipe installed.
1 May 1992 South Bend St Joseph Indiana 920098	On May 1, 1992, at 08:59 CDST, Marathon Pipeline (MPL) operations centre received a change in pressure alarm. At 09:02, a meter failure alarm (indicating no flow) was received and by 09:03 pumping units were shut down at Hammond, Indiana, Terminal. An excavation contractor grating top soil with a bulldozer, punctured the 6" pipeline with the blade. The pipeline remained covered with earth reducing the amount of product loss. The line had been previously located and flagged by MPL employees and was found at a depth of 3.5'. At the time the line was punctured, right-of-way markers and utility signs were in place, 58' north and upgrade of the point of impact. Approximately three feet of the damaged pipe was replaced with comparable hydrostatically tested pipe. The excavation contractor is coordinating with the Indiana Department of Environmental Management the remediation of the affected area.
2 May 1992 Cobb County Georgia 920099	Due to nature of leak (3" hairline crack in the pipe) it is impossible to provide an accurate estimate of the total amount of product released. \$400,000 of the estimated total property damage is to cover expected environmental cleanup costs during the next 2-3 years. At approximately 8:55 pm EDT, on May 2, 1992, a leak was discovered on Plantation's 26-inch, .312" wall thickness, grade X-52, petroleum products pipeline which operates between Collins, Mississippi, and Greensboro, North Carolina. The leak occurred 101 feet west of Ivy Pointe Drive in Cobb County, Georgia. The line pipe had a three inch long hairline crack in the twelve o'clock position. The section of the pipe which failed was severely scratched and dented over approximately 14 feet of the pipe. The scratches and dents were apparently made during subdivision development by excavation equipment while burying building debris (wooden poles, railroad ties, pipe and pieces of metal) over the pipeline. The pipe cracked through one of the dents. The pipeline was repaired with two 3' long full encirclement sleeves and one 8' long full encirclement sleeve.
27 May 1992 Washington Oklahoma 920107	Pipeline started up against a blocked valve, causing pipeline to rupture, releasing product to ground. Emergency response personnel were immediately dispatched to site for cleanup and repairs.
5 June 1992 Cook Illinois 920108	Third party contractor was making a 30" bore (west to east) under railroad tracks, when it hit the west shore pipeline (north-south route) running on the east side of tracks.

Date, location and report ID	Incident description provided by pipeline operator
10 June 1992 Garyville St John Louisiana 920117	Product was released through a longitudinal hairline crack in the pipe. The pipe was repaired and the line was placed in service.
19 June 1992 Victoria Texas 920118	The incident occurred when a battery backup system failed causing the rate control valve to abruptly close at our Victoria Terminal delivery facility during a full stream delivery of unleaded gasoline, causing a surge condition to rupture the line.
6 August 1992 West Fargo Cass North Dakota 920150	Contractor working for the Corporation of Engineers hit the pipeline with earth moving equipment (scraper) during the construction of a 4 foot deep drainage ditch.
19 September 1992 San Patricio 920172	Leak was caused by external corrosion. The amount of product lost was 709 barrels. Approximately 91'9" of new 12" pipe was installed where leak occurred.
13 October 1992 Moon Allegheny Pennsylvania 920191	A contractor at a new housing subdivision was moving some earth with a bulldozer and damaged the pipeline with the dozer's blade. A gouge of about 6" x 3" was put in the pipeline. The original pipe depth prior to any earth moving was 40 inches. The pipeline shut down immediately on automatic controls. State and federal agencies were notified as required. Product release containment operations commenced promptly. Approximately 200 cubic yards of affected soil was removed under the direction of the Pennsylvania Department of Environmental Resources. The damaged pipeline section was replaced with pre-tested stock pipe, x-rayed, and pipeline service restored on October 15, 1992.
3 November 1992 Sprague Lincoln Washington 920206	Farmer was sub-soiling his wheat field and hit Chevron Pipeline's pipe. Spokane Station closed because of low flow and the leak detection alarmed. Salt Lake control notified Pasco operator. Pasco operator shut down mainline pumps. Twenty-five minutes after the accident the farmer had got to a phone and called Salt Lake control. Chevron Pipeline personnel were dispatched to MP 658 with spill trailer and repair equipment. Salt Lake compliance notified all required. The pipeline was repaired and placed back in service. The affected soil was transported to an incinerator for thermal desorption (heated to 800 degree F to reduce the total petroleum hydrocarbon level to about 20 ppm), and transported back to the site. No injuries or additional property damage occurred. The need to call before digging, deep tilling work, and so forth, was discussed with several farmers adjacent to the site.
3 November 1992 Cobb County Georgia 920215	At 07:30 EST on November 3, 1992, the Cobb County, Georgia, fire department notified Colonial's control centre that gasoline had been discovered on Colonial's right-of-way near the intersection of Georgia highways 120 and 176. The fire department had investigated after receiving a report of a gasoline odour in this vicinity. The 10", 12", and 16" parallel pipelines in this area were shut down and a Colonial maintenance team was dispatched to the site and verified that a leak existed. Notification was made to the Georgia Environmental Protection Division at 09:02 EST and to the National Response Center (Report No. 143111) at approximately 09:30 EST. On November 5, 1992, after extensive excavations, the 16" Atlanta Junction to Chattanooga, Tennessee, pipeline was found lying on a rock. The abrasion between the rock and pipeline had resulted in some wall thickness reduction and a small dent and crack. The pipeline was repaired by installing a 16" x 36" full encirclement sleeve and after non-destructive testing, was returned to service. An estimated 2 barrels of gasoline escaped from the system. One barrel of gasoline was recovered. One barrel was lost to evaporation and absorption into the surrounding soil. Contaminated soil is stockpiled awaiting disposal.

Date, location and report ID	Incident description provided by pipeline operator
5 November 1992 Long Beach California 920214	Leak from valve vault was reported to operations control centre by company personnel at approximately 9:30 am following which line was shut down. Company personnel then secured the site. Vault was pumped out and, after safe access to the vault was obtained, flange was tightened and leak was stopped.
10 November 1992 Uinta County Wyoming 920203	At approximately 1:30 am on November 10, 1992, a seam failed on the 8-inch Pioneer pipeline system in Uinta County in south-west Wyoming. This failure released approximately 1834 bbls of commercial jet fuel (kerosene) to the environment. The product entered a draw adjacent to the right of way and flowed about ¼ mile; no surface water was present in this drainage. The cause of the seam failure is unknown at this time, however, a metallurgical analysis will be performed on the pipe to determine the cause.
20 November 1992 Brooklyn Park Hennepin Minnesota 920230	A contractor hit the pipeline with earth moving equipment (i.e. scraper) during the construction of a roadway. The roadway that was under construction was Regent Parkway.
21 November 1992 Oregon Lucas Ohio 920222	During sudden shutdown of downstream pump units, the main line pressure rose to about 1240 psi. The pipeline failed because of localised corrosion. The upstream pump station shut down immediately. Emergency procedures were initiated including the nearby coastguard were notified in a timely manner. The product that escaped into a nearby stream was contained prior to entering the Maumee Bay. There was no apparent damage to wildlife. Cleanup was completed as directed by the local coastguard and the Ohio Environmental Protection Agency. The failed pipe segment was sent to Kiefner Associates in Columbus, Ohio, for laboratory analysis.
21 November 1992 El Paso Texas 920227	At approximately 2:40 pm on November 21, 1992, the Artesia operator became aware that the CPU on the 6" line and faulted. Within minutes the operator in Artesia, New Mexico noticed the decrease in flow. Operator called product foreman and shut down mainline pumps and booster station, then called El Paso Terminal and advised the 6" line be shut in at El Paso. El Paso terminalman called to inform Artesia operator that John Hayden with the El Paso Fire Department had called and reported gasoline leak in the Zaragosa Road and Vista Del Sol area. Terminalman had block valve at Ysleta Terminal closed, which is upstream of the leak, stopping flow. Navajo employees and equipment as well as contractor employees and equipment were immediately dispatched to repair pipeline had clean spill area. When the pipe was uncovered it was evident that the pipeline ruptured at a point on the line where it had been hit by unknown parties causing deformation of the pipe including loss of approximately 40% of the wall thickness (a gouge about 12" long and 3/8" in width). Pipeline was repaired and operations resumed at 6:45 on November 22, 1992. Cleanup of spill area is in progress. The normal operating pressure at this point on the pipeline is less than 200 psig when flowing. For that reason we normally leak test this portion of the pipeline at approximately 750 to 800 psig, however with the control valve closing we have calculated that the pressure may have reached 1400-1480 psig. Since the rupture we have designed and are presently installing a control valve 15 miles upstream of residential areas in El Paso (MP 128). This valve will prevent the pressure from exceeding safe working pressure. We have formed a sub-committee with Chevron Pipeline Company and Southern Pacific Pipeline Company to work more closely with the El Paso Fire Department and the zoning and planning divisions of the city of El Paso to help prevent third party damage. We are also designing and will install relief valves sized to prevent high pressure conditions within El Paso. These relief valves will be located at the El Paso Eastside Terminal and will relieve into tankage at the terminal. Additional computer controls have been added to monitor the position of the relief valves. Supplemental report received January 24, 1997 changes property damage from \$300,000 to \$720,800.

Date, location and report ID	Incident description provided by pipeline operator
14 December 1992 Prince Georges Maryland 930007	Utility contractor boring road crossing beneath Suitland Parkway for a 4" conduit. Machine was operating from north side of roadway, auger struck line pipe located on south side of roadway. 'One-call' system advised of projected construction on December 8, 1992, a meeting was scheduled between operator/contractor for December 11, 1992, which contractor cancelled. The meeting never occurred prior to the accident.
14 January 1993 Kapolei Oahu Hawaii 930008	At about 7:30 am on January 14, 1993, the 10" diameter refined products pipeline was struck by a front-end loader operated by Fletcher Pacific Construction Company Limited making a hole approximately 5" x 3". At the time of the impact there was no flow through the pipeline, which contained JP-8 at a pressure of approximately 250 psig. Approximately 17,000 gallons of product was released. Approximately 13,000 gallons were recovered and returned to the refinery. The impact occurred approximately 100' east of MP 3.0, several hundred feet west of a new shopping centre that is being built in the area. During the preceding weeks Fletcher Pacific had undertaken excavations in the area to install a concrete stormwater culvert 8' x 7'. The culvert had been completed and largely backfilled, with only the last 50' still to be covered. This section included the area where the 10" pipeline crossed over the culvert. Soil from the excavation had been stockpiled over the area where the pipeline was struck. On January 14, 1993, Fletcher Pacific employees were backfilling around the last 50' of the culvert. A large Komatsu PC-44 excavator was being used to reclaim soil from the stockpile when the incident occurred. Approximately 5' of the line containing the damaged portion has been replaced.
14 January 1993 Sanders County Montana 930012	On January 14, 1993, a pipeline failure occurred on the Yellowstone pipeline in Sanders County, Montana, on the Flathead Indian Reservation. The release was discovered by the landowner who called the emergency phone number shown on an adjacent pipeline marker. The system was immediately shut down remotely by Conoco's operations centre. Petroleum product entered the nearby Camas Creek; small pools of product were observed for approximately 1700 feet downstream of the release site. Cleanup has included the use of siphon dams, absorbent materials and soil excavation.
28 January 1993 Pinal Arizona 930021	Upon initial notification of a potential leak on Santa Fe Pacific Pipeline's (SFPP's) 6" Phoenix-Tucson pipeline, we immediately shut down operations and drained back product into Phoenix Terminal and dispatched personnel to close the appropriate block valves. SFPP was unable to verify a discharge from the pipeline. The negative pressure test and condition of the product removed indicates the line is not presently leaking, although a small pinhole leak at higher pressure is possible. The gasoline at the site has been displaced by water. SFPP will not be able to inspect the original Gila River crossing until the water level and flow rate are reduced. Therefore, SFPP has decided to leave the pipeline out of service until a new pipeline crossing can be installed.
16 March 1993 Dallas Texas 930051	At 7:00 am on March 16, 1993, the Hearne to Dallas 10" mainline was shut down and stopped to tie in new 2 mile section of 10" at MP 140 and replace corroded railroad crossing at MP 142.5. The line was cold cut prematurely at 10:45 am with approximately 95 psi of nitrogen and gasoline released to the atmosphere.

Date, location and report ID	Incident description provided by pipeline operator
19 March 1993 Pottawattamie Iowa 930048	<p>On Friday, March 19, 1993, at 8:25 am, Clarence Graham working for Havens Construction Company, Inc. (Havens), Liberty, Missouri, hit the six (6) inch National Coop Refinery Association (NCRA) products pipeline with a caterpillar 245B trackhoe. The trackhoe bucket punctured a hole in the pipeline - 2" x 3½" and also dented the pipeline in three other locations. Approximately three hundred and sixty-five (365) barrels of no-lead gasoline escaped into a forty-eight (48) inch diameter sewer main and the three (3) foot gravel base at a bell hole that was being excavated for the installation of a manhole. Havens had been contracted by the city of Council Bluffs, Iowa to install the forty-eight (48) inch diameter sewer main. The NCRA products pipeline was clearly marked as required by DOT 195.410 and the closest marker was eighty (80) feet north of the accident in a north-south fence line. The consulting engineer, Wells Engineers Environmental, Inc. who designed the project, and the city of Council Bluffs, Iowa were aware of both the existence and the location of the pipeline. NCRA Products Pipeline was not notified, either by telephone or via Iowa Underground Plant Location Service, Inc. that the forty-eight (48) inch diameter sewer main was being was being constructed in the vicinity of the products pipeline. NCRA Products Pipeline was contacted about the accident by Kenny Leslie, the superintendent for Havens, at 8:35 am. The pipeline was shut down by 8:41 am. The mainline block valves were closed on each side of the accident by 9:12 am. The damaged section of line pipe - one hundred and sixteen and one-half (116½) inches long was cut out and replaced with another section. The new section of line pipe specifications are listed below: outside diameter - 6.625", wall thickness - .432", API 51 Grade B, seamless. Hydrostatically tested to 1700 psig on May 5, 1981. The welds were x-rayed by Professional Service Industries, Inc., Omaha, Nebraska and passed API 1104. The somastic coating was replaced with royston primer and greenline tape. The NCRA products pipeline was started back up on Friday, March 19, 1993 at 11:52 pm. Cleanup of the no-lead gasoline lost began on Friday, March 19, 1993 at 10:15 am and was completed on Wednesday, March 24, 1993 at 12:00 pm. A total of three hundred and sixty-five (365) barrels of no-lead gasoline was recovered.</p>
1 April 1993 Sioux Iowa 930058	<p>At 1:18 am on April 1, 1993, Amoco's Tulsa Control Center noted a sudden drop in pressure at our inactive Hawarden pumping station. Concurrently, the flow rates into the downstream Sioux Falls terminal dropped dramatically. The controller, immediately shut the system down and activated our emergency response plan. A head pipeliner located at Sioux City proceeded north toward Hawarden attempting to identify the leak location while closing upstream valves in the process. A terminal operator at Sioux Falls was called out to inspect that facility and then follow the line south out of that location. The National Response Center was contacted and the suspected leak was logged as Report No. 165155 by Petty Officer Mauldin at 04:26 EST. The next morning a patrol plane was contracted to fly the pipeline right-of-way between Sioux Falls and Sioux City. Nothing was found. At about 2:30 pm on April 1, 1993, an Amoco employee on a ground search confirmed the location of the break at the pipeline crossing of the Big Sioux river just north of Hawarden, Iowa. At the time of the discovery, the Big Sioux was 6½ feet above flood stage. Only minimal traces of gasoline could be found. On April 2, 1993, the river crossing was evacuated, cut, and physically isolated from the balance of the system. On April 5, 1993, while still above flood stage, a diver went down into the Big Sioux. The diver confirmed the line was broken in two about 45 feet from the south bank on the Iowa side of the river. On April 22, 1993, a new crossing, using the directional drilling method, was completed and the line was returned to service from the river. It was confirmed that the failure involved a clean break at a girth weld. With concurrence of DOT, whose personnel were on site, the pipe will be sent to Amoco's Naperville, Illinois Research Center for a detailed metallurgical analysis. The diver also indicated the line was partially exposed as a result of scouring along the river bed.</p>
3 April 1993 Creek Oklahoma 930091	<p>County road grader hit line causing leak. Line was well marked with markers on either side of the road. Line was 18" deep in bar ditch. Line has been repaired and lowered.</p>

Date, location and report ID	Incident description provided by pipeline operator
6 April 1993 Lenexa Johnson Kansas 930069	Line flyer reported dead spots in grass at MP 33. Phillips Pipeline personnel investigated and discovered an oily residue. The 8" line was shut down and blocked in. Excavation of the line began. The leak was located and clamped. The failed pipe section was removed and replaced.
28 April 1993 Brazoria Texas 930079	A report of a spot of dead vegetation on the pipeline right-of-way was called in by the pipeline aerial patrol. The pipeline walking patrol verified that a hydrocarbon smell and residence were apparent at a location near Jones Creek, Texas inside Peach Point Wildlife Preserve. The walking patrol informed the refinery stock dispatcher of the findings. Although the leak was strongly suspected to be on the #3 products pipeline, which had last carried base aviation gasoline, all three finished products pipelines in the right-of-way were shut down as a precaution until laboratory analysis could verify the line involved. The stock dispatcher called the refinery technical assistant who arrived on-site at approximately 8:00 pm. A sample of the hydrocarbon at the leak site was taken and transported to Phillips 66 company laboratory for analysis. Laboratory analysis confirmed that the line involved was the #3 products pipeline. The refinery technical assistant began notification of company personnel, environmental personnel, and repair crews. Outside agencies were contacted including the Texas Railroad Commission, Texas Water Commission, the National Response Center, and Texas Parks and Wildlife. Since the leak site was relatively small and isolated, the pipeline was down blocked, the hour was late, repair crews were lined up to arrive first light on Thursday, April 29, 1993. Repair crews arrived at the site at approximately 7:15 am. The leak site was excavated and the leak location was found. The leak on the line was on the bottom of the pipe which appeared to be in the centre of a small indentation in the pipe. The original coating on the pipe was still intact. No signs of current excavations in the area were found. A pipeline repair clamp was installed over the pipe and indentation. The line was started back up to verify the integrity of the repair. No problems were found. Plans are to remove the section of line containing the clamp by September, 1993, so that the pipe section in question may be evaluated by metallurgical examination. The estimated cost of removing this section of pipe is included in the estimated total property damage. A plan for cleanup of the leak repair site has been filed with the Texas Water Commission.
18 May 1993 Gonzales Texas 930074	A severe thunder storm was passing through the area. Lightning caused damage to an electrical coil allowing the control valve to immediately cycle to the open position causing excess operating pressure on the pipeline.
20 May 1993 Gonzales Texas 930086	A severe thunder storm was passing through the area. Lightning caused damage to an electrical coil allowing the control valve to immediately cycle to the open position causing excess operating pressure on the pipeline.
31 May 1993 Novi Township Oakland Michigan 930101	A sheen on a small water puddle in a road drainage ditch was reported to the local emergency centre. The emergency centre contacted the local fire department. The local fire department, having recently attended a Buckeye public awareness program, asked the emergency centre to contact Buckeye. All required notifications were made in a timely manner. Investigation of the incident revealed the cause to be a failed longitudinal weld on a support sleeve used to reinforce a TD Williamson 101 2" thread-o-ring nipple. The support sleeve was removed. Repairs were made by installing a certified segment of pre-tested 12", 250X-52 pipe. This replacement pipe segment was coated after the tie in welds were successfully x-rayed. Any affected soil was removed and the site cleanup was completed to the satisfaction of the Michigan Department of Natural Resources. The failed weld in the support sleeve has been sent to an outside firm for further analysis.

Date, location and report ID	Incident description provided by pipeline operator
1 June 1993 San Patricio Texas 930096	Leak occurred inside of 16" road casing on pipeline road crossing. Replaced with 200' of new pipe.
19 June 1993 Macon Illinois 930118	At approximately 03:54 CDT on June 19, 1993, a low suction switch at the Wabash Macon Station, caused the pump units, at that station, to be shut down. The remaining three pumps running on the Wood River to Champaign leg of the Wabash system were shut down at 03:58 CDT by an analyst, at the Findlay Operations Center, and the Wood River operator. At 03:59 the Findlay Operations Center analyst notified the area foreman of the incident. The area foreman dispatched personnel to the area to investigate and close the mainline block valves. Marathon Pipeline Company and contract emergency response personnel were put on alert. Sheriffs in five counties, in the potentially affected area, and the Illinois Emergency Management Agency were notified of the possibility of a pipeline leak. The National Response Center was notified at 07:08 CDT of the leak. At 07:15 CDT the release location was discovered in a corn field approximately 3 miles downstream of Macon Pump Station. The released product entered Finley creek and was contained there by a system of containment dams. A 50 foot joint of 12" pipe was found to have a seam failure. The joint of pipe containing the failure was removed from the pipeline and forwarded to an independent laboratory for analysis. A replacement joint of pipe, which had been previously hydrostatically tested, was installed in the pipeline. Cleanup and disposal of contaminated earth is being coordinated with the Illinois EPA, Office of Chemical Safety, Emergency Response Unit.
20 July 1993 Baltimore Maryland 930119	At 11:01 EDT on July 20, 1993, Colonial personnel were notified by a third party of the presence of a gasoline odour and a sheen on a tributary of Long Green Creek near Hydes, Maryland. Colonial's line 36 from Aberdeen Junction to North Baltimore delivery traversed this area, and at 11:21 EDT the line was shut down. An investigator was dispatched to the scene and found small bubbles of gasoline leaking into the creek. Emergency response personnel, including a local spill contractor, were immediately dispatched to the scene to begin containment and cleanup activities. A containment dam downstream of the leak and absorbent diapers were installed to assist the recovery of product. Local fire and police departments were called to the site and at 12:50 EDT the National Response Center was notified of the incident (Report No. 187501). At 1300 EDT the state of Maryland Department of the Environment was notified of the incident. Excavation of the pipeline revealed product was leaking from a small crack in a gouge. This gouge appeared to be the result of third party mechanical damage. The damaged section was removed and replaced with pre-hydrostatically tested pipe. The section of the pipe containing the damage has been forwarded to an independent metallurgist for analysis. The environmental department has impact studies and are monitoring continuing cleanup activities. It is estimated that less than 20 gallons of gasoline escaped from the system and 5 gallons of gasoline were recovered.
29 July 1993 Brown Kansas 930120	The WPL #3-8" pipeline was struck and punctured at milepost 80+24 by a Padonia township owned and operated grader. The grader was being used to rebuild low spots in the road. There was no one-call notification. The line depth had been reduced to approximately 10 inches through significant erosion. The pipeline warning signs were in place on both sides of the road with the nearest marker 8 feet away. They were not obstructed and were clearly visible. The pipeline was pumping gasoline at the time. The line was shut down within 2 or 3 minutes. The operations control centre received an excess flow alarm and almost immediately following received a phone call from the leak site. The product was contained within the ditch which was promptly dammed up by the road grader.
6 August 1993 Toluca Marshall Illinois 930136	At 10:55 am on Friday, August 6, a caller telephoned and reported there was gasoline coming out of a vent pipe at 322 E, Santa Fe Road in Toluca, Illinois. Operations supervisor left immediately to verify it was our leak. By 12:00 noon he contacted Mazon office and contractors were contacted and Norco employees left for leak site. Vacuum truck was called to remove product, casing was removed until leak was located, new tested pipe was installed to replace corroded pipe.

Date, location and report ID	Incident description provided by pipeline operator
12 August 1993 Hidalgo Texas 930186	Leak was caused by third party damage, it appeared not to have been hit recently. Several other pipelines are located within close proximity to coastal right-of-way. New pipe was installed where the leak occurred.
30 August 1993 Jefferson Davis Louisiana 930174	On August 30, 1993, Colonial maintenance personnel were excavating the 40" line 01 near Bayou Nezpique in Louisiana to investigate an indication recorded by an internal magnetic inspection tool. During the excavation, gasoline fumes were discovered. After the pipe was exposed, an 8 foot long, longitudinal indentation was found on the pipe in the 7 to 9 o'clock position. Upon closer examination, a 1.5" crack was found in the indentation, but no product was found leaking from the crack and only when the line pressure was higher than the 100 psig the line was operating at during the excavation. At 16:05 CDT the National Response Center (Report No. 195396) was notified of the incident. Telephonic notification of the incident was also made to the local sheriff's department, the Louisiana Department of Environmental Quality, and as a courtesy, the south-west region of the Office of Pipeline Safety. Repair to the pipeline was made by the installation of a foot long, full encirclement sleeve. All sleeve welds were inspected by magnetic particle examination and the sleeve was coated with primer and polyken tape. The source of the outside force damage that caused the indentation cannot conclusively be determined.
2 September 1993 Berwick Township Adams Pennsylvania 930185	Third party operating ditching equipment, while installing drain lines on a golf course, hit Sun Pipeline Company's 6" Icedale to Allegheny pipeline.
14 September 1993 Seminole Oklahoma 930178	Gene Smith, landowner, reported leak to dispatcher, they notified Lee Cokeley who took control of incident and called out necessary personnel and equipment. Containment and vacuuming operations were implemented. A temporary clamp was installed to stop leakage.
5 October 1993 Chariton Missouri 930150	Release caused by external corrosion inside casing. The Arco Pipeline Company Control Center started pipeline up against a closed valve. This occurred during a scheduled start up to Toledo, Ohio. The pump stations at Hartsdale, Indiana and Goshen, Indiana were both started causing surge pressure in the pipe. The resulting pressure exceeded the strength of the pipe causing a longitudinal stress fracture of pipe.
18 October 1993 Macon Missouri 930154	Release caused by external corrosion inside casing.
18 October 1993 Coffeyville Montgomery Kansas 930198	At approximately 08:21 hours on October 18, 1993, a caller contacted the Williams Pipeline Company (WPL) Operations Control Center and reported that he smelled gasoline near the intersection of First Street and Englewood Street in Coffeyville, Kansas. The operations control department immediately shut down operations on the #2-8" Coffeyville - Caney Junction pipeline and contacted the WPL southern region office. The southern region office immediately dispatched emergency response personnel to investigate the report. At approximately 20:30 hours on October 18, 1993, a leak was found. At 21:00 hours the leak was plugged and arrested. The cause of the spill was determined to be an external corrosion pit in the pipeline. The pipeline was repaired by replacing a section of the pipe. Approximately 215 barrels of unleaded gasoline were spilled with 89 barrels recovered. WPL coordinated the cleanup efforts with the Kansas Department of Health and Environment.

Date, location and report ID	Incident description provided by pipeline operator
27 October 1993 City of Allentown Pennsylvania 930203	At approximately 09:10 on October 27, 1993, Olshan Demolishing Company was removing old piping from Exxon abandoned tank farm in Lehigh County, City of Allentown, Pennsylvania. Company was using a Kamotsu PC 400 LC excavator with a hydraulic sheer attachment and removing underground piping at the facility. Piping was not being excavated before sheering and removing pipe. Contractor started to remove Mobil's in-service 6" line rupturing the pipe causing the spill. The unleaded gasoline vaporised, causing the population around the leak site to be evacuated. Part B. Specific location - in the City of Allentown.
28 October 1993 Lincoln Colorado 930208	Henkles and McCoy Construction was laying a telephone cable for Eastern Slope Telephone Company. They called the utilities notification centre of Colorado on October 27, 1993, to set up a meeting at the location for a line locate on October 28, 1993, at 12:17 pm MDT. Henkles and McCoy struck our pipeline at 10:37 am MDT, before we were due to meet with them to locate the pipeline. A Chase employee was on his way to meet with them when the accident happened.
30 November 1993 Dixon Solano California 940007	Santa Fe Pacific Pipeline employee walking along right-of-way saw product on the ground (10" diameter wet spot). Employee used mobile telephone to call in and report. Pipeline was shut down immediately. Wet spot disappeared. Pipeline drained into Sacramento. Inspection revealed several pinholes within a 1" area. Pipeline repaired by welding on a three-foot sleeve.
1 December 1993 Washington Franklin Missouri 940005	At approximately 21:16 hours on December 1, 1993, Conoco Pipeline oil movements group in Houston observed a pressure deviation indicating a possible release downstream of Washington Station on the No. 2 Wood River line. Shutdown procedures were implemented and the remotely operated valve at Washington Station was closed to isolate the suspected release. Field personnel were immediately contacted and dispatched to the possible release site. Upon arriving at the location field personnel also closed the manual block valve immediately downstream of the release site. The release was located in the 1600 block of South Point Road between old Highway 100 and Dubois Creek. Containment booms were deployed at three locations on Dubois Creek to minimise contamination of the Missouri River, located downstream approximately ¼ of a mile. Visual inspection of the pipe revealed a break in the acetylene weld. Approximately 35 feet of pipe was replaced on the #2 line. Weld bands were placed on both the road crossing tie-in welds and the creek crossing tie-in welds on both the No. 1 and No. 2 lines. The break appears to be the result of severe subsidence magnified by three factors 1). Local flooding loosening the soil, as this area was submerged during the flooding of 93. 2). Settlement of the ditchline of foreign pipeline crossing which runs parallel to old Highway 100 and is located almost directly over the break and 3). Heavy traffic on old Highway 100 during weakened roadbed conditions; settlement in the roadbed was clearly visible.
7 December 1993 Wise County Texas 940010	At approximately 08:45 hours on December 7, 1993, our 8 5/8" Southlake products pipeline ruptured near US Highway 287 in Wise County approximately 7 miles south-east of Decatur, Texas. Upon investigation it was discovered the pipe had been struck by a drilling machine operated by a seismic crew in the area about September 1993. The accident allowed 1260 barrels of unleaded gasoline to escape, of which 443 barrels was subsequently recovered. The product did not ignite and no injuries were sustained. The pipeline was repaired without incident by replacing 40 feet of line with pre-tested pipe and returned to service.

Date, location and report ID	Incident description provided by pipeline operator
8 December 1993 Lancaster Pennsylvania 940024	In response to operational information which suggested the possibility of a leak, the 6 inch Icedale to Allegheny line was shut down on December 8, 1993, at 13:10 hours. A pressure check immediately followed in tandem with line isolating activities which indicated a potential leak within an approximate ten mile segment. Once the approximate 10 mile segment was identified, line walkers and helicopter overflights were immediately dispatched to confirm/deny a leak. No evidence of a leak was discovered. Further line isolation activities were performed which identified a suspect two mile segment. Environmental consultants and two soil gas contractors were hired to assist in locating the leak. On December 13, 1993, the leak was discovered in a farmer's field just west of the Conestoga Valley Industrial Center. There was no superficial evidence of any petroleum products at this location. All product entered the subsurface via shallow bedrock which was located immediately adjacent to the line. Upon excavation, it was observed that the pipeline was struck in numerous locations by a third party.
25 December 1993 Carson California 940021	Leak occurred in small section of uncoated pipe at Arco's Los Angeles refinery and was found at 3:00 pm. Line was shut down and contaminated soil was excavated and removed and line was repaired. Part i - caused by corrosion at coating break.
29 December 1993 Murtaugh Twin Falls Idaho 940012	At 09:31 am, on December 29, 1993, the Chevron Pipeline pump station at Glens Ferry, Idaho was shut down to allow passage of a smart pig. The controller noticed alarms outside of those expected under the circumstances. At 09:38, the pump at the Murtaugh Pump Station downstream of Glens Ferry shut down. Unexpected alarms continued to be received at the control centre. At 09:40 the controller shut down another pump downstream. At 09:48 he contacted field personnel in two areas, suspecting that a leak may have occurred in a segment of line between Murtaugh and Glenn Ferry. By 09:51 the entire line was shut down and the block valve at Murtaugh was closed. The leak was found at 13:00 pm and a crew was sent to the scene.
25 January 1994 Solano California 940089	On January 25, 1994, Santa Fe Pacific Pipeline personnel detected a possible leak on the Concord-Sacramento 14" pipeline. Upon excavation, a pinhole leak was confirmed. Repairs were completed on January 27, 1994, and the line was returned to service following a satisfactory pressure test. Cleanup was completed on February 1, 1994, and environmental remediation is under way.
14 March 1994 Baton Rouge East Baton Rouge Louisiana 940080	On the afternoon of March 14, 1994, a contract employee working for Plantation discovered a small amount of gasoline around Plantation's 12-inch outgoing MDA block valve. The block valve was excavated and the downstream flange of the valve was found to be leaking. The flange bolts were tightened to stop the leak, then the line was pressured and no leak was observed. The line was returned to service and the valve was visually monitored. A valve box will be installed around the valve to allow for future visual inspections.
15 March 1994 Osage Oklahoma 940097	Failure of 3/8" tubing fitting on pressure controller at booster station. Pressure controller allowed discharge pressure to increase above the control set point.
17 March 1994 Los Angeles California 940083	Operator pumped against a closed valve, gasket blew out on valve #11009 at 400 psig.
1 April 1994 Platte Nebraska 940108	The longitudinal weld seam failed which resulted in an approximate 27 inch long rupture. Metallurgical tests performed subsequent to the failure indicate the failure was caused by hook cracks concentrated along the longitudinal weld seam. The metallurgical report has been submitted to the Office of Pipeline Safety regional office in Kansas City, Missouri.

Date, location and report ID	Incident description provided by pipeline operator
21 April 1994 Los Angeles California 940148	<p>Excel Paving Company were contracted by Los Angeles County Public Works to widen the intersection of Garfield and Telegraph. In order to widen the turning radius from Garfield to Telegraph, Excel cut down an embankment located behind the previous curb. Mobil's 8" pipeline was located in the embankment with approximately 5-6' of cover. The pipeline location was previously marked and drawings were forwarded to both the county and the contractor respectively prior to the removal of the embankment. While the contractor was trying to finish the grade with a large grading excavator the blade punctured a 2" diameter hole in the top of Mobil's 8" pipeline. The pipeline was immediately shut down and isolated and corrective measures were implemented at this time to diminish any additional problems.</p>
29 April 1994 Payne Oklahoma 940126	<p>Pressure loss detected on line by SCADA system. Personnel sent out to investigate and discovered leak. Excavated site and found external localised corrosion had caused pinhole leak. Repaired leak and resumed normal operations.</p>
8 May 1994 Indiana County Pennsylvania 940132	<p>Control room received a call at 21:40 hours on May 8, 1994, from the Indiana County HAZMAT team of a gasoline leak in West Wheatfield township, Indiana County, Pennsylvania. Within four hours of this notification, Sun Pipeline Company, contractors and local responders had contained the leak. The US Environmental Protection Agency and the Pennsylvania DER, who had oversight responsibility for the cleanup of this incident, lauded our emergency response and subsequent remediation efforts. The pipeline was not operating at the time of the leak, but was 'laid-down' under pressure (372 psi at Delmont Terminal) with premium gasoline. Line was inactive due to a planned 'shutdown'. Part b - approximately 2.5 miles north of the town of Robinson, Indiana County, Pennsylvania. From the intersection of routes 22 and 259, proceed south on Route 259 for approximately one mile; incident was approximately 3000 feet west of this location. Part d - to be determined from laboratory analysis of pipe; information to be submitted in a supplemental report.</p>
18 May 1994 Kansas City Wyandotte Kansas 940137	<p>On May 17, 1994, at approximately 08:47 hours, Vicki Beach, Williams Pipeline (WPL) regional administrative coordinator, received a call from the Kansas City Water and Sewer Department about the apparent presence of gasoline in their sewer system. At 08:50 Hursk WPL's area maintenance supervisor was dispatched to the site and confirmed the presence of gasoline at 09:01 hours. WPL's operations control was immediately notified of the situation and all active lines in the corridor were shut down. At approximately 09:30 hours, WPL emergency responders had a backhoe and emergency response equipment in place, and by 11:30 hours the mainline valves were closed to isolate the leak site. At approximately 03:00 hours, May 18, 1994, a pinhole size leak, caused by external corrosion, was discovered. The WPL area maintenance crew placed a temporary patch on the pipeline at approximately 04:00 hours and by 15:00 hours the WPL crew had installed two (2) patches and full sleeve on the pipeline to permanently repair the corroded area. An analysis of the leak occurrence indicated that approximately 33 barrels of gasoline had leaked from the pipeline of which 26 barrels were recovered through contaminated soil excavation. The cleanup effort was coordinated with the Kansas City Fire Department, Kansas Office of Emergency Management, federal DOT, the Kansas Department of Health and Environment and the EPA.</p>

Date, location and report ID	Incident description provided by pipeline operator
2 June 1994 Sedgwick County Kansas 940176	<p>At approximately 02:00 on June 2, 1994, the Chase El Dorado mainline pump station went down on low suction pressure. The El Dorado booster station went down on high discharge pressure, shutting down the pipeline. These events alerted control centre personnel in Wichita, Kansas to a problem of unknown origin and type. Control centre personnel immediately communicated with Chase personnel in El Dorado, in an effort to locate the problem. When it was determined that the problem was not located at either the pump station or the booster station, Chase personnel began checking the pipeline. It was determined that the problem was not located between the main line pump station and the booster station. Chase personnel then began checking the pipeline downstream of the booster station. While Chase personnel were in the process of checking the pipeline downstream of the booster station, control centre personnel in Wichita received a telephone call from the Sedgwick County 911 operator, notifying control centre personnel of discharged product at the junction of 69th Street North and Webb Road in rural Sedgwick County. This telephone call was received at approximately 03:15 on June 2, 1994. Chase confirmed that there was a leak at 04:10 and emergency crews were immediately dispatched to the location of the leak and began containment efforts. The pipe was excavated, removed and sent to metallurgical consultants in Houston, Texas, for analysis. Analysis of the pipe showed that the leak was caused by an inactive cell of external corrosion. Pressure on the pipeline has been reduced to 1180 psig. Chase personnel are in the process of arranging for an internal inspection of the pipeline.</p>
2 June 1994 Sedgwick Kansas 940177	<p>Subsequent to the June 2, 1994, leak on the Chase pipeline, the affected portion of pipe was removed and replaced with a new section of pipe with temporary, weld plus ends. The pipeline was placed back into operation with Chase personnel present at the site. One of the weld plus ends on the new pipe failed with the surge pressure as the pipeline was placed back into operation, causing the discharge of jet fuel. The pipeline was immediately shut down the block valves closed on the pipeline, preventing drain down. Emergency crews present at the site during the leak recovered the discharged product from the excavation. The pipeline remained down until the weld plus ends were permanently welded.</p>
13 June 1994 Throop Cayuga New York 940162	<p>At approximately 07:00, operator and its contract crew began an exploratory excavation to expose an anomaly indication as indicated by a smart pig log. Backhoe operator was excavating on the south side of pipeline. At approximately 08:00, the backhoe operator hit a ¼" nipple and valve that was 9" long and perpendicular to the pipe, cracking the nipple, causing the spill. Product sprayed into the excavated ditch and was contained. Secondary containment ditches were excavated south of the primary ditch as a precaution. Pipeline was properly repaired and put back into service. Contaminated soil was removed and hauled to an approved disposal site.</p>
21 June 1994 Haskell Oklahoma 940152	<p>On Tuesday June 21, 1994, at 2:05 pm, the patrol pilot notified the southern region office of dead vegetation along the pipeline right-of-way near milepost 184 on the Duncan to Fort Smith line. Immediately, the Tulsa dispatcher was notified to shut the line down and a member of the maintenance crew was sent to the site for verification. At 4:00 pm on June 21, 1993, the leak was confirmed. At approximately 5:00 pm, the leak was isolated by closing the block valves on either side of the leak while equipment was being mobilised to the site for repair. At approximately 6:30 pm, the backhoe and additional personnel arrived at site. At approximately 7:00 pm, the leak was exposed and it was determined that there was a pinhole size leak caused by external corrosion. The leak was immediately stopped using temporary clamps and the site was excavated further to make safe for welding. At 8:00 am on Wednesday June 22, 1994, the permanent patch was welded on the line and the line was put back in service on June 23, 1994. Full scale remediation was completed by July 15, 1994, except for the discing of the soils, which is an ongoing process.</p>

Date, location and report ID	Incident description provided by pipeline operator
18 July 1994 Menard Illinois 940186	<p>At 21:15 hours on July 17, 1994, Williams Pipeline Company (WPL) was notified of a suspected leak near MP 545. At that time, the line was shut down and pressured up for static pressure loss monitoring; the operator at Menard Terminal was instructed to close the valve at MP 544; and the area maintenance crew was dispatched to the scene. The area maintenance crew arrived at the site at 01:45 hours on July 18, 1994 and discovered product escaping from drain tile at approximately 02:00 hours at which time an excavating contractor was contacted and containment and absorbent booms were placed in the drainage ditch. The excavating contractor arrived at the site at 03:30 hours and by 05:30 hours the leak area was discovered and excavation of the pipeline commenced. The excavation, hampered by high 'LEL' levels in the area, continued until 15:00 hours when the leak was discovered. The leak was found to be a result of a pinhole in a girth weld. At 16:00 hours, the leak stopped by 'clamping off' the leak with a full encirclement sleeve and rubber stopper. At 19:30 hours, the repair operation was halted again due to high 'LEL' levels for safe welding. On the morning of July 19, 1994, the maintenance crew returned to the leak site and completed the welding of the full encirclement sleeve and put the line back in service at 13:00 hours. Remediation activities began by authorising borings to be made to define the extent of the contamination and to monitor the quality of the groundwater. Further remediation was halted awaiting the approval of the landowner regarding our proposed remediation plan based upon the boring analysis.</p>
23 July 1994 Montgomery Kansas 940185	<p>At 14:00 hours on July 22, 1994, Tulsa dispatching noticed a loss in throughput and immediately shut the line down and pressured the system up for a static pressure check. At 16:05 hours, the area maintenance crew was notified that pressure was continuing to drop on the pipeline and requested the valve at Caney Junction be closed for further leak isolation, which was completed at 19:00 hours. At this time the right-of-way was driven to inspect for leaks at road crossings. At 19:30 hours, excavation contractors were called to arrive at the site the morning of July 23. At 08:00 hours on July 23, the maintenance crew began walking the line and the pilot patrol was dispatched to fly over the line to look for the leak. At 10:00 hours, the pilot patrol discovered the leak near milepost eleven (11). By 10:45 hours, the maintenance crew arrived and excavation began. At 11:45 hours, a temporary patch was clamped to the line stopping the leak. Because of high 'LEL' levels in the repair area, the welding of the permanent patch could not be completed until 19:30 hours, at which time the line was placed back in service. Cleanup of the leak area began on July 23, 1994, by digging trenches to determine the extent of the contaminated area. The ditches were then ignited to remediate the free product present. Additional ditches were excavated on July 24, which were also ignited. The contaminated soils were then land farmed and are expected to be placed back in the excavated area during the latter part of 1994.</p>
27 July 1994 Saline Kansas 940183	<p>Central dispatch received a rate of change alarm showing an increase in flow and a decrease in pressure. Emergency procedures were implemented and the line was blocked in. The leak was located and the cause determined to be external corrosion. The damaged section was replaced and the line returned to service.</p>
26 August 1994 Union County Arkansas 940218	<p>At approximately 15:00 hours CDT, August 26, 1994, a leak was discovered on our 4" system in Union County, Arkansas. Personnel were immediately dispatched to the location of the leak. After isolation of the site, it was determined timber clearing equipment operating on the right-of-way had driven over the pipeline and had deformed the pipe. This resulted in a pinhole failure in an area which also exhibited evidence of surface corrosion. Removal of this section and installation of new pipe was completed on August 27, 1994. Cleanup operations were concluded and the system restarted on August 27, 1994.</p>
12 September 1994 Rapid City Pennington South Dakota 940227	<p>While conducting monitoring well inspection, product was found in observation well #1. The source was found to be 3 leaking lines under the west dike wall of tank #4. These leaks have been repaired.</p>

Date, location and report ID	Incident description provided by pipeline operator
20 October 1994 Near Houston Harris County Texas 940236	<p>On Thursday, October 20, 1994, a pressure drop and significant rate increase on line 01, were noted at Houston Station by the local station operator and by the line controller in Atlanta, Georgia at approximately 08:31 CDT. The line was immediately shut down and company personnel began searching for a possible leak. Personnel were also dispatched to close block valves between Houston Station and Shiloh Station. At 09:37 CDT gasoline was found in a new channel created by flood waters of the San Jacinto River, approximately 12.5 miles downstream of Houston Station. The pipeline was severed near the west bank of the new channel. Shortly after the discovery of the location of the leak, the gasoline fumes ignited near the River Road area of Channelview, Texas. Telephonic notice was made to the NRC at 09:24 CDT on October 20, 1994, Report No. 266190. It is estimated that 20,000 barrels of gasoline escaped from the severed pipeline, all of which was consumed by the fire or lost to evaporation. While at the present time the estimated total property damages are undetermined, the combined costs for the line 01, line 02 and the Texaco crude oil line breaks are expected to exceed \$10,000,000. This incident is under investigation by the NTSB. The number of persons (1851) injured is a combined total with line 02 break and Texaco crude oil line (see Report #940237 for line 02 information).</p>
10 November 1994 Nueces Texas 950010	<p>A sheen was spotted on Nueces Bay by a Koch Pipeline patrol pilot. Coastal States Crude Gathering Company personnel verified leak and shut the pipeline down. The line was purged of product with nitrogen to locate leak and begin repairs. A split sleeve clamp was installed on the line. The sheen was observed to have dissipated rapidly. There appears to have been no damage to the shoreline or any other marine habitat.</p>
20 December 1994 Red River Natchitoches Louisiana 950024	<p>At 13:53 hours CST December 20, 1994, Texas Eastern Pipeline Company personnel identified a shut down of two remote pumping facilities on the company's 20" P-2 pipeline. The emergency plan was immediately implemented. Local authorities between the two pump stations were notified of the potential for a pipeline release and the system was blocked in. The OPA 90 spill response plan was immediately implemented upon confirmation of the release location. Based on a report from local authorities, it was determined that the Red River crossing had failed. At the time of the failure, the Red River was in high flow condition, which hampered efforts to visually inspect the river crossing. The pipeline failed due to a washout of cover around the line, however, the exact cause of the failure is unknown. The Louisiana Department of Environmental Quality declared cleanup of the incident site complete on December 22, 1994. Installation of a new bored crossing was begun on December 24 and the line was placed back into service on January 5, 1995.</p>
3 May 1995 Henry Virginia 950085	<p>At approximately 4:00 pm EDT, on May 3, 1995, a leak was discovered on Plantation's 8.625 inch OD, 0.188" wall thickness, grade X-52, petroleum products pipeline which operates between Greensboro, North Carolina and Roanoke, Virginia. The leak occurred in a remote area near Foxfire Road (Virginia Route 618) between Dyers Store Road (Virginia Route 614) and Barrows Mill Road (Virginia Route 663) in Henry County, Virginia. The seamless line pipe had a 2-inch long hairline crack with a pinhole at the twelve o'clock position. The crack was within a dent which measured 0.22" in depth. During excavation of the pipeline leak, a rock was discovered resting on the pipe. The pipeline was repaired with a 4' long full encirclement sleeve.</p>

Date, location and report ID	Incident description provided by pipeline operator
10 June 1995 Audrain Missouri 950113	<p>At approximately 05:00 hours on June 10, 1995, operations control notified the region office person on call that the pressure had dropped on a section of the TCS 12" line between Centralia, Missouri (MP 401) and Madisonville, Missouri (MP 443) . At the time of the drop in pressure, the line was holding a static pressure of approximately 650 psi. Field personnel were dispatched to close valves at MP 411 and 421 to further isolate the line. This caused the pressure to stabilise at both Centralia and Madisonville. Pressure gauges were then installed to verify pressure dropped, field personnel began walking the line and flying the ten mile section to locate the leak. The leak was found at approximately 12:30 hours at MP 417 +25. The maintenance crew began recovery and containment efforts by digging trenches downgrade of the line, which prevented any contamination of a nearby creek. The line was excavated the leak was clamped off for installation of a 12" full encirclement sleeve. The line was excavated approximately 110 feet on both sides of the leak site to inspect the integrity of the pipe and coating. Repairs were made to additional localised corroded areas which were completed June 11, 1995. The line was officially turned over to operations control at 16:00 hours on June 12, 1995. Cleanup efforts included in situ burning along with soil excavation and land farming on site. This work was done in co-operation with the Missouri Department of Natural Resources. It is expected to take a couple of months for complete cleanup and restoration of the leak site.</p>
17 June 1995 Yolo California 950110	<p>D-7 caterpillar working for Port of Sacramento hit pipeline. There was no one-call notification made. Caterpillar operator called fire department, who informed Chevron Pipeline Company dispatch office. Dispatch shut down pipeline.</p>
17 July 1995 Lacon Township Marshall Illinois 950133	<p>Contractor working for state of Illinois, Department of Conservation, was repairing a levee with dragline. Contractor failed to utilise one-call system and failed to observe pipeline markers across property. Dragline removed cover over pipeline and punctured pipeline with dragline bucket.</p>
11 August 1995 Carson California 950151	<p>Received a call from a third party informing GATX that the grass appeared to be dead near our pipeline marker. After investigating, the soil appeared to have a petroleum odour. Excavation of the area revealed a pipeline leak in the casing under the road. The old pipe was removed and approximately 130 feet of new pipe was replaced through the casing.</p>
29 August 1995 Nueces Texas 950160	<p>Leak was originally thought to be a coastal refinery leak on August 26, 1995. On August 29, 1995, blocked in Houston 12" block valve on south side of Corpus Ship Channel - pressured up on line and would not hold; continued excavation coastal refinery had initiated in search of leak. Found leak early morning of August 30, 1995; attempted to install split sleeve clamps but would not hold due to damage of the pipe; installed half wrap clamp which held until permanent pipe replacement was made on September 12, 1995.</p>
20 September 1995 Bee Texas 950172	<p>While starting pipeline up from Corpus line blew out.</p>
22 September 1995 Bee Texas 950179	<p>A pressure drop occurred at 21:04 hours on September 20, 1995, on the 12" segment of the San Antonio refined products pipeline system between the Normana and Karnes City pump stations. The line had just returned to service just prior to the noted pressure drop. Coastal personnel were immediately dispatched to the area where the leak was suspected to have occurred. Due to inclement weather (thunderstorms) and the rural location of the pipeline, the leak was not actually located until 11:00 hours on September 22, 1995. A 10' split, 2" wide in the 12" pipe was found upon excavation of the site. Subsequently, the MOP and operating pressures were lowered on the system and a metallurgical analysis of the failed pipe is being conducted.</p>

Date, location and report ID	Incident description provided by pipeline operator
4 October 1995 Montrail County North Dakota 950181	<p>On October 4, 1995, at approximately 4:14 pm MDT, a state contractor working for the state of North Dakota on a state highway construction project, hit an 8" diameter petroleum products pipeline owned and operated by Cenex Pipeline, Inc. at a location approximately 4 miles west of New Town, North Dakota. The impact of the earth-moving equipment caused the steel pipeline to rupture, releasing unleaded gasoline to the ground, and possibly a small quantity to Lake Sakakawea. A detailed description of the incident location is: north of Highway 23, approximately 4 miles west of New Town, North Dakota, and ¼ mile east of Four Bears Bridge, section 14, T152N, R93W, Montrail County, North Dakota. A total of 1136 barrels (47,712 gallons) of unleaded gasoline was leaked; approximately 330 barrels (13,860 gallons) of which was recovered and transported to the Cenex Pipeline terminal in Minot, North Dakota. The loss of pipeline pressure resulting from the rupture was immediately detected at the pipeline control centre in Laurel, Montana, and the pipeline was shut down by 4:16 pm. The state contractor used earth-moving equipment on site to construct berms which contained the gasoline, and minimised the volume reaching nearby Lake Sakakawea. Block valves located on each side of the rupture were closed, isolating the section of pipeline. Federal and state governmental agencies were notified through the National Response Center. Cenex response crews were dispatched to the scene, working through the night to pump the contained gasoline into tank trucks, and to ensure that none of it reached the water. Sorbent materials and containment booms were deployed near the shore of Lake Sakakawea as a precautionary measure in the event that seepage of gasoline to the lake should occur. Visual on-ground inspections of the shoreline adjacent to the rupture conducted throughout the first night did not detect the presence of measurable oil on the water surface. A 3" to 4" wide sheen was observed, which extended for approximately 20 feet of the shoreline adjacent to the rupture. On the morning of October 5, the shorelines near the site were inspected by aircraft and by boat to verify that gasoline was not reaching the water. Following recovery of the contained gasoline, trenches were excavated to recover additional gasoline and impacted groundwater. The damaged section of pipeline was replaced by October 6. Approximately 5,570 cubic yards of gasoline-impacted soil was excavated from the site, and removed to a state-approved landfarm facility for treatment during the days following the incident. Samples were collected from soil remaining at the excavation surfaces to verify the achieved cleanup levels. Clean soils from the highway construction project were used to backfill the excavations. The cleanup was completed on Wednesday, October 18, 1995. An environmental geologist from the North Dakota Division of Water Quality was on site during most of the cleanup effort. The site cleanup was also monitored by representatives of the state Department of Transportation, Montrail County, and Fort Berthold Indian Reservation.</p>
16 October 1995 Quay New Mexico 950187	<p>At approximately 15:20 hours on October 16, 1995, West Emerald experienced a leak in its 6" products pipeline between Amarillo, Texas and Tucumcari, New Mexico. The line was immediately shut down and block valves closed in the area of the leak. There were no injuries, fire or evacuation during the incident. Investigation of the pipe showed a ½" split along the longitudinal weld seam approximately 1/8" wide. The full joint of pipe was sleeved to prevent any further occurrence of leakage and returned to service without incident.</p>
8 November 1995 Craig Oklahoma 950195	<p>At approx. 09:37 hours on November 8, 1995, a spill occurred at MP 178.8 on the #3-1 2" Tulsa Junction - Heyworth line section. Approximately 126 barrels of N-grade were released. Williams Pipeline Company (WPL) maintenance personnel were excavating the pipeline in preparation for replacement of a mainline gate valve at this location when the backhoe struck a 3" tap and valve which was connected to the line. The connection between the tap and the pipeline failed resulting in the spill. Maintenance personnel immediately contacted the operations control centre and the pipeline operations were shut down. The operations control centre contacted the southern region office and emergency response personnel and equipment were dispatched to the site. The WPL personnel on site secured the area and utilised equipment that was on-site to contain the released product. Additional response personnel and equipment arrived on site and recovered 35 barrels of free product. The remaining product was remediated through soil excavation and bio-remediation techniques. Environmental response efforts were coordinated with the Oklahoma Corporation Commission.</p>

Date, location and report ID	Incident description provided by pipeline operator
11 December 1995 Laurel Yellowstone Co. Montana 960007	<p>On December 11, 1995 at approximately 3:37 pm Mountain Time, a contractor installing a fibre optics communication cable on Cenex refinery property in Laurel, Montana hit an 8" diameter petroleum products pipeline owned and operated by Cenex Pipeline, Inc. The impact of the excavation implement caused the steel pipe to rupture, releasing unleaded gasoline to the ground. The precise quantity of gasoline released could not be determined, but did not exceed 15 barrels (630 gallons). The incident was reported to the National Response Center (federal government), the Montana Department of Environmental Quality, and the Yellowstone County disaster and emergency services. The loss of pipeline pressure resulting from the rupture was immediately detected at the pipeline control centre in Laurel, Montana, and the pipeline was shut down in 40 seconds. All of the released gasoline soaked into the gravel soils, and was not recoverable in liquid form. Approximately 300 cubic yards of impacted soil was excavated from the site for removal to a landfarm treatment facility. The excavation was backfilled with soil from the refinery property.</p>
31 December 1995 Garfield Oklahoma 960019	<p>An external corrosion leak occurred due the excavation activity of the landowner. Part d comments: line was damaged by an excavator and an assumption is made that a corrosion cell developed.</p>
6 February 1996 Rodeo Contra Costa California 960030	<p>A small corrosion leak on the buried pipeline allowed product to migrate upwards into a small marsh area and adjacent to Selby Pond. The product sheen that formed on top of the pond was noticed by workers at an adjacent refinery. Santa Fe Pacific Pipeline was notified, shut down and repaired the pipe with a sleeve.</p>
17 February 1996 Pottawatomie Oklahoma 960040	<p>On February 17, 1996, at 10:00 pm the control centre noticed an hourly loss of 40 barrels. At 11:00 pm the control centre noticed 40 additional barrel loss and shut down pipeline with about 200 psi pressure. The pressure was monitored and by 1:09 am on February 18 the pressure had dropped to 65 psi. By 2:10 am field personnel had manually blocked the line section and started to look for the leak. The leak was located at 5:40 am on February 18. Notification was made and contract personnel were notified. A temporary repair was completed at 7:30 am on February 18.</p>
28 March 1996 Louisville Jefferson County Kentucky 960069	<p>The Ashland Control Center, in Ashland Kentucky, received a phone call from the Jefferson County Fire Department at approximately 1:30 pm CST, March 28, 1996, and said there was gasoline coming from the ground on the north side of Outerloop in Louisville, Kentucky. The Ashland Control Center called the tri-state division and set up a conference call with the three parties. The pipeline was shut down until we could verify the leak. The district supervisor from Lebanon Junction, Kentucky was dispatched and verified the leak at approximately 2:15 pm CST. Pipeline crews were dispatched from Lebanon Junction, Kentucky, Owensboro, Kentucky, and Albion, Illinois. Heritage Remediation in Louisville, Kentucky was called out and placed 8 booms across Pond Creek to stop the progress of a very light sheen. The maintenance crew excavated the pipeline and discovered that the pipe had been damaged by a third party. The damage was severe enough that a permanent repair clamp could not be used. A temporary clamp was installed to stop the leak until a stopple contractor arrived, pipeline drained and repairs made. The damaged section of pipe was cut out and replaced by 14 feet of pre-tested pipe. The pipeline was placed back into service on Saturday, March 30, 1996 at approximately 4:00 am CST. The initial cleanup effort has been completed and contaminated dirt has been removed for bio-remediation at Waste Management's outer loop landfill. Remediation efforts will continue until such time as soil analysis is satisfactory with the Kentucky Division of Waste Management.</p>

Date, location and report ID	Incident description provided by pipeline operator
23 April 1996 Cherokee South Carolina 960080	<p>At 18:10 EST on April 23, 1996, the Atlanta Control Center received a call from a landowner near Blacksburg, South Carolina, reporting product in a small stream near Colonial's two pipelines that traverse this area. The two pipelines, a 36-inch distillate line and a 40-inch gasoline line were immediately shut down and personnel were dispatched to the area to investigate. A company representative arrived at the site and noted a small amount of gasoline in the creek. Emergency response personnel and response and repair contractors were dispatched immediately to the scene to begin containment and recovery operations. The 40-inch gasoline line was exposed and the source of the leak was found to be a small crack located at the junction of two overlapping dents on the bottom of the pipe. The line was repaired by installing a repair clamp over the dents and crack. As of April 21, 1996, approximately 33 barrels of gasoline had been recovered. The environmental team is continuing recovery activities. The investigation and cleanup continues into the incident. An amended report will be filed at a later date to provide the amount of product spilled, the pressure of the line when the incident occurred, and the hydrostatic pressure at the spill site.</p>
9 May 1996 El Paso Texas 960077	<p>A 12:55 pm the Artesia operator noticed a pressure and rate drop on the 6" El Paso products line and called El Paso. At 12:59 pm the Artesia operator suspected a problem and shut the line down, blocked in MP 128. At 13:05 pm El Paso Terminal superintendent called and said a third party had dug into our line inside Hueco Tanks State Park. Navajo employees and equipment, as well as contractor employees and equipment, were dispatched to repair the pipeline and clean the spill site area. Pipeline was repaired and operations resumed at 9:00 pm. Environmental study and cleanup are in progress. At 2:15 on May 9, 1996, telephonic notice was given to the National Response Center - Mr Checkan (Report #340565).</p>
17 May 1996 Greensboro Guilford North Carolina 960091	<p>On May 17, 1996, at 15:30 hours Colonial Pipeline Company was notified of a sheen of product on a creek off Indian Hills Lane. All three Selma stublines were shut down at 15:34 hours. The National Response Center was notified at 16:24 hours (Report number 342514). The source of the leak was discovered to be on line 23 at 22:42 hours. Two dents were found on the pipeline at the 12:00 and 1:00 o'clock positions. The leak resulted from a crack located between the dents. An 18-inch sleeve was installed, and the pipeline was restarted at 07:06 hours on May 18, 1996. The final cleanup was completed on May 24, 1996.</p>

Date, location and report ID	Incident description provided by pipeline operator
23 May 1996 Grammercy St James Louisiana 960092	<p>The precise time and duration of the release are unknown at this time. The release appears to have begun sometime after 22:00 hours CDT on May 23, 1996. The release occurred in a tidally affected swamp, situated between US Highway 61 (Airline Highway) and the Kansas City southern railroad, and product migrated into the Blind River. The pumps at Garyville Station were shut down and local Marathon Pipeline Company (MPL) personnel were dispatched to the area to investigate the situation. After the release location was discovered, the block valves on either side of the release site were closed. During the response, a portion of Airline Highway and the railroad were closed to traffic. The National Response Center and the Louisiana Department of Environmental Quality were promptly notified of the incident. An incident command centre was set up within hours and a response team consisting of Marathon personnel and several response contractors were brought in to effect the response. Approximately 3600 feet of boom was placed at strategic locations in the Blind River and its tributaries to contain the release. The response area was routinely monitored for flammable atmosphere, benzene and carbon dioxide to ensure safety of personnel and public. Some monitoring was also done for total petroleum hydrocarbons and total VOC. We believe that no member of the public was affected. Throughout the incident we monitored vital signs of the personnel working in the affected area. The principle affected area was bermed off to further prevent potential off-site migration of residual hydrocarbons. During the initial response, Marathon worked closely with state and federal agencies to assess potential impacts to water and wildlife, and we continue these site assessments to develop long term remediation plans. The failed section of pipe was replaced with a 24-foot section of comparable pre-tested pipe. Further inspection of the line discovered an additional location with surface damage. The pipe at this second location was replaced with an 18-foot section of comparable pre-tested pipe. Plans are being formulated to conduct an internal inspection of the pipeline with an in-line inspection tool (smart pig). The line has been returned to operation and, as a precaution, the system is being operated at a reduced maximum pressure of 875 psig until the analysis of the line condition can be completed.</p>
23 May 1996 Williamsport Lycoming Pennsylvania 960095	<p>The post-leak internal inspection using an Enduro geometry pig, indicates that there were two anomalies classified as 'sharp' in the immediate vicinity of the leak. These 'sharp' indications prohibited passage of an Atlas wireline magnetic flux inspection tool. It was impractical to expose the line to conduct an external inspection due to the Susquehanna river and its conditions. Based upon the above, we could not determine a specific cause of the leak. We replaced the entire crossing as per our correspondence with OPS.</p>
6 June 1996 Chautauqua Kansas 960103	<p>Contractor was pulling rock towards line when bucket teeth slipped off rock and gouged the pipeline causing release of product. A sleeve was welded into place and the line was returned to service.</p>
10 June 1996 Hendricks Indiana 960106	<p>At approximately 15:30 on June 10, 1996, Marathon Pipeline Company's (MPL's) operations centre located Findlay, Ohio, was notified by a property owner that there appeared to be a small quantity of hydrocarbon floating on standing water in a farm field four miles north-east of Brownsburg, Indiana. MPL's #2-10" products line and Martinsville to Indianapolis 8" products line, which are known to traverse the area in question, were shut down and MPL personnel responded to the site. Upon site investigation, it was determined that the Martinsville to Indianapolis line was not involved, but the #2-10" was directly under the area of free product. The pipe line was excavated and a pinhole caused by external corrosion was discovered. Free product was recovered with a vacuum truck and most of the affected soil was excavated and stockpiled on plastic. The affected area of pipe was temporarily clamped until fuel oil could be moved through the pipeline to the release location. A 26 foot section of pipe was removed and replaced with hydrostatically tested pipe on June 13, 1996. The pipeline was returned to normal operations at 17:00 on June 13, 1996. MPL is working with the Indiana Department of Environmental Management to remove the affected soil and remediate the site.</p>

Date, location and report ID	Incident description provided by pipeline operator
17 June 1996 Everett Snohomish Washington 960100	<p>Contractor reported product a sheen on drainage ditch at east end of Ebbey Island. Line(s) were immediately shut down and a helicopter was dispatched to the area. Sheen on water was identified near 20" line crossing. Excavated area on south side of retention dike revealed a buckle in pipe at 3-R bend. Cleanup was accomplished by sorbents, skimmer and soil removal. Downtime on 20" line estimated at +100 hours, property damage estimated at + \$10,000. OPS notification at 11:35 on June 17, 1996, incident No. 347536 - Rutheford.</p>
19 June 1996 Parker Texas 960111	<p>On June 19, 1996, at approximately 2:20 pm we received a call at our Aledo Terminal that our pipeline had been struck while a farmer was ploughing his field near Brock, Texas. Our station operator then called our pipeline control in Abilene to shut down the pipeline. Our station operator then went to investigate and access the situation at the leak site. Upon arrival of our maintenance crew a temporary clamp was placed on the line, and the cleanup process began. Approximately 250' of 6" pipe was replaced on June 24, 1996. Cleanup procedures are being developed with the TNRCC.</p>
17 July 1996 Middletown Delaware Pennsylvania 960135	<p>The chain of events began with the complaint of odours by the (123 Pennel Road) resident to their local municipality. The local municipality investigated and contacted Sun Pipeline Company (SPL). The line section was investigated and excavated. After excavating, the release was verified by SPL. A 1500 psi clamp was placed on the damaged section and free product removal began. Approximately two weeks later SPL re-excavated the site and cut the damaged section out, replacing it with new pipe and coating. The section removed was sent out for metallurgical analysis. It is believed that the pipe and insulation were damaged years ago when a sewer lateral was installed at the (123 Pennel Road) residence. The damaged pipe section showed damage only in the area of the lateral. This work was part of a borough project tying in laterals to all the homes on the street. The laterals were installed around 1969-70. SPL became a member of the 'one-call' system in the late 80's.</p>
29 July 1996 Clark Nevada 960131	<p>At 11:20 (Military Time) on July 29, 1996, just prior to the pipeline rupture, both the 8" mainline and the 6" lateral contained jet aviation fuel. The 6" lateral was operating between 200 and 400 psi, and fuel was entering into the west tankage of the McCarran Airport at a rate of about 1170 barrels per hour. The pipeline is monitored by a dispatcher from the control desk, located at the Colton, California, Terminal. From this location the dispatcher can monitor the pipeline rate, operating pressures, and the status of mainline pumps and valves. At approximately 11:25 the Colton Terminal dispatcher, Paul Wilson, lost the communications link with the McCarran West Station. The communications link is a microwave network which allows Calnev to continuously monitor the pipeline status. Although the communications had failed, product continued to pump into the McCarran West tankage. At 11:31 the control valve that allows product into the McCarran West Airport closed. This valve is programmed to close automatically if communications are not restored within five minutes. At this time the dispatcher was in the process of bringing the Valley Wells pumps on line, the line section near the station was slack, with almost no pressure. When the McCarran valve closed it did not result in an immediate increase in pressure apparent to the dispatcher, and the pressures appeared to fluctuate. However, the pipeline pressures at Bracken peaked at 970 psi. At 11:39 the Calnev maintenance man, Pat Massey, was on the other side of the I-15 freeway in the parking lot of the Hacienda Hotel. Pat saw, "a geyser", but was not sure if it was Calnev pipeline product, or possibly a water line. He travelled to the Bracken Junction intersection and determined that product was flowing from the pipeline. Pat immediately called the Colton Terminal via a cellular phone. Pat then contacted Ken Seale, Las Vegas Terminal manager, and informed him of the incident. Calnev did not have any construction activities ongoing in this area, and Pat did not see any other construction equipment in the area. At approximately 11:43 the Colton pipeline superintendent, Jeff Parrish, received a phone call from Calnev maintenance man, Pat Massey, who informed Jeff that there was a pipeline rupture, and product was spraying out of the line. At 11:45 the Colton dispatcher shut down the mainline pump stations, closed the motor operated valve (MOV) at the Bracken Junction, and opened the McCarran West valve.</p>

Date, location and report ID	Incident description provided by pipeline operator
6 September 1996 Richmond Chesterfield Virginia 960136	Plantation was notified of possible release by property owner who smelled gasoline. Plantation investigated and discovered an apparent mill defect. The mill defect was located at an approximate station number of 205+88 in the 7 o'clock position. A full encirclement sleeve was placed over the defect. Plantation will remove the failed section of pipe and test it for cause of failure.
11 September 1996 Elmira Solano California 960159	The local sewer utility agency had reports of elevated vapour concentrations in a section of sewer pipe. After some investigation they contacted Santa Fe Pacific Pipeline. A section of pipe was excavated in the vicinity of a sewer crossing and a weld seam weep was found. The leak was repaired and a subsurface investigation and cleanup has been initiated .
26 September 1996 Grand Haven Michigan 960161	A construction contractor, not working for the Wolverine Pipeline Company, was widening a road for a school in Grand Haven, Michigan, and struck the Wolverine pipeline. Wolverine personnel immediately shut down the line due to the rate fluctuation before 911 contacted them. The fire department was dispatched by the 911 operator. The bulldozer operator was transported to the hospital with 2 nd degree burns to his hands and face. After the fire department put the fire out, the Wolverine personnel put a clamp on the 8" line and the pipeline was down for approximately 48 hours. At this time we put a test on the clamp and then put it back into service. Approximately 102 barrels of gasoline were released, of which 98 were involved in the fire.
8 October 1996 Elbert Colorado 960167	A third party contractor, excavating with a trackhoe to install a foreign pipeline crossing, struck and punctured Phillips Pipeline's 8" pipeline. Phillips Pipeline shut down the line immediately and closed the valves. A one-call had been placed and the line was located, marked, and visible at the time of the accident.
7 January 1997 Fort Worth Tarrant Texas 970031	On Sunday afternoon, January 19, 1997, our terminal at Aledo, Texas, was contacted by a Carswell Base employee that there had been reported a fuel odour near the base. Fuel was seeping into a creek approximately 1500' from the pipeline. At the time the source of the fuel was unknown. After sampling and testing it was determined the product was JP-8 jet fuel. On January 20 Pride took responsibility for the spill. The pipeline was then nitrogen purged. Cleanup of the area and creek is now in progress under the supervision of Pride and the TNRCC. Investigation determined leak occurred during shipment on January 7, 1997. No further shipments have been made on this segment of the system.
5 February 1997 Otero New Mexico 970036	Navajo's contacted maintenance crew, while in the process of preparing to set magnets for an internal inspection device (linalog), hit an unknown underground ¾" bleeder valve which was welded to our pipeline at the 12 o'clock position. This valve was not known to be on our pipeline. We believe now that it was installed when the pipeline was built as a bleeder valve used during hydrostatic testing. There were no markings or records to indicate the presence of this valve. The backhoe used to excavate the pipeline caused the valve to begin to leak at the weld. The leak was confined to the bellhole, where vacuum trucks recovered it immediately. The recovered product was transported to our terminal in El Paso, Texas. The pipeline was repaired and returned to service early the next morning.
19 February 1997 Cook Illinois 970045	On Wednesday February 19, 1997, at approximately 10:30 pm the Clark Blue Island Refinery was notified by the Blue Island Fire Department that they had found an area along the Midlothian Creek where gas appeared to be bubbling up. Clark immediately implemented its emergency procedures and responded to the area. Clark excavated the soil around the Hammond pipeline and found a pin size hole in the Hammond pipeline. The pin size hole was inside a casing and also under a plastic spacer. The protective coating appeared to be worn away under the spacer. A two foot section of pipe was removed and replaced. The section of the line was pressure tested and the line was returned to service.

Date, location and report ID	Incident description provided by pipeline operator
24 February 1997 Ross Butler Ohio 970046	At approximately 15:45 hours CDT on February 24, 1997, Texas Eastern Pipeline Company (TEPPCO) personnel received telephonic notification of a third party incident. A bulldozer clearing brush from the banks of a small tributary to Dry Run Creek approximately 2.8 miles north-east of Ross, Ohio, had hit TEPPCO's 6" line. The TEPPCO emergency plan was immediately initiated, the system was isolated and the valves near the incident site were closed. Jet A kerosene released from the site flowed onto the tributary. TEPPCO personnel placed coffer dams along Dry Run Creek beginning just south of the tributary junction and was able to contain all the product from reaching additional waterways. The damaged pipe was removed and new pipe placed into the system. TEPPCO restarted the pipeline on February 25, 1997.
16 April 1997 Wyandotte Kansas 970071	On April 16 at 17:22 hours a third party struck Williams Pipeline's #6-10 at milepost 163 while operating a front-end loader. The operator of the loader called 911 at 17:32 hours. The fire department arrived on the site at 17:39 hours. They evaluated the situation and then called WPL's Fairfax Pump Station at 17:45 hours to inform them that one of their lines was spraying either gasoline or natural gas. WPL Fairfax Pump Station dispatched mainline maintenance personnel to investigate at 17:50 hours. The mainline maintenance personnel informed the station personnel that the #6-10 line had failed. Operations control shut down the originating pump station at 18:04 hours and closed the Kansas City delivery valve at 18:08 hours. They found that the fire department had already contained the release. Operations control opened the Kansas City delivery valve at milepost 156 at 18:53 hours. Maintenance personnel stopped the leak at 23:15 hours. The line was repaired on April 17, 1997, at 17:30 hours and returned to service at 18:00 hours. The impacted soils will be remediated to Kansas Department of Health and Safety acceptable levels by discing in place and excavating and land farming. Field measurements and laboratory confirmation samples will be used to document remediation of the impacted soils. The remediation process should be complete by the end of the year.
18 April 1997 Onondaga New York 970066	On Friday April 18, 1997, a maintenance crew was performing a routine vehicle patrol when they noticed a small patch of dead grass around a casing vent pipe. After further investigation the release was located in the line pipe within the casing under Mud Mill Road. The defective line pipe was subsequently removed from the casing and a small pinhole was discovered. The defective line pipe was cut out and replaced with a certified hydrostatically tested line pipe section spanning the cased roadway. All applicable agencies were notified and all released product was contained in the immediate area. Recovery and cleanup activities were conducted under the supervision of the New York Public Service Commission and the New York Department of Environmental Conservation.
26 April 1997 Kidder North Dakota 970079	A damaged area of pipe consisting of a scrape/dent developed into a small hairline crack approximately 3½" long. The scrape/dent was caused by outside force. However, it is not certain whether that outside force occurred as a result of mill damage, original construction damage, or a third party hit.

Date, location and report ID	Incident description provided by pipeline operator
30 April 1997 Crawford Kansas 970077	<p>At 07:45 on Wednesday April 30, 1997, the Williams Pipeline Iola maintenance crew discovered contaminated soil and gasoline near milepost 214 while performing pipeline reconditioning work. Operations control was immediately notified of the condition and asked to remove pressure from the line. This was accomplished by shutting down the originating pump station at Tulsa and allowing the downstream pump station at Shelpdon to remain on line to pump product away from the leak site until the pumping unit went down on low suction pressure. The gate valves were then closed at mileposts 207 and 218, isolating the suspected leak at approximately 08:45 hours. Vacuum trucks arrived on site at approximately 13:30 hours to begin picking up free product that had accumulated in ditches dug with the backhoe that was already on site with the reconditioning crew. Additional trackhoes and dump trucks arrived on the site at approximately 14:20 hours to assist with excavating the line and stockpiling the contaminated soil for land farming. The actual leak location was found at a line depth of twelve to fifteen feet at approximately 22:30 hours. The leaks two seepers were immediately clamped off for the later permanent repairs which occurred on Monday, May 5, 1997. The impacted soils will be remediated to Kansas Department of Health and Safety (KDHE) acceptable levels by discing in place and excavating and land farming. Field measurements and laboratory confirmations samples will be used to document remediation of the compacted soils as required by the KDHE. The remediation process should be complete by the end of the year.</p>
8 May 1997 Oregon Ogle Illinois 970085	<p>On May 8, 1997, Amoco's Tulsa Control Center (TCC) controllers in Tulsa, Oklahoma, and field specialists in Oregon, Illinois, were electronically tuning the control valve at Oregon Station. At approximately 08:45 hours electronic data received at TCC indicated low suction pressure at the Oregon Station. Taking precaution in case of an outage, TCC personnel immediately opened upstream valves into Rochelle Terminal while running a downstream pump at Stockton Station in order to evacuate the pipeline fill in the vicinity of Oregon Station. Field specialist verified instruments with field gauges and closed manual block valves at MP 140, 124, and 123. TCC notified the maintenance team leader and instructed a company patrol plane to fly the segment from Oregon to Dubuque, while field specialist patrolled the same segment on the ground. The search continued and the leak was found by ground patrol at approximately 11:00 on May 9, 1997. Third party damage is suspected. Vacuum equipment and additional emergency response personnel were sent to the site and began cleanup and repair operations.</p>

APPENDIX 3 - UK DATA

Table A3.1
UK incident descriptions

Date & location	Description
7 July 1972 Staffordshire	A mechanical excavator fractured an existing 10 inch multiproduct pipeline whilst preparing for a new pipeline. There was a spillage of 14, 724 gallons (67 m ³) from a 7.5 inch long by 3.5 inch wide tear in the pipeline. The release gushed 60 feet into the air. No one was injured, there was no fire or explosion. No pollution to potable water. It took 15 minutes from breach to pump shutdown.
1984 UK	An 8.62 inch pipeline failed due to internal corrosion caused by small amounts of HF acid in product (alkylate). The line failed at the lowest point of the overland section where water had collected and had formed an interface. The cause was verified by metallurgical examination. Fire occurred when a mechanical digger, excavating in marshland to expose the leak, severed a live electrical cable igniting the 236 m ³ of alkylate.
1986 (possibly Little Warley)	A 14 inch pipeline was breached by the teeth of a chain excavator on the front of a large trenching machine which was laying land drains. A data logger at the central control centre detected a change in the line balance, which was immediately confirmed by a telephone call from the contractor who caused the damage. The pipeline was shut down. Approximately 280 m ³ of kerosene was spilled. The affected section of line was isolated to minimise the spillage and the emergency crew was able to uplift the product at a greater rate than the leakage. Some of the product passed through a new sewage pipe into a nearby sewage works. This product was collected and safely disposed of without any environmental effect upon the sewage works. Controlled drain for a further a four hours after the initial release stopped the release.
19 September 1986 West Lavington	An excavator gouged a hole in a 6 inch multi-product pipeline and 22000 gallons were lost. Approximately 52 m ³ were released under pressure in 25 minutes. The incident was caused by a failure of a utility's contractors to carry out their role in using ranging rods for marking the pipeline and to check construction drawings for the position of the pipeline.
8 October 1986 Little Warley	A 14 inch jet fuel pipeline was punctured by mechanical digger.
7 July 1989 Dartford Marshes Kent	2000 gallons of petrol leaked from a damaged pipeline forming a lake of petrol in the surrounding fields. An explosion was feared as fumes carried towards a power station. Firemen covered the area with foam and washed it down with water. The water authority was put on alert. The release was from a leaking flange gasket on an above ground installation.
3 August 1989 Great Haywood Staffordshire	Wrapping damage and corrosion led to a leak from this 10 inch pipeline involving a fine spray. A small amount of product entered a land drain. This leak originated from a pinhole caused by corrosion on a dent, which occurred due to land drainage work. About 53 m ³ of gas oil were discharged.
23 November 1990 Wilton North Tees	The supports of a 6 inch above ground pipeline collapsed. About 14 m ³ of gasoline was observed as a fine spray.
21 February 1991 Stansted Airport	Loss of 30,000 gallons of kerosene during pressure testing/commissioning. The kerosene migrated into a river and travelled a distance of 9 km downstream.
14 February 1994 Grays Essex	An explosion and fire occurred during pigging operations in a 12 inch unleaded gasoline pipeline between the jetty and the interchange, resulting in rupture at two locations. Compressed air was being used to push a pig train with nitrogen between the pigs, after unloading unleaded petrol. No firm conclusions as to the cause of the explosion were made. A similar incident to this occurred in January 1995.

Date & location	Description
17 January 1995 Grays Essex	<p> This incident involved a 12 inch unleaded gasoline pipeline. Two pigs, separated by a 200 foot volume of nitrogen, were being pushed through the pipeline by compressed air at 40 psi. The line had been used to discharge unleaded petrol from a ship. The first pig had arrived at the pig trap and had been removed. The second pig had entered the manifold section and was about 50 feet from the trap when an explosion occurred, rupturing the line some 30 feet downstream. More severe damage to a pig diverter and pipework was sustained some 300 feet downstream. There were no injuries. No ignition source was suspected, other than a possible static electrical discharge which ignited compressed air tainted with residual gasoline behind the second pig. The actual quantity of gasoline involved in the fire and explosion was minimal, and fortunately the explosion did not affect bulk storage tanks some 10 meters from the pipeline. A momentary fireball engulfed two diesel tanks. Fragments of valve bodies were propelled 30 feet from the line narrowly missing other storage tanks. A crater about 10 feet wide was created in the ground over the pipeline, which was buried under a roadway to a depth of approximately two metres. A similar incident to this occurred in February 1994. </p>

APPENDIX 4 - WORLDWIDE INCIDENTS

Table A4.1
Incident descriptions from various sources (including all known fire and fatality/injury events worldwide)

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
3 September 1970 Jacksonville Maryland USA (see also Section 4.3.5)	A fracture in a gasoline pipeline allowed liquid to escape. Contractors dug a trench to access the leak. The following day, accumulated vapours and entrapped liquid in soil, spilled into the trench and were ignited by a vehicle backfiring. Five workers were burned in the ensuing fire. Approximately 30,156 US gallons of kerosene and gasoline were released in the incident.				Yes	Yes	5		a) MHIDAS (AN 1208) b) IChemE database c) NTSB report PAR-71-2
3 November 1970 Stanlow Cheshire UK	A leak of petrol, possibly caused by mechanical failure, flooded a tunnel containing other pipelines under the Manchester ship canal.			Possibly mechanical failure					MHIDAS (AN 990)
5 September 1975 Rosendaal Netherlands	A pipeline failure led to a leak of gasoline for 8 to 17 minutes. An explosion occurred and windows were broken 900 m away. Two people died.				Yes	Yes		2	IChemE database
29 September 1976 Europe	An 8 inch pipeline was ruptured due to agricultural works being undertaken without prior notice to the operating company. A tractor ruptured the line and was itself burnt out in the subsequent fire. All of the 153 m ³ of gasoline product released was burnt due to ignition from an unknown source, probably the tractor itself. The operating company was notified about the release by a third party.	153 m ³		TPA	Yes				CONCAWE 1976

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
16 June 1976 Los Angeles California USA (see also Section 4.3.4)	An 8 inch pipeline was struck and ruptured by excavation equipment. Gasoline sprayed from the rupture drenching nearby buildings. Ignition occurred 90 seconds later. The subsequent fire and explosions killed 9 people, injured 14 and caused extensive property damage in a busy town thoroughfare. An entire block of buildings was involved in the fire and at one stage flames were shooting 300 feet into the air. A vapour cloud developed due to mechanical spray formation through the rupture, aided by atmospheric circulation set up by the high pressure fuel escape. The accident investigations determined that the probable cause of the accident was the rupture of the pipeline by excavation equipment, due to the operator being unaware of the pipeline's precise depth and location.			TPA	Yes	Yes	14	9	a) MHIDAS (AN 631) b) IChemE database c) NTSB report PB-264 347
30 January 1980 Bayamon Puerto Rico USA (see also Section 4.3.3)	An 8 inch products pipeline was struck and ruptured by a bulldozer during maintenance work on a nearby water pipe. Gasoline from the rupture sprayed downhill and ran off into a small creek and then into a populated area 2 km away. About 1½ hours later, gasoline vapours were ignited by an undetermined source and exploded. The subsequent fire killed 1 person and extensively damaged 25 houses. A contributory factor in the accident was the lack of temporary markers, indicating the exact location where the pipeline crossed under the water pipe. Gasoline vapours were ignited at 11:20 am in the populated area and flames travelled back to the accident scene some ten minutes later. Approximately 77,700 US gallons of petrol leaked in total, most of which burned. People were not evacuated until after the fires had first occurred.	Release run off ignited after 1½ hours.		TPA	Yes	Yes		1	a) MHIDAS (AN 373) b) IChemE database c) NTSB report PAR-80-6
6 March 1980 Manassas Virginia USA (Kerosene)	A 32 inch pipeline ruptured, forming an 11 foot break, releasing 336,000 gallons at about 3000 gallons/min. Kerosene was detected at least 14 miles downstream in a river. Considerable damage to the ecology occurred and at least 5000 fish were killed. One person was mildly injured.	336,000 gallons at about 3000 gallons/min.					1		NTSB report PAR-81-2

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
9 March 1980 Fredricksburg Virginia USA (Kerosene)	A ruptured kerosene pipeline owned by Colonial Pipeline Co. caused the largest inland spill in Virginian history to date. 63,000 gallons poured into Rappahannock river polluting the drinking water of 50,000 people.	63,000 gallons							IChemE
9 May 1980 Medfield Massachusetts USA	An estimated 15,000 gallons of gasoline spilled from an underground pipeline. There was some environmental damage but no fire.	15,000 gallons			No	No			MHIDAS (AN 3513)
19 November 1980 Port Arthur Texas USA	A pipeline ruptured allowing 29,000 gallons of gasoline to flow into a residential area, forcing the evacuation of 240 families. There was no fire, explosion or injuries.	29,000 gallons			No	No			a) MHIDAS (AN 3509) b) Hazardous Materials Newsletter
16 April 1981 Chonan South Korea (Aviation fuel)	A secret underground fuel pipe supplying South Korean armed forces was severed by a mechanical digger. Aviation fuel was ignited by hot household ashes. The ensuing fire killed 1 and injured 3. 1000 people were evacuated and 36 houses were destroyed. The incident caused power-cuts in nearby areas.			TPA	Yes		3	1	IChemE
20 January 1982 La Venta Mexico	A 6 inch pipeline carrying petrol ruptured. The released material was ignited and exploded. 5 people were killed and 25 were injured with serious burns. These people lived in shacks near the PEMEX owned pipeline.				Yes	Yes	25	5	a) MHIDAS (AN 359) b) IChemE
4 June 1982 Eulless Texas USA	A bulldozer ruptured an 8 inch pipeline releasing liquid through an 8 inch by 0.5 inch tear. About 400 barrels of product escaped. Fire-fighters used a bulldozer to dam the pipeline.	400 barrels 8 x 0.5 inch tear		TPA	No	No			MHIDAS (AN 3489)
10 September 1982 Roanoke Texas USA	An 8 inch pipeline released 40,000 gallons of unleaded gasoline after being punctured by a bulldozer. The spill was contained within a creek bed which was foamed to prevent ignition. 20 nearby homes were evacuated and the highway over the creek was closed for 24 hours.	40,000 gallons		TPA	No	No			a) MHIDAS (AN 3500) b) Hazardous Materials Newsletter
1983 Red Cloud Nebraska USA	A road grader hit a gasoline pipeline causing a spillage and fire.			TPA	Yes	No			IChemE

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
18 February 1984 UK	An 8.62 inch pipeline failed due to internal corrosion caused by small amounts of HF acid in product (alkylate). The line failed at the lowest point of the overland section where water had collected and had formed an interface. The cause was verified by metallurgical examination. Fire occurred when a mechanical digger, excavating in marshland to expose the leak, severed a live electrical cable igniting the 236 m ³ of alkylate.	236 m ³		Internal corrosion	Yes				CONCAWE 1984
25 February 1984 Cubatão Brazil (see also Section 4.3.6)	Gasoline leaked from a pipeline owned by Petrobras and spread over a wide area. On ignition, fire destroyed 500 shanty homes making 2500 people homeless and killing 89-508 people. The cause of the incident was unknown.				Yes	Yes	31 b	89 a b > 508 c	a) MHIDAS (AN 822) b) Loyds Weekly Casualty c) Hazardous Materials Newsletter d) IChemE
25 March 1984 Missouri City Texas USA	A rupture of an 8 inch gasoline pipeline resulted in a spillage of thousands of gallon. 240 homes were evacuated. A 1 mile long drainage ditch was used to contain the spillage.	Thousands of gallons							MHIDAS (AN 1058)
18 December 1984 Spain (Aviation fuel)	A pipeline carrying aviation fuel between US military bases was bombed by terrorists in 3 places. The bombs were planted on valves. Fire and explosion resulted.			Terrorism	Yes	Yes			a) MHIDAS (AN 1041) b) IChemE
23 July 1985 Kaycee Wyoming USA (Aviation fuel) (see also Section 4.3.8)	A girth weld cracked on an 8 inch pipeline during a re-coating project resulting in a release of jet fuel. The pipeline contents escaped under pressure, atomising and igniting. One person was killed immediately and 6 people died in the subsequent fire. The operating company was criticised for failure to identify substandard welds.			Mechanical or corrosion	Yes		6	1	a) NTSB report PAR-86/01 b) IChemE
2 August 1985 Indianapolis USA	Gasoline leaked from a ruptured pipeline into a creek. A pump used to recover the material into road vehicles ignited the gasoline.				Yes				IChemE
23 September 1985 Staten Island USA	A 12 inch gasoline pipeline rupture caused extensive spillage in streets. No ignition occurred.				No	No			MHIDAS
31 January 1986 USA	Third party damage to a 14 inch line resulted in a release of 3,589 barrels of gasoline and a fire.	3,589 barrels		TPA	Yes				DOT

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
22 February 1986 Muskegon Michigan USA	A defective girth weld on an 8 inch line led to the release of 230 barrels of gasoline, which ignited and resulted in fire. There were no injuries.	45 psig 230 barrels		Mechanical failure	Yes				DOT database
8 July 1986 Mounds View Ramsey County Minnesota USA (see also Section 4.3.2)	Unleaded gasoline under 1434 psig spewed from a 7½ ft long opening along the longitudinal seam of a pipeline. Vaporised gasoline combined with air and liquid gasoline and flowed along neighbourhood streets and was subsequently ignited by a passing car 20 minutes later. The car caught fire and the driver was injured. The initial rupture awakened residents; a family thinking they were in danger ran out into the a vapour cloud and were engulfed by a fireball. Contributing to the extent of the incident was the non availability of remotely operated valves or automatic shutdown capability on the pipeline. The cause of the incident was a corrosion failure due to deficiencies in cathodic protection.	1550 psi pressure drop to 37 psi. Flow downhill into sewer and drains and streets. 493 barrels	1 hour 40 minutes	Corrosion	Yes	Yes	1	2	a) MHIDAS (AN 2612) b) DOT database c) Firehouse January 1987 d) NTSB report PAR-87/02 e) IChemE
7 October 1986 King of Prussia Montgomery Pennsylvania USA	A pressure drop was detected in a 109 mile pipeline, and pumps were shut down 4 minutes later. A company noticed gasoline on their property. An estimated 140,000 gallons eventually escaped at the break and some bubbled up through the ground. Manual valves either side of the break were closed but this still left three to four miles of pipeline to drain at the breakpoint. Nearby shopping malls, industrial parks and roads were evacuated. Most of the spill was recovered.	140,000 gallons	4 minutes after detection	Not known	No	No			a) MHIDAS (AN 3547) b) NFPA c) Article from 'Foam Facts' published by National Foam d) DOT database
22 November 1986 Tustin Orange County California USA	Thousands of gallons of gasoline poured from a 10 inch pipeline resulting in the evacuation of about 1500 people. The damming of a flood control channel prevented the spill reaching a nearby ecological area.	Thousands of litres			No	No			a) MHIDAS (AN 3510) b) Hazardous Materials Newsletter
26 March 1987 Caroline County Virginia USA	Third party damage resulted in the release of 952 barrels from a 12 inch jet fuel line. The release subsequently ignited. There were no injuries.	952 barrels			Yes				DOT database

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
11 June 1987 Centreville Fairfax County Virginia USA	A bulldozer punched a hole in an underground gasoline pipeline. At least 15,000 gallons of gasoline was released, some went 100 ft into the air. Gasoline, under an initial pressure of 190 psig, sprayed over 6 townhouses and a wooded area. Over 700 people were evacuated from nearby schools and housing. 13 emergency personnel suffered from exposure to fumes. Fire-fighters kept a foam spray over two siltation ponds and the puncture site.	15,000 gallons from a 4 inch by 4 inch hole. The spraying of gasoline lasted for approximately 10 minutes.	6 minutes after rupture detection	TPA	No	No	13		a) MHIDAS (AN 3031) b) Washington Post 12/6/87 c) DOT database
15 January 1988 Everett Massachusetts USA	An underground pipeline leaked an estimated 20,000 gallons of gasoline into a river. Ice flow on the river and the extremely cold temperatures combined to contain the spill and limit the serious potential for ignition of gasoline vapours.	20,000 gallons			No	No			a) MHIDAS (AN 3434) b) Hazardous Materials Newsletter
25 April 1989 Altona Victoria Australia	100,000 litres of petrol spilled from a 1 m crack in a pipeline. This followed temporary repairs to the line the previous day. All of the spill was recovered. Trains were stopped in case of spark ignition. The crack was believed to be caused by pressure variation. The consequences of the release were reduced because the pipeline had been shut the day of the incident because of a national holiday.	100,000 litres from a 1 metre crack. The leak is believed to have originated from a cracked weld.	Not known	Corrosion or mechanical failure	No	No			a) MHIDAS (AN 3837) b) IChemE database c) Lloyds Weekly Casualty Report d) HCB Incident Log e) 'The Age' Thursday 27 April 1989
25 May 1989 San Bernardino California USA (see also Section 4.3.1)	A high pressure pipeline exploded in a fireball as a result of a train wreck several days earlier when heavy equipment deployed to remove the wreck inflicted TPA damage. The 14 inch pipeline, operating at 1700 psig, failed. Ineffective pipeline isolation, through the failure of a check valve to operate, exacerbated the incident and a large volume of petrol was released. 2 died and 31 were injured, as petrol sprayed onto nearby housing and was ignited.			TPA	Yes	Yes	31	2	a) DOT database b) IChemE database c) NTSB report RAR-90/02
7 July 1989 Dartford Marshes Kent UK	2000 gallons of petrol leaked from a damaged pipeline forming a lake of petrol in the surrounding fields. An explosion was feared as fumes carried towards a power station. Firemen covered the area with foam and washed it down with water. The water authority was put on alert. The release was from a leaking flange gasket on an above ground installation.	2000 gallons							a) MHIDAS (AN 1767) b) IChemE database c) HCB Incident Log

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
28 July 1989 France	In order to build a path a bulldozer driver 'borrowed' earth from along the path of a pipeline and in doing so perforated the pipe during a loading manoeuvre. The release ignited sometime later and three bystanders were killed in the fire. 253 m ³ of naphtha of spewed out from the rupture at 36 m ³ /h. The pipeline was de-pressurised after fifty minutes. Clearly, in this incident there was inadequate emergency service control over the incident site, allowing the bystanders to be exposed to the fire.	253 m ³ of naphtha at 36 m ³ /h			Yes			3	CONCAWE 1989
1990 Nepean Canada	A corroded pipeline 2 metres under the ground caused the loss of 11 to 1600 litres of gasoline which formed in a large pool about 8 m below ground level. The company involved was fined.	1600 litres		Corrosion					a) IChemE database b) Lloyds List 23/5/1992
23 January 1990 Montonui New Zealand	A gasoline pipeline leaked for six months before detection.	Not known	Not known	Not known	No	No			a) MHIDAS (AN 4619) b) IChemE database c) Loss Control Newsletter First Quarter 1990
30 March 1990 Freeport Pennsylvania	A landslide ruptured a 10 inch pipeline causing a spillage of gasoline diesel and fuel oil into a river. A 30 mile oil slick from resulted from the 75,000 gallon loss.	75,000 gallons		Natural disaster					IChemE database
24 November 1990 Teessport UK	An investigation was launched after a petrol pipeline sprang a leak. Police sealed off roads and firemen covered the petrol with foam.	Not known	Not known	Not known	No	No			MHIDAS (AN 4878)
5 May 1991 Germany	Sinkage of a pipeline in a mining area led to a rupture. The gasoline leak, adjacent to a major Germany-Holland motorway, forced the closure of the route during repair and cleanup work.	275 m ³							a) CONCAWE 1991 b) Platt's Oilgram News 15 May 1991
13 November 1991 Eutaw Greene County Alabama USA	A contractor was removing a section of the pipeline casing when gasoline vapours escaping from the pipeline ignited, causing a small fire. This flame was immediately extinguished. Twenty-one gallons of gasoline was lost from the pipeline, of which 20 were recovered.	21 gallons			Yes				DOT database
1 March 1992 Montgomery Texas USA	A rupture of a gasket or O ring on a line combined with a block valve failure led to the release and ignition of 474 barrels of gasoline from a 28 inch line. No injuries were reported.	474 barrels			Yes				DOT

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
22 April 1992 Guadalajara Mexico (see also Section 4.3.10)	The slow and continued leakage of gasoline from a transmission pipeline resulted in a migration of gasoline vapours into the sewage system under a congested area in Guadalajara. An external source ignited these vapours and consequently a series of explosions occurred along the path of the sewer system through a 20 block area. These explosions resulted in the decimation of a 20 block area and some 252 deaths.				Yes	Yes	1361	252	Reuters
21 November 1992 Oregon Lucas Ohio USA	About 90 tons of gasoline spilled into a creek from a pipeline. Vacuum trucks and booms were used to clean up the spill. 6 muskrats were reported killed.	90 tons			No	No			a)MHIDAS (AN 5957) b)IChemE database c)DOT database d)HCB Incident Log e)Lloyds Casualty Weekly 18/12/92
2 November 1993 Uong Bi Quang Ninh Vietnam (see also Section 4.3.7)	47 people burned to death and 48 were injured when a leaking petrol pipeline exploded. Most of casualties were local residents collecting petrol pouring out of the pipeline. Victims were burnt within the first few minutes by flaming fuel.	Not known	Not known	Not known	Yes		48 a b	47 a b	a)MHIDAS (AN 6530, 6554) b)IChemE database c)HCB Incident Log d)Reuters
26 November 1993 Bischofsheim Hessen Germany	A leak of 50 m ³ from the line between Rotterdam and Frankfurt was discovered during routine checks.	50 m ³			No	No			IChemE database
6 January 1994 Richmond USA	Pipelines carrying products (including gasoline) to local terminals leaked. The total leakage volume was estimated at around 3000 gallons.	3000 gallons							a)MHIDAS (AN 6644) b)IChemE database
14 February 1994 Grays Essex UK	An explosion and fire occurred during pigging operations in a 12 inch unleaded gasoline pipeline between the jetty and the interchange, resulting in rupture at two locations. Compressed air was being used to push a pig train with nitrogen between the pigs, after unloading unleaded petrol. No firm conclusions as to the cause of the explosion were made. A similar incident to this occurred in January 1995.				Yes	Yes			Private communication

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
14 April 1994 Monterrey Mexico	Fire and explosion occurred on a 14 inch gasoline pipeline after thieves attempted to divert gasoline from the line. One person died and three people were injured.				Yes	Yes	1	3	a) IChemE database b) Reuters
20 October 1994 Near Houston Harris County Texas USA (see also Section 4.3.9)	A 40" gasoline pipeline was ruptured in floodwaters at a river crossing. The release ignited, and fires burnt on floodwaters and along river banks, burning boats and houses. A 36" fuel oil pipeline ruptured shortly afterwards. It was believed that the first damage was caused by a large object striking pipelines, or by loose moorings, which allowed pipelines to snap. Riverside homes and hospitals were evacuated. About 60-1851 people were injured.	20,000 bbl		Natural disaster	Yes		Up to 70 minor injuries a h 1851 e 2 serious and 545 minor g 60 d		a) MHIDAS (AN 7144) b) IChemE database c) Lloyds Casualty Weekly d) Loss Control Newsletter Issue 4 1994 e) DOT database f) HCB Incident Log g) NTSB report SIR-96/04 h) Hazardous Materials Newsletter
20 December 1994 Red River Natchitoches Louisiana USA	A pipeline ruptured and at least 320 te of gasoline spilt from the 20 inch line. No injuries or fire were reported. The exact cause of rupture was unknown. Cleanup teams attended the incident.	320 te gasoline			No	No			a) MHIDAS (AN 7261) b) DOT database c) HCB Incident Log
17 January 1995 Grays Essex UK	An explosion and fire occurred during pigging operations. The actual quantity of gasoline involved in the fire and explosion was minimal, and fortunately the explosion did not affect bulk storage tanks some 10 meters from the pipeline. A momentary fireball engulfed two diesel tanks. Fragments of valve bodies were propelled 30 feet from the line narrowly missing other storage tanks. A crater about 10 feet wide was created in the ground over the pipeline, which was buried under a roadway to a depth of approximately two metres.				Yes	Yes			Private communication
17 February 1995 Villahermosa Tabasco Mexico	An explosion occurred in a gasoline pipeline and secondary blasts occurred in LPG and natural gas pipelines. Flames shot 50-75 m into the air. About 23 people were injured, and three were killed. Plants and exports were paralysed. Sabotage was ruled out as a cause.				Yes	Yes	23 b d 22 a c	3 e 1 a b c d	a) MHIDAS (AN 7362) b) HCB Incident Log c) Loss Control Newsletter Issue 1 1995 d) Lloyds List 20 February 1995 e) Reuters 3 March 1995

Date and location	Description	Release details	Time to shut off	Cause	Fire	Explosion	Injuries	Deaths	Reference
8 November 1995 Lake Forest Illinois USA	A leak of gasoline occurred when a bulldozer broke an underground pipeline. 80 people were evacuated.			TPA	No				a) MHIDAS (AN 7736) b) Loss Control Newsletter Issue 4 1995
26 September 1996 Grand Haven Michigan USA	A construction contractor struck a pipeline with a bulldozer. there was a fire and he was transported to hospital with 2nd degree burns to his hands and face. Approximately 102 barrels of gasoline were released, of which 98 were involved in the fire.	102 barrels		TPA	Yes		1		DOT database
4 December 1996 Spain	During the clearing of land, an excavator scoop struck a pipeline. This impact caused a rupture and subsequent fire. A lorry driver who was near the excavator was badly burned and died. All of the product flowing through the hole was allowed to burn to avoid the contamination of nearby aquifers.			TPA	Yes			1	CONCAWE 1996
Date unknown Belgium	Communist terrorists planted a bomb on a valve on a product pipeline which exploded and caused a fire. No casualties were sustained.			TPA	Yes				CONCAWE
Date unknown Western Australia	A leakage of motor spirit occurred from a pipeline in an urban area about 15 miles from a refinery. The line was being recommissioned following modifications. The leak occurred after a few hours, and was soon ignited by a kerosene warning lamp hung on a protective barrier. The fire was later extinguished.			Corrosion	Yes				iChemE
Date unknown Country unknown	Thieves attempted to steal gasoline from an atypical section of pipeline on a bridge. The gasoline was ignited, probably by the thieves. There were no casualties.			TPA	Yes				CONCAWE



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