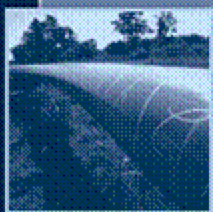
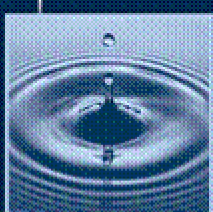




ADVANTICA

A Germanischer Lloyd Company

STONER SOFTWARE

Benchmarking Analysis, Risk Analysis and Model, Replacement Analysis and Computerized Main Prioritization and Ranking Program

Philadelphia Gas Works
Final Report
June 2, 2008

Enhancing Safety and Performance

Table of Contents

Executive Summary

Background

Advantica have been engaged by Philadelphia Gas Works (PGW) to carry out a study into their current mains replacement policy for cast iron and their future mains replacement requirements. As part of this study, a detailed benchmarking of their current position has been carried out by comparing their distribution system with that of comparable gas utilities in the U.S., in particular those centered on a central inner city. PGW have also agreed to implement Advantica's mains replacement software offering Mains Replacement Prioritization (MRP), to assist them in building future replacement plans, thus this report uses the results from some initial runs of MRP to determine recommended replacement levels with associated risk, going forward.

Benchmarking Study

The benchmarking study for PGW was extensive and the full results are contained within the main body of the report, but the main points arising from this exercise are detailed within this summary. PGW was compared with two separate groups of utilities. The larger group of 27 companies (including PGW) was used as a broad comparison of "industry standard" practices, and covered the utilities primarily in the eastern half of the U.S. Seven of the companies in the broader benchmark group were pulled out for a closer comparison to PGW. These seven gas distribution companies were selected by PGW as having systems most similar to PGW's system. The seven systems are all centered around a central inner city, and are thus considered to be the most-comparable benchmark that could be used. These companies tended to operate reasonable amounts of older, cast iron pipe and were predominantly located in the northeastern part of the U.S.

The statistics presented within this benchmarking study report are primarily publicly available and have been sourced from the "U.S. Department of Transportation's Annual Report for Gas Distribution System," covering the 10-year period ending in 2006.

The main points to emerge from this study are as follows:

1. Within the larger group of utilities, PGW has a much higher than average proportion of cast iron pipe. This will increase the overall risk from the system as breaks from cast iron pipe are one of the most common causes of incidents.
2. Within the smaller group of utilities, PGW has an average proportion of cast iron pipe. This smaller group contains 49% of all the cast iron in operation in the US, but only 5% of the population of all materials, showing that this group is close to PGW in terms of its material composition.
3. Within the larger group of utilities, PGW has the lowest percentage of polyethylene pipes. Polyethylene is considered to have the lowest risk of serious incidents due to its extreme resistance to joint leakage, fracture and corrosion.
4. Within the smaller group, PGW has the highest percentage of cast iron, the lowest percentage of polyethylene, and the lowest percentage of bare steel.

5. PGW's distribution of pipe by diameter is comparable with the smaller group, but PGW has much less small diameter (less than 2-inch) pipe in comparison with the larger group, since the majority of their system is operated at low pressure (6"wc) and PGW eliminated small diameter CI during the late 80's early 90's as part of its main replacement program.
6. PGW has one of the highest proportions of pre-1940 pipe within the larger group, but an average proportion when compared within the smaller group.
7. PGW has an average percentage of PE services within both the larger and smaller benchmark group.
8. PGW has one of the shortest average service line lengths within the larger group and the shortest within the smaller group. This is an important factor in the risk arising from main breaks and to a lesser extent for joint leaks, as gas will have shorter distance to migrate into nearby property.
9. When compared with other utilities, there is marked difference between the classification of leaks within PGW and elsewhere, in particular the high number of leaks classified as due to "natural forces," compared to other companies. PGW attributes 90% of their leaks to this cause, compared with only 14% for the larger group and 22% for the smaller group. This may be a real difference, or more likely, a difference of interpretation of the classifications.
10. In terms of unaccounted-for gas, PGW ranks as having one of the highest figures within the largest group and the highest within the smaller group, but previous studies have suggested that there may be a high level of unreliability associated with these figures.
11. Trends in joint and break leaks are not available via the DOT statistics, but Advantica carried out a separate, confidential survey, to determine figures from six companies (five from the smaller benchmark group and one from the larger group). The 10-year trend in cast iron breaks and joint leaks for PGW shows a reasonably level trend for breaks, suggesting that the current level of cast iron replacement is sufficient to stabilize the break rate. There is, however, a slight upward trend for joint leaks, suggesting that the replacement level should perhaps need adjusting upwards to reverse this trend or keep it level. It must be noted that weather also plays an important factor in the number of breaks per year that a utility experiences.
12. A comparison of joint leaks as a percentage of total leaks, from this anonymous group, has shown that PGW's percentage is average.
13. A comparison of incident rates over the period 1986 to 2004 has shown that the PGW rate was significantly higher than the average for all U.S. gas companies over this period, an average of just under 25 incidents per 100,000 miles of mains and services per year compared to a national average of around 7 per 100,000 miles per year. However, the general trend for PGW has shown a reduction in incidents in recent years.
14. The main cause of incidents within PGW has been recorded as "outside force." This is the same pattern as seen within the U.S. as a whole.
15. The largest source of incidents appears to be mains. This is seen for both PGW and the U.S. as a whole.
16. The vast majority of incidents within PGW occur on cast iron pipes, on 4 to 6-inch mains, on older pipes, within the winter months. This pattern is similar to the national situation.

Replacement policy

As well as examining PGW's current position in terms of operating statistics, Advantica has also examined PGW's position in relation to replacement levels, in particular those of cast iron. The main points of this examination are listed below.

1. In terms of replacing its cast iron population over the 10 year period ending in 2006, PGW rank in the lowest quartile within the larger group, having replaced a total 156.3 miles or approximately 8.8% of its' main from the starting point of 1,768 of the CI system compared to an average of 13%. For the smaller group however, it matches the average reduction. The ten (10) year average for replacement is 15.6 miles, the five year average is 20.2 miles and the most recent replacement level equates to just more than 18 miles per year.
2. PGW's replacement of cast iron over the period 2001 to 2006 has been approximately twice as high as in the years 1998 to 2000.
3. If PGW were to increase its replacement level to 24 miles per year, it would rank second highest in the smaller benchmark group. If it were to reduce replacement to 12 miles per year, it would rank second lowest.
4. If PGW continued to replace at its recent rate of 18 miles per year, using a random approach, its year of final replacement would be 2096. This compares with 2063 for the company with the best rate of replacement (24 miles) and 2291 for the company with the worst rate of replacement (12 miles).
5. Following discussion with PGW staff, regarding replacement techniques and the constraints imposed by working in an urban area, Advantica have suggested the following for reducing the costs of repairs and replacement of mains:
    - Revisit longer term contracts
    - Schedule larger replacement areas/projects
    - Discuss paving requirements with the City
6. As part of the survey conducted by Advantica, participants were asked for suggestions for replacement techniques which they would recommend for reducing costs. The details of these are contained within the main body of the report. Advantica has also provided PGW with a flowchart aid to selecting construction techniques.
7. Finally, the survey collected details of repair and replacement costs for each of the participants. PGW has a relatively low cost per repair of $1,660 per mains break repair, compared to an average of $3,300. PGW has an average replacement cost of $0.7 million per mile, comparing favorably to an overall average of $1.1.

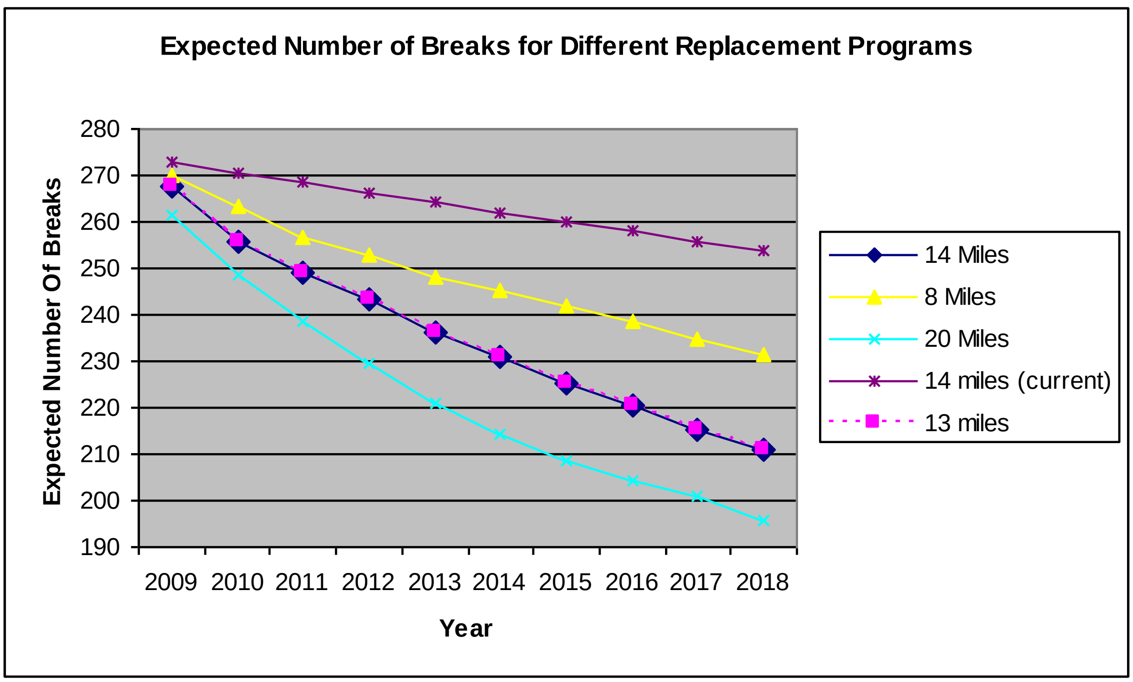
Alternative replacement scenarios using MRP

The previous two sections have examined the current status of PGW in terms of operating statistics and replacement policy. Advantica has also carried out some analysis to determine if the present policy can be improved by the application of MRP, Advantica's prioritization model. MRP has been populated with pipe details for PGW, namely pipe sizes, their geographical location, their associated leaks and information relating to service length. This has enabled

Advantica to generate a number of different replacement scenarios based upon different levels of risk-based replacement and their associated costs, to determine how effective they are at reducing breaks, avoiding breakage repair costs, and improving safety.

Replacement levels of 12 miles, 17 miles, 18 miles and 24 miles, using MRP, have been examined, together with 18 miles using PGW's current methodology. The results of running these scenarios are presented in the following graph, in terms of a reduction in expected breaks over a 10-year period by applying different annual rates of replacement and methodologies.

It is important to note that PGW's annual program is made up of prudent and enforced replacement. The prudent portion has historically been selected using PGW's current prioritization tool. The enforced has to be carried out due to city, state, federal and other utility projects outside the control of PGW. Traditionally, the enforced has accounted for around 4 miles per year. The scenarios which are presented within this report, using MRP, have removed 4 miles from the total to simulate the actual situation, thus the 18 mile scenario is actually 14 miles of cast iron, the 24 mile is actually 20 miles and so on. The output from MRP has been amended to produce a graphical output for breaks per year rather than leaks, as PGW has traditionally measured its replacement program against the trend in breaks not leaks. The following graph shows the results of applying MRP to a number of different scenarios, based upon different lengths of replacement.



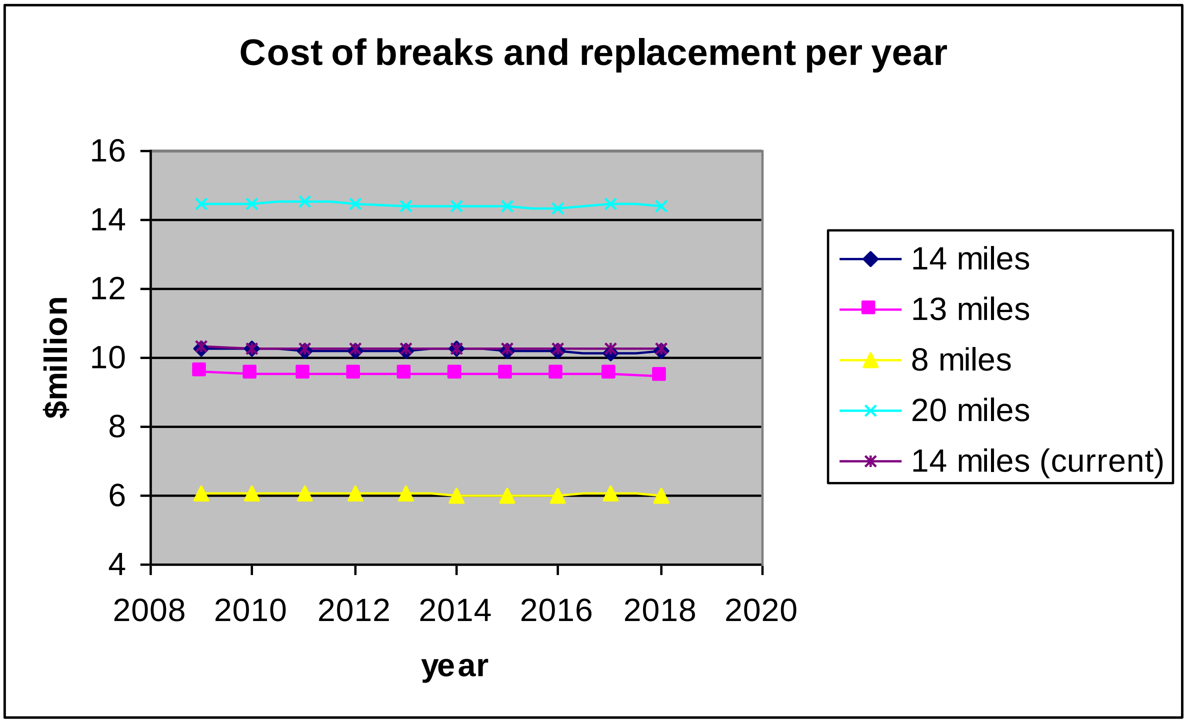
As expected, the more pipe is replaced, the greater the reduction in breaks per year. The average breakage rate over the 10 year period 1997 to 2006 within PGW has been 370. MRP predicted a starting level of 275 for 2008. It is important to note that the output from MRP predicts the number of breaks associated with specific pipes. The average level of breaks of 370 is based upon all breaks, whether they are assigned to pipes or not. When PGW's historical data is examined further to extract only those breaks associated with pipes, the average reduces to 254 – this is in comparison to a predicted average from MRP of 275.

The graph also shows that there is a distinct difference between 14 miles (18 miles total) using PGW's current policy versus 14 miles (18 miles total) using MRP. The level of predicted breaks for 13 or 14 miles is very similar, but the 14 mile scenario does reduce breaks slightly quicker than the 13 mile scenario. In terms of percentage reduction, the scenarios performances are summarized in the following table.

Scenario	Description	Breaks in year 0	Breaks in year 10	% reduction in length of cast iron	% reduction in breaks
A	18 miles of cast iron per year, random (14 miles prudent)	275	253	8%	8%
B	18 miles of cast iron per year (14 miles using MRP Risk)	275	209	8%	24%
C	17 miles of cast iron per year (13 miles using MRP risk)	275	211	7.5%	23%
D	12 miles of cast iron per year (8 miles using MRP Risk)	275	231	5%	16%
E	24 miles of cast iron per year (20 miles using MRP risk)	275	196	11%	29%

The previous table shows that the application of MRP is effective for all scenarios, in reducing cast iron breaks, and hence incidents; each one removing proportionally more breaks than the corresponding length replaced, and all of them more effective than the current policy. The table also shows that any move away from the 14 mile (18 mile total) program will reduce the effectiveness of reducing breaks and hence incidents.

The cost of replacement and repair has also been considered. An increase in replacement will increase replacement costs but reduce future breakage repair costs. The following graph summarizes the total cost of each scenario, in terms of replacement and breakage repair costs. The 14 mile (18 mile total) current and MRP scenarios have similar levels of costs, as the cost of replacement is the same in both cases, and is much greater than the cost of breakage repairs. However, as can be seen in the previous graph, the reduction in future breaks is much greater if MRP is used to prioritize the 14 miles.



Conclusions and Recommendations

The results of the analysis carried out by Advantica have shown that PGW operates a distribution system which is typical of one operating in a central inner city area, where the mains population is very well established and there are constraints on the amount of replacement possible because of the density of other services and property.

Because of this particular type of system, PGW has a higher than average level of leaks and incidents, older than average pipes, and a lower than average polyethylene population. It is therefore imperative that any replacement policy is as effective as possible at identifying the pipe segments that present the greatest likelihood of leaks and incidents, and replacing them as early as possible in the program.

The application of MRP to the population of pipes within PGW has shown that PGW could continue to operate a policy of 18 miles per year, of prudent and enforced, but significantly reduce the level of future breaks, simply by identifying a different population of those 18 miles. It has been assumed that 4 miles of the 18 is still outside the control of PGW as it is enforced replacement, but the remaining 14 miles could be identified using the MRP risk model. This would identify those cast iron mains with the highest probability of breaking and causing an incident. This program will have a similar cost to the current 18-mile policy, but is estimated to produce significant savings in terms of breaks avoided over the subsequent 10-year period. An 18-mile program, directed by MRP over the next 10 years reduces the cast iron population by around 8% but the estimated reduction in breaks over the same period is 24%.

Background

Natural gas is an inherently risky commodity to handle. U.S., state, and sometimes local authorities strictly regulate its movement in collection systems at the wellhead, through transmission pipelines crossing the entire country, and through distribution pipelines carrying the commodity to millions of households plus commercial and industrial sites. Yet its transport by pipelines has proven by far to be the safest way to move critically required energy supplies throughout the country. This is a testimonial to the dedicated performance of professionals such as PGW's employees, who understand the nature of – and the hazards of – the product they are entrusted with, and the proper ways to ensure the safety of their employees and most of all the public.

PGW and other urban-centered gas distribution utilities face particular challenges in maintaining their systems at generally recognized industry standards, when compared to gas utilities that operate primarily in a suburban environment. This is especially true when it comes to installation and maintenance. With little or no opportunity to supply newer suburban development areas, PGW's gas mains tend to be older and in need of more maintenance. Statistically, PGW has some of the oldest and highest miles of mains of the most risky pipe materials – cast iron and un-protected steel – in the industry. These mains are located underneath old and narrow streets that are some of the busiest roadways in the nation. The complexity of the street network creates an environment that is difficult to work in for all Philadelphia utilities, which in turn creates congestion underneath the road surfaces where many utilities have installed their facilities, many of which have long been abandoned.

In addition to the complex street network, homes have been constructed very close to the road. This limits the size of lawns that permit undiscovered gas leaks to escape to the atmosphere. In fact, many home frontages are completely covered by asphalt, all the way to the road, which does not allow gas to easily escape. This creates added risks of the migration of natural gas since gas that is released during a leak has nowhere to collect except in basements or other underground structures.

All of these factors place an added stress on PGW to operate a natural gas system that is safe and reliable while optimizing PGW's capital fund.

As is the case with any industry, companies must periodically re-evaluate their practices to ensure they are keeping pace with industry, regulatory, and public standards. In an effort to perform their due diligence, PGW embarked on a benchmark analysis initiative to evaluate their risk management processes with respect to their cast iron and non-cathodically protected steel pipe. In order to obtain the focus that this initiative requires, PGW teamed with Advantica to perform much of the analysis on PGW risk management processes.

Advantica's Approach

Advantica's approach to evaluating PGW's practices for managing its cast iron and non-cathodically protected steel was to perform a two-part analysis. The first part of the analysis compared PGW against its industry peers. This analysis compared statistics for key operating parameters such as number of leaks, cause of leaks, number of incidents, miles of main, number of services, miles replaced each year, replacement techniques, and so on. The goal was to compare PGW over a broad spectrum of areas with respect to mains replacement.

The utilities incorporated into the benchmark study were grouped into three categories:

- An industry-wide sampling of 27 utilities.
- Seven selected utilities with a close resemblance to PGW.
- Four utilities (including PGW) that provide service within the state of Pennsylvania.

The groups in the study were strategically chosen to provide PGW with analytical results at a national, local, and peer level. The utility comparisons provide PGW with a clear picture of how its risk management practices compare with the industry.

The second part of Advantica's analysis was to use a statistical model to assess the overall condition of PGW's cast iron and non-protected steel mains. The statistical model is contained within Advantica's Mains Replacement Prioritization (MRP) product, which was implemented at PGW as part of this initiative. The MRP analysis reviewed each metallic main in the system. The factors incorporated in the analysis included main breaks, main leaks, age, material, geographic proximity to other mains, and size. The result of the statistical analysis was a condition assessment of the system today and into the future. Based on this assessment, Advantica was able to estimate the leak rate of the system over time, as well as the minimum required main replacement rate to keep up with the wear out rate of the system. Because this is a main-by-main analysis, the results will provide a strategic roadmap for targeting the riskiest mains first.

The key to the entire analysis was to bring the results from both processes together to form an overall assessment of PGW's replacement process and provide recommendations on areas of improvement. The final sections of this report will provide a summary of the results and recommendations that were formulated based on this assessment. The immediate sections that follow will provide further details on both the benchmark study and the MRP statistical analysis.

Benchmark Study of Operating Statistics

Natural gas systems are unique because the majority of the assets are out of sight, and thus their physical condition cannot be directly observed or easily measured. Inspections cannot be readily made as they might be for an electric utility. Instead, natural gas utilities must rely on the review of installation records, maintenance callouts (piping leaks, breaks, and incidents), repair and replacement programs, and replacement budgets. These reviews are best made in a comparative manner whereby PGW's performance is assessed not in isolation but in relative performance against similar gas utilities. This provides a comparison against "standard utility practice," which provides a measure of actual results.

To determine how well PGW has performed in maintaining its distribution system, Advantica used a number of data collection and analytical techniques during the course of its study. The techniques included extensive benchmark comparisons using publicly available information, survey collection of some non-public information, and interviews and discussions with members of PGW's Distribution Department. These formed the basis for Advantica's benchmark assessment of PGW's relative performance.

The sections to follow provide an overview of the utilities selected for the benchmark analysis, the statistics collected, and a summary of each benchmark parameter. The final sections of this study provide a summary of the results and recommendations for areas of improvement based on this phase of the assessment.

Benchmark Companies

PGW and Advantica together selected the natural gas distribution companies that were used as "benchmarks." PGW's performance in many installation and maintenance areas was then compared against the performance of these benchmark companies to provide an "industry standard" measure of PGW's relative performance.

To conduct the benchmark study, public records of performance were gathered by assembling each benchmark company's annual reports on their systems for the most recent 10 years available (1997 - 2006). These reports, entitled "U.S. Department of Transportation's Annual Report for Gas Distribution System," are mandatory for all U.S. distribution companies (about 1,400 companies), as required under Title 49 of the Code of Federal Register, Part 191. Each distribution company sends in its system information on a structured form (Form RSPA F 7100 1-1), filling in the blanks with information about their piping system. The required information includes data on the amount of pipe (miles), age, type of material, diameter, and leaks encountered in both service-lines and mains. Once submitted, all information from each distribution company is entered annually into a composite database and made available to the general public. Unfortunately, these data entry and processing steps can introduce occasional typos. Care must be taken by the user to correct any errors, such as decimal point positioning or wrong category assignments. This task is made easier by comparing data for each selected company for all 10 years, to check for consistent figures and correct categories.

Instead of using a single group of benchmark companies, Advantica and PGW agreed to use two groups for most comparisons. A larger group of 26 utilities (plus PGW) was used for a broad comparison of "industry standard" practices. The results of this comparison indicate how PGW's distribution system compares across a representative sample of utilities. Seven of the companies in the broad benchmark were selected by PGW for a closer comparison. The seven systems were all centered around a central inner city, similar to PGW, and were thus considered to be the most comparable benchmark that could be used.

A major criterion for selection of these particular utilities was the presence of cast iron mains in their systems. This is an important factor in the condition and operation of PGW's system, as will be shown throughout this report. In order to include cast iron mains, it was necessary to concentrate the selection on older gas utilities. (Cast iron has not been installed in systems built in the last 40 years, when newer and better piping materials became available.) Most of the older gas utilities operated in the eastern part of the U.S., so the benchmark groups include predominantly eastern, older systems.

Larger Benchmark Group – Company Information

The following table provides information on the 26 companies used for the large benchmark study. The table includes the commonly known name for each utility, the shorthand abbreviations that are used in this report, the major cities where each utility operates, and the latest name for the utility or its parent firm that has come about in the last 10 years or so, through consolidation or purchase of gas companies. The large benchmark group includes three other utilities operating in the State of Pennsylvania, who have the same regulatory body (PUC). These utilities are highlighted in green in the table. PGW is highlighted in yellow.

PGW and the 26 Selected Benchmark Distribution Utilities

	Utility Name	Abbrev. Name	Major City Served	Latest Owner / Parent Co. / Name
1	Alabama Gas Co.	ALGAS	Birmingham	Alagasco
2	Atlanta Gas Light	AGL	Atlanta	AGL Resources
3	Baltimore Gas & Electric	BG&E	Baltimore	Constellation Energy
4	Boston Gas	BOSG	Boston	Keyspan En./ National Grid
5	Brooklyn Union Gas	BUG	Brooklyn	Keyspan En./ National Grid
6	Cincinnati Gas & Electric	CINGY	Cincinnati	Cynergy/ Duke
7	Columbia Gas of Ohio	CGO	Columbus	NiSource
8	Columbia Gas of Penn.	CGP	York	NiSource
9	Consolidated Edison of NY	CONED	Manhattan	Consolidated Edison of NY
10	Elizabethtown Gas	ELIZ	Elizabethtown	AGL Resources/ Pivotal Holdings
11	Equitable Gas Company	EQU	Sub. Pittsburgh	Equitable Resources
12	Indiana Gas Co.	IGC	Evansville	Vectren
13	Laclede Gas	LACL	Saint Louis	Laclede Gas
14	Lone Star Gas Company	LSG	Dallas	Ensearch Corp./ Atmos Energy
15	Long Island Lighting	LILCO	Queens	Keyspan Energy/National Grid
16	Memphis Light Gas & Water	MLGW	Memphis	Memphis Light Gas & Water
17	Michigan Consolidated Gas	MICON	Detroit	DTE Energy
18	National Fuel Gas (NY only)	NATFG	Buffalo	National Fuel Gas

	Utility Name	Abbrev. Name	Major City Served	Latest Owner / Parent Co. / Name
19	New Jersey Natural	NJN	So. Jersey	South Jersey Resources
20	Niagara Mohawk Power	NIMO	Syracuse	National Grid
21	Northern Illinois Gas	NIGAS	Sub. Chicago	Nicor, Inc.
22	Peoples Gas Light & Coke	PGL&C	Chicago	Integrys
23	Philadelphia Electric Co.	PECO	Sub. Philadelphia	Exelon
24	Philadelphia Gas Works	PGW	Philadelphia	Philadelphia Gas Works
25	Public Service Electric & Gas	PSE&G	Newark	PSEG Enterprises
26	Southern Connecticut Gas	SCONN	Bridgeport	Energy East
27	Washington Gas (DC only)	WGL	Dist. Columbia	Washington Gas
	= PA Co.		= PGW	

Smaller Benchmark Group – Company Information

The following table presents the smaller benchmark group of seven utilities that PGW selected from the broader benchmark group. These utilities are considered to have systems that are most similar to PGW.

PGW and the Seven Selected Benchmark Distribution Utilities

	Utility Name	Abbrev. Name	Major City Served	Latest Owner / Parent Co. / Name
1	Baltimore Gas & Electric	BG&E	Baltimore	Constellation Energy
2	Boston Gas	BOSG	Boston	Keyspan En./ National Grid
3	Brooklyn Union Gas	BUG	Brooklyn	Keyspan En./ National Grid
4	Consolidated Edison of NY	CONED	Manhattan	

	Utility Name	Abbrev. Name	Major City Served	Latest Owner / Parent Co. / Name
5	Michigan Consolidated Gas	MICON	Detroit	DTE Energy
6	Peoples Gas Light & Coke	PGL&C	Chicago	Integrys
7	Philadelphia Gas Works	PGW	Philadelphia	
8	Public Service Electric & Gas	PSE&G	Newark	PSEG Enterprises

System Statistics for All Benchmark Companies

In order to categorize the individual characteristics of each of the benchmark companies, the overall statistics on their size are presented in this section. Miles of mains and numbers of service lines for each benchmark utility are shown first. Next, the composition of the distribution system is described in terms of the type of pipe materials used in the system, the diameter of the pipes, age of installation of the pipes, etc. The emphasis of the benchmark study, however, is main lines rather than service lines, and in particular one type of mains material – cast iron. The focus, therefore, is on these items, and system statistics will emphasize the key issues in these areas.

Larger Benchmark Group – Mains, Services, and Amount of Cast Iron

The following table provides data on the miles of main lines and numbers of service lines for all benchmark utilities. The first direct comparisons of PGW's system to those of the benchmark companies can be seen in the amount of cast iron mains existing today in their piping systems. Ranked on the total miles of cast iron main, PGW is shown in this table to have one of the largest amounts of cast iron main in its system. Since cast iron is now considered to be an obsolete piping material, and since it is also considered by many to be the "riskiest" material used in a gas distribution system, companies listed in the lower part of the table would have the most mileage of cast iron mains to replace in order to bring their systems up to more modern industry standards. PGW is shown to be in the fourth quartile of the benchmark comparison for this first statistic.

Key Statistics for the 27 Broadest Benchmark Companies

Quartile	Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Number of Services, 2006	Total Miles Cast Iron Mains, 2006
I	1	EQU	3,307	245,178	47
I	2	CGP	7,260	415,339	74
I	3	NJN	6,550	444,947	96
I	4	AGL	29,843	1,541,013	113
I	5	MLGW	4,763	303,006	146
I	6	IGC	12,134	611,243	177
I	7	CGO	19,591	1,333,900	281
II	8	LILCO	7,496	495,550	395
II	9	NIGAS	32,671	1,958,191	446
II	10	WGL	1,191	122,032	451
II	11	NATFG	9,537	450,269	463
II	12	CINGY	5,358	398,443	517
II	13	SCONN	2,258	129,449	730
II	14	NIMO	8,436	528,160	762
III	15	ELIZ	3,026	200,123	793
III	16	PECO	6,614	405,291	836
III	17	LACL	8,264	607,489	880
III	18	LSG	27,985	1,472,036	884
III	19	ALGAS	10,372	535,553	1,134
III	20	BG&E	6,747	510,752	1,365
III	21	CONED	4,256	380,795	1,396
IV	22	PGW	3,019	446,281	1,624
IV	23	PGL&C	4,025	507,300	1,664
IV	24	BUG	4,033	559,627	1,778
IV	25	BOSG	6,175	477,072	2,289
IV	26	MICON	18,390	1,188,295	2,737
IV	27	PSE&G	17,504	1,238,131	4,453

Quartile	Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Number of Services, 2006	Total Miles Cast Iron Mains, 2006
Average, 27 benchmark companies			10,030	648,351	983
Total, 27 benchmark companies			270,805	17,505,465	26,532
Total, all U.S. companies			1,214,042	63,534,950	37,129
27 benchmark companies as a percentage of total U.S. companies			22%	28%	71%

This table shows that PGW has 1,624 miles of cast iron in its system. This compares with the average cast iron mileage of 983 for the 27 benchmark companies. More importantly, perhaps, is the mileage shown in the table (3,019) for all of PGW's mains. This figure is much lower than the average total mains mileage (of 10,030) shown for the average system mileage of all 27 benchmark companies. This indicates that even though PGW's system is only one-third the size of the average benchmark company's, PGW has more cast iron than most of them.

Another statistic shown in the above table is that, in total, the 27 companies selected for the large benchmark group contain an overwhelming portion (71%) of all the cast iron mains existing in the U.S. This is in contrast to their much smaller portion of all mains mileage (22%) in the U.S. The high proportion of cast iron verifies the selection of the above group of utilities as a comparable benchmark.

Smaller Benchmark Group – Mains, Services and Amount of Cast Iron

The following table, also ranked on the total miles of cast iron in each system, compares PGW's system against the systems of the seven "Most Comparable" benchmark firms.

Key Statistics for the Seven Most Comparable Benchmark Companies

Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Number of Services, 2006	Total Miles Cast Iron Mains, 2006
1	BG&E	6,747	510,752	1,365
2	CONED	4,256	380,795	1,396
3	PGW	3,019	446,281	1,624
4	PGL&C	4,025	507,300	1,664
5	BUG	4,033	559,627	1,778
6	BOSG	6,175	477,072	2,289
7	MICON	18,390	1,188,295	2,737
8	PSE&G	17,504	1,238,131	4,453

Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Number of Services, 2006	Total Miles Cast Iron Mains, 2006
Average, 8 benchmark companies		8,019	663,532	2,163
Total, 8 benchmark companies		64,149	5,308,253	17,306
Total, all U.S. companies		1,214,042	63,534,950	37,129
8 benchmark companies as a percentage of all U.S. companies		5%	8%	47%

In the table above, the comparison of PGW to the smaller, more comparable set of benchmark companies indicates that PGW's system is quite comparable in cast iron mileage. (PGW's is 1,624, while the average is 2,163.) However, PGW's system is again much smaller than the others (PGW at 3,019, while the average is 8,019), meaning that PGW has a higher proportion of cast iron in its system than others. This higher proportion will be brought out in more depth in succeeding comparisons.

Again, we can note that almost half (47%) of all the cast iron in the U.S. is represented in this small benchmark group. This is again in contrast to their much smaller portion of all mains mileage (5%) in the U.S. The extremely high proportion of the country's cast iron represented in this group of eight utilities is a good indication that the group of "most comparable" utilities was well chosen for comparability to PGW.

Pennsylvania Benchmark Utilities – Mains, Services, and Amount of Cast Iron

Three additional Pennsylvania utilities are included in the larger benchmark grouping above (highlighted in green in a preceding table). Two of these utilities – Equitable Gas and Columbia Gas of Pennsylvania – have only a small amount of cast iron in their systems. The third Pennsylvania utility – Philadelphia Electric Company, or PECO – has a significantly smaller amount of cast iron than does PGW, even though its system is significantly larger. Advantica's observation here is that PGW has a different degree of concern regarding cast iron mains than do the other Pennsylvania utilities shown.

Types of Materials Used for Mains

A key measure of the condition of a gas distribution company's system lies in the type of materials that comprise its mains and service lines. More "modern" systems are thought to be those that contain higher proportions of the more modern (i.e. less risky) types of materials. More modern materials are thought to correlate with lower break rates, fewer leaks, less unaccounted-for gas, and so on.

Larger Benchmark Group – Types of Materials Used for Mains

The previous benchmark comparison focused on the amount of cast iron mains in each utility's system. The following benchmark comparisons show the proportions of all types of materials used in the mains of each system. The focus and ranking here is on plastic (polyethylene) mains, since this material is generally considered to be the most modern type of material available for use in gas pipes.

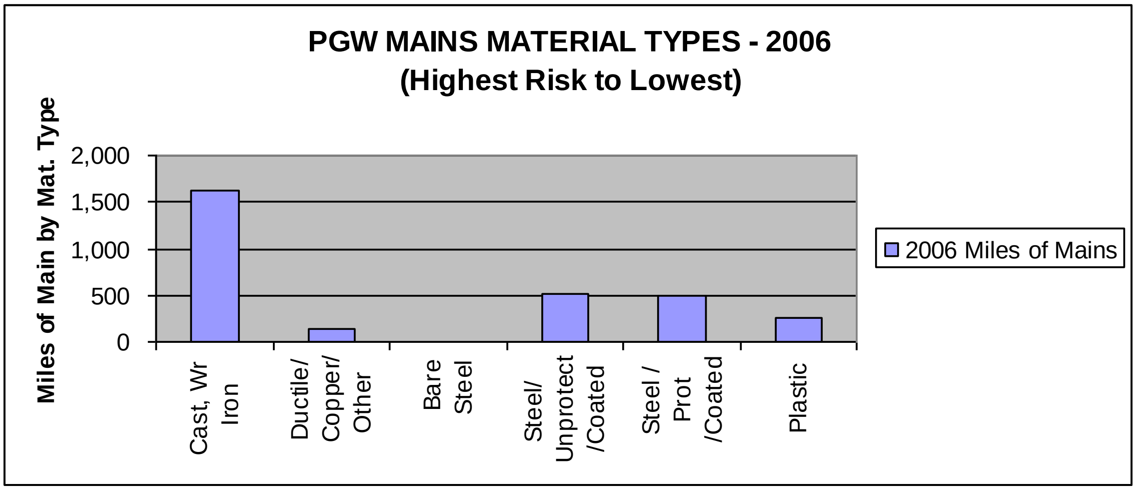
Mains by Material Type – 27 Benchmark Companies (2006)

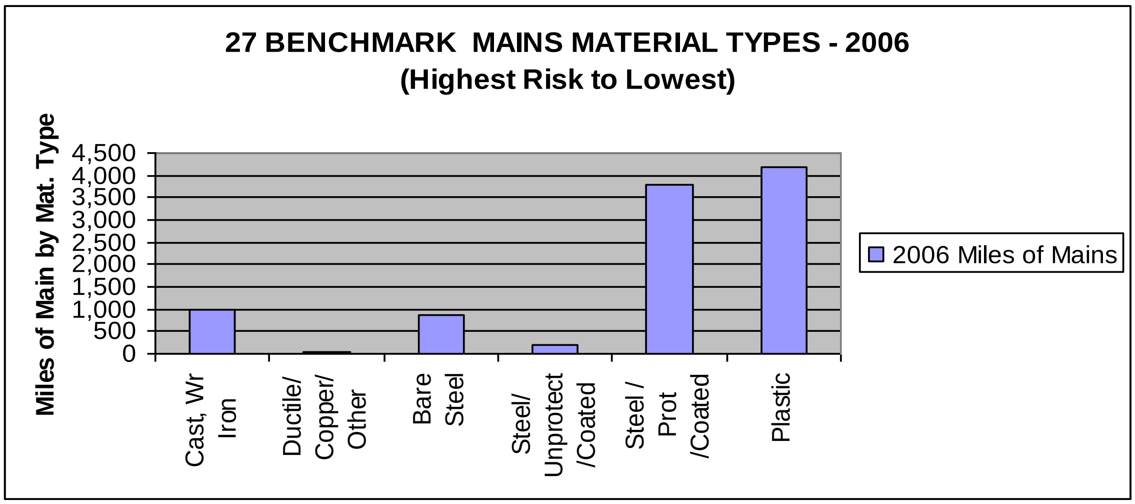
Quartile	Ranking	Abbrev Name	Cast, Wr Iron	Ductile/ Copper /Other	Bare Steel	Steel/ Unprotect/ Coated	Steel/ Prot/ Coated	Plastic	Total Mains
I	1	AGL	0%	0%	2%	0%	37%	60%	100%
I	2	LSG	3%	0%	13%	0%	29%	54%	100%
I	3	IGC	1%	0%	7%	0%	38%	54%	100%
I	4	NATFG	5%	0%	26%	0%	21%	48%	100%
I	5	MICON	15%	0%	3%	7%	28%	47%	100%
I	6	NIMO	9%	0%	1%	4%	42%	45%	100%
I	7	CGO	1%	0%	19%	0%	34%	45%	100%
II	8	EQU	1%	0%	25%	4%	25%	44%	100%
II	9	MLGW	3%	0%	0%	0%	54%	43%	100%
II	10	NJN	1%	0%	7%	1%	48%	43%	100%
II	11	CINGY	10%	0%	2%	0%	46%	42%	100%
II	12	CGP	1%	0%	31%	0%	26%	42%	100%
II	13	LACL	11%	0%	0%	0%	49%	40%	100%
III	14	ELIZ	26%	1%	0%	0%	33%	40%	100%
III	15	PSE&G	25%	0%	3%	5%	27%	40%	100%
III	16	PECO	13%	1%	6%	2%	41%	38%	100%
III	17	BG&E	20%	0%	1%	0%	41%	37%	100%
III	18	ALGAS	11%	1%	6%	5%	43%	34%	100%
III	19	SCONN	32%	0%	4%	1%	28%	34%	100%
III	20	LILCO	5%	0%	40%	11%	12%	32%	100%
IV	21	CONED	33%	0%	29%	1%	9%	28%	100%

Quartile	Ranking	Abbrev Name	Cast, Wr Iron	Ductile/ Copper /Other	Bare Steel	Steel/ Unprotect/ Coated	Steel/ Prot/ Coated	Plastic	Total Mains
IV	22	WGL	38%	0%	3%	6%	27%	27%	100%
IV	23	BOSG	37%	0%	18%	10%	12%	23%	100%
IV	24	NIGAS	1%	0%	1%	0%	75%	23%	100%
IV	25	PGL&C	41%	8%	0%	0%	30%	21%	100%
IV	26	BUG	44%	0%	10%	0%	28%	18%	100%
IV	27	PGW	54%	5%	0%	17%	16%	9%	100%
Average, 27 Benchmark Companies			10%	0%	9%	2%	38%	42%	100%

Inspection of the above table shows that firms that have either recently undertaken extensive mains modernization programs (e.g. AGL), or operate in service territories that have permitted a good proportion of system expansion in recent decades, have high proportions of plastic mains. Gas companies that have had to operate within restricted territorial bounds, or companies that have not undertaken aggressive modernization programs, tend to have smaller proportions of plastic mains.

The following comparable bar charts show directly how PGW's main material types contrast with the average material types of each of the three groups we compare to PGW. In the first chart, PGW's mains material types are shown. The next chart shows the average material types for the broadest group of twenty-seven benchmark companies:

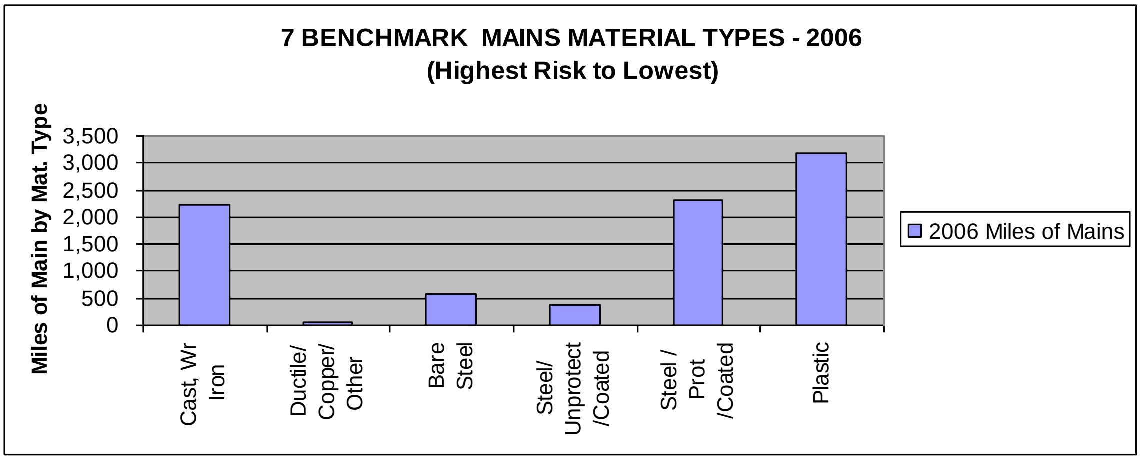




The above charts show that PGW's material types fall mostly into the more obsolete material types that are on the left side of each chart, whereas the twenty-seven benchmark systems as a whole have mostly the more modern material types shown on the right-hand side of the charts.

Smaller Benchmark Group – Types of Materials Used for Mains

The following chart presents the types of materials used in the mains of the seven natural gas companies most comparable to PGW. The types of materials are arranged again so that the material types that are most "obsolete" are at the left end of the chart and the most modern material types are at the right:

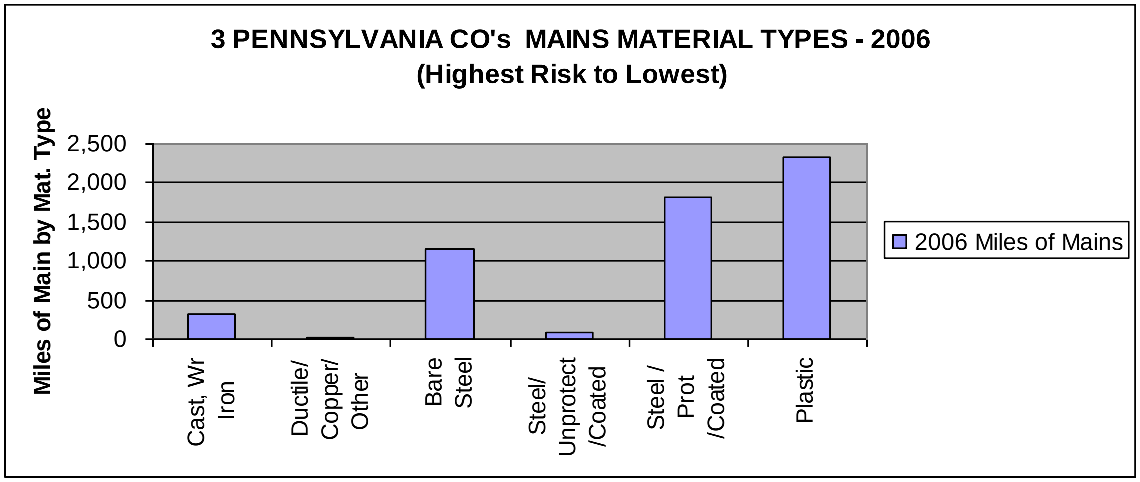


The average material types shown for the seven benchmark companies in the above chart are seen to include a substantial mileage of cast iron – much like PGW. However these seven benchmarks, taken as a whole, also have substantially more protected steel and plastic mains.

PGW has a smaller amount (0 miles) of bare (uncoated) steel than either of the above benchmark groups. This material (as well as ductile iron and cast iron) is generally targeted for replacement within modernization programs. Unprotected steel is frequently replaced as well, if it can't be electrically protected.

Pennsylvania Benchmark Utilities – Types of Materials Used for Mains

The other three Pennsylvania utilities are seen in the following table to have a moderate amount of cast iron and significant mileage of both protected/ coated steel and plastic mains in their systems:



The three PA Companies shown above were shown in a previous table to all have close to the average plastic content of 42% exhibited by the twenty-seven utilities in the larger benchmark group, falling into the second or third quartile. PGW's position in the fourth quartile is a result apparently of its limited expansion opportunities for new plastic mains into new geographic areas, and therefore PGW is forced to place more reliance upon replacement programs to increase its mileage of plastic main. At its recent replacement mileage of about 18 miles per year, it will be many years until PGW can also show significant mileage of plastic main.

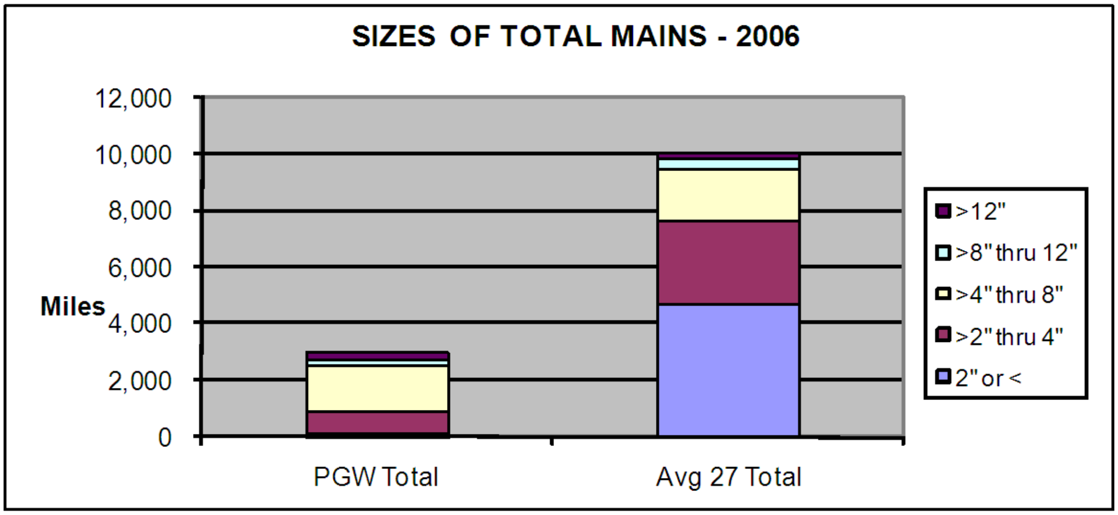
Size Ranges of Mains

PGW operates primarily a low-pressure gas distribution system, with pressures generally in the 4.5- to 9.5-inches of water-column pressure range. These very low pressures contribute to the safety of PGW's system since they reduce the amount of gas that escapes when a leak or break occurs. However, the low pressure requires larger-diameter mains to deliver the same amount of gas. Larger diameter mains of a given material type are more costly to purchase and install, but they also contribute to the system's safety since larger-diameter mains have thicker walls.

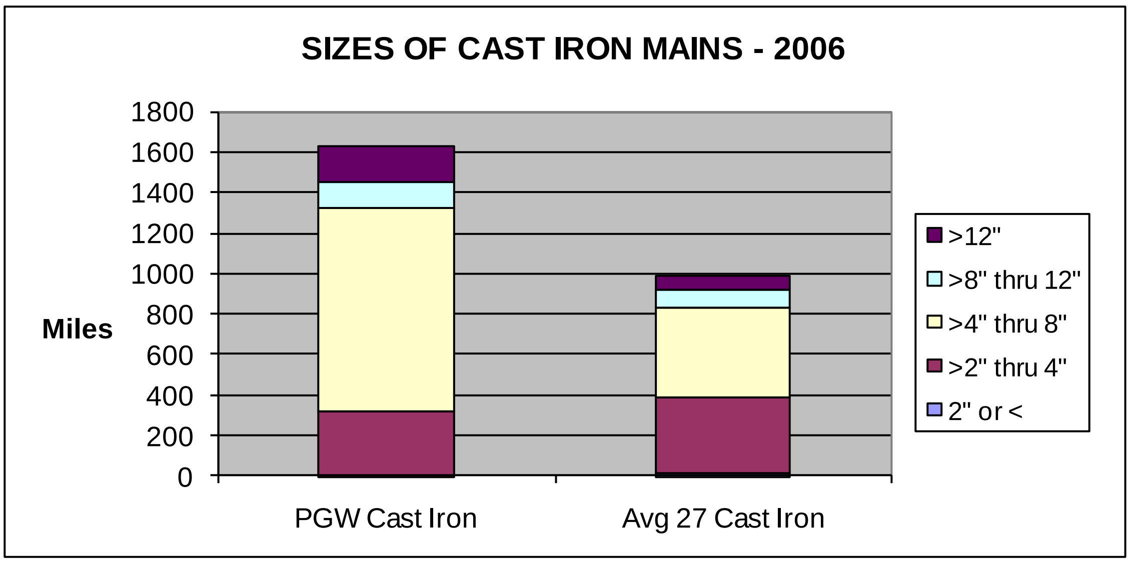
Larger Benchmark Group – Size Ranges of Mains

The following chart illustrates the size ranges of mains for both PGW and for the average utility in the larger benchmark group. The chart compares the mileage of each pipe diameter used in the systems. The first chart presents mains of all material types. The second chart presents the mileage of just the cast iron mains.

For total material types, the average utility, on the right side of the chart, has about half of its mains in the two-inch (or less) diameter range as shown below. PGW has virtually no mains of that diameter. The difference is primarily due to PGW's predominately low pressure system in place than in the benchmark firms. Plastic mains can have small diameters because they can support much higher pressures of gas. PGW's system, on the left side of the chart, is shown to contain primarily pipe diameters four-inch and larger, but little over eight-inch.

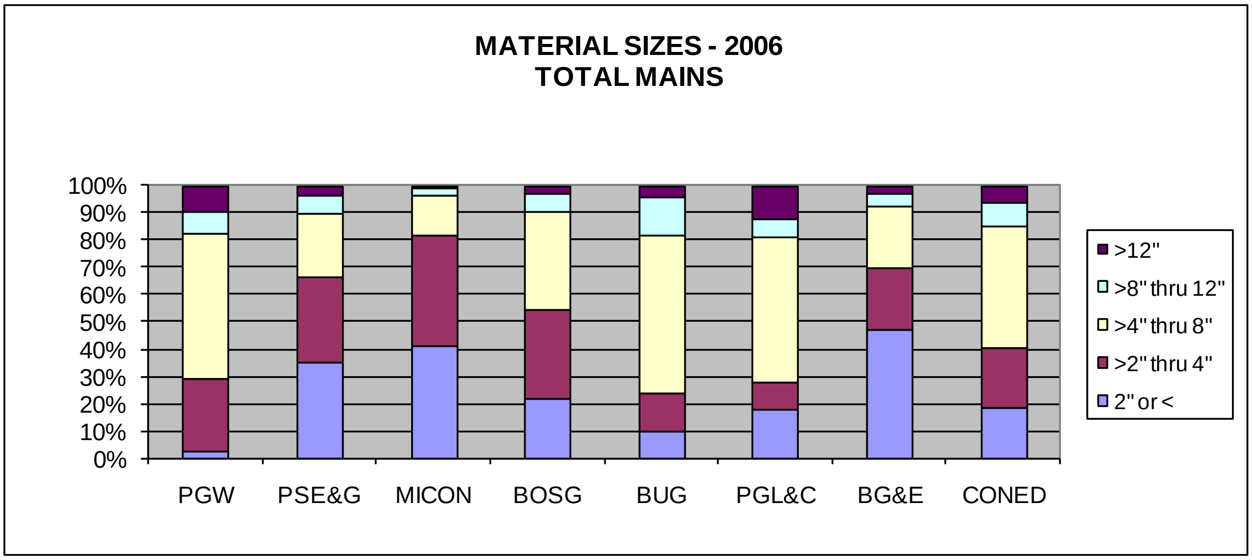


In the following chart, where only cast iron mains are depicted, PGW's system is shown to contain more cast iron than the typical company in the 27-benchmark group. PGW's C.I. mains are similar to the larger group in terms of mileage of four-inch main, but PGW's system has much more of the six- or eight- inch size.



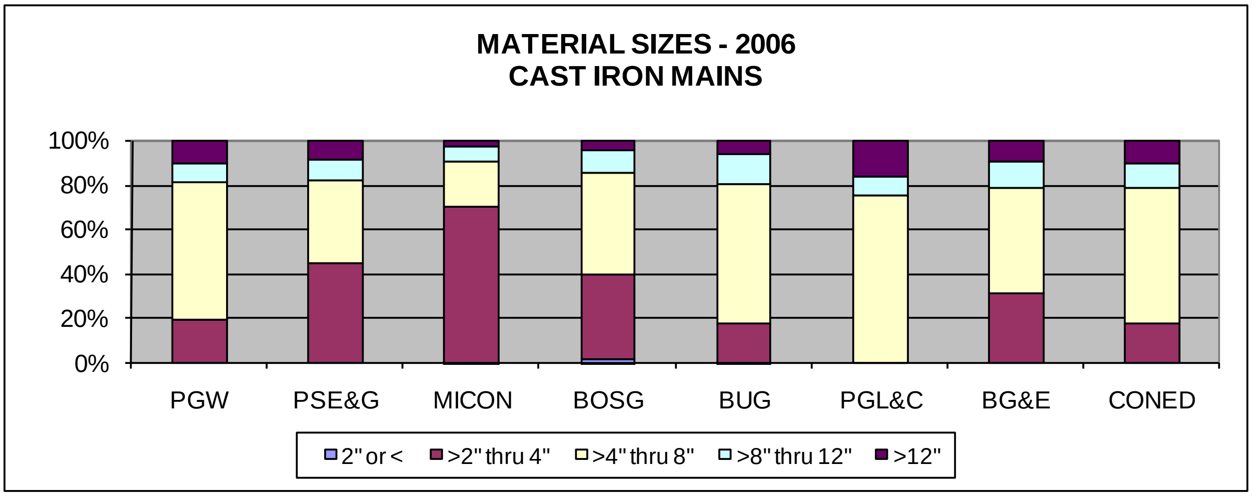
Smaller Benchmark Group – Size Ranges of Mains

The following chart of the seven most comparable benchmark companies again shows that PGW has less 2-inch main that the others – again probably signifying less plastic in its system. The amounts of all larger diameters, however, seem to be comparable.



The chart below shows the same diameter information as the chart above. However, it represents only the cast iron portion of each system, rather than all material types.

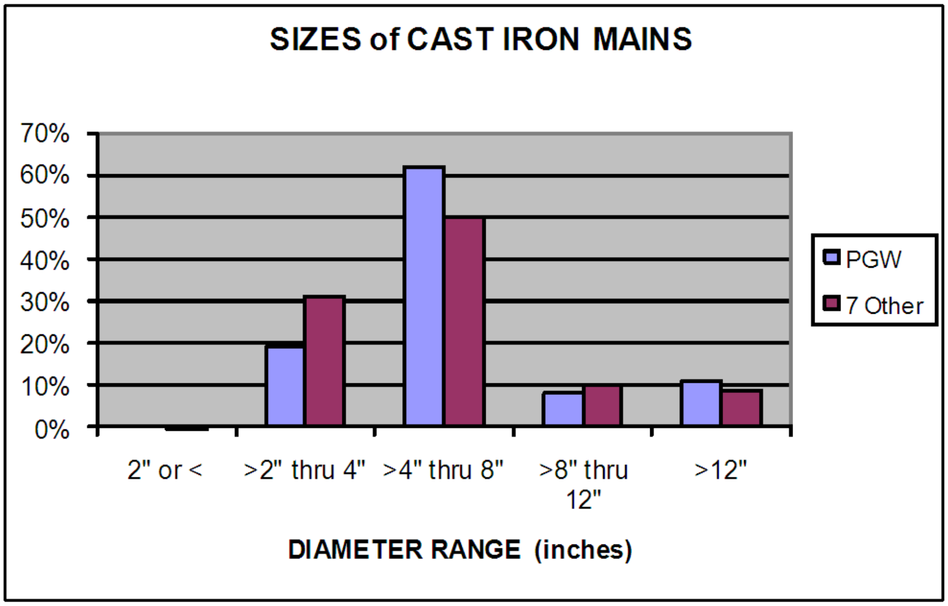
Small-diameter cast iron mains are more susceptible to breakage than large–diameter cast iron mains. This is due to the very low beam strength of cast iron, meaning that it cannot bend like plastic or steel pipes can when subjected to stresses. PGW's size ranges for its cast iron mains appear comparable to – or larger (better) than – those of the other seven utilities shown. This is partly due to PGW's emphasis on preferential replacement of small-diameter cast iron, a generally accepted safety measure.



The cast iron size ranges for the smaller benchmark group can also be compared as a whole against PGW's size ranges, as shown below.

In the following chart, there appears to be comparability in cast iron main sizes among these utilities, when taken as a group. Note that none of the most comparable utilities appear to have any significant amount of 2-inch or smaller cast iron remaining in their systems.

PGW also has less 4-inch main than the group taken as a whole.



Age Ranges of Mains

PGW, founded in 1836, is one of the oldest gas companies in the U.S., and as such it would be expected to have some of the oldest mains. In its early years, cast iron was the type of material in common usage. Gas companies formed in later years, as well as gas companies that have undergone significant mains modernization programs, will in general have smaller percentages of cast iron main remaining in their systems.

Larger Benchmark Group – Age Ranges of Mains

The following table shows the decades in which the mains remaining in each system were installed for the 27 companies in the large benchmark group. The ranking in the table is based on the percent of main each gas company has that was installed in the oldest decade (pre-1940).

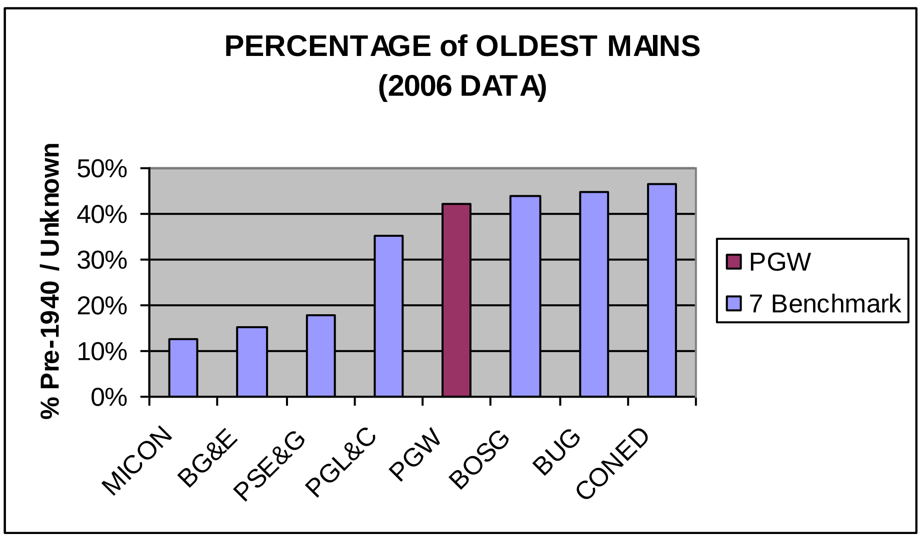
Remaining Miles of Main by Construction Decade

Quartile	Ranking	Abbrev. Name	Un-known	Pre-1940	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	Total Mains Installed	% Total Mains Pre 1940 or Unknown
I	1	NIGAS	0	619	405	4,521	7,872	4,967	4,332	4,420	5,535	32,671	2%
I	2	NJN	0	208	51	590	1,576	378	1,383	1,453	911	6,550	3%
I	3	AGL	800	182	144	1,460	4,856	4,198	6,510	7,037	4,656	29,843	3%
I	4	IGC	84	363	138	960	2,500	1,162	2,037	3,031	1,859	12,134	4%
I	5	ALGAS	772	0	553	1,929	1,657	1,295	1,416	1,891	859	10,372	7%
I	6	NIMO	0	680	63	1,747	1,675	709	1,215	1,712	635	8,436	8%
I	7	CINGY	0	470	62	276	1,016	396	632	1,264	1,241	5,358	9%
II	8	MLGW	0	464	464	465	930	932	558	697	253	4,763	10%
II	9	PECO	0	689	159	633	1,241	735	1,062	1,363	732	6,614	10%
II	10	CGO	0	2,069	339	2,957	4,371	2,263	2,702	3,105	1,785	19,591	11%
II	11	LACL	0	912	98	1,103	1,968	1,251	912	1,327	693	8,264	11%
II	12	MICON	0	2,338	854	2,241	3,506	2,147	1,431	3,976	1,897	18,390	13%
II	13	EQU	0	427	116	289	428	435	526	653	433	3,307	13%
II	14	BG&E	0	1,040	210	828	1,052	584	276	1,898	859	6,747	15%
III	15	NATFG	0	1,486	267	870	1,854	1,124	1,545	1,578	813	9,537	16%
III	16	CGP	0	1,227	262	1,087	1,247	695	1,077	1,054	611	7,260	17%
III	17	PSE&G	0	3,104	443	1,935	3,069	1,556	3,069	2,940	1,388	17,504	18%
III	18	LILCO	0	1,605	490	1,298	1,310	438	467	922	966	7,496	21%
III	19	LSG	0	6,835	1,423	3,216	4,570	2,510	3,768	2,701	2,962	27,985	24%
III	20	SCONN	0	659	39	168	385	222	304	288	193	2,258	29%
III	21	ELIZ	962	6	4	50	331	218	553	615	287	3,026	32%
IV	22	PGL&C	0	1,417	0	341	290	332	637	587	421	4,025	35%
IV	23	PGW	0	1,268	210	524	365	182	217	133	120	3,019	42%

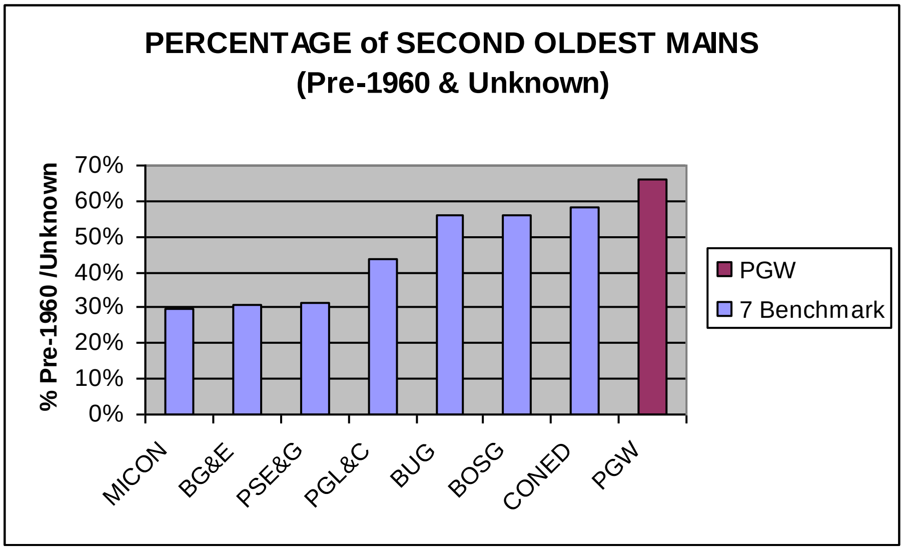
Quartile	Ranking	Abbrev. Name	Un-known	Pre-1940	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	Total Mains Installed	% Total Mains Pre 1940 or Unknown
IV	24	BOSG	0	2,713	210	536	912	350	222	597	636	6,175	44%
IV	25	BUG	0	1,800	125	329	401	275	367	416	320	4,033	45%
IV	26	WGL	143	408	42	99	99	68	109	158	65	1,191	46%
IV	27	CONED	0	1,976	168	333	290	303	339	554	293	4,256	46%
		TOTAL	2,761	34,965	7,339	30,785	49,771	29,725	37,665	46,370	31,423	270,805	
		Average	102	1,295	272	1,140	1,843	1,101	1,395	1,717	1,164	10,030	14%

Smaller Benchmark Group – Age Ranges of Mains

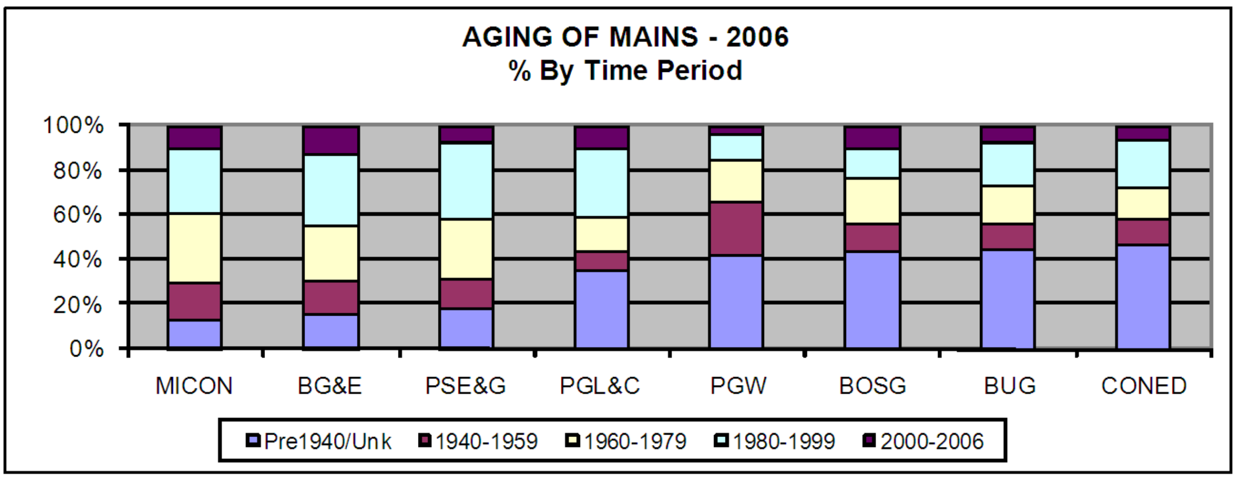
The following chart shows the percentage of mains that were installed during the oldest time period for the most comparable group of seven benchmark companies.



A similar chart is shown below for the percentage of mains installed through 1960 (the second-oldest time grouping).



Another chart for these gas companies, showing the ages of all mains, is shown below.



Service Line Statistics

The next several comparisons are directed at service line statistics. Tables showing the numbers of services by material type and the average service length are presented.

Number of Services by Material Type

Larger Benchmark Group – Number of Services by Material Type

The following table ranks each of the twenty-seven benchmark companies on their total number of service lines. PGW ranks above the middle of the list, having somewhat fewer than the average number of services:

Total Number of Services (2006)

Quartile	Ranking	Abbrev. Name	Steel Services	Copper Services	Polyethylene Services	Other Services	Total Services
I	1	WGL	29,019	12,189	80,824	0	122,032
I	2	SCONN	49,423	190	79,836	0	129,449
I	3	ELIZ	35,536	42,672	121,908	7	200,123
I	4	EQU	74,721	5,785	164,672	0	245,178
I	5	MLGW	110,803	0	192,203	0	303,006
I	6	CONED	151,558	25,078	203,226	933	380,795
I	7	CINGY	40,423	69,535	283,509	4,976	398,443
II	8	PECO	66,618	2,831	335,842	0	405,291
II	9	CGP	153,648	0	261,691	0	415,339
II	10	NJN	134,609	0	310,338	0	444,947
II	11	PGW	175,036	42	271,203	0	446,281
II	12	NATFG	141,249	0	309,020	0	450,269
II	13	BOSG	172,805	10,410	186,040	107,817	477,072
III	14	LILCO	198,443	5,775	291,332	0	495,550
III	15	PGL&C	50,948	19,852	411,608	24,892	507,300
III	16	BG&E	180,553	27,261	302,938	0	510,752
III	17	NIMO	163,706	20,064	341,003	3,387	528,160
III	18	ALGAS	283,621	1,229	250,658	45	535,553

Quartile	Ranking	Abbrev. Name	Steel Services	Copper Services	Polyethylene Services	Other Services	Total Services
III	19	BUG	93,239	142,141	324,247	0	559,627
III	20	LACL	135,402	100,335	371,752	0	607,489
IV	21	IGC	149,055	138	462,050	0	611,243
IV	22	MICON	315,936	144,697	727,651	11	1,188,295
IV	23	PSE&G	534,278	33,201	670,646	6	1,238,131
IV	24	CGO	491,552	0	842,348	0	1,333,900
IV	25	LSG	564,455	0	907,581	0	1,472,036
IV	26	AGL	364,650	57	1,176,306	0	1,541,013
IV	27	NIGAS	454,938	94,473	761,081	647,699	1,958,191
Total, 27 benchmark companies			5,316,224	757,955	10,641,513	789,773	17,505,465
Average, 27 benchmark companies			196,897	28,072	394,130	29,251	648,351

Larger Benchmark Group – Percent of Services by Material Type

The previous benchmark comparison focused on the number of service lines in each utility's system. The following benchmark comparisons show the proportions of all types of materials used in the service lines of each system. The focus here is on plastic (polyethylene) services since this material is generally considered to be the most modern type of material available for use in gas pipes.

Services by Material Type – 27 Benchmark Companies (2006)

Quartile	Ranking	Abbrev. Name	Steel Services	Copper Services	Polyethylen e Services	Other Services	Total Services
I	1	MLGW	16%	1%	83%	0%	100%
I	2	CONED	10%	4%	81%	5%	100%
I	3	CGP	24%	0%	76%	0%	100%
I	4	ALGAS	24%	0%	76%	0%	100%
I	5	NIGAS	10%	17%	71%	1%	100%
I	6	BUG	30%	0%	70%	0%	100%
I	7	NIMO	31%	0%	69%	0%	100%

Quartile	Ranking	Abbrev. Name	Steel Services	Copper Services	Polyethylene Services	Other Services	Total Services
II	8	SCONN	30%	2%	67%	0%	100%
II	9	MICON	24%	10%	66%	0%	100%
II	10	CGO	31%	4%	65%	1%	100%
II	11	PGL&C	37%	0%	63%	0%	100%
II	12	IGC	37%	0%	63%	0%	100%
II	13	PGW	37%	0%	63%	0%	100%
III	14	ELIZ	38%	0%	62%	0%	100%
III	15	LSG	38%	0%	62%	0%	100%
III	16	AGL	27%	12%	61%	0%	100%
III	17	PECO	22%	17%	61%	0%	100%
III	18	NATFG	18%	21%	61%	0%	100%
III	19	EQU	39%	0%	61%	0%	100%
III	20	NJN	35%	5%	59%	0%	100%
IV	21	BG&E	40%	1%	59%	0%	100%
IV	22	WGL	17%	25%	58%	0%	100%
IV	23	LILCO	43%	3%	54%	0%	100%
IV	24	PSE&G	40%	7%	53%	0%	100%
IV	25	LACL	53%	0%	47%	0%	100%
IV	26	CINGY	36%	2%	39%	23%	100%
IV	27	BOSG	23%	5%	39%	33%	100%
Average, 27 benchmark companies			30%	4%	61%	5%	100%

In the table above, PGW is shown to rank right in the middle of the 27 benchmark companies. Its proportion of plastic service pipes is shown to be 63%, which is slightly higher than the average (61%). PGW has an aggressive modernization program for services, converting some 38,800 services from steel to plastic during the last 10-year period (1997 - 2006). During its main replacement programs each year, as a main is replaced, Advantica understands that PGW’s policy is that all of the services connected to that main are also renewed. PGW’s current proportion of plastic service lines is an outstanding accomplishment for any gas distribution company, but particularly so for a company that does not enjoy the luxury of extending its system into new suburban areas where modern plastic services can be installed when the customer is first connected.

Smaller Benchmark Group – Percent of Services by Material Type

The following table presents the types of materials used in the service lines of the natural gas companies most comparable to PGW. The table is ranked according to percentage of plastic (polyethylene) service lines, which are the most modern material type.

Services by Material Type – Seven Benchmark Companies (2006)

Ranking	Abbrev. Name	Steel Services	Copper Services	Polyethylene Services	Other Services	Total Services
1	CONED	10%	4%	81%	5%	100%
2	BUG	30%	0%	70%	0%	100%
3	PGL&C	37%	0%	63%	0%	100%
4	PGW	37%	0%	63%	0%	100%
5	BG&E	40%	1%	59%	0%	100%
6	WGL	17%	25%	58%	0%	100%
7	PSE&G	40%	7%	53%	0%	100%
8	BOSG	23%	5%	39%	33%	100%
Average, 8 benchmark companies		29%	5%	61%	5%	100%

PGW is shown in the above table to rank fourth out of eight – slightly better than the average of the comparable utilities. Its proportion of plastic service pipes is shown to be 63%, which is slightly higher than the average (61%) for all eight benchmark companies.

Pennsylvania Benchmark Utilities – Percent of Services by Material Type

PGW's proportion of plastic services is comparable to the plastic percentage of the other three Pennsylvania gas utilities shown in the table for the larger benchmark group. Two of the other Pennsylvania gas utilities – PECO and Equitable – are ranked just below PGW, right at the average plastic material proportion (61%) exhibited by both benchmark groups. Columbia Gas of Pennsylvania ranks higher than PGW at 76% plastic services.

Length of Service Lines

The average length of a service line for a gas company can reveal much about the general nature of its environment. Long service lines appear mainly in suburban and country environments, where customers are set back significant distances from the roadway. Shorter average lengths reveal urban environments where customers are located close to the roads. Extremely short lengths can also indicate very narrow roads, such as those constructed prior to the advent of motorized vehicles. In general, the shorter the service line length, the greater the risk of gas migration from a main break or joint leak into the customer's location.

Larger Benchmark Group – Length of Service Lines

The following table illustrates the average length of service lines for each gas utility in the larger benchmark grouping.

Average Service Length (2006)

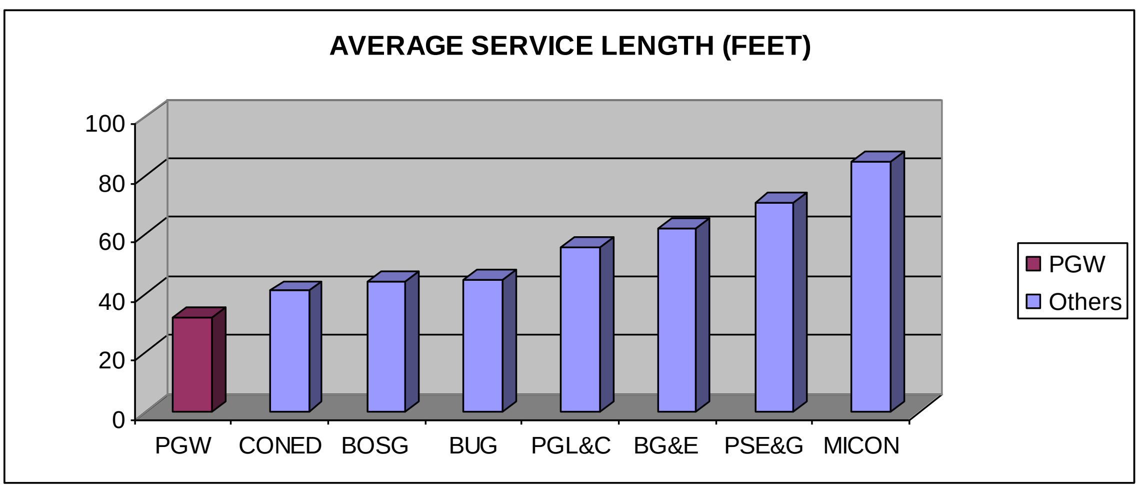
Quartile	Ranking	Abbrev. Name	Total Services, 2006	Average Service Length (feet), 2006
I	1	ALGAS	535,553	122
I	2	AGL	1,541,013	104
I	3	IGC	611,243	88
I	4	MICON	1,188,295	85
I	5	NJN	444,947	79
I	6	PSE&G	1,238,131	71
I	7	NIMO	528,160	71
II	8	PECO	405,291	71
II	9	LACL	607,489	67
II	10	LILCO	495,550	65
II	11	CINGY	398,443	65
II	12	BG&E	510,752	62
II	13	MLGW	303,006	60
III	14	SCONN	129,449	60
III	15	PGL&C	507,300	56
III	16	NIGAS	1,958,191	53
III	17	CGP	415,339	52
III	18	ELIZ	200,123	52
III	19	NATFG	450,269	50
III	20	WGL	122,032	50

Quartile	Ranking	Abbrev. Name	Total Services, 2006	Average Service Length (feet), 2006
IV	21	BUG	559,627	45
IV	22	BOSG	477,072	44
IV	23	CONED	380,795	41
IV	24	PGW	446,281	32
IV	25	LSG	1,472,036	32
IV	26	CGO	1,333,900	20
IV	27	EQU	245,178	17
Total, 27 benchmark companies			17,505,465	1,614
Average, 27 benchmark companies			648,351	60

PGW has one of the shortest average service lengths (32 feet) of any of the 27 benchmarked companies shown above, ranked in the middle of the fourth quartile. The average length for all 27 companies is 60 feet.

Smaller Benchmark Group – Length of Service Lines

PGW, as shown in the following chart, has the shortest service lines (average 32 feet long) of any of the most comparable benchmark companies. Short service lines are good for minimizing installation and renewal costs. However, there is more risk involved, since short services indicate narrow streets that can lead to more congestion and potential mains interference problems.



Shorter services also indicate the possibility that a solid service cover all the way from the street to the buildings could potentially not provide a path for gas to escape therefore increasing the probability for gas in building incidents.

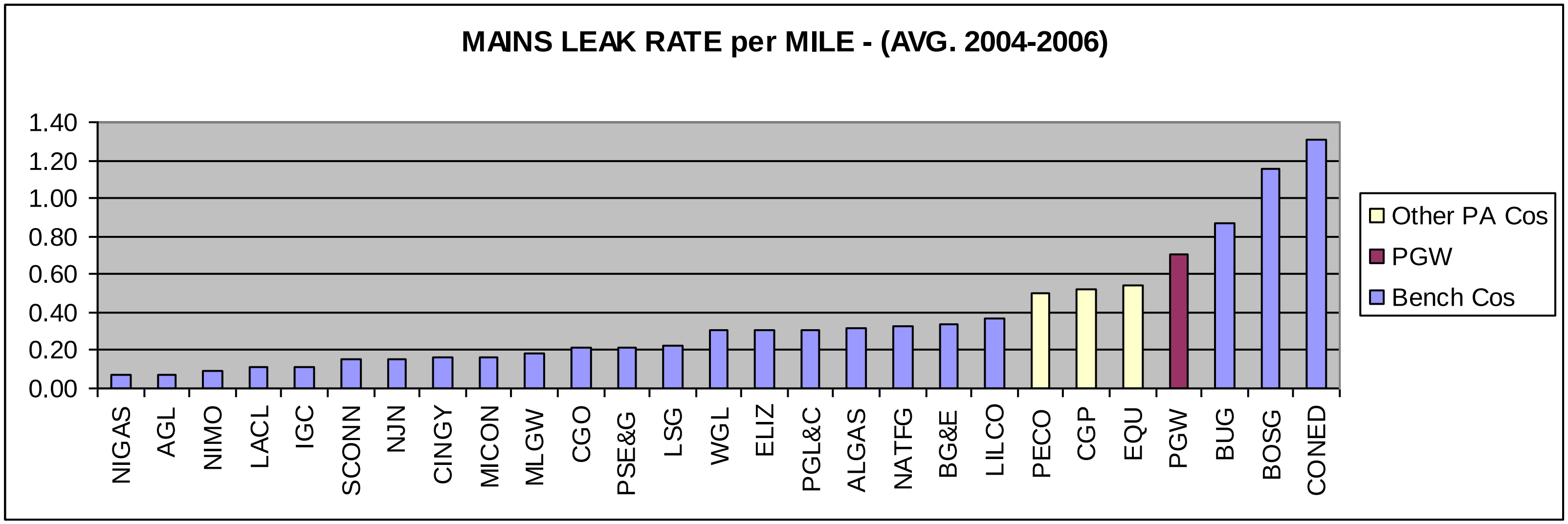
Leaks & Unaccounted-For Gas (UFG)

Two measures of escaping gas are present in the data compiled by the DOT for each distribution company's system: leak rates and unaccounted-for gas (UFG) percentage rates. In the following section, we will review mains leaks per mile, their underlying causes, and system-wide annual UFG percentages.

Larger Benchmark Group – Mains Leak Rate

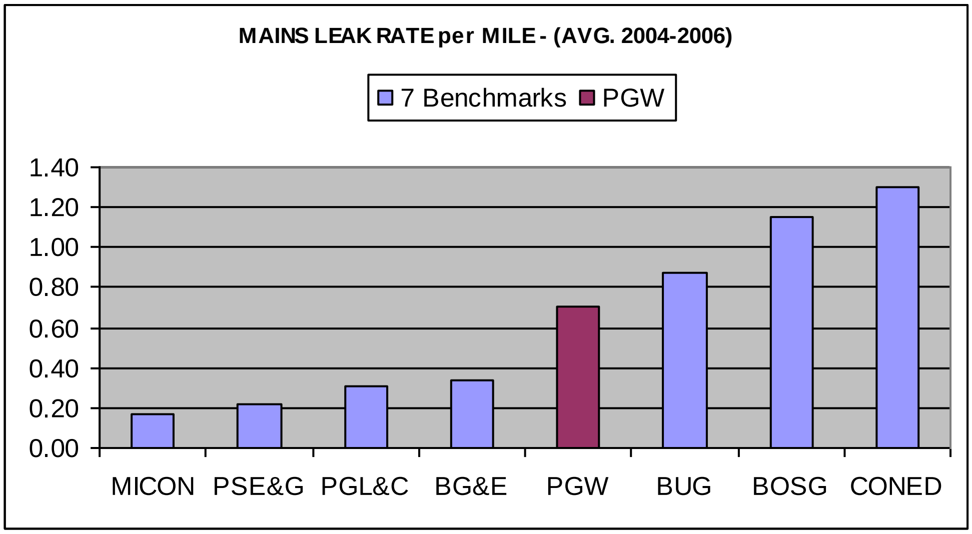
This mains leak rate data was extracted from the annual DOT reports for each utility. The following chart shows the leak rates reported by all 27 benchmark gas utilities. Leak rate is the average number of mains leaks reported for the last 3 years (2004 - 2006) for all categories of leaks, divided by the latest year's (2006) mileage of mains reported for each utility's distribution system. Causal categories for leaks were expanded and redefined in 2004, eliminating the possibility for comparisons over a longer time period than 3 years.

PGW ranks toward the higher end of the benchmark group, with a leak rate of 0.70 per mile of main. In rough generalities, the companies with large amounts of more recently installed or replaced main systems (for example, higher contents of plastic mains) exhibit the lower leak rates, and conversely those with older systems that have higher portions of cast iron mains fall at the higher end. There are also exceptions; for example, two of the three other Pennsylvania companies (CGP and EQU) have smaller amounts of cast iron and higher amounts of plastic, but still report leak rates toward the higher end of the benchmark comparison.


MAINS LEAK RATE per MILE - (AVG. 2004-2006)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
NIGAS
AGL
NIMO
LACL
IGC
SCONN
NJN
CINGY
MICON
MLGW
CGO
PSE&G
LSG
WGL
ELIZ
PGL&C
ALGAS
NATFG
BG&E
LILCO
PECO
CGP
EQU
PGW
BUG
BOSG
CONED
Other PA Cos
PGW
Bench Cos

Smaller Benchmark Group – Mains Leak Rate

For the smaller group of seven benchmark utilities that are the most comparable to PGW, PGW falls in the middle of the group in terms of leak rate per mile of main. The three gas companies ranked higher than PGW in leak rate – BUG, BOSG, and CONED – all have relatively high cast iron and relatively low plastic proportions in their mains system, compared to the larger group of 27 companies. However compared to PGW, these three gas utilities all have somewhat smaller amounts of cast iron and somewhat higher amounts of plastic. One could argue from this that PGW, with its more obsolete material types, is performing better than the three companies with higher leak rates, at least in this perspective.



Causes of Mains Leaks

Gas distribution systems are required to assign the cause of each leak in their system and report the number of leaks each year according to standard classifications of cause. A comparison of causes can indicate whether or not a particular operator is experiencing approximately the same causes as others, or whether there is something peculiar to their system that is skewing the pattern of leaks into a particular causal category.

Larger Benchmark Group – Causes of Mains Leaks

The table below presents the average 3-year causes for the leaks in each of the 27 benchmark companies. Gas companies are listed in this table according to their number of leaks per mile of main.

Average Mains Leaks (3-year Average, 2004 – 2006)

Abbrev. Name	Corrosion / Mains	Natural Forces/ Mains	Excavation / Mains	Other Outside Force Damage/ Mains	Material Or Welds/ Mains	Equipment / Mains	Operations / Mains	Other/ Mains	Total Mains Leaks	Total Miles of Mains, 2006	Average Leaks per Mile of Main
NIGAS	322	227	423	0	1,061	0	0	392	2,425	32,671	0.07
AGL	542	30	992	46	307	255	32	56	2,259	29,843	0.08
NIMO	222	93	82	32	21	9	3	321	783	8,436	0.09
LACL	306	36	205	10	24	171	4	200	957	8,264	0.12
IGC	214	27	122	67	308	130	23	522	1,412	12,134	0.12
SCONN	35	65	16	0	5	213	1	3	338	2,258	0.15
NJN	505	101	108	2	125	31	22	92	986	6,550	0.15
CINGY	152	452	153	1	92	1	1	29	882	5,358	0.16
MICON	1,267	261	271	0	43	550	1	650	3,043	18,390	0.17
MLGW	14	5	81	34	180	78	216	262	870	4,763	0.18
CGO	2,865	83	417	0	31	115	98	520	4,129	19,591	0.21
PSE&G	776	2,317	127	234	70	0	54	181	3,759	17,504	0.21
LSG	955	121	1,553	351	414	76	561	2,280	6,311	27,985	0.23
WGL	119	76	31	0	91	0	0	44	362	1,191	0.30
ELIZ	74	58	47	34	67	29	6	610	925	3,026	0.31
PGL&C	60	50	130	50	1	5	0	942	1,238	4,025	0.31
ALGAS	781	125	389	24	156	249	23	1,541	3,289	10,372	0.32
NATFG	2,590	57	155	4	98	2	12	228	3,147	9,537	0.33
BG&E	185	206	99	32	23	281	23	1,444	2,292	6,747	0.34
LILCO	1,149	237	132	0	218	29	0	964	2,728	7,496	0.36
PECO	2,676	97	128	0	25	36	0	354	3,315	6,614	0.50
CGP	2,991	43	235	0	16	89	107	276	3,757	7,260	0.52
EQU	1,364	1	43	13	24	22	0	328	1,794	3,307	0.54
PGW	126	1,913	18	1	11	33	1	12	2,115	3,019	0.70
BUG	319	72	175	8	135	23	0	2,773	3,506	4,033	0.87
BOSG	1,907	2,901	104	26	413	42	13	1,708	7,113	6,175	1.15

Abbrev. Name	Corrosion / Mains	Natural Forces/ Mains	Excavation / Mains	Other Outside Force Damage/ Mains	Material Or Welds/ Mains	Equipment / Mains	Operations / Mains	Other/ Mains	Total Mains Leaks	Total Miles of Mains, 2006	Average Leaks per Mile of Main
CONED	2,006	180	63	0	3	253	0	3,047	5,551	4,256	1.30
TOTAL	24,521	9,835	6,300	967	3,962	2,719	1,200	19,779	69,283	270,805	9.79
AVERAGE	908	364	233	36	147	101	44	733	2,566	10,030	0.36

Smaller Benchmark Group – Causes of Mains Leaks

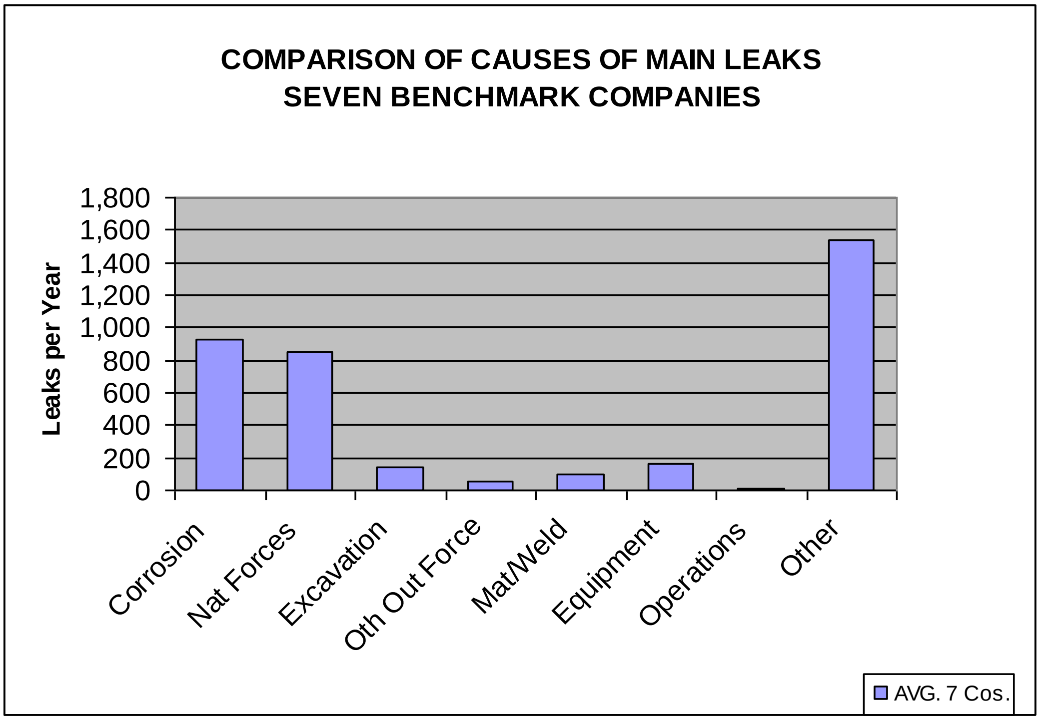
The information in the table above regarding causes of leaks is repeated below for the seven most-comparable gas companies.

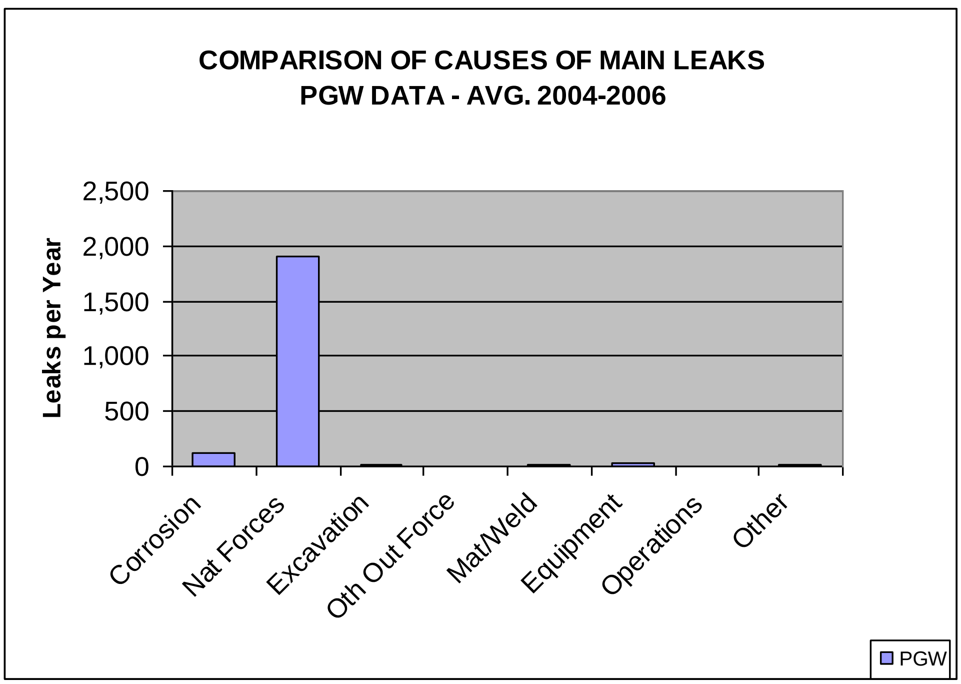
Main Leaks per Mile and Leak Causes
PGW and Seven Selected Benchmark Distribution Utilities

Abbrev. Name	Corrosion/ Mains	Natural Forces/ Mains	Excavation/ Mains	Other Outside Force Damage/ Mains	Material Or Welds /Mains	Equipment / Mains	Operations /Mains	Other/ Mains	Total Mains Leaks	Total Miles of Mains, 2006	Average Leaks per Mile of Main
MICON	1,267	261	271	0	43	550	1	650	3,043	18,390	0.17
PSE&G	776	2,317	127	234	70	0	54	181	3,759	17,504	0.21
PGL&C	60	50	130	50	1	5	0	942	1,238	4,025	0.31
BG&E	185	206	99	32	23	281	23	1,444	2,292	6,747	0.34
PGW	126	1,913	18	1	11	33	1	12	2,115	3,019	0.70
BUG	319	72	175	8	135	23	0	2,773	3,506	4,033	0.87
BOSG	1,907	2,901	104	26	413	42	13	1,708	7,113	6,175	1.15
CONED	2,006	180	63	0	3	253	0	3,047	5,551	4,256	1.30
Totals	6,519	5,987	969	349	687	1,153	91	10,746	26,502	61,130	4.35
AVG. 7 Cos.	931	855	138	50	98	165	13	1,535	3,786	8,733	0.62

Comparison of Causes of Main Leaks

The following chart shows leak causes for PGW from 2004 through 2006. The second chart below shows the same information for the seven gas companies in the smaller benchmark group.





Notice the difference in patterns shown for causes of leaks for PGW compared to those for the smaller benchmark group. This may indicate that, for some reason, PGW's mains are more susceptible to natural forces (such as frost heave) than are the mains of other gas companies. But the more logical explanation is just a difference in classification of causes by the operating staffs. Most other utilities classify joint leaks as "Other" where PGW classifies joint leaks as "Natural Forces".

Classification of Mains Leaks

The instructions for classification of leak causes are shown below.

- **Corrosion:** Leak resulting from a hole in the pipe or other component that galvanic, bacterial, chemical, stray current, or other corrosive action causes.
- **Natural Forces:** Leak resulting from earth movements, earthquakes, landslides, subsidence, lightning, heavy rains/floods, washouts, flotation, mudslide, scouring, temperature, frost heave, frozen components, high winds, or similar natural causes.
- **Excavation:** Leak resulting from damage caused by earth moving or other equipment, tools, or vehicles. Include leaks from damage by operator's personnel or contractor or people not associated with the operator.
- **Other Outside Force Damage:** Leak caused by fire or explosion and deliberate or willful acts, such as vandalism.
- **Material and Welds:** Leak resulting from failure of original sound material from force applied during construction that caused a dent, gouge, excessive stress, or other defect that eventually resulted in a leak. This includes leaks due to faulty wrinkle bends, faulty field welds, and damage sustained in transportation to the construction or fabrication site. Also include leak resulting from a defect in the pipe material, component, or the longitudinal weld or seam due to faulty manufacturing procedures. Leaks from material deterioration, other than corrosion, after exceeding the reasonable service life, are reported under "Other."
- **Equipment and Operations:** Leak resulting from malfunction of control/relief equipment including valves, regulators, or other instrumentation; stripped threads or broken pipe couplings on nipples, valves, or mechanical couplings; or seal failures on gaskets, O-rings, seal/pump packing, or similar leaks. Also include leaks resulting from inadequate procedures or safety practices, or failure to follow correct procedures, or other operator error.
- **Other:** Leak resulting from any other cause, such as exceeding the service life, not attributable to the above causes.

The above Federal Instructions on Leaks Classification can also be found at the following DOT website:

> http://ops.dot.gov/library/forms/gasd/GasDistAnnualInstructions_122007_Final_7100_1_1.doc

End-of-Year Outstanding Leaks

In addition to the number of leaks reported per year, another measure of leaks that is included in the data required by the DOT is called "Outstanding Leaks." This is a one-time, instantaneous count of the number of leaks in an operator's backlog. It is a measure of the speed of response in clearing out the reported leaks. The count is taken on the final day of the year.

Larger Benchmark Group – End-of-Year Outstanding Leaks

The table below presents data for all 27 benchmark companies regarding end-of-year (EOY) leaks reported and a calculation of EOY leaks reported per mile.

PGW's end-of-year leak backlog (per mile of main) ranks in the second quartile of the following table. However, we would caution on the quality of the figures submitted for these DOT statistics by all utilities, since differences can occur due to different reporting policies.

The differences for companies relate to whether they should file just their number of Class 1 leaks, or whether they should file the total of Class 1, Class 2, and Class 3 leaks. A strict reading of the instructions, which state that the operator should enter "the number of known system leaks at the end of the year scheduled for repair," has apparently led some companies to only submit Class 1 leaks, since many other leaks may have been reported but not yet verified. After discussing the apparent intent of the instruction with OPS personnel, their impression is that most of the benchmark companies are submitting all classes of leaks, or at least Classes 1 and 2. However, we would point out that individual interpretations of these instructions by each gas company may vary.

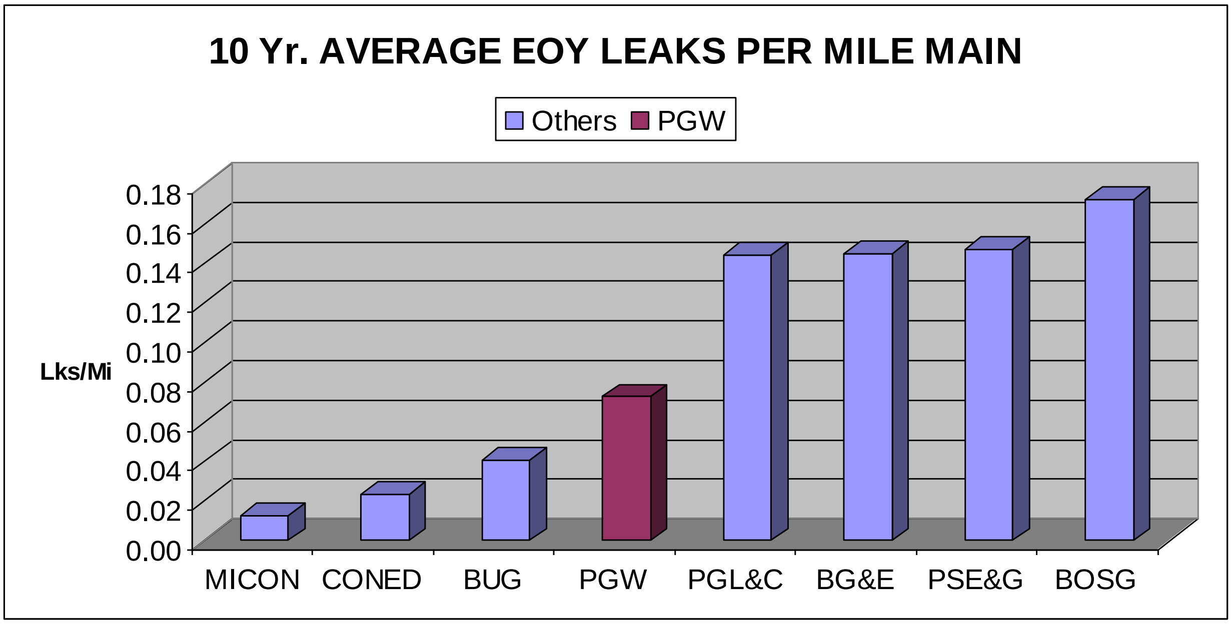
End-of-Year Leaks Outstanding
(10-Year Average)

Quartile	Ranking	Abbrev. Name	End-of-Year Reported Leaks	Total Miles of Mains, 2006	Avg. EOY Leaks per Mi. of Main
I	1	MICON	237	18,390	0.01
I	2	NATFG	205	9,537	0.02
I	3	CONED	100	4,256	0.02
I	4	AGL	712	29,843	0.02
I	5	LILCO	243	7,496	0.03
I	6	NIMO	291	8,436	0.03
I	7	BUG	164	4,033	0.04
II	8	ALGAS	614	10,372	0.06
II	9	PGW	219	3,019	0.07

Quartile	Ranking	Abbrev. Name	End-of-Year Reported Leaks	Total Miles of Mains, 2006	Avg. EOY Leaks per Mi. of Main
II	10	SCONN	255	2,258	0.11
II	11	CGO	2,727	19,591	0.14
II	12	PECO	944	6,614	0.14
II	13	PGL&C	582	4,025	0.14
III	14	BG&E	979	6,747	0.15
III	15	ELIZ	443	3,026	0.15
III	16	PSE&G	2,575	17,504	0.15
III	17	IGC	1,883	12,134	0.16
III	18	NIGAS	5,102	32,671	0.16
III	19	LSG	4,566	27,985	0.16
III	20	BOSG	1,065	6,175	0.17
IV	21	CINGY	1,180	5,358	0.22
IV	22	MLGW	1,107	4,763	0.23
IV	23	CGP	1,750	7,260	0.24
IV	24	LACL	2,182	8,264	0.26
IV	25	WGL	340	1,191	0.29
IV	26	NJN	2,231	6,550	0.34
IV	27	EQU	1,445	3,307	0.44
Total, 27 benchmark companies			34,141	270,805	3.97
Average, 27 benchmark companies			1,264	10,030	0.15

Smaller Benchmark Group – End-of-Year Outstanding Leaks

The following chart for the seven gas companies most comparable to PGW shows that the number of leaks reported by PGW ranks favorably low compared to those of the benchmarked companies.



Pennsylvania Benchmark Utilities – End-of-Year Outstanding Leaks

The above table for the 27 larger benchmark companies shows that two of the other Pennsylvania utilities (CGP and EQU) rank in the fourth quartile. PECO ranks in the second quartile for EOY leaks on a per-mile-of-main basis, along with the fourth Pennsylvania utility. Comparatively low EOY leak data shown above for all of PGW's most-comparable benchmark companies may be real or it may arise from different interpretations of the guidelines for entry of different classes of leaks, as discussed above.

Unaccounted-For Gas

In addition to leak counts and leaks outstanding, a third measure reported annually for the integrity of a system is called unaccounted-for gas (UFG). UFG is calculated by an extremely complicated formula, unique to each company, which attempts to account for the difference between all of the inputs of gas to the system (such as gas purchases) and all of the outputs (such as sales or inventory). The difference is considered gas which must have been lost from the system. One complication in the calculation has to do with an enormous amount of measurements which have to be compensated due to differences in temperatures and pressures, meter accuracy, theft of service and escape of gas due to Third Party Damage.

Larger Benchmark Group – Unaccounted-For Gas

The following table ranks each of the 27 benchmark companies on their 10-year average amount of UFG reported to the DOT. Statistics are also shown in the table for percentage of cast iron mains and for percentage of cast iron and unprotected steel mains, since these are the categories of mains that are most likely to have gas leaks which would be sources of UFG.

10-Year Average UFG Statistics (1997 – 2006)

Quartile	Ranking	Abbrev. Name	Unacct for Gas%	Cast Iron as a % of Total Mains	Cast Iron & Unprotected Steel as a % of Total Mains
I	1	MICON	0.7	16%	26%
I	2	PSE&G	0.7	28%	35%
I	3	CGO	0.7	2%	22%
I	4	IGC	0.7	2%	13%
I	5	CINGY	0.8	17%	21%
I	6	NJN	1.0	2%	13%
I	7	BUG	1.0	47%	57%
II	8	ALGAS	1.4	12%	15%
II	9	NIMO	1.4	11%	22%
II	10	NATFG	1.5	6%	34%
II	11	NIGAS	1.5	2%	2%
II	12	CGP	1.5	1%	35%
II	13	AGL	1.7	1%	5%
III	14	ELIZ	1.7	29%	29%

Quartile	Ranking	Abbrev. Name	Unacct for Gas%	Cast Iron as a % of Total Mains	Cast Iron & Unprotected Steel as a % of Total Mains
III	15	CONED	1.9	34%	68%
III	16	LILCO	2.1	6%	58%
III	17	PGL&C	2.2	46%	46%
III	18	BG&E	2.2	23%	25%
III	19	BOSG	2.3	40%	66%
III	20	LACL	2.3	12%	12%
IV	21	PECO	2.5	14%	23%
IV	22	LSG	2.6	4%	18%
IV	23	MLGW	2.6	4%	4%
IV	24	SCONN	2.8	35%	41%
IV	25	PGW	2.8	57%	74%
IV	26	WGL	3.6	40%	50%
IV	27	EQU	4.9	2%	36%
Average, 27 benchmark companies			1.9	18%	32%

In the above table, PGW ranks in the fourth quartile, along with two other Pennsylvania gas companies, as having high amounts of reported UFG. A weak correlation, at best, appears between UFG and either of the percentages of mains shown in the table. Advantica would caution that many prior studies have indicated that UFG figures are typically unreliable. They appear to be as much a result of accounting errors – subtracting two large numbers to get their difference – as they are indicative of gas leaks.

Smaller Benchmark Group – Unaccounted-For Gas

The following chart shows that PGW's amount of UFG is the highest in the smaller benchmark group of gas utilities.

10-Year Average UFG Statistics (1997 – 2006)

Ranking	Abbrev. Name	Unaccounted for Gas %	Cast Iron as a % of Total Mains	Cast Iron & Unprotected Steel as a % of Total Mains
1	MICON	0.7	16%	26%
2	PSE&G	0.7	28%	35%
3	BUG	1.0	47%	57%
4	CONED	1.9	34%	68%
5	PGL&C	2.2	46%	46%
6	BG&E	2.2	23%	25%
7	BOSG	2.3	40%	66%
8	PGW	2.8	57%	74%
Average, 8 Benchmark Companies		1.7	36%	50%

Trends in Breaks and Joint Leaks

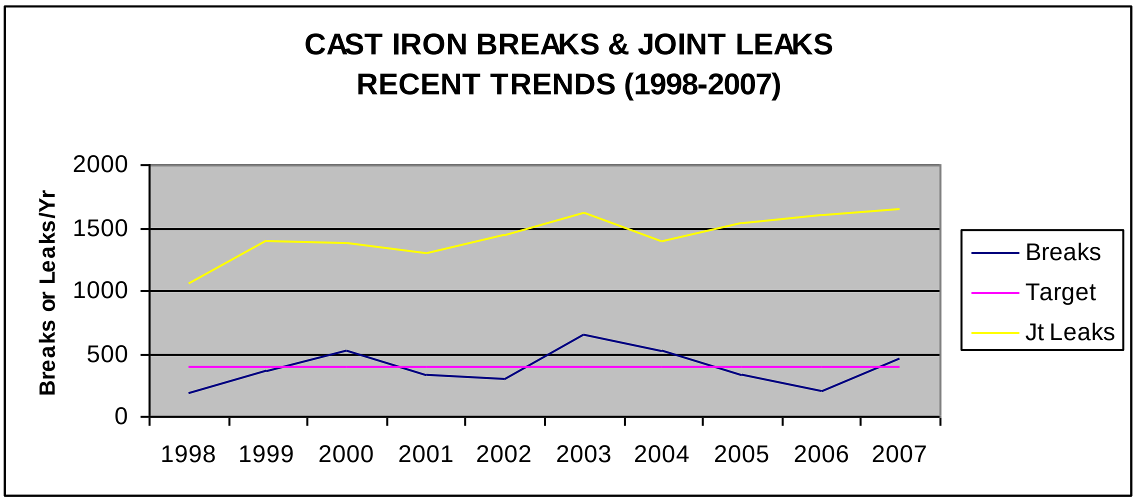
Longer-term trends in the annual numbers of cast iron main breaks and cast iron main joint leaks can be used to ascertain the sufficiency of replacement budgets. The following sections present 10-year curves of these indicators for PGW's cast iron system.

PGW – Cast Iron Breaks and Joint Leaks

PGW's trend in cast iron main breaks over the past decade has been quite level and very close to, or just under, its long-run target of 400 main breaks per year. This indicates that PGW's budgeted mileage for replacement of ageing cast iron has been appropriate to stabilize the break rate or the right amount to keep main breaks under control. Higher mileages of replacement would be expected to result in a break trend that would point slightly downward; lower annual replacement mileages would be expected to result in an upward trend for the break curve.

PGW's trend over the last decade for cast iron joint leaks appears to be trending upward, indicating a possible need for higher budgets in this area to bring the joint leak curve back to a level or declining trend.

The following chart illustrates these recent trends in PGW's cast iron main breaks and joint leaks.

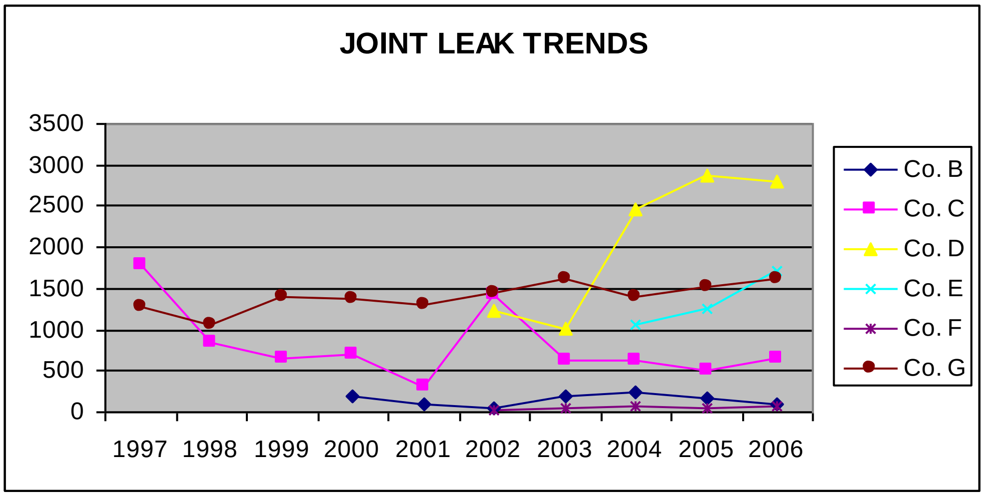


Smaller Benchmark Group – Cast Iron Breaks and Joint Leaks

Statistics on cast iron main breaks and cast iron joint leaks are not available for the benchmarked companies from the publicly available DOT annual report data source. They are lumped together with other sources of leaks. However, Advantica was able to solicit this type of information, and some replacement cost information, from most of PGW's most comparable benchmark companies by conducting a written survey. It is necessary to respect the privacy of these individual companies, since many of the survey questions were in sensitive areas. Thus, Advantica has grouped the responses so that individual companies are not identified. The same grouped information was made available to the participating survey respondents in return for their confidential disclosure.

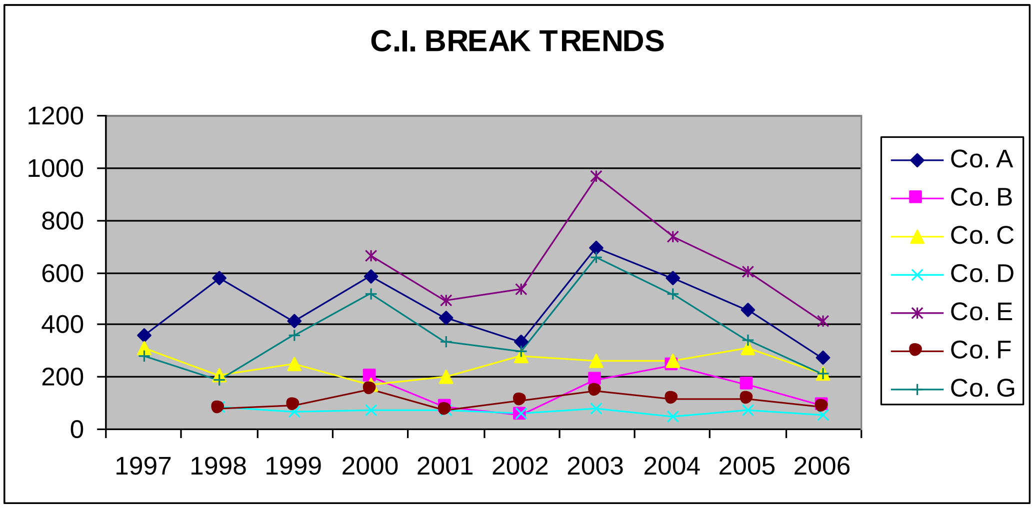
The following charts display the results of the companies that responded to the survey. This group includes five of the most comparable companies plus one from the larger benchmark group that is related to a most-comparable utility. Although the identities of these utilities are disguised, PGW is coded as "Co. G" in the comparisons.

Trends for joint leaks for all of the surveyed utilities are shown in the first chart below. Note that PGW's trend curve (shown as Co. G) differs slightly from its trend curve shown above, as the data is for a slightly different time period (1997 - 2006) below. Company A did not provide data for this comparison and B and D only provided partial data.



In general, PGW's joint leak trend, although inclining, is more regular than the trends for a few of the surveyed firms. This may be a reflection of the consistency of PGW's replacement budget for cast iron mains.

Also included in the survey were trends for cast iron main breaks. The following chart shows these trends for all of the surveyed firms.



The peaks and valleys shown in the same years for many of the survey companies may indicate that breaks are caused by cold weather. In general, many of PGW's most comparable utilities seem to have their break rates under control, as does PGW.

Incident Comparisons, Causes, and Correlations to System Parts

The definition for an "Incident" is as follows:

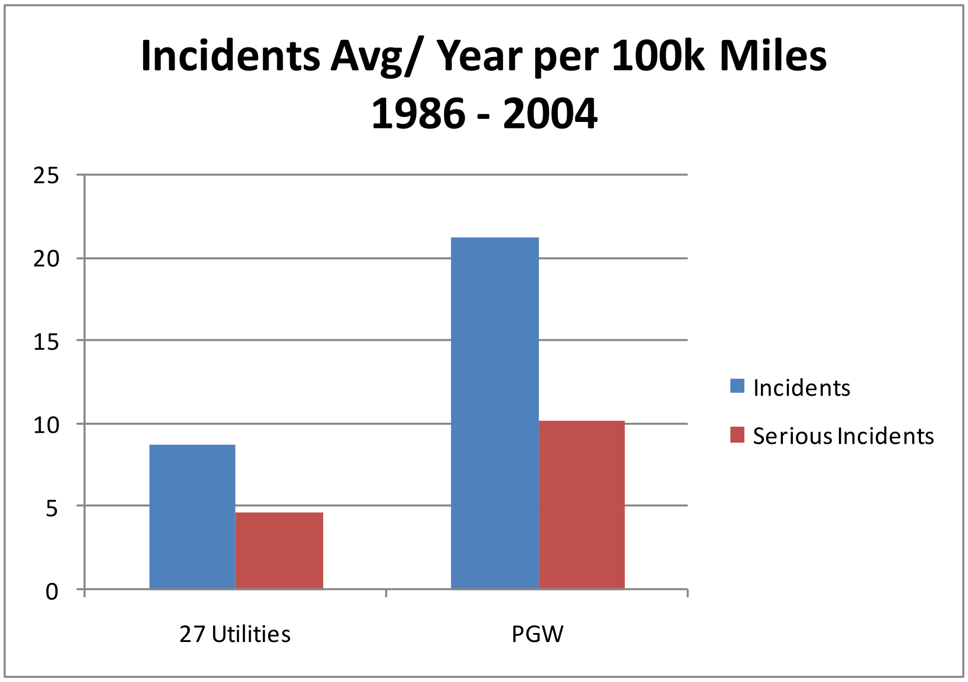
1. A release of gas from a pipeline or LNG facility and either:
    a. A death, or
    b. A personal injury necessitating in-patient hospitalization, or
    c. Property damage of $50,000 or more (incl. cost of gas lost)
2. Or, an emergency shutdown of an LNG facility
3. Or, a significant event in the judgment of the operator

NOTE: Definition of incident is Per Title 49, Sect. 191.3 of Code of Federal Regulations.

The definition for a "Serious Incident" is an incident involving either a fatality or a personal injury that requires admission to, and confinement in, a hospital facility (i.e. either 1.a or 1.b above).

Comparison of Benchmark Incident Statistics vs. PGW's

Advantica used DOT data to compare PGW's incident rates against those of the 27 benchmark companies over the 19-year period from 1986 through 2004 using a standard of incidents per year per 100,000 miles of main. Over this period PGW's incident rates (both total incidents and serious incidents) were about twice the incident rates of the benchmark firms, as shown in the following chart:

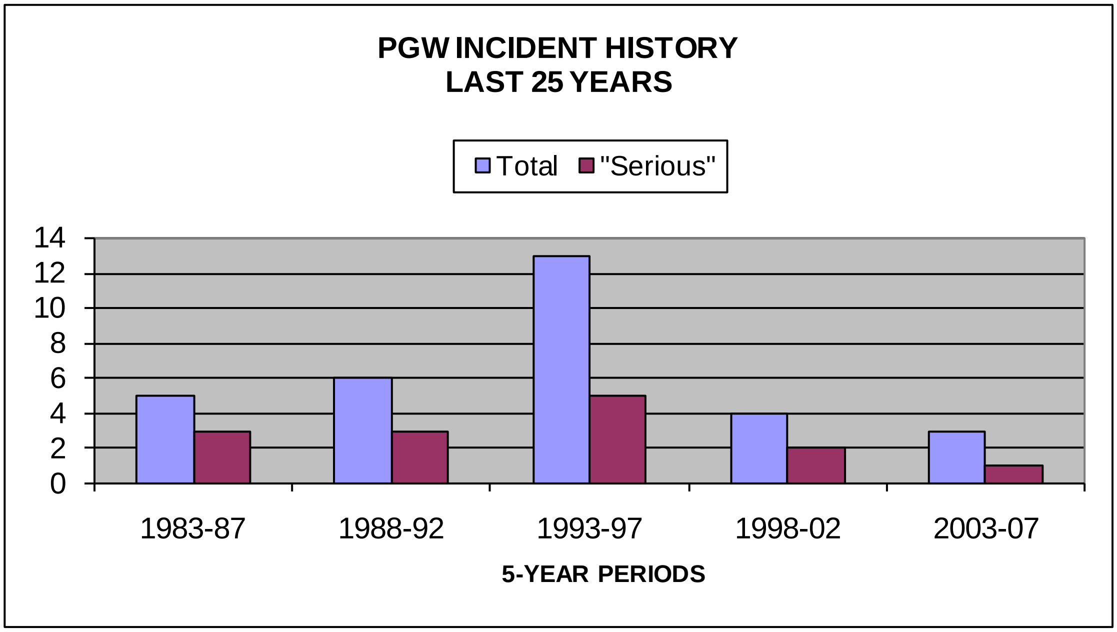


The statistics shown above for the 27 benchmark companies confirm incident statistics found in other studies of incidents across the entire U.S. gas distribution area. For instance in 2005, the AGF (American Gas Foundation) published almost identical incident rates for the entire U.S. over a 13-year period from 1990 to 2002.

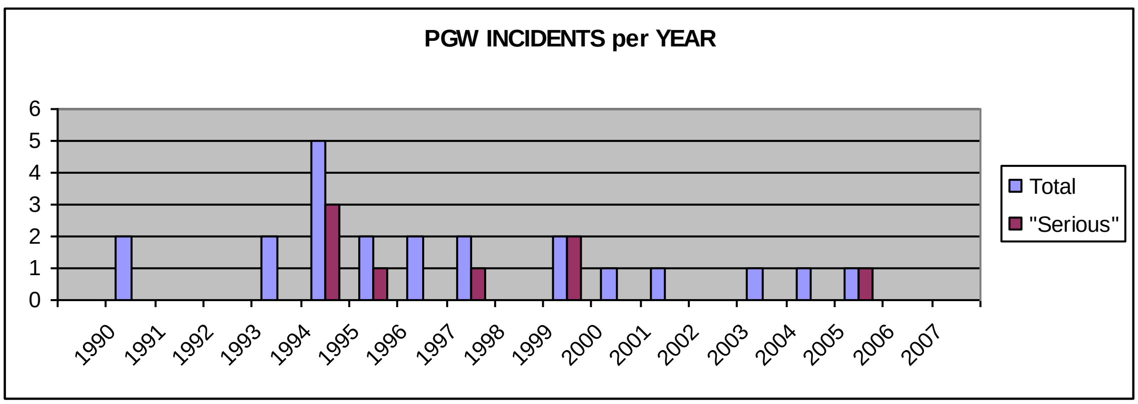
PGW's Incident Rates

The following chart contains the numbers of incidents experienced by PGW in each 5-year period during the last twenty-five year period. It indicates that PGW experienced a period of relatively high incidents during the middle of the period compared in the DOT data, shown previously. PGW also went through a period of very high incidents prior the time periods shown above (early 1980s).

PGW's incident history over the past 25 years, grouped in 5-year periods, is shown in the following chart.

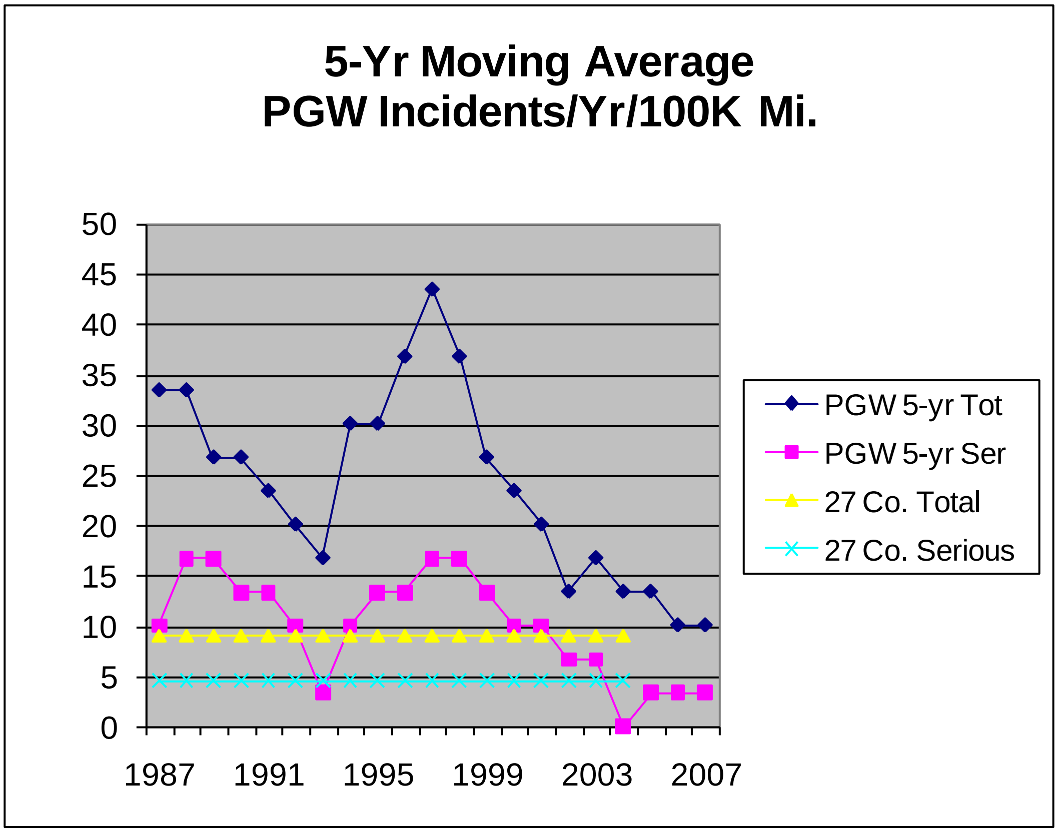


In recent years, the incidents occurring in PGW's system have declined markedly for both total incidents and for serious incidents, as shown below.

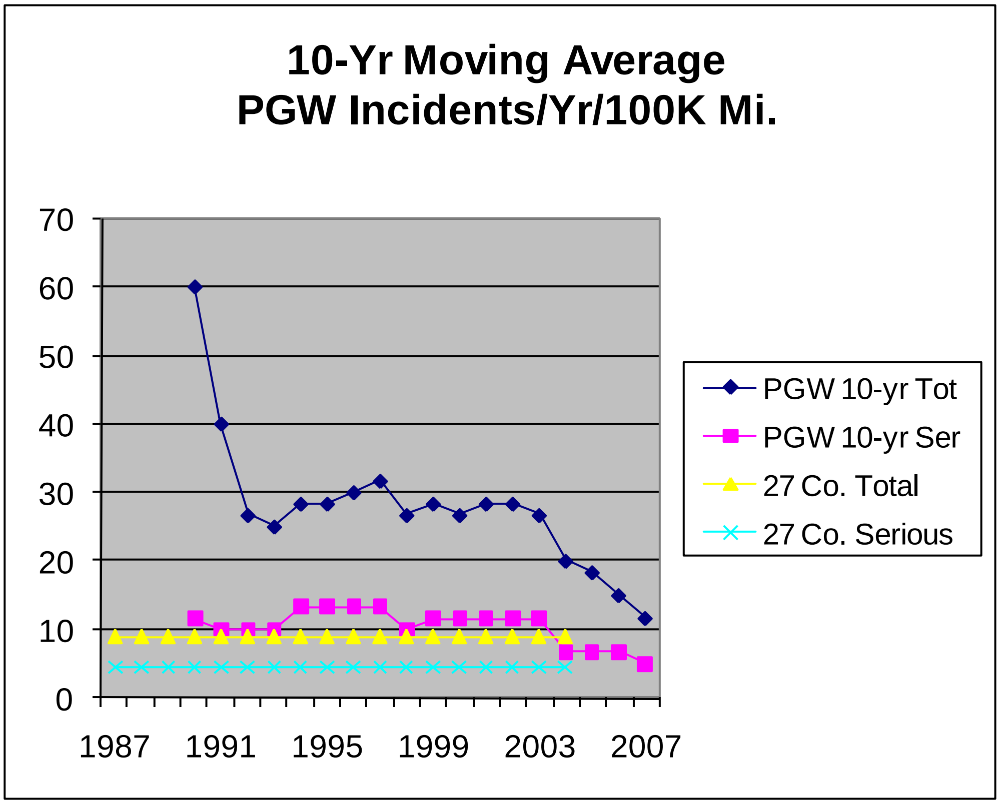


One of the best ways of illustrating trends is through the use of rolling time periods. This technique is illustrated below for rolling time periods of different lengths. The first chart employs a 5-year rolling time period. Incident counts are shown at each point on PGW's curves representing the sum of incidents occurring during the preceding 5 years. Also shown on these charts, for comparison purposes, are the incident averages contained in the DOT study, which closely approximate those of the large (27 company) benchmark group.

The following chart demonstrates that PGW's rolling 5-year incident record is trending down very close to the U.S. figures, both for total incidents and for serious incidents.



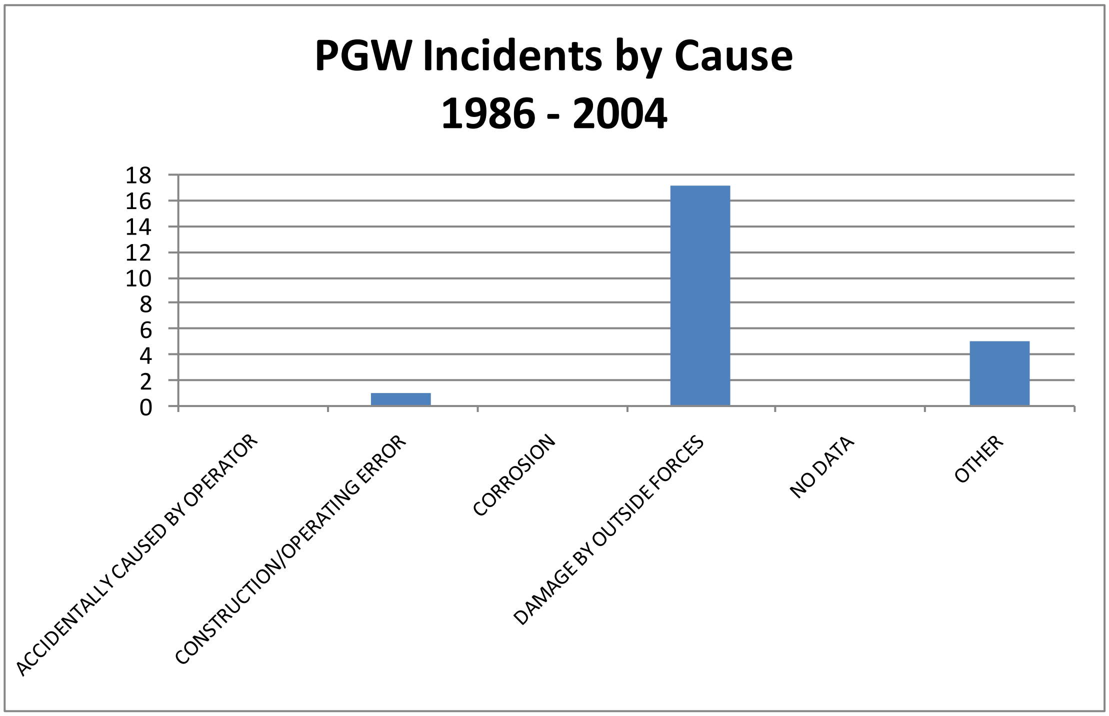
The following chart shows comparable data for 10-year rolling time periods.



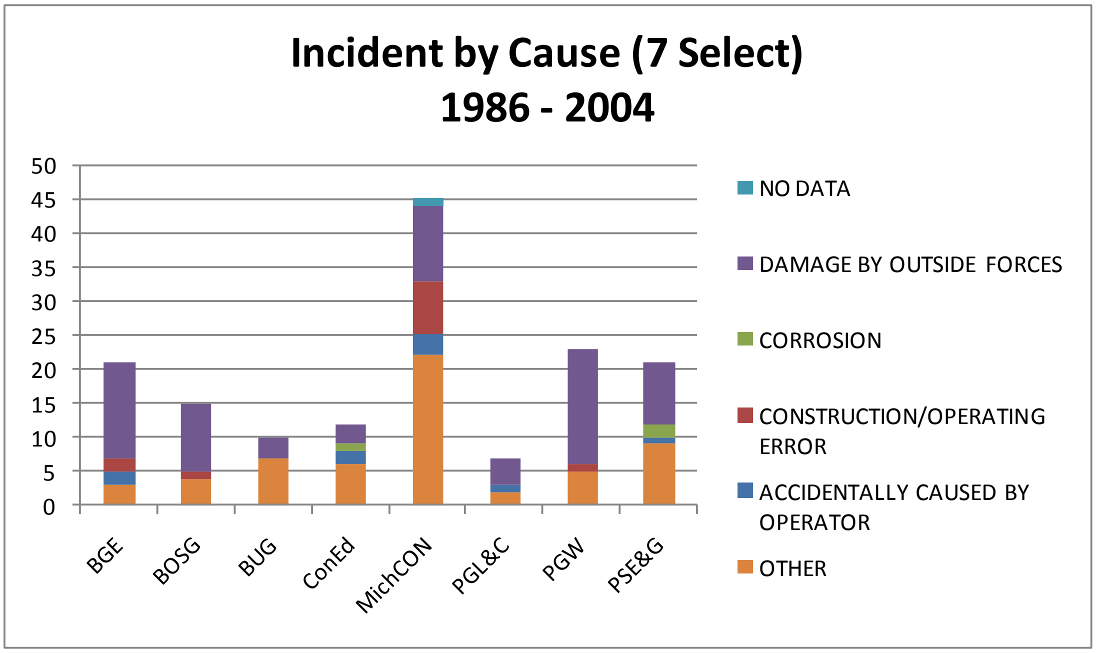
The decline in PGW's trend of total incidents is even more dramatic viewed as a 10-year cumulative trend since the first years shown above reach back to the early 1980s, when PGW experienced a rash of incidents.

Incidents by Cause

The following chart shows PGW's incidents classified by cause. This chart indicates that the majority of the causes reported by PGW for their incidents are "Outside Forces" and "Other."



For comparison, the following chart shows the incident causes compiled from DOT data.



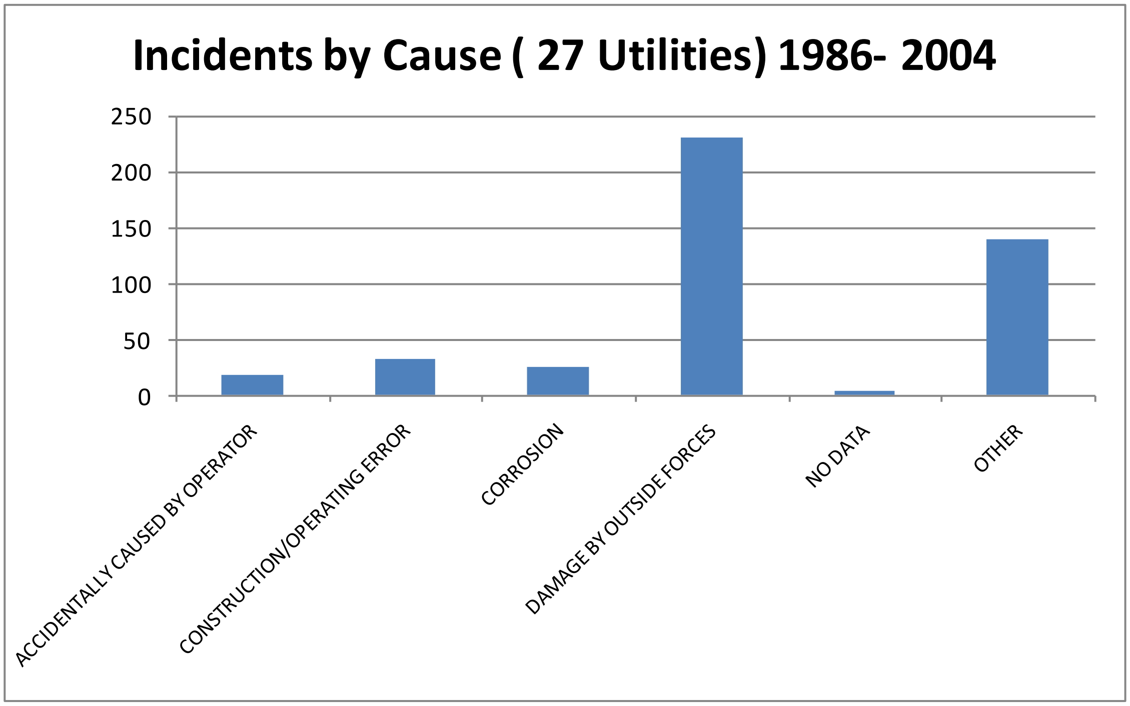
The above chart indicates that PGW's incident rate is second highest among the smaller benchmark group, but near the average incident rate, since MichCon's rate is so high that it brings the average higher.

The chart also shows that several other of the most-comparable benchmark utilities (such as BG&E and Boston Gas), in addition to PGW, designate their primary cause of incidents to be "Damage by Outside Forces".

Every one of the seven utilities shown above considers "Other" to be a significant cause.

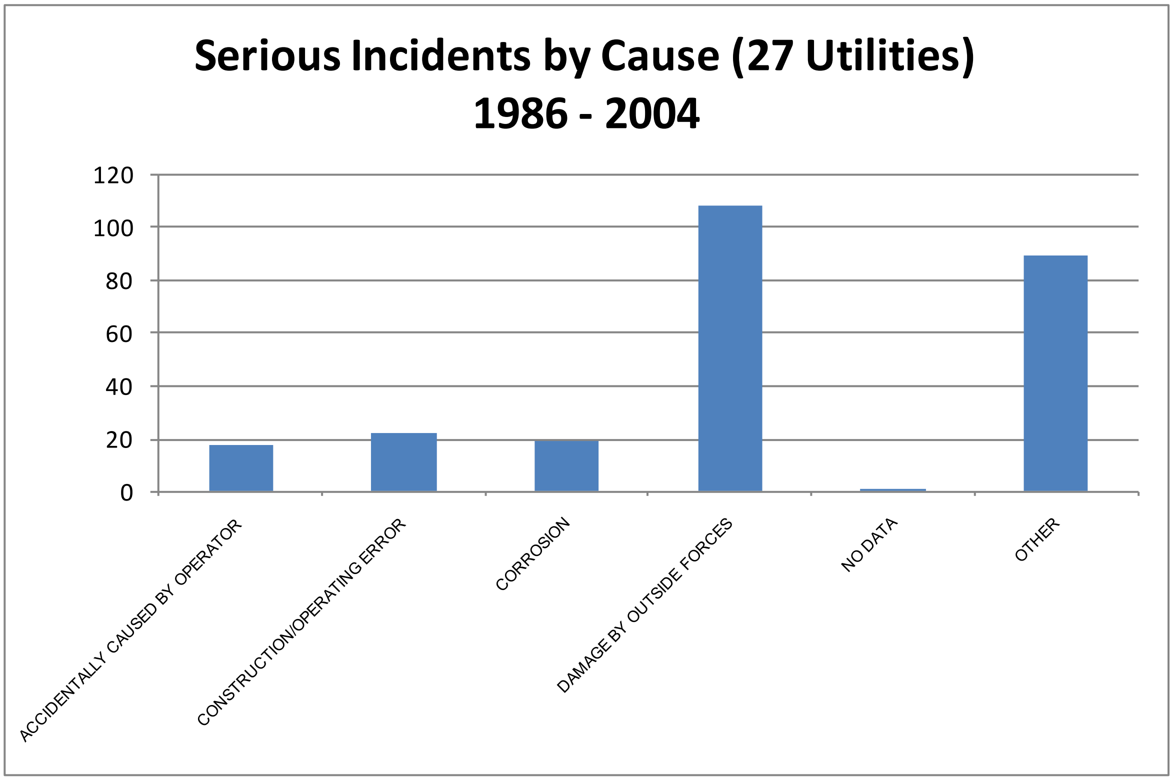
Incident Causes for Larger Benchmark Group

The following chart indicates that the same two primary causes of incidents seen in the PGW data and in the smaller group data also govern for the larger benchmark group:



The above charts show the same general pattern for incident causes in both PGW and the 27 utilities as a whole.

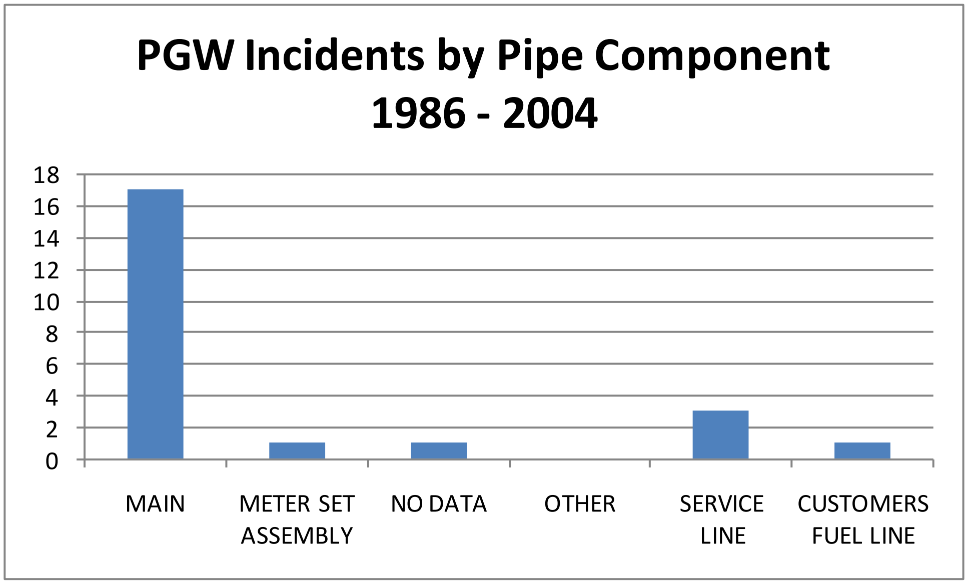
Furthermore, if we consider just the “Serious” incidents, rather than total incidents, the 27 utilities statistics indicate that the same general cause pattern applies, as shown below. The total number of serious incidents for the 27 utilities is 256.



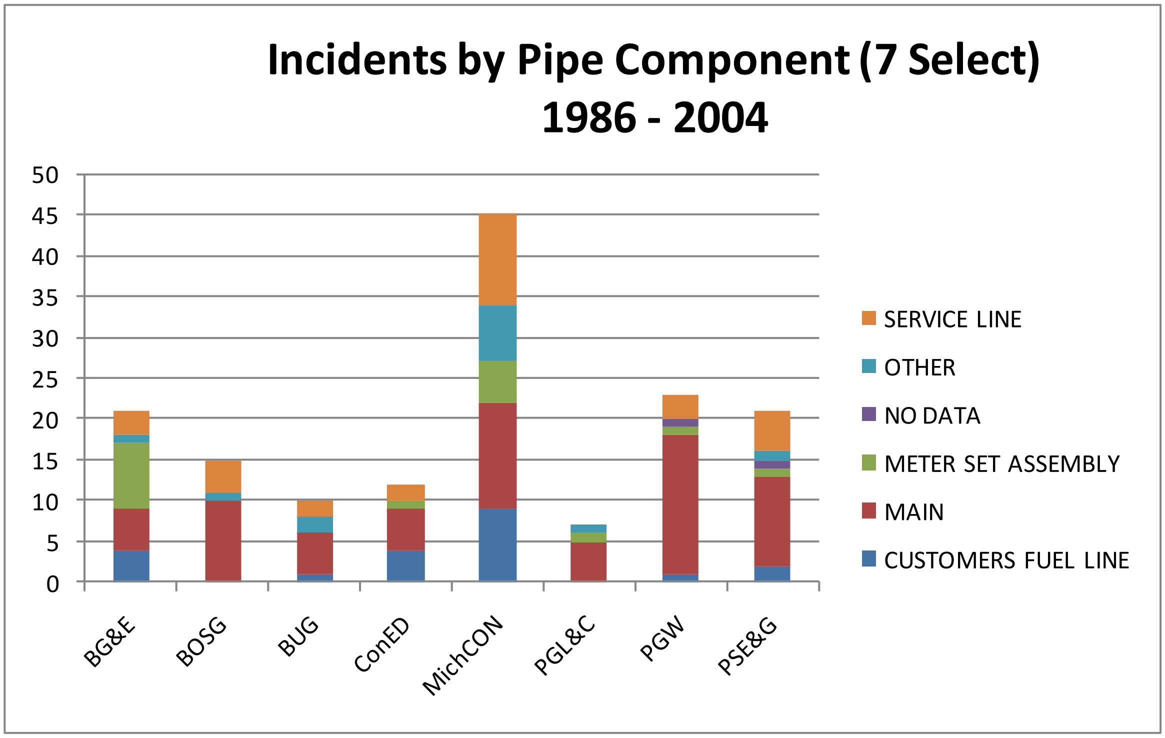
The similarity in 27 select company patterns shown above for serious incidents and for total incidents seems to indicate that they differ only in degree, not in any attributable cause. Furthermore the similarity of PGW's cause patterns to those of the 27 utilities might indicate that PGW's incidents are not caused by anything peculiar to its system, but rather are caused by the same factors present in other utility systems.

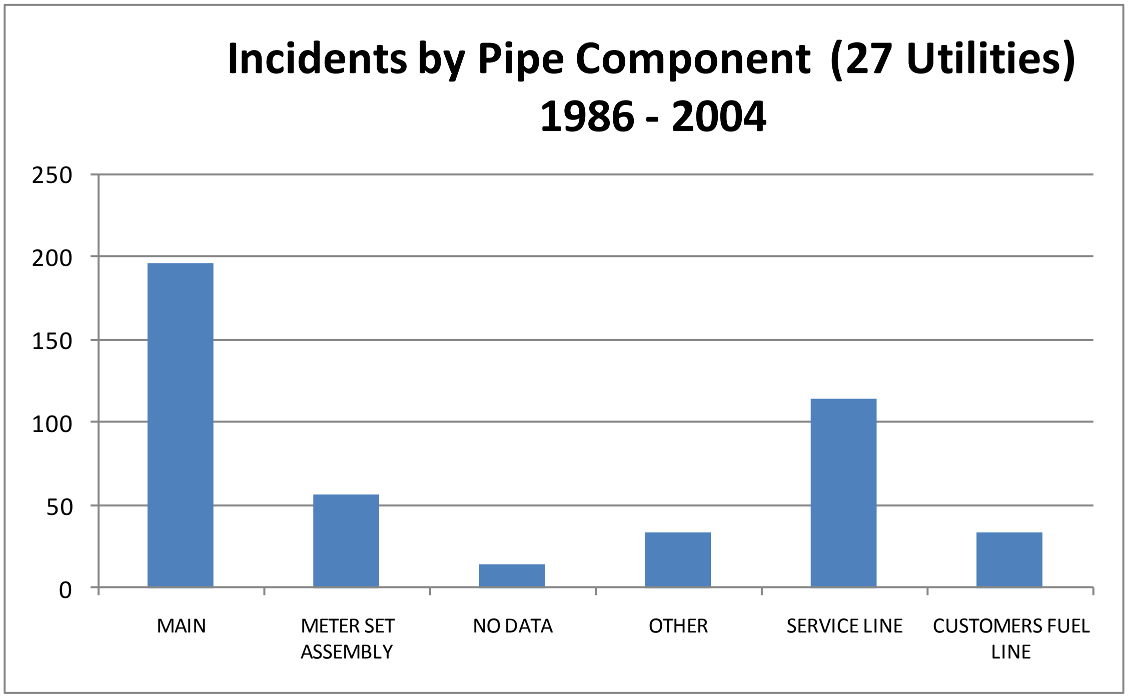
PGW Incidents by Part of System

The following chart shows the particular part of PGW's piping and metering system that is associated with the incidents recorded over the 20-year period ending in 2005. This chart indicates that over the period shown, the majority of PGW's total incidents, as well as the majority of its serious incidents, occur in its mains. Meter set assemblies are involved in the second-highest number of "total" incidents, although there have been no serious incidents there. The second-highest number of "serious" incidents occurs in the "Other" category that includes such parts as customer black-iron or flexible piping.



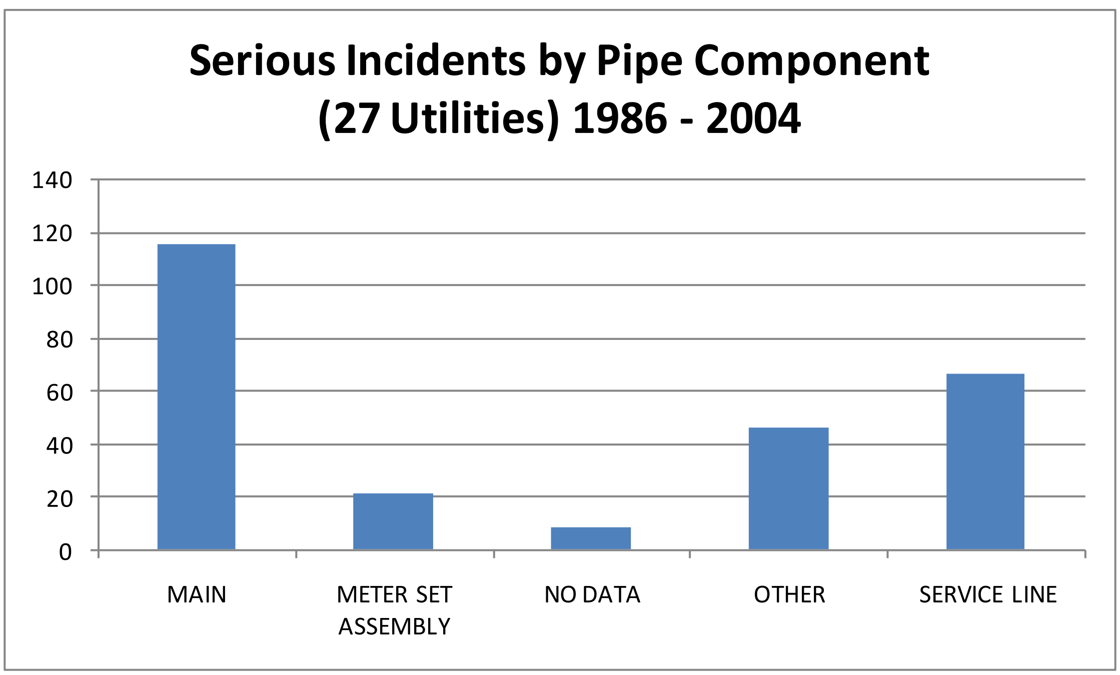
Incidents by Part of System for Smaller and Larger Benchmark Groups





Both benchmark groups shown above point to “Main” as the part of their systems that is primarily involved in incidents. This is identical to the experience of PGW.

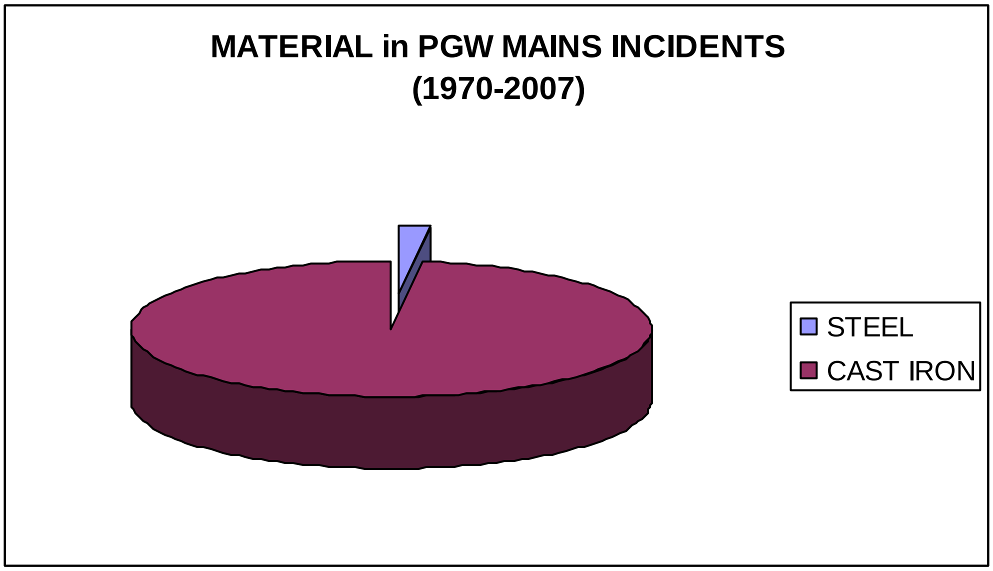
For comparison to the above chart, the chart below shows the parts of the systems of the other operators in the 27-utility study that are involved in serious incidents.



For the 27 utilities, serious incidents occur primarily in the mains portion of the average system. Incidents occurring in service lines are the second most likely cause. The lower proportion of service-line incidents observed at PGW, when compared to the entire U.S. average, may be attributable to the high proportion of plastic services in its system. It's certainly a credit to PGW's service-line renewal efforts that this part of their system has been modernized. A modernized service-line effort protects PGW's customers by keeping gas incidents further away from the premises.

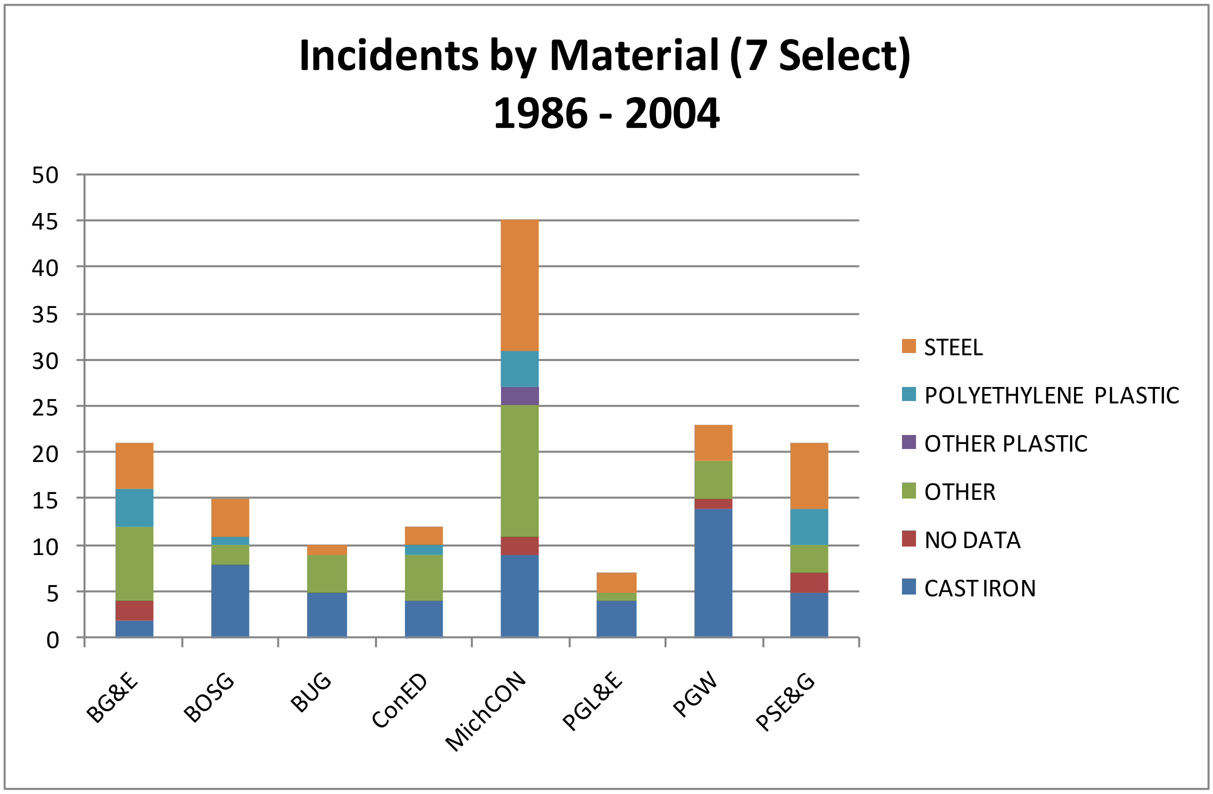
PGW Incidents by Type of Material

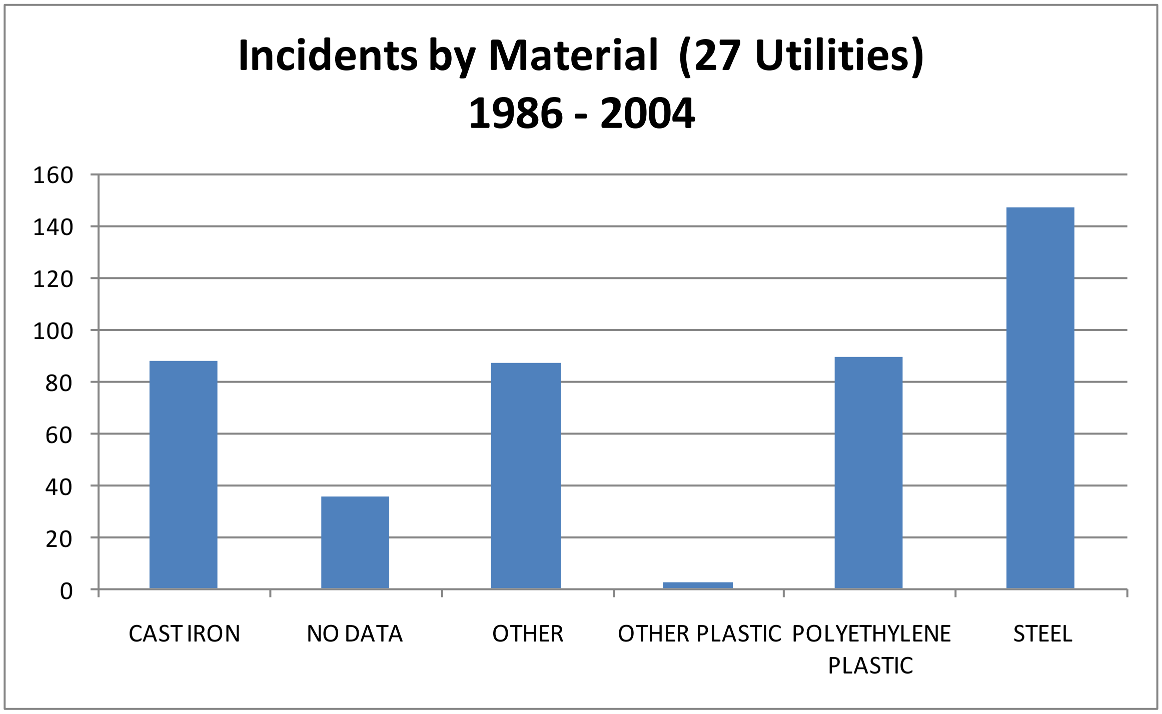
An analysis of PGW's incidents occurring in its mains piping shows that incidents occur predominantly in cast iron portions of its mains system, as shown below.



The extremely low proportion of incidents occurring in PGW's steel piping system may be related to the way the materials typically leak. Steel has enough strength to resist breakage from natural causes. Therefore, most steel leaks involve pitting caused by corrosion. These pits are typically very small, permitting the leak to be discovered after only small amounts of gas leakage.

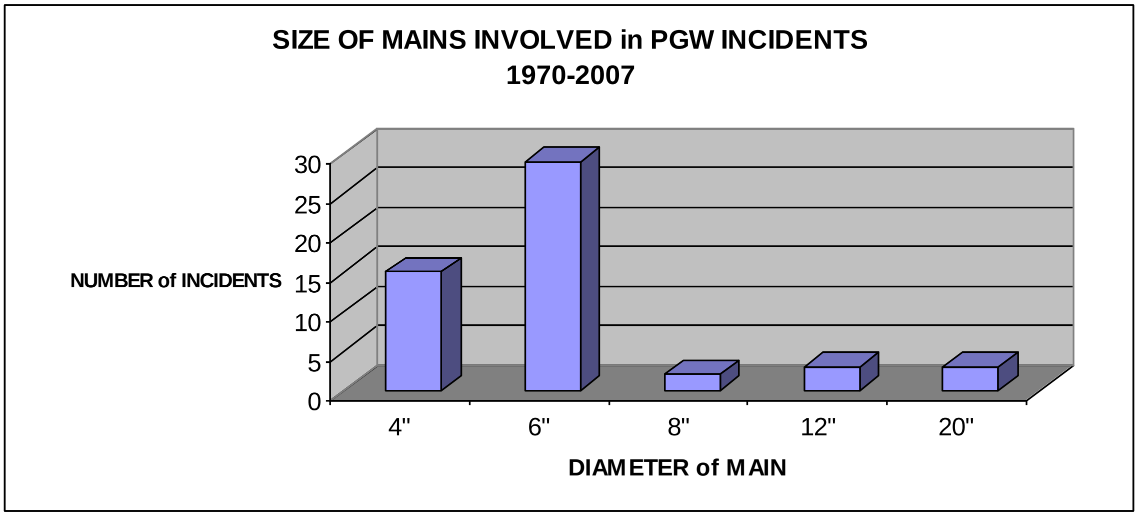
Cast iron mains, however, have a very low beam strength permitting pipe breakage from certain types of natural causes (such as freeze-thaw cycles, undermining from waterline leaks, or frost heavage). Leaks from broken pipes can emit substantial gas prior to discovery.

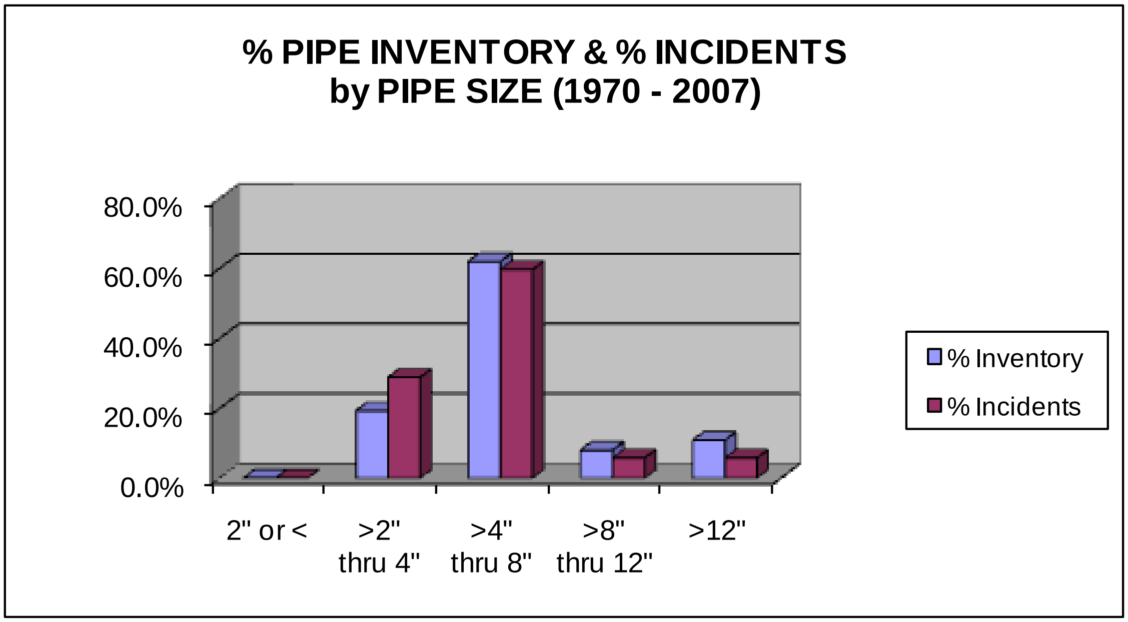

Incidents by Material (7 Select)
1986 - 2004
50
45
40
35
30
25
20
15
10
5
0
BG&E
BOSG
BUG
ConED
MichCON
PGL&E
PGW
PSE&G
STEEL
POLYETHYLENE PLASTIC
OTHER PLASTIC
OTHER
NO DATA
CAST IRON

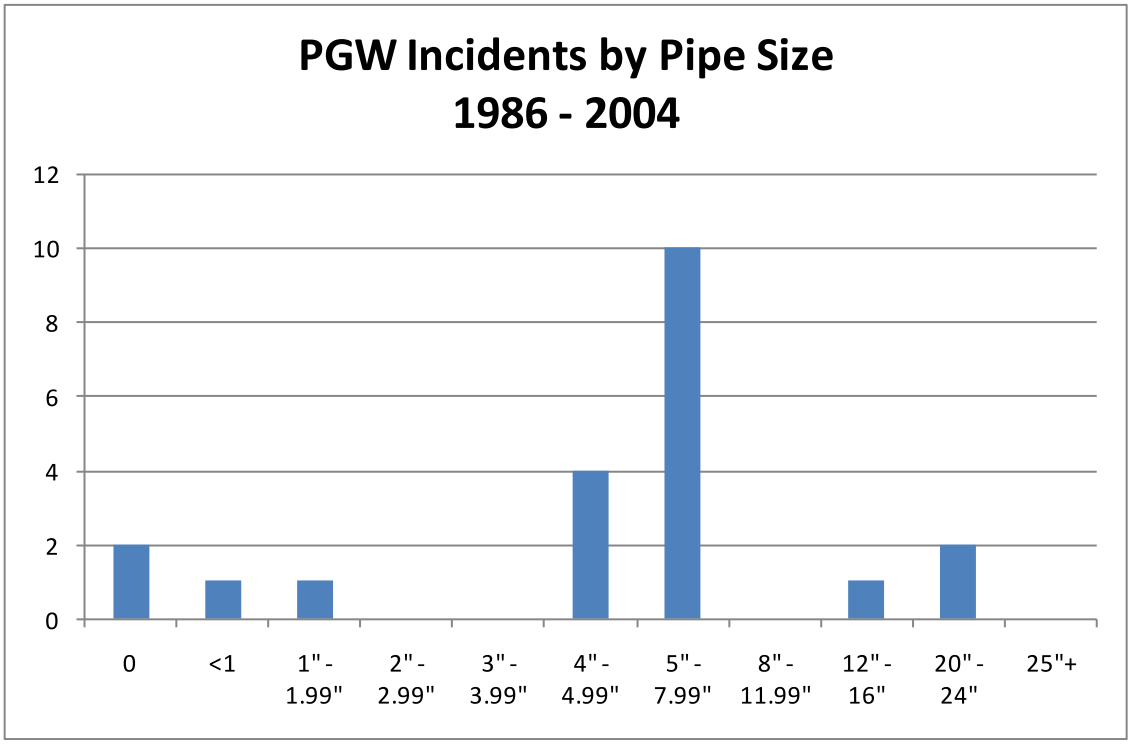

Incidents by Material (27 Utilities)
1986 - 2004
160
140
120
100
80
60
40
20
0
CAST IRON
NO DATA
OTHER
OTHER PLASTIC
POLYETHYLENE PLASTIC
STEEL

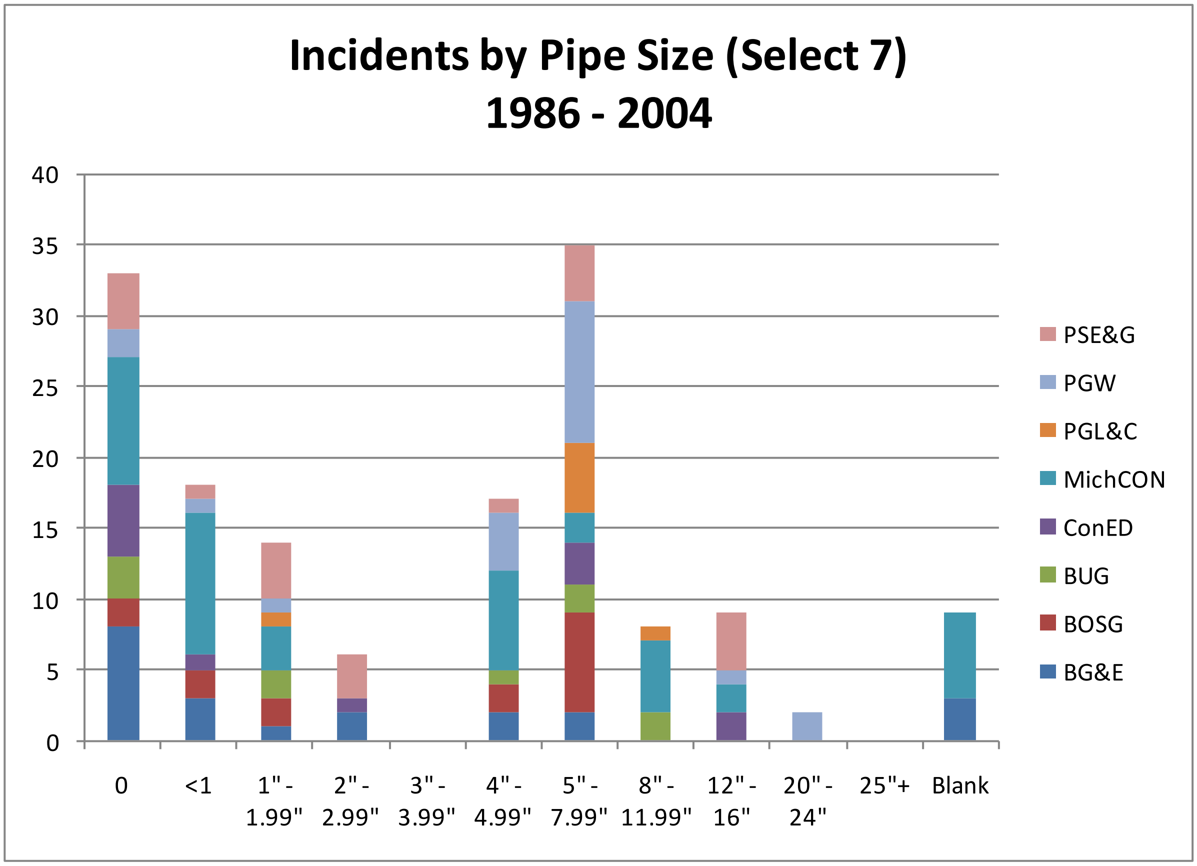
PGW Incidents by Size of Pipe

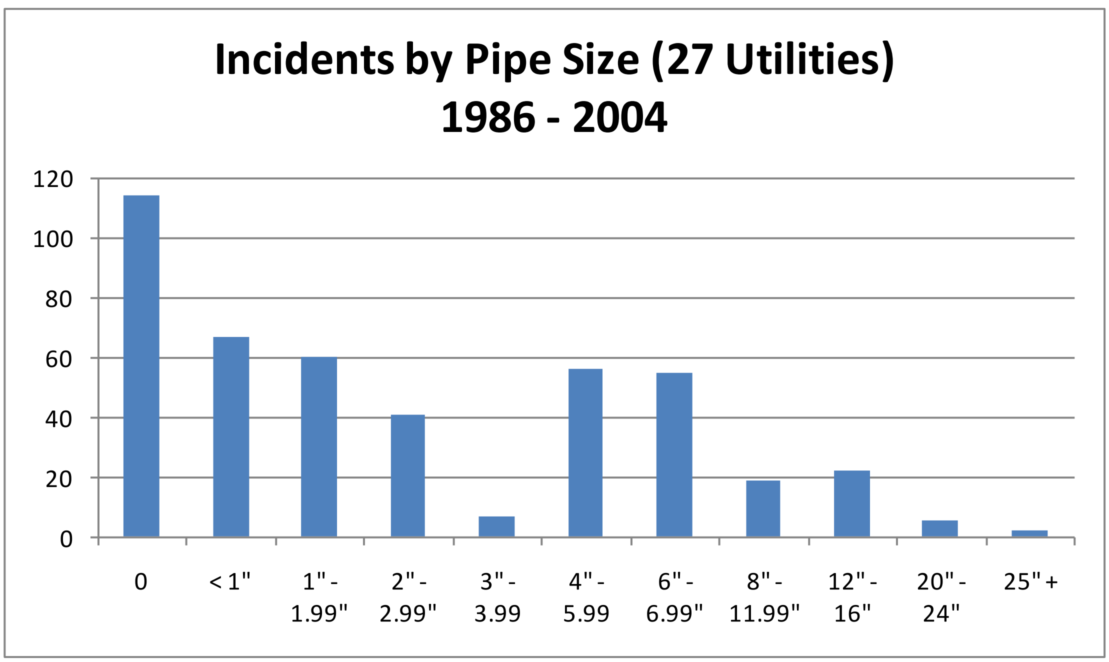
The following chart shows that most of the incidents occurring in PGW's system are from small-diameter pipes, either 4-inch or 6-inch. This was first considered to be a function of the thinner walls that small pipes possess, when compared to larger-diameter mains. Thinner walls would have less ability to withstand natural causes of breakage.






PGW Incidents by Pipe Size
1986 - 2004
12
10
8
6
4
2
0
0
<1
1" - 1.99"
2" - 2.99"
3" - 3.99"
4" - 4.99"
5" - 7.99"
8" - 11.99"
12" - 16"
20" - 24"
25"+

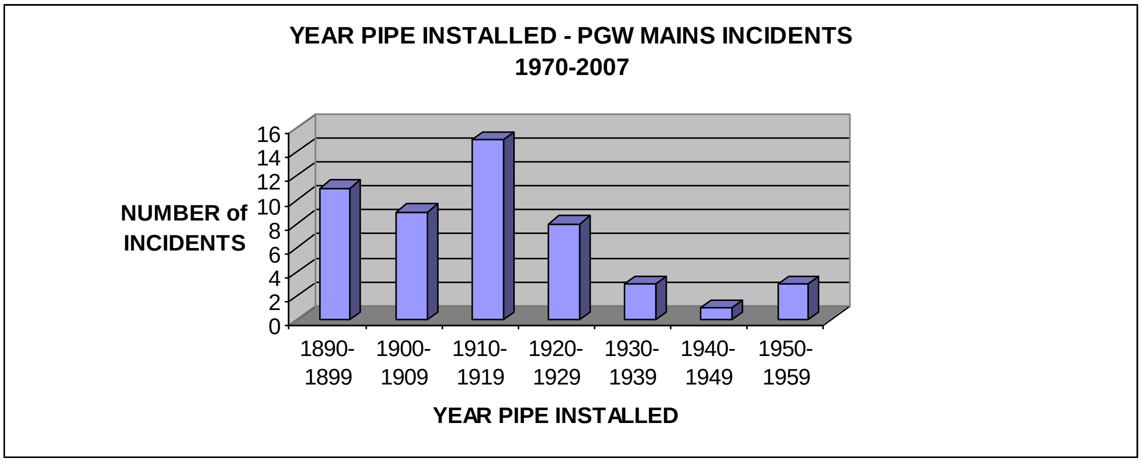

Incidents by Pipe Size (Select 7)
1986 - 2004
40
35
30
25
20
15
10
5
0
0
<1
1" - 1.99"
2" - 2.99"
3" - 3.99"
4" - 4.99"
5" - 7.99"
8" - 11.99"
12" - 16"
20" - 24"
25"+
Blank
PSE&G
PGW
PGL&C
MichCON
ConED
BUG
BOSG
BG&E

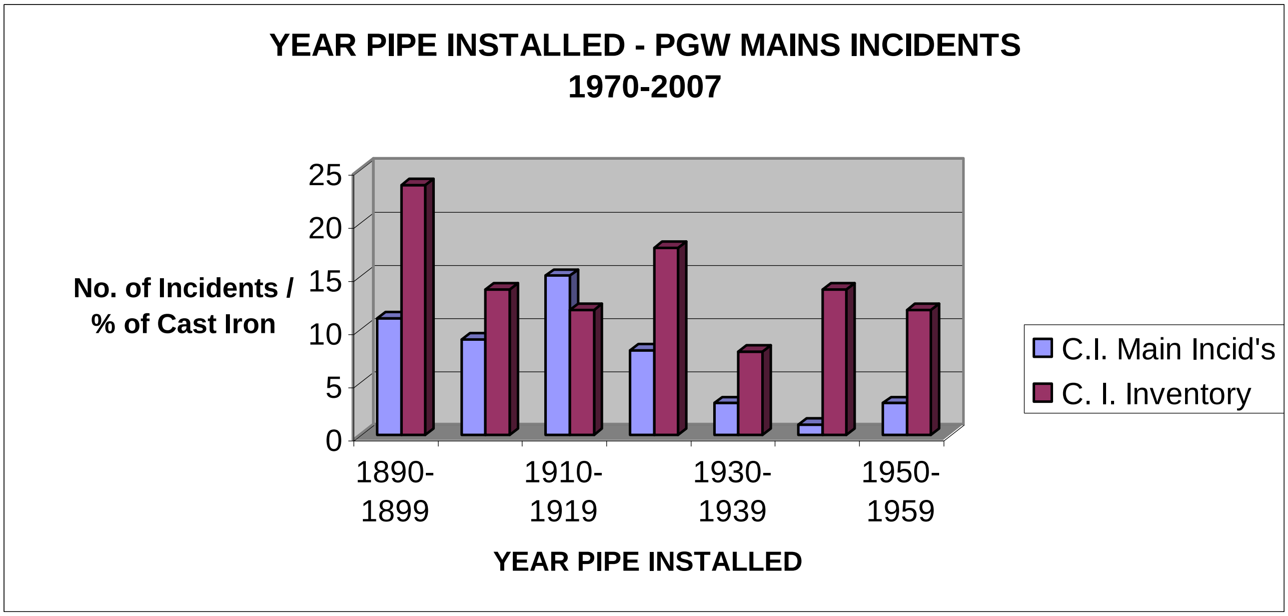

Incidents by Pipe Size (27 Utilities)
1986 - 2004
120
100
80
60
40
20
0
0
< 1"
1" - 1.99"
2" - 2.99"
3" - 3.99
4" - 5.99
6" - 6.99"
8" - 11.99"
12" - 16"
20" - 24"
25" +

PGW Incidents by Age of Main

The first of the two following charts shows that older vintage pipes are involved in the majority of mains incidents at PGW. Older mains can be worn from the inside due to scouring from particles carried by the gas. Since the mains involved in PGW incidents are primarily cast iron, they can also deteriorate from the outside due to a corrosion-like process known as graphitization. This process depends partly on the soil type in which the main is installed.

However the second chart below shows that PGW's existing inventory of cast iron main is also skewed toward earlier decades. The net effect of both trends seems to be a slight effect of incidents being due to the age of the cast iron mains.

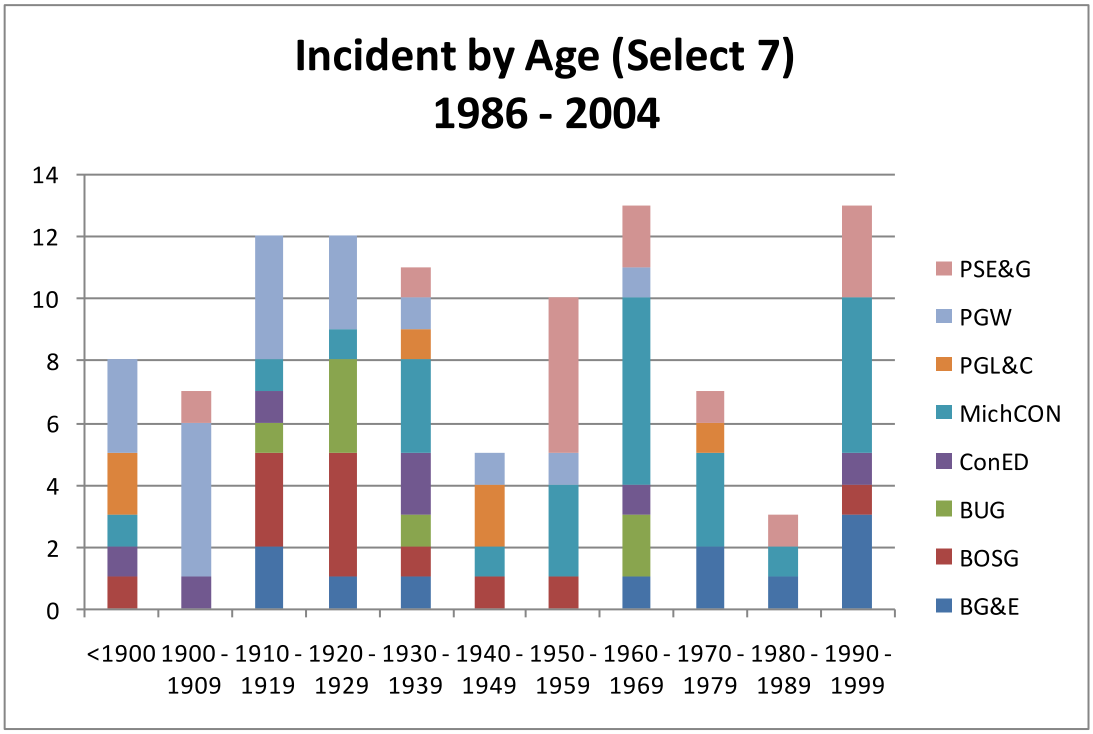


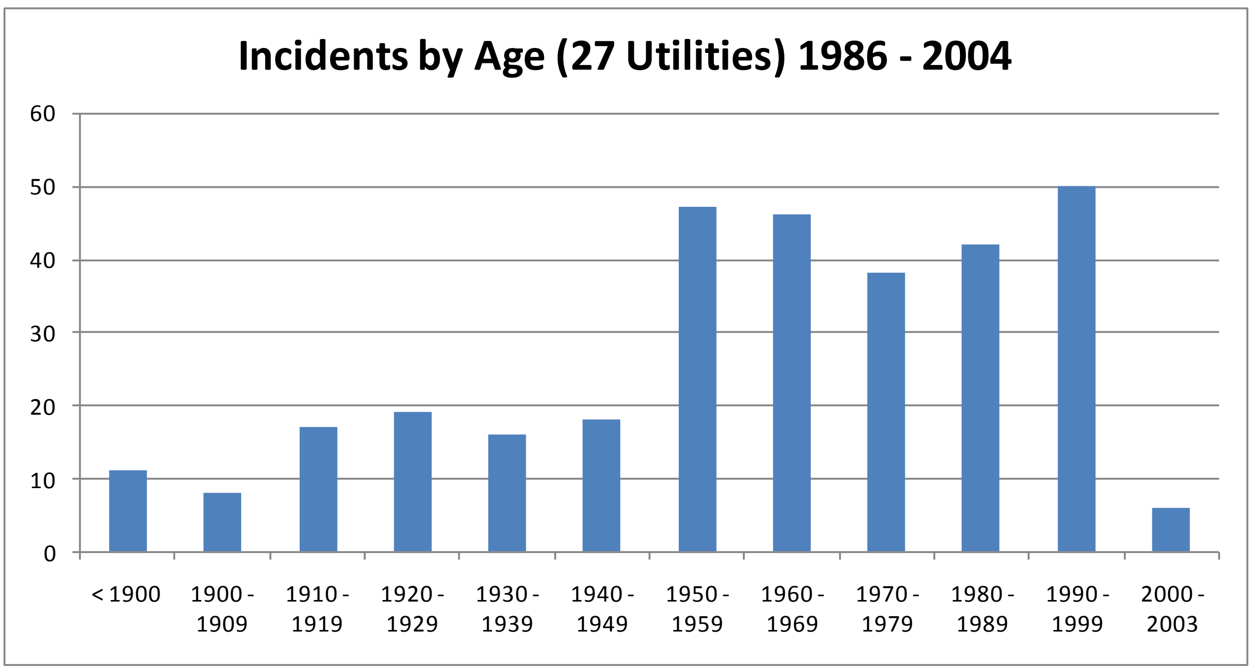


(PGW) Percentage of Mains by Decade
(as of February 2008)

Years	Length %
1890-1899	12%
1900-09	7%
1910-19	6%
1920-29	9%
1930-39	4%
1940-49	7%
1950-59	17%
1950-59 (Cast Iron)	6%

The above table provides data on the percentage of the entire system that was installed in each decade. The previous chart illustrates incidents by year pipe was installed by since it covers a 37 year period, is not directly related to the current percentages displayed in the table.



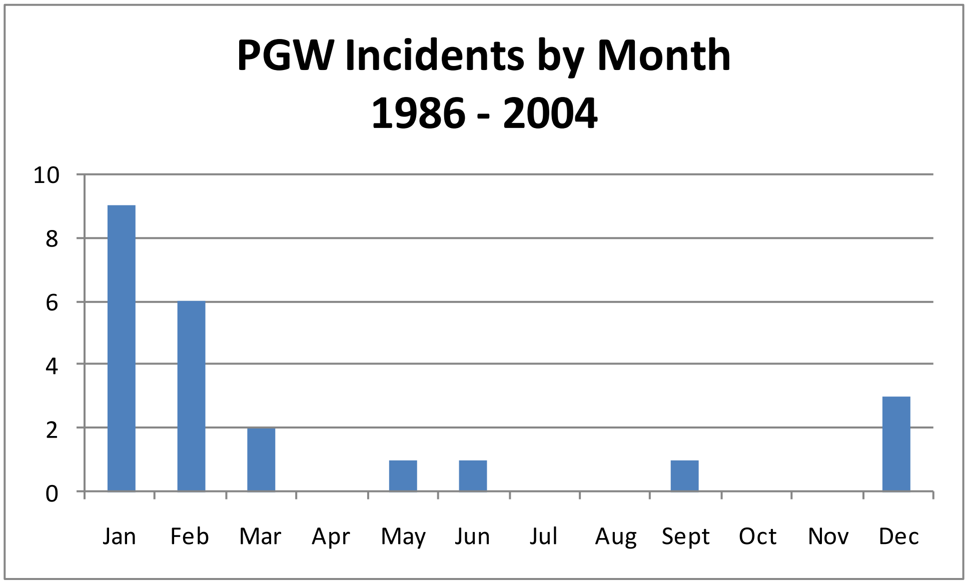


Particularly for the larger benchmark group, incidents seem to be the reverse of the age effect shown by PGW. For this group, incidents occur predominantly in pipe mains installed since 1950. This probably represents however incidents being caused by failure of a different material type. Steel (as well as polyethylene) was a main piping material installed after 1950. Also the larger benchmark group includes companies that have expanded significantly in recent years – meaning they now have major amounts of mains installed in recent decades.

PGW Incidents by Time of Year

The following chart shows that cold temperature is associated with the vast majority of PGW's incidents, since they occur primarily in the winter months. Frost heave, temperature cycling, and water-line breaks are all typical causes.

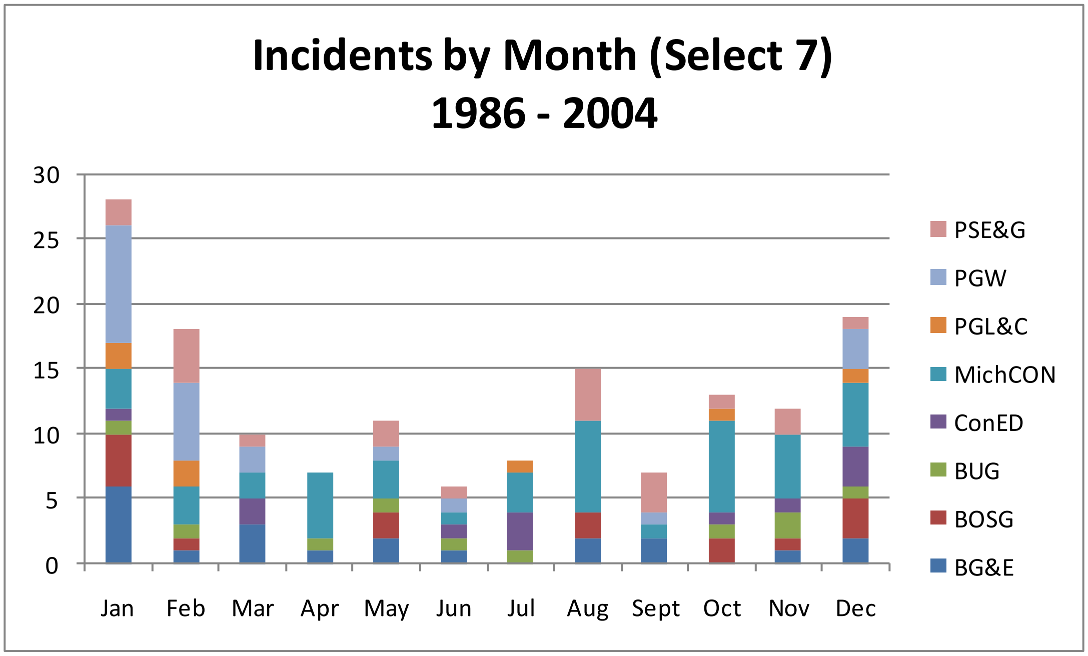
The following bar chart categorizes PGW's incidents occurring on mains according to the month they occurred.

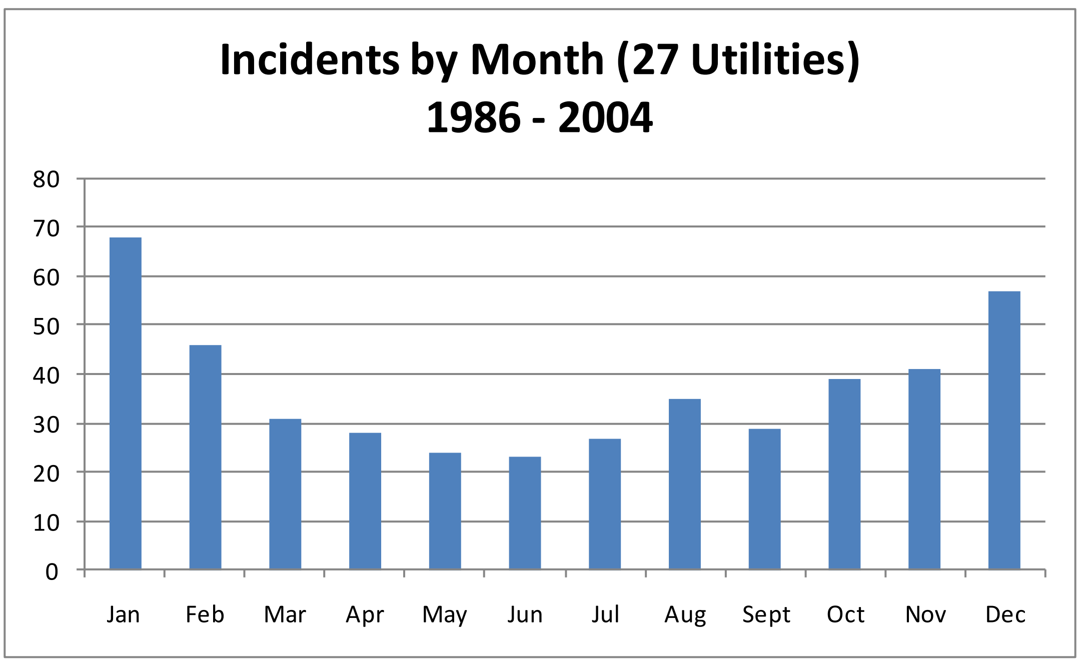


There were 23 incidents occurring in PGW's mains system from 1986 through 2004. Of these, the cause was classified as "Damage by Outside Forces" for 17 of them. These were further broken down as attributed to:

- Earth Movement: Frost 7
- Earth Movement: Subsidence 6
- Outside/Third Party 2
- Earth Movement: Other 2

Benchmark Group Incidents by Time of Year





The two charts shown above for the smaller and larger benchmark groups show a definite pattern of incidents occurring in winter months. However the pattern is not as pronounced as is PGW's. This may indicate that some of PGW's mains are not buried as deeply as those of the benchmark groups, permitting frost heave to be more of a cause of incidents at PGW.

Conclusions on Causes of Incidents

From all of the incident data that Advantica has reviewed above, and from prior studies that Advantica has been involved in, the following causes of incidents seem to be a factor at PGW:

- Primary Cause – PGW's incidents are primarily attributed to "Damage by Outside Forces", as are the incidents of most of the benchmark companies
- Part of System – "Mains" seem to be the primary part of PGW's system involved in incidents, as it is with the benchmark companies
- Material Type – Cast iron seems to be the primary material involved in incidents occurring on PGW's mains, more so than at benchmark companies
- Age – There may be a correlation of age of main and incident rate at PGW (although this is not apparent with the other benchmark companies as a whole)
- Depth of Cover – There appears to be a greater temperature effect for PGW than for the benchmark companies as a whole

Surprisingly, size of main does not seem to be a large cause of incidents at PGW. Incidents seem to be in proportion to PGW's inventory of main sizes.

Repair and Replacement Issues

PGW, like many other gas companies with a large amount of cast iron main in their systems, spends a significant portion of its budget in repairing and replacing cast iron. The following sections of this report compare PGW's performance in these areas to those of other benchmark utilities.

Larger Benchmark Group – Cast Iron Replacement Statistics

The following table presents the cast iron reduction statistics for all 27 companies in the larger benchmark group. These statistics are shown for the most recent 10-year period ending in 2006. The table shows that the average company in this broad benchmark has replaced 13% of its cast iron mileage during the past 10 years. PGW has replaced 8%, placing it in the fourth quartile in this broader sample of benchmarked companies.

Cast Iron Mains Reduction by Broadest Benchmark Companies

Quartile	Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Miles Cast Iron Mains, 1997	Total Miles Cast Iron Mains, 2006	10-year Cast Iron Mains Reduction	10-year Cast Iron Percentage Reduction	Cast Iron as a % of Total Mains, 2006
I	1	AGL	29,843	328	113	-215.0	-66%	0%
I	2	CINGY	5,358	1,043	517	-526.1	-50%	10%
I	3	NJN	6,550	178	96	-82.0	-46%	1%
I	4	MLGW	4,763	239	146	-93.0	-39%	3%
I	5	EQU	3,307	66	47	-19.0	-29%	1%
I	6	NATFG	9,537	645	463	-182.0	-28%	5%
I	7	CGP	7,260	101	74	-27.0	-27%	1%
II	8	NIMO	8,436	1,024	762	-262.0	-26%	9%
II	9	NIGAS	32,671	572	446	-126.0	-22%	1%
II	10	IGC	12,134	214	177	-37.0	-17%	1%
II	11	PGL&C	4,025	1955	1,664	-291.0	-15%	41%
II	12	CGO	19,591	328	281	-48.0	-15%	1%
II	13	WGL	1,191	527	451	-76.0	-14%	38%
III	14	LSG	27,985	1,007	884	-123.0	-12%	3%
III	15	SCONN	2,258	829	730	-99.0	-12%	32%
III	16	ELIZ	3,026	893	793	-100.0	-11%	26%

Quartile	Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Miles Cast Iron Mains, 1997	Total Miles Cast Iron Mains, 2006	10-year Cast Iron Mains Reduction	10-year Cast Iron Percentage Reduction	Cast Iron as a % of Total Mains, 2006
III	17	BOSG	6,175	2,572	2,289	-282.6	-11%	37%
III	18	BUG	4,033	1,964	1,778	-193.0	-10%	44%
III	19	PECO	6,614	922	836	-86.0	-9%	13%
III	20	ALGAS	10,372	1,238	1,134	-103.7	-8%	11%
IV	21	PSE&G	17,504	4,847	4,453	-393.0	-8%	25%
IV	22	PGW	3,019	1,766	1,624	-142.0	-8%	54%
IV	23	LACL	8,264	955	880	-75.0	-8%	11%
IV	24	LILCO	7,496	427	395	-32.0	-7%	5%
IV	25	CONED	4,256	1,499	1,396	-103.0	-7%	33%
IV	26	BG&E	6,747	1,461	1,365	-96.0	-7%	20%
IV	27	MICON	18,390	2,833	2,737	-96.0	-3%	15%
Weighted average, 27 benchmark companies			10,030	1,127	983	-144.8	-13%	10%

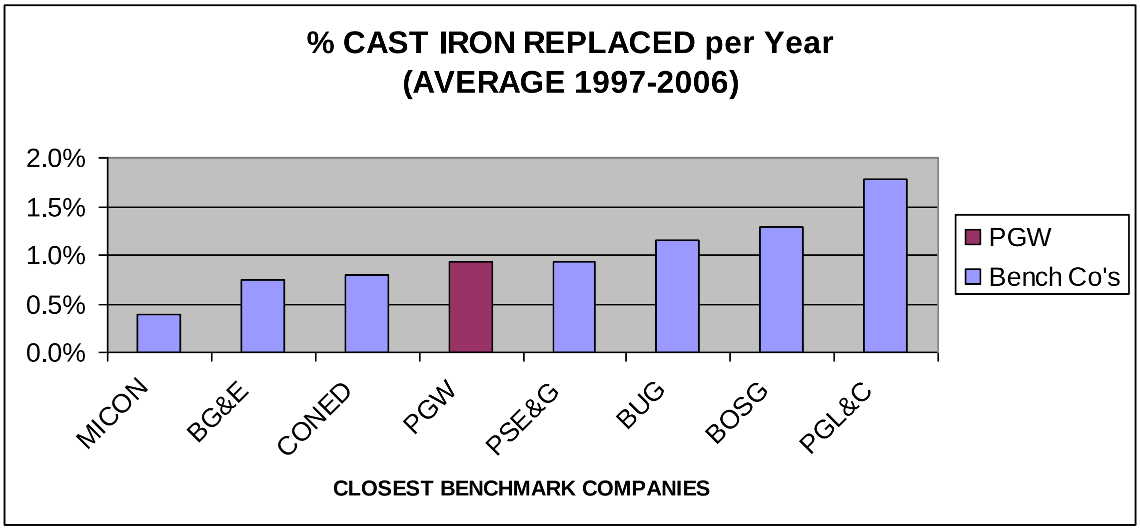
Smaller Benchmark Group – Cast Iron Replacement Statistics

In the table below, PGW is shown to rank in the middle of the most comparable companies in the smaller benchmark group (fifth out of eight). PGW is also shown to have the same 10-year reduction percentage as the average of all eight companies (8%, equivalent to an annual replacement of 0.8%).

Cast Iron Mains Reduction by Most-Comparable Benchmark Companies

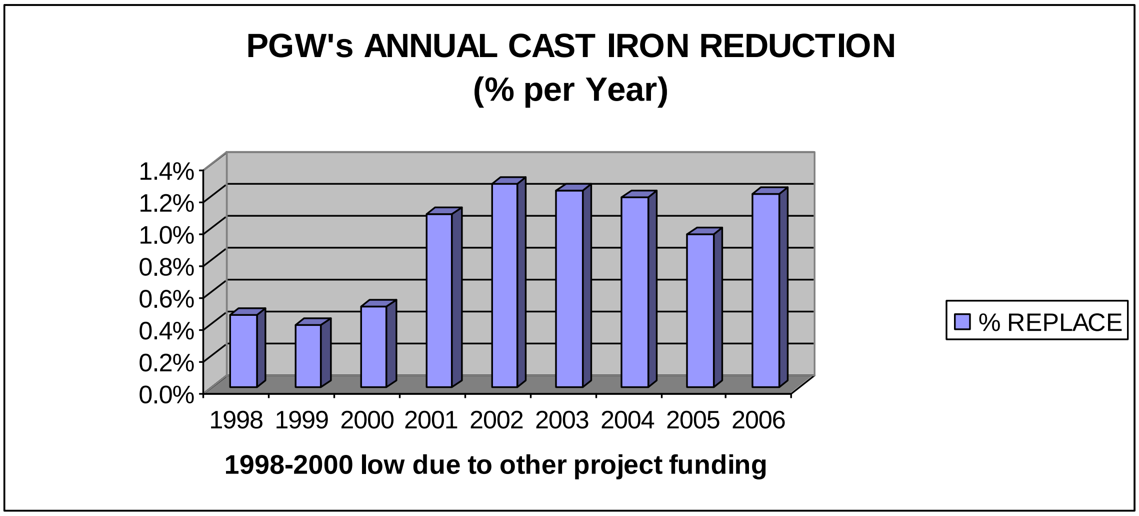
Ranking	Abbrev. Name	Total Miles of Mains, 2006	Total Miles Cast Iron Mains, 1997	Total Miles Cast Iron Mains, 2006	10-year Cast Iron Mains Reduction	10-year Cast Iron Percentage Reduction	Cast Iron as a % of Total Mains, 2006
1	PGL&C	4,025	1955	1,664	-291.0	-15%	41%
2	BOSG	6,175	2,572	2,289	-282.6	-11%	37%
3	BUG	4,033	1,964	1,778	-193.0	-10%	44%
4	PSE&G	17,504	4,847	4,453	-393.0	-8%	25%
5	PGW	3,019	1,766	1,624	-142.0	-8%	54%
6	CONED	4,256	1,499	1,396	-103.0	-7%	33%
7	BG&E	6,747	1,461	1,365	-96.0	-7%	20%
8	MICON	18,390	2,833	2,737	-96.0	-3%	15%
Weighted average, 8 benchmark companies		8,019	2,362	2,163	-199.6	-8%	27%

The following chart shows the percentage of cast iron replaced by year for the 10-year period ending in 2006 for the most comparable companies in the small benchmark group.



PGW's Annual Replacement Trend

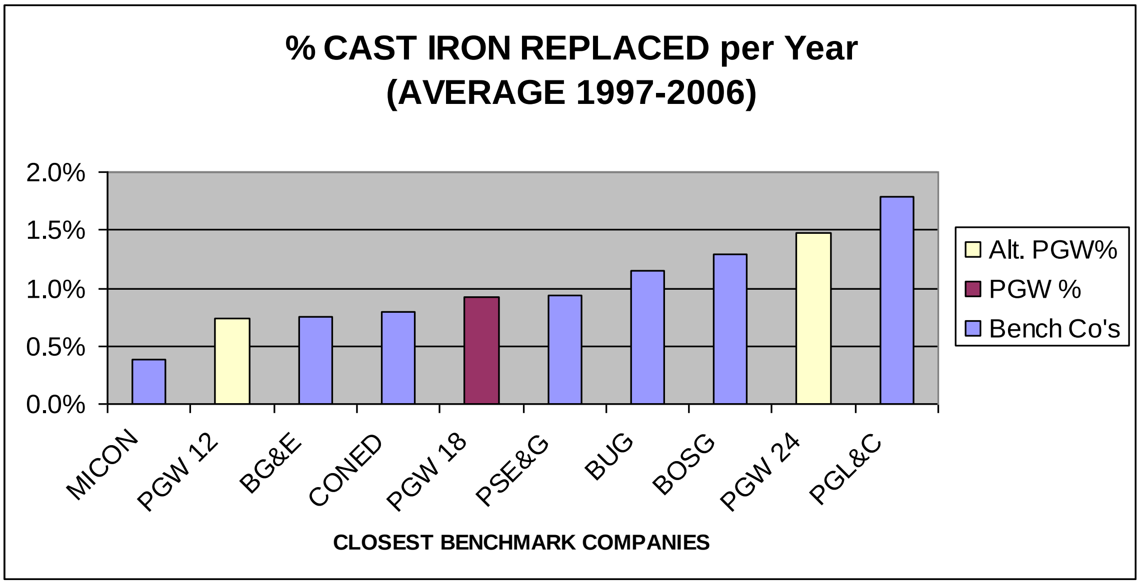
PGW's replacement percentages for cast iron have been about 1% per year for the most recent years. In the years 1998 through 2000, however, lower percentages are observed, due to the high funding of other PGW projects. The 1% rate is equivalent to just under 18 miles of cast iron reduction per year (17.7 miles).



Analysis of Hypothetical Alternate Replacement Rates at PGW

Advantica has compared the possible effects of two alternate future replacement rates for PGW's cast iron mains. In addition to the current 10-year replacement mileage of about 18 miles per year, Advantica analyzed the effects of increasing this rate by one-third (to 24 miles per year) and of decreasing this rate by one-third (to 12 miles per year). Advantica first investigated the change in ranking that would result from the alternate replacement rates. Second, Advantica looked at the resultant ages of mains that would follow from both the current and the alternate replacement rates. Third, Advantica compared the age of cast iron mains that will occur at other utilities, if they continue replacing at their current rates.

The changes in ranking for the current (approximately 18 miles per year) and alternate replacement rates (12 and 24 miles per year), when compared to the seven other companies in the smaller benchmark group, are shown below.



As shown in the above chart, at the current rate of 18 miles reduction per year, PGW is ranked in the middle of the most comparable benchmark group. At a reduced rate of 12 miles per year, PGW would fall to the second-lowest company, above MICON and below BG&E. At an increased rate of 24 miles per year, PGW would rise to the second-highest company, above BOSG and below PGL&C.

Age Effects of Alternate Replacement Rates for PGW

The following table analyzes the three replacement rates of 18 miles per year (current rate), 12 miles per year (reduced rate), and 24 miles per year (increased rate). The table indicates that the current program will remove all cast iron by 2096, while the reduced-rate program will do so by 2141 and the increased-rate program will do so by 2074. The chart also shows that a "random-age" replacement program would be replacing pipes as old as 196 years (current program), 241 years old (reduced program), or 174 years old (increased program). These replacement ages could be reduced somewhat if PGW intentionally targets older segments of main in its mains replacement program.

	18-mile per year replacement rate	**12-mile per year replacement rate**	**24-mile per year replacement rate**
Current cast iron miles of main – 2006	1,624	1,624	1,624
Current and alternate replacement miles	18	12	24
Replacement percentage rates	1.1%	0.7%	1.5%
Last install date	1965	1965	1965
Estimated oldest install date	1900	1900	1900
Current age of newest cast iron	43	43	43
Current age of oldest cast iron	108	108	108
Years to replace at given mileage	90	135	68
Year of final replacement	2096	2141	2074
Final age of newest cast iron	131	176	109
Final age of oldest cast iron	196	241	174

Final Replacement Year for Most-Comparable Benchmark Companies

In order to assess the alternate final replacement years shown in the table above through a comparable framework, the following table shows the expected final replacement year for all cast iron for the benchmark gas companies. The calculations assume that the full replacement mileage that each company has been averaging will continue until all cast iron is removed for each company.

Year of Final Cast Iron Replacement –
Most Comparable Benchmark Companies

Ranking	Abbrev. Name	Current Cast Iron Miles of Main – 2006	10-Year Average Replacement Miles	Years to Replace at Average Mileage	Year of Final Replacement
1	PGL&C	1,664	29.1	57	2063
2	BOSG	2,289	28.3	81	2087
3	BUG	1,778	19.3	92	2098
4	PSE&G	4,453	39.3	113	2119
5	PGW	1,624	14.2	114	2120
6	CONED	1,396	10.3	136	2142
7	BG&E	1,365	9.6	142	2148
8	MICON	2,737	9.6	285	2291
–	PGW-18	1,624	18.0	90	2096

This table assumes a continuation of PGW's average replacement mileage over the past 10-year period (14.2 miles per year). Also show, at the bottom of the table, are the results assuming the full replacement mileage rate demonstrated in the most recent years (18 miles per year).

Replacement Techniques to Lower Cost

State-of-the-Art Replacement Techniques Currently in Use at PGW

Through discussions with PGW's Distribution staff members, Advantica notes that PGW currently employs the following industry-standard replacement techniques:

- The "Keyhole" repair technique for cast iron joint repair using epoxy-based encapsulation of bell joints. PGW also uses the keyhole methods to renew/abandon services and to install corrosion protection systems.
- Electric fusion fittings for plastic pipe connections on both mains and services.
- Pipe-insertion techniques for running plastic mains through cast-iron mains when flow rates permit using a smaller diameter.
- Internal pipe-traveling video inspection devices to locate breaks and assess internal pipe condition.
- Roadway saw cutting to reduce paving restoration on main replacement projects.

Techniques Not Promising at PGW

Advantica notes that the following commonly used replacement techniques have been tried at PGW and rejected since they proved to be inapplicable for PGW's system:

- Directional drilling for new mains. There have proved to be too many underground facilities in the way to use this drilling technique.
- Pipe lining of cast iron mains with a rubberized internal coating. There have proved to be too many services connections required that result in a requirement for excavation at too-frequent intervals. PGW has tried options of this that permit internal cutting for service connections.
- Pipe bursting for replacement with larger-diameter lines. There have proved to be too many underground facilities near their mains that have even resulted in pavement upheaval during the bursting process.
- Contractor handling of live-gas tie-ins. This has been a long-time bargaining-unit issue at PGW.

Suggested Techniques for Reducing Costs of Repair and/or Replacement

Following discussions with PGW's staff and reviewing the "lessons learned" from the Business Transformation (BT) Initiative, Advantica would suggest investigation of the following ideas for reducing the cost of repairs and replacement mains at PGW:

- Recast longer-term replacement contracts in the following ways:
  - Include cost escalators.
  - Remove some paving requirements since many contractors want to get in and out without coming back to the job-site for car movement and paving.

  - Eliminate some specialty work that eliminates bids from contractors unfamiliar with the special requirements.
- Try to schedule larger replacement areas in order to reduce the number of required tie-ins.

State-of-the-Art Replacement Techniques Suggested in the Survey

The survey conducted by Advantica regarding joint leaks and breaks asked for suggestions for replacement techniques that have helped lower costs for the surveyed companies. Recommended techniques were put forth in four separate areas: Installation, Repair, Replacement, and Inspection/Integrity Testing.

Participants in the survey suggested the following techniques. The numbers of respondents recommending the same techniques are included.

Installation of Mains

The following table provides the results from the survey regarding installation techniques. Although the participants were able to use these techniques to lower costs, they are not necessarily recommended for PGW. For example, Joint Trenching would probably not have been successful at PGW during the periods when cast iron was being installed, since it would have brought utilities such as water lines closer to PGW's facilities, rather than farther away.

Installation Technique	Survey Respondents
Directional Boring	2
Joint Trenching	1
Plowing	1
Insertion of Smaller Diameter	1
Saw Cutting Roadways	1
Specialized Equipment - Ditch Witch	1
Specialized Equipment - Concrete Grinder	1

Repair of Mains

As shown in the table below, most of the survey respondents recommend keyhole techniques for bell-joint encapsulation and other uses. This technique is used at PGW.

Repair Technique	**Survey Respondents**
Keyhole Excavation & Encapsulation for:	
Joint Repairs	6
Mains & Fittings	1
Cured-in-Place Liners	1

Replacement of Mains

As shown in the table below, the survey respondents used a variety of techniques for mains replacement.

Mains Replacement Technique	**Survey Respondents**
Cured-in-Place Pipe Liners	1
Pipe Bursting	1
Solid PE Liners	1
Direct Burial Using Directional Bore	1
Replace 2 Mains in Block With 1	1
Avoiding State Highways	1
Development of MRP Software	1

Inspection or Integrity Testing of Mains

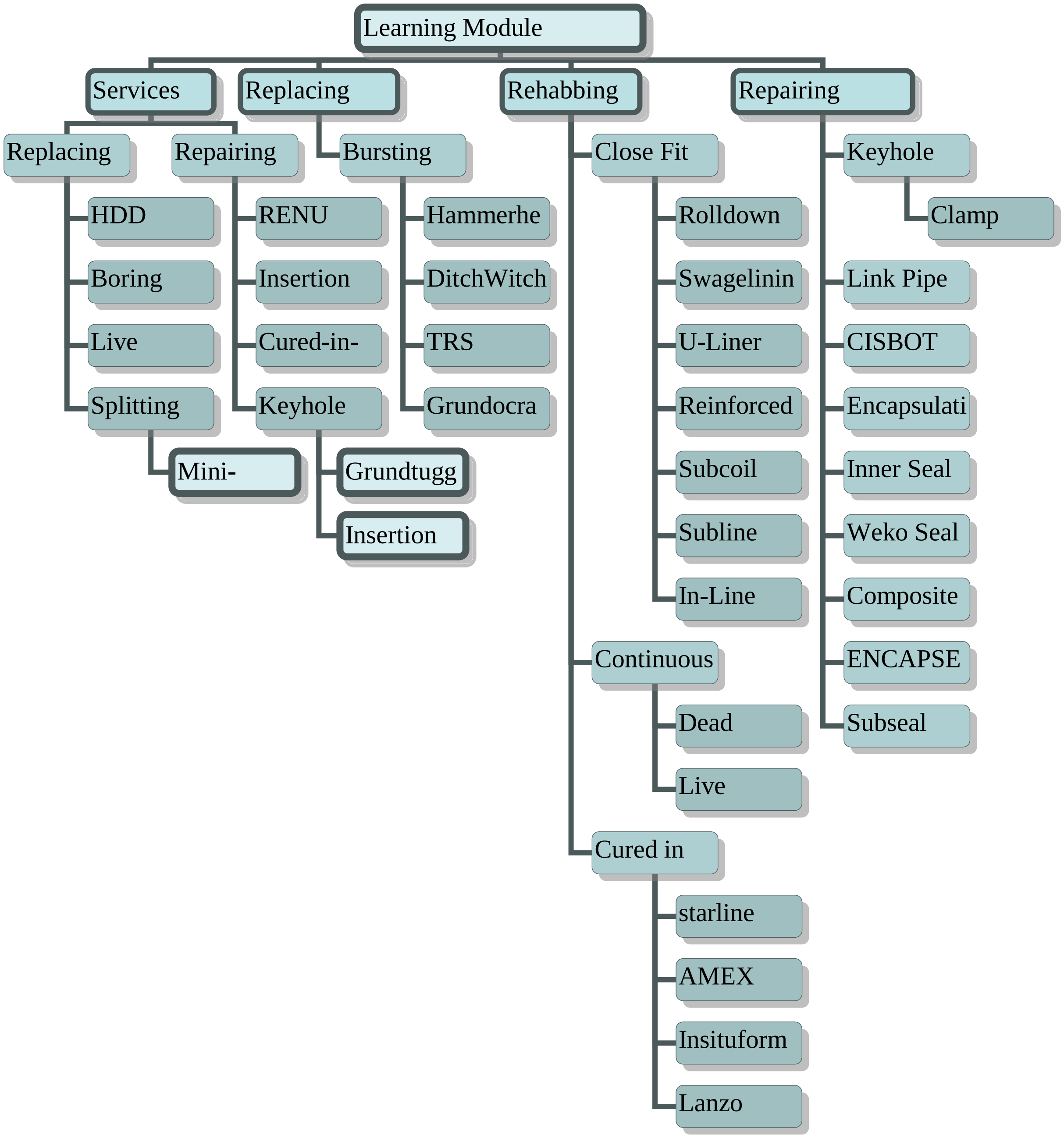
As shown in the table below, the majority of respondents to our survey used leak surveys or construction monitoring for inspection of mains.

Inspection or Integrity Testing Technique	Survey Respondents
Leak Surveys	3
Construction Monitoring	3
Smart Pigs (for transmission lines)	2
Fusion Inspectors on Crews	1

Additional Aids to Select Construction Techniques

In addition to the techniques recommended by the survey participants, Advantica would point to two additional sources of information for PGW:

- The following website contains a selection guide for Utility Construction Methods: www.gastechnology.org/ucg.
- The following chart can help guide operators to the existing construction techniques available in a number of areas:


Learning Module
Services
Replacing
Rehabbing
Repairing
Replacing
Repairing
Bursting
Close Fit
Keyhole
HDD
RENU
Hammerhe
Rolldown
Clamp
Boring
Insertion
DitchWitch
Swagelinin
Link Pipe
Live
Cured-in-
TRS
U-Liner
CISBOT
Splitting
Keyhole
Grundocra
Reinforced
Encapsulati
Mini-
Grundtugg
Subcoil
Inner Seal
Insertion
Subline
Weko Seal
In-Line
Composite
Continuous
ENCAPSE
Dead
Subseal
Live
Cured in
starline
AMEX
Insituform
Lanzo

Repair and Replacement Costs

Survey participants were queried on typical repair and replacement costs for cast iron mains in their utility. Their responses are presented in the following tables.

Mains Break Repair Cost
($Thousand/Break)

Ranking	Survey Participant	Mains Break Repair Cost ($Thousand/Break)
1	Co. D	$1.2
2	Co. C	$1.5
3	Co. G	$1.7
4	Co. E	$2.0
5	Co. F	$2.3
6	Co. A	$4.2
7	Co. B	$10.0
Average		$3.3

The average cast iron main repair cost for each surveyed company was reported to be $3,300 per repair. PGW, shown above as Company "G", reported the fairly low repair cost of $1,660 per repair.

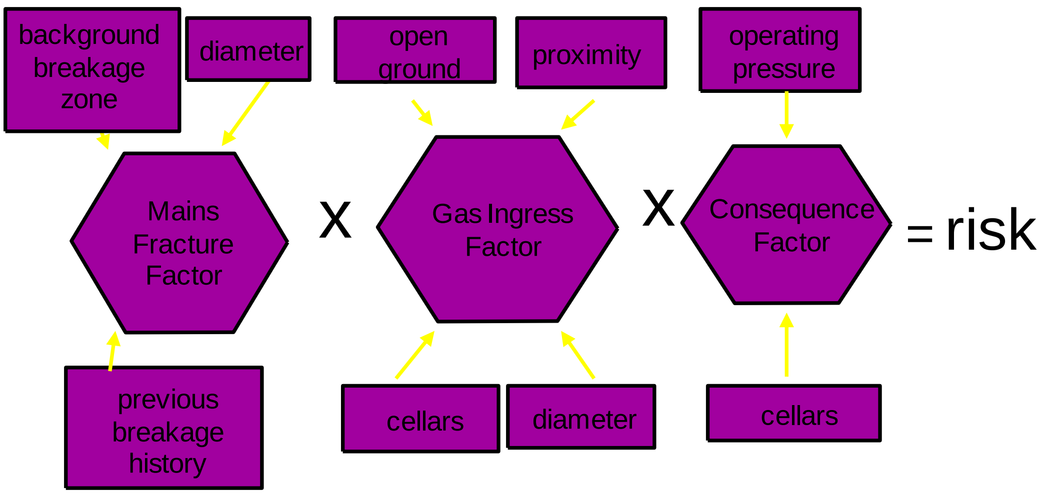
**Mains Replacement Cost
($ Million / Mile)**

Ranking	Survey Participant	Mains Replacement Cost ($Mill/Mi)
1	Co. C	$0.3
2	Co. A	$0.7
3	Co. G	$0.7
4	Co. F	$1.2
5	Co. E	$1.3
6	Co. B	$1.5
7	Co. D	$1.6
Average		$1.1

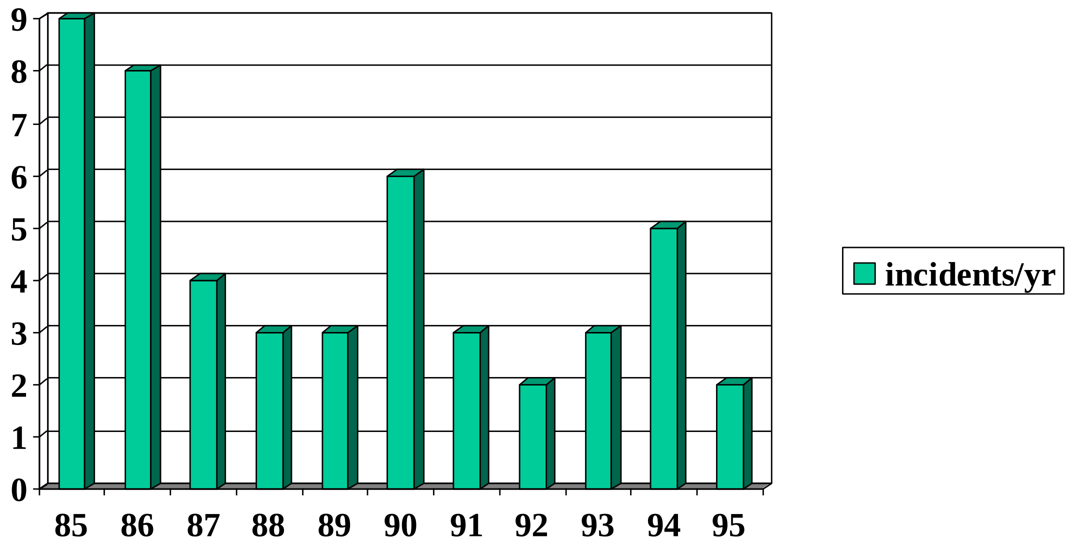
Survey participants reported that their average replacement cost for cast iron mains was $1.1 million per mile. PGW's replacement cost of $0.7 million per mile of cast iron is significantly lower than average.

Dynamic Risk Model

The dynamic risk model developed for PGW is based on the risk model developed for the UK gas industry. The original model, developed in the 1980s, was called the Points Scheme. It was based on modeling a three-stage process: gas leaking from a pipe segment, the gas migrating underground from the pipe into nearby property, and the gas subsequently building up to a flammable mixture and igniting, causing damage to the property and possible injury or fatality to any occupants. At each stage of the process, different elements were thought to act upon the likelihood of each stage occurring.



The Points Scheme was essentially a ranking program, and the Points Score for each pipe segment was used to compare one pipe against another in terms of its priority for replacement. The weightings within the model for each element were largely intuitive rather than based upon analysis of historical data. The model was used between 1985 and 1995 and recommended the annual replacement of approximately 1% of the cast iron population in use at the time, around 75,000 miles, at an approximate annual cost of $240 million. The 1% was selected to reach a target of replacing all cast iron above a Points threshold of 1200 points by 1995. This was deemed to be an acceptable level to reduce incidents to a level of around three per year and keep it stable over the coming years. Although the Points model was based on ranks rather than an actual measure of risk, there was a steady decrease in explosion incidents over the period, suggesting that the model had been reasonably successful at targeting pipes presenting the greatest risk.



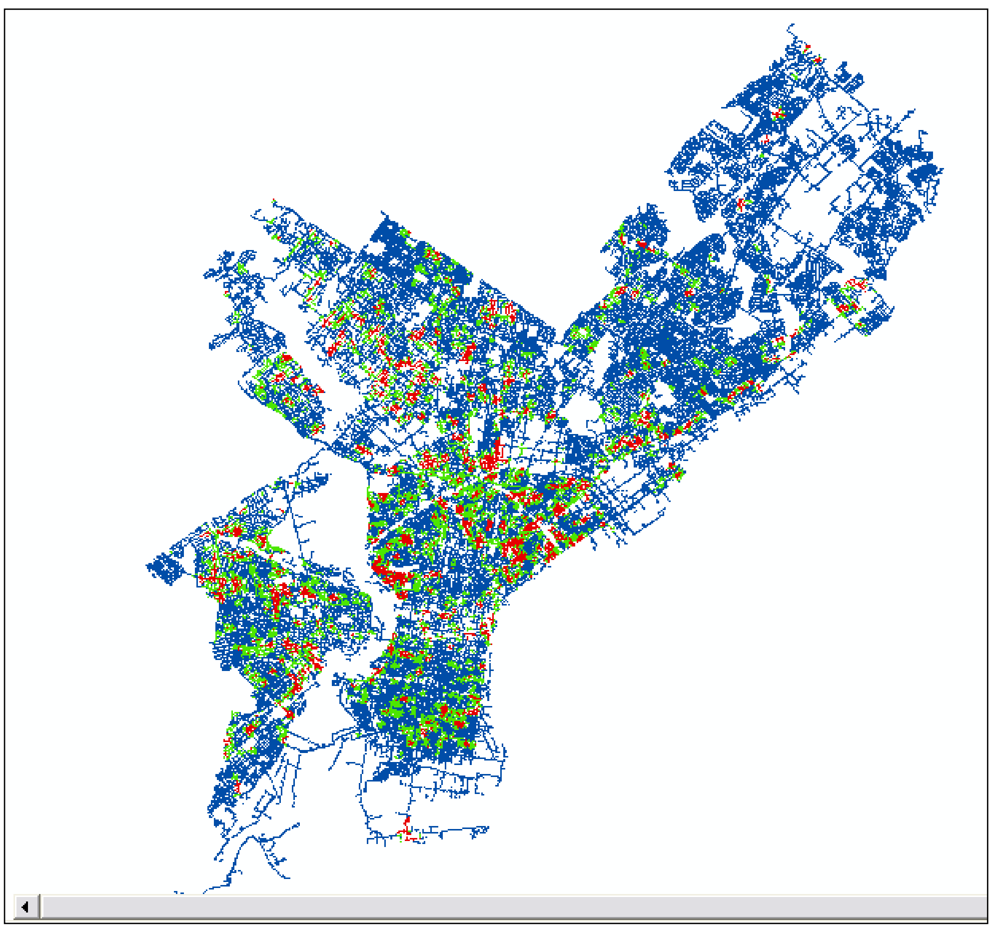
In 1995, the development of a refined model began, based on analysis of actual historical failure. It was based on data from one million cast and ductile iron pipe segments, covering 20 years of failure data and 10 years of gas in building and incident data. The model kept the three-stage process but the weightings within the model and the relationship between the individual elements were generated by regression analysis performed on the data. The result was the Risk Model, now incorporated into MRP (Mains Replacement Prioritization), and the output from the model was a risk score for each pipe segment in terms of incidents per length per year. This allowed, for the first time, the reduction in risk to be numerically linked to the length (and hence cost) of replacement, so that replacement plans could be presented to the UK gas regulators, Ofgem (The Office of Gas and Electricity Markets), and the HSE (Health and Safety Executive). The model was finalized in 1999 and presented to HSE, who then endorsed it, and it was implemented across the UK in 2000. In 2002, following an inquiry into a serious incident in 1999, the UK gas industry was subject to an enforcement notice from HSE, forcing them to replace all cast and ductile iron mains within 100 feet of property in the following 30 years. The Risk Model is used by all network gas companies in the UK to prioritize that replacement.

The model is now in use within other gas utilities around the world and has recently been implemented within PGW. In order to install a version which is aligned with PGW's distribution system, the models within MRP have to be calibrated. This involves calculating the overall level of failures with PGW, and using this information to scale the models accordingly. This is because the MRP base models are based on data from the UK, and each utility will have a failure rate that is less or greater than this rate depending on such factors as previous replacement policies, or geographical location (affecting weather conditions), all of which will affect the overall level of leakage repairs.

MRP contains two models: Condition and Risk. Risk models the likelihood of a leak leading to a serious incident, (mains break) as described above, whereas Condition measures the first stage of the process only, i.e. the likelihood of a leakage repair.

The Condition model requires data for each pipe segment on material, age, length, previous leaks, and Background Failure Zone, or BFZ. These are "hotspots" of failure activity and are generated by examining all pipes, their locations, and their associated leaks. Previous analysis has shown a very strong link between the likelihood of a pipe leaking and the leakage behavior of other pipes in its vicinity. This is especially important when trying to determine how a pipe will behave when it has not yet experienced any leakage repairs. This normally accounts for over 90% of the system; therefore, any policy that relies on prioritizing replacement based on previous leaks alone will only be able to assess around 10% of the system. The introduction of BFZs means that all pipes will have factors associated with them that will discriminate them from their neighbors in terms of Condition or risk score.

All data required to generate Condition scores was loaded into MRP for PGW (taken from the Underground Facilities System (UFS) or Detail Main Maps (DMM)), and BFZs and Condition Scores were calculated. The predominant material in PGW is cast iron, and the predominant failure mode is joint leaks. The following picture shows the distribution of Background Joint Zones (BJZs) for the PGW area as generated by MRP. Areas in red are high zones, areas in green are medium, and areas in blue are low. Pipes lying within a high BJZ are much more likely to experience a joint leak than identical pipes lying within a low BJZ. The same theory is applicable to Background Breakage Zones and Background Corrosion Zones.



MRP will also calculate Risk scores for each pipe. The data required all relate to the pipe and its environment and include the following:

- Proximity of the pipe to nearby property
- The presence of basements in nearby property
- The type of ground surface between the pipe and nearby property (i.e. paved or open)
- The diameter of the pipe
- Its operating pressure.

For the implementation within PGW, the proximity has been estimated by the use of service length. Most properties have been assumed to have basements, and paved ground between the main and nearby property. The diameter and operating pressure are already known.

Pipe Replacement Prioritization

Once Condition and Risk values were generated for all metallic pipes within PGW, Advantica carried out an analysis based on the application of several different replacement scenarios to determine some suitable replacement programs for PGW to consider. All of the scenarios were based upon the use of the Risk model, i.e. those with the highest risk value were identified for replacement first. The current level of cast iron replacement applied within PGW is just less than 18 miles per year. This includes both prudent (risk driven) and enforced (due to diversions etc, and assumed to be random). This has been considered as the base replacement level with which to compare other levels of replacement, namely 24 miles per year and 12 miles per year. The base scenario, A, assumes that the 18 miles of pipes are selected at random. In reality of course, this is not the case, as some selection criteria has been applied based upon PGW's own methodology. Scenarios B, C and D and E, based on highest Risk score first, work down the list of pipes prioritized by Risk score. Within the 18 miles of cast iron replacement, the recent annual average for enforced is 4 miles, thus the 18 miles scenario is actually the replacement of 14 miles of 'prudent' cast iron . Similarly, the 12 mile scenario is actually 8 miles of prudent and the 24 mile scenario is 20 miles of prudent.

These scenarios can be described as follows:

Scenario	Description of scenario	Time period
A	18 miles of cast iron per year, pipes selected at random (14 miles of prudent, but based on PGW's own criteria)	10 years
B	18 miles of cast iron per year, (14 miles of prudent selected by MRP Risk score, highest score first)	10 years
C	17 miles of cast iron per year, (13 miles of prudent selected by MRP Risk score, highest score first)	10 years

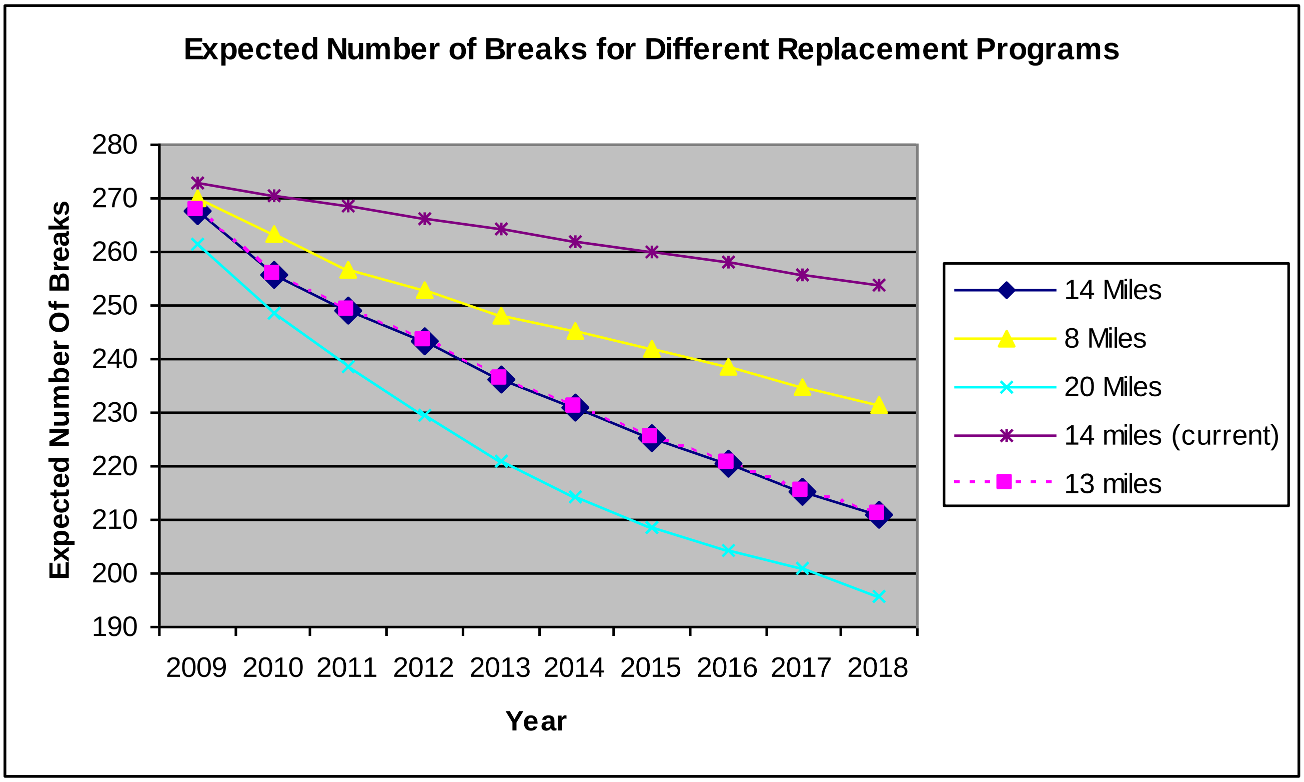
D	12 miles of cast iron per year, (8 miles of prudent selected by MRP Risk score, highest score first)	10 years
E	24 miles of cast iron per year, (20 miles of prudent)selected by Risk score, highest score first)	10 years

For each of these scenarios using MRP, the model identified a specific set of pipes to replace each year. Each of these pipes will have an expected number of breakage repairs associated with it, based on the Risk score. Thus, for each set of pipes replaced each year, they will have an associated total number of breakage repairs which are then assumed to be removed from the system when the pipe is replaced. MRP calculated this reduction in breaks each year, so that various scenarios could be compared with one another.

The following table summarizes the performance of each scenario in terms of its total cost and the reduction in predicted breakage repairs (fractures). The cost of replacement for each scenario was calculated by using the average cost of $0.7 million per mile over the 10-year period. . The starting point, in terms of predicted cast iron breaks was 275 breaks/year, as predicted by MRP. The average breakage rate over the 10 year period 1997 to 2006 within PGW has been 370. It is important to note that the output from MRP predicts the number of breaks associated with specific pipes. The average level of breaks of 370 is based upon all breaks, whether they are assigned to pipes or not. When PGW's historical data is examined further to extract only those breaks associated with pipes, the average reduces to 254 – this is in comparison to a predicted average from MRP of 275, showing that MRP has produced an accurate estimate of the real situation.

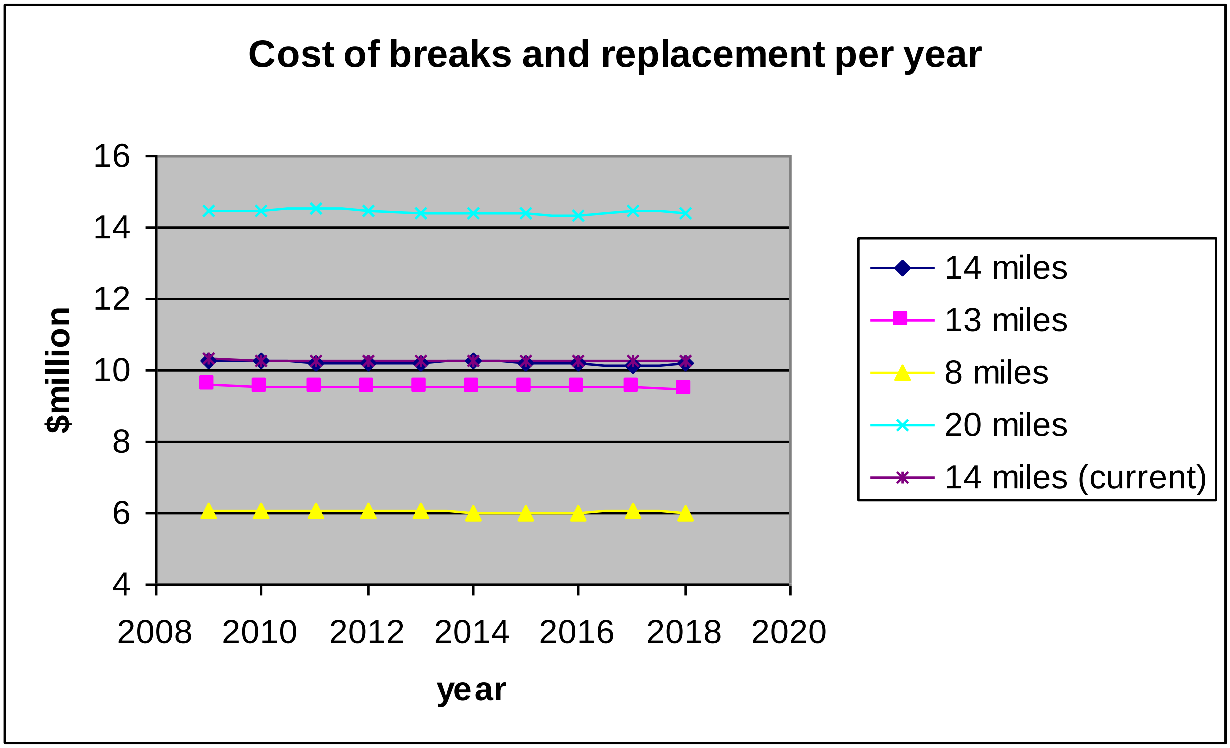
Scenario	**Description**	**Cost of replacement over 10 years ($ million)**	**Breaks in year 0**	**Breaks in year 10**	**% reduction in length of cast iron**	**% reduction in breaks**
A	18 miles of cast iron per year, random (14 miles prudent)	98	275	253	8%	8%
B	18 miles of cast iron per year, 14 miles using MRP Risk	98	275	209	8%	24%
C	17 miles of cast iron per year, 13 miles using MRP risk	91	275	211	7.5%	23%
D	12 miles of cast iron per year, MRP Risk, 8 miles using MRP Risk	56	275	231	5%	16%
E	24 miles of cast iron per year, MRP Risk, 20 miles using MRP risk	141	275	196	11%	29%

The results of all these scenarios are summarized in the following graph, which shows the expected reduction in breakage repairs from each replacement scenario.



The above graph shows some interesting results. All of the scenarios using MRP reduce breakage repairs quicker than the current program. The greater the length replaced each year, the quicker the reduction in breakage repairs, as one would expect. The comparison between the current program and the 18-mile program using MRP has shown that, even though the costs are the same for both programs, the reduction in breakage repairs is much greater when using MRP.

The cost of replacement and repair has also been considered. The average cost of a breakage repair has been assumed to be $1660. The average cost of replacement has been assumed to be $0.7 million per mile. An increase in replacement will increase replacement costs but reduce future breakage repair costs. The following graph summarizes the total cost of each scenario, in terms of replacement and breakage repair costs. The 14 mile (18 mile total) current and MRP scenarios have similar levels of costs, as the cost of replacement is the same in both cases, and is much greater than the cost of breakage repairs. However, as can be seen in the previous graph, the reduction in future breaks is much greater if MRP is used to prioritize the 14 miles.



The costs associated with each scenario are summarized in the following table.

Scenario	Description	Cost of replacement over 10 years ($ million)	Cost of breaks over 10 years ($ million)	Overall cost over 10 years ($ million) (Cost of replacement + cost of breaks)
A	18 miles of cast iron per year, pipes selected at random (14 miles of prudent)	98	3.9	102
B	18 miles of cast iron per year, pipes selected by MRP Risk score (14 miles prudent)	98	3.9	102
C	17 miles of cast iron per year, pipes selected by MRP risk score (13 miles prudent)	91	3.9	95
C	12 miles of cast iron per year, pipes selected by MRP Risk score (8 miles prudent)	56	4.1	60
D	24 miles of cast iron per year, pipes selected by MRP Risk score (20 miles prudent)	140	3.7	144

The scenarios examined within this report all relate to prioritizing pipe replacement based on the Risk score. This is the most effective way to reduce breakage repairs and the associated costs. Prioritizing replacement by Risk score is also the most effective way of reducing serious incidents. In this way, both repairs and serious incidents can be targeted. MRP allows the user to run a number of different scenarios which can be compared against one another so that the most suitable program can be selected, based on a balance between replacement expenditure and improved safety/condition. The results of the MRP scenarios summarized within this report have shown that the current policy of 14 miles of prudent can be improved upon by using MRP to identify mains for replacement, ensuring that the current replacement expenditure is kept at a similar level but the reduction in future breaks (and hence incidents) is greatly improved.