Report 2007-A

Pipeline Performance in Alberta, 1990-2005

April 2007

Alberta Energy and Utilities Board

ALBERTA ENERGY AND UTILITIES BOARD
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1 Introduction

The Alberta Energy and Utilities Board (EUB) is responsible for the regulation of energy projects in Alberta. As energy industry-related pipelines are included in the EUB mandate, the EUB issues licences for pipeline construction and maintains an extensive database of licence information going back to the beginning of the energy industry in Alberta. Additional responsibilities of the EUB include inspection and surveillance of pipeline construction and operation; the EUB maintains records of these activities as well.

At the end of 2005 there were over 377 000 kilometres (km) of energy-related pipelines in Alberta. This report provides a summary and analysis of that pipeline inventory, as well as an evaluation of the types and frequency of incidents and failures that occurred in relation to those pipelines during the period 1990-2005 inclusive.

Pipelines under EUB jurisdiction include all pipelines except

- low-pressure gas distribution network pipelines operating at 700 kilopascals (kPa) or less (unless they are operated in connection with an EUB-licensed facility),
- water pipelines (unless they are operated in connection with an EUB-licensed facility),
- sewage pipelines,
- pipelines under the jurisdiction of the National Energy Board,
- pipelines situated wholly within a refinery, processing plant, marketing plant, or manufacturing plant,
- pipelines carrying fuel from a tank and situated wholly within a consumer's property, and
- pressure piping systems under the jurisdiction of the *Safety Codes Act*.

Note that these exemptions are listed here in brief; any official interpretation should be taken from Sections 1(1)(t) and 2 of the Alberta *Pipeline Act*. The Alberta *Pipeline Act* and *Pipeline Regulation* are the legislative standards applicable to the regulation of pipelines in Alberta; copies can be obtained from the offices of the Alberta Queen's Printer or downloaded from the EUB Web site www.eub.ca.

The EUB and its precursor, the Energy Resources Conservation Board (ERCB), previously published pipeline performance data. Earlier publications were

- *An Analysis of Pipeline Performance in Alberta* (*Report D83-G*, 1983)
- *Pipeline Performance in Alberta* (*Report 91-G*, 1991)
- *Pipeline Performance in Alberta* (*Report 98-G*, 1998)

Those reports provided summations of the amount of pipeline in Alberta, followed by analysis of pipeline incidents and of the failure performance of various types of pipeline infrastructure. This 2007 report follows the same general concept, but also includes a more in-depth assessment of the details of the pipeline infrastructure currently in place and an analysis regarding spill frequencies and spill volumes, along with 42 figures to depict this information.

Inquiries regarding this report may be directed to the EUB Operations Group at (403) 297-8432.

2 Data Collection Parameters

To collect and compile data for this report, the EUB contracted the consulting firm of Visible Data, Inc., of Calgary, Alberta, which provides specialized data analysis services to the oil and gas industry. The EUB provided carefully defined data collection parameters and objectives to Visible Data, which then developed the search queries and compiled the resultant data. The various charts and graphs of the compiled data were developed by the EUB Communications Group.

The evaluation period used in this report is from January 1, 1990, through December 31, 2005. Data were obtained from two EUB databases, the Pipeline Attribute database and the Environmental Incidents database (now replaced by the Field Information System). Data were downloaded on March 1, 2006, in order to allow for data gathering and input to be completed for incidents and applications that occurred at the end of 2005. Both of the databases are live systems, meaning that they are constantly changing as licensing data are amended and updated and environmental incidents are updated. For example, pipelines are constantly being added, discontinued, abandoned, or returned to service. Thus the inventories are subject to daily variation. Incident data are also updated as investigation work is completed and new information obtained.

The Pipeline Attribute database includes the basic licensing and physical information on all operating, discontinued, abandoned, and permitted pipelines. Permitted pipelines were included in the tally for the 2005 year, as once the licence is issued the EUB does not know when construction is complete or when the pipeline is actually put into service. It has been necessary to assume that pipelines were commissioned in the year they were licensed. The total of pipeline recorded in the EUB database to the end of 2005 is 377 248 km, made up of 235 707 individually identified pipeline segments. This includes 2363 km of pipeline (1131 segments) that have no dates specified. For the purposes of this report, these have been assumed to be old construction occurring prior to 1990, and therefore they are included in the tally of pipeline installed prior to 1990.

We note that the data for cumulative length per year and length per product class, as collected for this report, do not agree consistently with length data collected in prior statistical studies. The reasons for this are complex, as data collection methods and computer platforms have changed considerably since data collection was originally begun in 1975. The most likely causes of discrepancies are licence dates that were changed at the time of future licence amendments and the actual relicensing of existing pipeline to different product categories or operating status.

In gathering the length data for this report, a method was developed that examined the existing licensing data to estimate the construction year. The EUB Pipeline Attribute database contains four different date fields, which complicates determining the most likely construction date. For this purpose, the earliest date on record was generally used, but where recorded dates showed inconsistencies or overlap in the year, original construction date selection was made based on the following declining priority: Original Permit Approval Date, Permit Expiry Date, Permit Approval Date, and Last Occurrence Year. This was believed to provide the most likely construction date for each pipeline. Each individual pipeline segment was evaluated separately.

In comparison to the previously published length data, discrepancies in the reported lengths become smaller moving towards recent time, and figures published in previous statistical reports since about 2001 are in reasonable agreement with the data collected for this report. The net realization of all this is that, despite best effort, the amount of pipeline attributed to a specific construction year is an estimate and becomes less certain as we look farther back into past years.

Many EUB pipelines are licensed to carry multiple products, either due to production stream changes during the year (e.g., enhanced oil recovery schemes) or batch transmission of product. For the purposes of this report and the previous report in 1998, multiple substances are prioritized in accordance to the following declining order of priority: sour gas (SG), high vapour pressure product (HVP), crude oil (CO), oil effluent (OE), low vapour pressure product (LV), natural gas (NG), fuel gas (FG), salt (produced) water (SW), miscellaneous liquids (ML), miscellaneous gases (MG), fresh water (FW). (Note that in some instances in this report and in the figures oil effluent is sometimes called by its more colloquial name, multiphase.) Because of the categorization system, a batch products pipeline licensed to carry HVP, CO, and LV products will be captured as HVP in the summary of inventory. Based on length, the number of multiple product pipelines accounts for 5102 km, or 1.35% of the entire Alberta inventory; thus the statistical significance of the classification uncertainty is small. Of note is the observation that because most of these multiple substance pipelines are batch transmission pipelines carrying segregated product, most of them will have been captured in the HVP or CO substance categories.

Pipeline diameter data show that for the smaller pipeline sizes, there were many recorded variations slightly off the nominal values. This is likely due to data entry errors, although pipes of older vintage did sometimes vary. It was therefore necessary to broaden the diameter ranges to capture similar-sized pipeline into nominal classes. For instance, a wide variety of pipe dimensions in the 1 to 2.5 inch ranges were found; these have all been categorized as 60.3 millimetre (mm) (2") pipe for simplicity. Similarly, 3.5" pipe has been included with 88.9 mm (3") pipe, 4.5" pipe has been included with the 114.3 mm (4") pipe, and 5" pipe has been included with 168.3 mm (6") pipe.

Material classes have been grouped together as well to simplify data analysis. In this report, materials are listed as steel, aluminum, composite, fibreglass, polyethylene, and other. Fibreglass denotes the traditional rigid stick-type fibreglass, and composite denotes the newer spoolable composite pipes. The “other” category includes asbestos cement, ductile cast iron, cellulose acetate butyrate, polybutylene, polyvinyl chloride (PVC), and unknown. There are fewer than 850 km of these “other” materials in aggregate.

Any pipeline failure or hit upon a pipeline requires reporting to the EUB. Records of those pipeline incidents include a cause of failure. To simplify charting, these have been grouped into eleven classes of similar nature, as described in the following table.

EUB legislation requires pipeline operators to report any pipeline incident that results in a loss of pipeline product, regardless of volume, or any incident where a pipeline was struck. This requirement is applicable regardless of the status of the pipeline; thus even hits on discontinued or abandoned pipelines must be reported. Spills occurring within facilities (such as satellites, batteries, or plants) are not considered to be part of the pipeline system and so would not be included in the pipeline incident data.

Pressure test failures were **not** included in the operating incident data evaluation, as test failures do not occur under actual operating

Causes of Pipeline Failure by Class

Report cause class	Cause of failure in raw data
Construction damage	• Construction damage (improperly applied or damaged coatings, inadequate support, faulty alignment, bending)
Damage by others	• Damage by others (third-party excavation or interference)
Earth movement	• Earth movement (watercourse change, slope movement, heaves, subsidence)
External corrosion	• Corrosion, external • Mechanical pipe damage (dents, scrapes, gouges leading to corrosion)
Internal corrosion	• Corrosion, internal
Joint failure	• Mechanical joint failure (gasket or o-ring failure, internal joint coating failure, mechanical couplings) • Miscellaneous joint failure (butt fusion, interference joints, fibreglass bonded or threaded joints, explosive welding)
Overpressure	• Overpressure failure
Pipe	• Pipe failure (pipe body failure due to stress corrosion cracking [SCC], hydrogen-induced cracking [HIC], cracking, fatigue, laminations)
Valve/fitting	• Valve failure (seal blowouts, pig trap failures) • Installation failure (at compressor, pump, meter station)
Weld	• Girth weld failure (not by corrosion) • Seam rupture (electrical resistance weld [ERW] or other seam weld failure) • Other weld failure (weldolets, thermowells)
Other	• Installation failure (compressor, pump, or meter station) • Operator error • Unknown (pipe cannot be exposed/examined) • Miscellaneous (erosion, vandalism, lightning, flooding)

conditions. An analysis of pressure test failures has been conducted separately, and that information is also contained in this report. The number of pipeline incidents recorded in the reporting period was 12 848, comprising 11 433 leaks, 758 ruptures, and 657 hits that did not result in product loss. The number of test failures for that period, not included in the 12 848, was 1256.

In the environmental incident reporting database, there are only six available substance codes to choose from when an incident is recorded. They are CO, NG, OE, SG, WA (FW and SW), and OT (other). Only one substance code is recorded in the incident database: it is the first of the alphabetical series. Thus a failure on a CO/LVP/HVP pipeline when carrying HVP product would be recorded as a CO pipeline failure, whereas this same pipeline would have been counted as an HVP pipeline in the attribute database. A failure occurring on an HVP-only pipeline would be recorded as occurring in the "other" category. This mismatch between the two independent databases, though unfortunate, is not expected to result in significant misinterpretation, as the number of multiple substance pipelines is only 1.35%, based on length.

Figures reporting data from pipeline spills indicate that there have been more spills than actual incidents. This is not an error, as some incidents release more than one substance (i.e., oil, water, and gas), each of which is recorded separately for spill measurement purposes. Spilled fluids are categorized into five classes: sour gas (contains greater than 10 moles hydrogen sulphide (H_2S) per kilomole of natural gas), hydrocarbon gas, hydrocarbon liquid, water, and other. Bitumen, condensate, and HVP are included with the hydrocarbon liquids. Acid gas is included with sour gas.

A measure of overall annual pipeline performance is calculated by dividing the number of failures recorded for each calendar year by the total kilometres of operating and permitted pipeline on record at calendar year-end. Discontinued and abandoned pipelines are not included in this calculation. There is of course some inaccuracy in the calculated values due to the consistently changing nature of the pipeline database, as previously discussed.

The EUB database includes 5116 km of pipeline licensed by the National Energy Board (NEB). Those pipelines are included in the total inventory as they do physically exist in Alberta. However, the EUB is not involved in the regulation of those pipelines and thus the EUB incident database has no record of a failure related to any of these licences. The specifics of the NEB pipeline inventory in Alberta is as follows:

Substance	Length (km)
Crude oil	1090
Fuel gas	12
Natural gas	2137
Sour gas	41
Oil effluent	5
LVP	55
HVP	1776

NEB pipelines are those that cross a provincial or national border. In the case of the 5116 km reported here, 90% of that length is the transmission pipelines of major pipeline operators.

While the inclusion of this pipeline in the overall pipeline inventory will have a minor influence on the failure frequency numbers, the only substances for which this would be significant are natural gas, crude oil, and "other" (including LVP and HVP.) If the additional NEB mileage were removed, the average failure frequency of these three substances (for the year 2005 as an example) would increase from 1.61 to 1.74 for crude oil, from 1.55 to 1.57 for natural gas, and from 0.98 to 1.03 for "other." In respect to Figure 28, the difference would not be discernible.

3 Conclusions

3.1. Inventory Highlights

Alberta's pipeline inventory continues to experience steady growth. As of year-end 2005, Alberta totalled 377 248 km of pipeline. For the 15 years ending in 2005, the growth of pipeline infrastructure averaged 6.2% per year, with the highest two being 8.6% growth in 1997 and 7.7% growth recorded in 2005. Natural gas pipelines make up the largest portion of the inventory, 62%.

Operating pipelines (including new pipelines still licensed as "permitted") constitute 89.7% of the entire inventory, followed by abandoned pipeline, at 6.5%, and discontinued pipeline, at 3.8%. The great majority of all pipeline is constructed of steel, at 89.7%. The next largest material category is polyethylene, at 5.7%, followed by aluminum, at 2.2%, and fibreglass, at 1.9%. In terms of internal corrosion protection, 4.8% of pipeline contains some sort of corrosion barrier inside, and almost half of water pipelines contain some sort of internal corrosion barrier. Some types of pipeline, such as polyethylene, and the composite materials are inherently corrosion resistant. In comparison to EUB *Report 98-G*, this report shows significant growth in the amount of non-metallic materials being used for pipeline in recent years, as steel now makes up about 90% of the provincial total in comparison to the previous 94%. The use of advanced composite and polymer materials has great potential to reduce the number of corrosion-related pipeline failures.

3.2. Pipeline Incident and Performance Highlights

During the period 1990 to 2005, there were 12 848 pipeline incidents reported to the EUB (not including test failures). Of these, 657 were hits with no release, leaving 12 191 resulting in a pipeline release. Of all releases, 93.8% were leaks, and the other 6.2% were ruptures. A leak is defined as a situation where a pipeline may be losing product but continuing to operate. A rupture is a situation where the pipeline has been compromised to the point where it cannot continue to operate. The clear decline in the number of pipeline ruptures over the last eight years is a positive trend. The number of pipeline failures related to each product classification has been relatively steady, although 2005 shows an increase in the number of pipeline failures occurring in natural gas pipelines.

Internal corrosion continues to be the most prevalent cause of pipeline failure during the reporting period, representing 57.7% of all releases, followed by external corrosion at 12.0%. The combined total of 69.7% is a little higher than the total for corrosion presented in *Report 98-G*, which indicated 51.2% and 13.3% respectively, for a combined total of 64.5%.

Of all pipeline releases, 90.5% occurred on pipelines 60.3 mm (2") to 168.3 mm (6") in diameter, the most common pipelines used in Alberta's oil and gas gathering fields. Similarly, it was determined that 96% of all reported pipeline spills were of less than 100 m^3 of liquid or 100 000 m^3 of gas, again reflecting the prevalence of small-diameter pipelines. Of the reported spills or releases, 29.8% of recorded releases were hydrocarbon liquid, 23.6% hydrocarbon gas, 44.4% water, 1.9% sour gas, and 0.3% other materials.

When reviewing the average frequency of pipeline incidents, it is found that while the last ten years have shown a steady, gradual decrease in the number of incidents occurring per 1000 km of installed pipeline, reaching a low of 2.2 in 2004, the year 2005 saw a slight upward bump, mostly attributable to a higher number of natural gas pipeline failures, bringing the incident rate for 2005 to 2.4 incidents per 1000 km. Some of the product classes have quite low, steady failure frequency rates, suggesting that it may be difficult in some cases to realize much further improvement with incremental effort. However, the EUB is concerned about the increasing number of "other" failure causes being reported. "Other" includes installation failures (at a compressor, pump, or meter station,) operator error, miscellaneous (erosion, vandalism, lightning, flooding), and unknown (pipe cannot be exposed for investigation.) In years past only a few failures have been attributed to these causes, and the EUB is concerned that the recent increase in number of "other" failures may be serving to mask other data trends related to cause.

There were 1311 pipeline releases resulting from pressure testing and requalification testing. Of these, 85.8% were plain water; the remainder were various fluids.

4 Data Analysis

The following section contains 42 figures, along with brief interpretations and commentary, prepared by senior members of the Compliance and Operations Branch, Pipeline Section.

Figure 1 shows that as of December 31, 2005, there were 377 248 km of EUB-licensed pipeline in Alberta. This inventory includes 235 707 individually identified segments, with the simple average length of a pipeline segment being 1.60 km. This may seem counterintuitive when considering that pipelines are generally envisioned as long cross-country facilities, but in fact it reflects the reality that in Alberta the majority of pipelines are indeed short segments, 1 or 2 km in length, leading from individual producing wells to gathering facilities for treatment or processing. Larger group pipelines then carry the commingled production away, but these are much fewer than the small-diameter flow lines. The largest portion of the total inventory is natural gas pipeline, comprising about 62% of the inventory. Under EUB licensing protocol, natural gas pipelines may not contain more than 10 moles of H_2S per kilomole of natural gas, equivalent to 1%, or 10 000 parts per million. Pipelines having gas containing greater than 10 moles of H_2S per kilomole of natural gas are licensed as sour gas pipelines.

Pipeline classification generally follows the designation of a producing well. Thus gas pipeline is associated with a gas well. There may also be hydrocarbon liquids and water associated with the gas well. Where the composition of produced fluids causes the well to be classified as an oil well, the associated pipeline is licensed as a multiphase pipeline. Crude oil pipelines are generally considered to be carrying treated product where initial processing has removed gas and water. Water pipelines are those used for water supply or collection and for water injection. Sour gas pipelines are those where the H_2S content exceeds 10 moles of H_2S per kilomole of natural gas. They could also contain water and hydrocarbon liquids. Pipelines classified as “other” carry HVP products, such as ethane, propane, butane, ethylene, and mixes of produced natural gas liquids, as well as LVP products, such as fuel oil, motor fuel, and condensate. Additional pipelines contained in the “other” classification include hydrogen, carbon dioxide, nitrogen, ammonia, polymer, sulphur, etc.

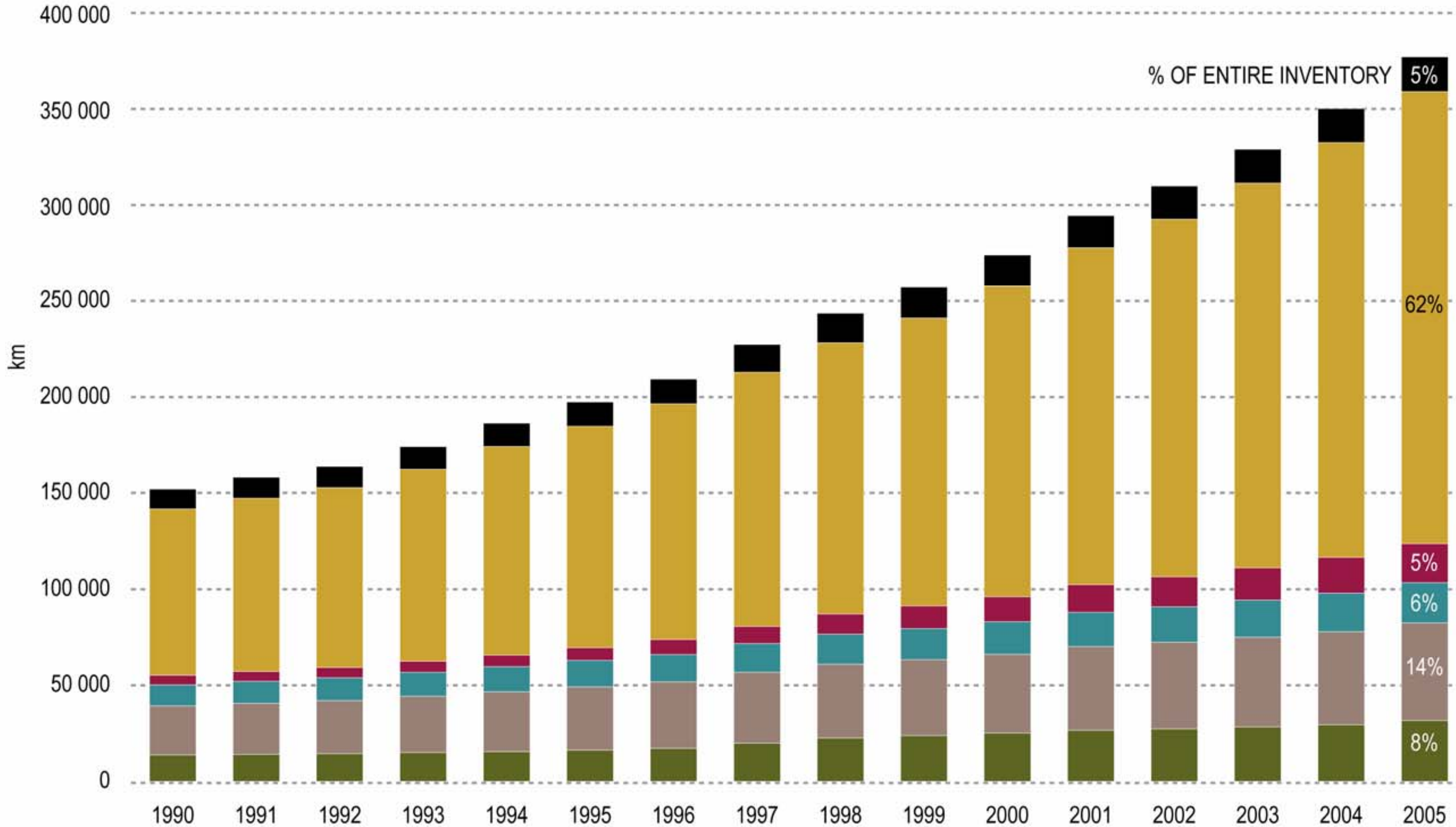
For the 15 years ending in 2005, the annual increase in pipeline infrastructure averaged 6.2% per year, with the highest two being 8.6% growth in 1997 and 7.7% growth recorded in 2005.

Average Length of Pipeline Segments
All pipelines current to December 31, 2005; includes abandoned, discontinued, operating, and permitted lines

	Average length per segment (km)	Total length (km)	Number of segments
Crude oil	3.74	18019	4812
Natural gas	1.73	235592	136023
Sour gas	2.45	20168	8244
Fresh water	1.47	6445	4397
Salt/produced water	1.09	14403	13212
Oil well effluent	0.88	50977	57790
Fuel gas	1.71	12839	7493
HVP	6.77	11880	1754
LVP	6.33	5432	858
Miscellaneous gases	0.98	756	775
Miscellaneous liquids	2.12	739	349
Totals		**377248**	**235707**
Average length	1.60		

Figure 1. Length of pipelines in Alberta by year and substance

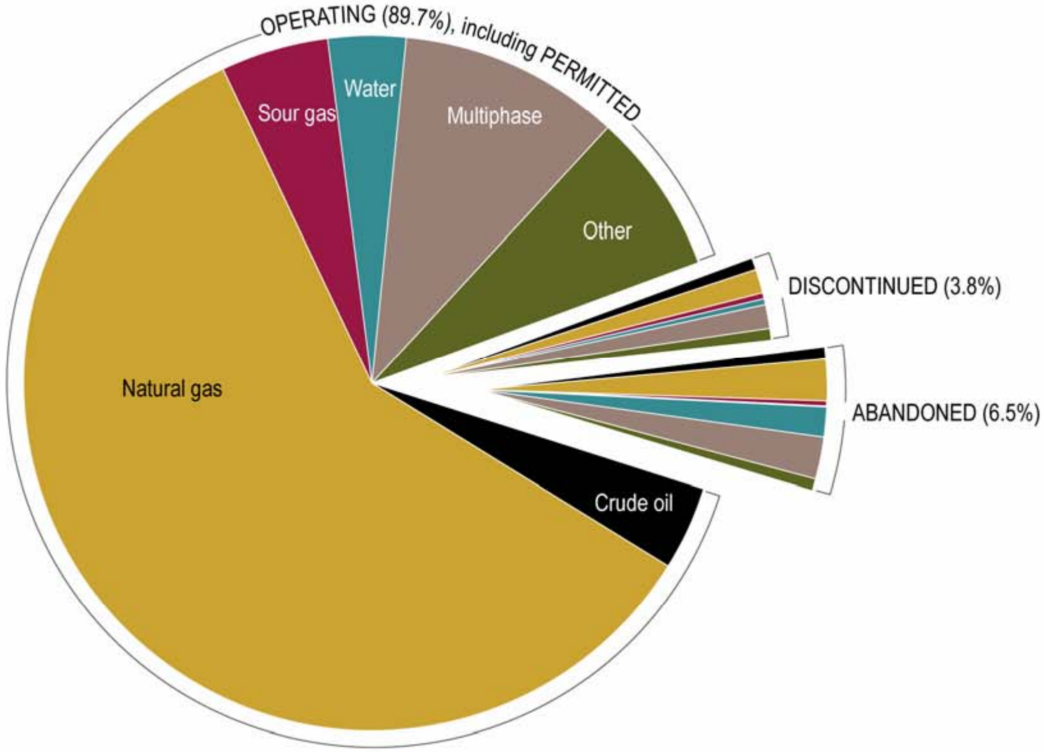
All pipelines current to December 31, 2005



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Crude oil	10 284	10 829	11 280	11 749	12 106	12 606	12 853	14 442	15 340	16 137	16 423	16 703	17 213	17 568	17 698	18 019
Natural gas	86 501	90 060	93 472	99 981	108 517	115 102	122 505	132 192	141 010	149 712	161 522	175 396	186 227	200 250	215 903	235 592
Sour gas	4 948	5 164	5 325	5 821	6 114	6 769	7 747	8 848	10 442	11 740	12 957	14 374	15 545	16 709	18 562	20 168
Water	10 926	11 416	11 850	12 394	13 113	13 812	14 421	15 164	15 825	16 346	16 941	17 750	18 364	19 235	19 984	20 847
Multiphase	25 552	26 543	27 598	29 275	31 102	32 880	34 655	36 844	38 383	39 470	41 075	43 785	45 309	46 911	48 594	50 977
Other	13 761	14 084	14 446	15 042	15 502	16 280	17 154	19 886	22 576	23 846	25 189	26 534	27 267	28 320	29 444	31 645
Total (km)	**151 973**	**158 095**	**163 970**	**174 262**	**186 454**	**197 449**	**209 335**	**227 376**	**243 577**	**257 252**	**274 108**	**294 542**	**309 925**	**328 993**	**350 186**	**377 248**

Figure 2 shows that as of the end of December 2005, about 89.7% (338 448 km) of the Alberta pipeline inventory was listed as operating (or permitted, as permitted and operating are combined, as permitted pipeline automatically converts to operating after one year), 3.8% (14 371 km) was listed as discontinued, and 6.5% (24 430 km) as abandoned. These numbers fluctuate, since pipeline status is being changed daily as companies modify or terminate projects. Changes to the *Pipeline Regulation* in 2005 have also led to additional amendments to pipeline status, as the regulation required licensees to properly discontinue and abandon pipelines that had been existing in an unused state or to include pipeline that is not flowing but licensed as operating within the licensee's corrosion mitigation program.

Figure 2. Length of pipelines in Alberta by status and substance
All pipelines current to December 31, 2005



	OPERATING (including Permitted)		DISCONTINUED		ABANDONED			% of
	km	% of product type	km	% of product type	km	% of product type	Total km	entire inventory
Crude oil	14 902	82.7	1511	8.4	1606	8.9	18 019	4.8
Natural gas	223 921	95.1	4082	1.7	7588	3.2	235 592	62.5
Sour gas	18 120	89.8	1067	5.3	982	4.9	20 168	5.3
Water	14 463	69.4	1502	7.2	4882	23.4	20 847	5.5
Multiphase	38 536	75.7	4356	8.6	8058	15.8	50 977	13.5
Other	28 479	90.0	1853	5.9	1313	4.2	31 645	8.4
Total	**338 448**	**89.7**	**14 371**	**3.8**	**24 430**	**6.5**	**377 248**	**100.0**

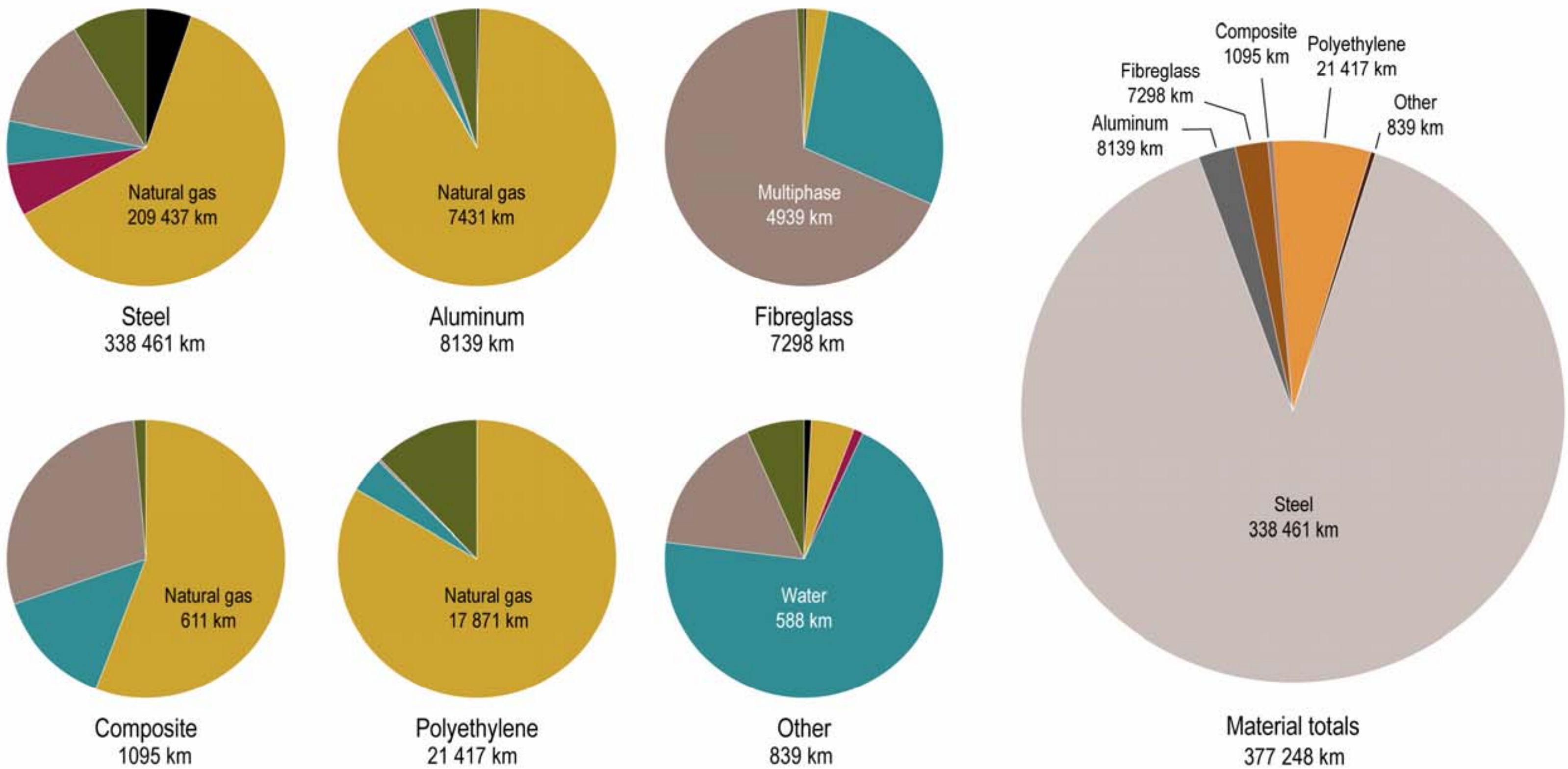
Figure 3 shows two concepts: how much pipeline of each material class exists and what services those materials are used in. The second concept shows the overall use of each material in proportion to each other and the whole.

The six small pie graphs show the six primary pipe material classes: steel, aluminum, fibreglass, composite, polyethylene, and other. Each of these graphs shows in what service that pipeline material is used; for example, the great majority of aluminum pipeline is used in natural gas service. The predominant use of fibreglass pipeline is in multiphase service.

The large pie shows the proportion of each material in use overall. The predominant pipeline material is steel, which has been used in almost 90% of the total pipeline infrastructure, compared to 94% stated in *Report 98-G*. Thus there has been meaningful growth in the use of polymeric and composite pipeline as an alternative to steel. With improved technology allowing higher working pressures for both polymeric and composite pipeline and the inherent corrosion resistance of polymers, industry is choosing to use these products more frequently.

Figure 3. Installed pipelines by pipe material and substance

All pipelines current to December 31, 2005



SUBSTANCE CARRIED	PIPE MATERIAL: Steel		Aluminum		Fibreglass		Composite		Polyethylene		Other		Total	% of
	km	%	km	%	km	%	km	%	km	%	km	%	km	Inventory
Crude oil	17 949	99.6	39	0.2	22	0.1	1	<0.1			8	<0.1	18 019	4.8
Natural gas	209 437	88.9	7431	3.1	200	<0.1	611	0.3	17 871	7.6	41	<0.1	235 592	62.4
Sour gas	20 135	99.8	24	0.1							10	<0.1	20 168	5.3
Water	16 921	81.2	199	0.9	2093	10.0	151	0.7	896	4.3	588	2.8	20 847	5.5
Multiphase	45 471	89.2	50	0.1	4939	9.7	316	0.6	63	0.1	138	0.3	50 977	13.5
Other	28 549	90.2	395	1.3	45	0.1	15	<0.1	2 586	8.2	54	0.2	31 645	8.4
Total	**338 461**	**89.7**	**8139**	**2.2**	**7298**	**1.9**	**1095**	**0.3**	**21 417**	**5.7**	**839**	**0.2**	**377 248**	**100.0**

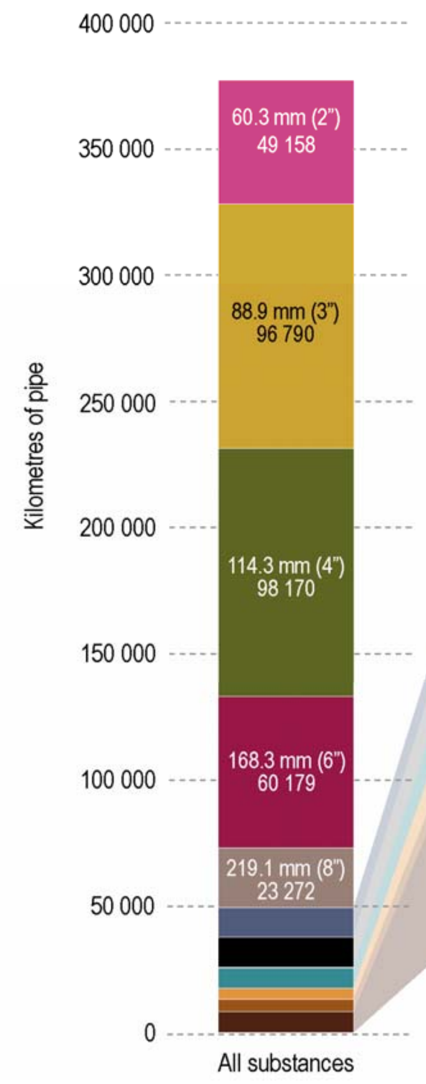
Figures 4a-4g show how much pipeline is installed for each product class and what sizes of pipe are used. Figure 4a shows how the large majority of pipeline in Alberta is small diameter. Figure 4b, on natural gas, shows, for example, that pipe of 2" to 6" nominal size makes up a total of 194 791 km of the entire 235 592 km of natural gas pipeline. The length of other sizes of pipe can also be determined from the chart. To clarify graphing, some of the sizes have been combined into one colour band.

The tables in Figures 4c through 4g provide the data for each of the other product classes.

A common trend for natural gas, oil effluent, water, and sour gas pipelines is that pipe sizes used are typically small. Larger pipe sizes become more predominant in the crude oil and “other” product categories, as they both contain a significant amount of transmission pipeline for treated or refined product. There is a significant amount of very large pipeline inventory shown in the natural gas category, which of course reflects the major natural gas transmission pipeline systems in Alberta.

Figure 4a. Total installed pipelines by pipe size

All pipelines current to December 31, 2005



PIPELINE SIZE mm	(inches)	km
273.1	(10)	11 793
323.9	(12)	11 583
355.6	(14)	475
406.4	(16)	7 684
457.0	(18)	606
508.0	(20)	3 808
559.0	(22)	586
610.0	(24)	4 830
660.0	(26)	61
711.0	(28)	
762.0	(30)	2 686
813.0	(32)	8
864.0	(34)	781
914.0	(36)	2 075
1 067.0	(42)	1 989
1 219.0	(48)	714
1 524.0	(60)	1
Total all sizes		**377 249**

Figure 4b. Installed pipelines by pipe size and substance (natural gas)

All pipelines current to December 31, 2005

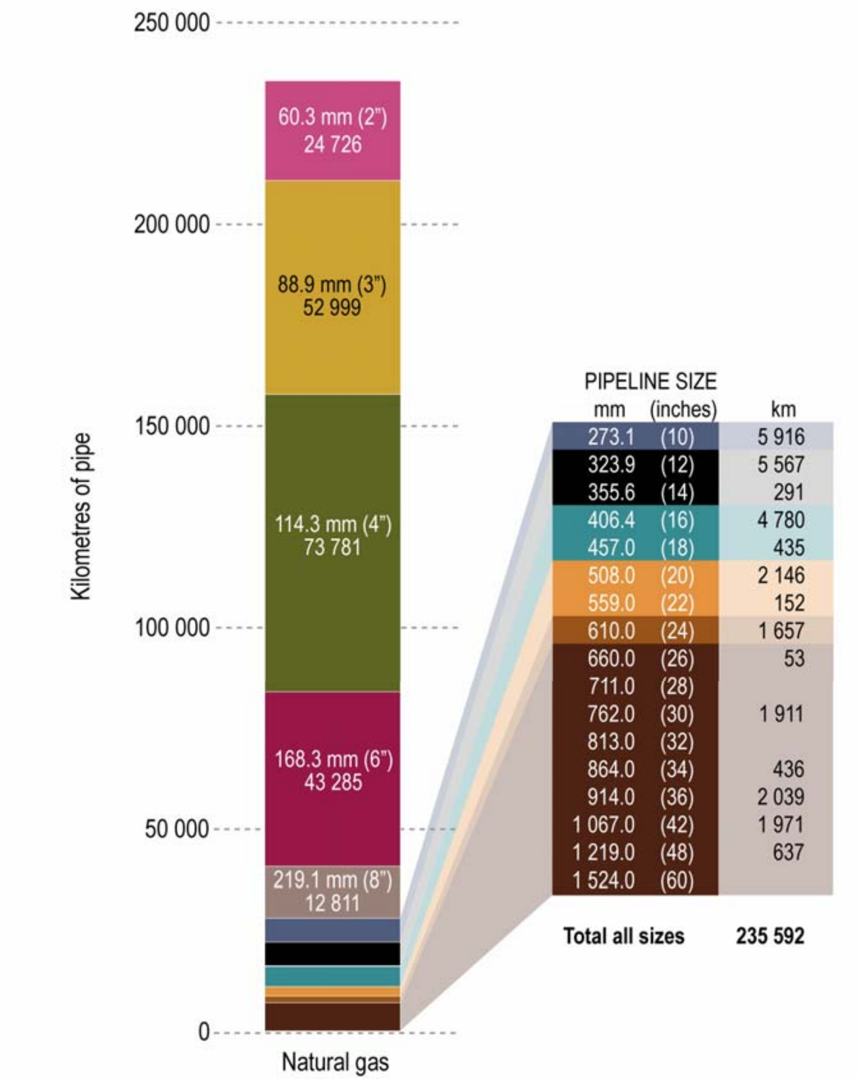


Figure 4c. Installed pipelines by pipe size and substance (crude oil)

All pipelines current to December 31, 2005

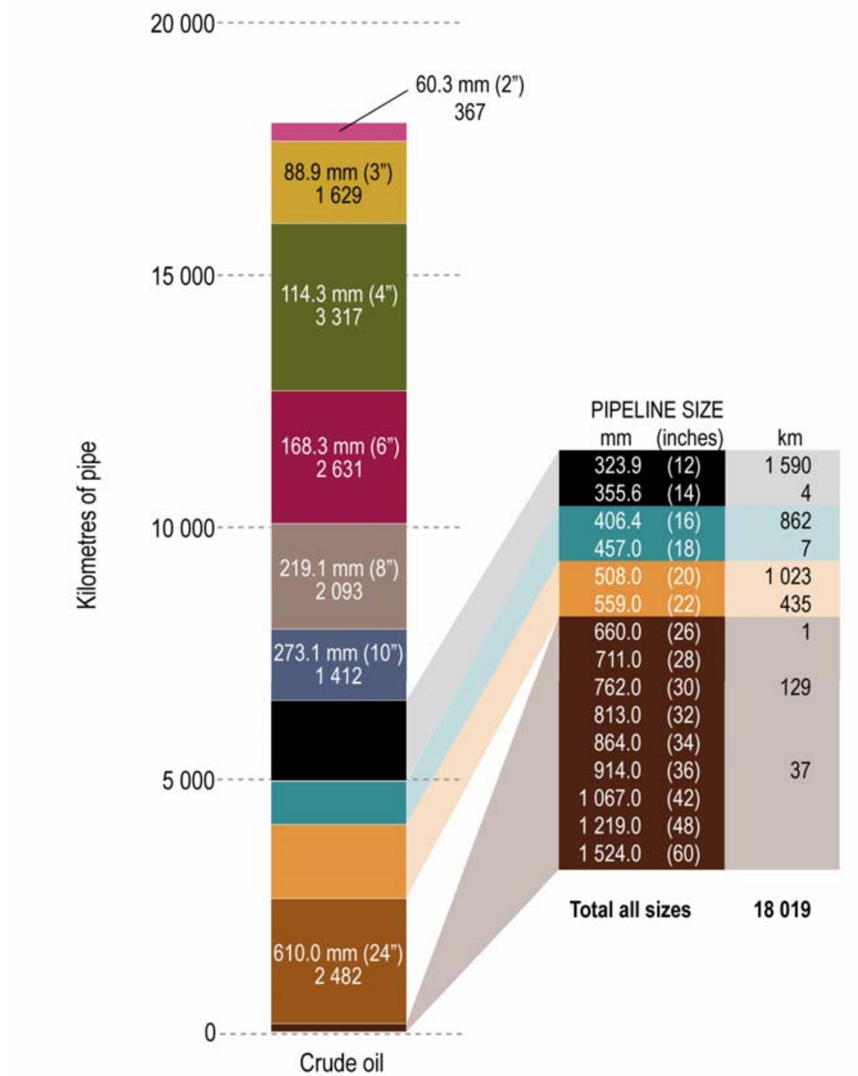


Figure 4d. Installed pipelines by pipe size and substance (sour gas)

All pipelines current to December 31, 2005

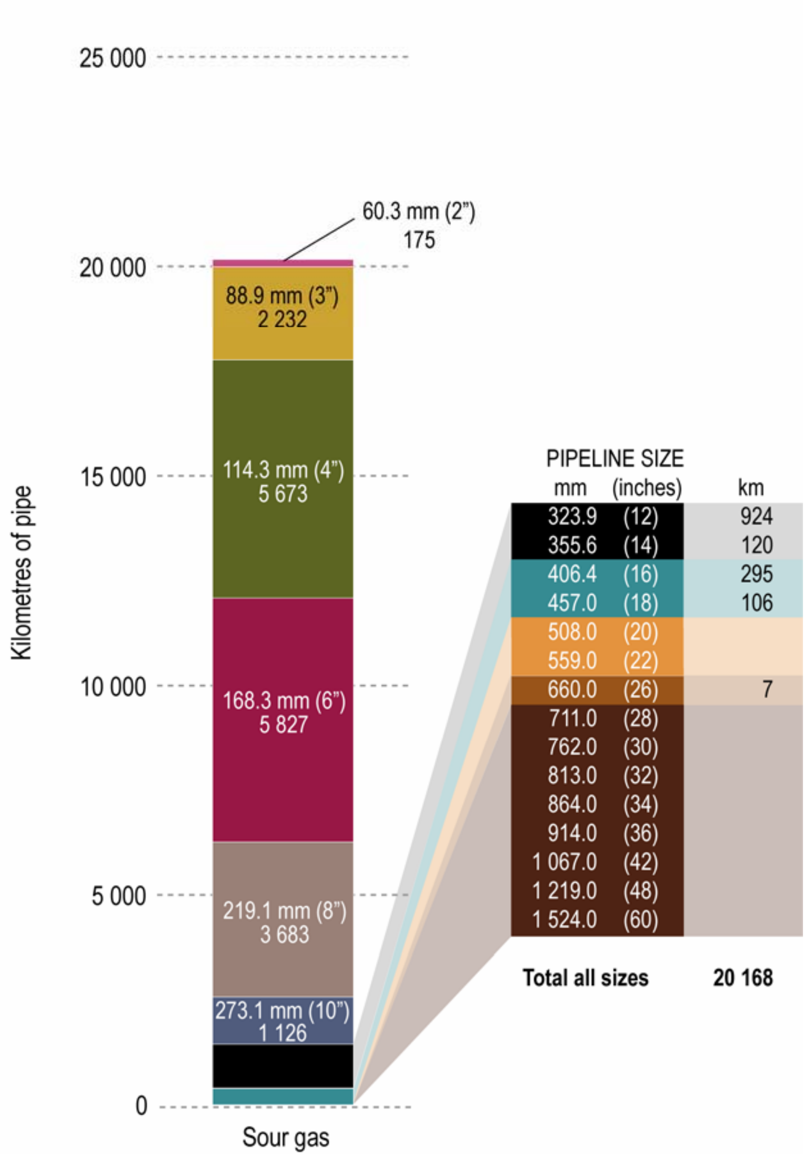


Figure 4e. Installed pipelines by pipe size and substance (water)

All pipelines current to December 31, 2005

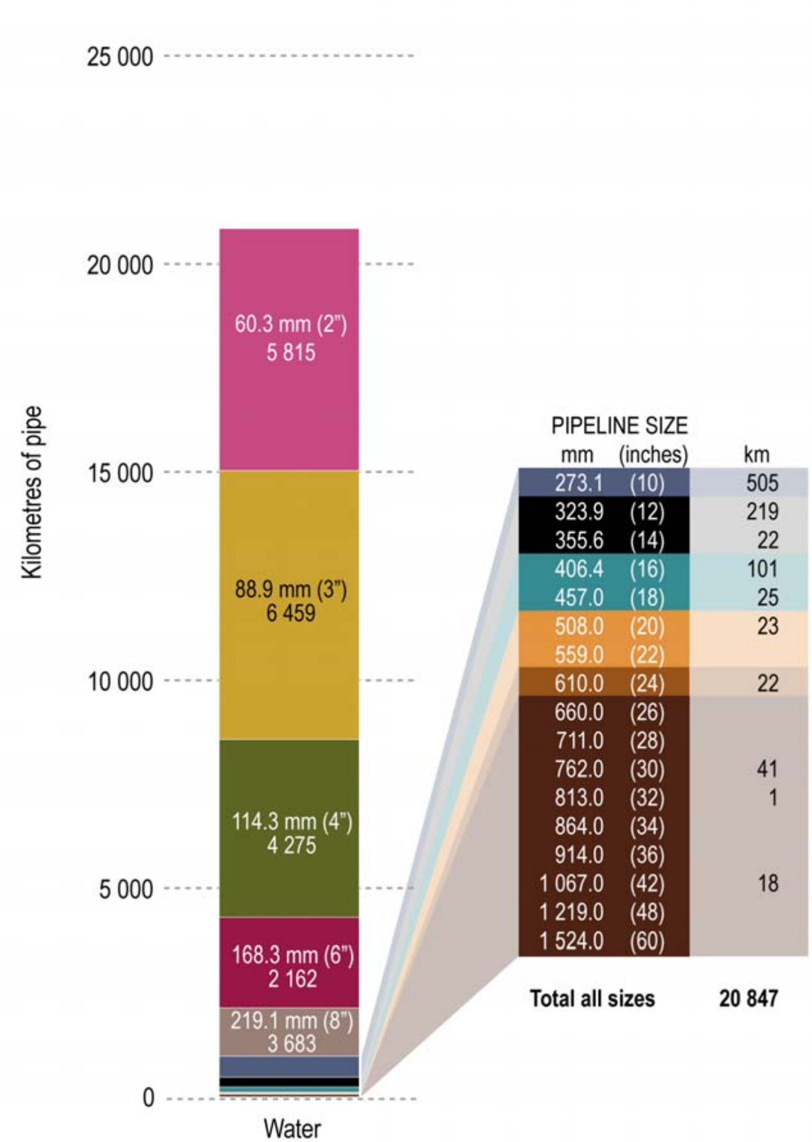


Figure 4f. Installed pipelines by pipe size and substance (multiphase)

All pipelines current to December 31, 2005

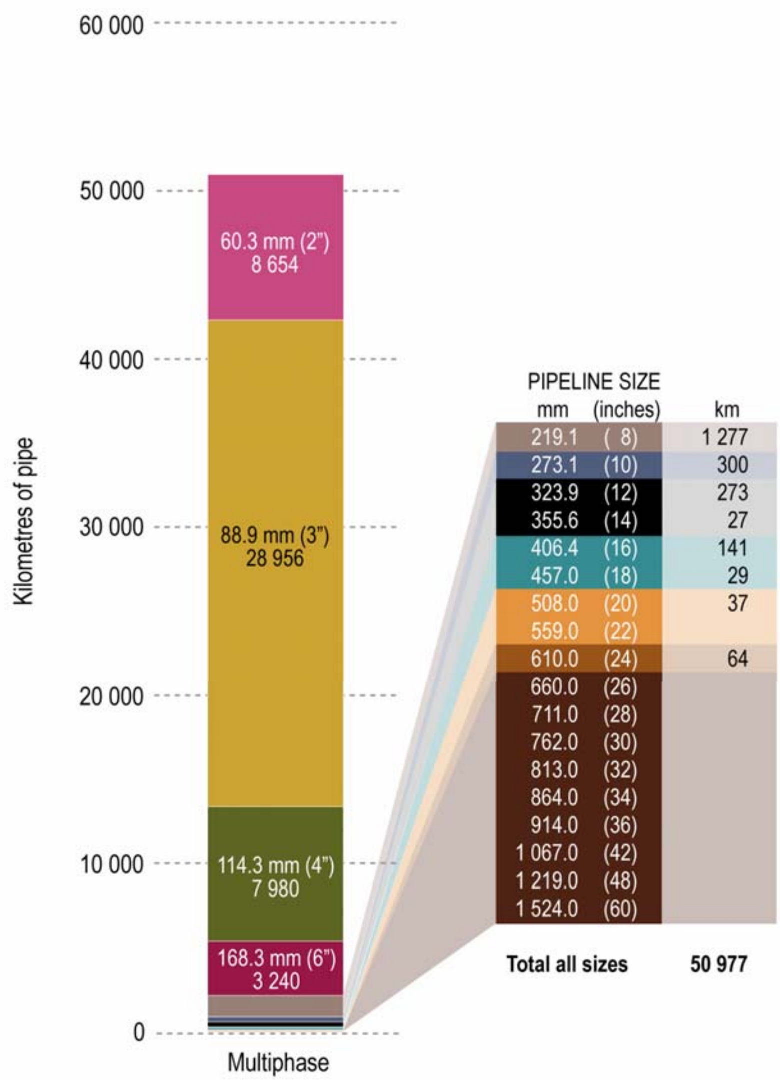


Figure 4g. Installed pipelines by pipe size and substance (other)

All pipelines current to December 31, 2005

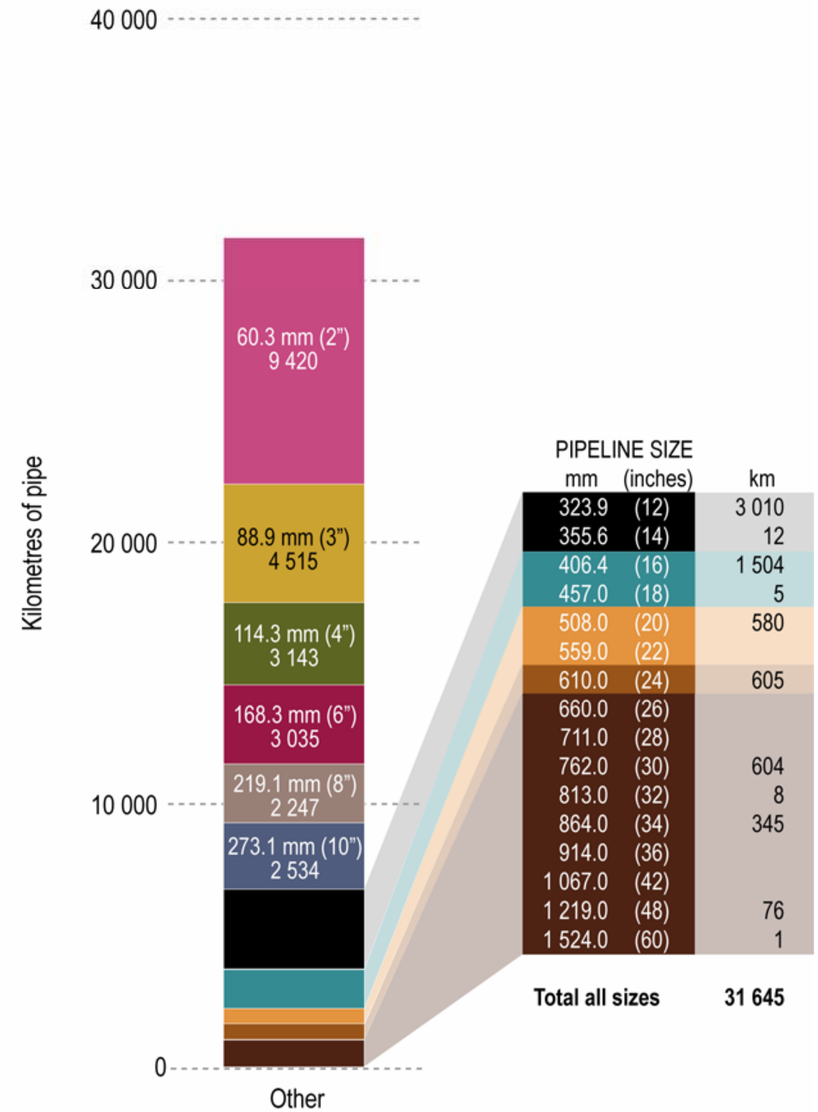


Figure 5 shows how much pipeline in Alberta is constructed of steel, as well as how much of those steel pipes have a fixed internal corrosion barrier installed. The large pie chart in Figure 5 shows the relative proportion of each substance class that is carried in the steel pipeline infrastructure.

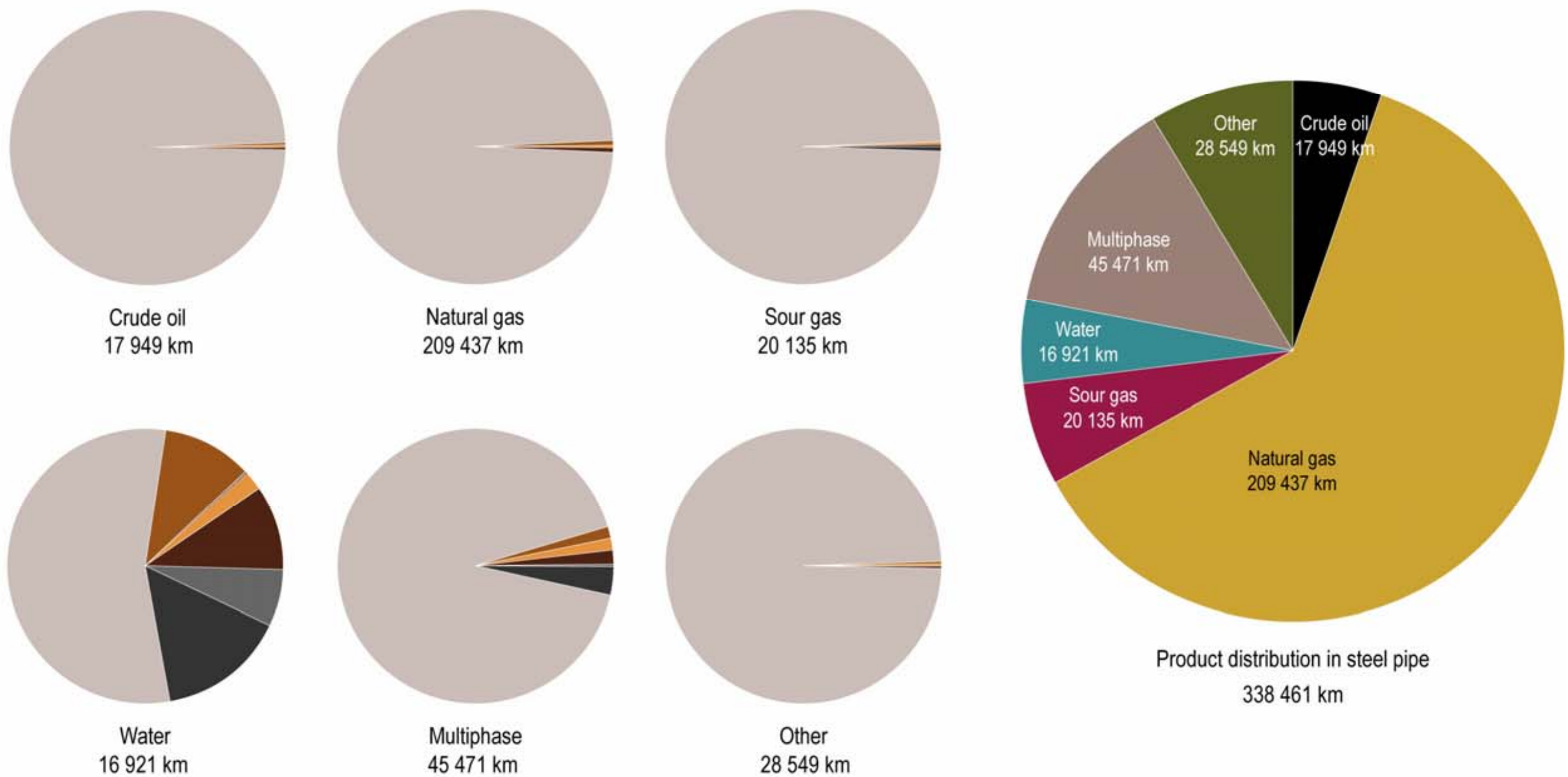
The categories of internal corrosion protection are none (bare pipe), thin film (baked-on polymer coatings), slip lined (loose-fit liners or pipe), polyvinyl chloride (liners), cement (bonded lining), expanded (tight-fit plastic liner), and other. Data show that 94.8% (320 977 km) of steel pipeline contains no internal corrosion barrier. The six small pie charts in Figure 5 show the amount of each corrosion prevention method used in each substance class.

The most successful of the various types of corrosion barrier have been expanded plastic liners and freestanding plastic or composite pipe. In some systems, cement lining and thin-film lining have also worked successfully, but these systems must be installed and operated carefully for sustained performance.

Although the majority of pipe is shown as having no internal corrosion barrier, this does not suggest that this pipe does not have internal corrosion prevention. The most common method used to protect steel pipelines against corrosion is the application of filming corrosion inhibitors (chemicals), accompanied by regular pipeline pigging (cleaning) to remove water and contaminants. This method is widely used and can be very effective when properly implemented.

Figure 5. Types of internal corrosion prevention installed in steel pipelines in Alberta's pipeline inventory

All pipelines current to December 31, 2005



CORROSION PREVENTION

SUBSTANCE CARRIED	Cement		Expanded		None		Other		PVC		Slip lined		Thin film		Total	% of
	km	%	km	%	km	%	km	%	km	%	km	%	km	%	km	Inventory
Crude oil	1	<0.1	46	0.3	17 801	99.2	20	0.1			49	0.3	33	0.2	17 949	5.3
Natural gas	74	<0.1	266	0.1	205 976	98.4	1 849	0.9			264	0.1	1 006	0.5	209 437	61.9
Sour gas	2	<0.1	163	0.8	19 893	99.0	7	<0.1			59	0.3	11	0.1	20 135	6.0
Water	1 428	8.4	3113	18.4	7 624	45.0	2 198	13.0	40	2.0	483	2.9	2 034	12.0	16 921	5.0
Multiphase	178	0.4	1 713	3.8	41 430	91.1	704	1.6	7	<0.1	644	1.4	794	1.8	45 471	13.4
Other	1	<0.1	37	0.1	28 254	99.0	158	0.5			30	0.1	68	0.2	28 549	8.4
Total	**1 684**	**0.5**	**5 339**	**1.6**	**320 977**	**94.8**	**4 935**	**1.5**	**47**	<0.1	1 530	0.4	3 948	1.2	338 461	100.0

The data presented in Figure 6 show that the number of recorded pipeline incidents has been fairly stable over the reporting period, typically around 800 annually. These data exclude test failures, as they do not occur under normal pipeline operating conditions. As pipeline infrastructure has increased about 6.2% per year over the last 15 years, it is encouraging to see that the number of incidents has not similarly increased. Looking at incidents per installed length, pipeline incident frequency has actually decreased over the last several years. This conclusion is demonstrated clearly in Figures 28 and 29.

There has been a noticeable decrease in the number of pipeline ruptures over the last 15 years. This suggests that the pipeline industry is successfully monitoring pipelines for problems, anomalies, and situations that might lead to catastrophic failure. There have been steady advances in technologies for internal pipeline inspection and in predictive modelling that assists in the interpretation of when pipeline corrosion or other defects might deteriorate into unsafe conditions. The data suggest that these tools are being applied successfully. The small pie chart in Figure 6 shows that of all incidents, 89% resulted in leaks, 5.9% resulted in ruptures, and 5.1% were hits with no product loss. However, those numbers are average values for the entire period of the report, and it is obvious that the frequency of rupture has been considerably less than 5.9% in the last few years; in fact, in 2005 ruptures represented only 1.2% of all incidents.

The last three years of the reporting period show an increase in the number of hits on buried pipeline. This is disappointing, but not unexpected in view of the very robust oil and gas development in the last few years. Increased field activity increases the chance of unplanned pipeline contact, and the increasing presence of a “green” or inexperienced junior workforce may be impacting this negatively. In 2005 the *Pipeline Regulation* strengthened some of the requirements regarding safe ground disturbance practices, inspection, and training, and it is hoped that in subsequent years these enhancements will translate into a reduction in the annual number of hits.

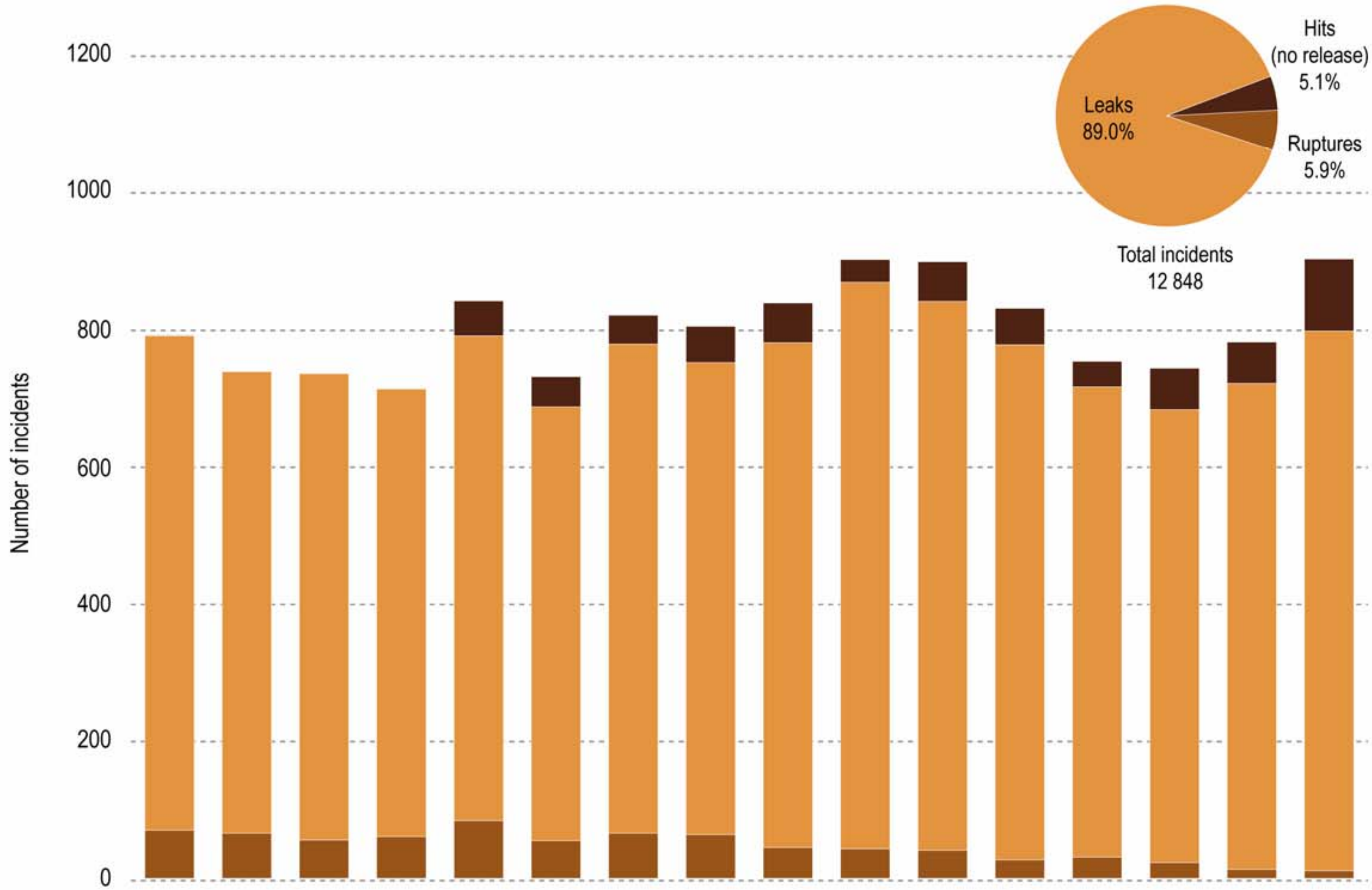
A simple analysis was done to see whether pipelines of certain product classes experienced more hits than others. By dividing the percentage of incidents caused by “damage by others” for each product class by the percentage of inventory that each class represented, a simple ratio was developed. For example, if a certain product pipeline represented 5% of the total pipeline inventory but experienced 10% of the number of “damage by other” incidents, the ratio was 2. The results are as follows:

Substance	Percentage of all incidents due to damage by others	Percentage of total inventory	Ratio
Crude oil	7.27	4.78	1.52
Multiphase	31.18	13.51	2.31
Natural gas	45.80	62.45	.73
Sour gas	2.45	5.35	.46
Water	7.84	5.53	1.42
Other	5.47	8.39	.65

This indicates that the more hazardous product classes, such as sour gas, natural gas, and “other” (which often contains HVP or LVP products), are experiencing fewer hits than the potentially lower risk product classes. This could suggest that shortcuts are being taken around certain types of pipeline. The relatively low ratio for natural gas pipelines, which are the most prolific substance class, suggests that mere abundance of pipeline does not necessarily translate into a higher number of hits. Industry should examine these data and consider why the differences exist. On a positive note, industry does seem to be exhibiting better care than “average,” that is, a ratio of 1, when excavating or working around pipelines carrying the most hazardous products.

Figure 6. Pipeline incidents, by type of incident per year

All pipeline incidents from January 1, 1990, to December 31, 2005 (includes all leaks, ruptures, and hits [did not result in product loss])

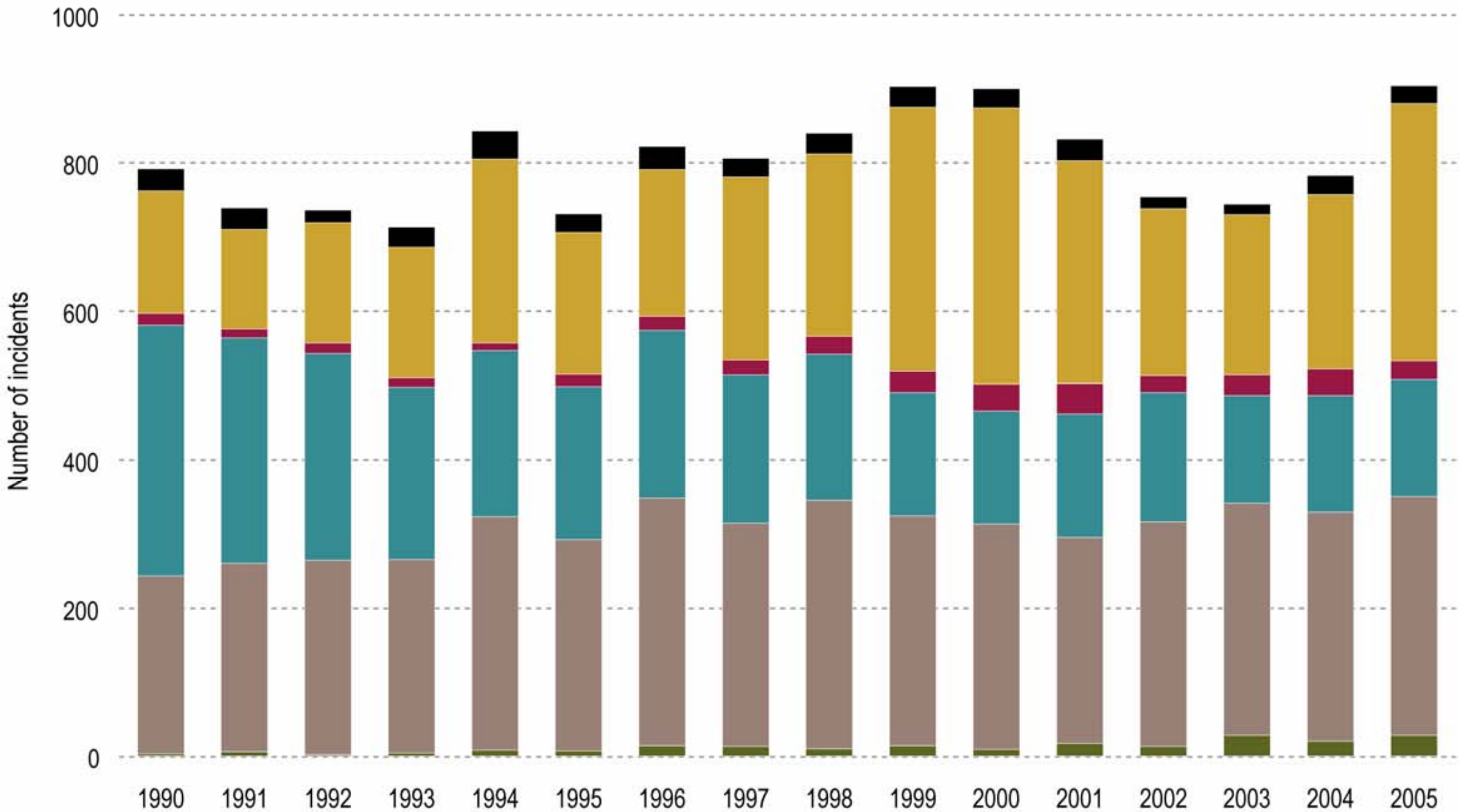


INCIDENT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of total
Hit	0	0	0	0	51	44	42	53	58	33	58	53	38	61	61	105	657	5.1
Leak	721	674	681	653	707	633	714	689	737	827	801	752	686	661	709	788	11 433	89.0
Rupture	71	66	56	61	85	55	66	64	45	43	41	27	31	23	13	11	758	5.9
Total number incidents	**792**	**740**	**737**	**714**	**843**	**732**	**822**	**806**	**840**	**903**	**900**	**832**	**755**	**745**	**783**	**904**	**12 848**	**100.0**

Figure 7 shows how the raw number of incidents for each product class has changed from year to year. A decrease in the number of water pipeline failures from 1990 is apparent, though the annual failure number seems to be quite static for the last several years. The only other significant trend shows that the number of natural gas pipeline failures declined following an increase in 1999 and 2000, but has recently increased again.

Figure 7. Pipeline incidents, by product per year

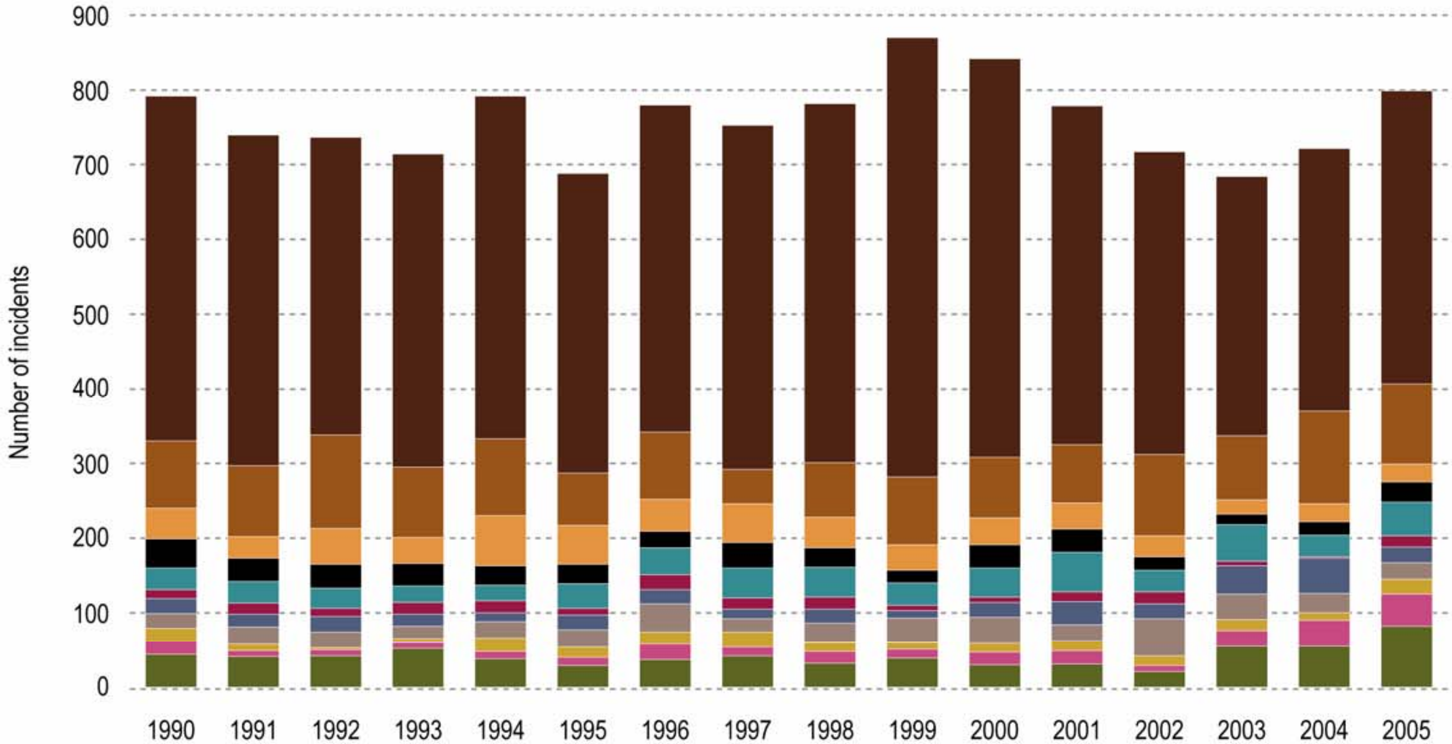
All pipeline incidents from January 1, 1990, to December 31, 2005 (includes all hits, leaks, and ruptures)



PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total	% of Total
	Numbers of incidents																	
Crude oil	29	29	17	27	38	25	31	25	28	28	26	29	16	14	25	24	411	3.2
Natural gas	166	135	163	177	248	192	198	247	246	356	372	300	226	217	236	347	3 826	29.8
Sour gas	16	12	14	12	10	16	19	20	24	28	36	41	22	27	35	25	357	2.8
Water	338	304	279	233	224	207	226	200	197	167	153	167	175	146	158	158	3 332	25.9
Multiphase	240	254	262	261	315	285	334	301	335	310	304	278	303	313	309	322	4 726	36.8
Other	3	6	2	4	8	7	14	13	10	14	9	17	13	28	20	28	196	1.5
Total	**792**	**740**	**737**	**714**	**843**	**732**	**822**	**806**	**840**	**903**	**900**	**832**	**755**	**745**	**783**	**904**	**12 848**	**100.0**

Figure 8a. Total number of releases by cause per year

All pipeline releases from January 1, 1990, to December 31, 2005 (leaks and ruptures only)



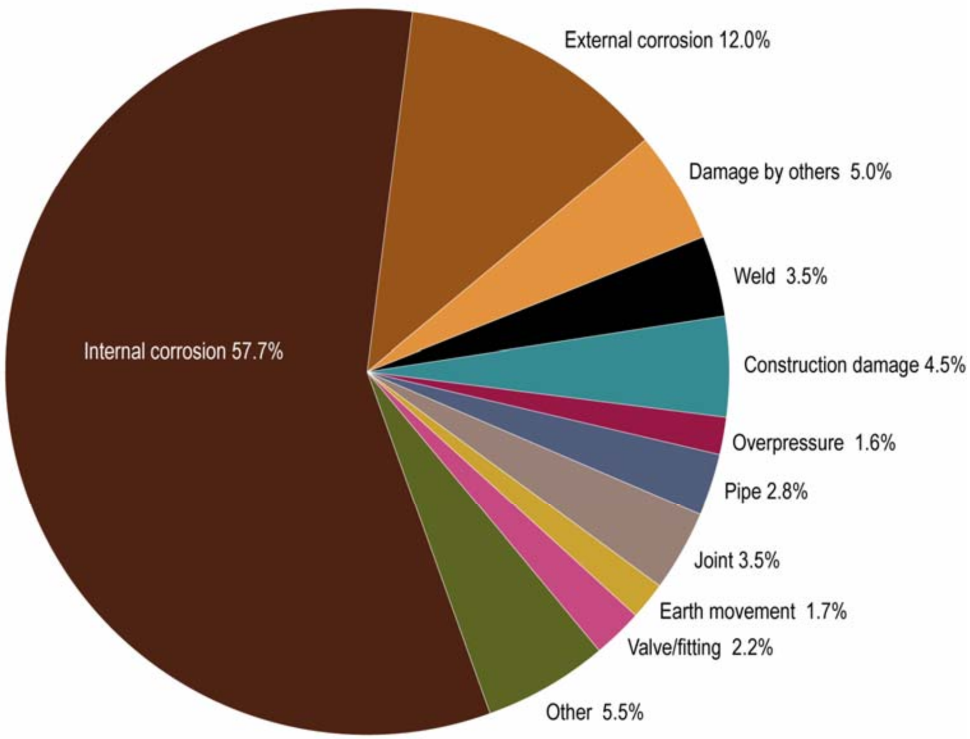
LEAK/RUPTURE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of total
Internal corrosion	462	443	399	419	459	401	438	461	481	588	534	454	405	347	352	392	7035	57.7
External corrosion	90	95	125	94	103	70	90	46	73	91	81	78	109	86	124	108	1463	12.0
Damage by others	41	29	48	35	67	52	43	52	41	34	36	35	28	19	24	24	608	5.0
Weld	39	31	32	30	26	26	22	34	26	17	31	31	18	14	18	27	422	3.5
Construction damage	29	29	27	22	21	33	36	40	40	30	39	53	29	49	29	45	551	4.5
Overpressure	12	15	11	16	16	9	20	15	16	7	7	13	16	6	2	15	196	1.6
Pipe	20	17	21	16	12	20	19	13	19	10	20	31	20	38	47	21	344	2.8
Joint	20	23	21	17	22	23	38	18	26	33	35	22	50	34	26	22	430	3.5
Earth movement	18	9	3	5	18	14	16	20	12	9	12	13	13	15	10	20	207	1.7
Valve/fitting	17	8	8	8	10	11	21	12	16	12	17	18	8	21	35	43	265	2.2
Other	44	41	42	52	38	29	37	42	32	39	30	31	21	55	55	82	670	5.5
Total number incidents	**792**	**740**	**737**	**714**	**792**	**688**	**780**	**753**	**782**	**870**	**842**	**779**	**717**	**684**	**722**	**799**	**12 191**	**100.0**

During all the years the EUB has tracked failure data, the predominant cause of pipeline failure has been internal corrosion, followed by external corrosion. This is not surprising, as most of Alberta's pipeline infrastructure is used for the production of raw oil and gas, which by nature can be highly corrosive. As pipes are mainly steel and are buried underground, corrosion of the external surfaces is also possible. Through regulatory direction and targeted surveillance and inspection, the EUB has drawn attention to these issues and encouraged industry to improve its operating practices. Figure 8a shows that for the years 2000 through 2005, these efforts may be having an impact, as the raw number of internal and external corrosion events has declined. However, offsetting this decline seems to be a pronounced increase in the number of "other" failures over the last three years. This raises the question of whether the cause of some of these "other" failures has been properly determined.

Figure 8b provides an averaged representation of the failure causes for leaks and ruptures over the reporting period. Internal and external corrosion constituted 69.7% of all failures, an increase over the 63% reported in *Report 98-G*. Given that over recent years the total number of pipeline releases has been relatively steady, this suggests that industry is being more successful at reducing failures of the other various types than it is at reducing failures due to corrosion. However, on a positive note, the overall failure frequency has been declining during this same time.

Figure 8b. Pipeline releases, by cause for all years combined

All pipeline releases from January 1, 1990, to December 31, 2005 (leaks and ruptures only)

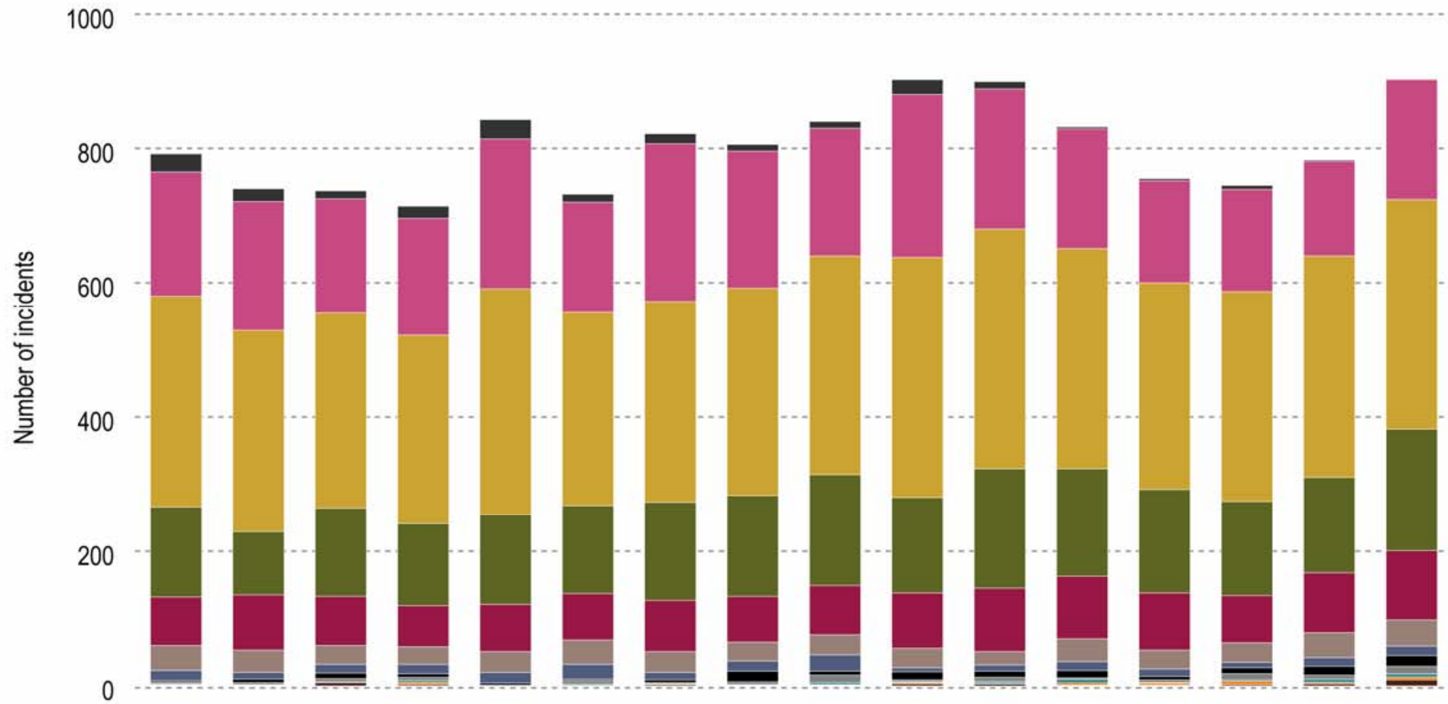


Total number of releases 12 191

Figure 9 shows that the great majority of pipeline incidents occur on small diameter pipeline, which reflects the actual infrastructure present in Alberta and the corrosive nature of the products carried in those small diameter pipelines. Averaged over the analysis period, 90.5% of all pipeline incidents occurred on pipe of 168.3 mm (6") diameter and smaller.

Figure 9. Pipeline incidents, by pipe size

All pipeline incidents from January 1, 1990, to December 31, 2005 (includes all hits, leaks, and ruptures)



SIZE OF PIPE mm (inches nominal)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of total
Not specified	27	19	12	18	29	12	15	10	10	22	11	3	3	6	2	1	200	1.5
60.3 (2)	185	192	170	174	223	164	235	204	190	243	209	178	152	152	141	179	2 991	23.3
88.9 (3)	314	300	291	281	337	288	299	309	326	358	357	328	308	313	330	342	5 081	39.5
114.3 (4)	134	94	131	122	133	131	146	150	165	142	178	160	154	140	142	181	2 303	17.9
168.3 (6)	72	82	73	61	70	69	76	68	73	82	94	93	85	70	89	103	1 260	9.8
219.1 (8)	37	33	28	26	31	36	31	28	30	29	20	34	28	29	37	39	496	3.9
273.1 (10)	15	10	13	14	16	22	11	15	24	6	9	13	11	8	13	14	214	1.7
323.9 (12)	2	5	8	5	3	2	4	16	6	12	9	11	5	9	13	16	126	1.0
355.6-406.4 (14/16)	3	3	5	5		5	2	4	11	3	6	2	4	9	6	11	79	0.6
457-508 (18/20)	1	1		3		2			3	1	3	6	1	2	5	5	33	0.3
559-610 (22/24)	1		1	3	1	1	1	1	1	2	1	3	3	5	2	4	30	0.2
762-1219 (30-48)	1	1	5	2			2	1	1	3	3	1	1	2	3	9	35	0.3
Total number incidents	**792**	**740**	**737**	**714**	**843**	**732**	**822**	**806**	**840**	**903**	**900**	**832**	**755**	**745**	**783**	**904**	**12 848**	**100.0**

Figure 10a shows that 66.2 % of water pipeline failures are caused by corrosion. Progress has been made in reducing the number of water pipeline failures, as shown in Figure 10b, although the raw number is relatively steady in recent years. Almost half of water pipelines do have internal corrosion protection, as shown in Figure 5.

Figure 10a. Water pipeline incidents, by cause for all years combined

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)

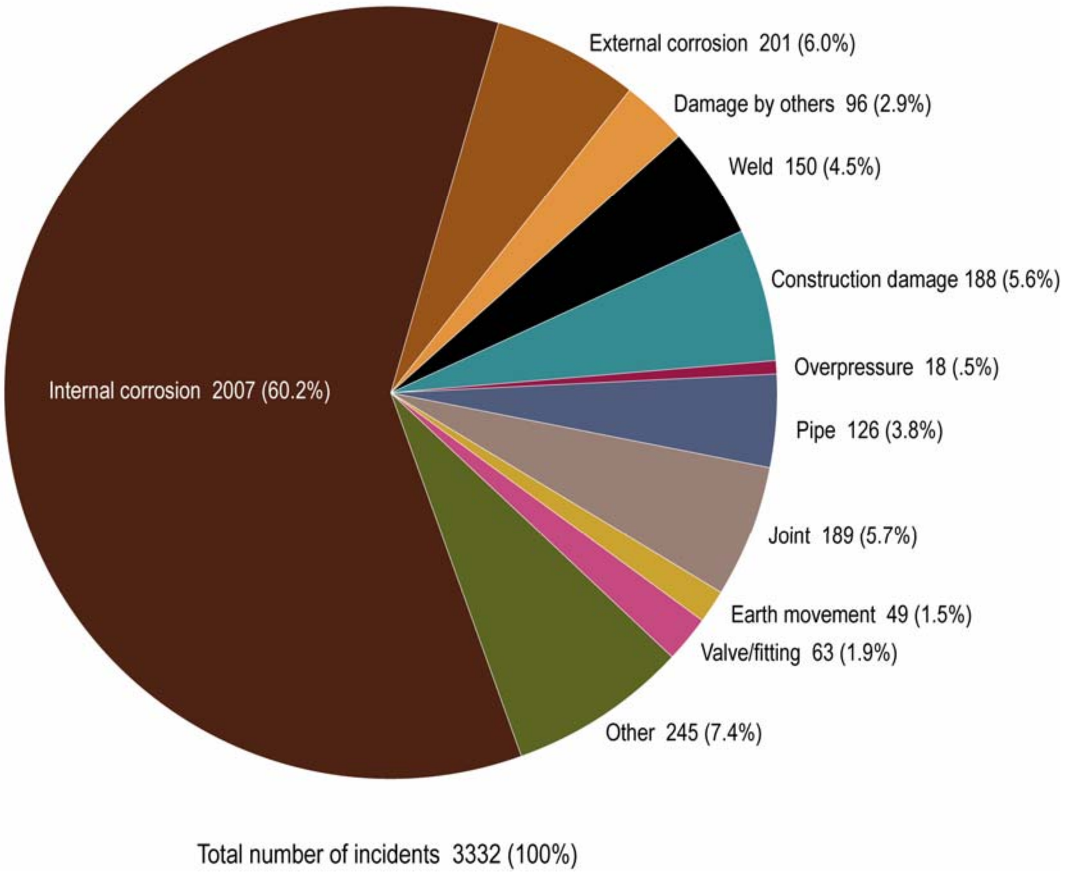
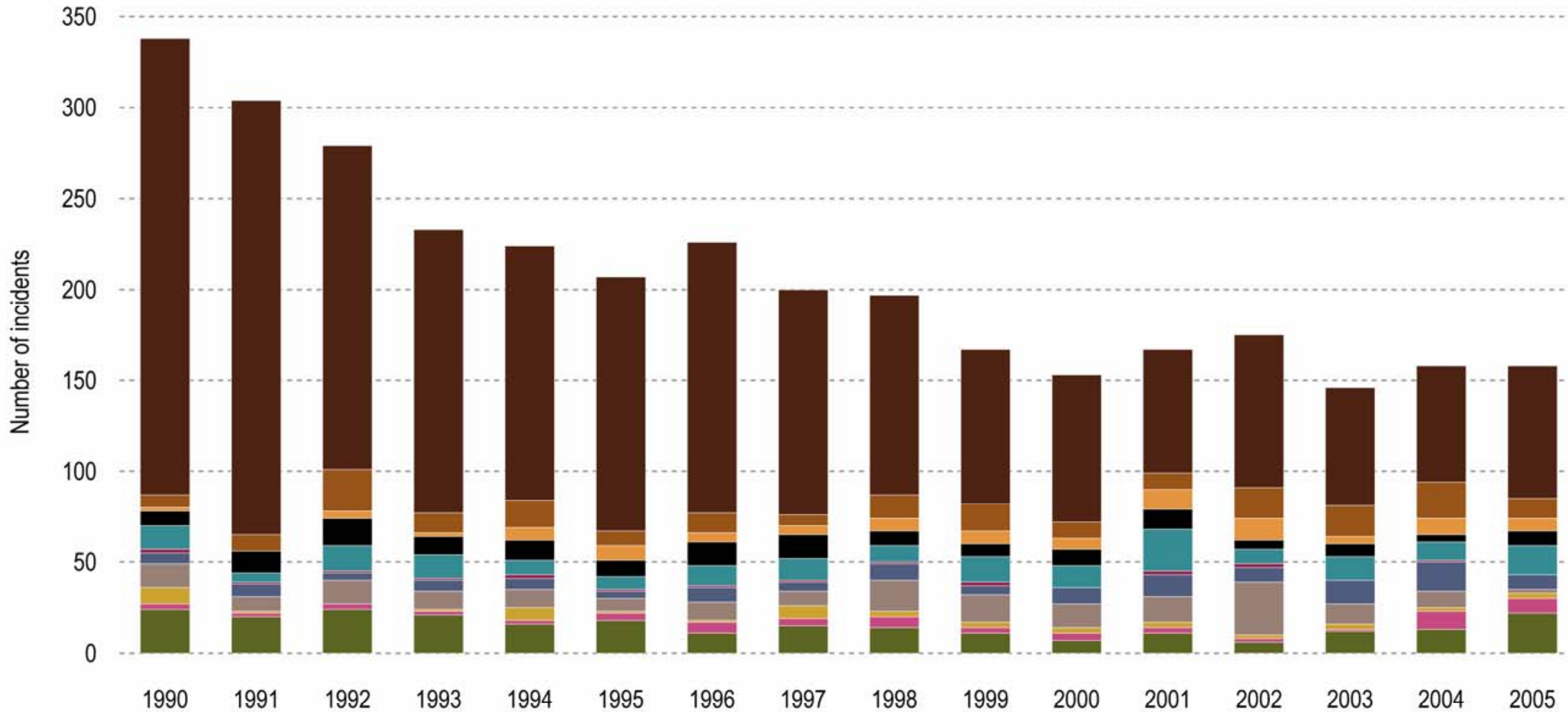


Figure 10b. Water pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion	251	239	178	156	140	140	149	124	110	85	81	68	84	65	64	73
External corrosion	7	9	23	11	15	8	11	6	13	15	9	9	17	17	20	11
Damage by others	2		4	2	7	8	5	5	7	7	6	11	12	4	9	7
Weld	8	12	15	10	11	9	13	13	8	7	9	11	5	7	4	8
Construction damage	13	5	14	13	8	7	11	12	9	14	12	23	8	13	10	16
Overpressure	2	1	1	1	2	1	1	1	1	2		2	2		1	
Pipe	6	7	4	6	6	4	8	5	9	5	9	12	8	13	16	8
Joint	13	8	13	10	10	7	10	8	17	15	13	14	29	11	9	2
Earth movement	9	1		1	7	1	1	7	3	3	3	3	2	3	2	3
Valve/fitting	3	2	3	2	2	4	6	4	6	3	4	3	2	1	10	8
Other	24	20	24	21	16	18	11	15	14	11	7	11	6	12	13	22
Total number incidents	**338**	**304**	**279**	**233**	**224**	**207**	**226**	**200**	**197**	**167**	**153**	**167**	**175**	**146**	**158**	**158**
% of total	**10.2**	**9.1**	**8.4**	**7.0**	**6.7**	**6.2**	**6.8**	**6.0**	**5.9**	**5.0**	**4.6**	**5.0**	**5.3**	**4.4**	**4.7**	**4.7**

Figure 11a shows that 69.2% of multiphase pipeline failures are caused by corrosion. It can be hard to mitigate corrosion in multiphase pipelines, as variations in water content make it difficult to select and maintain effective inhibitor films. There appears to be a relatively high number of external corrosion failures as well. This is likely due to exterior coating damage, as some of these systems operate at higher temperatures where coating systems tend to deteriorate over time. Figure 11b shows that in recent years operators seem to be reducing the number of corrosion failures.

Figure 11a. Multiphase pipeline incidents, by cause for all years combined

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)

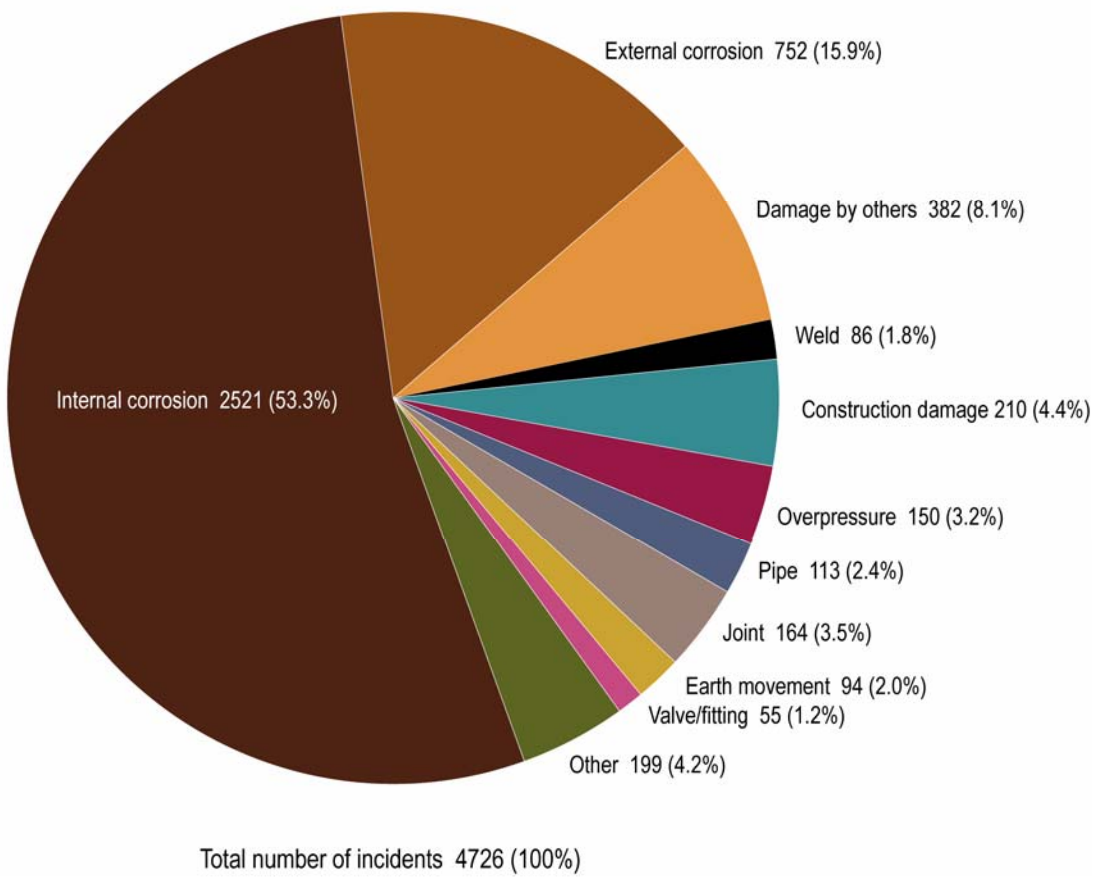
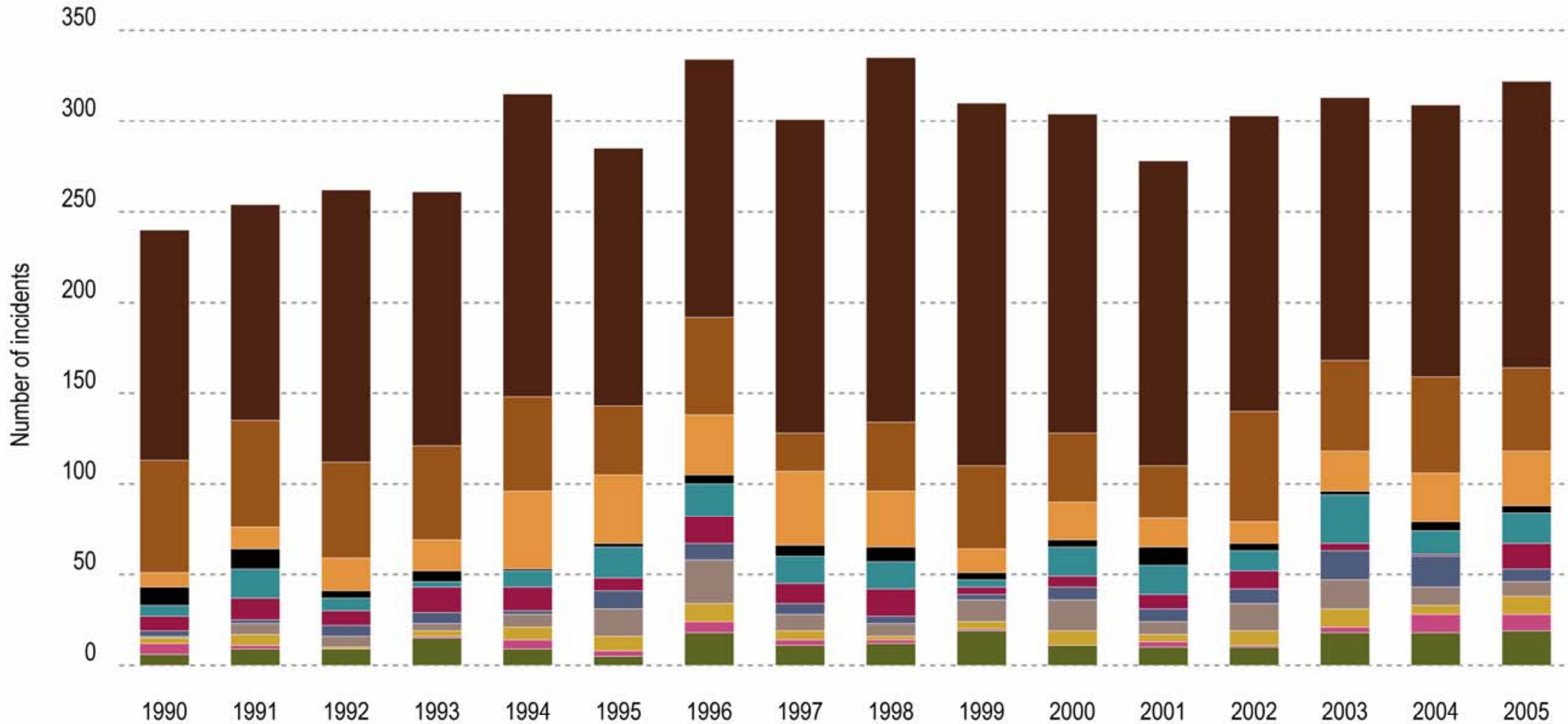


Figure 11b. Multiphase pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion	127	119	150	140	167	142	142	173	201	200	176	168	163	145	150	158
External corrosion	62	59	53	52	52	38	54	21	38	46	38	29	61	50	53	46
Damage by others	8	12	18	17	43	38	33	41	31	13	21	16	12	22	27	30
Weld	10	11	4	6	1	2	5	6	8	4	4	10	4	2	5	4
Construction damage	6	16	7	3	9	17	18	15	15	4	16	16	11	27	13	17
Overpressure	8	12	8	14	13	7	15	11	15	4	6	8	10	4	1	14
Pipe	3	2	6	6	2	10	9	6	4	3	7	7	8	16	17	7
Joint	1	6	6	4	7	15	24	9	7	12	17	7	15	16	10	8
Earth movement	3	6	1	3	7	8	10	5	2	4	8	4	8	10	5	10
Valve/fitting	6	2		1	5	3	6	3	2	1		3	1	3	10	9
Other	6	9	9	15	9	5	18	11	12	19	11	10	10	18	18	19
Total number incidents	**240**	**254**	**262**	**261**	**315**	**285**	**334**	**301**	**335**	**310**	**304**	**278**	**303**	**313**	**309**	**322**
% of total	**5.1**	**5.4**	**5.5**	**5.5**	**6.7**	**6.0**	**7.1**	**6.4**	**7.1**	**6.6**	**6.4**	**5.9**	**6.4**	**6.6**	**6.5**	**6.8**

Figure 12a shows that crude oil pipelines experience a very small number of failures and that corrosion is responsible for a smaller proportion of crude oil pipeline failures, 37.7%, than of raw production fluids pipeline failures. This is understandable, as oil in major shipping pipelines will have had water removed before being shipped and should be less corrosive. Proportionally, the number of failures due to damage by others seems high for crude oil pipelines. This may be simply the result of the reduced number of corrosion failures, which tends to make all other failure causes seem greater in proportion.

Pipeline failures caused by damage by others are reviewed in Figures 16 and 17.

Figure 12b shows an increase in the number of failures in the "other" category, which seems to be a trend for some other products as well and which may indicate that accurate cause of failure is not being conclusively determined.

Figure 12a. Crude oil pipeline incidents, by cause for all years combined

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)

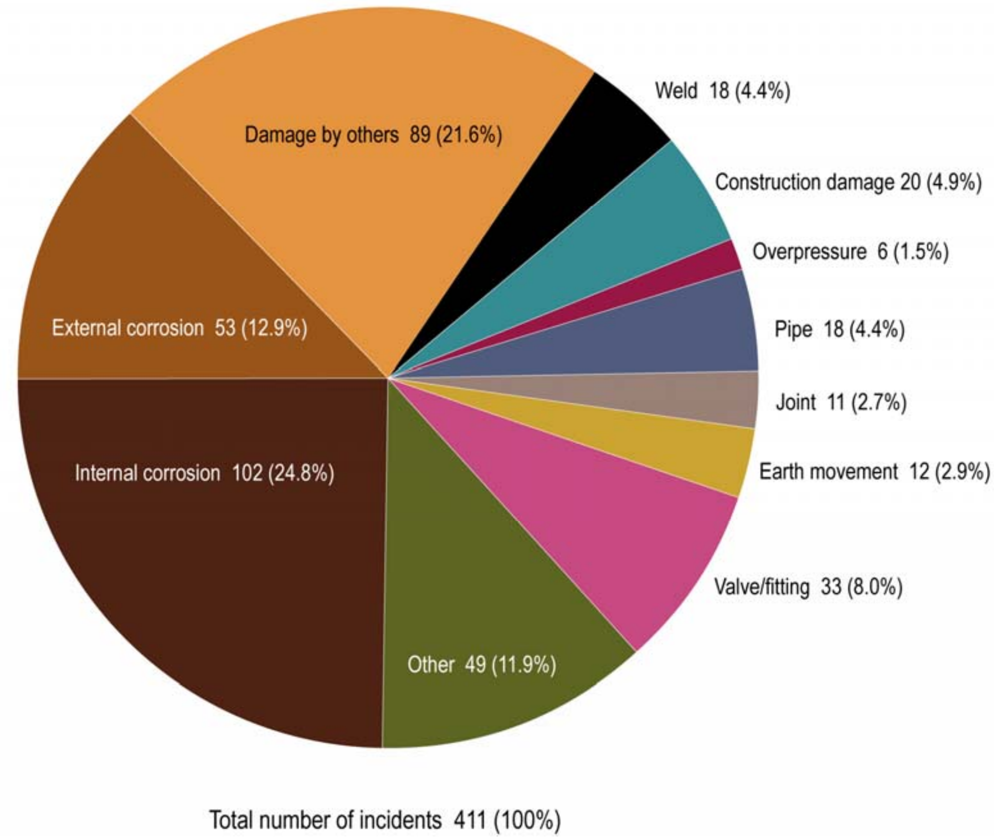
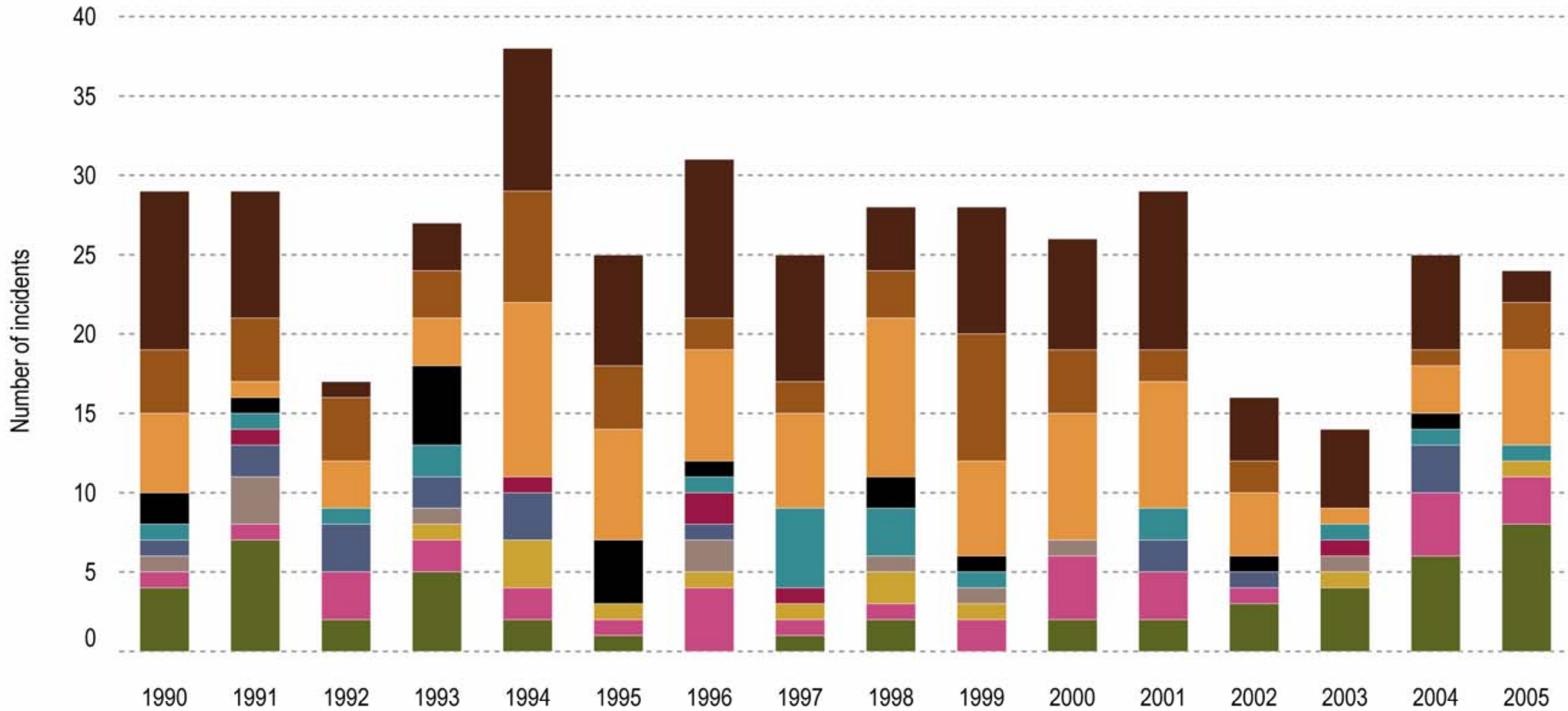


Figure 12b. Crude oil pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion	10	8	1	3	9	7	10	8	4	8	7	10	4	5	6	2
External corrosion	4	4	4	3	7	4	2	2	3	8	4	2	2		1	3
Damage by others	5	1	3	3	11	7	7	6	10	6	8	8	4	1	3	6
Weld	2	1		5		4	1		2	1			1		1	
Construction damage	1	1	1	2			1	5	3	1		2		1	1	1
Overpressure		1			1		2	1						1		
Pipe	1	2	3	2	3		1					2	1		3	
Joint	1	3		1			2		1	1	1			1		
Earth movement				1	3	1	1	1	2	1				1		1
Valve/fitting	1	1	3	2	2	1	4	1	1	2	4	3	1		4	3
Other	4	7	2	5	2	1		1	2		2	2	3	4	6	8
Total number incidents	**29**	**29**	**17**	**27**	**38**	**25**	**31**	**25**	**28**	**28**	**26**	**29**	**16**	**14**	**25**	**24**
% of total	**7.1**	**7.1**	**4.1**	**6.6**	**9.2**	**6.1**	**7.5**	**6.1**	**6.8**	**6.8**	**6.3**	**7.1**	**3.9**	**3.4**	**6.1**	**5.8**

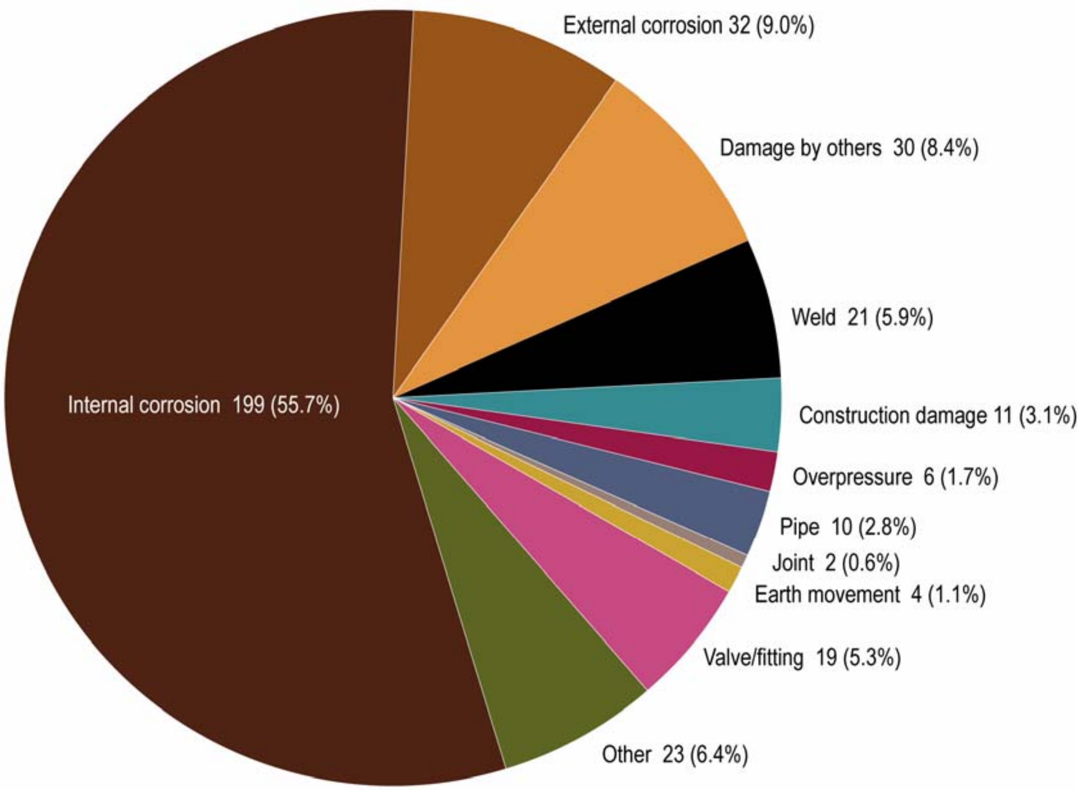
Figure 13a shows that internal corrosion continues to be the primary cause of sour gas pipeline failures, as expected due to the very corrosive nature of sour gas production. The EUB conducts a high level of technical review and surveillance on sour gas pipeline and continually looks for opportunities to improve regulations directed at the operation of sour gas pipelines. In the 2000-2003 period, the EUB drew industry attention to an increasing number of weld failures in sour service, and it appears that some improvement has already resulted.

Figure 13b also suggests improvements in corrosion control measures.

However, the EUB is concerned about the number of “other” failures being recorded in the last three years, which could suggest that an accurate cause of failure has not always been determined.

Figure 13a. Sour gas pipeline incidents, by cause for all years combined

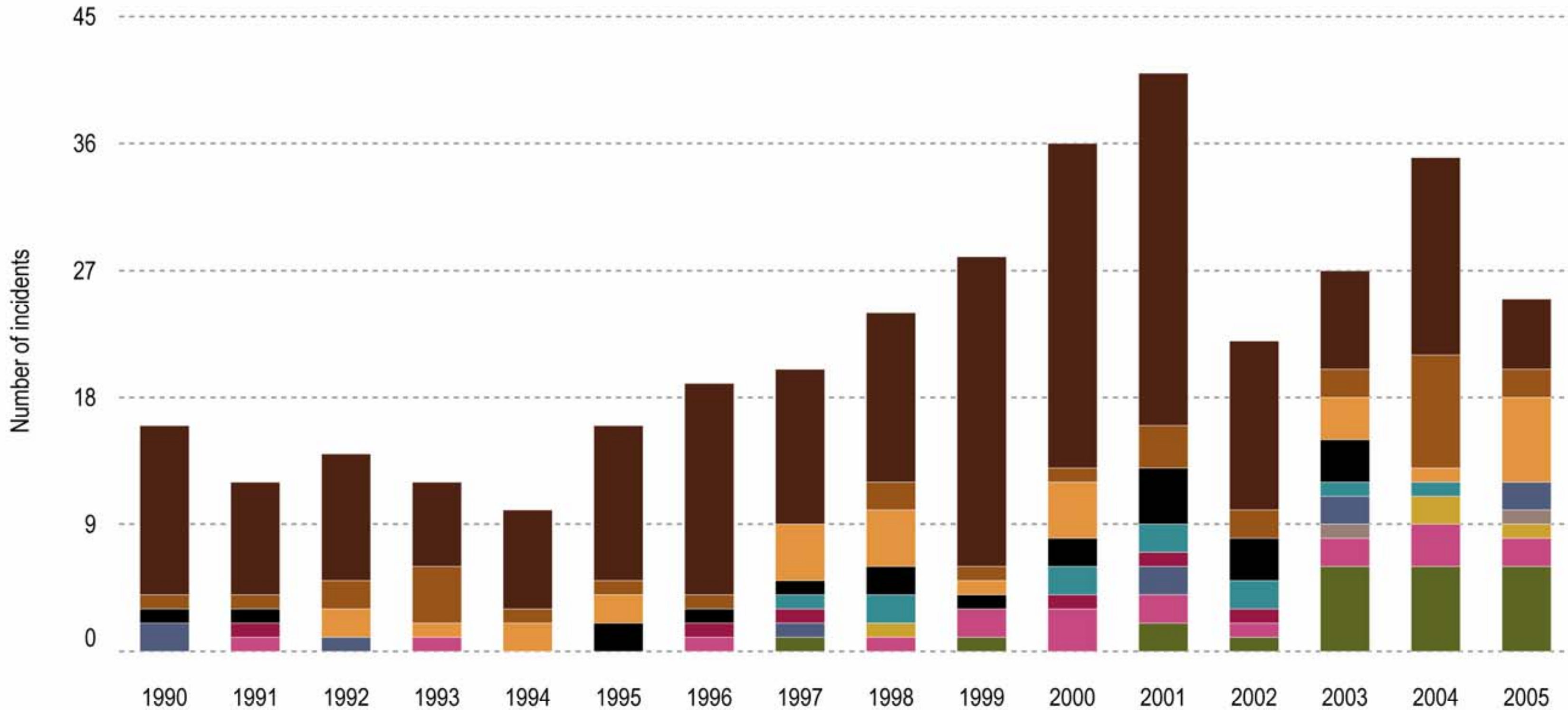
January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



Total number of incidents 357 (100%)

Figure 13b. Sour gas pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion	12	8	9	6	7	11	15	11	12	22	23	25	12	7	14	5
External corrosion	1	1	2	4	1	1	1		2	1	1	3	2	2	8	2
Damage by others			2	1	2	2		4	4	1	4			3	1	6
Weld	1	1				2	1	1	2	1	2	4	3	3		
Construction damage								1	2		2	2	2	1	1	
Overpressure		1					1	1			1	1	1			
Pipe	2		1					1				2		2		2
Joint														1		1
Earth movement									1						2	1
Valve/fitting		1		1			1		1	2	3	2	1	2	3	2
Other								1		1		2	1	6	6	6
Total number incidents	**16**	**12**	**14**	**12**	**10**	**16**	**19**	**20**	**24**	**28**	**36**	**41**	**22**	**27**	**35**	**25**
% of total	**4.5**	**3.4**	**3.9**	**3.4**	**2.8**	**4.5**	**5.3**	**5.6**	**6.7**	**7.8**	**10.1**	**11.5**	**6.2**	**7.5**	**9.8**	**7**

Natural gas pipelines include dry sales gas, as well as wet or dry produced gas, and may contain H_2S at levels up to and including 10 moles H_2S per kilomole of natural gas. There are a large number of small-diameter gas lines, as shown in Figure 4a, and a great number of these carry corrosive wet raw gas, the primary cause of a significant number of natural gas pipeline failures. As shown in Figure 14a, internal corrosion causes 57.4% of natural gas pipeline failures. Most of the failures occur on pipelines 6" and smaller, as shown in Figure 9.

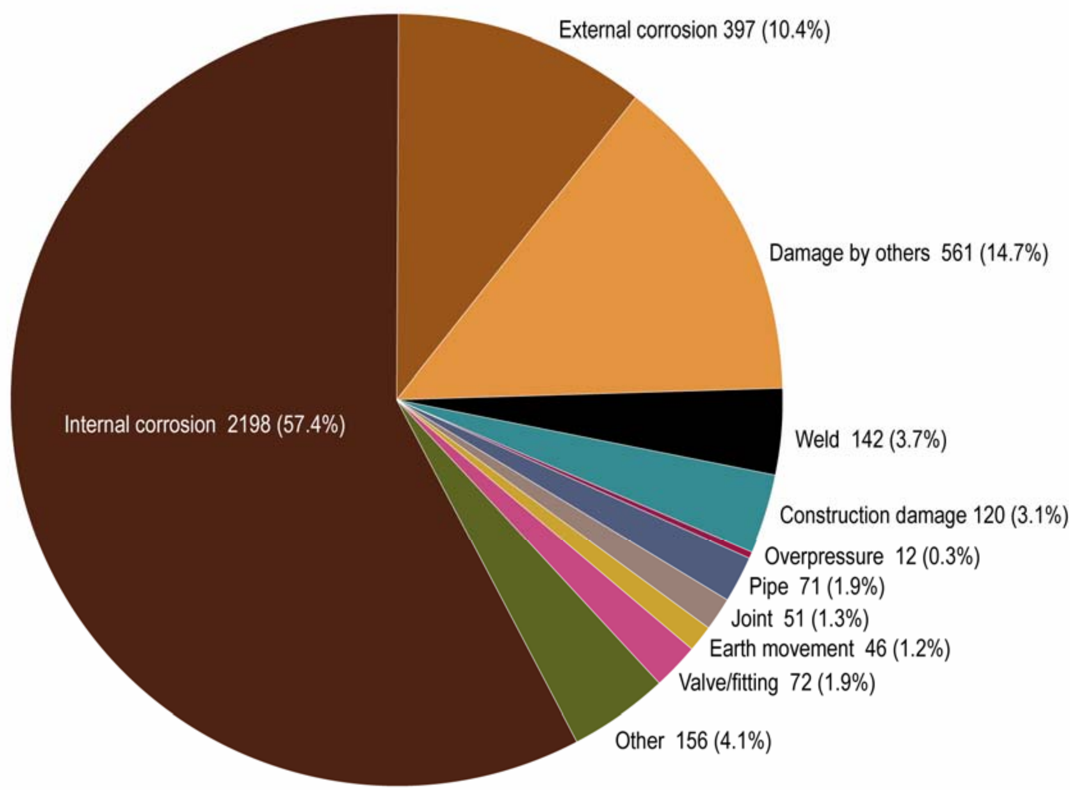
Analysis of the data shows that of the 235 592 km of natural gas pipeline, about 11% contains some H_2S within the 10 mol/kmol criterion. This ratio has been fairly consistent over the span of this report. A separate subcategory of gas pipeline, called fuel gas pipeline, is included within the natural gas pipeline category for the purposes of this report. Analysis shows that about 1% of those pipelines had some H_2S content within the 10 mol/kmol criterion.

Figure 14b shows a pronounced spike in the number of natural gas pipeline failures for the year 2005. Although corrosion failure numbers increased slightly in 2004 and more in 2005, the numbers are still much lower than those for 1999 and 2000. The failure numbers had been reduced in the years after 2000 due to a concerted industry effort to address failures occurring in wet shallow-gas pipelines in southeastern Alberta.

When analyzing the recent increase, two interesting facts came to light. The first is that of all the 3826 incidents on natural gas pipeline during this reporting period, 51.4% occurred in the Medicine Hat Field Centre area. This includes the large area of densely packed low-pressure sweet gas production around the Suffield/Medicine Hat area. Much of that low-volume gas production produces formation waters, resulting in difficult conditions for corrosion mitigation. The second fact is that when looking at other regions of the province, it was evident that natural gas pipeline failure numbers had increased in every area of the province, and no particular regional differences could be identified. Evaluation confirmed that the majority of failures continued to occur primarily on the small gathering system pipelines of 60.3 mm (2") to 168.3 mm (6") diameters. There were a few more recorded incidents on large-diameter natural gas pipeline, but analysis found that a number of these were scheduled test program failures and the remainder were attributable to a random distribution of causes. The EUB intends to further examine the increased number of natural gas pipeline failures to determine what efforts might be made to reverse the trend.

Figure 14a. Natural gas pipeline incidents, by cause for all years combined

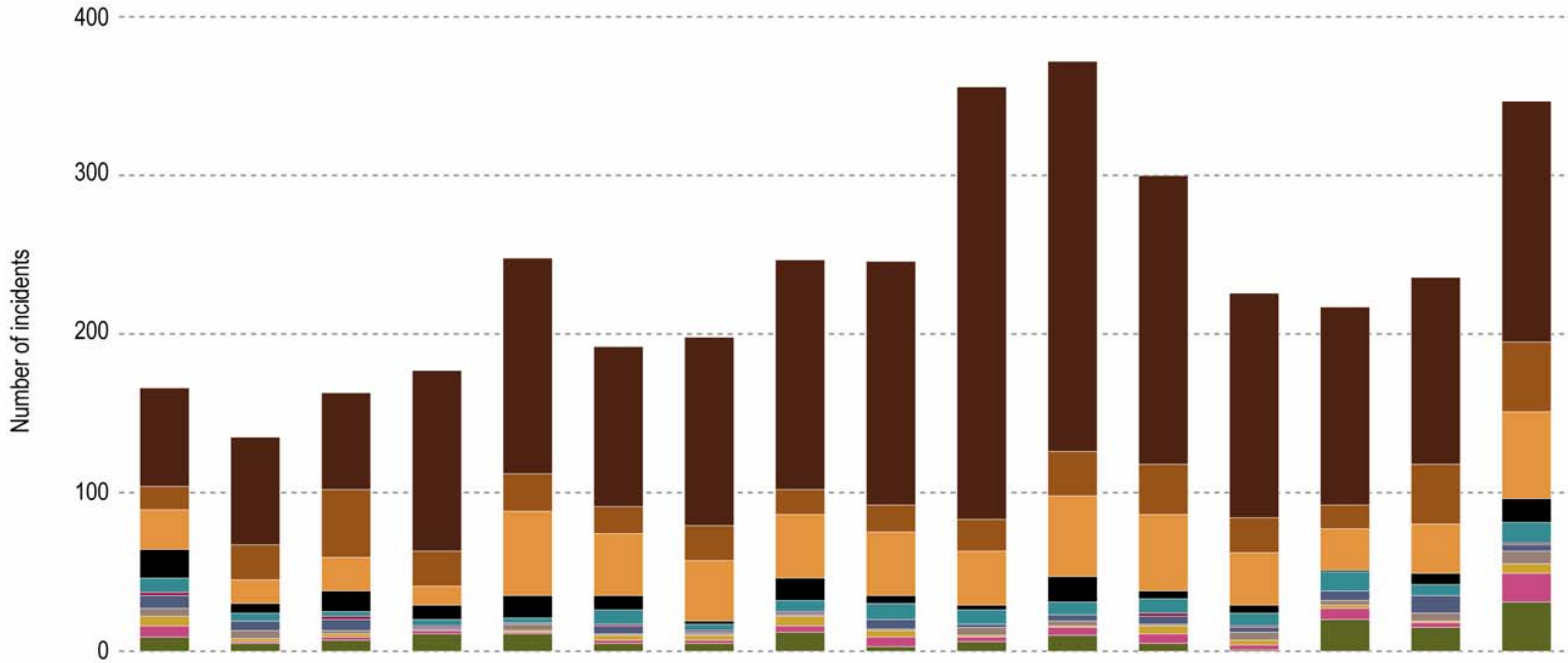
January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



Total number of incidents 3826 (100%)

Figure 14b. Natural gas pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)

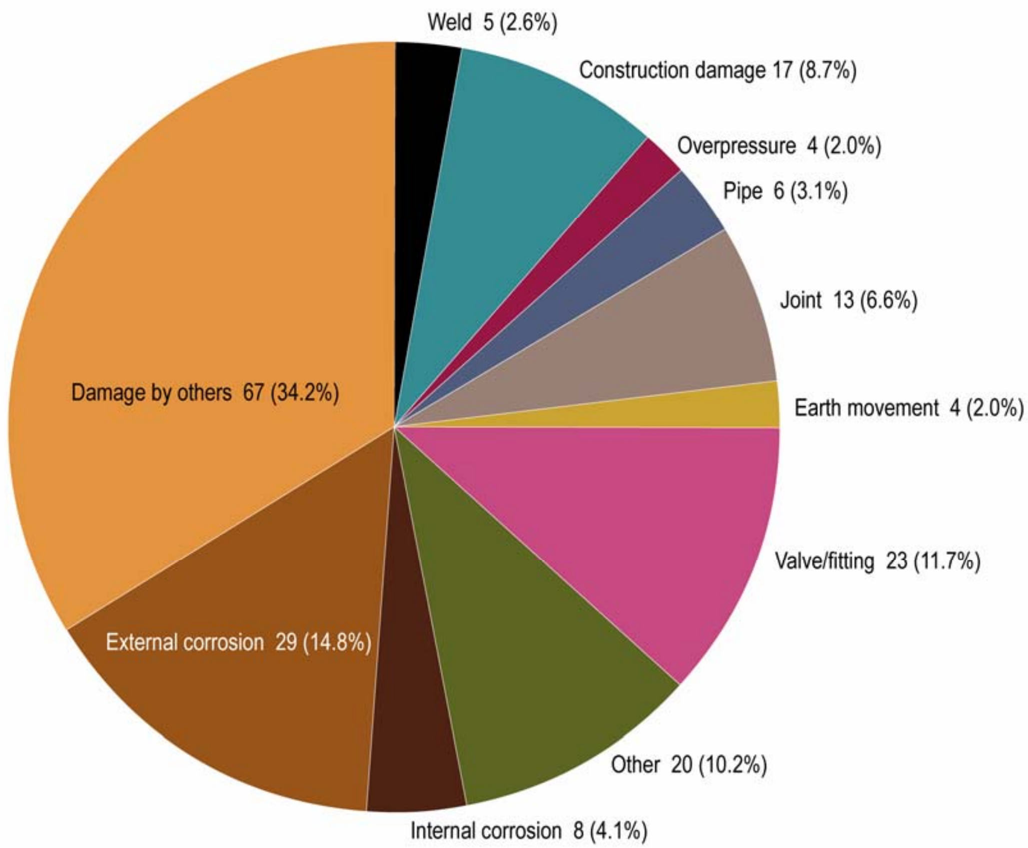


CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion	62	68	61	114	136	101	119	145	154	273	246	182	142	125	118	152
External corrosion	15	22	43	22	24	17	22	16	17	20	28	32	22	15	38	44
Damage by others	25	15	21	12	53	39	38	40	40	34	51	48	33	26	31	55
Weld	18	6	13	9	14	9	2	14	5	3	16	5	5	1	7	15
Construction damage	9	5	3	4	3	9	4	7	10	9	8	9	8	1	7	13
Overpressure	2		2	1		1	1	1				2	1			1
Pipe	8	6	7	1	1	5	1	1	6	2	4	5	3	6	11	4
Joint	5	5	2	1	4	1	1	1	1	5	3	1	5	3	5	8
Earth movement	6	2	2		1	3	3	6	4	1	1	5	3	2	1	6
Valve/fitting	7	1	2	2	1	2	2	4	6	3	5	6	3	7	3	18
Other	9	5	7	11	11	5	5	12	3	6	10	5	1	20	15	31
Total number incidents	**166**	**135**	**163**	**177**	**248**	**192**	**198**	**247**	**246**	**356**	**372**	**300**	**226**	**217**	**236**	**347**
% of total	**4.3**	**3.5**	**4.3**	**4.6**	**6.5**	**5.0**	**5.2**	**6.5**	**6.4**	**9.3**	**9.7**	**7.8**	**5.9**	**5.7**	**6.2**	**9.1**

Figures 15a and 15b show that the causes of failure in the “other product” category are varied, due to an overall low number of failures and the relative lack of corrosion-related failures. As most “other” pipelines carry refined or processed substances, corrosion is infrequent. Third-party incidents make up a greater proportion of the failure causes, due to the reduced number of corrosion failures. Pipelines in this category include a significant number of LVP and HVP product pipelines traversing highly populated urban and suburban areas. Constant vigilance is exercised by operators in those areas to ensure that rights-of-way are patrolled frequently and that public in the area is aware of the presence of the pipelines. This could partly explain why pipelines in this product class exhibit the second-lowest ratio of third-party hits, as shown in the simple analysis in the commentary of Figure 6. The higher proportion of valve and fitting incidents and the recent increase in the number of those incidents are likely the result of recent increased operator awareness and monitoring of fugitive emissions in response to greenhouse gas conservation efforts.

Figure 15a. All "other product" pipeline incidents, by cause for all years combined

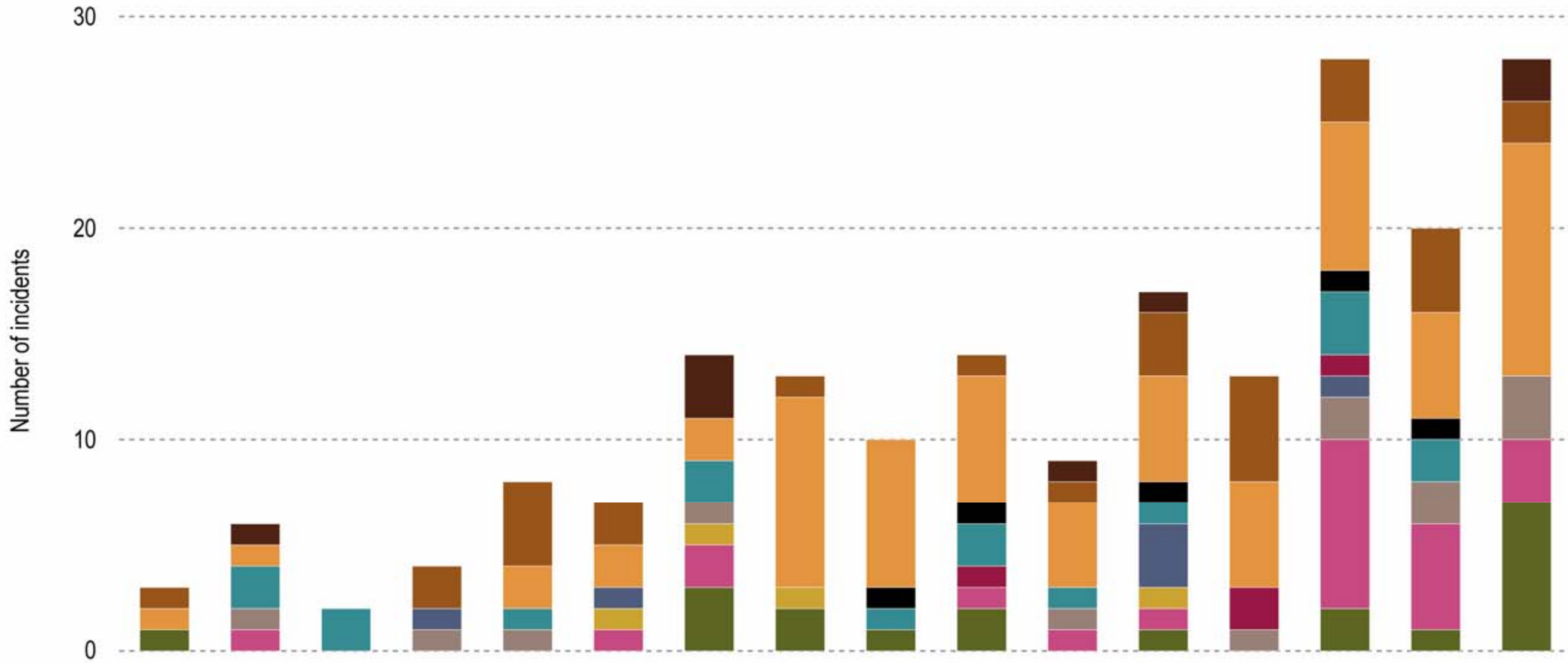
January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



Total number of incidents 196 (100%)

Figure 15b. All “other product” pipeline incidents, by cause per year

January 1, 1990, to December 31, 2005 (includes hits, leaks, and ruptures)



CAUSE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Internal corrosion		1					3				1	1				2
External corrosion	1			2	4	2		1		1	1	3	5	3	4	2
Damage by others	1	1			2	2	2	9	7	6	4	5	5	7	5	11
Weld									1	1		1		1	1	
Construction damage		2	2		1		2		1	2	1	1		3	2	
Overpressure										1			2	1		
Pipe				1		1						3		1		
Joint		1		1	1		1				1		1	2	2	3
Earth movement						1	1	1				1				
Valve/fitting		1				1	2			1	1	1		8	5	3
Other	1						3	2	1	2		1		2	1	7
Total number incidents	**3**	**6**	**2**	**4**	**8**	**7**	**14**	**13**	**10**	**14**	**9**	**17**	**13**	**28**	**20**	**28**
% of total	**1.5**	**3.1**	**1.0**	**2.1**	**4.1**	**3.6**	**7.1**	**6.6**	**5.1**	**7.1**	**4.6**	**8.7**	**6.6**	**14.3**	**10.2**	**14.3**

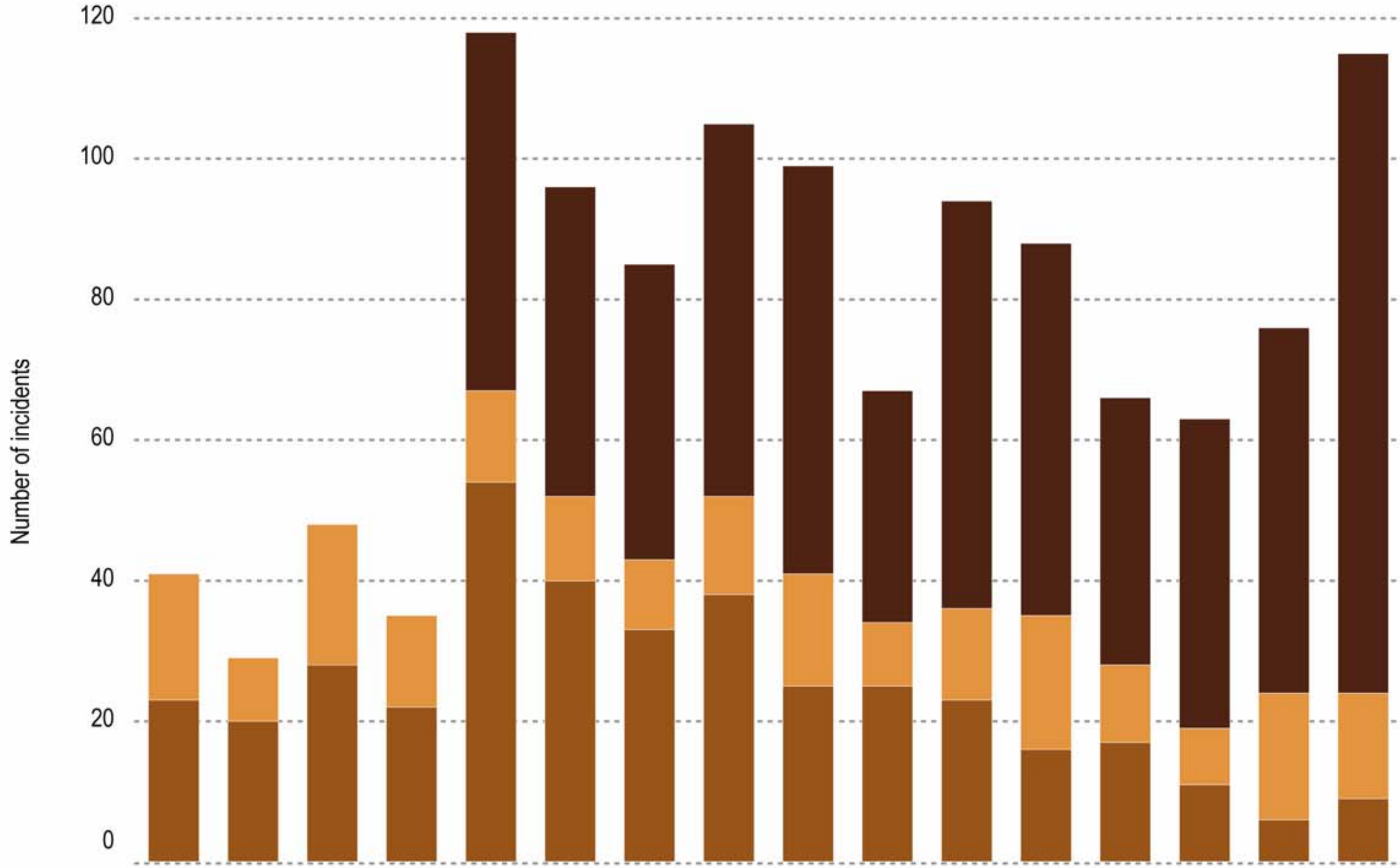
Figure 16 shows the annual number of pipeline hits and whether those hits resulted in a leak or rupture of the pipeline. Prior to 1994, the EUB did not record pipeline hits that did not result in product loss. Since beginning to record such hits, early data showed that about one out of every two pipeline hits resulted in product loss and, worse, that many pipeline ruptures resulted, potentially creating an immediately dangerous situation. Fortunately, over the last several years the number of product releases caused by third-party damage has decreased, particularly the number of ruptures. This is very positive, as it implies a safer workplace for the excavation contractors and reduced risk to the public.

There is a correlation between the number of damage incidents and the robust level of industry activity: a jump in incidents occurred in 2004 and 2005, reflecting current robust oil patch activity. As discussed for Figure 6, growing field activity increases the chance of unplanned pipeline contact, and the increasing presence of an inexperienced junior workforce may also be contributing to this.

In 2005 the *Pipeline Regulation* strengthened the requirements for safe ground disturbance practices, excavation inspection, and personnel training. It is hoped that in subsequent years these will translate into a reduction of the number of annual hits.

Figure 16. Pipeline incidents due to damage by others per year

All pipeline incidents from January 1, 1990, to December 31, 2005

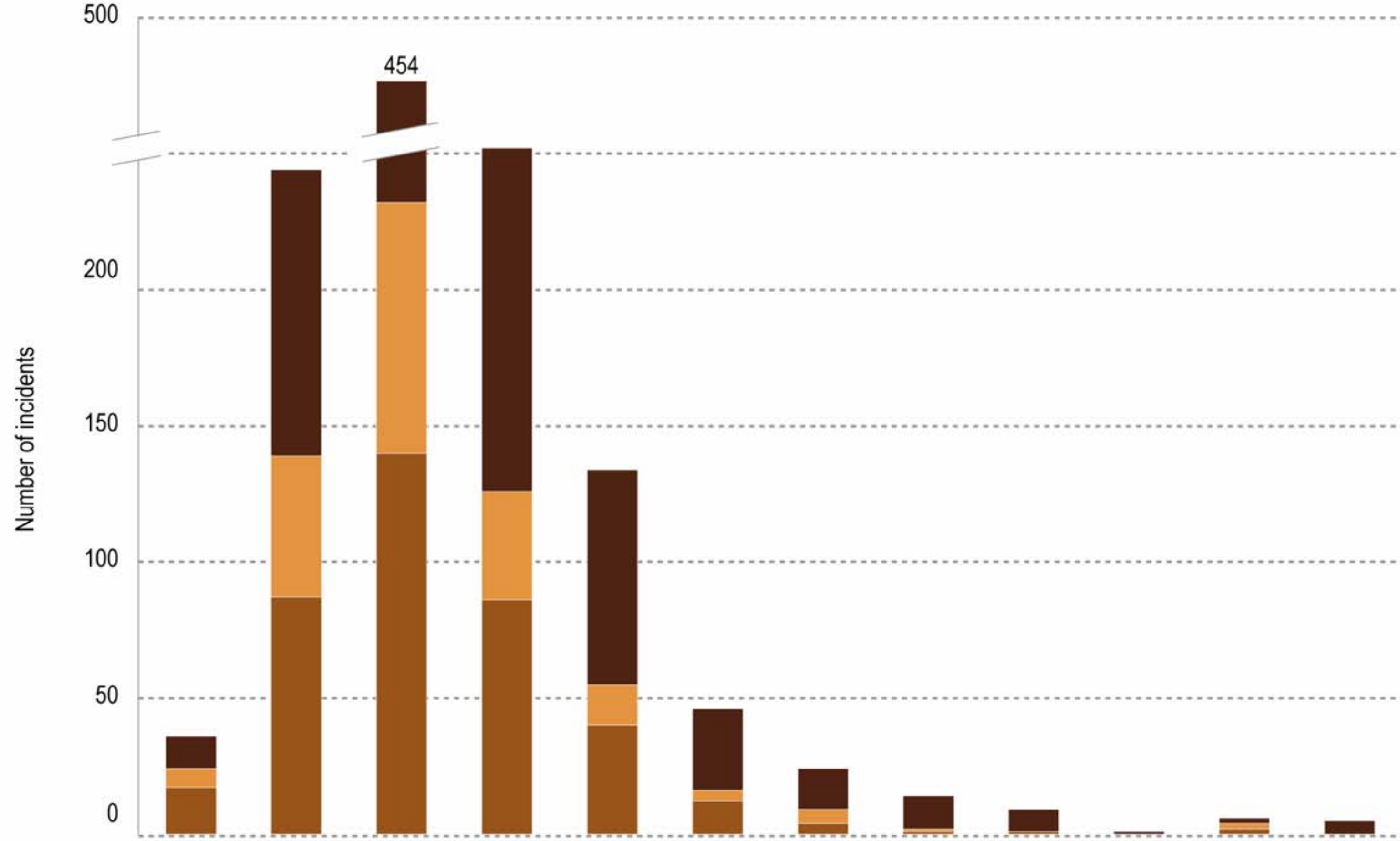


TYPE OF FAILURE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of total
Hit (no product loss)					51	44	42	53	58	33	58	53	38	44	52	91	617	50.4
Leak	18	9	20	13	13	12	10	14	16	9	13	19	11	8	18	15	218	17.8
Rupture	23	20	28	22	54	40	33	38	25	25	23	16	17	11	6	9	390	31.8
Total number incidents	**41**	**29**	**48**	**35**	**118**	**96**	**85**	**105**	**99**	**67**	**94**	**88**	**66**	**63**	**76**	**115**	**1225**	**100.0**

Figure 17 confirms that third-party damage occurs most frequently on pipelines between 60.3 mm (2") and 168.3 mm (6") diameter, which corresponds to the proportion of pipe sizes that make up the largest portion of the province's inventory. Figure 17 also shows that third-party damage occurs infrequently on large-diameter transmission pipelines, probably because their location is well known, they are well marked, and operators typically conduct frequent right-of-way surveillance.

Figure 17. Damage by others, by pipe size for all years combined

All pipeline incidents from January 1, 1990, to December 31, 2005

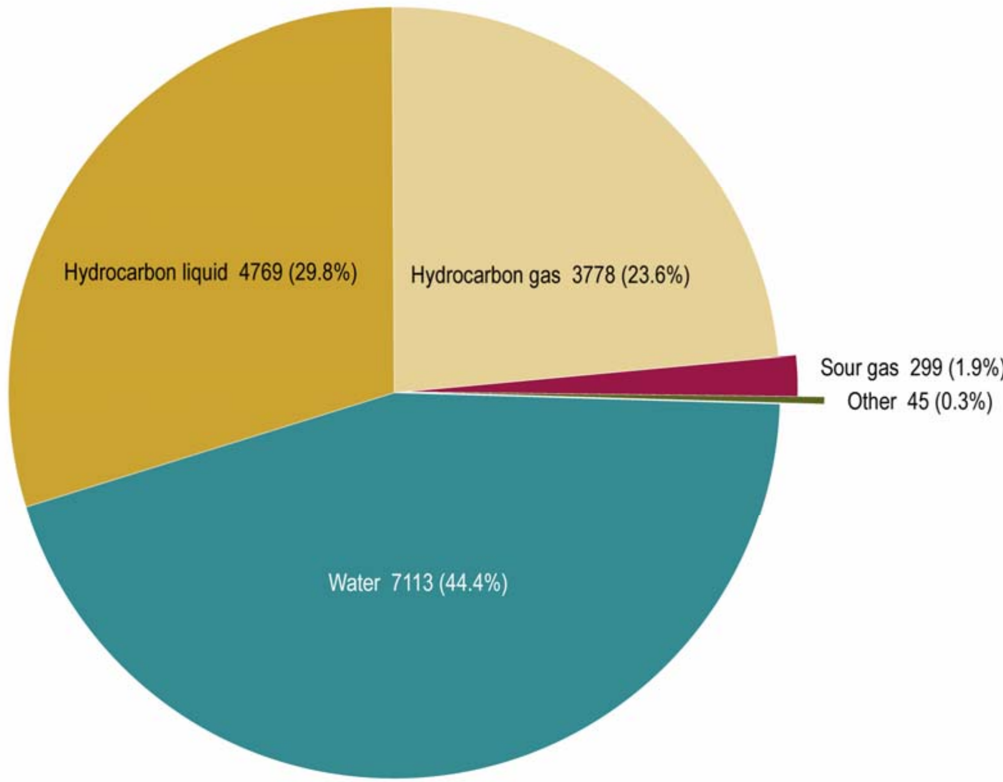


SIZE OF PIPE mm (nominal inches)	Not specified	60.3 (2)	88.9 (3)	114.3 (4)	168.3 (6)	219.1 (8)	273.1 (10)	323.9 (12)	355.6-406.4 (14-16)	508 (20)	559-610 (22-24)	762-914 (26-36)	Total number	% of total
INCIDENTS														
Hit (no product loss)	12	105	222	126	79	30	15	12	8	1	2	5	617	50.4
Leak	7	52	92	40	15	4	5	1			2		218	17.8
Rupture	17	87	140	86	40	12	4	1	1		2		390	31.8
Total number incidents	**36**	**244**	**454**	**252**	**134**	**46**	**24**	**14**	**9**	**1**	**6**	**5**	**1225**	
% of total	**2.9**	**19.9**	**37.1**	**20.6**	**10.9**	**3.8**	**2.0**	**1.1**	**0.7**	**0.1**	**0.5**	**0.4**		**100.0**

Figure 18 shows the number and composition of the 16 004 releases from pipeline that occurred during the reporting period. There were more releases than incidents, which is to be expected because raw fluid production often consists of multiple substances that are recorded separately in the estimation of spill volumes. Spills from pressure tests are excluded from the analyses of Figures 18 to 25 and are evaluated separately in Figures 26 and 27.

Figure 18. Number of pipeline releases, total for all years

All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

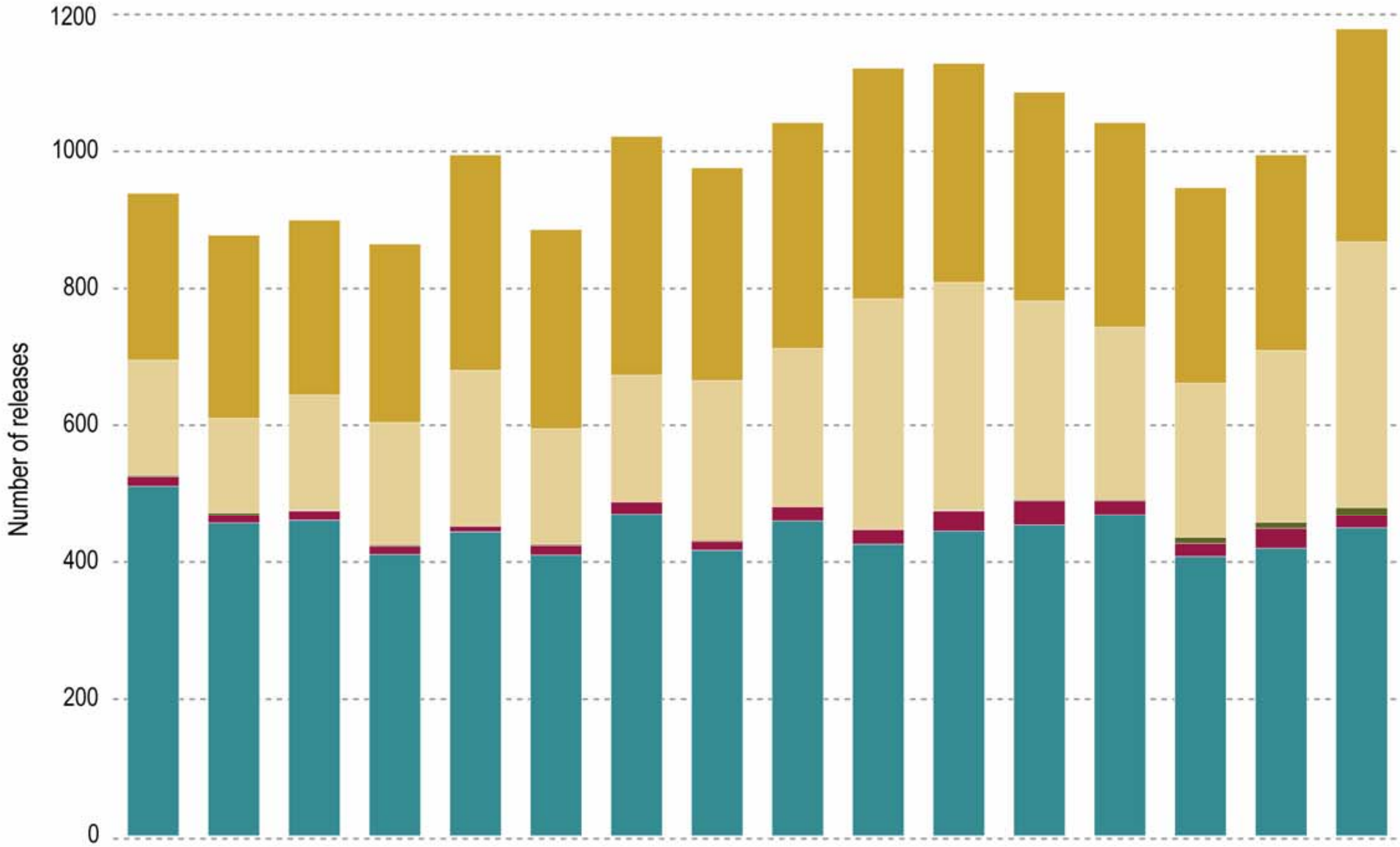


Total number of releases 16 004 (100%)

Other than a general mild increase in numbers of releases coincident with the increasing size of the pipeline inventory, there are no unusual trends indicated by Figure 19. Although the length of installed pipeline has increased on average by 6.2% per year, the number of releases has remained fairly constant, suggesting a overall reduction in the frequency of spills based on installed pipeline length.

Figure 19. Pipeline releases by substance released per year

All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

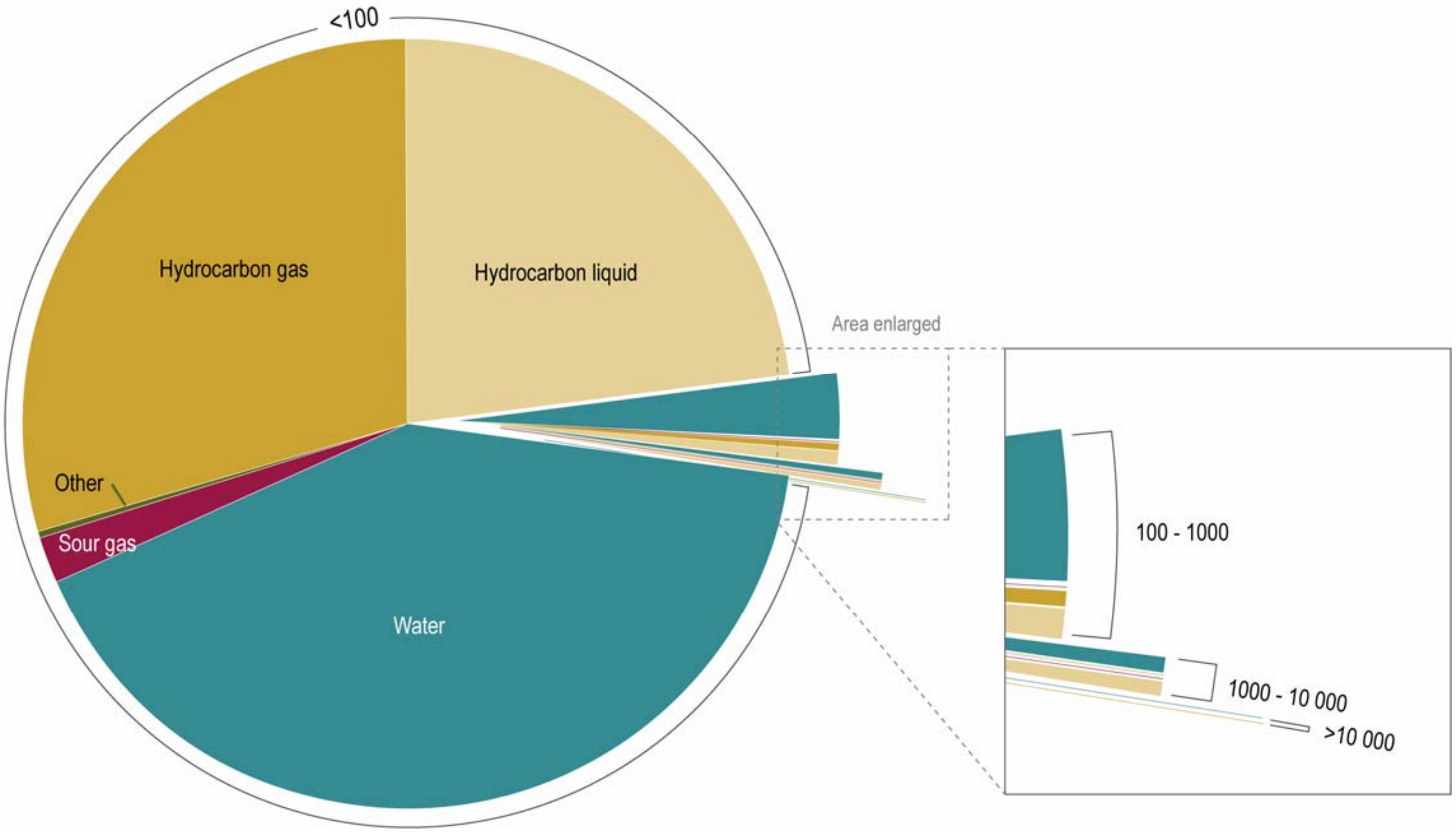


PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of total
Hydrocarbon liquid	244	268	256	261	315	291	349	311	330	337	320	305	299	286	286	311	4769	29.8
Hydrocarbon gas	168	138	168	179	228	169	185	234	231	338	333	291	252	225	251	388	3778	23.6
Other	2	4	1	2		2		1			1	1	1	9	9	12	45	0.3
Sour gas	14	11	14	12	8	14	18	13	21	21	30	36	21	19	29	18	299	1.9
Water	511	457	461	411	444	410	470	417	460	426	445	454	469	408	420	450	7113	44.4
Total number releases	**939**	**878**	**900**	**865**	**995**	**886**	**1022**	**976**	**1042**	**1122**	**1129**	**1087**	**1042**	**947**	**995**	**1179**	**16 004**	
% of total	**5.9**	**5.5**	**5.6**	**5.4**	**6.2**	**5.5**	**6.4**	**6.1**	**6.5**	**7.0**	**7.1**	**6.8**	**6.5**	**5.9**	**6.2**	**7.4**		**100.0**

The EUB requires that the volume of spilled substance be reported in the event of a pipeline release. The accuracy of these reports varies, as not all pipelines are equipped with metering and sometimes the starting time of an event is unknown. Best estimates are made based on production rates, pipeline capacities, metering, and measurement of spill areas. In the case of gas production, the gas disperses, making accurate measurement difficult.

Release volumes are divided into four volume classes: less than 100 m^3 of liquid, or 100 000 m^3 of gas; 100 to 1000 m^3 of liquid or 100 000 to 1 000 000 m^3 of gas; 1000 to 10 000 m^3 of liquid or 1 000 000 to 10 000 000 m^3 of gas, and greater than 10 000 m^3 of liquid or 10 000 000 m^3 of gas. Figure 20 shows that of the 16 004 releases, 96.0% fall into the smallest category. Another 3.5% are between 100 and 1000. Releases greater than 1000 m^3 liquid or 1 000 000 m^3 gas constituted only 0.5% of the events. Of all sour gas releases, only six (2%) exceeded 100 000 m^3.

Figure 20. Number of pipeline releases, by substance and volume
All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

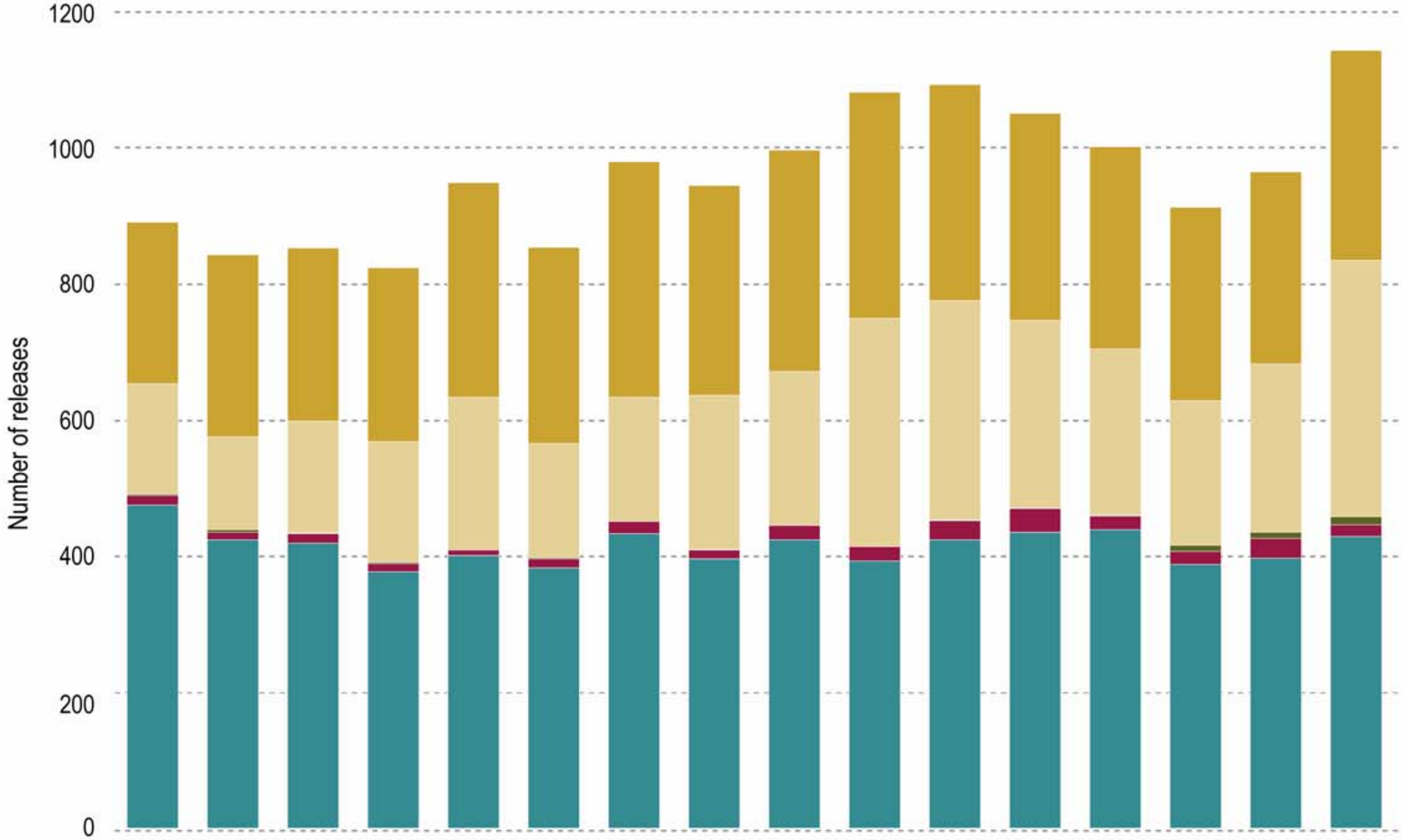


	RELEASE VOLUME, m³ (LIQUIDS) OR 10³ m³ (GAS)				Total number
	<100	100 - 1000	1000 - 10 000	>10 000	
Hydrocarbon liquid	4717	46	6		4769
Hydrocarbon gas	3684	64	26	4	3778
Water	6621	450	41	1	7113
Sour gas	293	5	1		299
Other	45				45
Total	**15 360**	**565**	**74**	**5**	**16 004**

Figure 21 shows the release breakdown for the smallest volume category of releases by substance and year. In this volume class, the water, liquid hydrocarbon, and gaseous hydrocarbon releases are each responsible for approximately a third of the recorded releases. There is also a small number of sour gas and “other” releases. The releases in this volume class account for 96% of the number of all releases.

Figure 21. Pipeline releases <100 m^3 (liquids) or <100 10^3 m^3 (gas), by substance and year

All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

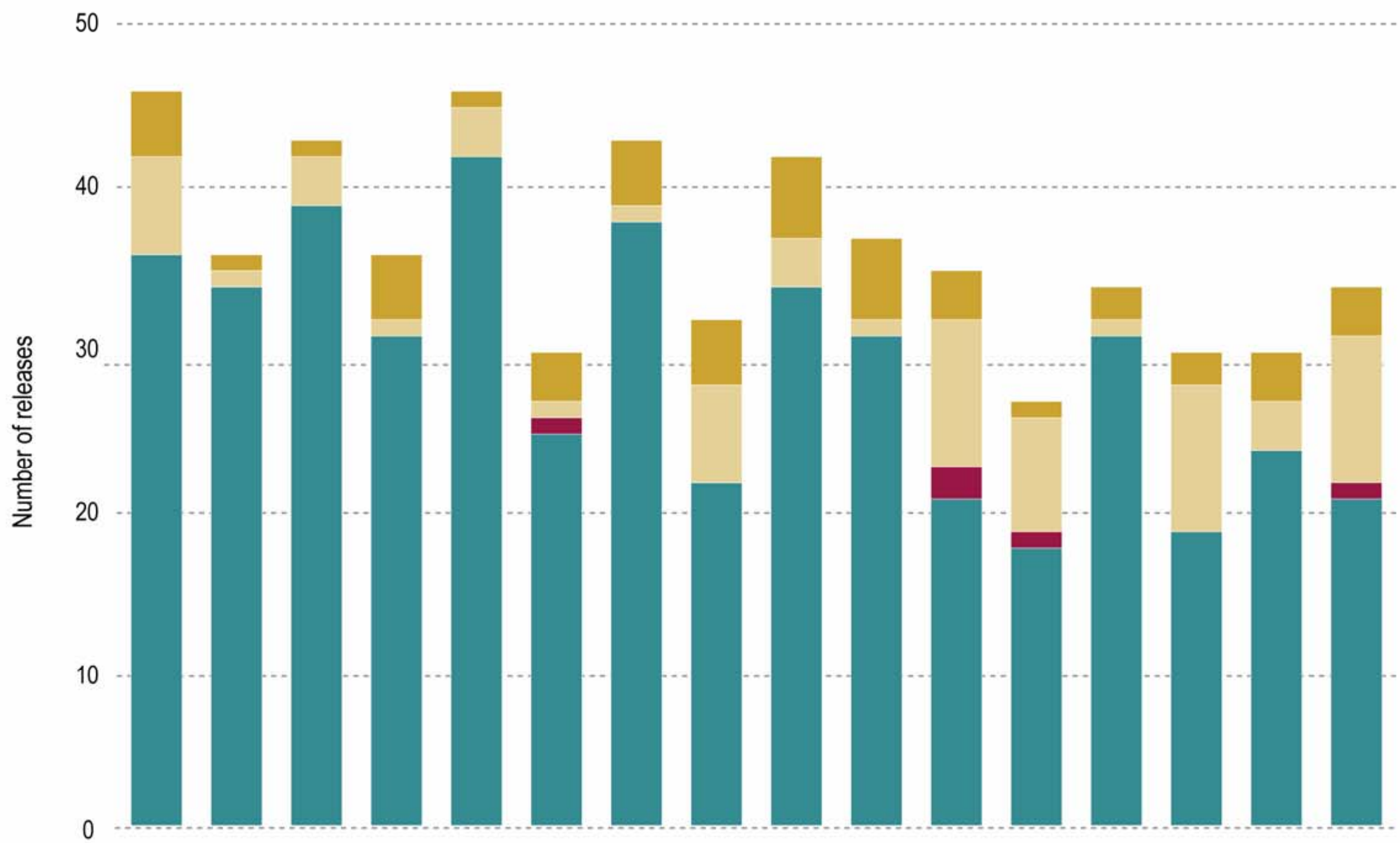


PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of all releases by number
Hydrocarbon liquid	238	267	254	255	314	288	345	307	325	332	317	304	297	284	282	308	4 717	29.5
Hydrocarbon gas	162	137	165	178	225	168	183	227	226	335	322	275	244	213	247	377	3 684	23.0
Other	2	4	1	2		2		1			1	1	1	9	9	12	45	0.3
Sour gas	14	11	14	12	8	13	18	13	21	21	28	35	20	19	29	17	293	1.8
Water	474	423	418	376	400	382	432	395	423	392	423	434	438	387	396	428	6 621	41.4
Total number releases	**890**	**842**	**852**	**823**	**947**	**853**	**978**	**943**	**995**	**1080**	**1091**	**1049**	**1000**	**912**	**963**	**1142**	**15 360**	**96.0**

Figure 22 shows that releases in the second volume class account for 3.5% of the total number. The higher proportion of water pipeline releases of medium volume suggests that either water pipeline failures are not readily detected or the flow rates are high to create these spills. The Canadian Standards Association is considering whether instrumented leak detection requirements should be applied to produced water pipelines, and it is possible that future editions of CSA Z662 may include this requirement. A positive trend is that the number of these medium-size releases seems to be gradually declining.

Figure 22. Pipeline releases 100 - 1000 m^3 (liquids) or 100 - 1000 10^3 m^3 (gas), by substance and year

All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

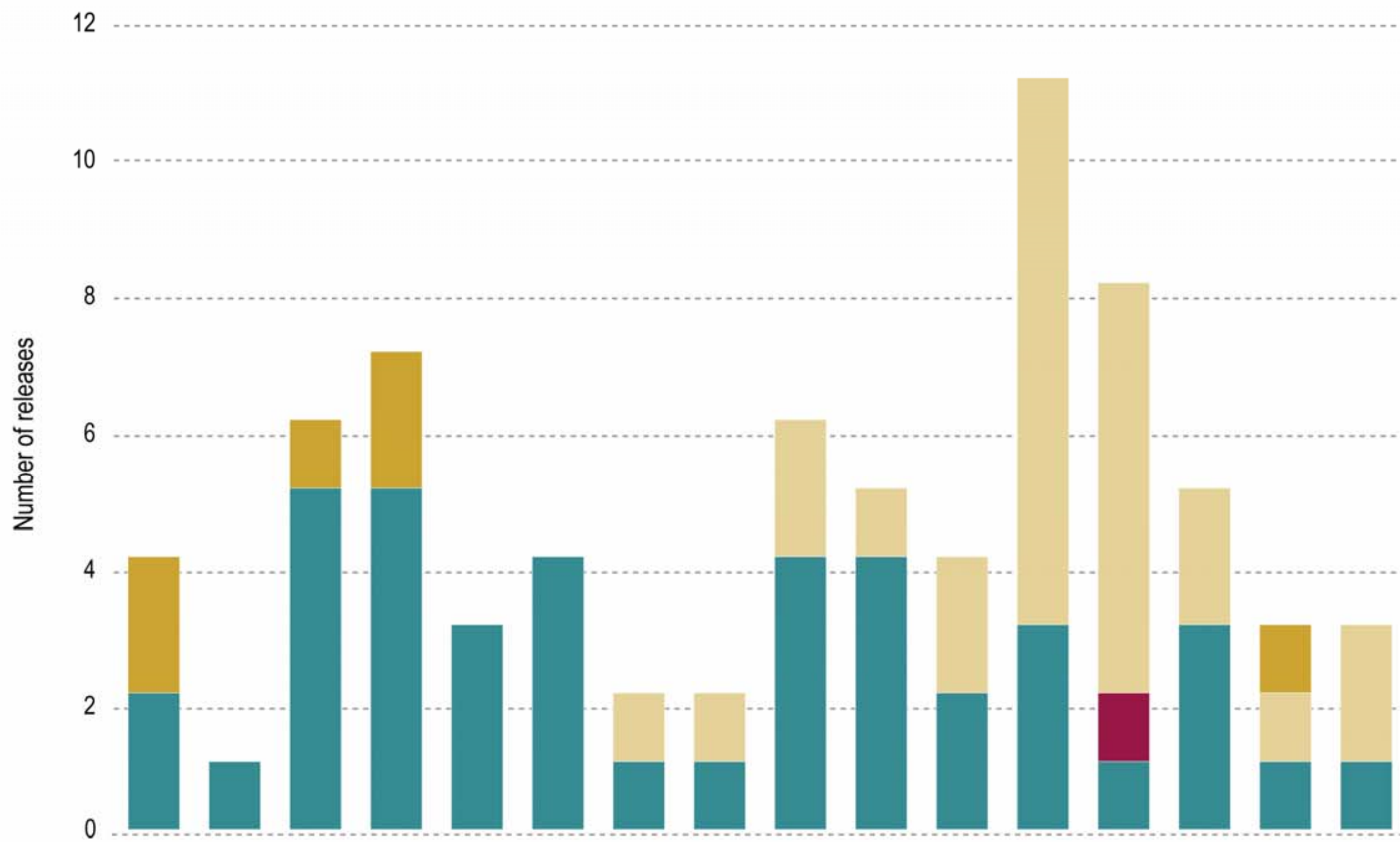


PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of all releases by number
Hydrocarbon liquid	4	1	1	4	1	3	4	4	5	5	3	1	2	2	3	3	46	0.3
Hydrocarbon gas	6	1	3	1	3	1	1	6	3	1	9	7	1	9	3	9	64	0.4
Sour gas						1					2	1				1	5	<0.1
Water	35	33	38	30	41	24	37	21	33	30	20	17	30	18	23	20	450	2.8
Total number releases	**45**	**35**	**42**	**35**	**45**	**29**	**42**	**31**	**41**	**36**	**34**	**26**	**33**	**29**	**29**	**33**	**565**	**3.5**

Figure 23 shows that large-volume releases account for about 0.5% of all releases. Most of the failures in the earlier part of the reporting period occurred in water pipelines, but those release numbers dropped noticeably in recent years. There were some significant large natural gas pipeline releases in the 2001-2002 period, but the most recent years show a marked improvement.

Figure 23. Pipeline releases 1000 - 10 000 m^3 (liquids) or 1000 - 10 000 10^3 m^3 (gas), by substance and year

All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

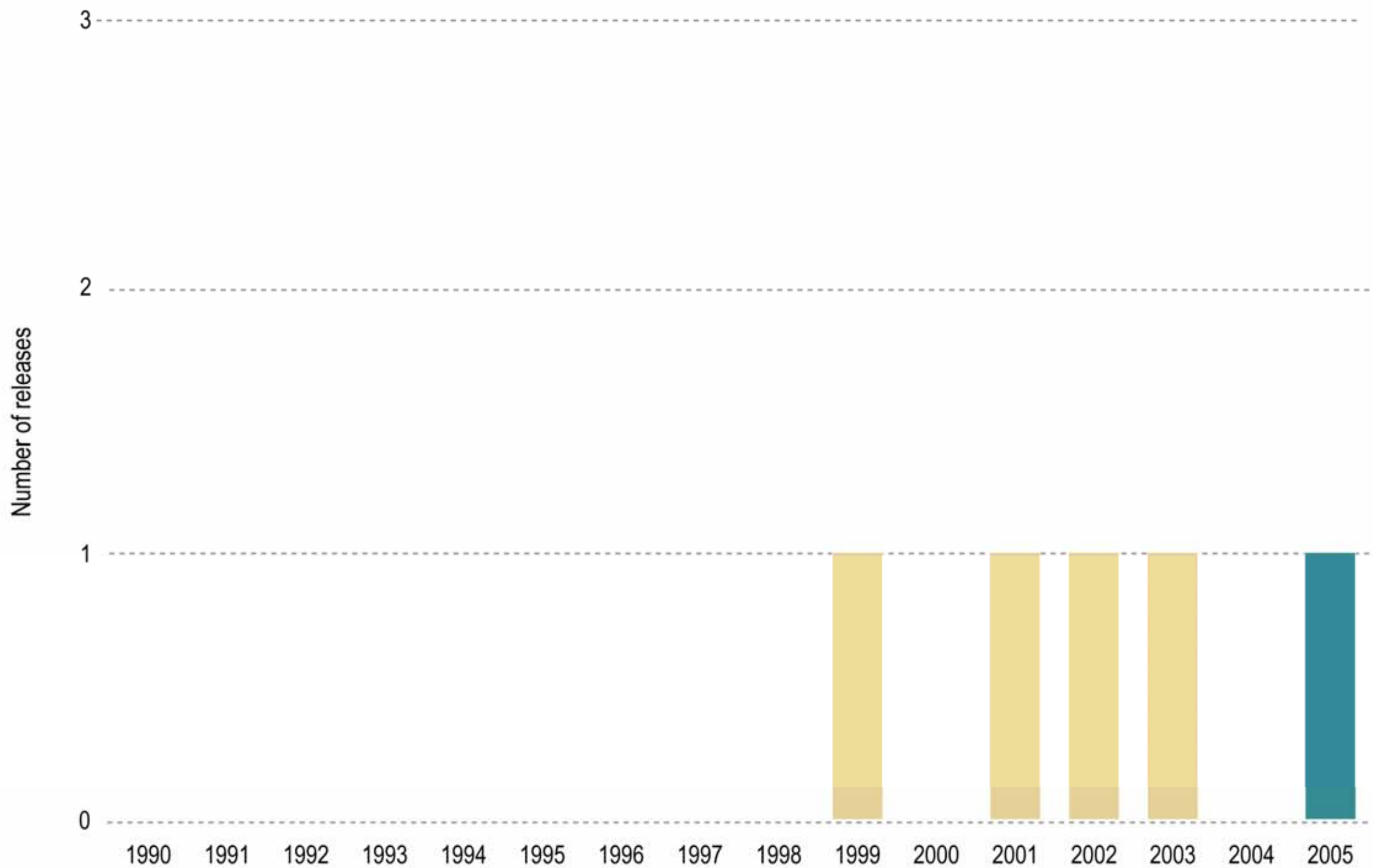


PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of all releases by number
Hydrocarbon liquid	2		1	2											1		6	<0.1
Hydrocarbon gas							1	1	2	1	2	8	6	2	1	2	26	0.2
Sour gas													1				1	<0.1
Water	2	1	5	5	3	4	1	1	4	4	2	3	1	3	1	1	41	0.3
Total number releases	**4**	**1**	**6**	**7**	**3**	**4**	**2**	**2**	**6**	**5**	**4**	**11**	**8**	**5**	**3**	**3**	**74**	**0.5**

Fortunately, very large releases are rare, as indicated in Figure 24. There have been a few isolated pipeline failures on sweet gas transmission pipelines that resulted in large volumes of released gas due to the large diameter and long length of the transmission line segments. The released gas will either disperse or burn if it is ignited.

Figure 24. Pipeline releases >10 000 m^3 (liquids) or >10 000 10^3 m^3 (gas), by substance and year

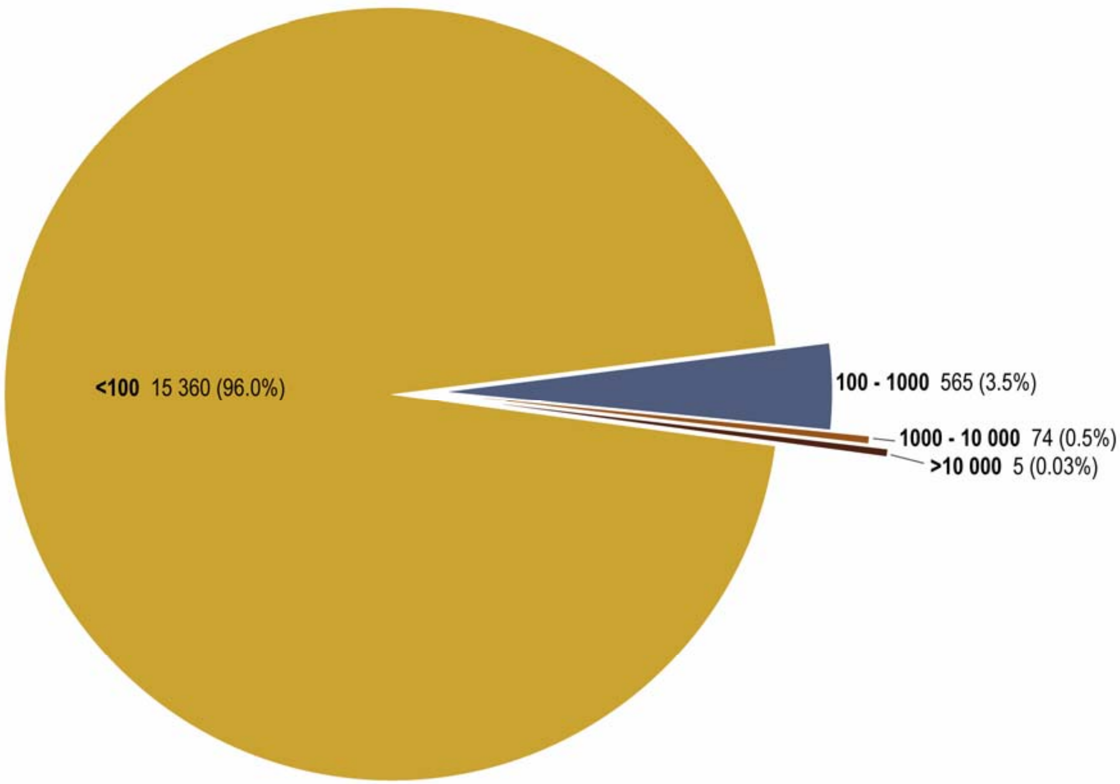
All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)



PRODUCT	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total number	% of all releases by number
Hydrocarbon gas										1		1	1	1			4	<0.1
Water																1	1	<0.1
Total number releases										**1**		**1**	**1**	**1**		**1**	**5**	<0.1

Figure 25 shows the proportions of each release volume class in relation to the total number of releases.

Figure 25. Number of pipeline releases, by volume
All pipeline releases from January 1, 1990, to December 31, 2005 (test failures are excluded)

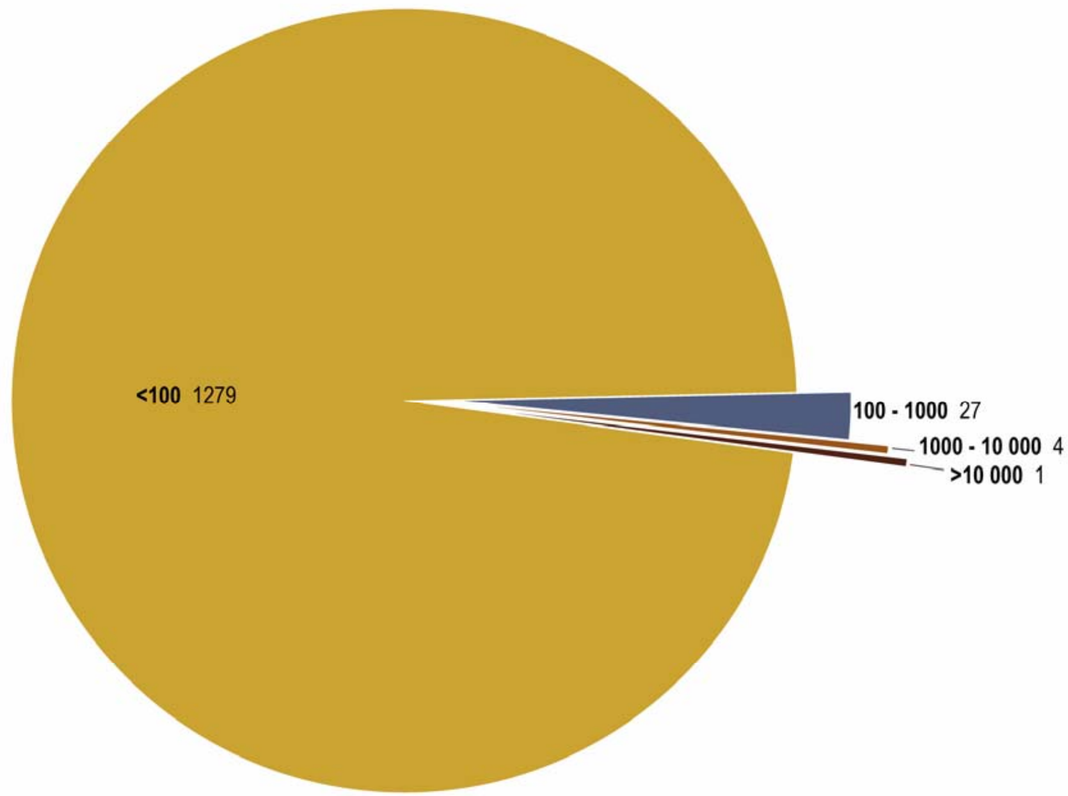


	RELEASE VOLUME, M^3 (LIQUIDS) OR 10^3 M^3 (GAS)				Total	% of
	<100	100 - 1000	1000 - 10 000	>10 000	number	all releases
Total	**15 360**	**565**	**74**	**5**	**16 004**	**100.0**

Pipeline releases that occur during pressure testing of a pipeline, whether for qualification of new pipeline or requalification of existing pipeline, have not been included in the previous figures. During the reporting period, 1311 releases occurred during pressure testing. Figure 26 shows the proportions of each volume class in relation to the total number of releases.

Figure 26. Pipeline release volumes from pressure test, m^3 (liquids) or 10^3 m^3 (gas)

All pipelines from January 1, 1990, to December 31, 2005 (leaks and ruptures only)



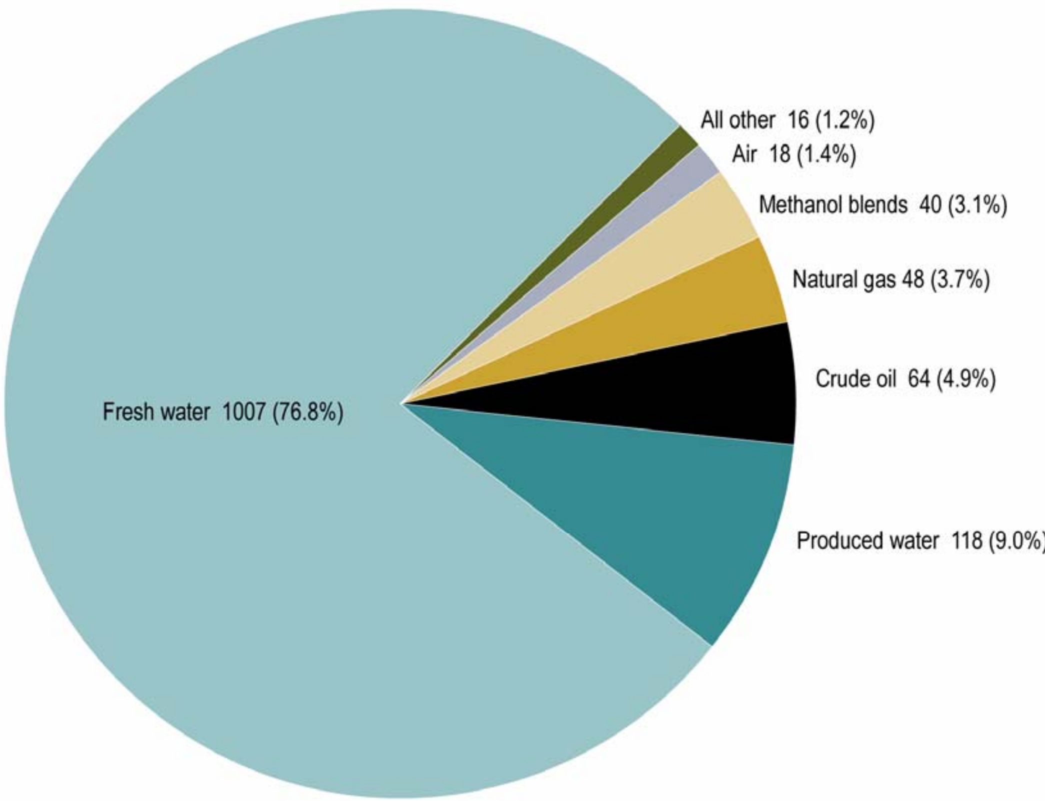
	RELEASE VOLUME, m^3 (LIQUIDS) OR 10^3 m^3 (GAS)				Total	% of
	<100	100 - 1000	1000 - 10 000	>10 000	number	all releases
Total	**1279**	**27**	**4**	**1**	**1311**	**100.0**

During the reporting period, there were 1311 substance releases from 1256 pressure test failures. 76.8% of the releases were fresh water, and the remaining 23.2 % were a variety of other products. In Figure 27, substances combined into the natural gas category include fuel gas, gas production (raw), gas production (marketable), and natural gas. The produced water category includes process water, produced water, and corrosion inhibited water.

Pressure tests are conducted for a number of reasons, such as proving out new construction, verifying integrity, requalifying for a higher operating pressure or change of substance, and identifying near-critical defects.

Figure 27. Pipeline releases from pressure test, by substance

All pipelines from January 1, 1990, to December 31, 2005 (leaks and ruptures only)



1256 actual events resulted in 1311 released volumes

The data for Figure 28 were compiled by taking the cumulative length of all pipeline of each product class at each year-end and dividing that by the number of incidents recorded for that year for the product class. Frequency of incidents is reported as the number of incidents occurring per 1000 km of pipeline.

Figure 28 shows that most pipeline substances exhibit a relatively low, and reasonably steady, incident frequency in the range of about 1 to 2 incidents per 1000 km per year. The exceptions are water and multiphase pipelines. Water pipelines are very susceptible to corrosion unless coated with an internal corrosion barrier. Industry has showed significant progress in bringing down the water pipeline failure rate, particularly in the early years of this reporting period. It appears that more improvement is becoming more difficult to achieve, as the failure rate has levelled out.

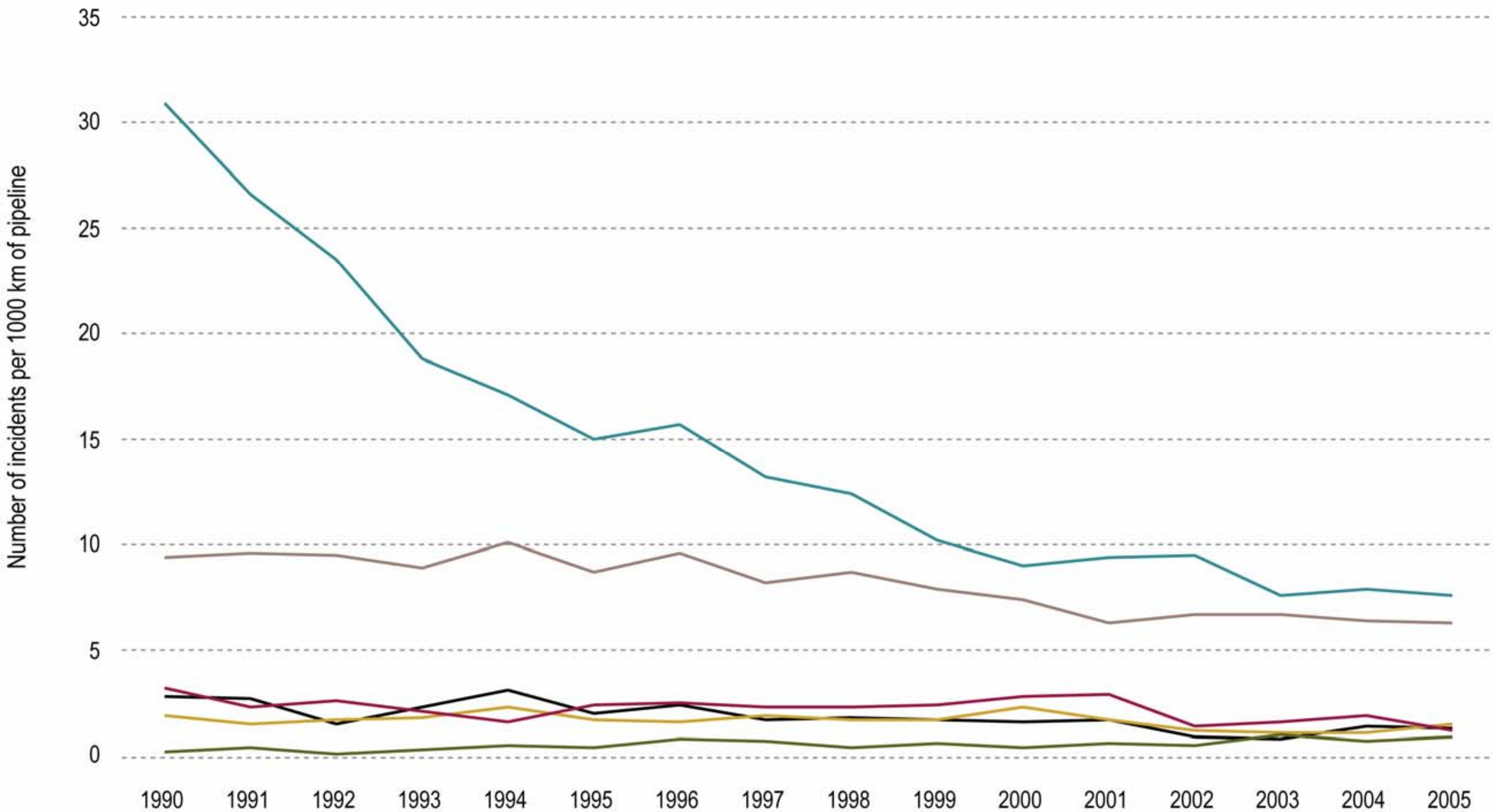
Multiphase pipelines are also very susceptible to corrosion, as they typically carry some water. If the amount of oil is sufficient to wet out the interior surface of pipe, the oil may be effective in protecting the steel from corrosion. However, when that oil film is disrupted or is insufficient to coat the pipe, corrosion can occur. Corrosion inhibition can be effective, but must be carefully administered to ensure that inhibition systems work effectively in the water and oil environments. Industry appears to be making gradual improvement in the performance of these multiphase pipelines as well, although the failure rate remains high, at 6.3 failures per 1000 km.

The failure rates for crude oil, natural gas, sour gas, and other pipelines have been nearly steady over the reporting period. Of particular interest are the failure rates for sour gas pipelines, which are currently at an all-time low of 1.2 per 1000 km. This is very encouraging, as it demonstrates that operators of these critical pipelines are operating them very carefully. Indeed, the failure rate on these sour gas pipelines, which carry corrosive, untreated production, is bettered only by pipelines in the "other" category, which are primarily pipelines shipping clean hydrocarbon products.

The only apparent disappointment is a minor increase in the failure rate of natural gas pipelines in 2005. Some of these pipelines do contain wet, corrosive raw natural gas, which contributes to the number of failures. More analysis will be conducted to look for problem areas that could be addressed further.

Figure 28. Average frequency of pipeline incidents, by year

All pipelines from January 1, 1990, to December 31, 2005 (includes all hits, leaks and ruptures)



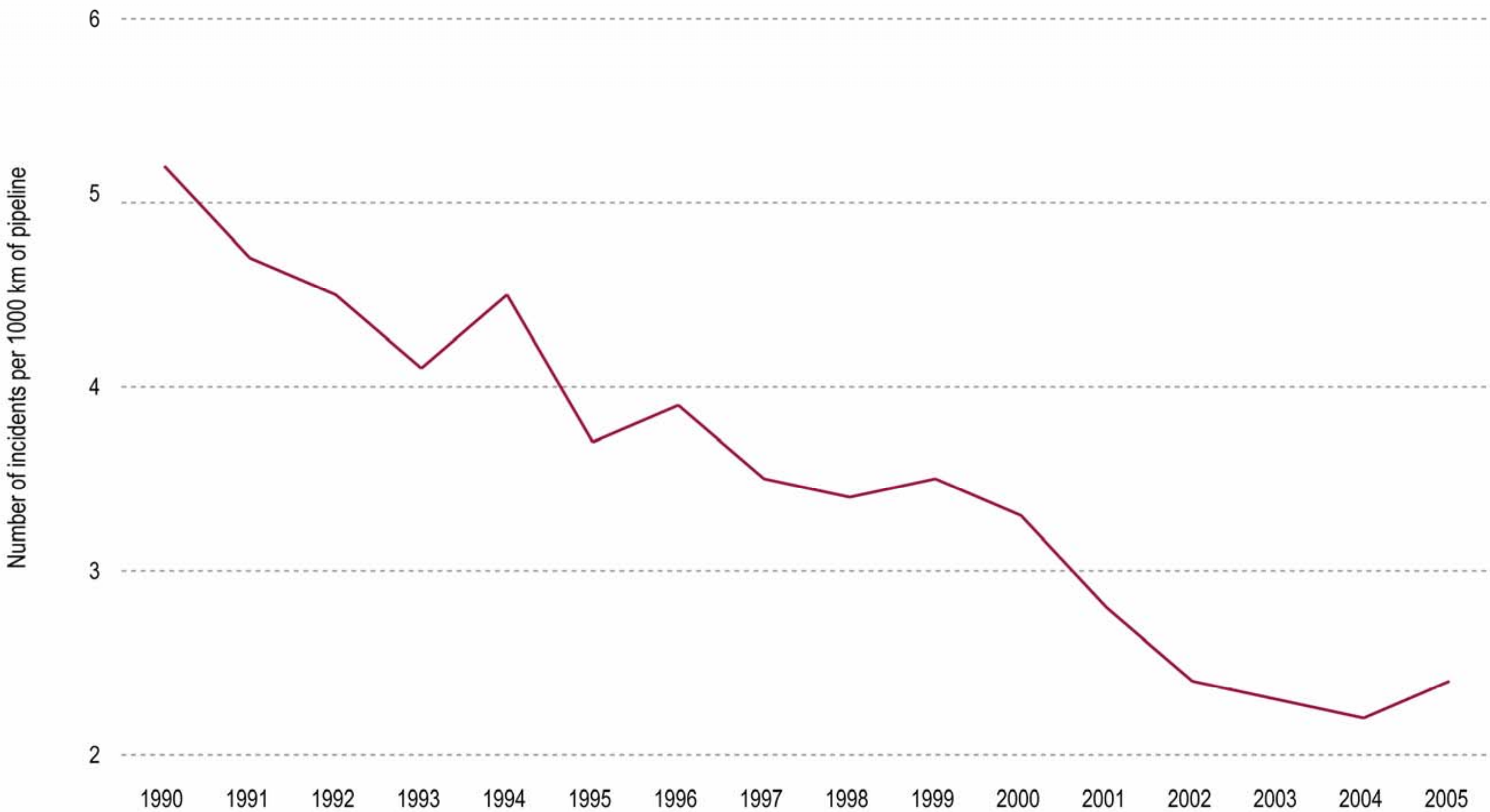
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Crude oil	2.8	2.7	1.5	2.3	3.1	2.0	2.4	1.7	1.8	1.7	1.6	1.7	0.9	0.8	1.4	1.3
Natural gas	1.9	1.5	1.7	1.8	2.3	1.7	1.6	1.9	1.7	1.7	2.3	1.7	1.2	1.1	1.1	1.5
Sour gas	3.2	2.3	2.6	2.1	1.6	2.4	2.5	2.3	2.3	2.4	2.8	2.9	1.4	1.6	1.9	1.2
Water	30.9	26.6	23.5	18.8	17.1	15.0	15.7	13.2	12.4	10.2	9.0	9.4	9.5	7.6	7.9	7.6
Multiphase	9.4	9.6	9.5	8.9	10.1	8.7	9.6	8.2	8.7	7.9	7.4	6.3	6.7	6.7	6.4	6.3
Other	0.2	0.4	0.1	0.3	0.5	0.4	0.8	0.7	0.4	0.6	0.4	0.6	0.5	1.0	0.7	0.9

Data for Figure 29 were compiled by taking the cumulative length of operating and permitted pipeline at each year-end and dividing that by the number of incidents recorded for the year.

Over the reporting period, pipeline failure frequency has dropped from 5.2 to a low of 2.2 in 2004. In 2005 there was a slight rebound, to 2.4, due to an increased number of natural gas pipeline incidents. However, the overall trend shows a very successful performance story, in that industry has exhibited a steady, measurable reduction in the frequency of pipeline failures. Pipeline failures are very costly from the perspective of lost production and royalties, environmental damage and cleanup, increased greenhouse gas emissions, and loss of public goodwill. The EUB will continue to work with industry to continue this trend of improvement. Targets for a few years ahead will be to introduce and implement pipeline integrity management programs, bring more corrosion-resistant pipeline materials into common use, improve leak detection methods, and maintain relevant and meaningful regulations to assist in improving pipeline performance.

Figure 29. Average frequency of pipeline incidents, by year

All pipelines from January 1, 1990, to December 31, 2005, all products (includes all hits, leaks and ruptures)



Incidents/1000 km	5.2	4.7	4.5	4.1	4.5	3.7	3.9	3.5	3.4	3.5	3.3	2.8	2.4	2.3	2.2	2.4

5 Future Initiatives

The EUB is always looking for ways that pipeline performance may be enhanced. Over the last decade, the EUB has been a strong proponent of trying new corrosion-resistant composite and polymeric materials and has worked with industry to allow numerous installations of newly developed materials. Many of these have exhibited excellent performance and are now being used regularly. The EUB expects growth in this sector, especially as more new materials come to market. The EUB will, however, monitor performance of these materials carefully to ensure that the materials provide satisfactory performance.

Senior technical staff from the EUB Pipeline Section participate in technical work groups for the *Canadian Standards Association (CSA) Standard Z662: Oil and Gas Pipeline Systems*, the main governing document for technical requirements related to pipeline design, construction, and operation in Canada. This ensures that experiences seen in Alberta are brought to the discussion table and that changes to the standard can be made if necessary. A new edition of *CSA Standard Z662* is expected in mid-2007, which will specify technical requirements for and acceptance of certain non-metallic and composite pipelines, improved construction standards for sour service pipelines, guidelines for pipeline integrity management programs, and various other improvements.

The EUB recently completed a review of the requirements for HVP product pipelines, and recommendations from that work were included in a revision to the *Pipeline Regulation* completed in 2005. Many other changes were also made in that revision, such as improvements to the way pipelines are discontinued or abandoned, improvements to ground disturbance practices around pipelines, additional right-of-way inspection, and annual corrosion control evaluations. The EUB reviews and updates the *Pipeline Regulation* periodically as the need arises.

On occasion the EUB conducts examination of specific pipeline issues and works with industry to see where improvements can be made. One such initiative was to examine different methods of initiating emergency shutdown valve closure to make sure that current methodology is still appropriate. The EUB has also been working on projects to re-evaluate existing requirements for emergency response planning around pipelines and make change as appropriate. Projects being considered include developing criteria for evaluating material compliance with sour service specifications and detailed processes for conducting assessments of integrity management programs to see that they meet regulatory requirements.

6 Other Information

Technical standards and regulatory information related to pipeline can be found in the following documents:

Alberta Pipeline Act
Alberta Pipeline Regulation

American Society of Mechanical Engineers (ASME) B16.5 Pipe Flanges and Flanged Fittings
ASME B31.3 Process Piping

Canadian Standards Association (CSA) Standard Z662: Oil and Gas Pipeline Systems
CSA Standard Z245.1: Steel Pipe
CSA Standard Z245.11: Steel Fittings
CSA Standard Z245.12: Steel Flanges
CSA Standard Z245.15: Steel Valves
CSA Standard Z245.20: External Fusion Bond Epoxy Coating for Steel Pipe
CSA Standard Z245.21: External Polyethylene Coating for Pipe
CSA Standard B137 Series 2: Thermoplastic Pressure Piping Compendium

EUB Directive 022: Use of Bimodal High-Density Polyethylene Pipe in Oil and Gas Service
EUB Directive 026: Setback Requirements for Oil Effluent Pipelines
EUB Directive 041: Adoption of CSA Z662-03, Annex N, as Mandatory
EUB Directive 056: Energy Development Applications and Schedules (also contains a number of reference tools for pipeline applications)
EUB Directive 066: Requirements and Procedures for Pipelines (pipeline inspection guide)
EUB Directive 071: Emergency Preparedness and Response Requirements for the Upstream Petroleum Industry
EUB Guide 30: Guidelines for Safe Construction near Pipelines
EUB Information Letter 2002-02: Strength and Leak Pressure Testing of Pipelines Using Gaseous Test Media
EUB Provincial Surveillance and Compliance Summary 2005; also previous years' annual ST-57 Summaries

NACE MR0175/ISO 15156: Materials for use in H_2S-Containing Environments in Oil and Gas Production